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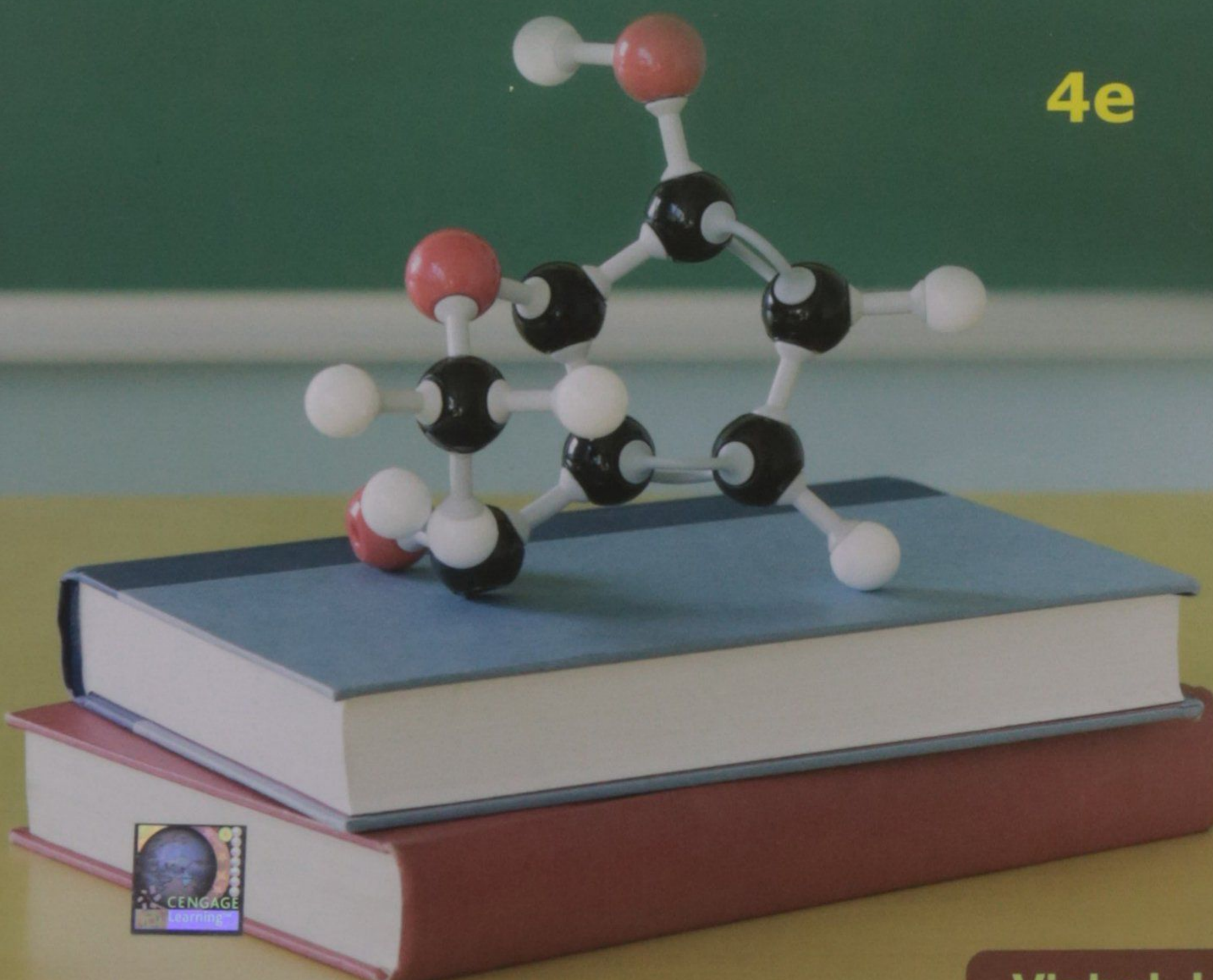

Vishal Joshi

Problems and Solutions in INORGANIC CHEMISTRY for JEE (Main & Advanced)

3e

V. JOSHI

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Problems and Solutions in Inorganic Chemistry for JEE (Main & Advanced), 3e

V. Joshi

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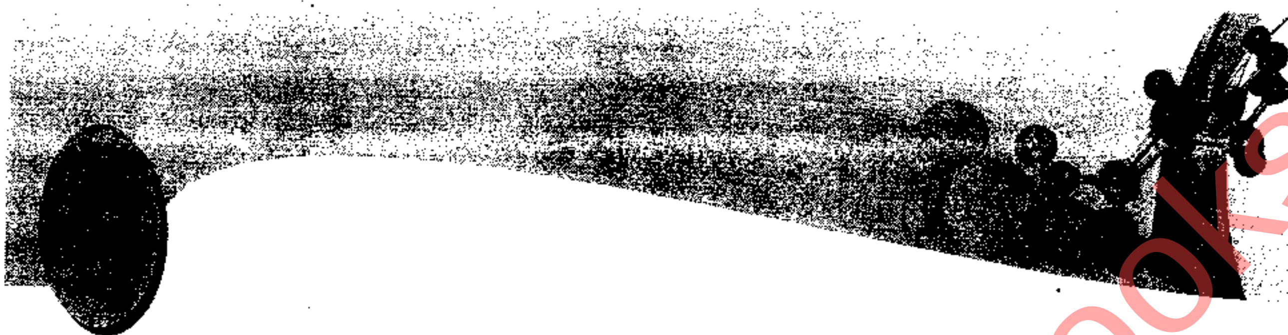

Preface

It is a matter of great pleasure for me to present this edition of *Problems and Solutions in Inorganic Chemistry for JEE (Main & Advanced)* before Joint Entrance Examination (JEE) aspirants. During teaching hours, I felt that the facts may be made more and more clear to the students through problematic approach. Although an ocean of material in inorganic is available with the students, but the approach to design the problems has been changed in recent years and if one tries in this ocean, it will be very difficult task to make the students more familiar with the trends and tricks to solve problems. The present problem book has been presented in the current scenario of stiff competition and is well equipped with the facts of subject, yet the winner is one who knows how to use these equipments with accuracy and efficiency. The book includes the problems based on the latest pattern being followed by JEE.

Most of the chapters in the book have been divided into eight sections, and the problems in each section have been designed such that they fulfill both the requirements of an aspirant, i.e., knowledge of subject and practice.

1. Single Correct Answer Type
2. Multiple Correct Answers Type
3. Comprehension Type
4. Assertion-Reasoning Type
5. Matching Column Type
6. Integer Answer Type
7. NCERT Exemplar Exercises
8. Archives (Previous Years' Questions)

V. JOSHI

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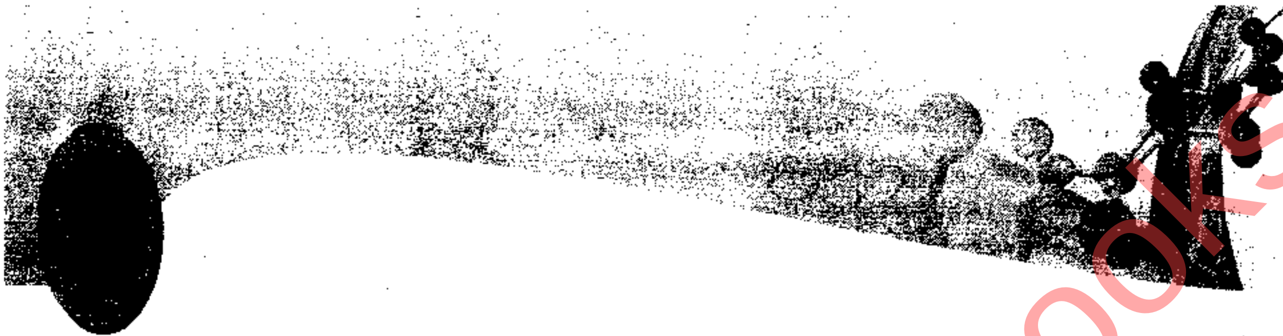
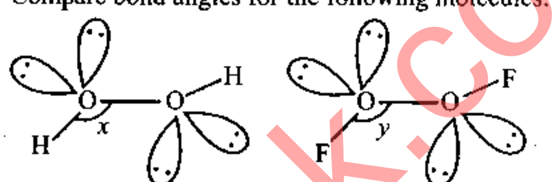


Chemical Bonding (Part-A)

JEE (Main) Exercises

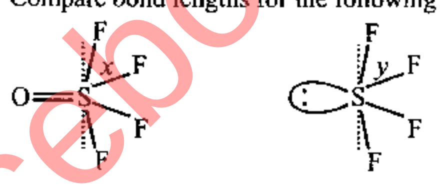
Single Correct Answer Type

1. Compare bond angles for the following molecules:



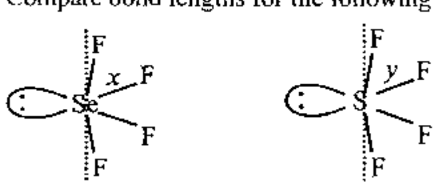
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

2. Compare bond lengths for the following molecules:

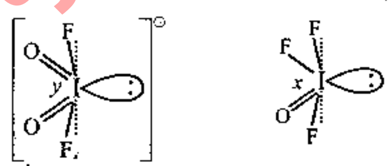


(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

3. Compare bond lengths for the following molecules:

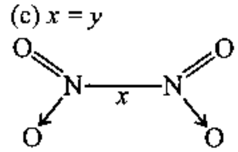
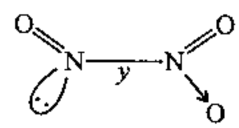


(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

4. 

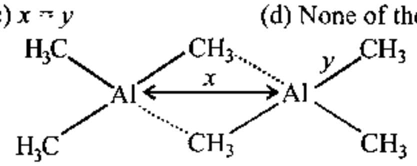
Compare x and y bond lengths for the above given molecules:

(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

5.  and 

Compare x and y bond lengths for the above given molecules:

(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

6. 

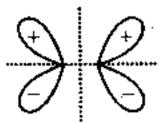
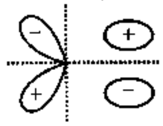
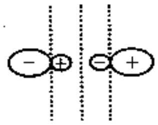
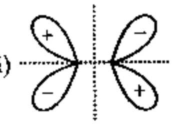
Compare x and y bond lengths for the above given molecule:

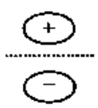
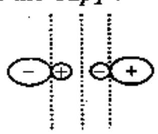
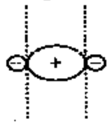
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

7. Which of the following silicate is called pyroxene?
(a) Orthosilicate (b) Pyrosilicate
(c) 2D silicate (d) Single-chain silicate

8. Which of the following silicate is called amphibole?
(a) Single-chain silicate (b) Double-chain silicate
(c) 2D silicate (d) Cyclic silicate

9. Which of the following silicate is called disilicate?
(a) Orthosilicate (b) Pyrosilicate
(c) Single-chain silicate (d) None of these

10. Select the correct diagram for the π^*2p_y-orbital:
(a)  (b) 
(c)  (d) 

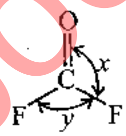
11. Select the correct diagram for the $\sigma 2p_x$-orbital:
(a)  (b) 
(c)  (d) None of these

12. Nature of O_2 molecule is:
(a) Paramagnetic (b) Diamagnetic
(c) Both (a) and (b) (d) None of these

13. Which of the following has the highest boiling point?
(a) Ne (b) He
(c) CH_4 (d) Xe

14. The cationic part of solid XeF_6 is having the "_______" shape:
(a) Linear (b) Angular
(c) Square pyramidal (d) Tetrahedral

15. Compare x and y bond angles in the following molecule:



(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

16. A metal oxide is acidic when:
(a) $\sqrt{\varphi} < 2.1$ (b) $\sqrt{\varphi} = 2.1$ to 3.2
(c) $\sqrt{\varphi} > 3.2$ (d) None of these

17. Find out the similarities between I_2Cl_6 and Al_2Cl_6:
(a) Both have $3C - 4e^-$ bond
(b) Both have sp^3-hybridization for the central atom
(c) Both are nonplanar
(d) All are correct

18. Which of the following set has the same bond order?
(a) $N_2, O_2^{2+}, NO^+, CN^{\ominus}$ (b) $N_2^{2-}, O_2, NO^-, NO_2^+$
(c) $NO, N_2^-, O_2^+, NO^{2+}$ (d) All are correct

19. In the hydrolysis of ICl, the products are:
(a) HI + HCl (b) HI + HOCl
(c) HCl + HOI (d) HOCl + HOI

20. Which of the following geometry is not possible when the central atom is having sp^3d-hybridization?
(a) TBP (b) Trigonal planar
(c) Linear (d) T-shaped

21. Select the correct statement:
(a) If molecule has any polar bond, then it is always polar
(b) Solubility of noble gases increases in water down the group when their size increases because London dispersion force increases
(c) First ionization energy of Al is greater than that of gallium
(d) $XeF_5^{\oplus}$ has distorted octahedral geometry

22. Which is the correct order for different forces?
(a) E_D (Dipole–induced dipole interaction) > E_K (Dipole–dipole interaction) > E_L (London force)
(b) E_K (Dipole–dipole interaction) > E_D (Dipole–induced dipole interaction) > E_L (London force)
(c) E_D (Dipole–induced dipole interaction) > E_L (London force) > E_K (Dipole–dipole interaction)
(d) All forces are equally strong

23. Which of the following compounds are the common product/s obtained in the hydrolysis of XeF_6 and XeF_4?
(a) XeO_2F_2 (b) HF
(c) XeO_3 (d) Both (b) and (c)

24. Which of the following statement is incorrect for CO molecule?
(a) Intramolecular Lewis acid–base interaction is present
(b) Charge separation is present
(c) σ-bond, π-bond, and back-bond all are present together
(d) Direction of dipole moment is from C to O

25. Find the incorrect match:
(a) Al_2Cl_6 : 3C-4e bond is present
(b) $Al_2(CH_3)_6$: All carbon atoms are sp^3-hybridized
(c) I_2Cl_6 : Nonplanar
(d) Al_2Br_6 : Nonpolar

26. Which the following interaction form nonbonding molecular orbital when z-axis is the bonding axis?
(a) $d_{yz} + d_{z^2}$ (b) $d_{yz} + d_{xy}$
(c) $d_{x^2-y^2} + d_{xy}$ (d) All form N.B.M.O.

27. Which of the following molecule/species is polar?
(a) O_3 (b) NO_2^+
(c) Para-dichlorobenzene (d) None of these

28. Which of the following is most covalent?
(a) CuCl (b) NaCl
(c) AgCl (d) AuCl

29. When NF_3 undergoes hydrolysis at room temperature, then the product will be:
(a) HNO_2 (b) N_2O_3
(c) $NO + NO_2$ (d) None of these

30. Select the incorrect order:
(a) Thermal stability : $LiNO_3 < NaNO_3 < KNO_3$
(b) Solubility : $LiNO_3 < NaNO_3 < KNO_3$
(c) Thermal stability : $Be(OH)_2 < Ca(OH)_2 < Sr(OH)_2$
(d) Solubility : $Be(OH)_2 < Ca(OH)_2 < Sr(OH)_2$

31. Which of the following does not contain three electron bond?
(a) ClO_2 (b) CO_2
(c) O_2^- (d) NO

32. Which of the following ions is diamagnetic?
(a) N_2^+ (b) O_2^-
(c) Be_2^+ (d) NO^+

33. Which of the following is not an electron-deficient compound?
(a) $BeEt_2$ (b) $AlMe_3$
(c) B_2H_6 (d) $Si(CH_3)_4$

34. The BCl_3 is a planar molecule, whereas NCl_3 is a pyramidal because:
(a) N — Cl bond is more covalent bond than B — Cl bond
(b) B — Cl bond is more polar than N — Cl bond
(c) nitrogen atom is similar to boron atom
(d) BCl_3 has no lone pair but NCl_3 has a lone pair or electrons

35. Which of the following molecule has the largest bond angle?
(a) BF_3 (b) NH_3
(c) CO_2 (d) SF_6

36. Which compound possesses the greatest lattice energy?
(a) LiBr (b) LiCl
(c) LiI (d) LiF

37. The common features among the species CN^-, CO, and NO^+ are:
(a) Bond order three and isoelectronic
(b) Bond order three and weak field ligands
(c) Bond order two and π-acceptors
(d) Isoelectronic and weak field ligands

38. Which of the following molecular species has unpaired electron(s)?
(a) N_2 (b) F_2
(c) O_2^- (d) O_2^{2-}

39. Covalent compounds have low melting points because:
(a) Covalent molecules have definite shape
(b) Covalent bond is weaker than ionic bond
(c) Covalent bond is less exothermic
(d) Covalent molecules are held by weak van der Waals' forces of attraction

40. Which of the following has a zero dipole moment?
(a) ClF (b) PCl_3
(c) SiF_4 (d) $CFCl_3$

41. The bond order of O_2^+ is:
(a) 1 (b) 1.5
(c) 2.5 (d) 3

42. In which of the following species is the underline carbon having sp^3-hybridization?
(a) $CH_3—\underline{C}OOH$ (b) $CH_3—\underline{C}H_2—OH$
(c) $CH_3—\underline{C}O—CH_3$ (d) $CH_2{=}\underline{C}H—CH_3$

43. A square planar complex is formed by hybridization of which atomic orbitals?
(a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$
(c) s, p_x, p_y, d_{z^2} (d) s, p_x, p_z, d_{xy}

44. Which of the following compound has the smallest bond angle?
(a) SH_2 (b) NH_3
(c) SO_2 (d) OH_2

45. Which of the following statement is not correct for sigma and pi-bonds formed between two carbon atoms?
(a) A sigma bond is stronger than a pi-bond
(b) Bond energies of sigma and pi-bonds are of the same order

(c) Free rotation of atoms about a sigma bond is allowed but not in case of a pi-bond

(d) A sigma bond determines the direction between carbon atoms, but a pi-bond has no primary effect in this regard

46. Number of covalent bonds in MgH_2 is:

(a) Zero (b) 1

(c) 2 (d) 4

47. Only iodine forms heptafluoride IF_7, but chlorine and bromine give pentafluorides. The reason for this is:

(a) Low electron affinity of iodine

(b) Unusual pentagonal bipyramidal structure of IF_7

(c) That the larger iodine atom can accommodate more number of smaller fluorine atom around it

(d) Low chemical reactivity of IF_7

48. Based on lattice energy and other considerations which one of the following alkali metal chloride has the highest melting point?

(a) KCl (b) RbCl

(c) LiCl (d) NaCl

49. Which of the following cannot exist on the basis of M.O. theory?

(a) C_2 (b) He_2^+

(c) H_2^+ (d) He_2

50. Which of the following has fractional bond order?

(a) O_2^{2+} (b) O_2^{2-}

(c) F_2^{2-} (d) H_2^-

51. The correct order of a dipole moment is:

(a) $CH_4 < NF_3 < NH_3 < H_2O$

(b) $NF_3 < CH_4 < NH_3 < H_2O$

(c) $NH_3 < NF_3 < CH_4 < H_2O$

(d) $H_2O < NH_3 < NF_3 < CH_4$

52. In water molecule, oxygen is:

(a) *sp*-hybridized (b) sp^3-hybridized

(c) sp^2-hybridized (d) None of these

53. According to Fajan's rule, ionic character increases for:

(a) Large cation and small anion

(b) Small cation and small charge on cation

(c) Small cation and large charge on cation

(d) Large cation and no charge on cation

54. Which one of the following order is not in accordance with the property stated against it?

(a) F > Cl > Br > I: Electronegativity

(b) $F_2 > Cl_2 > Br_2 > I_2$: Bond dissociation energy

(c) $F_2 > Cl_2 > Br_2 > I_2$: Oxidizing power

(d) HI > HBr > HCl > HF: Acidic property in water

55. The species having octahedral shape is:

(a) SF_6 (b) BF_4^-

(c) PCl_5 (d) BO_3^{3-}

56. Which one of the following sets of ions represent a collection of isoelectronic species?

(a) $K^+, Cl^-, Ca^{2+}, Sc^{3+}$ (b) $Ba^{2+}, Sr^{2+}, K^+, Ca^{2+}$

(c) $N^{3-}, O^{2-}, F^-, S^{2-}$ (d) $Li^+, Na^+, Mg^{2+}, Ca^{2+}$

57. Which of the following molecules/ions are all the bonds not equal?

(a) SF_4 (b) SiF_4

(c) XeF_4 (d) BF_4^-

58. The decreasing values of bond angles from NH_3 (107°) to SbH_3 (91°) down the group-15 of the periodic table is due to:

(a) Increasing *bp–bp* repulsion

(b) Increasing *p*–orbital character in sp^3

(c) Decreasing *lp–bp* repulsion

(d) Increasing electronegativity

59. Arrange the following compounds in order of increasing dipole moment:

(I) Toluene (II) *m*-dichlorobenzene

(III) *o*-dichlorobenzene (IV) *p*-dichlorobenzene

(a) I < IV < II < III (b) IV < I < II < III

(c) IV < I < III < II (d) IV < II < I < III

60. Linear combination of two hybridized orbitals, belonging to two atoms and each having one electron, leads to:

(a) Sigma-bond (b) Double bond

(c) Coordinate covalent bond

(d) Pi-bond

61. In compound *X*, all the bond angles are exactly 109°28′. *X* is:

(a) Chloromethane (b) Iodoform

(c) Carbon tetrachloride (d) Chloroform

62. The correct order of bond angle is:

(a) $PF_3 = PCl_3 = PBr_3 = PI_3$

(b) $PF_3 < PBr_3 < PCl_3 < PI_3$

(c) $PI_3 < PBr_3 < PCl_3 < PF_3$

(d) $PF_3 < PCl_3 < PBr_3 < PI_3$

63. Which compound among the following has more covalent character?

(a) $AlCl_3$ (b) AlI_3

(c) MgI (d) NaI

64. The compound with the maximum dipole moment among the following is:

(a) *p*-Dichlorobenzene (b) *m*-Dichlorobenzene

(c) *o*-Dichlorobenzene (d) Carbon tetrachloride

65. Pauling's electronegativity values of elements are useful in predicting:

(a) Polarity of bonds in molecules

(b) Position of elements in periodic table

(c) Coordination number

(d) Dipole moment of various molecules

66. The structure of ICl_2^- is:

(a) Trigonal (b) Octahedral

(c) Square planar (d) None of these

67. In H_2^- ion, the bond order is:

(a) Zero (b) 1/2

(c) –1/2 (d) 1

68. The shape of ClO_3^- according to VSEPR model is:

(a) Planar triangle (b) Pyramidal

(c) Tetrahedral (d) Square planar

69. The state of hybridization for the transition state of hydrolysis mechanism of BCl_3 and SF_4 are respectively:

(a) sp^2, sp^3d (b) sp^3, sp^3

(c) sp^3, sp^3d^2 (d) sp^3, sp^3d

70. Which of the following molecular species has unpaired electron(s)?

(a) N_2 (b) F_2

(c) O_2^- (d) O_2^{2-}

71. Which of the following two are isostructural?

(a) XeF_2, IF_2^- (b) NH_3, BF_3

(c) CO_3^{2-}, SO_3^{2-} (d) PCl_5, ICl_5

72. According to molecular orbital theory for O_2^+:

(a) Bond order is less than O_2 and O_2^+ is paramagnetic

(b) Bond order is more than O_2 and O_2^+ is paramagnetic

(c) Bond order is less than O_2 and O_2^+ is diamagnetic

(d) Bond order is more than O_2 and O_2^+ is diamagnetic

73. The maximum number of 90° angles between bond pair–bond pair of electron is observed in:

(a) sp^3d^2-hybridization (b) sp^3d-hybridization

(c) dsp^2-hybridization (d) dsp^3-hybridization

74. Which species is diamagnetic in nature?

(a) He_2^+ (b) H_2

(c) H_2^+ (d) H_2^-

75. Which of the following does not contain isoelectronic species?

(a) PO_4^{3-}, SO_4^{2-}, ClO_4^- (b) CN^-, N_2, C_2^{2-}

(c) SO_3^{2-}, CO_3^{2-}, NO_3^- (d) BO_3^{3-}, CO_3^{2-}, NO_3^-

76. The correct increasing covalent nature is:

(a) NaCl < LiCl < $BeCl_2$ (b) $BeCl_2$ < NaCl < LiCl

(c) $BeCl_2$ < LiCl < NaCl (d) LiCl < NaCl < $BeCl_2$

77. Which is expected to show paramagnetism?

(a) ClO_2 (b) SO_2

(c) CO_2 (d) SiO_2

78. Which of the following tetrahalide is not easily hydrolyzed?

(a) CCl_4 (b) $SiCl_4$

(c) $GeCl_4$ (d) $SnCl_4$

79. Which of the following molecule is planar?

(a) $[I(CN)_2]^-$ (b) PCl_3F_2

(c) PCl_5 (d) SF_4

80. Which of the following molecule has sp^3d-hybridization?

(a) SOF_4 (b) SF_4

(c) XeF_3^+ (d) All

81. Which of the following molecule/ion has a zero dipole moment?

(a) ClF_3 (b) ICl_2^-

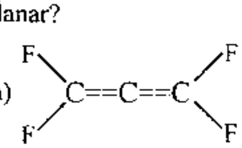
(c) SF_4 (d) None of these

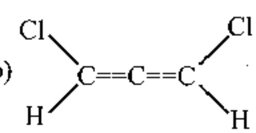
82. Select the correct ionic mobility order in water?

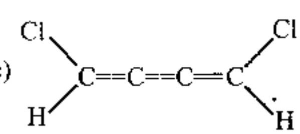
(a) $Be^{2+} > Ba^{2+}$ (b) $Li^+ > Rb^+$

(c) $I^- < Cl^-$ (d) $Na^+ > Mg^{2+} > Al^{3+}$

83. Which of the following molecule is polar as well as planar?

(a)


(b)


(c)


(d) None of these

84. What is the hybridization of Xe in cationic part of solid XeF_6?

(a) sp^3d^3 (b) sp^3d

(c) sp^3d^2 (d) sp^3

85. Which of the following molecule(s)/ion(s) are isoelectronic?

(a) CO_2 and N_2O (b) CO_2 and CN_2^{2-}
(c) C_6H_6 and $B_3N_3H_6$ (d) All are isoelectronic

86. Select the correct order of polarizing power of cation?

(a) $Na^+ < Mg^{2+} < Si^{4+} < Al^{3+}$
(b) $Mg^{2+} > Si^{4+} > Al^{3+} > Na^+$
(c) $Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$
(d) $Al^{3+} < Si^{4+} < Mg^{2+} < Na^+$

87. Select the correct order of thermal stability of bicarbonates:

(a) $NaHCO_3 > KHCO_3 > RbHCO_3 > CsHCO_3$
(b) $RbHCO_3 > CsHCO_3 > NaHCO_3 > KHCO_3$
(c) $KHCO_3 > RbHCO_3 > CsHCO_3 > NaHCO_3$
(d) $NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$

88. Identify the correct order of bond angle in following species:

$$\overset{\oplus}{C}H_3,\quad CH_4,\quad \overset{\ominus}{C}H_3$$

(a) $\overset{\ominus}{C}H_3 > CH_4 > \overset{\oplus}{C}H_3$ (b) $CH_4 > \overset{\ominus}{C}H_3 > \overset{\oplus}{C}H_3$
(c) $\overset{\oplus}{C}H_3 > CH_4 > \overset{\ominus}{C}H_3$ (d) $\overset{\oplus}{C}H_3 = CH_4 = \overset{\ominus}{C}H_3$

89. Which of the following molecule/ion has higher B — O bond length?

(a) H_3BO_3 (b) $[B(OH)_4]^-$
(c) Both (a) and (b) have equal B—O bond length
(d) None of these

90. Which of the following molecule has $3C-4e^-$ bond?

(a) Al_2Cl_6 (b) Be_2Cl_4
(c) I_2Cl_6
(d) All are having $3C-4e^-$ bond

91. Which of the following molecule does not exist?

(a) He_2 (b) $H — H^+$
(c) $He — He^+$ (d) Li_2

92. Certain derivatives of phenol such as Kr (phenol)$_2$, Xe (phenol)$_2$, Rn (phenol)$_2$, etc., may result due to which type of interaction?

(a) Dipole–dipole (b) Ion–dipole
(c) Ion–induced dipole (d) Dipole–induced dipole

93. In organic homologous series, the higher members show the higher melting and boiling point due to the:

(a) Dipole–dipole interaction
(b) Ion–dipole interaction
(c) London dispersion forces
(d) Dipole–induced dipole interaction

94. Select the correct order of unpaired e^- of antibonding molecular orbitals in following species:

(a) $O_2 > O_2^{2-} > O_2^-$ (b) $O_2 > O_2^- > O_2^{2-}$
(c) $O_2 > O_2^{2-} \approx O_2^-$ (d) $O_2 \approx O_2^{2-} \approx O_2^-$

95. Select the correct order of the first ionization potential:

(a) $NO > N_2$ (b) $N_2 > NO$
(c) $NO \approx N_2$ (d) None of these

96. Select the correct order of the first ionization potential:

(a) $F_2 > F$ (b) $F_2 \approx F$
(c) $F > F_2$ (d) None of these

97. Which of the following element does not show inert pair effect?

(a) Tl (b) Pb
(c) Bi (d) Sn

98. Which of the following compound is not a strong oxidizing agent?

(a) PbO_2 (b) $PbCl_4$
(c) Pb_2O_3 (d) CCl_4

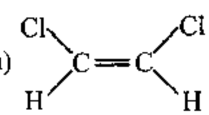
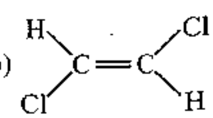
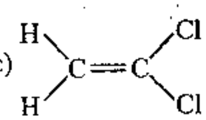
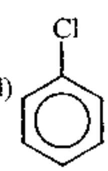
99. Which of the following does show reducing property?

(a) Ge(II) (b) Sn(II)
(c) Both (a) and (b) (d) None of these

100. Which of the following molecule is not showing zero dipole moment?

(a) $C_6H_4(NO_2)$ (para) (b) $C_6H_4(CH_3)_2$ (para)
(c) $C_6H_4(OH)_2$ (para)
(d) All compounds are showing zero dipole moment

101. Which of the following molecule has almost zero dipole moment?

(a) 
(b) 
(c) 
(d) 

102. Select the correct increasing order of π bond formation tendency from the following:

(a) Si — O > P — O > S — O > Cl — O
(b) Si — O < P — O < S — O < Cl — O
(c) Cl — O < Si — O < P — O < S — O
(d) Si — O < Cl — O < P — O < S — O

103. Choose the correct order of bond strength by overlapping of atomic orbitals:

(a) $1s\text{-}1s > 1s\text{-}2s > 1s\text{-}2p$ (b) $2s\text{-}2s > 2s\text{-}2p > 2p\text{-}2p$
(c) $2s\text{-}2p > 2s\text{-}2s > 2p\text{-}2p$ (d) $1s\text{-}1s > 1s\text{-}2p > 1s\text{-}2s$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which one of the following bonds has the highest bond energy?
   (a) C – C (b) Si – Si
   (c) Ge – Ge (d) Sn – Sn

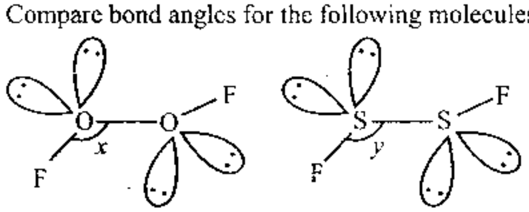
2. Which of the following is incorrect?
   (a) Among Cl, Ar, and K, K has the smallest ionization potential
   (b) Among CH_4, NH_3, and HF, HF has the highest boiling point
   (c) Among Cl_2, Br_2, and I_2, Br_2 has the lowest boiling point
   (d) Among HOI, HOBr, and HOCl, HOI is the weakest acid

3. PCl_5 and PBr_5 exist in sp^3d-hybrid state in gaseous phase. But in solid state, which of the following statement is true?
   (a) P in PCl_5 exists in sp^3-hybridization state, while P in PBr_5 exists in sp^3d^2 and sp^3-hybridization states
   (b) P in PCl_5 and PBr_5 exists in sp^3d^2 and sp^3-hybridization state
   (c) P in PCl_5 exists in sp^3d^2 and sp^3-hybridization states, while P in PBr_5 exists in sp^3-hybridization state
   (d) P in PCl_5 and PBr_5 exists in sp^3-hybridization state

4. Which of the following halide does not exist?
   (a) PbF_4 (b) $PbCl_4$
   (c) PbI_2 (d) PbI_4

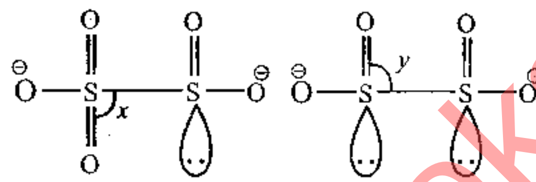
5. If the π-back bonding involves the lone pair of central atom, then bond angle gets opened up due to:
   (a) Increase of *bp/bp* repulsion for the enhanced bond multiplicity
   (b) Decrease of *lp/lp* and *lp/bp* repulsion(s) on the central atom
   (c) Both (a) and (b) (d) None of these

6. Compare bond angles for the following molecules:



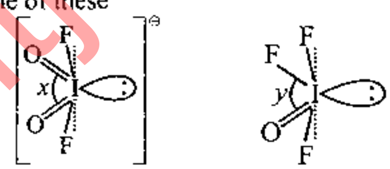
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

7. Compare S—O bond angle for the following molecules:

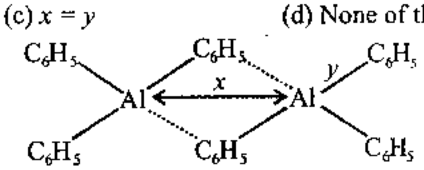


   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

8. Compare $F-\hat{Br}-O$ and $O-\hat{Br}-O$ in $FBrO_3$ molecule:
   (a) $F-\hat{Br}-O > O-\hat{Br}-O$
   (b) $F-\hat{Br}-O < O-\hat{Br}-O$
   (c) $F-\hat{Br}-O = O-\hat{Br}-O$
   (d) None of these

9. 

   Compare x and y bond angles for the above given molecules:
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

10. 

   Compare x and y bond lengths for the above given molecule:
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

11. Which of the following reaction(s) is/are not possible?
   (i) $(CH_3)_2O + BF_3 \longrightarrow (CH_3)_2O \rightarrow BF_3$
   (ii) $(SiH_3)_2O + BF_3 \longrightarrow (SiH_3)_2O \rightarrow BF_3$
   (iii) $H_3N + BF_3 \longrightarrow H_3N \rightarrow BF_3$
   (iv) $(CH_3)_2O + BF_4^- \longrightarrow (CH_3)_2O \rightarrow BF_4^-$
   (a) (i) and (ii) (b) (i), (iii), and (iv)
   (c) (ii) and (iv) (d) (ii) and (iii)

12. $Si_6O_{18}^{12-}$ unit is an example of:
   (a) 3D silicate (b) Double chain silicate
   (c) Cyclic silicate (d) 2D silicate

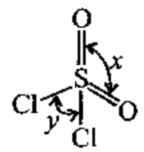
13. Which of the following molecule/ion has higher number of e^- in A.B.M.O.?

(a) O_2^+ (b) O_2^{2-}

(c) O_2^{2+}

(d) All have equal number of unpaired e^-

14. Compare x and y bond angles in the following molecule:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

15. Predict the nature of metal oxide if $\phi = 2.1$ for metal cation:

(a) Amphoteric (b) Acidic

(c) Basic (d) Neutral

16. The correct order of bond angle is:

(a) $H_2O > OF_2 > SF_2 > H_2S$

(b) $H_2O > SF_2 > OF_2 > H_2S$

(c) $H_2O > OF_2 > H_2S > SF_2$

(d) $H_2O > H_2S > OF_2 > SF_2$

17. In which of the following molecules all A—X bond lengths are identical?

[A = central atom and X = surrounding atom]

(a) XeF_4 (b) PF_5

(c) Both (a) and (b) (d) SF_4

18. Which of the following species has smallest N—O bond length?

(a) NO (b) NO^-

(c) NO^+ (d) N_2O

19. The compounds in which the mentioned bond angle in parenthesis is found to be greater than expected not due to back bonding is:

(a) H_3SiNCS (∠ Si—N—C) (b) BI_3 (∠ I—B—I)

(c) MeNCS (∠ CNC) (d) None of these

20. Select from each set the molecule or ion having the smallest bond angle:

(i) NH_3, PH_3 or AsH_3 (ii) $\overset{+}{O_3}$, O_3

(iii) NO_2^- or O_3

(iv) X—S—X angle in $SOCl_2$ and SOF_2

(a) NH_3, $\overset{+}{O_3}$, O_3, $SOCl_2$

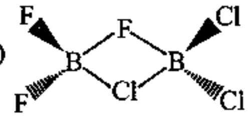
(b) PH_3, $\overset{+}{O_3}$, NO_2^-, SOF_2

(c) AsH_3, O_3, NO_2^-, SOF_2

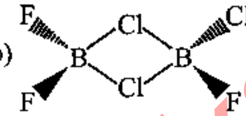
(d) AsH_3, $\overset{+}{O_3}$, O_3, SOF_2

21. What will be the transition state to get BF_2Cl and BCl_2F from the reaction between BF_3 and BCl_3?

(a)



(b)



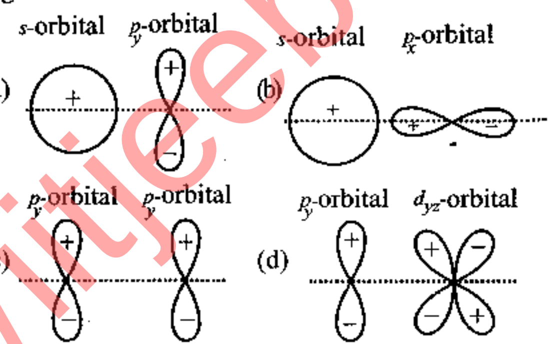
(c) Both (a) and (b) (d) None of these

22. Which of the following bond has the highest energy?

(a) Se—Se (b) Te—Te

(c) S—S (d) O—O

23. Which of the following overlaps leads to sigma bonding if x is internuclear axis?



24. The decreasing order of bond angle is:

(a) $NO_2 > NO_2^+ > NO_2^-$ (b) $NO_2^- > NO_2 > NO_2^+$

(c) $NO_2^+ > NO_2 > NO_2^-$ (d) $NO_2^+ > NO_2^- > NO_2$

25. Which has higher bond energy and stronger bond?

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

26. Which of the following is most stable?

(a) Pb^{2+} (b) Ge^{2+}

(c) Si^{2+} (d) Sn^{2+}

27. According to Fajan's rule, polarization is more when:

(a) Small cation and large anion

(b) Small cation and small anion

(c) Large cation and large anion

(d) Large cation and small anion

28. The bond strength in O_2^+, O_2, O_2^-, and O_2^{2-} follows the order:

(a) $O_2^{2-} > O_2^- > O_2 > O_2^+$ (b) $O_2^+ > O_2 > O_2^- > O_2^{2-}$

(c) $O_2 > O_2^- > O_2^{2-} > O_2^+$ (d) $O_2^- > O_2^{2-} > O_2^+ > O_2$

29. Among the following compounds the one that is polar and has the central atom with sp^2-hybridization is:

(a) H_2CO_3 (b) SiF_4

(c) BF_3 (d) $HClO_2$

30. Which pair represents isostructural species?

(a) CH_3^- and CH_3^+ (b) NH_4^+ and NH_3

(c) SO_4^{2-} and BF_4^- (d) NH_2^- and BeF_2

31. Among KO_2, electron, BaO_2, and NO_2^+, unpaired electron is present in:

(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-

(c) KO_2 only (d) BaO_2 only

32. Among LiCl, $BeCl_2$, BCl_3, and CCl_4, the covalent bond character follows the order:

(a) $LiCl > BeCl_2 > BCl_3 > CCl_4$

(b) $LiCl < BeCl_2 < BCl_3 < CCl_4$

(c) $LiCl > BeCl_2 > CCl_4 > BCl_3$

(d) $LiCl < BeCl_2 < BCl_3 > CCl_4$

33. The correct order of decreasing polarisability of ion is:

(a) Cl^-, Br^-, I^-, F^- (b) F^-, I^-, Br^-, Cl^-

(c) I^-, Br^-, Cl^-, F^- (d) F^-, Cl^-, Br^-, I^-

34. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order:

(I) K_2CO_3 (II) $MgCO_3$ (III) $CaCO_3$ (IV) $BeCO_3$

(a) I < II < III < IV (b) IV < II < III < I

(c) IV < II < I < III (d) II < IV < III < I

35. Which has triangular planar shape?

(a) CH_3^+ (b) ClO_2^-

(c) H_3O^+ (d) ClO_3^-

36. Highest covalent character is found in which of the following?

(a) CaF_2 (b) $CaCl_2$

(c) CaI_2 (d) $CaBr_2$

37. C—O—C angle in ether molecule is:

(a) 110° (b) 90°

(c) 180° (d) 109°28′

38. In P_4O_{10} molecule, bridging P–O bond length is:

(a) Larger than that of in P_4O_6

(b) Lesser than that of in P_4O_6

(c) Equal to that of in P_4O_6

(d) Cannot be compared

39. The nodal plane in the π-bond of ethene is located in:

(a) The molecular plane

(b) A plane parallel to the molecular plane

(c) A plane perpendicular to the molecular plane which bisects the carbon–carbon σ-bond at right angle

(d) A plane perpendicular to the molecular plane which contains the carbon–carbon σ-bond

40. The state of hybridization of boron and oxygen atom in boric acid (H_3BO_3) is respectively:

(a) sp^3, sp^3 (b) sp^2, sp^3

(c) sp^3, sp^2 (d) sp^2, sp^2

41. Which of the following has regular tetrahedral shape?

(a) I_3^- (b) SF_4

(c) $[BF_4]^-$ (d) XeF_4

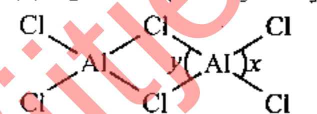
42. The correct order of bond angles is:

(a) $H_2S < NH_3 < BF_3 < SiH_4$

(b) $NH_3 < H_2S < SiH_4 < BF_3$

(c) $H_2S < NH_3 < SiH_4 < BF_3$

(d) $H_2S < SiH_4 < NH_3 < BF_3$

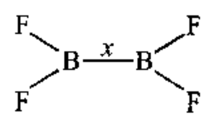
43. 

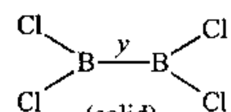
Compare x and y bond angle in above molecule:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

44. Compare B—B bond length in following molecules:





(solid)

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

45. How many S—S linkage(s) is/are present in sodium tetrathionate?

(a) 4 (b) 3

(c) 2 (d) 1

46. Find the maximum number of atoms that lie in the same plane in PCl_5 molecule:

(a) 3 (b) 5

(c) 4 (d) 2

47. In which of the following cases hydrolysis takes place through S_N2 and S_N1 mechanism, respectively?

(A) P_4O_{10}, $SiCl_4$ (B) NCl_3, NF_3

(C) $SiCl_4$, SiF_4 (D) SF_4, TeF_6

48. What may be the geometry of molecule if AX_3 molecule has non-zero dipole moment?

(a) Trigonal planar (b) Bent T-shape

(c) Pyramidal (d) Both (b) and (c)

49. If Hund's rule is not applicable, then bond order and magnetic behavior of O_2 molecule is:

(a) 2, Paramagnetic (b) 2, Diamagnetic

(c) 2.5, Paramagnetic (d) 2.5, Diamagnetic

50. The existence of intermolecular forces is supported by the facts:
(a) Non ideality of real gases
(b) Liquefaction of gases
(c) Both (a) and (b)
(d) None of these

51. Select the incorrect statement:
(a) On adding one electron in NO^+, the bond length increases
(b) Boron is paramagnetic while carbon is diamagnetic
(c) CO and N_2 both have different bond order
(d) CO and N_2 both have same bond order

52. Select the correct order of first ionization potential:
(a) $N > O_2$ (b) $O_2 > N$
(c) $O_2 = N$ (d) None of these

53. Select the correct order of first ionization potential:
(a) $N > N_2$ (b) $N < N_2$
(c) $N \approx N_2$ (d) None of these

54. Select the correct order of polymerization tendency from the following:
(a) Si — O > P — O > S — O > Cl — O
(b) P — O > S — O > Cl — O > Si — O
(c) Cl — O > S — O > P — O > Si — O
(d) Si — O < P — O < S — O < Cl — O

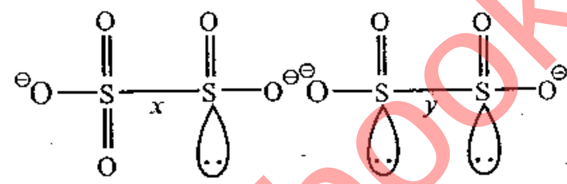
55. Choose the incorrect statement:
(a) Reducing power in aqueous solution is maximum for lithium metal
(b) Electron affinity order $O^+ > O > O_2^{2-} > O^{2-}$
(c) Order of oxidation number of oxygen $O_3 > KO_2 > BaO_2 > K_2O$
(d) pH of aqueous solution $LiCl > BeCl_2 > MgCl_2 > AlCl_3$

56. Given the species N_2, CO, NO^+, and CN^- which of the following statements are true for this:
(I) All the species are diamagnetic
(II) All the species are isostructural
(III) All the species have identical bond order
(IV) More than one species have zero dipole moment
(a) I, II, and III (b) I, II, III, and IV
(c) III and IV (d) I and II

57. Which is not correctly matched?
(a) XeO_3 : Trigonal bipyramidal
(b) ClF_3 : Bent T-shape
(c) $XeOF_4$: Square pyramidal
(d) XeF_2 ; Linear shape

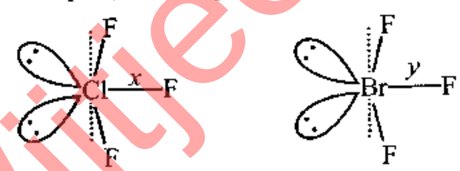
58. The bond order of CO molecule on the basis of molecular orbital theory is:
(a) Zero (b) 2
(c) 3 (d) 1

59. Compare S—S bond length from the following molecules:



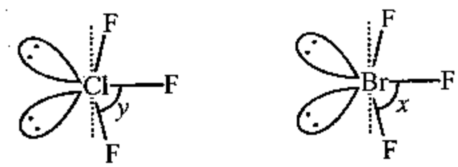
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

60. Compare bond length from the following molecules:

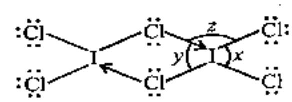


(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these.

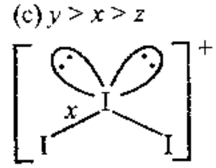
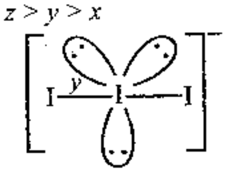
61. Compare bond angle from the following molecules:



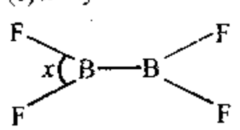
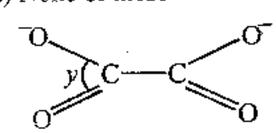
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

62. 

Compare x, y, z bond angle from the above given molecule:
(a) $x > y > z$ (b) $x > z > y$
(c) $y > x > z$ (d) $z > y > x$

63.  and 

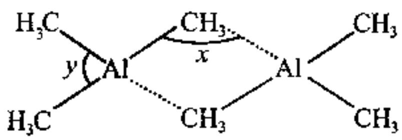
Compare bond length from the above given molecules:
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

64.  

Compare x and y bond angle from the above given molecules:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

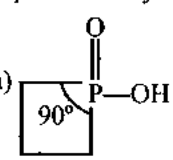
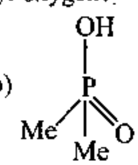
65. 

Compare x and y bond angle from the above given molecule:

(a) $x > y$ (b) $y > x$

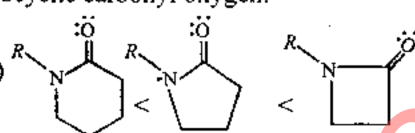
(c) $x = y$ (d) None of these

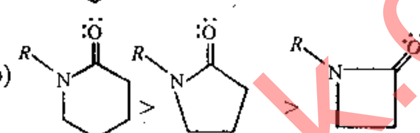
66. Which of the following compound is more basic with respect to exocyclic carbonyl oxygen?

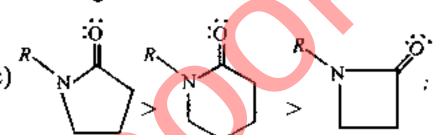
(a)  (b) 

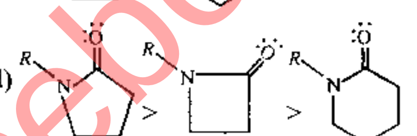
(c) Both are equally basic (d) None of these

67. Select the correct order of Lewis basic strength for exocyclic carbonyl oxygen:

(a)  ; R = Me

(b)  ; R = Me

(c)  ; R = Me

(d)  ; R = Me

68. If the π-back bonding involves the vacant orbital of the central atom, then the bond angle gets widened due to:

(a) The increased *bp/bp* repulsion for the enhanced bond multiplicity

(b) The decreased of *lp/lp* and *lp/bp* repulsion(s)

(c) Both (a) and (b)

(d) None of the above

69. In which of the following structure, the number of shared oxygen atom per tetrahedron is two and half?

(a) 2D silicate (b) 3D silicate

(c) Amphibole (d) Ortho silicate

70. Calculate the % p-character in the orbital occupied by the lone pairs in water molecule:

[Given: $\angle$HOH is 104.5° and cos (104.5) = – 0.25]

(a) 80% (b) 20%

(c) 70% (d) 75%

71. Correct order for the boiling point between CCl_4 and $SiCl_4$:

(a) $CCl_4 > SiCl_4$ (b) $SiCl_4 > CCl_4$

(c) $SiCl_4 = CCl_4$ (d) None of these

72. Hybridization of central atom is independent of the phase/state of the compound in case of:

(a) BeH_2 (b) N_2O_5

(c) XeF_6 (d) PF_5

73. Select the correct order for I.E.:

(a) CO > N_2 (b) N_2 > CO

(c) $N_2 < O_2$ (d) N < O

74. Which of the following molecules has the weakest bond?

(a) H_2 (b) Li_2

(c) F_2 (d) O_2

75. Which of the following molecule/ion does not contain unpaired electrons?

(a) O_2^{2-} (b) B_2

(c) N_2^+ (d) O_2

76. Among the following species, identify the isostructural pairs:

$$NF_3,\ NO_3^-,\ BF_3,\ H_3O^+,\ HN_3$$

(a) [NF_3, NO_3^-] and [BF_3, H_3O^+]

(b) [NF_3, HN_3] and [NO_3^-, BF_3]

(c) [NF_3, H_3O^+] and [NO_3^-, BF_3]

(d) [NF_3, H_3O^+] and [HN_3, BF_3]

77. Which of the following statement is correct for $CsBr_3$?

(a) It is a covalent compound

(b) It contains Cs^{3+} and Br^- ions

(c) It contains Cs^+, and Br_3^- ions

(d) It contains Cs^+, Br^- and lattice Br_2 molecule

78. Iron is tougher than sodium because:

(a) Iron atom is smaller

(b) Iron atoms are more closely packed

(c) Metallic bonds are stronger in iron

(d) None of these

79. van der Waals' forces are applied to:

(a) Inert gases only (b) Rare gases only

(c) Mixture of gases (d) Elementary gases only

80. The correct order of hybridization of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5 and BCl_3 is:

(a) dsp^2, dsp^3, sp^2, sp^3 (b) sp^3, dsp^2, sp^3d, sp^2

(c) dsp^2, sp^2, sp^3, dsp^3 (d) dsp^2, sp^3, sp^2, dsp^3

81. Specify the coordination geometry around and hybridization of N and B atom in a 1 : 1 complex of BF_3 and NH_3:

(a) N : tetrahedral, sp^3; B : tetrahedral, sp^3

(b) N : pyramidal, sp^3; B : pyramidal, sp^3

(c) N : pyramidal, sp^3; B : planar, sp^2

(d) N : pyramidal, sp^3; B : tetrahedral, sp^3

82. The bond order in NO is 2.5 while that in NO^+ is 3. Which statement is true for these two species?

(a) Bond length is unpredictable

(b) Bond length in NO is greater than that in NO^+

(c) Bond length in NO^+ is equal to that in NO

(d) Bond length in NO^+ is greater than that in NO.

83. Which of the following acid is not formed during the stepwise hydrolysis of P_4O_{10}?

(a) Tetrameta phosphoric acid

(b) Hypophosphoric acid

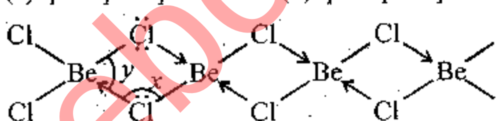
(c) Pyrophosphoric acid

(d) Tetra polyphosphoric acid

84. Which of the following overlapping is used for the formation of $3C-2e^-$ bond in chain polymer of $BeMe_2$?

(a) sp - sp - sp (b) sp^2 - sp^2 - sp^2

(c) sp^2 - sp^3 - sp^2 (d) sp^3 - sp^3 - sp^3

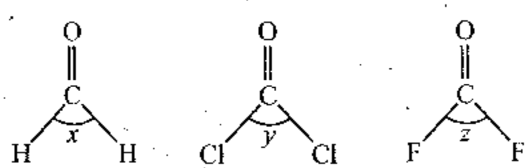
85. 

Compare x and y bond angle in above molecule:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

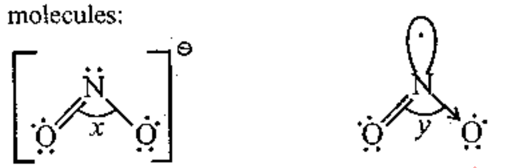
86. Select the correct order of bond angle in following molecules:



(a) $x > z > y$ (b) $x > y > z$

(c) $z > y > x$ (d) $y > x > z$

87. Select the correct order of bond angle in following molecules:



(a) $x < y$ (b) $y < x$

(c) $x = y$ (d) None of these

88. $[Be(OCH_3)_2]_n$ is a high polymer, and is soluble in hydrocarbon solvent. Which type of bond is present in this polymer?

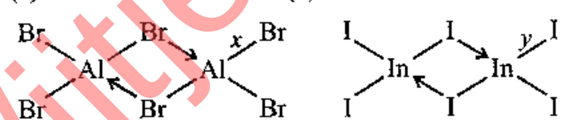
(a) $3C\text{-}2e^-$ (b) $3C\text{-}4e^-$

(c) $2C\text{-}3e^-$ (d) None of these

89. Which type of bond is present in $[BeF_2]_n$ polymer?

(a) $3C-2e^-$ (b) $3C-4e^-$

(c) $2C-3e^-$ (d) None of these

90. 

Compare x and y bond length in above molecules?

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

91. Which of the following hydrides has the strongest reducing nature?

(a) CH_4 (b) SiH_4

(c) GeH_4 (d) SnH_4

92. Which of the following molecule has intramolecular H-bonding?

(a) Ortho-nitrophenol (b) Ortho-boric acid

(c) Both (a) and (b) (d) None of these

93. If Pauli exclusion principle is not applicable and one orbital has three e^-, then last e^- of N_2 molecule is present in:

(a) $\sigma(2s)$ orbital (b) $\overset{*}{\sigma}(2S)$ orbital

(c) $\overset{*}{\pi}2p_y$ orbital (d) $\pi\ 2p_y$ orbital

94. Select the incorrect statement:

(a) If the orbitals differ largely in energy, the cost of hybridization energy becomes large

(b) The hybridization in phosphorus between 3s and 3p-orbitals may be possible and the participation of 3d orbitals in the hybridization with the 3s and 3p-orbitals is not expected because of their (i.e., 3d orbital) much higher energy

(c) The d-orbital participation generally requires to bond with highly electronegative elements

(d) PH_5 does not exist but PCl_5, PF_5 exist through the formation of sp^3d^2 hybridization

95. Select the incorrect statement:

(a) $[SiH_6]^{2-}$ has sp^3d^2 hybridization

(b) PF_5 has sp^3d-hybridization

(c) SF_6 has sp^3d^2-hybridization

(d) All are correct statements

96. Given the correct order of initials T or F for following statements. Use T if statement is true and F it is false:

Statement-1: π bond is formed by sideways overlapping of $d_{x^2-y^2}$ and p_y orbital along x-axis.

Statement-2: Zig-zag geometry would be suggested for the $[I(CN)_2]^-$.

(a) T F (b) F T

(c) T T (d) F F

97. Select the correct statement:

(a) The S — F bond length is longer in SF_6 compared to that in SF_2

(b) In PCl_5 axial bonds are smaller than that of equatorial bonds

(c) In IF_7 axial bonds are longer than that of equatorial bonds

(d) All are correct

98. Select the correct order of first ionization potential:

(a) $O_2 > NO$ (b) $O_2 < NO$

(c) $O < NO$ (d) $O = NO$

99. Select the correct order of first ionization potential:

(a) $O_2^{2+} > O_2$ (b) $O_2^{2+} < O_2$

(c) $O_2 \approx O_2$ (d) None of these

100. In case of Na metal if the number of Na atom increases, the difference in energy between successive MOs in Na $(Na)_n$ molecule:

(a) Increases (b) Decreases

(c) May increase or decrease

(d) No change

101. Which of the following statement is/are true?

(I) Borazine is aromatic

(II) There are four isomeric disubstituted borazine molecule $B_3N_3H_4X_2$

(III) Borazine is more reactive towards addition reactions than benzene

(IV) Banana bonds in B_2H_6 are longer but stronger than normal B—H bonds

(a) I, II, and III (b) I, II, and IV

(c) I, II, III, and IV (d) only II

102. Which of the following statements are correct for the compound $C_3N_3(N_3)_3$?

(I) It contains three pi bonds

(II) Its structure is planar

(III) C and N atoms are sp^2-hybridized in the ring

(IV) N_3^- groups are attached with N-atoms

Select the correct code:

(a) I, II, and III (b) II and III

(c) I, III, and IV (d) All

103. N_2H_4 (hydrazine) combines with $(CH_3)_3N$ via:

(a) An ionic bond (b) A coordinate bond

(c) A covalent bond

(d) Combination is not possible

Multiple Correct Answers Type

1. Select the correct statements:

(a) The combination of s-orbital and p-orbital, with the increase of p-character, the bond angle decreases

(b) $H-\hat{C}-H$ bond angle > $H-\hat{C}-F$ bond angle in CH_3F molecule

(c) $F-\hat{C}-F$ bond angle > $H-\hat{C}-F$ bond angle in CHF_3 molecule

(d) All are correct statement

2. Which of the following molecule(s) is/are having pyramidal structure?

(a) PH_3 (b) $P(SiH_3)_3$

(c) NH_3 (d) PCl_2^+

3. Select the correct statements:

(a) The hybrid orbitals may be equivalent or not

(b) The hybridization defines a geometry of the molecule

(c) The hybrid orbitals are having much greater bonding strength compared to the pure atomic orbital

(d) The hybrid orbitals are having much lesser bonding strength compared to the pure atomic orbital

4. Select the correct statement(s) for bond distance:

(a) The bond distance decreases with the increase of bond order

(b) $\equiv C-H < {}^{=}_{-}{>}C-H < {-}{}^{-}_{-}{>}C-H$ (order of C—H bond distance)

(c) $\equiv C-C\equiv < {}^{-}_{=}{>}C-C\equiv < {}^{=}_{-}{>}C-C{<}^{=}_{-} < {-}{}^{-}_{-}{>}C-C{<}^{=}_{-}$ (order of C — C bond distance)

(d) The bond distance increases with the increase of bond order

5. Bond length depends upon:
(a) Bond order (b) π-bonding
(c) State of hybridization (d) None of these

6. Select the correct statements:
(a) The bond length in BF_3 is shorter than that of BF_4^-
(b) OCl_2 has $2p_\pi$–$3d_\pi$ back bonding
(c) $(AlCl_3)_2$ is not electron deficient but $(Al(Me)_3)_2$ is electron deficient
(d) In B_2H_6, all the hydrogens are not identical

7. Select the correct order of first ionization potential:
(a) $N_2 > O_2$ (b) $N_2 > O$
(c) $O > O_2$ (d) $O_2 \approx N_2$

8. Select the correct statements:
(a) The +1 oxidation state compared to the +3 oxidation state gets gradually more stabilized as we move from top to bottom in III group
(b) Tl (III) being unstable, acts as a good oxidizing agent to get reduced to Tl (I)
(c) $SnCl_2$ is a good oxidizing agent
(d) All are incorrect

9. Which of the following molecule(s) has/have zero dipole moment?
(a) CH_4 (b) CBr_4
(c) C_2H_2 (d) None of these

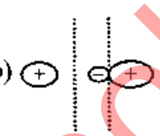
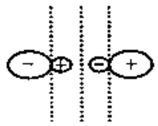
10. Which of the following molecules have zero dipole moment and tetrahedral structure?
(a) CCl_4 (b) $SnCl_2$
(c) $SnCl_4$ (d) CO_2

11. Select the correct statements:
(a) van der Waals' radii is always larger than the covalent radii
(b) The bond length of a particular bond depends on the state of hybridization of the involved atoms
(c) When s %-character increases, then bond length increases
(d) All are incorrect

12. Which of the following silicates are nonplanar?
(a) Single chain (b) Double chain silicate
(c) 2D or sheet-like silicate
(d) Cyclic silicate

13. Select the correct statements:
(a) $Ca_3Si_3O_9$ is an example of cyclic silicate
(b) Four corner oxygen atoms per tetrahedron are shared in 3D silicates
(c) 2D, sheet-like silicates are planar
(d) Silicate are ionic covalent compound

14. Which of the following molecule(s) is/are planar?
(a) ICl_3 (b) H_2O
(c) XeF_2 (d) $I_3^{\ominus}$

15. Select the correct diagram(s) for anti-bonding molecular orbitals:
(a) 
(b) 
(c) 
(d) None of these

16. If z is internuclear axis, then which type of overlapping is/are not possible?
(a) s and p_x (b) s and p_y
(c) $p_x + p_z$ (d) $p_y + p_z$

17. Select the correct statement for non-bonding and anti-bonding orbitals:
(a) Non-bonding orbitals have same energy than the atomic orbitals from which they are formed
(b) Anti-bonding orbitals have higher energy than the atomic orbitals from which they are formed
(c) Non-bonding orbital have higher energy than the atomic orbitals from which they are formed
(d) Anti-bonding orbital have lower energy than the atomic orbitals from which they are formed

18. Which of the following is/are true for B_2 and C_2 molecules according to M.O.T?
(a) Both are having 1σ and 1π bond
(b) Both are having same bond length
(c) Both are having different bond order
(d) B_2 is paramagnetic and C_2 is diamagnetic in nature

19. Select the correct statements:
(a) For a given cation, covalent character increases with increase in the size of the anion
(b) For a given anion, covalent character increases with decrease in the size of the cation
(c) Covalent character increases with increasing charge on either ion
(d) Covalent character is greater for cations with pseudo-inert gas configuration than the noble gas configuration.

20. Which of the following statement(s) is/are correct?
(a) B_2H_6 is non-planar (b) B_2H_6 is non-polar
(c) B_2H_6 is e^- deficient
(d) B_2H_6 has two 3C—2e^- bond

21. Which of the following statement(s) is/are correct?
(a) Dipole moment of diborane is zero
(b) Diborane is a Lewis acid
(c) Diborane has incomplete octet
(d) Di-borane has four $2C-2e^-$ bond

22. Select the correct statement(s):
(a) In diborane 12 valence e^- are involved in bonding
(b) In diborane, maximum six atoms, two boron and four terminal hydrogen, lie in the same plane.
(c) Diborane has ethane-like structure
(d) In diborane, bridging bonds are stronger and longer than the terminal bonds

23. Select the correct statement for P_4O_{10}:
(a) It has four sp^3-hybridized phosphorous atoms
(b) It has higher s%-character in P—O bond than the P_4O_6
(c) It has a cage-like structure
(d) It has $p_\pi - d_\pi$ bonding

24. Select the correct order of acidic nature of non-metal oxide:
(a) $CO > CO_2$ (b) $CO_2 > CO$
(c) $CO_2 > SiO_2$ (d) $CO_2 < SiO_2$

25. Select the correct order of acidic nature of non-metal oxide:
(a) $SO_2 > SO_3$ (b) $SO_3 > SO_2$
(c) $NO < NO_2$ (d) $NO > NO_2$

26. Select the correct order of acidic nature of metal oxide:
(a) $MnO < Mn_3O_4 < Mn_2O_3 < Mn_2O_7$
(b) $CrO < Cr_2O_3 < CrO_3 < CrO_2$
(c) $MnO < Mn_2O_3 < Mn_3O_4 < Mn_2O_7$
(d) $CrO < Cr_2O_3 < CrO_2 < CrO_3$

27. Select the correct statement(s):
(a) Solubility of alkali metal's chlorate decreases down the group
(b) Solubility of alkali metal's perchlorate decreases down the group
(c) Solubility of alkali metal's nitrate decreases down the group
(d) Solubility of alkali earth metal's sulphate increases down the group

28. In each of the following pairs, select the species having the greater resonance stabilization:
(i) HNO_3 and NO_3^- (pair I)
(ii) $H_2C=O$ and $H-\underset{\underset{O}{\|}}{C}-O^{\ominus}$ (pair II)
(a) HNO_3 has greater resonance in pair (I)
(b) NO_3^- has greater resonance in pair (I)
(c) $H_2C=O$ has greater resonance in pair (II)
(d) $H-\underset{\underset{O}{\|}}{C}-O^{\ominus}$ has greater resonance in pair (II)

29. Select the correct order of lattice energy:
(a) $LiF < LiBr < LiI$ (b) $LiCl > LiBr > LiI$
(c) $LiCl > NaCl > KCl$
(d) $BeCO_3 < MgCO_3 < SrCO_3 < BaCO_3$

30. Which of the following molecule(s) is/are having pyramidal structure?
(a) ClO_3 (b) H_3O^+
(c) NH_3 (d) PCl_3

31. Which of the following is/are paramagnetic in nature?
(a) B_2 (b) O_2
(c) NO^+ (d) O_2^-

32. The species having identical bond order with NO^+ is/are:
(a) CN^- (b) O_2^+
(c) CO (d) N_2

33. Which of the following is/are paramagnetic in nature:
(a) O_2 (b) O_2^+
(c) O_2^- (d) O_2^{2-}

34. Which of the following is/are diamagnetic?
(a) Super oxide ion (b) Oxygen molecule
(c) Carbon molecule (d) Nitrogen molecule

35. Which of the following compounds possesses Lewis acid character?
(a) AlF_3 (b) SiF_4
(c) PF_5 (d) BF_3

36. The species that contain peroxide ions is/are:
(a) KO_2 (b) SrO_2
(c) BaO_2 (d) Na_2O_2

37. Which is/are not correct for B_2H_6 structure?
(a) It has 4B—H terminal bonds and two $3C-2e$ bonds
(b) It has six B—H terminal bonds and one $3C-2e$ bond
(c) It has four B—H terminal bonds two $3C-2e$ bonds and one B—B bond
(d) It has ionic interaction between $[BH_2]^+$ and $[BH_4]^-$

38. Which of the following is/are neutral oxide?
(a) CO (b) ZnO
(c) N_2O (d) SnO_2

39. Which of the following acids contain P in 5+ oxidation state?
(a) Orthophosphoric acid (b) Metaphosphoric acid
(c) Phosphorus acid (d) Pyrophosphoric acid

40. Which of the following can act as Lewis acid?
(a) SiF_4 (b) $SnCl_4$
(c) CCl_4 (d) SF_4

41. Which of the following molecules is/are diamagnetic?
(a) Li_2 (b) B_2
(c) C_2 (d) N_2

42. Which of the fallowing oxides are amphoteric?
(a) HgO (b) ZnO
(c) PbO_2 (d) SnO_2

43. Which of the following is/are paramagnetic?
(a) H_2^+ (b) H_2^-
(c) H_2 (d) He_2^+

44. Select the correct statement(s):
(a) PbI_4, FeI_3 do not exist while $PbCl_4$, $FeCl_3$ exist
(b) $PbCl_4$, $FeCl_3$ do not exist white PbI_4, FeI_3 exist
(c) CO_2 is gaseous while SiO_2 is solid
(d) CO_2 is solid while SiO_2 gaseous

45. Select the correct order (for hydrolysis at room temperature):
(a) $SiCl_4 < CCl_4$ (b) $CCl_4 < SiCl_4$
(c) $NCl_3 > NF_3$ (d) $NCl_3 < NF_3$

46. Select the correct order (for hydrolysis at room temperature):
(a) $SF_4 < SF_6$ (b) $SF_4 > SF_6$
(c) $TeF_6 > SeF_6$ (d) $TeF_6 < SeF_6$

47. Select the correct statement(s):
(a) The e^- cloud of cation will get deformed by that of the anion, but as the electrons in the cation are much more tightly bond due to excess positive charge on cation so distortion is negligible
(b) With the increase of polarization, the degree of covalency increases
(c) With the increase of ionic potential, the polarizing power of the cation increases
(d) With the decrease of ionic potential the polarizing power of the cation increases

48. Select the correct statement(s):
(a) With the decrease of the size of the cation, the polarizing power increases
(b) With the decrease of positive charge on the cation, the polarizing power of cation increases
(c) If the inner electrons are very much efficient to screen the valence electrons, then the effective nuclear charge experienced by outermost electron is less
(d) With the increases of positive charge on the cation, the polarizing power of cation increases

49. Select the correct order of polarizing power of cations when their size are almost same:
(a) $Na^+ > Cu^+$ (b) $Cu^+ > Na^+$
(c) $K^+ < Ag^+$ (d) $Ag^+ < K^+$

50. Select the correct statement(s):
(a) For the same charge and the same size, a pseudo noble gas type cation with 18 e^- in the outermost shell is more polarizing than the cation of noble gas type with 8 e^- in the outermost shell
(b) The degree of covalency increases in descending a group in the transition metal ions for a particular oxidation state
(c) Size increases in descending a group in the transition metal ions for a particular oxidation state
(d) Covalency decreases in descending a group in the transition metal ions for particular oxidation

51. Select the correct statement(s):
(a) The larger anions with more negative charges are more polarizable
(b) The polarizability sequence is $I^- > Br^- > Cl^- > F^-$
(c) The covalency runs in the order $ZnCl_2 < CdCl_2 < HgCl_2$
(d) The polarizing power among the transition series varies as follows: 3*d*-series < 4*d*-series < 5*d*-series

52. Select the incorrect order for the given properties:
(a) Thermal stability : $BaSO_4 > SrSO_4 > CaSO_4$
(b) Solubility : $BaSO_4 > SrSO_4 > CaSO_4$
(c) Thermal stability : $Li_2CO_3 < Na_2CO_3 < K_2CO_3$
(d) Solubility : $Li_2CO_3 > Na_2CO_3 > K_2CO_3$

53. Select the correct order of their thermal stability:
(a) $LiF > NaF > KF > RbF > CsF$
(b) $KF > KCl > KBr > KI$
(c) $LiCl > NaCl > KCl > RbCl > CsCl$
(d) $Li_2O > Na_2O > K_2O > Rb_2O$

54. Which of the following order is /are correct for acidic nature of oxides?
(a) $Li_2O > Na_2O > K_2O > Rb_2O$
(b) $MgO > CaO > SrO > BaO$

(c) $NiO > MgO > SrO > BaO$

(d) $Al_2O_3 > MgO > SrO > BaO$

55. Which of the following oxides are amphoteric?

(a) ZnO (b) BeO

(c) Al_2O_3 (d) Pb_2O_3

56. Select the correct statement(s):

(a) The overlap become better when the overlapping orbitals have comparable energy

(b) The order of increasing tendency of polymerizations $SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$

(c) With the increase in positive oxidation state the energy of the 3*d*-orbitals gradually decreases and it favours the π-bonding interaction

(d) The system where the π bonding is not effective, the stabilization is attained through the single bonded structure, i.e., through the polymerization

57. Which of the following moelcule(s) gives only acid(s) on hydrolysis?

(a) PCl_3 (b) SF_4

(c) NCl_3 (d) P_4O_6

58. Which of the following species have the same bond order?

(a) $\bar{C}N$, N_2 (b) N_2^{2+}, N_2^{2-}

(c) N_2^{2-}, O_2 (d) NO, N_2^{2+}

59. Which of the following conversions does not represent the process of dimerization?

(a) $BeH_2 \longrightarrow BeH_2$ (solid)

(b) $S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

(c) $NO \longrightarrow N_2O_2$ (d) $ClO_3 \longrightarrow Cl_2O_6$

60. Select the correct options for following statement(s):

(a) sp^3-hybrid orbitals are at 90° to one another

(b) sp^3d^2 adjacent hybrid orbitals are at 90° to one another

(c) sp^2-hybrid orbitals are at 120° to one another

(c) Bond order of N—O bond in NO_3^- is $1\frac{1}{3}$

61. Which of the following species/molecules have the same shape but different hybridization?

(a) XeF_2, CO_2 (b) I_3^-, $HgCl_2$

(c) OCl^-, CO (d) SO_2, OCl_2

62. Select the correct statement(s):

(a) The crystal structure of $NaHCO_3$ and $KHCO_3$ both show hydrogen bonding, but are different. In $NaHCO_3$ the HCO_3^- ions are linked into an infinite chain, while in $KHCO_3$ a dimeric anion is formed

(b) The BeX_2 molecules polymerize to form chains containing bridging halogen groups; for example, in $(BeF_2)_n$ and $(BeCl_2)_n$, each halogen forms one normal covalent bond and uses a lone pair to form a coordinate bond

(c) $[Be(Me_2)_n]$ has essentially the same structure as $(BeCl_2)_n$ but the bonding in the methyl compound is best regarded as three center two electron bonds covering one Me and Be atoms

(d) Beryllium salts are acidic when dissolved in pure water because the hydrated ion hydrolyzed producing H_3O^+

63. Select the correct order for the given properties:

(a) $MgC_2O_4 > CaC_2O_4 > SrC_2O_4 > BaC_2O_4$: Solubility order

(b) $BeS_2O_3 < MgS_2O_3 < CaS_2O_3 < SrS_2O_3$: Solubility order

(c) $KO_3 < RbO_3 < CsO_3$: Thermal stability order

(d) $LiNO_3 < NaNO_3 < KNO_3 < CsNO_3$: Thermal stability order

64. Select the correct statements:

(a) More electronegative atom prefers the hybrid orbital of the central atom in which the *s*-character is less

(b) More electronegative atom prefers the hybrid orbital of the central atom in which the *s*-character is more

(c) Lone pair prefers to stay with that hybrid orbital which has less *s*-character

(d) Lone pair prefers to stay with that hybrid orbital which has more *s*-character

65. Select the correct order:

(a) Bond strength : $NO^- < NO < NO^+$

(b) N—O bond angle : $NO_2^+ < NO_2^- < NO_3^-$

(c) Thermal stability : $LiF > NaF > KF > RbF > CsF$

(d) Hydrated size : $Be^{2+}(aq) < Mg^{2+}(aq) < Ca^{2+}(aq) < Sr^{2+}(aq) < Ba^{2+}(aq)$

66. Select the correct statements:

(a) XeF_2 is linear and XeF_6 is capped octahedral

(b) Xe can only form compounds with the highly electronegative elements

(c) SF_6 and SH_6 both have sp^3d^2-hybridization

(d) All are correc

67. Select the correct statements:

(a) The symmetrical molecules such as CH_4, CCl_4, CO_2, CS_2, C_6H_6 do not have any dipole moment

(b) SO_2, H_2O, and H_2S being angular in geometry possess the net dipole moment

(c) Direction of dipole moment of hybrid lone pair moment is away from the central atom

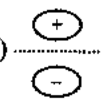
(d) All are incorrect

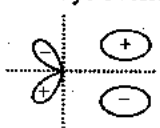
68. Which of the following is/are an example of orthosilicate?

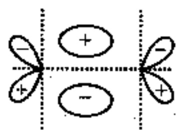
(a) $ZrSiO_4$ (b) Mg_2SiO_4

(c) $Zn_3Si_2O_7$ (d) Asbestos

69. Select the correct diagram for bonding molecular orbitals which are formed by sideways overlapping:

(a) 

(b) 

(c) 

(d) None of these

70. If x is internuclear axis, then which type of overlapping is/are responsible for the formation of N.B.M.O.?

(a) $d_{xy} + p_x$ (b) $d_{xy} + s$

(c) $s + p_y$ (d) $s + p_z$

71. Which of the following species are paramagnetic in nature?

(a) F_2 (b) OF

(c) NO (d) B_2

72. Select the incorrect statements:

(a) Peroxide ion has longer bond length than O_2

(b) Superoxide ion has longer bond length than peroxide ion

(c) Dioxygenyl ion (O_2^+) has longer bond length than O_2

(d) Dioxygenyl ion (O_2^+) has smaller bond length than O_2

73. Select the correct order of bond angle:

(a) $OsF_2 < OsCl_2 < OsBr_2$ (b) $SbCl_3 < SbBr_3 < SbI_3$

(c) $PI_3 > AsI_3 > SbI_3$ (d) $PI_3 < AsI_3 < SbI_3$

74. Select the correct statement(s):

(a) Solubility of alkaline earth metal's thiosulphate decreases down the group

(b) Solubility of alkaline earth metal's carbonate increases down the group

(c) Solubility of alkali metal's carbonate increases down the group

(d) Solubility of alkali metal's carbonate decreases down the group

75. In which of the following compounds, S is in +6 oxidation state?

(a) H_2SO_5 (b) $H_2S_2O_8$

(c) $Na_2S_4O_6$ (d) H_2SO_4

76. Which of the following metal carbonates decompose on heating?

(a) Li_2CO_3 (b) Na_2CO_3

(c) K_2CO_3 (d) $MgCO_3$

77. Which of the following oxoanions contain S—S bond?

(a) $S_2O_3^{2-}$ (b) $S_2O_4^{2-}$

(c) $S_2O_6^{2-}$ (d) $S_2O_7^{2-}$

78. Which of the following statement(s) is/are correct for PCl_5?

(a) P atom is sp^3d-hybridized and has trigonal bipyramidal geometry.

(b) It acts as a Lewis acid

(c) On hydrolysis it forms phosphoric acid

(d) Axial Cl atoms are closer to equatorial Cl atoms

79. Which are the correct statements for NO_2?

(a) It is paramagnetic and dimerizes to N_2O_4

(b) N_2O_4 is planar and diamagnetic

(c) NO_2 is linear containing an odd number of electrons

(d) N—O bonds in NO_2 are of different lengths

80. According to M.O. theory for the atomic species "C_2" which is not correct?

(a) Bond order is zero and it is paramagnetic

(b) Bond order is zero and it is diamagnetic

(c) Bond order is two and it is paramagnetic

(d) Bond order is two and it is diamagnetic

81. Which of the following does not contain O—O bond?

(a) $S_2O_8^{2-}$ (b) $S_4O_6^{2-}$

(c) SO_5^{2-} (d) $S_2O_7^{2-}$

82. Which of the following compound/ion is/are having pyramidal geometry?

(a) ClO_3^- (b) $(SiH_3)_3N$

(c) $(CH_3)_3N$ (d) CH_3^+

83. Select the correct statement(s):

(a) Para-dihydroxy benzene is polar while para-dimethyl benzene is non-polar

(b) Dipole moment of NH_3 is larger than that of NF_3

(c) The direction of dipole moment in CO is from C to oxygen

(d) All are incorrect

84. Select the correct statement(s):

(a) The transition metal ion is more polarizing compared to the alkali and alkaline earth metal ions of comparable size for a particular oxidation state

(b) The solubility of silver halides in water runs as $AgF > AgCl > AgBr > AgI$

(c) LiCl is soluble in organic solvents while NaCl is insoluble in such solvents

(d) All are incorrect

85. Select the correct statement(s):

(a) CH_3NCS is angular while SiH_3NCS is linear

(b) Both CH_3NCS and SiH_3NCS are linear

(c) CH_3NCS is linear while SiH_3NCS is bent

(d) The Lewis acid strength of boron halides runs as $BF_3 < BCl_3 < BBr_3 < BI_3$

86. Select the correct statement(s):

(a) The rate of hydrolysis of SiH_4 is higher than that of CH_4

(b) The hydrolytic products of NCl_3, NF_3, and PCl_3 are of different types

(c) The hydrolytic products of NCl_3 and BCl_3 are of same type

(d) The hydrolytic products of NCl_3, NF_3, and PCl_3 are of same type

87. Select the correct statement(s):

(a) Diamond is hard while graphite is soft and slippery

(b) The degree of covalency in the following compounds runs as $HgX_2 > CdX_2 > ZnX_2$

(c) Zns is white, CdS is yellow, while HgS is black

(d) Diamond is soft while graphite is hard

88. Select the correct order for the given properties:

(a) Thermal stability : $BeCO_3 < MgCO_3 < CaCO_3$

(b) Solubility : $BeCO_3 > MgCO_3 > CaCO_3$

(c) Thermal stability : $Li_2SO_4 < Na_2SO_4 < K_2SO_4$

(d) Solubility : $Li_2O > Na_2O > Cs_2O$

89. Select the incorrect order for the given properties:

(a) $Li^+(aq) > Na^+(aq) > K^+(aq) > Rb^+(aq) > Cs^+(aq)$: Ionic mobility

(b) $Li^+(aq) < Na(aq) > K^+(aq) > Rb^+(aq) > Cs^+(aq)$: Hydrated size of ion

(c) $F^-(aq) > Cl^-(aq) > Br^-(aq) > I^-(aq)$: Hydrated size of ion

(d) $F(aq) < Cl^-(aq) < Br^-(aq) < I^-(aq)$: Ionic mobility

90. Select the correct statements:

(a) *s*-block metal oxides are basic in nature, except BeO which is amphoteric

(b) *p*-block metal oxides are acidic in nature, except NO, N_2O, CO, H_2O

(c) *d*-block metal oxides are basic, acidic, and amphoteric in nature

(d) *d*-block metal oxides are only basic in nature

91. Choose the incorrect statement:

(a) All S — F bond lengths are identical in SF_4

(b) All Cl — F bond length are identical in ClF_3

(c) All ∠ FClF angles are identical in ClF_3

(d) All possible angle in BF_2Cl are 120°

92. Select the correct statement(s):

(a) When $d_{x^2-y^2}$ or d_{xy} orbitals combine in parallel planes, then δ or δ* molecular orbitals are formed

(b) When $d_{x^2-y^2}$ and d_{xy} orbitals combine in parallel planes, then N.B.M.O. are formed

(c) When d_{yz} and d_{xz} orbitals combine in along the *y*-axis, then N.B.M.O. orbitals are formed

(d) No interaction is possible when p_z and d_{xz} orbitals overlap with collinear *z*-axis

93. The dipole moment of AX_3, BX_3, and CY_3 are 4.97×10^{-30}, 0.60×10^{-30}, and 0.00 C.M. respectively, then the shape of molecules may be:

(a) Pyramidal, T-shape, trigonal planar

(b) Pyramidal, trigonal planar, T-shape

(c) T-shape, pyramidal, trigonal planar

(d) Pyramidal, T-shape, linear

94. Select the correct statement(s) for following molecules:

(I) $PF_2(CH_3)_3$ (II) $PF_2(CF_3)_3$

(a) Both have trigonal bipyramidal structure

(b) Both have the same dipole moment

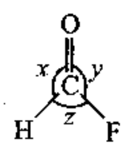
(c) P—F bond length is longer in $PF_2(CH_3)_3$ than in $PF_2(CF_3)_3$

(d) P—F bond length is longer in $PF_2(CF_3)_3$ than in $PF_2(CH_3)_3$

95. Select the incorrect statement for adjacent bond angle:
(a) In CF_2 and OF_2, OF_2 has higher bond angle
(b) In PF_4^+ and PF_4^-, PF_4^- has higher bond angle
(c) In ClF_3 and BF_3, ClF_3 has lower bond angle
(d) Both NH_3 and PH_3 have the same bond angle

96. Which of the following statement is correct in the context of the allene molecule C_3H_4?
(a) The central carbon is *sp*-hybridized
(b) The terminal carbon atoms are sp^2-hybridized
(c) The planes containing the CH_2 groups are mutually perpendicular to permit the formation of two separate π-bonds
(d) Central atom is sp^2-hybridized

97. Which of the following relationship is correct for the following figure:



(a) $x = y = z$ (b) $x = y > z$
(c) $x > 120°$ (d) $z < 120°$

98. Which of the following are correct statements about white phosphorus (P_4)?
(a) Each P atom has one lone pair of electrons in a molecule of P_4
(b) It has tetrahedral structure with 109°28' bond angle
(c) There are six P—P linkages in a molecule of P_4
(d) It undergoes disproportionation on reaction with alkalies

99. Select the correct order for the given properties:
(a) NaF > KF > LiF > RbF > CsF: Melting point order
(b) CuCl > NaCl: Covalent character
(c) $BeSO_4 < CaSO_4 < SrSO_4 < BaSO_4$: Thermal stability order
(d) LiI > NaI > KI > RbI > CsI: Solubility order

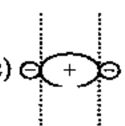
100. Which of the respective orders are correct?
(a) $NH_3 > SbH_3 > AsH_3 > PH_3$: Thermal stability order
(b) Liquid hydrogen < liquid helium: boiling point order
(c) $BeCO_3 > SrCO_3 > BaCO_3$: K_p value order during their thermal dissociation in closed container
(d) $O_2 > KO_2 > K_2O_2$: Magnetic moment order

101. Select the correct statements:
(a) The alkali metal salts of azide and cyanate are isomorphous
(b) The lone pairs and multiple bonds preferably occupy the equatorial positions in trigonal bipyramidal
(c) In PCl_3F_2, the fluorine preferably occupy the axial positions of the trigonal bipyramidal
(d) All the bond angles in CH_4 are identical but these are not identical in CH_2F_2

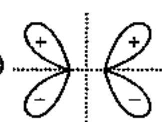
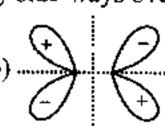
102. Select the correct statements:
(a) The colors of halogens (X_2) are: F_2 (pale yellow), Cl_2 (yellowish green), Br_2 (reddish brown), I_2 (violet)
(b) Halogen molecules are diamagnetic
(c) The bond length of the peroxo-linkage (O — O) in F_2O_2 is remarkably shorter compared to that in other peroxo compound, e.g., H_2O_2, Ba_2O_2
(d) All are incorrect

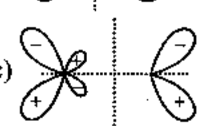
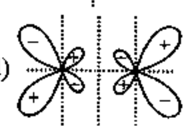
103. Select the correct diagram for bonding molecular orbitals which are formed by axial overlapping:

(a)  (b) 

(c)  (d) None of these

104. Select the correct diagram for anti-bonding molecular orbitals which are formed by side-ways overlapping:

(a)  (b) 

(c)  (d) 

105. Which of the following is/are incorrect about solubility trend in group I and II?

		Least soluble in water	Most soluble in water
(a) Thiosulphate	:	BaS_2O_3	BeS_2O_3
(b) Oxalate	:	BaC_2O_4	BeC_2O_4
(c) Chromate	:	$BeCrO_4$	$BaCrO_4$
(d) Bicarbonate	:	$NaHCO_3$	$CsHCO_3$

106. Select the correct statement(s):
(a) Solubility of alkali earth metal's oxide decreases down the group

(b) Solubility of alkaline earth metal's sulphide increases down the group

(c) Solubility of alkali metal's hydroxide increases down the group

(d) Solubility of alkali metal's fluorides increases down the group

107. Select the correct statement(s):

(a) Solubility of alkaline earth metal's chromate decreases down the group

(b) Solubility of alkaline earth metal's chromate increases down the group

(c) Solubility of alkaline earth metal's hydroxide decreases down the group

(d) Solubility of alkaline earth metal's hydroxide increases down the group

108. Which is/are correct representation of boranes?

(a) $B_n H_{n+4}$ (b) $B_n H_{n+6}$

(c) $B_n H_{2n+2}$ (d) None of these

109. Which of the following compound(s) is/are peroxy-acids?

(a) $HClO_4$ (b) H_2SO_5

(c) $H_2S_2O_8$ (d) H_3PO_5

110. Which of the following species do not exist?

(a) XeF_3 (b) XeF_4

(c) XeF_5 (d) XeF_6

111. Select the correct statement(s):

(a) $SnCl_4$ hydrolyzes more readily than $SnCl_2$

(b) $BeCO_3$ is thermally more unstable compared to $MgCO_3$

(c) $PbCl_2$ is white while PbI_2 is colored

(d) PbI_2 is white while $PbCl_2$ is colored

112. Select the correct statement(s):

(a) Compared to Me_3N, $(SiH_3)_3N$ has got almost no basicity

(b) The molecular formulas of nitrogen and phosphorus are N_2 and P_4, respectively; similarly, oxygen exists as O_2 while sulphur exists as S_8

(c) The dipole moment of R_3NO is much greater compared to that of R_3PO

(d) All the B—O bond lengths are not identical in polyborates

113. Select the correct statement(s):

(a) The tendency of polymerization of the oxyanions lies in the sequence

$SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$

(b) The molecular structure of $S_4N_4H_4$ and $S_4N_4F_4$ are different

(c) The bond strength of P—O linkage is maximum in OPF_3 compared to all other analogous halogen compound

(d) The structural geometries of NO_2^+ and NO_2 are different

114. Select the correct order of bond angle:

(a) $H-\hat{P}-H\ (PH_3) < F-\hat{P}-F\ (PF_3)$

(b) $F-\hat{N}-F\ (NF_3) < H-\hat{N}-H\ (NH_3)$

(c) $F-\hat{O}-F\ (OF_2) < H-\hat{O}-H\ (H_2O) < Cl-\hat{O}-Cl\ (OCl_2)$

(d) $H-\hat{P}-H\ (PH_3) > F-\hat{P}-F\ (PF_3)$

115. Select the correct order of bond angle:

(a) $Br-\hat{P}-Br\ (OPBr_3) > Cl-\hat{P}-Cl\ (OPCl_3) > F-\hat{P}-F\ (OPF_3)$

(b) $H-\hat{C}-H(CH_4) > H-\hat{N}-H(NH_3)$

(c) $H-\hat{C}-H(CH_4) < H-\hat{N}-H(NH_3)$

(d) $Br-\hat{P}-Br\ (OPBr_3) < Cl-\hat{P}-Cl\ (OPCl_3) < F-\hat{P}-F\ (OPF_3)$

116. Which of the following molecule(s) has/have $d_\pi - p_\pi$ bonding?

(a) $H_2S_2O_3$ (b) P_4O_{10}

(c) SO_3 (d) P_4S_{10}

117. Select the correct order of polarizing power of cation:

(a) $Li^+ > K^+ > Na^+$ (b) $Li^+ > Na^+ > K^+$

(c) $Ba^{2+} > Ca^{2+} > Be^{2+}$ (d) $Be^{2+} > Mg^{2+} > Ca^{2+}$

118. Select the correct order of polarizing powers of cations when their sizes are almost same:

(a) $Cd^{2+} > Ca^{2+}$ (b) $Ca^{2+} > Cd^{2+}$

(c) $Au^+ < Rb^+$ (d) $Au^+ > Rb^+$

119. Select the correct order for the given properties:

(a) Thermal stability order : $NaNO_3 < KNO_3 < RbNO_3$

(b) Solubility in water : $NaNO_3 > KNO_3 > RbNO_3$

(c) Melting point order : $NaF > KF > RbF$

(d) Covalent character order : $NaF > KF > RbF$

120. Which of the following metal oxide(s) gives metal and oxygen on heating?

(a) $NaNO_3$ (b) KNO_3

(c) $Hg(NO_3)_2$ (d) $AgNO_3$

121. Select the correct order of their thermal stability:

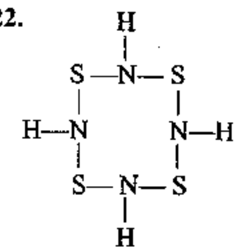
(a) $LiOH < NaOH < KOH < RbOH < CsOH$

(b) $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$

(c) $NaO_2 < KO_2 < RbO_2 < CsO_2$

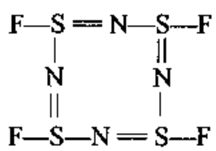
(d) $NaO_2 > KO_2 < RbO_2 < CsO_2$

122.



$S_4N_4H_4$

(Tetrasulphur tetramide)



$S_4N_4F_4$

(Tetrathiazyl tetrafluoride)

Select the correct statement(s) for the above given structures:

(a) In $S_4N_4H_4$, the hydrogens never go on sulphurs while in $S_4N_4F_4$, fluorines get preferably attached with sulphur atoms

(b) The highly electronegative fluorines on being placed on sulphur atoms can appreciably contract the 3*d*-orbital of S to facilitate $N(2p_\pi) \longrightarrow S(3d_\pi)$ π–bonding

(c) If in $S_4N_4H_4$, hydrogens go to the sulphurs, no effective π–bonding occurs through the 3*d*-orbitals of S

(d) N—H bond is stronger than the S—H bond

123. Select the correct statement for thiazyl trifluoride (NSF_3):

(a) S—N bond length is 141.5 pm, probably the shortest one between S and N

(b) The three highly electronegative fluorine substituents contract the 3*d*-orbitals of sulphur sufficiently to effect the strong π-bonding with the half-filled *p*-orbitals of nitrogen

(c) The bond angle $F-\hat{S}-F = 94°$ indicates the involvement of almost pure *p*-orbitals of S in binding the fluorine atoms

(d) The very strong bonding (due to multiple bond formation) between N and S demands the participation of *s*-character enriched orbitals of sulphur

124. Select the correct statement(s):

(a) $BeCl_2$ tends to dimerize to a 3-coordinate structure in vapor phase, but linear monomer is also known at high temperature

(b) BeF_2 has $3C - 4e^-$ bond

(c) Bond lengths in all the boron trihalides are shorter than expected for single bonds

(d) BeF_2 is analogous to CO_2 and BF_3 analogous to SO_3

125. Select the correct statement(s):

(a) $CH_3 - C - CH_3$ angle in $(CH_3)_2C = CH_2$ is smaller and the $CH_3 - C = CH_2$ angle is larger than the trigonal 120°

(b) $O - I - F$ angle is less than 90° (89°) in $IOF_4^{\ominus}$

(c) In $SeOCl_2$, Cl — Se — Cl angle is less than the Cl—Se—O angle

(d) $POCl_3$ is tetrahedral with a double bond between P and O. There is no lone pair on central atom

126. Select the correct statement(s):

(a) Two ions isoelectronic with carbon suboxide C_3O_2 are $N_5^{\oplus}$ and $OCNCO^+$

(b) C_3O_2 is linear, both $N_5^{\oplus}$ and $OCNCO^+$ are bent at the central nitrogen

(c) C_3O_2 is formed by dehydration of malonic acid by P_2O_5

(d) C_3O_2 has 4σ and 4π bond in its structure

127. Correct statement(s) about NH_3 and PH_3 is/are:

(a) μ_D of $PH_3 < \mu_D$ of NH_3

(b) PH_3 is stronger Lewis base than NH_3

(c) $\angle H-N-H > \angle H-P-H$

(d) Both have sp^3-hybridization

128. Select the correct statement(s):

(a) Due to the absence of vacant orbital of N-atom, NCl_3 does not undergo hydrolysis

(b) Order of rate of hydrolysis in SF_6, SeF_6, and TeF_6, is $SF_6 < SeF_6 < TeF_6$

(c) Only proton donor acids are formed as final hydrolyzed product of SF_4

(d) Hybridization of central atom in transition state changes during hydrolysis of BCl_3

129. Select the correct properties for the following molecules:

(I) CH_2F_2 (II) CHF_3 (III) CH_3F

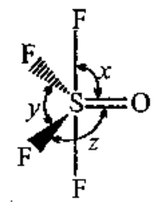
(a) C — F bond length order: $CH_3F > CH_2F_2 > CHF_3$

(b) C — H bond length order: $CH_3F > CH_2F_2 > CHF_3$

(c) Shape is not perfect tetrahedral for given compounds

(d) Dipole moment is non-zero for given compounds

130. The incorrect order of bond angle in the following molecule is/are:



(a) $y = z > x$ (b) $z > y > x$

(c) $y > x > z$ (d) $x > y > z$

131. The planar compounds are:

(a) $\ddot{N}(SiH_3)_3$ (with respect to N)

(b) IF_4^-

(c) BF_3 (d) BrF_3

132. Select the correct statement(s):

(a) Solubility of group IA fluorides and carbonates increases down the group

(b) LiF is insoluble or very less soluble in water, whereas other alkali metals fluorides are soluble

(c) Hydrogen peroxide acts as a reducing agent in the presence of other oxidizing agent. This is because it can take up an atom of oxygen to give water and oxygen gas

(d) All the carbonates and bicarbonates of alkali metals are soluble except $NaHCO_3$ and solubility increases down the group but Li_2CO_3 is sparingly soluble

133. Select the correct order of acidic strength:

(a) $BF_3 > Me_3B$

(b) $HC\equiv C-H$ (sp carbon) $< H_2C=CH-H$ (sp^2carbon) $< H_3C-CH_2-H$ (sp^3carbon)

(c) $BF_3 < Me_3B$

(d) $HC\equiv C-H$ (sp carbon) $> H_2C=CH-H$ (sp^2carbon) $> H_3C-CH_2-H$ (sp^3carbon)

134. Correct order of bond energy for PH_3, NH_3 and NF_3, PF_3:

(a) $B.D.E._{N-H} > B.D.E._{P-H}$

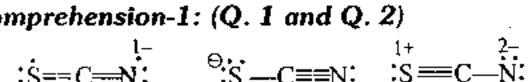
(b) $B.D.E._{N-H} < B.D.E._{P-H}$

(c) $B.D.E._{N-F} > B.D.E._{P-F}$

(d) $B.D.E._{N-F} < B.D.E._{P-F}$

Comprehension Type

Comprehension-1: (Q. 1 and Q. 2)



(A) (B) (C)

In the thiocyanate ion, SCN^-, three resonance structures are consistent with the electron-dot method. Structure A has only one negative formal charge on the nitrogen atom, the most electronegative atom in the ion. Structure B has a single negative charge on the S, which is less electronegative than N. Structure C has charges of –2 on N and +1 on S, consistent with the relative electronegativities of the atoms but with a larger charge and greater charge separation than the first.

1. Predict the hybridization of atom which is bonded with H in structure of HNCS:

(a) sp (b) sp^2

(c) sp^3 (d) No hybridization

2. HNCs is isostructural with:

(a) HN_3 (b) NH_3

(c) CO_2 (d) None of these

Comprehension-2: (Q. 3 to Q. 5)

Many bond angles can be explained by either electronegativity or size arguments. Molecules with larger difference in electronegativity values between central and outer atoms have smaller bond angles. As the size of outer atom increases, the angle increases. The size of central atom can also be used to determine the bond angles in the series.

3. Consider the following molecules:

(I) H_2O (II) H_2S

(III) H_2Se (IV) H_2Te

Arrange these molecules in increasing order of bond angle:

(a) I < II < III < IV (b) IV < III < II < I

(c) I < II < IV < III (d) II < IV < III < I

4. Consider the following hydrides and arrange them in increasing order of bond angles:

(I) NH_3 (II) PH_3

(III) AsH_3 (IV) SbH_3

(a) I < II < III < IV (b) IV < III < II < I

(c) I < III < II < IV (d) IV < II < III < I

5. Which has the smallest bond angle ($X-S-X$) in the given molecules?

(a) OSF_2 (b) $OSCl_2$

(c) $OSBr_2$ (d) OSI_2

Comprehension-3: (Q. 6 to Q. 8)

The simplest phosphoric acid (H_3PO_4) contains three replaceable H-atom and is tribasic.

6. The basicity of $H_4P_2O_7$ is:

(a) 1 (b) 2

(c) 3 (d) 4

7. The oxidation state of P in H_3PO_5 is:
(a) +3 (b) +5
(c) +7 (d) None of these

8. Which of the following is known as glacial phosphoric acid?
(a) HPO_3 (b) H_3PO_3
(c) H_3PO_3 (d) H_3PO_4

Comprehension-4: (Q. 9 to Q. 11)

Polarization is an important phenomenon which is helpful in determination of covalent nature of compound. With the help of Fajan's rule one can easily predict the nature of compound.

9. Which of the following halide possess the highest covalent character?
(a) LiF (b) LiCl
(c) LiBr (d) LiI

10. Which of the following possess the least covalent character?
(a) LiCl (b) NaCl
(c) KCl (d) CsCl

11. The correct increasing covalent nature is:
(a) $NaCl < LiCl < BeCl_2$ (b) $BeCl_2 < NaCl < LiCl$
(c) $BeCl_2 < LiCl < NaCl$ (d) $LiCl > NaCl > BeCl_2$

Comprehension-5: (Q. 12 to Q. 14)

Bond order is associated with the strength of bond and bond length. The higher the bond order, the smaller will be the bond length and stronger will be the bond.

12. Arrange O_2, O_2^+, O_2^- and O_2^{2-} in order of increasing bond order:
(a) $O_2 < O_2^- < O_2^{2-} < O_2^{2+}$ (b) $O_2^{2-} < O_2^- < O_2 < O_2^+$
(c) $O_2^- < O_2^{2-} < O_2^+ < O_2$
(d) $O_2^{2-} < O_2^+ < O_2^- < O_2$

13. Which of the following species has the longest O—O bond?
(a) O_2 (b) O_2^+
(c) O_2^- (d) O_2^{2-}

14. Which of the following has the highest O—O bond energy?
(a) O_2 (b) O_2^{2-}
(c) O_2^- (d) O_2^{2-}

Comprehension-6: (Q. 15 to Q. 18)

The rule governing the transition from ionic to covalent bonding are called Fajan's rules. They are based on the deformation of the interacting ions in the bond A^+ $B^{\ominus}$ (polarization of ions).

15. Select the correct statement:
(a) Solubility of hydroxides of group I A increases down the group, while for group II A it decreases down the group
(b) Solubility of hydroxides of *s*-block metal cations increases down the group
(c) Solubility of carbonates of *s*-block metal cation decreases down the group
(d) Solubility of carbonates of *s*-block metal cation increases down the group

16. Select the correct statement:
(a) Solubility of bicarbonates of Na^+, K^+, Rb^+, Cs^+ decreases down the group
(b) Thermal stability of nitrates of group I A cations decreases down the group
(c) Solubility of chromates of group II A cation increases down the group
(d) Melting point of fluorides of Na^+, K^+, Rb^+, Cs^+ decreases down the group

17. Which of the following compound has the highest thermal stability?
(a) NaCl (b) CsCl
(c) KCl (d) RbCl

18. Which of the following is most covalent?
(a) CuCl (b) NaCl
(c) AgCl (d) AuCl

Comprehension-7: (Q. 19 to Q. 21)

The molecule in which an atom is associated with more than 8 electrons is known as hypervalent molecule and less than 8 electrons is known as hypovalent molecule. All hypervalent molecules must have $d\pi$–$p\pi$ bonding but the molecules having back bonding need not always have $d\pi$–$p\pi$ bonding.

19. Which of the molecule is not hypovalent but complete its octet?
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlF_3 (d) BF_3

20. Which of the following molecule is having complete octet?
(a) $BeCl_2$ (dimer) (b) BeH_2 (dimer)
(c) $BeH_2(s)$ (d) $BeCl_2(s)$

21. Which of the following molecule is not having $d\pi$–$p\pi$ bonding?
(a) BCl_3 (b) P_4O_{10}
(c) PF_3 (d) $B_3N_3H_6$

Comprehension-8: (Q. 22 to Q. 24)

NO has 11 valence electrons. It is impossible for all to be paired, and hence this is an odd electron molecule and the gas is paramagnetic.

22. Which of the following is the correct decreasing bond order for NO, NO^+, and NO^-?
(a) $NO > NO^- > NO^+$ (b) $NO^- > NO^+ > NO$
(c) $NO^- > NO > NO^+$ (d) $NO^+ > NO > NO^-$

23. Which of the following species has the smallest N—O bond length?
(a) NO (b) NO^-
(c) NO^+ (d) N_2O

24. Which of the following is diamagnetic?
(a) NO (b) NO^-
(c) NO^+ (d) NO_2

Comprehension-9: (Q. 25 to Q. 28)

NO is a colorless gas and an important intermediate in the manufacture of nitric acid by catalytic oxidation of ammonia.

25. Which of the following is a neutral oxide?
(a) NO (b) NO_2
(c) N_2O_3 (d) N_2O_5

26. Which of the following is known as anhydride of nitric acid?
(a) N_2O_3 (b) N_2O_4
(c) N_2O_5 (d) N_2O

27. Which of the following is/are isoelectronic and isostructural with CO_2?
(a) NO_2 (b) NO_2^+
(c) NO_2^- (d) NO_3^-

28. In which of the following the O—N—O bond angle is the highest?
(a) NO_2 (b) NO_2^+
(c) NO_2^- (d) NO_3^-

Comprehension-10: (Q. 29 to Q. 31)

I_2 has less solubility in water so its solubility increases on adding KI solution when KI and I_2 react, then a species X is formed and solubility of I_2 solution increases.

29. Hybridization of anionic part of X is:
(a) sp^2 (b) sp^3
(c) sp^3d (d) sp^3d^2

30. Geometry of anionic part of X is:
(a) Linear (b) T-shape
(c) Pyramidal (d) See-saw

31. Anionic part of X is:
(a) Non-planar (b) Planar
(c) Both (a) and (b) (d) None of these

Comprehension-11: (Q. 32 to Q. 34)

Bent's rule is consistent with VSPER theory. According to Bent's rule, the more electronegative substituent attaches itself to hybrid orbital that contains more p-character or less s-character.

32. The molecule/ion in which bond angle is less than 109°:
(a) $\overset{+}{N}F_4$ (b) CCl_4
(c) ClO_4^- (d) None of these

33. Select pair of compounds in which both have different hybridization but have the same molecular geometry:
(a) BF_3, BrF_3 (b) ICl_2^-, $BeCl_2$
(c) BCl_3, PCl_3 (d) PCl_3, NCl_3

34. Find the species which is not perfectly planar:
(a) $\dot{C}H_3$ (b) $\dot{C}HF_2$
(c) $:CH_2$ (d) $\dot{N}O_2$

Comprehension-12: (Q. 35 to Q. 37)

Hybridization is the measure to express the molecular shapes reasonably. Hybridization, although theoretical, but is highly correlated with molecular shapes or inter orbital angles. If there is any departure in geometry (on the basis of VSEPR theory), the apparent departure in hybridization can be observed and the following characteristic relationship is the easiest way to interpret that departure. Any hybrid orbital made by s and p-orbitals is characterized by the following relationship.

$$f_s = \frac{1}{i+1} \text{ or } f_p = \frac{i}{i+1} \text{ and } i = \frac{f_p}{f_s}$$

For sp^3, $i = 3$ and sp^2, $i = 2$; for an orbital $f_s + f_p = 1$ while all the s-p hybrids of gien atom must satisfy the condition,

$$\Sigma f_s = 1.00$$

d and the inter orbital angle between two equivalent (same f_s and same f_p) hybrid orbitals is given by

$$\cos\theta = \frac{-1}{i}$$

35. VSEPR theory suggests a small departure from 109° 28' for NH_3 molecule. The H — N — H bond angle has been found to be 107°. What kind of hybrid orbital will be occupied by the non-bonding pair of electron?
(a) sp^3 (b) $sp^{3.4}$
(c) $sp^{2.13}$ (d) sp^2

36. What s-character is used by the carbon atom in the orbitals directed to hydrogen atom in CH_2F_2 molecule? [H — C — H bond angle in CH_2F_2 is 111.9° (cos 111.9° = – 0.3729)]

(a) 27.1% (b) 37.29%
(c) 29% (d) 29.99%

37. In BFClBr molecule the minimum % s-character provided from the central atom is in the bond:

(a) B — F (b) B — Cl
(c) B—Br (d) Cannot be predicted

Comprehension-13: (Q. 38 to Q. 40)

When two compounds ACl_3 and DCl_3 of two elements A and D are mixed together a compound $ADCl_6$ is formed. Structural analysis showed that $ADCl_6$ is an ionic compound. Given that DCl_3 is trigonal planar and ACl_3 is trigonal pyramidal, predict the shape of the anion.

38. If anion has see-saw shape, then the shape of cation formed is:

(a) Linear (b) Bent
(c) Pentagonal bipyramidal
(d) Trigonal planar

39. If shape of anion is tetrahedral, then the shape of cation formed is:

(a) Tetrahedral (b) Bent
(c) Linear (d) Trigonal planar

40. Shape of DCl_4^- is:

(a) See-saw (b) Perfect tetrahedral
(c) Square planar (d) none of these

Comprehension-14: (Q. 41 to Q. 43)

Lewis concept of covalency of an element involves octet rule. Later on it was found that many elements in their compounds, e.g., BeF_2, BF_3 etc. have incomplete octet whereas PCl_5, SF_6, etc. have expanded octet. This classical concept also failed in predicting the geometry of molecules. Modern concept of covalence was proposed in terms of valence bond theory. Hybridization concept along with valence bond theory successfully explained the geometry of various molecules but failed in many molecules. The geometry of such molecules was explained by VSEPR concept. Finally molecular orbital theory was proposed to explain many other molecules.

41. Which are true statements among the following?

(I) I_3^+ has bent structure
(II) p_π-p_π bonds are present in SO_2
(III) SeF_4 and CH_4 has same shape
(IV) XeF_2 and CO_2 has same shape
(V) SF_4 is sea-saw structure whereas ICl_3 is T-shaped.

(a) I, II, IV, V (b) I, II, III, IV
(c) II, III, IV, V (d) I, III, IV, V

42. The bond angle NO_2^+, NO_2, and NO_2^- are, respectively:

(a) 180°, 134°, 115° (b) 115°, 134°, 180°
(c) 134°, 180°, 115° (d) 115°, 180°, 130°

43. Which statements are correct for CO and N_2 according to molecular orbital theory?

(I) Bond order of CO and N_2 are 3 and 3
(II) Bond order of CO and N_2 are same
(III) During the formation of N_2^+ from N_2 bond length increases
(IV) During the formation of CO^+ from CO, the bond length decreases

(a) II, IV, I (b) I, II, III, IV
(c) I, III (d) I, II, III

Assertion-Reasoning Type

1. **Statement-1:** XeF_4 exists while XeH_4 does not exist.
Statement-2: In XeH_4 d-orbital contraction is absent.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** PH_3 exists but PH_5 does not exist while both PCl_3 and PCl_5 exist.
Statement-2: PH_3 has sp^3-hybridization.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

3. **Statement-1:** B and C form their stable halides as BX_3 and CX_4, while Tl and Pb produce their stable halides as TlX and PbX_2.
Statement-2: Both PbX_4 and TlX_3 are strong oxidizing agent.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

4. **Statement-1:** The two —CH_2 groups in C_2H_4 do not rotate freely around the bond connecting them, although the two — CH_3 groups in C_2H_6 have almost an unhindered rotation around the C — C bond.

Statement-2: C_2H_4 has π bond and the overlap of the atomic *p*-orbitals making up this bond would be destroyed if the — CH_2 groups rotate.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

5. **Statement-1:** Carbonates and silicates are isostructural.

Statement-2: Carbon and silicon have the same number of valence shell electrons.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

6. **Statement-1:** SiF_4 undergoes partial hydrolysis.

Statement-2: Back bonding from F to Si increases the bond order of Si — F bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

7. **Statement-1:** $FeCl_3$ and $FeCl_2$ exist in dimer form in vapor phase.

Statement-2: In dimer form, they have ($3C—4e^-$) bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

8. **Statement-1:** The number of bonding electrons in N_2 and N_2^- is same.

Statement-2: The bond order and bond length of N_2^+ and N_2^- are same.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

9. **Statement-1:** In peroxy disulphuric acid central atoms are sp^3 hybridized.

Statement-2: Peroxy disulphuric acid contains one peroxy (— O — O —) linkage.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

10. **Statement-1:** The O — O bond length in H_2O_2 is shorter than that of O_2F_2.

Statement-2: H_2O_2 has an open book-type structure.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

11. **Statement-1:** The B — F bond lengths in BF_3 and BF_4^- are different.

Statement-2: In BF_3, B — F bond aquires some double bond character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

12. Statement-1: Boiling point of HF is lesser than water.

Statement-2: Hydrogen bonding in water is weaker than HF.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

13. Statement-1: The molar conductance of the following aqueous ion is

$$Cs^+ > Rb^+ > Na^+ > K^+ > Li^+$$

Statement-2: The more the hydration of cation the lesser the conductivity.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

14. Statement-1: Superoxides of alkali metals are paramagnetic.

Statement-2: Superoxides contain the O_2^- ion which has one unpaired electron in its antibonding orbital.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

15. Statement-1: The ionic character exist in H_2 molecule but no dipole moment or bond moment exists permanently.

Statement-2: It arises so, as the two ionic forms having bond moments in opposite directions contribute equally to nullify the effect.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

16. Statement-1: When the unshared pairs house in the hybrid orbitals, its consideration becomes accountable and it is referred to as hybrid lone pair moment.

Statement-2: The hybrid orbital concentrated the electron cloud in some particular directions and the electron cloud remains under the control of a single nucleus.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

17. Statement -1: The central carbon-carbon bond in butane is larger than that in 1,3-butadiene.

Statement -2: The more is *s*-character in hybridization, the lesser is the bond length.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

18. Statement-1: $(CH_3)_3Si-OH$ is more acidic than $(CH_3)_3C-OH$.

Statement-2: $(CH_3)_3Si-OH$ has back bonding.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

19. Statement-1: The S — O bond distance in SO_2F_2 is identical with that in SO_2.

Statement-2: S and O are double bonded in both molecules.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

20. Statement-1: Bond order for both NO^+ and NO^- is 2.5.

Statement-2: NO^+ is more stable than NO^-.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

21. Statement-1: The bond angle of PBr_3 is greater than that of PH_3, but bond angle of NBr_3 is less than that of NH_3.

Statement-2: Electronegativity of phosphorus atom is less than that of nitrogen.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

22. Statement-1: F_2 has higher bond energy than the Cl_2.

Statement-2: Electronegativity of fluorine is more than that of chlorine.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

23. Statement-1: The acidic strength sequence $BMe_3 < B(MeO)_3$

Statement-2: The acidic strength can also be explained by considering the existing back bonding.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

24. Statement-1: NO^+ is more stable than the NO, and CO^+ is also more stable than the CO.

Statement-2: NO^+ formed when NO has lost an anti-bonding electron, and CO^+ formed when CO has lost N.B.M.O. e^- having anti-bonding character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

25. Statement-1: Ag_2S is much less soluble in water than Ag_2O.

Statement-2: S^{2-} is much larger than O^{2-}; so polarization of S^{2-} is higher than O^{2-}.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

26. Statement-1: Oxyacids of group VI A elements: H_2SO_4, H_2SeO_4, H_6TeO_6.

Statement-2: The lighter member where $O(2p) \longrightarrow X(3d, 4d)\,\pi$ bonding is significant forms strong π-bonds to give XO_4^{2-}.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

27. Statement-1: The order of π bond formation tendency is Si—O < P—O < S—O< Cl—O.

Statement-2: On moving from left to right along a period, the effective nuclear charge generally increases and consequently the energy of the 3d-orbital decreases from Si $\rightarrow$ P $\rightarrow$ S $\rightarrow$ Cl.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

28. **Statement-1:** $p_\pi - p_\pi$ bonding is much more significant than the $p_\pi - d_\pi$ bonding.

Statement-2: In $p_\pi - p_\pi$ bonding, the overlapping lobes are parallel, and as a result there occurs a pure sideways (~ at 180°) overlap; on the other hand, in p_π–d_π bonding the lobes of the overlapping d orbitals are at an angle < 180° to the lobes of the p-orbital.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

29. **Statement-1:** CCl_4 is stable while $PbCl_4$ is powerful oxidizing agent.

Statement-2: Due to inert pair effect the stability of the 2+ state increases on moving down the group from carbon to lead.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

30. **Statement-1:** The calculated value of dipole moment of LiI = 11.5 D in the gaseous state is more than its experimental value (3.25D).

Statement-2: In LiI the electron charge cloud of I^- ion is polarized by Li^+ ion; hence the flow of electric charge occurs from I^- to Li^+ ion.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

31. **Statement-1:** Borazole is more reactive than benzene.

Statement-2: Electrophiles attacks at nitrogen and not at boron atom in inorganic benzene.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

32. **Statement-1:** $FeCl_3$ is stable but FeI_3 is unstable

Statement-2: I^- is a strong reductant and Fe^{3+} is oxidant and thus I^- reduces Fe^{3+} to Fe^{2+}; on the other hand, Cl^- is weak reductant.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

33. **Statement-1:** The C—O bond in CO^+ is longer than in CO.

Statement-2: In changing from CO to CO^+, the electron is removed from nonbonding molecular orbital having anti-bonding character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

34. **Statement-1:** The canonical forms in which the negative charge resides on the electronegative atoms contribute more, but in BF_3 the $p_\pi - p_\pi$ back bonding places a positive charge on F which is more electronegative than B.

Statement-2: This disfavor is compensated due to the formation of an additional π-bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) BCl_3	(p) Proton donor oxyacid is formed as a final hydrolyzed product

(b) NCl_3	(q) sp^3d^2-hybridized central atom in transition state during hydrolysis
(c) SF_4	(r) Orthophosphoric acid is formed as final hydrolyzed product
(d) PCl_5	(s) Weak monobasic Lewis acid is formed as hydrolyzed product

2. Match the column:

Column-I	Column-II
(a) BF_3	(p) Intra Lewis acid base interaction
(b) $B_3N_3H_6$	(q) $2p_\pi - 2p_\pi$ back bonding
(c) $N(SiH_3)_3$ (with respect to N)	(r) Planar
(d) BCl_3	(s) sp^2-hybridization
	(t) Non-polar

3. Match the column:

Column-I	Column-II
(a) $\overset{\ominus}{C}Cl_3$	(p) $2p_\pi - 3d_\pi$ back bonding
(b) CCl_2	(q) Planar
(c) $B_3N_3H_6$	(r) Direction of back bonding is Cl to central atom
(d) BCl_3	(s) $2p_\pi - 3p_\pi$ back bonding
	(t) $\mu = 0$

4. Match the column:

Column-I	Column-II
(a) $(BeCl_2)_2$	(p) $3C—2e^-$ bond
(b) $(BeH_2)_2$	(q) $3C—4e^-$ bond
(c) $(ICl_3)_2$	(r) sp^3-hybridization w.r.t. central atom (Be, Al, I)
(d) $(AlH_3)_2$	(s) Non-planar
	(t) Planar

5. Match the column:

Column-I	Column-II
(a) CH_2F_2	(p) $H-\hat{C}-H$ bond angle is greater than 109.5°
(b) CH_3F	(q) $F-\hat{C}-F$ bond angle is less than 109.5°
(c) CHF_3	(r) Perfect tetrahedral structure
(d) CF_4	(s) sp^3-hybridization
	(t) Non-planar

6. Match the column:

Column-I	Column-II
(a) SF_4	(p) L.P. present in axial position
(b) PCl_3F_2	(q) L.P. present in equatorial position
(c) XeF_4	(r) F atoms are present in axial position
(d) XeF_5^-	(s) μ (dipole moment) = 0
	(t) Non-planar

7. Match the column:

Column-I	Column-II
(a) $XeOF_2$	(p) Two lone pairs are present in equatorial position
(b) $ClOF_3$	(q) One lone pair is present in equatorial position
(c) SOF_4	(r) sp^3d-hybridization
(d) SF_4	(s) Bent T-shape
	(t) See-saw shape

8. Match the column:

Column-I	Column-II
(a) sp-hybridization	(p) CO_2
(b) sp^2-hybridization	(q) CS_2
(c) sp^3-hybridization	(r) $SnCl_4$
(d) sp^3d-hybridization	(s) NO_3^-
	(t) AsF_5

9. Match the column:

Column-I	Column-II
(a) $Cr_2O_7^{2-}$	(p) Species having $X—O—X$ linkage
(b) Pyroxene chain silicate	(q) Only one corner per tetrahedron is shared
(c) Thiosulphite ion	(r) All X-atom(s) is/are sp^3-hybridized

Note: All X-atoms are considered as central atom

(d) $B_3O_6^{3-}$	(s) Overall species is planar
	(t) Six number of X — O bonds are identical in length

10. Match the column:

Column-I	Column-II
(a) $BeCl_2$	(p) $3C—4e^-$ bond is present in dimer
(b) BCl_3	(q) Having sp^3-hybridization in hydrolyzed product from central atom in basic medium
(c) $AlCl_3$	(r) Planar in its formation
	(s) Change in hybridization of the central atom during dimerization

11. Match the following:

Column-I	**Column-II (Dominating force)**
(a) Xenon–H_2O	(p) Dipole–dipole interaction
(b) Ethanol–H_2O mixture	(q) London forces
(c) Liquid He	(r) Ion–dipole interaction
(d) Liquid HCl	(s) Dipole–induced dipole interaction

12. Match the following:

Column-I	**Column-II (Nodal plane)**
(a) $\sigma 2s$	(p) 0
(b) $\overset{*}{\sigma}2p_z$	(q) 1
(c) $\overset{*}{\pi}2p_x$	(r) 2
(d) $\overset{*}{\pi}2p_y$	(s) 3

13. Match the column:

Column-I	**Column-II (Dominating force)**
(a) Dipole–dipole interaction	(p) Na^+ ...... Cl — H
(b) Ion–dipole interaction	(q) CH_4 ...... CH_4
(c) Dipole–induced dipole interaction	(r) Cl — H ...... CH_4
(d) Instantaneous dipole–induced dipole	(s) H — Cl ...... H — Cl
	(t) H — H ...... H — H

14. Match the column:

Column-I	**Column-II (Dominating force)**
(a) Ion–dipole interaction	(p) H — F .... H — F
(b) Dipole–dipole interaction	(q) F^- .... H — F
(c) H-bonding	(r) Na^+ .... H — F
	(s) HCl .... HCl

15. Match the column:

Column-I	**Column-II**
(a) BF_3	(p) Intra Lewis acid–base interaction
(b) $H_3N: \longrightarrow BF_3$	(q) Inter Lewis acid–base interaction
(c) PF_3	(r) Planar
(d) SiF_4	(s) $2p_\pi - 3d_\pi$ back bonding
	(t) $2p_\pi - 2p_\pi$ back bonding

16. Match the column:

Column-I	**Column-II**
(a) Be H_2 (Solid)	(p) 3C—2e^- bond
(b) Be Cl_2	(q) 3C—4e^- bond
(c) $(Al\,Br_3)_2$	(r) Incomplete octet
(d) $(Ga\,H_3)_2$	(s) sp^3-hybridization
	(t) Non-planar

17. Match the column:

Column-I	**Column-II**
(a) B_2H_6	(p) Can act as Lewis acid
(b) BF_3	(q) Intramolecular Lewis acid–base interaction
(c) ICl_3	(r) Non-polar
(d) SiF_4	(s) Non-planar
	(t) Can undergo dimerization

18. Match the column:

Column-I	**Column-II**
(a) XeO_3F_2	(p) The species / compound is regular octahedral
(b) $SF_2(CH_3)_2$	(q) 5 number of atoms may lie in the same plane within the species/compound
(c) XeO_6^{4-}	(r) The species/compound utilizes $d_{x^2-y^2}$ orbital in its formation.
(d) $[I(CN)_2]^-$	(s) The species/compound utilizes d_{z^2} orbital in its formation.
	(t) The dipole moment of the compound/species is zero.

19. Match the column:

Column-I	**Column-II**
(a) ICl_3	(p) Hybridization of central atom is similar in both dimer and monomer forms
(b) $AlCl_3$	(q) Both monomer and dimer forms are planar
(c) AlF_3	(r) In dimer form all atoms are sp^3-hybridized
(d) NO_2	(s) Does not exist in dimer form

20. Match the column:

Column-I	**Column-II**
(a) BF_3	(p) $3p_\pi - 2p_\pi$
(b) P_4O_{10}	(q) $2p_\pi - 3d_\pi$

(c) $B_3N_3H_6$ (r) $2p_\pi - 2p_\pi$

(d) BCl_3 (s) Cage like structure

(t) Planar

21. Match the column:

Column-I	Column-II
(a) Linear shape	(p) CS_2
(b) sp-hybridization	(q) XeF_2
(c) sp^3d-hybridization	(r) C_2H_2
(d) CO_2 is isostructural to	(s) NCO^-
	(t) $HgCl_2$

22. Match the column:

Column-I	Column-II
(a) XeO_4	(p) Pyramidal
(b) XeO_3F_2	(q) Tetrahedral
(c) XeO_6^{4-}	(r) Trigonal bipyramidal
(d) XeO_3	(s) Octahedral

23. Match the column:

Column-I	Column-II
(a) $[Al(CH_3)_3]_2$	(p) $3C—2e^-$ bonds
(b) $[Be(CH_3)_2]_2$	(q) $3C—4e^-$ bonds
(c) $BeCl_2$ (solid)	(r) Vacant orbital participate in hybridization
(d) $(AlCl_3)_2$	(s) sp^3-hybridization w.r.t. central atom (Be, Al)
	(t) sp^2-hybridization w.r.t. central atom (Be, Al)
	(t) Non-planar

24. Match the column:

Column-I	Column-II
(a) CH_3NCS	(p) Bent structure with respect to central atom like (N, B or I)
(b) H_3SiNCS	(q) Planar structure with respect to central atom like (N, B, or I)
(c) BF_2^-	(r) $C-\hat{N}\cdot X$ bond angle > 120° where X is C or Si atom
(d) I_3^+	(s) sp-hybridized N atom in stable resonating structure

25. Column-I contains some chemical species and Column-II contains the type of hydride orbitals used in the formation of such species. Match the items of Column-I with those of Column-II and select the correct answer using the codes:

Column-I	Column-II
(a) CrO_4^{2-}	(p) sp^3d^2
(b) BF_4^-	(q) sp^3
(c) ICl_4^-	(r) d^3s
(d) $PtCl_4^{2-}$	(s) dsp^2

Integer Answer Type

1. Find out the number of species showing $H-\hat{C}-H$ > 109°28′:
CH_3F, CH_2F_2, CH_4, $CH_3C\equiv CH$, $\overset{+}{C}H_3$
2. Find the number of molecule(s) having octahedral geometry from the following:
S_2F_{10}, XeO_6^{4-}, PCl_6^-, $[SiF_6]^2$, SeF_6, TeF_6, SF_6, PO_4^{3-}
3. Find the number of corner shared per tetrahedron for pyro-silicate.
4. How many $d_\pi - p_\pi$ bonds are present in ClO_3^-?
5. Find the sum of oxidation state of phosphorus in H_3PO_4 and H_3PO_3.
6. How many atom(s) of $BeCl_2$ lie in the same plane?
7. How many atom(s) of BF_3 lie in the same plane?
8. How many atoms of PCl_5 lie in the same plane and find the number of such plane in PCl_5 molecule?
9. A cyclic silicate anion is represented as $[Si_3O_9]^{n-}$; find the value of n.
10. How many atom(s) of H_2O lie in the same plane?
11. In P_4O_{10}, find the number of oxygen atoms bonded to each phosphorous atom.
12. How many atom(s) of $SF_2(CH_3)_2$ may lie in equatorial plane?
13. How many corner oxygen atoms are shared in 2D silicate?
14. Find the number of σ bond and π bond in 1, 3-butadiene.
15. Find the sum of bond order and number of π-bonds in C_2 molecule on the basis of molecular orbital theory.
16. Find the number of amphoteric oxide(s) from the following:
NiO, Al_2O_3, B_2O_3, PbO_2, ZnO, MgO.
17. How many nodal plane is/are present in σ^*_{s-s} anti-bonding molecular orbital?
18. Find out the total number of all $2C—2e^-$ and $3C—4e^-$ bonds in $BeCl_2$.
19. Predict the basicity of final product (having sulphur) obtained when SF_4 undergoes hydrolysis.

20. Find the number of nonbonding molecular orbital(s) from the following (If x is internuclear axis):

$s + p_y$, $p_y + p_y$, $p_x + p_x$, $d_{xy} + s$, $d_{xy} + p_x$, $p_y + p_x$

21. How many unpaired electron(s) is/are present in O_2 molecule if Hund's rule is violated?

22. Find the sum of bond order and number of π bonds in B_2 molecule.

23. How many unpaired electron(s) is/are present in highest occupied molecular orbital (H.O.M.O.) of O_2 molecule?

24. What is the bond order of NO^+?

25. Find the number of unpaired e^- in dioxygenylion (O_2^+).

26. Find the bond order of peroxide ion.

27. Find the number of acid(s) from the following in which X—H bond is/are present. Given X is central atom:

H_3PO_2, $H_4P_2O_7$, $H_4P_2O_5$, $H_2S_2O_6$, H_3PO_3, H_3BO_3, H_2SO_4

28. How many σ bonds are present in C_2 (vap.)?

29. How many π bonds are present in B_2 molecule according to M.O.T?

30. Calculate the ratio of σ bonding electrons and π bonding electrons in B_2 molecule.

31. Calculate the ratio of σ bonding electrons and π bonding electrons in C_2 molecule.

32. Find the number of water molecules required to get the complete hydrolysis product of P_4O_6.

33. Find the number of water molecules required to get the complete hydrolysis product of $H_2S_2O_8$.

34. Find the number of parent acid formed from complete hydrolysis of P_4O_{10}.

35. Find the number of HCl molecule formed from complete hydrolysis of $SiCl_4$.

36. If Hund's rule is not applicable, then how many unpaired electrons are present in NO molecule?

37. When oleum ($H_2S_2O_7$) is completely hydrolyzed, then how many acidic hydrogens are present in the final product?

38. Find the number of molecule(s) having trigonal planar geometry from the following:

$OCCl_2$, $\overset{+}{C}H_3$, $\overset{-}{C}H_3$, ClF_3, I_3^-

39. Find the number of molecule(s)/ion(s) having tetrahedral geometry from the following:

OPF_3, $S_2O_3^{2-}$, XeO_4, SF_4, $TeCl_4$, NH_4^+

40. How many atom(s) of CH_4 lie in same plane?

41. Find out the total sum of B.A. of < 72° and 90° in pentagonal pyramidal shape.

42. How many same atoms of PCl_3F_2 lie in the same plane?

43. What is the basicity of the final hydrolyzed product (oxyacid) of P_4S_{10}?

44. How many atom(s) of BF_2^- lie in the same plane?

45. How many atom(s) of $S(CH_2)F_4$ may lie in the equatorial plane?

46. How many nodal plane is/are present in σ_{p-p} bonding molecular orbital?

47. Find the sum of nodal plane of π^*_{d-d} anti-bonding molecular orbital and π^*_{p-d} anti-bonding molecular orbital.

48. Find the number of delta bonding molecular orbital from the following set if z is the inter-nuclear axis:

$d_{x^2-y^2}$ and d_{xz}, $d_{x^2-y^2}$ or d_{xz}

49. Find the number of corner of O-atom shared per tetrahedron in 3D-silicate.

50. Find the ratio of bond order of N_2^{2+} to N_2^{2-}.

51. Find the ratio of the total number of electron(s) in bonding molecular orbital of O_2 to the total number of electrons in bonding molecular orbital of N_2 molecule.

52. Find the ratio of σ-bonds to π-bonds in $P_5O_{16}^{7-}$.

53. How many nodal plane(s) is/are present in $\overset{*}{\pi}2p_y$?

54. If Hund's rule is not applicable, then how many unpaired e^- are present in B_2 molecule?

55. Find the ratio between σ-bond and π-bond in $C_3N_3Cl_3$.

56. Find the ratio between π bonds and lone pairs of sp^2-hybrid orbitals in $C_3N_3(NH_2)_3$.

57. Find the number of molecule(s) is/are having zero dipole moment and linear shape from the following:

ClF_3, I_3^-, CO_2, $HgCl_2$, ICl_2^-, XeF_2

58. In XeF_5^- and XeF_5^+ find the sum of axial d-orbital which are used in hybridization of both species.

59. How many atoms of XeO_6^{4-} lie in the same plane?

60. How many maximum atoms of IF_7 are present in the same plane?

61. How many atom(s) of $S(CH_2)F_4$ may lie in the axial plane?

62. How many P — O — P linkage(s) is/are present in $P_4O_{12}^{4-}$?

63. The compound MX_6 is octahedral. Find the number of $X - \hat{M} - X$ angles in the compound.

64. Find the sum of nodal plane of σ^*_{s-s} anti-bonding molecular orbital and σ_{s-p} bonding molecular orbital.

65. How many nodal plane is/are present in π^*_{p-p} anti-bonding molecular orbital?

66. Find the sum of nodal plane of $\delta_{d_{xy}-d_{xy}}$ molecular orbital and $\delta^*_{d_{xy}-d_{xy}}$ anti-bonding molecular orbital.

67. Find the number of non-bonding molecular orbital from the following if z is the internuclear axis:

$d_{z^2}+s$, $d_{x^2-y^2}+s$, p_z+d_{xz} , $s+d_{yz}$

68. Find the number of non-bonding molecular orbital from the following set if z is the internuclear axis:

d_{yz} and d_{z^2} , d_{yz} and d_{xz} , $d_{x^2-y^2}$ and d_{xy}, d_{xz} or $d_{x^2-y^2}$

69. Calculate the number of molecules of HF which are contained in gaseous form due to hydrogen bonding if the density of HF in gaseous phase at 1 atm, 300 K is 3.248 g/l?

70. Find the number of pi bonding molecular orbital from the following set if z is the internuclear axis:

p_z and d_{z^2} , p_x and d_{xz} , d_{xz} or d_{yz} , d_{xz} and d_{yz}

71. How many nodal planes are present in $\pi 2p_y$ bonding molecular orbital?

72. How many nodal planes are present in δ bonding molecular orbital?

73. Find the ratio of the total number of σ bonds to lone pair of sp^2-hybrid orbitals in $C_3N_3(N_3)_3$.

74. Find the ratio of lone pairs to π bond (present in ring) in $C_3N_3(NH_2)_3$.

75. Find the ratio of the total number of bonds to the total number of lone pairs in $C_3N_3Cl_3$.

76. Find the ratio of lone pairs present on Cl atoms to sp^2-hybrid orbital in $C_3N_3Cl_3$ molecule.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Isostructural species are those which have the same shape and hybridization. Among the given species identify the isostructural pairs.

(a) [NF_3 and BF_3]
(b) [$BF_4^{\ominus}$ and NH_4^+]
(c) [BCl_3 and $BrCl_3$]
(d) [NH_3 and NO_3^-]

2. Polarity in a molecule and hence the dipole moment depends primarily on electronegativity of the constituent atoms and shape of a molecule. Which of the following has the highest dipole moment?

(a) CO_2
(b) HI
(c) H_2O
(d) SO_2

3. The types of hybrid orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ respectively are expected to be

(a) sp, sp^3, and sp^2
(b) sp, sp^2, and sp^3
(c) sp^2, sp, and sp^3
(d) sp^2, sp^3, and sp

4. Hydrogen bonds are formed in many compounds e.g., H_2O, HF, NH_3. The boiling point of such compounds depends to a large extent on the strength of hydrogen bond and the number of hydrogen bonds. The correct decreasing order of the boiling points of above compounds is:

(a) HF > H_2O > NH_3
(b) H_2O > HF > NH_3
(c) NH_3 > HF > H_2O
(d) NH3 > H_2O > HF

5. In PO_4^{-3} ion the formal charge on the oxygen atom of P–O bond is:

(a) + 1
(b) – 1
(c) – 0.75
(d) + 0.75

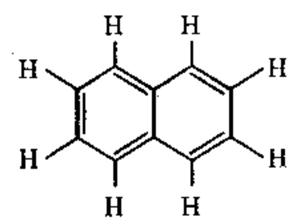
6. In NO_3^- ion, the number of bond pairs and lone pairs of electrons on nitrogen atom are:

(a) 2, 2
(b) 3, 1
(c) 1, 3
(d) 4, 0

7. Which of the following species has tetrahedral geometry?

(a) BH_4^-
(b) NH_2^-
(c) CO_3^{2-}
(d) H_3O^+

8. Number of π bonds and σ bonds in the following structure is:



(a) 6, 19
(b) 4, 20
(c) 5, 19
(d) 5, 20

9. In which of the following molecule/ion all the bonds are not equal?

(a) XeF_4
(b) BF_4^-
(c) C_2H_4
(d) SiF_4

10. In which of the following substances will hydrogen bond be strongest?

(a) HCl
(b) H_2O
(c) HI
(d) H_2S

11. If the electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$, the four electrons involved in chemical bond formation will be _____.

(a) $3p^6$ (b) $3p^6, 4s^2$
(c) $3p^6, 3d^2$ (d) $3d^2, 4s^2$

12. Which of the following angle corresponds to sp^2 hybridization?
(a) 90° (b) 120°
(c) 180° (d) 109°

Comprehension

The electronic configurations of three elements, A, B, and C are given below. Answer the questions 13 to 16 on the basis of these configurations.

A	$1s^2$	$2s^2$	$2p^6$	Ne		
B	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^3$	P
C	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^5$	Cl

13. Stable form of A may be represented by the formula:
(a) A (b) A_2
(c) A_3 (d) A_4

14. Stable form of C may be represented by the formula:
(a) C (b) C_2
(c) C_3 (d) C_4

15. The molecular formula of the compound formed from B and C will be:
(a) BC (b) B_2C
(c) BC_2 (d) BC_3

16. The bond between B and C will be:
(a) Ionic (b) Covalent
(c) Hydrogen (d) Coordinate

17. The electronic configuration of the outer most shell of the most electronegative element is:
(a) $2s^22p^5$ (b) $3s^23p^5$
(c) $4s^24p^5$ (d) $5s^25p^5$

18. Amongst the following elements whose electronic configurations are given below, the one having the highest ionisation enthalpy is:
(a) $[Ne]3s^23p^1$ (b) $[Ne]3s^23p^3$
(c) $[Ne]3s^23p^2$ (d) $[Ar]3d^{10}4s^24p^3$

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following attain the linear structure:
(a) $BeCl_2$ (b) NCO^-
(c) NO_2 (d) CS_2

2. CO is isoelectronic with:
(a) NO^+ (b) N_2
(c) $SnCl_2$ (d) NO_2^-

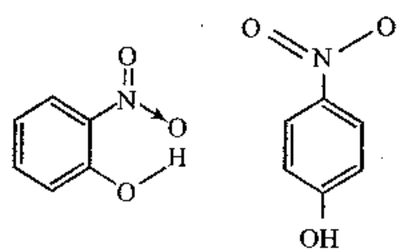
3. Which of the following species have the same shape?
(a) CO_2 (b) CCl_4
(c) O_3 (d) NO_2^-

4. Which of the following statements are correct about CO_3^{2-}?
(a) The hybridization of central atom is sp^3.
(b) Its resonance structure has one C–O single bond and two C=O double bonds
(c) The average formal charge on each oxygen atom is 0.67 units
(d) All C–O bond lengths are equal

5. Which of the following statements are not correct?
(a) NaCl being an ionic compound is a good conductor of electricity in the solid state
(b) In canonical structures there is a difference in the arrangement of atoms
(c) Hybrid orbitals form stronger bonds than pure orbitals
(d) VSEPR Theory can explain the square planar geometry of XeF_4

Short Answer Type

1. Explain the nonlinear shape of H_2S and nonplanar shape of PCl_3 using valence shell electron pair repulsion theory.
2. Explain the shape of BrF_5.
3. Structures of molecules of two compounds are given below:



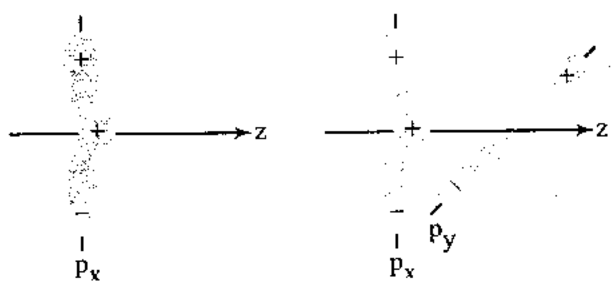
(I) (II)

(a) Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding?

(b) The melting point of a compound depends on, among other things, the extent of hydrogen bonding. On this basis explain which of the above two compounds will show higher melting point.

(c) Solubility of compounds in water depends on power to form hydrogen bonds with water. Which of the above compounds will form hydrogen bond with water easily and be more soluble in it.

4. Which type of overlap given in the following figure do not result in bond formation?



5. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

6. In both water and dimethyl ether ($CH_3-\ddot{\underset{\cdot\cdot}{O}}-CH_3$), oxygen atom is central atom, and has the same hybridization, yet they have different bond angles. Which one has greater bond angle? Give reason.

7. Write Lewis structure of the following compounds and show formal charge on each atom. HNO_3, NO_2, H_2SO_4

8. Give reasons for the following:
   (a) Covalent bonds are directional bonds while ionic bonds are nondirectional.
   (b) Water molecule has bent structure whereas carbon dioxide molecule is linear.
   (c) Ethyne molecule is linear.

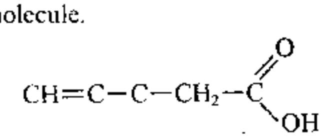
9. What is an ionic bond? With two suitable examples explain the difference between an ionic and a covalent bond?

10. Arrange the following bonds in order of increasing ionic character, give reason.

$$N-H,\ F-H,\ C-H, \text{ and } O-H$$

11. Explain why CO_3^{2-} ion cannot be represented by a single Lewis structure. How can it be best represented?

12. Predict the hybridization of each carbon in the molecule of organic compound given below. Also indicate the total number of sigma and pi bonds in this molecule.



13. Group the following as linear and nonlinear molecules:

$$H_2O,\ HOCl,\ BeCl_2,\ Cl_2O$$

14. Elements X, Y, and Z have 4, 5, and 7 valence electrons respectively. (a) Write the molecular formula of the compounds formed by these elements individually with hydrogen. (b) Which of these compounds will have the highest dipole moment?

15. Draw the resonating structure of
   (a) Ozone molecule
   (b) Nitrate ion

16. Predict the shapes of the following molecules on the basis of hybridization.
   BCl_3, CH_4, CO_2, NH_3

17. All the C–O bonds in carbonate ion (CO_3^{2-}) are equal in length. Explain.

18. What is meant by the term average bond enthalpy? Why is there difference in bond enthalpy of O–H bond in ethanol (C_2H_5OH) and water?

Matching Column Type

1. Match the species in Column-I with the type of hybrid orbitals in Column-II.

Column-I	Column-II
(a) SF_4	(p) sp^3d^2
(b) IF_5	(q) d^2sp^3
(c) NO_2^+	(r) sp^3d
(d) NH_4^+	(s) sp^3
	(t) sp

2. Match the species in Column-I with the geometry/shape in Column-II.

Column-I	Column-II
(a) H_3O^+	(p) Linear
(b) $HC\equiv CH$	(q) Angular
(c) ClO_2^-	(r) Tetrahedral
(d) NH_4^+	(s) Trigonal bipyramidal
	(t) Pyramidal

3. Match the items given in Column-I with examples given in Column-II.

Column-I	Column-II
(a) Hydrogen bond	(p) C
(b) Resonance	(q) LiF
(c) Ionic solid	(r) H_2
(d) Covalent solid	(s) HF
	(t) O_3

4. Match the shape of molecules in Column-I with the type of hybridisation in Column-II.

Column-I	Column-II
(a) Tetrahedral	(p) sp^2
(b) Trigonal	(q) sp
(c) Linear	(r) sp^3

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

1. **Assertion (A):** Sodium chloride formed by the action of chlorine gas on sodium metal is a stable compound.

   Reason (R): This is because sodium and chloride ions acquire octet in sodium chloride formation.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

2. **Assertion (A):** Though the central atom of both NH_3 and H_2O molecules are sp^3 hybridized, yet H–N–H bond angle is greater than that of H–O–H.

   Reason (R): This is because nitrogen atom has one lone pair and oxygen atom has two lone pairs.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

3. **Assertion (A):** Among the two O–H bonds in H_2O molecule, the energy required to break the first O–H bond and the other O–H bond is the same.

   Reason (R): This is because the electronic environment around oxygen is the same even after breakage of one O–H bond.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

Long Answer Type

1. (a) Discuss the significance/applications of dipole moment.
   (b) Represent diagrammatically the bond moments and the resultant dipole moment in CO_2, NF_3, and $CHCl_3$.

2. Briefly describe the valence bond theory of covalent bond formation by taking an example of hydrogen. How can you interpret energy changes taking place in the formation of dihydrogen?

3. Describe hybridization in the case of PCl_5 and SF_6. The axial bonds are longer as compared to equatorial bonds in PCl_5 whereas in SF_6 both axial bonds and equatorial bonds have the same bond length. Explain.

4. (a) Discuss the concept of hybridization. What are its different types in a carbon atom.
   (b) What is the type of hybridization of carbon atoms marked with star.

   (a) $\overset{*}{C}H_2{=}CH{-}\overset{\overset{\displaystyle O}{\|}}{\overset{*}{C}}{-}O{-}H$
   (b) $CH_3{-}\overset{*}{C}H_2{-}OH$
   (c) $CH_3{=}CH_2{-}\overset{\overset{\displaystyle O}{\|}}{\overset{*}{C}}{-}H$
   (d) $\overset{*}{C}H_3{-}CH{=}CH{-}CH_3$
   (e) $\overset{*}{C}H_3{-}C{\equiv}CH$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. In which of the following species the inter-atomic bond angle is 109°28?
   (a) NH_3 and $(BF_4)^{-1}$ (b) $(NH_4)^+$ and $(BF_4)^{-1}$
   (c) NH_3 and BF_3 (d) $(NH_2)^{-1}$ and BF_3

   (AIEEE, 2002)

2. Which of the following is arranged in an increasing order of their bond strengths?
   (a) $O_2^- < O_2 < O_2^+ < O_2^{2-}$
   (b) $O_2^{2-} < O_2^- < O_2 < O_2^+$
   (c) $O_2^- < O_2^{2-}\ O_2 < O_2^+$
   (d) $O_2^+ < O_2 < O_2^- < O_2^{2-}$ **(AIEEE, 2002)**

3. Hybridization of the underlines atom changes in
   (a) $\underline{Al}H_3$ changes to AlH_4^-

(b) H_2O changes to H_3O^+

(c) NH_3 changes to NH_4^-

(d) All of these

(AIEEE, 2002)

4. An ether is more volatile than an alcohol having the same molecular formula. This is due to
   (a) Alcohols having resonance structures
   (b) Inter-molecular hydrogen bonding in ethers
   (c) Inter-molecular hydrogen bonding in alcohols
   (d) Dipolar characteristics of ethers

(AIEEE, 2003)

5. Which one of the following pairs of molecules will have permanent dipole moments for both members?
   (a) NO_2 and CO_2 (b) NO_2 and O_3
   (c) SiF_4 and CO_2 (d) SiF_4 and NO_2

(AIEEE, 2003)

6. Which one of the following compounds has the smallest bond angle in the molecule?
   (a) OH_2 (b) SH_2
   (c) NH_3 (d) SO_2

(AIEEE, 2003)

7. The pair of species having identical shapes for molecules of both species is
   (a) XeF_2 and CO_2 (b) BF_3 and PCl_3
   (c) PF_5 and IF_5 (d) CF_4 and SF_4

(AIEEE, 2003)

8. The correct order of bond angles (smallest first) in H_2S, NH_3, BF_3 and SiH_4 is:
   (a) $H_2S < NH_3 < SiH_4 < BF_3$
   (b) $NH_3 < H_2S < SiH_4 < BF_3$
   (c) $H_2S < SiH_4 < NH_3 < BF_3$
   (d) $H_2S < NH_3 < BF_3 < SiH_4$

(AIEEE, 2004)

9. The bond order in NO is 2.5 while that in NO^+ is 3. Which of the following statements is true for these two species?
   (a) Bond length in NO^+ is equal to that in NO.
   (b) Bond length in NO is greater than in NO^+.
   (c) Bond length in NO^+ is greater than in NO.
   (d) Bond length is unpredictable.

(AIEEE, 2004)

10. The states of hybridization of boron and oxygen atoms in boric acid (H_3BO_3) are, respectively,
    (a) sp^3 and sp^2 (b) sp^2 and sp^3
    (c) sp^2 and sp^2 (d) sp^3 and sp^3

(AIEEE, 2004)

11. Which one of the following has the regular tetrahedral structure?
    (a) BF_4^- (b) SF_4
    (c) XeF_4 (d) $[Ni(CN)_4]^{2-}$

(AIEEE, 2004)

12. The maximum number of 90° angles between bond pair–bond pair of electrons is observed in:
    (a) dsp^2 hybridization
    (b) sp^3d hybridization
    (c) dsp^3 hybridization
    (d) sp^3d^2 hybridization

(AIEEE, 2004)

13. Lattice energy of an ionic compound depends upon:
    (a) Charge on the ion and size of the ion
    (b) Packing of ions only
    (c) Charge of ions only
    (d) Size of the ion only

(AIEEE, 2005)

14. Which of the following molecules or ions does not contain unpaired electrons?
    (a) N_2^+ (b) O_2
    (c) O_2^{2-} (d) B_2

(AIEEE, 2006)

15. In which of the following molecules or ions is all the bonds not equal?
    (a) XeF_4 (b) BF_4^-
    (c) SF_4 (d) SiF_4

(AIEEE, 2006)

16. The decreasing values of bond angles from NH_3 (106°) to SbH_3 (91°) down group-15 of the periodic table is due to:
    (a) Decreasing lp-bp repulsion
    (b) Decreasing electronegativity
    (c) Increasing bp–bp repulsion
    (d) Increasing p-orbital character in sp^3

(AIEEE, 2006)

17. Which of the following species exhibits the diamagnetic behavior?
    (a) NO (b) O_2^{2-}
    (c) O_2^+ (d) O_2

(AIEEE, 2007)

18. The charge to size ratio of a cation determines its polarizing power. Which one of the following sequences represents the increasing order of the

polarizing power of the cationic species K^+, Ca^{2+}, Mg^{2+}, and Be^{2+}?

(a) $Ca^{2+} < Mg^{2+} < Be^+ < K^+$
(b) $Mg^{2+} < Be^{2+} < K^+ < Ca^{2+}$
(c) $Be^{2+} < K^+ < Ca^{2+} < Mg^{2+}$
(d) $K^+ < Ca^{2+} < Mg^{2+} < Be^{2+}$

(AIEEE, 2007)

19. In which of the following ionization processes, the bond order has increased and the magnetic behaviour has changed?

(a) $N_2 \rightarrow N_2^+$ (b) $C_2 \rightarrow C_2^+$
(c) $NO \rightarrow NO^+$ (d) $O_2 \rightarrow O_2^+$

(AIEEE, 2007)

20. Which of the following hydrogen bonds is the strongest?

(a) O–H---F (b) O–H---H
(c) F–H---F (d) O–H---O

(AIEEE, 2008)

21. Which one of the following pairs of species has the same bond order?

(a) CN^- and NO^+ (b) CN^- and CN^+
(c) O_2^- and CN^- (d) NO^+ and CN^+

(AIEEE, 2008)

22. The bond dissociation energy of B–F in BF_3 is 646 J mol^{-1}, whereas that of C–F in CF_4 is 515 kJ mol^{-1}. The correct reason for higher B–F bond dissociation energy as compared with that of C–F is:

(a) Stronger σ bond between B and F in BF_3 as compared with that between C and F in CF_4
(b) Significant $p\pi$–$p\pi$ interaction between B and F in BF_3, whereas there is no possibility of such interaction between C and F ions in CF_4
(c) Lower degree of $p\pi$–$p\pi$ interaction between B and F in BF_3 than that between C and F in CF_4
(d) Smaller size of B-atom as compared with that of C-atom.

(AIEEE, 2008)

23. Using MO theory, predict which of the following species has the shortest bond length?

(a) O_2^+ (b) O_2^-
(c) O_2^{2-} (d) O_2^{2+}

(AIEEE, 2008)

24. Among the following, the maximum covalent character is shown by the compound:

(a) $FeCl_2$ (b) $SnCl_2$
(c) $AlCl_3$ (d) $MgCl_2$

(AIEEE, 2011)

25. The hybridization of orbitals of N atom in NO_3^-, NO_2^+, and NH_4^+ are respectively

(a) sp, sp^2, and sp^3 (b) sp^2, sp and sp^3
(c) sp, sp^3, and sp^2 (d) sp^2, sp^3, and sp

(AIEEE, 2011)

26. The structure of IF_7 is a:

(a) Square pyramid
(b) Trigonal bipyramid
(c) Octahedral
(d) Pentagonal bipyramid

(AIEEE, 2011)

27. The number of types of bonds between two carbon atoms in calcium carbide is:

(a) One sigma and one pi
(b) Two sigma and one pi
(c) Two sigma and two pi
(d) One sigma and two pi

(AIEEE, 2011)

28. Ortho-nitrophenol is less soluble in water than p- and m-nitrophenols because:

(a) o-Nitrophenol is more volatile steam than those of m- and p-isomers
(b) o-Nitrophenol shows intramolecular H-bonding
(c) o-Nitrophenol shows intermolecular H-bonding
(d) Melting point of o-nitrophenol is lower than those of m- and p-isomers

(AIEEE, 2012)

29. In which of the following pairs the two species are not isostructural?

(a) CO_3^{2-} and NO_3^- (b) PCl_4^+ and $SiCl_4$
(c) PF_5 and BrF_5 (d) AlF_6^{3-} and SF_6

(AIEEE, 2012)

30. Which one of the following molecules is expected to exhibit diamagnetic behaviour?

(a) C_2 (b) N_2
(c) O_2 (d) S_2

(JEE Main, 2013)

31. Which of the following is the wrong statement?

(a) ONCl and ONO^- are not isoelectronic

(b) O_3 molecule is bent

(c) Ozone is violet-black in solid state

(d) Ozone is diamagnetic gas

(JEE Main, 2013)

32. In which of the following pairs of molecules/ions, both the species are not likely to exist?

(a) H_2^+, He_2^{2-} (b) H_2^-, He_2^{2-}

(c) H_2^{2+}, He_2 (d) H_2^-, He_2^{2+}

(JEE Main, 2013)

33. Which of the following exists as covalent crystals in the solid state?

(a) Iodine (b) Silicon

(c) Sulphur (d) Phosphorus

(JEE Main, 2013)

34. Stability of the species Li_2, Li_2^-, and Li_2^+ increases in the order of:

(a) $Li_2 < Li_2^+ < Li_2^-$ (b) $Li_2^- < Li_2^+ < Li_2$

(c) $Li_2 < Li_2^- < Li_2^+$ (d) $Li_2^- < Li_2 < Li_2^-$

(JEE Main, 2013)

35. Which one of the following properties is **not** shown by NO?

(a) It combines with oxygen to form nitrogen dioxide

(b) Its bond order is 2.5

(c) It is diamagnetic in gaseous state

(d) It is a neutral oxide

(JEE Main, 2014)

36. The correct statement for the molecule, CsI_3, is:

(a) It contains Cs^{3+} and I^- ions

(b) It contains Cs^+, I^- and lattice I^2 molecule

(c) It is a covalent molecule

(d) It contains Cs^+ and I_3^- ions

(JEE Main, 2014)

37. The number and type of bonds in C_2^{2-} ion in CaC_2 are:

(a) Two σ bonds and one π – bond

(b) Two σ bonds and two π – bonds

(c) One σ bond and two π – bonds

(d) One σ bond and one π – bond

(JEE Main, 2014)

38. For the compounds

CH_3Cl, CH_3Br, CH_3I and CH_3F,

the correct order of increasing C-halogen bond length is:

(a) $CH_3F < CH_3Br < CH_3Cl < CH_3I$

(b) $CH_3F < CH_3Cl < CH_3Br < CH_3I$

(c) $CH_3Cl < CH_3Br < CH_3F < CH_3I$

(d) $CH_3F < CH_3I < CH_3Br < CH_3Cl$

[JEE Main, 2014]

39. Which of the following has unpaired electron(s)?

(a) O_2^- (b) N_2^{2+}

(c) O_2^{2-} (d) N_2

[JEE Main, 2014]

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The angle between two covalent bonds is maximum in ________ (CH_4, H_2O, CO_2).

(IIT-JEE, 1981)

2. The pair of molecules which forms the strongest intermolecular hydrogen bonds is ________ (SiH_4 and SiF_4, $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$ and $CHCl_3$, $H\overset{\overset{\displaystyle O}{\|}}{C}-OH$ and $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH$).

(IIT-JEE, 1981)

3. There are ________ π-bonds in a nitrogen molecule.

(IIT-JEE, 1982)

4. ________ hybrid orbitals of nitrogen atom are involved in the formation of ammonium ion.

(IIT-JEE, 1982)

5. The shape of $[CH_3]^+$ is ________.

(IIT-JEE, 1990)

6. The two types of bonds present in B_2H_6 are covalent and ________.

(IIT-JEE, 1994)

7. When N_2 goes to N_2^+, the N—N bond distance ________, and when O_2 goes to O_2^+ the O—O bond distance ________.

(IIT-JEE, 1996)

8. Among N_2O, SO_2, I_3^+, and I_3^-, the linear species are ________ and ________.

(IIT-JEE, 1997)

True/False Type

1. Linear overlap of two atomic p-orbitals leads to a σ-bond.

(IIT-JEE, 1983)

2. All molecules with polar bonds have dipole moment.

(IIT-JEE, 1985)

3. $SnCl_2$ is a non-linear molecule.

(IIT-JEE, 1985)

4. In benzene, carbon uses all the three p-orbitals for hybridization.
(IIT-JEE, 1987)

5. sp^3-hybrid orbitals have equal s and p characters.
(IIT-JEE, 1987)

6. The presence of polar bonds in a polyatomic molecule suggests that the molecule has non-zero dipole moment.
(IIT-JEE, 1990)

7. H_2O molecule is linear.
(IIT-JEE, 1993)

Single Correct Answer Type

1. The octet rule is not valid for which of the following molecules?
(a) CO_2 (b) H_2O
(c) O_2 (d) NO
(IIT-JEE, 1979)

2. The compound which contains both ionic and covalent bonds is:
(a) CH_4 (b) H_2
(c) KCN (d) KCl
(IIT-JEE, 1979)

3. The total number of electrons that take part in forming the bond in N_2 is:
(a) 2 (b) 4
(c) 6 (d) 10
(IIT-JEE, 1980)

4. Element X is strongly electropositive and element Y is strongly electronegative. Both are univalent. The compound formed would be:
(a) X^+Y^- (b) X^-Y^+
(c) $X-Y$ (d) $X \rightarrow Y$
(IIT-JEE, 1980)

5. Which of the following compounds is covalent?
(a) H_2 (b) CaO
(c) KCl (d) Na_2S
(IIT-JEE, 1980)

6. If a molecule MX_3 has zero dipole moment, the σ-bonding orbitals used by M (atomic number < 21) are:
(a) pure p (b) sp-hybridized
(c) sp^2-hybridized (d) sp^3-hybridized
(IIT-JEE, 1981)

7. The ion that is isoelectronic with CO is:
(a) CN^- (b) O_2^+
(c) O_2^- (d) N_2^+
(IIT-JEE, 1982)

8. Carbon tetrachloride has no net dipole moment because of:
(a) Its planar structure
(b) Its regular tetrahedral structure
(c) Similar sizes of carbon and chlorine atoms
(d) Similar electron affinities of carbon and chlorine
(IIT-JEE, 1983)

9. Which of the following does not have hydrogen bond?
(a) Phenol (b) Liquid NH_3
(c) Water (d) HCl
(IIT-JEE, 1983)

10. On hybridization of one s- and one p-orbital, we get:
(a) Two mutually perpendicular orbitals
(b) Two orbitals at 180°
(c) Four orbitals directed tetrahedrally
(d) Three orbitals in a plane
(IIT-JEE, 1984)

11. The molecule having one unpaired electron is:
(a) NO (b) CO
(c) CN^- (d) O_2
(IIT-JEE, 1985)

12. The hybridization of sulphur in sulphur dioxide is:
(a) sp (b) sp^3
(c) sp^2 (d) dsp^2
(IIT-JEE, 1986)

13. The bond between two identical non-metal atoms has a pair of electrons:
(a) Unequally shared between the two
(b) Transferred fully from one atom to another
(c) With identical spins
(d) Equally shared between them
(IIT-JEE, 1986)

14. Which of the following compounds has a zero dipole moment?
(a) 1,1-Dichloroethylene
(b) *cis*-1,2-Dichloroethylene
(c) *trans*-1,2-Dichloroethylene
(d) None of the above
(IIT-JEE, 1987)

15. The species in which the central atom uses sp^2-hybrid orbitals in its bonding is:
(a) PH_3 (b) NH_3
(c) CH_3^+ (d) SbH_3
(IIT-JEE, 1988)

16. The molecule that has a linear structure is:
(a) CO_2 (b) NO_2
(c) SO_2 (d) SiO_2
(IIT-JEE, 1988)

17. The Cl—C—Cl angles in 1,1,2,2-tetrachloroethene and tetrachloromethane, respectively, will be about:
(a) 120° and 109.5° (b) 90° and 109.5°
(c) 109.5° and 90° (d) 109.5° and 120°
(IIT-JEE, 1988)

18. The molecule which has a pyramidal shape is:
(a) PCl_3 (b) SO_3
(c) CO_3^{2-} (d) NO_3^-
(IIT-JEE, 1989)

19. Which of the following is paramagnetic?
(a) O_2^- (b) CN^-
(c) CO (d) NO^+
(IIT-JEE, 1989)

20. The molecule which has zero dipole moment is:
(a) CH_2Cl_2 (b) BF_3
(c) NF_3 (d) ClO_3
(IIT-JEE, 1989)

21. The type of hybrid orbitals used by the chlorine atom in ClO_2^- is:
(a) sp^3 (b) sp^2
(c) sp (d) None of these
(IIT-JEE, 1992)

22. The maximum possible number of hydrogen bonds a water molecule can form is:
(a) 2 (b) 4
(c) 3 (d) 1
(IIT-JEE, 1992)

23. Which of the following molecules is planar?
(a) NF_3 (b) NCl_3
(c) PH_3 (d) BF_3
(IIT-JEE, 1996)

24. The number and type of bonds between two carbon atoms in CaC_2 are:
(a) One σ-and one π-bond
(b) One σ-and two π-bonds
(c) One σ-and one-half π-bond
(d) One σ-bond **(IIT-JEE, 1996)**

25. Among the following species, identify the isostructural pairs:
NF_3, NO_3^-, BF_3, H_3O^+, N_3H
(a) [NF_3, NO_3^-] and [BF_3, H_3O^+]
(b) [NF_3, N_3H] and [NO_3^-, BF_3]
(c) [NF_3, H_3O^+] and [NO_3^-, BF_3]
(d) [NF_3, H_3O^+] and [N_3H, BF_3]
(IIT-JEE, 1996)

26. Arrange the following compounds in the order of increasing dipole moment: toluene (I), *m*-dichlorobenzene (II), *o*-dichlorobenzene (III), *p*-dichlorobenzene (IV):
(a) I < IV < II < III (b) IV < I < II < III
(c) IV < I < III < II (d) IV < II < I < III
(IIT-JEE, 1996)

27. The cyanide ions CN^- and N_2 are isoelectronic, but in contrast to CN^-, N_2 is chemically inert because of:
(a) Low bond energy
(b) Absence of bond polarity
(c) Unsymmetrical electron distribution
(d) Presence of more number of electrons in bonding orbitals
(IIT-JEE, 1997)

28. Among KO_2, AlO_2^-, BaO_2, and NO_2^+, unpaired electron is present in:
(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-
(c) KO_2 only (d) BaO_2 only
(IIT-JEE, 1997)

29. Which of the following compounds has sp^2-hybridization?
(a) CO_2 (b) SO_2
(c) N_2O (d) CO
(IIT-JEE, 1997)

30. Among the following compounds the one that is polar and has the central atom with sp^2-hybridization is:
(a) H_2CO_3 (b) SiF_4
(c) BF_3 (d) $HClO_2$
(IIT-JEE, 1993)

31. Which of the following contains both polar and non-polar bonds?
(a) NH_4Cl (b) HCN
(c) H_2O_2 (d) CH_4
(IIT-JEE, 1997)

32. The correct order of increasing C—O bond length in CO, CO_3^{2-}, CO_2 is:
(a) $CO_3^{2-} < CO_2 < CO$ (b) $CO_2 < CO_3^{2-} < CO$
(c) $CO < CO_3^{2-} < CO_2$ (d) $CO < CO_2 < CO_3^{2-}$
(IIT-JEE, 1999)

33. The geometry of H_2S and its dipole moment are:
(a) Angular and non-zero
(b) Angular and zero

(c) Linear and non-zero

(d) Linear and zero

(IIT-JEE, 1999)

34. The molecular shape of SF_4, CF_4, and XeF_4 are:

(a) The same, with 2, 0, and 1 lone pair of electrons, respectively

(b) The same, with 1, 1, and 1 lone pair of electrons, respectively

(c) Different, with 0, 1, and 2 lone pair of electrons, respectively

(d) Different, with 1, 0, and 2 lone pair of electrons, respectively

(IIT-JEE, 2000)

35. The hybridization of atomic orbitals of nitrogen in NO_2^+, NO_3^-, and NH_4^+ are:

(a) sp, sp^3, and sp^2, respectively

(b) sp, sp^2, and sp^3, respectively

(c) sp^2, sp, and sp^3, respectively

(d) sp^2, sp^3, and sp, respectively

(IIT-JEE, 2000)

36. The correct order of hybridization of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5, and BCl_3 is:

(a) dsp^2, dsp^3, sp^2, and sp^3

(b) sp^3, dsp^2, sp^3d, and sp^2

(c) dsp^2, sp^2, sp^3, and dsp^3

(d) dsp^2, sp^3, sp^2, and dsp^3

(IIT-JEE, 2001)

37. The common features among the species CN^-, CO, and NO^+ are:

(a) Bond order three and isoelectronic

(b) Bond order three and weak field ligands

(c) Bond order two and π-acceptors

(d) Isoelectronic and weak field ligands

(IIT-JEE, 2001)

38. Specify the coordination geometry around and hybridization of N and B atoms in a 1 : 1 complex of BF_3 and NH_3.

(a) N: tetrahedral, sp^3; B: tetrahedral, sp^3

(b) N: pyramidal, sp^3; B: pyramidal, sp^3

(c) N: pyramidal, sp^3; B: planar, sp^2

(d) N: pyramidal, sp^3; B: tetrahedral, sp^3

(IIT-JEE, 2002)

39. Identify the least stable ion among the following:

(a) Li^- (b) Be^-

(c) B^- (d) C^-

(IIT-JEE, 2002)

40. Which of the following molecular species has unpaired electron(s)?

(a) N_2 (b) F_2

(c) O_2^- (d) O_2^{2-}

(IIT-JEE, 2002)

41. Which of the following are isoelectronic and isostructural?

$NO_3^-, CO_3^{2-}, ClO_3^-, SO_3$

(a) NO_3^-, CO_3^{2-} (b) SO_3, NO_3^-

(c) ClO_3^-, CO_3^{2-} (d) CO_3^{2-}, SO_3

(IIT-JEE, 2003)

42. Which of the following has —O—O— linkage?

(a) $H_2S_2O_6$ (b) $H_2S_2O_8$

(c) $H_2S_2O_3$ (d) $H_2S_4O_6$

(IIT-JEE, 2004)

43. According to MO theory:

(a) O_2^+ is paramagnetic and bond order is greater than O_2

(b) O_2^+ is paramagnetic and bond order is less than O_2

(c) O_2^+ is diamagnetic and bond order is less than O_2

(d) O_2^+ is diamagnetic and bond order is more than O_2

(IIT-JEE, 2004)

44. The number of lone pair(s) in $XeOF_4$ is:

(a) 0 (b) 1

(c) 2 (d) 3

(IIT-JEE, 2004)

45. Which species has the maximum number of lone pair of electrons on the central atom?

(a) $[ClO_3^-]$ (b) XeF_4

(c) SF_4 (d) $[I_3^-]$

(IIT-JEE, 2005)

46. The species having bond order different from that in CO is:

(a) NO^- (b) NO^+

(c) CN^- (d) N_2

(IIT-JEE, 2007)

47. Among the following, the paramagnetic compound is:

(a) Na_2O_2 (b) O_3

(c) N_2O (d) KO_2

(IIT-JEE, 2007)

48. The percentage of p-character in the orbitals forming P—P bonds in P_4 is:

(a) 25 (b) 33

(c) 50 (d) 75

(IIT-JEE, 2007)

49. The species having pyramidal shape is:

(a) SO_3 (b) BrF_3
(c) SiO_3^{2-} (d) OSF_2

(IIT-JEE, 2010)

50. Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen?

(a) HNO_3, NO, NH_4Cl, N_2
(b) HNO_3, NO, N_2, NH_4Cl
(c) HNO_3, NH_4Cl, NO, N_2
(d) NO, HNO_3, NH_4Cl, N_2

(IIT-JEE, 2012)

51. In allene (C_3H_4), the type(s) of hybridization of the carbon atoms is(are):

(a) *sp* and sp^3 (b) *sp* and sp^2
(c) Only sp^3 (d) sp^2 and sp^3

(IIT-JEE, 2012)

52. Assuming 2s–2p mixing is NOT operative, the paramagnetic species among the following is:

(a) Be_2 (b) B_2
(c) C_2 (d) N_2

(JEE Advanced, 2014)

Multiple Correct Answers Type

1. CO_2 is isostructural with:

(a) $HgCl_2$ (b) C_2H_2
(c) $SnCl_2$ (d) NO_2

(IIT-JEE, 1986)

2. The linear structure is assumed by:

(a) $SnCl_2$ (b) CS_2
(c) NO_2^+ (d) NCO^-
(e) SO_2

(IIT-JEE, 1991)

3. The molecule(s) that will have dipole moment is/are:

(a) 2,2-dimethyl propane
(b) *trans*-2-pentene
(c) *cis*-3-hexene
(d) 2,2,3,3-tetramethyl butane

(IIT-JEE, 1992)

4. Which of the following has/have identical bond orders?

(a) CN^- (b) O_2^-
(c) NO^+ (d) CN^+

(IIT-JEE, 1992)

5. Pick out the isoelectronic structure from the following:

(I) CH_3^+ (II) H_3O^+ (III) NH_3 (IV) CH_3^-

(a) I and II (b) III and IV
(c) I and III (d) II, III, and IV

(IIT-JEE, 1993)

6. The critical temperature of water is higher than that of O_2 because the H_2O molecule has:

(a) Fewer electrons than O_2
(b) Two ionic bonds
(c) Two covalent bonds
(d) Dipole moment

(IIT-JEE, 1997)

7. The geometry and type of hybrid orbital present about the central atom in BF_3 are:

(a) Linear, *sp* (b) Trigonal planar, sp^2
(c) Tetrahedral, sp^3 (d) Pyramidal, sp^3

(IIT-JEE, 1998)

8. The nitrogen oxide(s) containing N—N bond is/are:

(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

(IIT-JEE, 2010)

9. Hydrogen bonding plays a central role in the following phenomena:

(a) Ice floats in water
(b) Higher Lewis basicity of primary amines than tertiary amines in aqueous solutions
(c) Formic acid is more acidic than acetic acid
(d) Dimerisation of acetic acid in benzene

(JEE Advanced, 2014)

Matching Column Type

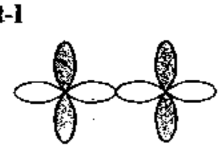
1. Match each of the diatomic molecules in Column-I with its property/properties in Column-II.

Column-I	Column-II
(a) B_2	(p) Paramagnetic
(b) N_2	(q) Undergoes oxidation
(c) O_2^-	(r) Undergoes reduction
(d) O_2	(s) Bond order ≥ 2
	(t) Mixing of *s*- and *p*-orbitals

(IIT-JEE, 2009)

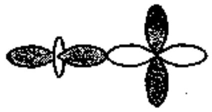
2. Match the orbital overlap figures shown in **List-I** with the description given in **List-II** and select the correct answer using the code given below the lists.

List-I **List-II**

(a)  (p) p-d σ antibonding

(b)  (q) d-d σ bonding

(c)  (r) p-d π bonding

(d)  (s) d-d σ antibonding

Code:

	p	q	r	s
(a)	2	1	3	4
(b)	4	3	1	2
(c)	2	3	1	4
(d)	4	1	3	2

(JEE Advanced, 2014)

Integer Answer Type

1. Based on VSEPR theory, the number of 90° F—Br—F angles in a molecule of BrF_5 is ________. **(IIT-JEE, 2010)**

2. Among the following, the number of compounds that can react with PCl_5 to give $POCl_3$ is
O_2, CO_2, SO_2, H_2O, H_2SO_4, P_4O_{10} **(IIT-JEE, 2011)**

3. The total number of lone-pairs of electrons in melamine is ________. **(JEE Advanced, 2013)**

4. A list of species having the formula XZ_4 is given below:
XeF_4, SF_4, SiF_4, BF_4^-, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ and $[PtCl_4]^{2-}$.
Defining shape on the basis of the location of X and Z atoms, the total number of species having a square planar shape is ________. **(JEE Advanced, 2014)**

Subjective Type

1. State four major physical properties that can be used to distinguish between covalent and ionic compounds. Mention the distinguishing features in each case. **(IIT-JEE, 1978)**

2. Write the Lewis dot structural formula for each of the following. Also give the formula of a neutral molecule which has the same geometry and the same arrangement of the bonding electrons as in each of the following.
(i) O_2^{2-} (ii) CO_3^{2-}
(iii) CN^- (iv) NCS^- **(IIT-JEE, 1983)**

3. How many σ-molecules and how many π-bonds are present in a benzene molecule? **(IIT-JEE, 1985)**

4. Arrange the following as stated.
"Increasing strength of hydrogen bonding (X—H—X)".
O, S, F, Cl, N **(IIT-JEE, 1991)**

5. Given reasons in two or three sentences only for the following:
"Hydrogen peroxide acts as an oxidising as well as a reducing agent". **(IIT-JEE, 1992)**

6. The dipole moment of KCl is 3.336×10^{-29} C m which indicates that it is a highly polar molecule. The inter atomic distance between K^+ and Cl^- in this molecule is 2.6×10^{-10} m. Calculate the dipole moment of KCl molecule if there were opposite charges of one fundamental unit located at each nucleus. Calculate the percentage ionic character of KCl. **(IIT-JEE, 1993)**

7. Explain the difference in the nature of bonding in LiF and LiI. **(IIT-JEE, 1996)**

8. Using the VSEPR theory, identify the type of hybridization and draw the structure of OF_2. What are the oxidation states of O and F? **(IIT-JEE, 1997)**

9. Interpret the non-linear shape of H_2S molecule and non-planar shape of PCl_3 using valence shell electron pair repulsion (VSEPR) theory. (Atomic number of H is 1, P is 15, Cl is 17.) **(IIT-JEE, 1998)**

10. Write the MO electron distribution of O_2. Specify its bond order and magnetic property. **(IIT-JEE, 2000)**

11. Which one is more stable in diethyl ether: anhydrous $AlCl_3$ or hydrous $AlCl_3$? Explain in terms of bonding. **(IIT-JEE, 2003)**

12. Using VSEPR theory, draw the shape of PCl_5 and BrF_5. **(IIT-JEE, 2003)**

13. Draw the shape of XeF_4 and OSF_4 according to VSEPR theory. Show the lone pair of electrons on the central atom. **(IIT-JEE, 2004)**

14. On the basis of ground electronic configuration, arrange the following molecules in the order of increasing O—O bond lengths. KO_2, O_2, $O_2[AsF_6]$ **(IIT-JEE, 2004)**

15. Predict whether the following molecules are iso-structural or not. Justify your answer.
$N(Me)_3$ and $N(SiMe_3)_3$ **(IIT-JEE, 2005)**

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Bond angle $\propto \dfrac{1}{\text{electronegativity of surrounding atom}}$
Electronegativity of F is higher than the H; hence $x > y$.

2. (b) $x = 153.9$ pm; $y = 154.5$ pm
Lone pair has more s%-character than the multiple bond; hence orbital having lone pair has more s%-character and other orbital has less s%-character. $s\% \downarrow$ bond length $\uparrow$.

3. (a) $x = 168$ pm; $y = 153.9$ pm
With increase in the size of central atom, the bond length increases.

4. (b) $y = 193$ pm; $x = 182$ pm

5. (b) $x = 175$ pm; $y = 186.4$ pm

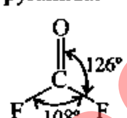
6. (a) Bridge bond lengths are longer than the terminal bonds

9. (b) Orthosilicate has SiO_4^{4-} unit.
Pyrosilicate has $Si_2O_7^{2-}$ unit.

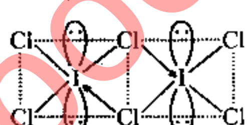
13. (d) All Xe molecules are non-polar; however, Xe has the greatest van der Waals' forces because it has higher boiling point.

14. (c) $XeF_6 \longrightarrow XeF_5^+ + F^-$
Square pyramidal

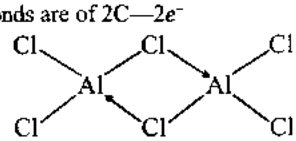
15. (a)



17. (a)



Hybridization of each I : sp^3d^2
Planar structure
2 bonds are of 3C—4e^-
4 bonds are of 2C—2e^-



Hybridization of each Al : sp^3
Non-planar structure
2 bonds are of 3C—4e^-
4 bonds are of 2C—2e^-

18. (d) M.O. configuration up to $14\bar{e}$

$$\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \pi 2py^2 = \pi 2pz^2 < \sigma 2px^2 < \overset{*}{\pi} 2py^0 = \overset{*}{\pi} 2pz^0$$

Example: For N_2, CN^-:
N_2, B.O. = 3.0 $\quad N_2^-$: B.O. = 2.5
CN^-, B.O. = 3.0 $\quad N_2^{2-}$ B.O. = 2.0

M.O. configuration for more than $14e^-$

$$\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \sigma 2px^2 < \pi 2py^2 = \pi 2pz^2 < \overset{*}{\pi} 2pz^1 = \overset{*}{\pi} 2py^1$$

Example: For O_2, NO:
O_2, B.O. = 2.0
O_2^+, B.O. = 2.5 $\quad NO^+$, B.O. = 3.0
O_2^{2+}, B.O. = 3.0 $\quad NO^-$, B.O. = 2.0
$\quad NO^{2+}$, B.O. = 2.5

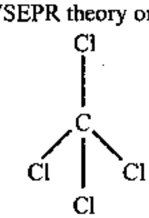
B.O. of N—O bond in NO_2^+ is 2

$$O = \overset{+}{N} = O$$

19. (c) $ICl + H_2O \xrightarrow{\text{room temp.}} HCl + HOI$
During the hydrolysis of interhalogen compounds, oxyacid of less electronegative or large sized halogen is formed, and other halogen forms halogen acid.

20. (b) From sp^3d-hybridization trigonal planar geometry is not possible, because in trigonal planar geometry lone pair electrons will be placed at the axial position, which violates VSEPR theory or Bent's rule.

21. (d) (a) Example:

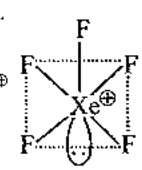


$\mu_{C-Cl} \neq 0$
$\mu_{net} = 0$

(b) Inert gas dissolves in water due to dipole–induced dipole, not by London dispersion force

(c) $Al = [Ne]\, 3s^2\, 3p^1$
$Ga = [Ar]\, 3d^{10}\, 4s^2\, 4p^1$ and I.E.$_{Ga}$ ≈ I.E.$_{Al}$
5.999 eV/atom $\quad$ 5.987 eV/atom
due to d-orbitals in Ga having weak shielding effect.

(d) $XeF_5^{\oplus}$



distorted square pyramidal

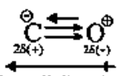
Xe is sp^3d^2-hybridization $\begin{cases} 5 \text{ bond pair} \\ 1 \text{ lone pair} \end{cases}$

23. (d) $\overset{6+}{Xe}F_6 + 3H_2O \longrightarrow \overset{6+}{Xe}O_3 + 6HF$ (No redox)
disprop.

$$3\overset{4+}{Xe}F_4 + 6H_2O \longrightarrow 2Xe + \overset{6+}{Xe}O_3 + 12HF + \frac{3}{2}O_2$$

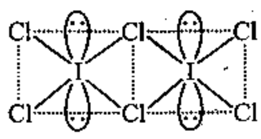
24. (d) $:\!C\!=\!\ddot{O}\!\longrightarrow :\!\bar{C}\!\equiv\!\overset{+}{O}\!:$

Incomplete octet



Overall direction

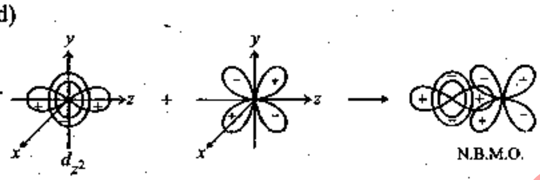
25. (c)

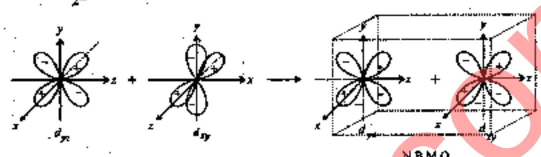


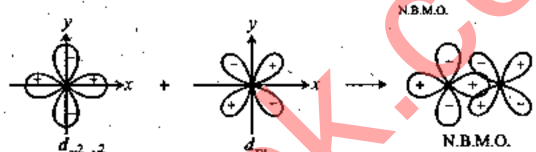
spd^2 spd^2

Square planar geometry for individual I-atoms, and to minimize the repulsion of lone pair on I-atoms overall molecule must be planar.

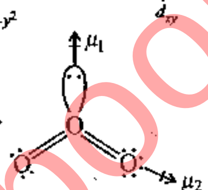
26. (d)

(a) 

(b) 

(c) 

27. (a) (a) →



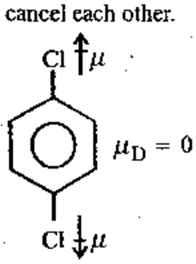
$\mu_0 \neq 0$

Central oxygen atom is surrounded by two oxygen atoms and a lone pair, hence in such unsymmetrical distribution μ_D of $O_3 \neq 0$.

$\ddot{O}\!=\!\overset{+}{N}\!=\!\ddot{O} \Rightarrow \mu_D$ of $NO_2^+ = 0$

sp Linear

Because both bond dipole moments of N—O bond cancel each other.



$\mu_D = 0$

28. (d) Increasing covalent character NaCl < CuCl < AgCl < AuCl.

Au^+ [Xe] $4f^{14}5d^{10}$; due to very poor shielding of $4f$ and $5d$ electrons, Au^+ has very high z_{eff} value in comparision to Na^+, Cu^+, Ag^+. Hence, AuCl is most covalent.

29. (d) Due to absence of vacant orbital at N in NF_3 it does not undergo hydrolysis at room temperature.

49. (d) Bond order for He_2 is zero.

50. (d) Bond order for $H_2^- = +1/2$

51. (a) Dipole moment of $CH_4 = 0$.

52. (b) O is sp^3-hybridized and H_2O is of V shape due to the presence of two lone pair of electrons in oxygen.

53. (a) The more is polarization of anion, the more is covalent character.

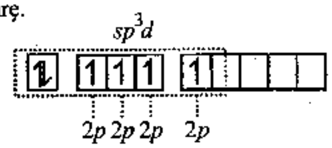
54. (a) Bond dissociation energy order:

Cl_2	>	Br_2	>	F_2	>	I_2
242.6		192.8		158.8		151.1 in kJ mol^{-1}

55. (a) S-atom in SF_6 is in sp^3d^2-hybridized state and shows octahedral shape.

56. (a) Each possesses 18 electrons.

57. (a) In SF_4, S has sp^3d-hybridization. Thus, it contains two axial and two equatorial bonds to give a see-saw structure.



58. (d) It is a reason for given fact.

59. (b) o-, m-, p-derivatives has α = 60°, 120°, and 180°, respectively and thus resultant vector has zero dipole moment in p-derivative. Also dipole moment of m-dichlorobenzene is more than toluene.

60. (a) Head on overlapping gives rise to σ-bond formation.

61. (c) CCl_4 has sp^3-hybridization giving regular tetrahedron geometry. In others the geometry is little distorted inspite of sp^3-hybridization due to different atoms on the vertices of tetrahedron.

62. (d) $PF_3 < PCl_3 < PBr_3 < PI_3$, the bond angle order is explained in terms of increasing electronegativity of halogens.

63. (b) Follow Fajan's rule.

64. (c) In o-dichlorobenzene, $\alpha = 60°$

$\therefore$ $\cos\alpha = +$ ve,

$$\mu = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2 \cos\alpha}$$

65. (a) Electronegativity difference in two atoms involved in bonding is a measure of polarity in molecule.

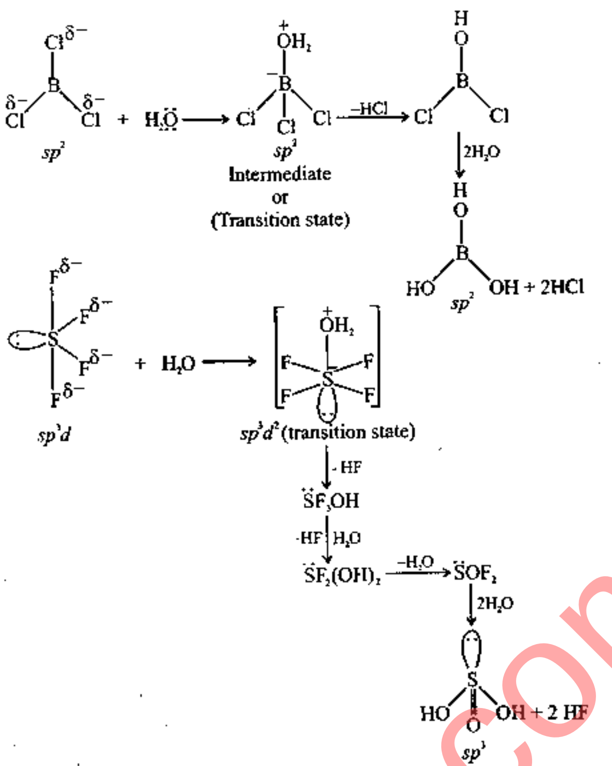
66. (d) ICl_2^- has sp^3d-hybridization and has three bond pairs and three lone pairs of electrons.

Geometry of $ICl_2^{\ominus}$ is a bent T shape.

67. (b) Bond order = $\frac{1}{2}$ [number of bonding electrons – number of antibonding electrons]

68. (b) ClO_3^- has sp^3-hybridization with one lone pair of electron.

69. (c)



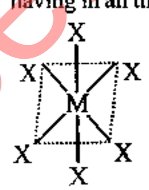
70. (c) O_2^- has one unpaired electron in its antibonding molecular orbital.

71. (a) Both are linear.

72. (b) Bond order for $O_2 = 2$ and for $O_2^+ = 2.5$

Both are paramagnetic (O_2 has 2 unpaired electrons; O_2^+ has one unpaired electron).

73. (a) sp^3d^2-hybridization leads for octahedral geometry having in all three bonds at 180° and 12 bonds at 90°.



74. (b) He_2^+ have three electrons, of which one must be unpaired. He_2^+ has one unpaired electron; H_2 has two (paired) electrons.

75. (c) SO_3^{2-} has 42 electrons, CO_3^{2-} has 32 electrons. NO_3^- has 32 electrons.

76. (a) Follow Fajan's rule.

77. (a) ClO_2 has 33 electrons, i.e., one unpaired.

94. (b) $O_2 = \sigma^2(1s)\ \overset{*}{\sigma}^2(1s)\sigma^2(2s)\ \overset{*}{\sigma}^2(2s)\sigma^2 2p_x\ \pi 2p_y^2$
$= \pi 2p_z^2\ \overset{*}{\pi}2p_y^1 = \overset{*}{\pi}2p_z^1$

Hence number of unpaired e^- in A.B.M.O. = 2

$O_2^- = \sigma^2(1s)\ \overset{*}{\sigma}^2(1s)\sigma^2(2s)\ \overset{*}{\sigma}^2(2s)\sigma^2 2p_x\ \pi 2p_y^2$
$= \pi 2p_z^2\ \overset{*}{\pi}2p_y^2 = \overset{*}{\pi}2p_z^1$

Hence number of unpaired e^- in A.B.M.O. = 1

$O_2^{2-} = \sigma^2(1s)\ \overset{*}{\sigma}^2(1s)\sigma^2(2s)\ \overset{*}{\sigma}^2(2s)\sigma^2 2p_x\ \pi 2p_y^2$
$= \pi 2p_z^2\ \overset{*}{\pi}2p_y^2 = \overset{*}{\pi}2p_z^2$

Hence number of unpaired e^- in A.B.M.O. = 0

100. (a) A serious deviation has been noticed for para-$C_6H_5(OH)_2$ for which the observed value is 1.64 D.

This deviation arises probably due to the lack of planarity of OH group with respect to the plane of ring. Thus, the two —OH links are probably remaining inclined to the plane of the ring.

101. (b) Generally, the trans compounds show zero dipole moment.

102. (b) Increasing order of π bond formation tendency:

Si — O < P — O < S — O < Cl — O

because Cl has the smallest size atom among Si, P, and S; hence due to less internuclear distance, sideways overlapping is most effective in case of Cl.

103. (d) When n is less, then overlapping is stronger.

Therefore, $1s$–$1s$ is strongest.

When one set is totally non-directional and n is also different, then directional nature of orbitals is seen:

$1s$–$2p > 1s$–$2p$

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) Bond energy order:

$\underset{2p-2p}{C \overset{\sigma}{—} C} > \underset{3p-3p}{Si \overset{\sigma}{—} Si} > \underset{4p-4p}{Ge \overset{\sigma}{—} Ge} > \underset{5p-5p}{Sn \overset{\sigma}{—} Sn}$

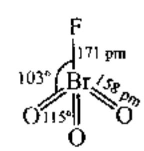
Extent of overlapping decreases in the order:

$2p - 2p > 3p - 3p > 4p - 4p > 5p - 5p$

6. (a) Bond angle α electronegativity of central atom.

7. (a) $x = 105°$; $y = 99°$

8. (b) According to Bent's rule

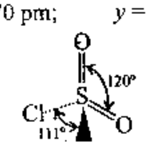


9. (a) $x = 100°$; $y = 98°$

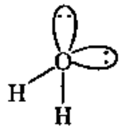
According to Bent's rule

10. (a) $x = 270$ pm; $y = 196$ pm

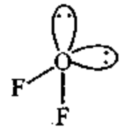
14. (a)



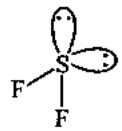
16. (a)



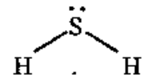
Hybridization: sp^3



Hybridization: sp^3



Hybridization: sp^3



No hybridization according to Drago's rule

Bond angle between H_2O and OF_2 is compared on the basis of Bent's rule.

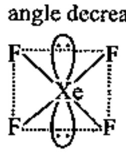
$\angle FSF$ in $SF_2 > \angle HSH$ in H_2S

From Drago's rule,

$\angle FOF$ in $OF_2 > \angle FSF$ in SF_2

On descending in a group for same substituents, bond angle decreases.

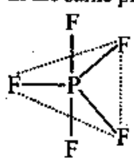
17. (a)



Hybridization of Xe: sp^3d^2

All four Xe — F bonds are of equal lengths as they lie in the same plane and are at 90° apart from each other.

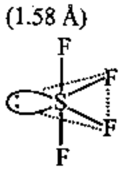
(b)



Hybridization: sp^3d

$(P-F)_{axial} > (P-F)_{equatorial}$
(1.58 Å) (1.53 Å)

(c)



Hybridization: sp^3d

$(S-F)_{axial} > (S-F)_{equatorial}$

18. (c) (a) NO : B.O. = 2.5
(b) NO^- : B.O. = 2.0
(c) NO^+ : B.O. = 3.0

$N\equiv N\rightarrow \ddot{O}: \longleftrightarrow :\bar{N}=\overset{+}{N}=\ddot{O}:$

(N–O) B.O. exp. = 1.5

19. (c) $CH_3-\dot{N}=C=S \longleftrightarrow CH_3-\overset{+}{N}\equiv C-S^-$

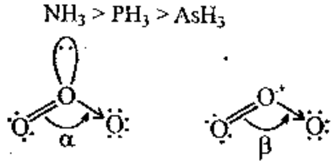
less than 120° ⟷ 180°

≈142°

20. (c) (i) According to Drago's rule, the trend of decreasing bond angle in NH_3, PH_3, and AsH_3 is:

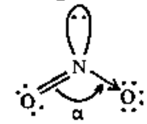
$NH_3 > PH_3 > AsH_3$

(ii)

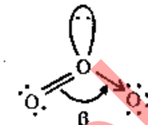


$\alpha < \beta$ because lone pair–double bond repulsion in O_3 is greater than single electron–double bond in O_3^+. Also, lone pair–single bond (electron pair) repulsion in O_3 is greater than single electron–single bond repulsion in O_3^+.

(iii)



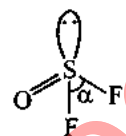
Hybridization of N: sp^2

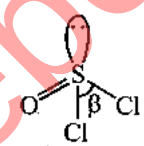


Hybridization of O: sp^2

According to Bent's rule, N — O bond (B.O. = 1.5) in NO_2^- has more p character than O — O bond (B.O. = 1.5) in O_3. Hence $\alpha < \beta$.

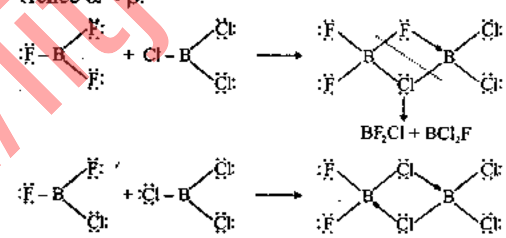
(iv)





According to Bent's rule, there is more p-character in S—F bond than in S—Cl bond in $SOCl_2$. Hence $\alpha < \beta$.

21. (a)



does not form due to crowding at B-atom due to large size of Cl-atoms.

25. (b) Bond energy of Cl_2 is highest among all halogen molecules. Bond energy of F_2, Cl_2, Br_2, I_2 are 37, 58, 46, and 36 kcal mol^{-1}, respectively.

26. (a) The tendency to show lower ionic state increases down the group due to inert pair effect.

27. (a) Small cation causes more polarization in anion. Also, larger anions are easily polarized by a cation.

28. (b) The bond order for O_2^{2-}, O_2^-, O_2, O_2^+ are 1.0, 1.5, 2.0, 2.5, respectively. The higher is bond order, the more is bond energy.

29. (a) Carbon in H_2CO_3 has sp^2-hybridization and also polar. BF_3 has sp^2-hybridized but is non-polar. SiF_4 has sp^3-hybridization. $HClO_2$ has sp^3-hybridization.

30. (c) Both SO_4^{2-} and BF_4^- have sp^3-hybridization and are tetrahedral.

31. (c) KO_2 has K^+ O_2^- structure having one unpaired electron.

32. (b) Smaller cation causes more polarization of anion.

33. (c) The larger is anion, the more is its polarization.

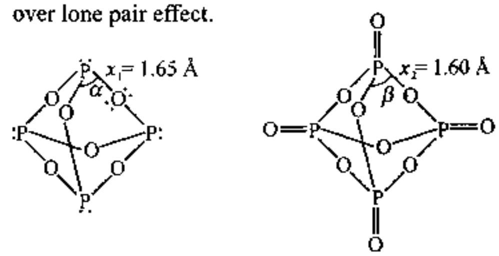
34. (b) The stability of carbonates increases with increasing electropositive character of metal.

35. (a) CH_3^+ possesses sp^2-hybridization.

36. (c) Larger anion is polarized more (Fajan's rule).

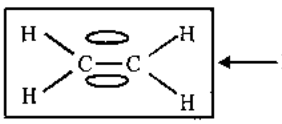
37. (a) In ether, sp^3-hybridized oxygen molecule shows a little larger angle than 109° 28′ due to steric effect of alkyl groups on two sides of it, which predominates over lone pair effect.

38. (b)



$x_1 > x_2$

39. (a) A π-bond has a nodal plane passing through the two bonded nuclei, i.e., molecular plane.



Nodal plane, i.e., molecular plane.

40. (d) Boric acid is $HO—\overset{\overset{\cdot\cdot}{O}H}{B}—OH$; boron has sp^2 and oxygen has sp^2-hybridization because of back bonding.

41. (c) Boron in $[BF_4]^-$ has regular tetrahedral geometry because of sp^3-hybridization on boron atom.

42. (c) The bond angles are

H_2S	NH_3	SiH_4	BF_3
92.6°	107°	109°28	120°

43. (a) $x = 118°$; $y = 79°$

44. (b) x = 172 pm; y = 175 pm

51. (c) CO and N_2 both have same (B.O. = 3) bond order.

54. (a) Increasing order of π bond formation tendency: $Si—O < P—O < S—O < Cl—O$

because Cl is the small size atom among Si, P, and S, hence due to less internuclear distance, sideways overlapping is most effective in case of Cl.

When π bond formation tendency increases, then polymerization tendency decreases.

58. (c) Bond order

$= \frac{1}{2}$ [bonding electrons – antibonding electrons]

59. (b) x = 217 pm; y = 239 pm

61. (b) Bond angle $\propto$ Electronegativity of central atom

Electronegativity of Cl is higher than Br, hence $y > z$

62. (b) $x = 94°$; $y = 84°$; $z = 91°$

Terminal chlorine has three lone pairs so repulsion is more between two terminal chlorine, but bridging chlorine has two lone pairs so repulsion between one terminal and one bridging chlorine is less than the terminal chlorine.

63. (c) x = 266 pm; y = 293 pm

In $I_3^{\oplus}$, there is sp^3 hybridization so $s\% < 25\%$ in bonded orbitals.

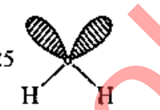
However, there is an sp^3d hybridization in I_3^-; so $s\%$ = 0 in axial orbitals. When $s\% \uparrow$ bond length $\downarrow$

64. (b) $x = 120$; $y = 126°$

According to Bent's rule

70. (c) $\cos\theta = \frac{-1}{i}$

$\cos(104.5°) = \frac{-1}{i} = -0.25$

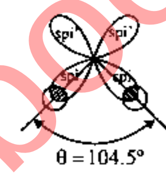


$\Rightarrow \quad i = 4$

Applying $\Sigma f_p = 3$

$\frac{2 \times i}{i+1} + 2\,fp' = 3$

$\frac{2 \times 4}{5} + 2f_p' = 3$



where f_p' = fraction of p-character in lone pair.

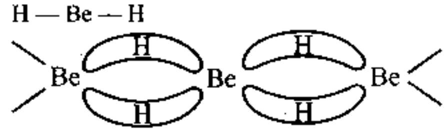
$f_p' = \frac{7}{10}$

$f_p'\% = 70\%$

71. (a) The magnitude of negative charge developed at chlorine atoms in $SiCl_4$ is more in comparison to negative charge developed at chlorine atoms in CCl_4, it is due to more electronegativity difference between Si and Cl than that of between C and Cl.

72. (d) $nBeH_{2(g)} \longrightarrow (BeH_2)_{n(s)}$

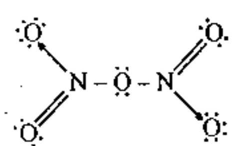
$H—Be—H$



Hybridization of Be: sp^3
(solid)

Hybridization of Be: sp
(gas)

(b) $[NO_2]^+ [NO_3]^+$



Hybridization of N in NO_2^+ : sp

Hybridization of N in NO_3^- : sp^2

(N_2O_5 in solid state)

Hybridization of each N: sp^2
(gaseous state)

(c)	XeF_6	$[XeF_5]^+ F^-$
	Gaseous state	Solid state
	Hybridization: sp^3d^3	Hybridization: sp^3d^2
(d)	PF_5	PF_5
	Gaseous state	Solid state
	Hybridization: sp^3d	Hybridization: sp^3d

73. (b) N_2 and CO are isoelectronic. To convert $N_2 \rightarrow N_2^+$, electron is removed from bonding M.O. evidenced by decrease in bond order. While the conversion $CO \rightarrow CO^+$ requires less energy than in case of N_2, because bond order of CO increases.

$CO_{(g)} \rightarrow CO^+_{(g)} + e$, I.E. = 1352 kJ/mol

$N_{2(g)} \rightarrow N_2^+{}_{(g)} + e$, I.E. = 1503 kJ/mol

$NO_{(g)} \rightarrow NO^+_{(g)} + e$, I.E. = 894 kJ/mol

$O_{2(g)} \rightarrow O_2^+{}_{(g)} + e$, I.E. = 1164 kJ/mol

75. (a) O_2 has two unpaired electron but are paired in O_2^{2-}.

76. (c) NF_3 and H_3O^+ have sp^3-hybridization; NO_3^- and BF_3 have sp^2-hybridization.

77. (c) $CsBr_3 \longrightarrow Cs^+ + Br_3^-$

78. (c) Electronegativity difference in two atoms involved in bonding is a measure of polarity in molecule.

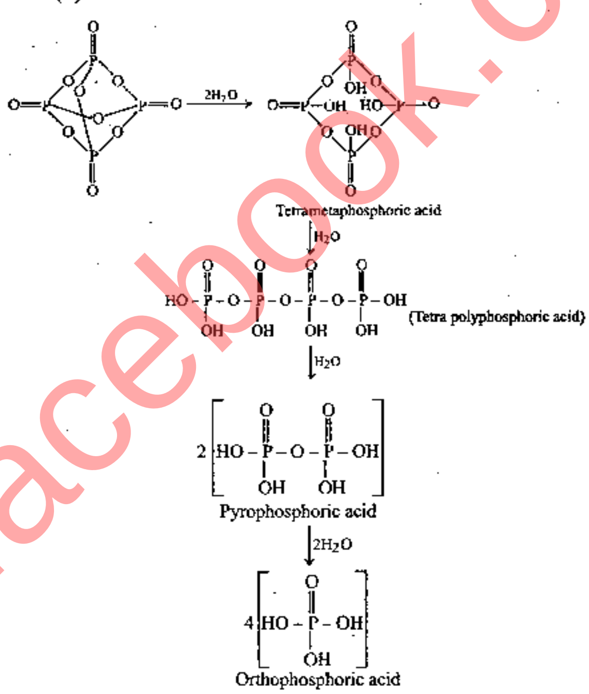
79. (c) Operates in each gaseous molecule.

80. (b) NH_3, $[PtCl_4]^{2-}$, PCl_5, and BCl_3 have sp^3, dsp^2, sp^3d, and sp^2-hybridization, respectively.

81. (a) No doubt NH_3 and BF_3 have sp^3 (pyramidal) and sp^2 (coplanar) hybridization, respectively, having one lone pair of electron on N atom which is responsible for pyramidal shape of NH_3 inspite of sp^3-hybridization. However, as soon as it is coordinated to BF_3, both attain tetrahedral geometry and acquire sp^3 hybridization.

82. (b) The larger is bond order, the smaller is bond length.

83. (b)



85. (b) $y = 98°$; $x = 82°$

86. (b) According to Bent's rule.

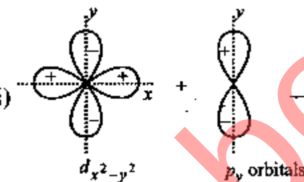
87. (a) $x = 115°$; $y = 132°$

90. (b) $y = 2.644$ Å $\quad x = 2.21$ Å

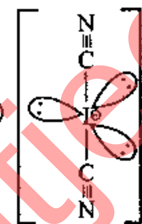
93. (d) $\sigma 1s^3 < \overset{*}{\sigma}(1s)^3 < \sigma 2s^3 < \overset{*}{\sigma}(2s)^3 < \pi 2py^2$

94. (d) PF_5 and PCl_5 exist through the formation of sp^3d-hybridization.

95. (a) $[SiH_6]^{2-}$ does not exist because of the absence of d-orbital contraction.

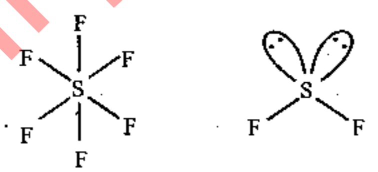
96. (d) (i) 

N.B.M.O. is formed

(ii) 

$[I(CN)_2]^-$ has linear geometry and sp^3d-hybridization.

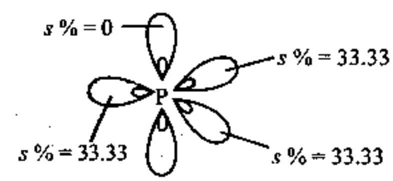
97. (a)



sp^3d^2 $\qquad$ sp^3

s % character ↑ $\qquad$ bond length ↓

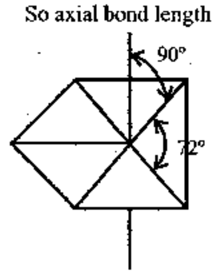
(b)



s %↑ $\qquad$ bond length ↓

So axial bond length is longer than the

(c)



For axial position	For equatorial position
$\cos 90° = \frac{s}{s-1}$	$\cos 72° = \frac{s}{s-1}$
s % = 0	s% = –ive

s% ↑ $\quad$ bond length ↓

So equatorial bond lengths are longer than axial bond lengths

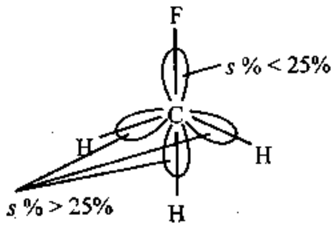
Multiple Correct Answers Type

1. (a), (b)

(a) $\cos\theta = \frac{p-1}{p}$

$\theta\uparrow \quad p\downarrow$

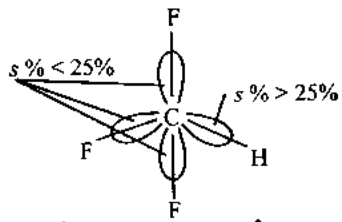
(b)



$s\,\% \uparrow$ Bond angle $\uparrow$

Hence $H-\hat{C}-H > F-\hat{C}-H$

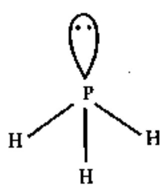
(c)



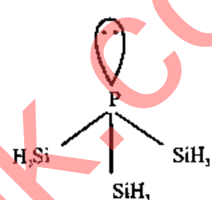
$s\,\% \uparrow$ Bond angle $\uparrow$

Hence $H-\hat{C}-F > F-\hat{C}-F$

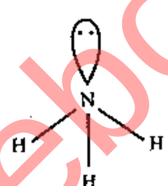
2. (a), (b), (c)



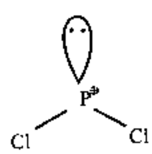
Pyramidal



Pyramidal

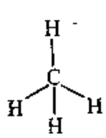


Pyramidal

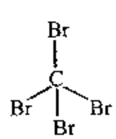


Bent

9. (a), (b), (c)



$\mu = 0$
Symmetrical molecule

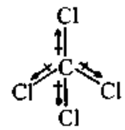


$\mu = 0$
Symmetrical molecule

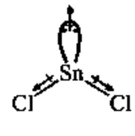
$H-C\equiv C-H$

$\mu = 0$
Symmetrical molecule

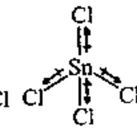
10. (a), (c)



$\mu = 0$
Tetrahedral structure



$\mu \neq 0$
Bent structure



$\mu = 0$
Tetrahedral structure

$O=C=O$
$\mu = 0$
Linear

12. (a), (b), (c), (d)

All silicates are non-planar because SiO_4^{4-} unit is tetrahedral.

27. (a), (b), (c)

Solubility of alkali earth metal's sulphate decrease down the group: $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

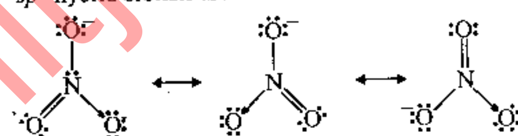
35. (b), (c), (d)

AlF_3 is ionic so it has complete octet.

60. (b), (c), (d)

(a) sp^3-hybrid orbitals are at 109°28' to each other

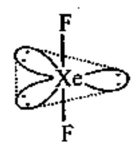
(d)



Bond order of N–O bond $= \frac{4}{3} = 1.33$

61. (a), (b), (c), (d)

(a)

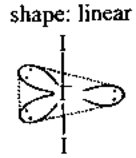


Hybridization: sp^3d
shape: linear

$O=C=O$

Hybridization: sp
shape: linear

(b)

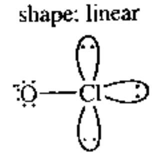


Hybridization: sp^3d
shape: linear

$Cl-Hg-Cl$

Hybridization: sp
shape: linear

(c)

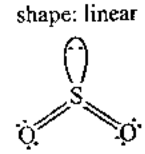


Hybridization of Cl: sp^3
shape: linear

$:C\equiv O:$

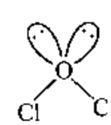
Hybridization of C: sp
shape: linear

(d)



Hybridization: sp^2

shape: V-shape/bent/ angular



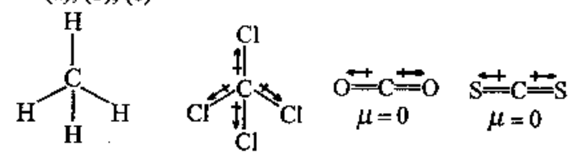
Hybridization of O: close to sp^3

shape: V-shape/bent/ angular

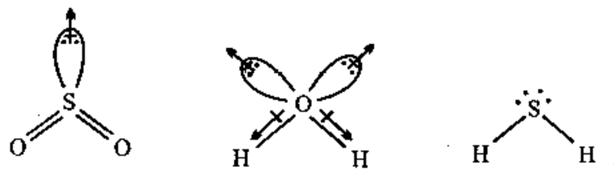
66. (a), (b)

SH_6 does not exist due to the absence of *d*-orbital contraction.

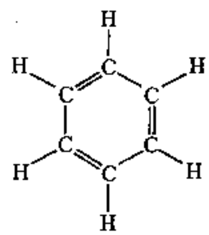
67. (a), (b), (c)



$\mu = 0$ Symmetrical molecule | $\mu = 0$ Tetrahedral structure | $\mu = 0$ Linear | $\mu = 0$ Linear

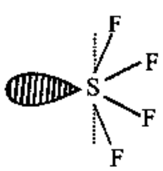


$\mu \neq 0$ Bent structure | $\mu \neq 0$ Bent structure | $\mu \neq 0$ Bent structure



$\mu = 0$

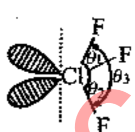
91. (a), (b), (c), (d)



S $\rightarrow$ sp^3d-hybridized

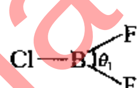
Axial bond length is greater than equatorial bond length (see-saw).

Cl $\rightarrow$ sp^3d-hybridized.



Axial and equatorial; bond length are different (nearly T-shape).

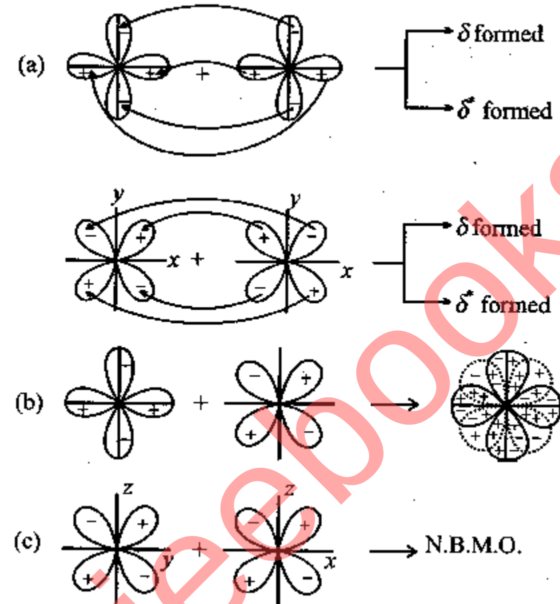
$\theta_1 = \theta_2 \neq \theta_3$



$\theta_1 < 120°$

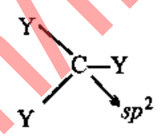
as per Bent's rule

92. (a), (b), (c), (d)



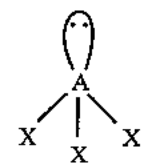
93. (a), (c)

Since the dipole moment of $CY_3 = 0$. It means C in CY_3 is sp^2-hybridized.



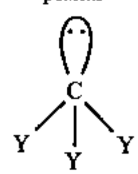
$\mu_{net} = 0$

Trigonal planar



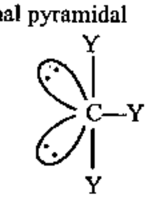
$\mu_{net} \neq 0$

Trigonal pyramidal



Trigonal pyramidal

$\mu_{net} \neq 0$

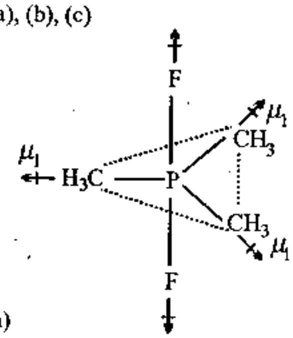


T-shape

$\mu_{net} \neq 0$

94. (a), (b), (c)

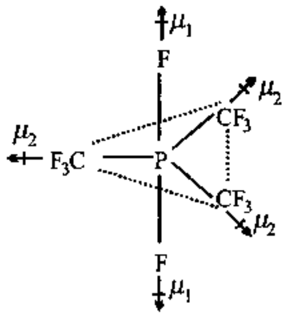
(a)



(I)

Hybridization of P: sp^3d

Hence, shape: trigonal bipyramidal



(II)

Hybridization of P: sp^3d

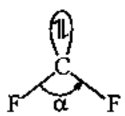
Hence, shape: trigonal bipyramidal

(b) μ_D of both I and II is equal to zero as all substituents are symmetrically arranged.

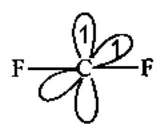
(c) According to Bent's rule, P – F bond length in PF_2Me_3 is longer than $PF_2(CF_3)_3$, because as a whole group CF_3 is more electronegative than CH_3 group by which polarity of P–F bond increases in $PF_2(CF_3)_3$ and P–F bond length decreases.

95. (a), (b), (d)

(a)

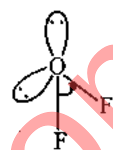


Singlet hybridization of C : sp^2
$\alpha \approx 120°$



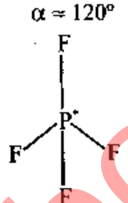
Triplet hybridization of C : sp
$\angle FCF = 180°$

OF_2:

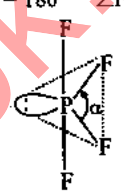


Hybridization of O : sp^3
$\angle FOF = 103°$

(b)

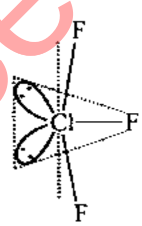


Hybridization of P: sp^3
$\angle = 109°28'$

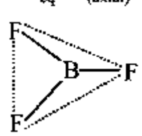


Hybridization of P: sp^3d
$\angle FPF$ (eq.) < 120°
$\angle F_{eq}\, PF_{(axial)} < 90°$

(c)



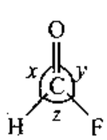
Hybridization of Cl: sp^3d
$\angle FClF = 87.5°$



Hybridization of B: sp^2
$\angle FBF = 120°$

(d) In NH_3, $\angle HNH = 107°$; In PH_3, $\angle HPH = 93.8°$

97. (c), (d)



Due to $-I$ effect of F (which is more compared to $+R$ effect of F-atom), the % p-character in C–F increases and consequently % s-character increases in C–H bond. Hence the bond angle order is $x > y > z$.

$x > 120°$; $z < 120°$

100. (c), (d)

(a) $NH_3 > PH_3 > AsH_3 > SbH_3$

As we move down the group, the size of the central atom increases and therefore its tendency to form stable covalent bond with small hydrogen atom decreases. Consequently, the strength of M—H bond and hence the thermal stability goes on decreasing as we move from NH_3 to BiH_3.

(b) The boiling point of liquid hydrogen is greater than liquid helium due to large surface area of hydrogen than Helium.

(c) According to Fajan rule, as ionic potential (ϕ) of cation increases thermal stability of metal carbonate decreases; hence k_p increases because reaction moves in the forward direction, so

$$MCO_3 \xrightleftharpoons{k_p} MO + CO_2$$

$$BeCO_3 > SrCO_3 > BaCO_3$$

(d) Magnetic moment = $\sqrt{n(n+2)}$ (where n = unpaired electron)

$O_2 = 2$ unpaired electron $\sqrt{2(2+2)} = \sqrt{8}$

$KO_2\ K^+ \rightleftharpoons O_2^-$ = 1 unpaired electron

$\sqrt{1(1+2)} = \sqrt{3}$

$K_2O_2\ 2K^+ \rightleftharpoons O_2^{2-}$ = 0 unpaired electron

$\sqrt{0(0+2)} = \sqrt{0}$

So magnetic moment order: $O_2 > KO_2 > K_2O_2$

106. (b), (c), (d)

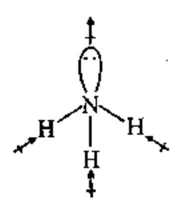
Solubility of alkaline earth metal's oxide increases down the group: BeO < MgO < CaO < SrO < BaO

120. (c), (d)

$$AgNO_3 \xrightarrow{\Delta} Ag + \frac{1}{2}O_2 + NO_2$$

$$Hg(NO_3)_2 \xrightarrow{\Delta} Hg + O_2 + 2NO_2$$

127. (a), (c)

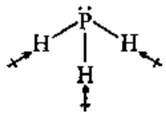


NH_3

Hybridization of N: sp^3

Bond angle $H\hat{N}H$ less than 109°

Lone pair exists in hybrid orbitals.



PH_3

Hybridization of P: No hybridization according to Drago's rule

$\angle HPH$ is close to $90°$.

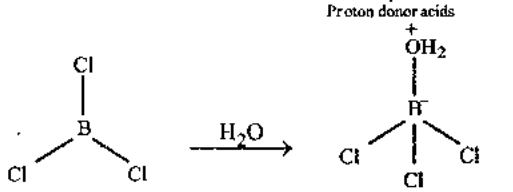
Lone pair exists in s-orbital.

Dipole moment of pure orbital is zero.

128. (b), (c), (d)

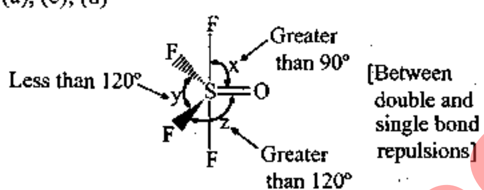
NCl_3 undergoes hydrolysis and H_2O attacks at Cl-atoms.

$$SF_4 + 3H_2O \xrightarrow{\text{room temp.}} \underbrace{H_2SO_3 + 4HF}_{\text{Proton donor acids}}$$



Hybridization: sp^2 Hybridization: sp^3 (Transition state)

130. (a), (c), (d)



134. (a), (d)

B.D.E.$_{N-H}$ > B.D.E.$_{P-H}$ because NH_3 has sp^3-hybridization, so N – H bond has more s % character.

When s % ↑ B.D.E.↑

Note: In PH_3 hybridization is not possible according to Drago's rule.

But both NF_3 and PF_3 have sp^3 hybridization.

B.D.E.$_{P-F}$ > B.D.E.$_{N-F}$ because PF_3 has back bonding.

Comprehension Type

15. (b) (a) Solubilities of hydroxides of alkali metals and alkaline earth metals increase downward because in both groups L.E. of hydroxides decreases at a faster rate than their hydration energies.

(b) Solubilities of carbonates of alkali metals increase downward while those of alkaline earth metals decrease downward.

Decreasing solubilities of alkaline earth metals carbonates: $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$ (based on $r^+ << r^-$)

Increasing solubilities of alkali metals carbonates

$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$ (exception to $r^+ << r^-$)

16. (d) (a) **Solubilities of bicarbonates:** $NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$ because the extent of association of HCO_3^- by intermolecular H bonding decreases from $NaHCO_3$ to $CsHCO_3$.

(b) **Thermal stability:** $LiNO_3 < NaNO_3 < KNO_3 < RbNO_3 < CsNO_3$. Thermal stability of an ionic compound having polyatomic anion such as NO_3^- inversely is proportional to polarization.

(c) Solubilities of chromates of II A cations:

$BeCrO_4 > MgCrO_4 > CaCrO_4 > SrCrO_4 > BaCrO_4$ (based on $r^+ << r^-$)

(d) Melting point of fluorides of alkali metals:

NaF > KF > RbF > CsF (decided by L.E.)

17. (a) Thermal stability of an ionic compound having monoatomic anion ∝ lattice energy.

Hence, NaCl is the most thermally stable.

18. (d) Increasing covalent character: NaCl < CuCl < AgCl < AuCl.

Au^+ [Xe] $4f^{14}5d^{10}$; due to very poor shielding of $4f$ and $5d$ electrons, Au^+ has very high z_{eff} value in comparision to Na^+, Cu^+, Ag^+. Hence, AuCl is most covalent.

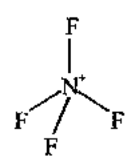
31. (b) $\underset{(X)}{KI} + I_2 \longrightarrow KI_3$

Anionic part of X is I_3^-

I_3^- has sp^3d-hybridization and linear geometry

I_3^- is planar

32. (d)

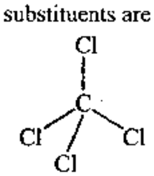


Hybridization of N: sp^3

$\angle FNF = 109.5°$

As all substituents are same.

(b)

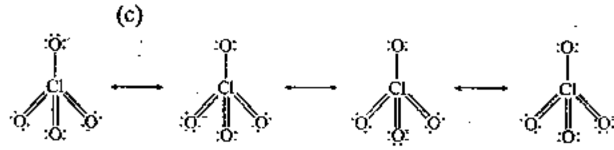


Hybridization of C: sp^3

$\angle ClCCl = 109.5°$

As all substituents are same.

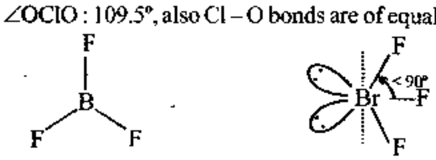
(c)



Hybridization of Cl: sp^3

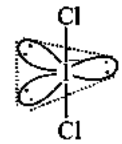
$\angle OClO$: 109.5°, also Cl – O bonds are of equal length.

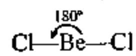
33. (b)



Hybridization of B: sp^2
Shape: trigonal planar

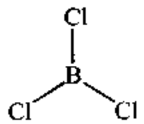
Hybridization of Br: sp^3d
Shape: bent T shape.

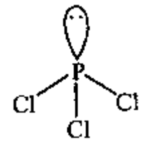
(b) 



Hybridization: sp^3d
Shape: linear

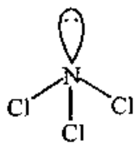
Hybridization: sp
Shape: linear

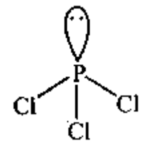
(c) 



Hybridization of N: sp^3
Shape: trigonal planar

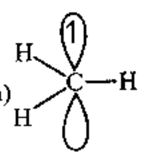
Hybridization of P: sp^3
Shape: triangular pyramidal

(d) 

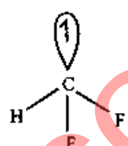


Hybridization of N: sp^3
Shape: triangular pyramidal

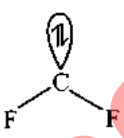
Hybridization of P: sp^3
Shape: triangular pyramidal.

34. (b) (a) 

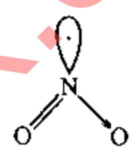
Planar

(b) 

Triangular pyramidal (non-planar)

(c) 

Planar (singlet carbene)

(d) 

Planar

35. (c) $f_p = 3 \times \left(\frac{i}{i+1}\right) + \left(\frac{i'}{1+i'}\right) = \frac{3}{i}$

For sp^3 — $sp^3 / sp^2 / sp^1$

$\cos\theta\,(107) = \frac{-1}{i}$ — $\Sigma f_s = 1$

$\cos 107° = 0.292$ — $\Sigma f_p = 3$

$-0.292 = \frac{-1}{i}$

$i = 3.4$

$f_s = 3 \times \frac{i}{3.4+1} + \frac{1}{1+i'} = 1$

$i' = 2.13$

36. (a) $\cos\theta = \frac{s}{(s-1)}$

$-0.3729 = \frac{s}{(s-1)} \Rightarrow \% = 27.1\%$

37. (a) F is more electronegative.

40. (b) As DCl_3 is trigonal planar; hence D belongs to boron family.

As ACl_3 is trigonal pyramidal; hence A belongs to nitrogen family.

$DCl_3 + ACl_3 \longrightarrow [DCl_2]^+[ACl_4]^-$ or $[ACl_2]^+[DCl_4]^-$

If anionic part is $[ACl_4]^-$ which has a see-saw structure, then cationic part will be $[DCl_2]^+$ where hybridization of D will be sp and hence shape will be linear.

If anionic part is DCl_4^- i.e., it is of tetrahedral shape, then cationic part will be ACl_2^+ which will be bent.

Assertion-Reasoning Type

2. (c) (i) PH_5 does not exist due to the absence of d-orbital contraction.

(ii) In PH_3 hybridization is absent according to Drago's rule.

3. (b) $Pb^{4+} + 2e^- \longrightarrow Pb^{2+}$

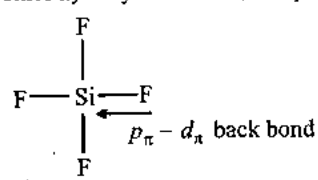
$Pb^{2+} > Pb^{4+}$ (due to inert pair effect).

$Tl^{3+} + 2e^- \longrightarrow Tl^+$

$Tl^+ > Tl^{3+}$ (due to inert pair effect).

6. (b) $3SiF_4 + 4H_2O \longrightarrow H_4SiO_4 + 2H_2[SiF_6]$

Out of three molecules of SiF_4, only one molecule becomes hydrolyzed. Hence, it is partial hydrolysis.



8. (c) M.O. configuration of

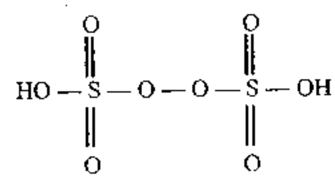
$N_2: \sigma 1s^2 < \overset{*}{\sigma}_{1s}{}^2 < \sigma 2s^2 < \overset{*}{\sigma}_{2s}{}^2 < \pi 2py^2 = \sigma 2pz^2 < \overset{*}{\sigma} 2px^2$

Number of bonding electrons in $N_2 = 10$

Number of bonding electrons in $N_2^- = 10$

Bond order of $N_2^+ = 2.5$; B.E. of $N_2^+ > N_2^-$ and B.E. of $N_2^+ > N_2^-$

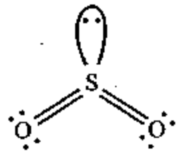
Bond order of $N_2^- = 2.5$

9. (b) 

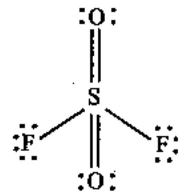
15. (a) $H_A^+ \ H_B^- \leftrightarrow H_A^- \ H_B^+ \leftrightarrow H_A : H_B$

H_2 has ionic character (2%) due to instantaneous dipole.

19. (d)



Hybridization: sp^2



Hybridization: sp^3

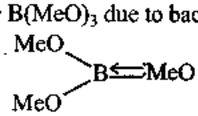
$\dot{S}-O$ bond distance in SO_2F_2 is not identical with that in SO_2.

24. (a) According to Coulson model.

25. (a) When size increases then polarization of ion increases and covalent character also increases and hence solubility in polar solvent decreases.

33. (d) According to Coulson model.

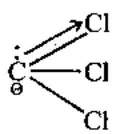
34. (a) $B(Me)_3 > B(MeO)_3$ due to back bonding.



Matching Column Type

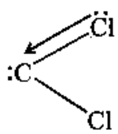
3. (a) p, q; (b) q, r, s; (c) q, t; (d) q, r, s, t

(a)



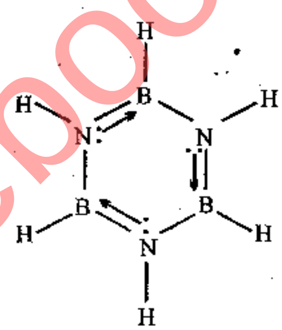
(i) $2p_\pi - 3d_\pi$ back bonding
(ii) $\mu \neq 0$
(iii) Polar
(iv) Non-planar

(b)



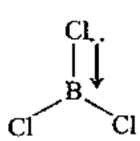
(i) $2p_\pi - 3p_\pi$ back bonding
(ii) Planar
(iii) $\mu \neq 0$, polar
(iv) Planar

(c) $B_3N_3H_6$



(i) $2p_\pi - 2p_\pi$ back bonding
(ii) $\mu = 0$
(iii) Non-polar
(iv) Planar

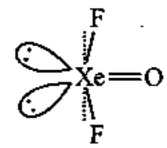
(d)



(i) $2p_\pi - 3p_\pi$ back bonding
(ii) $\mu = 0$
(iii) Non-polar
(iv) Direction of back bonding is from Cl to central atom
(v) Planar

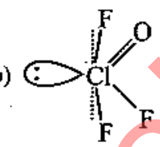
7. (a) p, r, s; (b) q, r, t; (c) r; (d) q, r, t

(a)



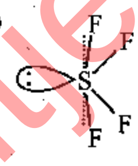
(i) sp^3d-hybridization
(ii) Bent T shape
(iii) Two lone pairs are present in equatorial position

(b)



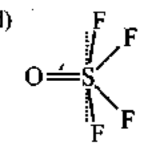
(i) sp^3d hybridization
(ii) See-saw shape
(iii) One lone pair is present in equatorial position

(c)



(i) sp^3d hybridization
(ii) See-saw shape
(iii) One lone pair is present in equatorial position

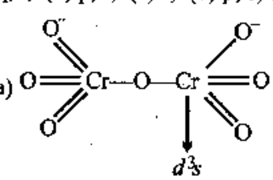
(d)



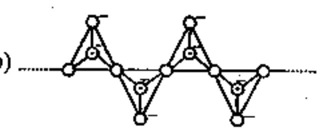
(i) sp^3d-hybridization
(ii) Trigonal bipyramidal shape

9. (a) p, q, t; (b) p, r; (c) r; (d) p, s, t

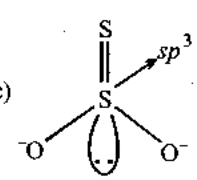
(a)



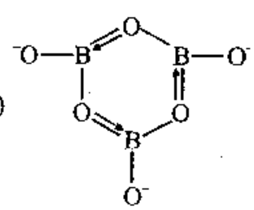
(b)



(c)



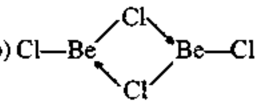
(d)



Aromatic, planar

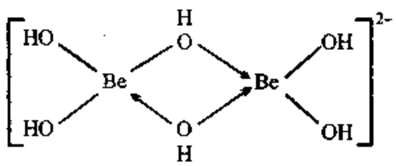
10. (a) p, q, r, s; (b) q, r; (c) p, q, r, s

(a) $BeCl_2$

(p) 

Dimer of $BeCl_2$ having two 3C – 4e bonds.

(q) $BeCl_2 \xrightarrow{H_2O}$



Polyhydroxy compound

$\downarrow$ NaOH

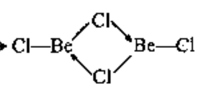
$[Be(OH)_4]^{2-}$

II

Hybridization of Be : sp^3

(r) Cl – Be – Cl ⇒ Planar molecule.

(s)

2Cl– Be– Cl $\xrightarrow{\text{dimerization}}$ 

Hybridization of Be: sp

Hybridization of Be : sp^3

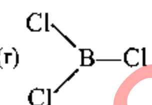
(b) BCl_3

(p) Due to $p\pi$–$p\pi$ back bonding and large size of Cl atom, BCl_3 does not undergo dimerization. Hence 3C–4$\bar{e}$ bonds cannot be formed.

(q) $BCl_3 \xrightarrow{H_2O} H_3BO_3$

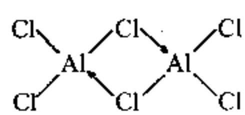
$\xrightarrow{OH^-} B(OH)_4^-$

Hybridization of B : sp^3

(r)  Hybridization of B: sp^2 ⇒ Planar

(c) $AlCl_3$

(p) $2AlCl_3$

$\xrightarrow{\text{dimerization}}$ 

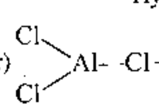
It has two 3C — 4$\bar{e}$ bonds.

(q) $AlCl_3 \underset{}{\overset{\text{Water}}{\rightleftharpoons}} Al^{3+}_{(aq.)} + 3Cl^-_{(aq.)}$

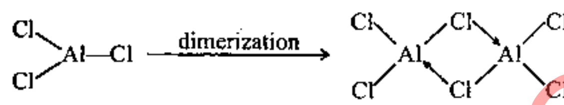
$\downarrow$ OH^-

$[Al(OH)_4]^-$

Hybridization of Al: sp^3

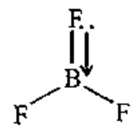
(r)  → Hybridization of Al: sp^2, hence planar

(s) 2



Hybridization of Al : sp^2 Hybridization of Al : sp^3

15. (a) p, r, t; (b) q; (c) p, s; (d) p, s

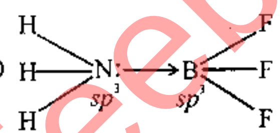
(a) 

(i) $2p_\pi - 2p_\pi$ back bonding

(ii) Planar

(iii) $\mu = 0$

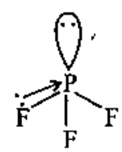
(iv) Inter Lewis acid–base interaction

(b) 

(i) Inter Lewis acid–base interaction

(ii) Non-planar

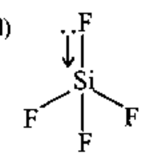
(iii) Back bonding absent because of the absence of vacant orbital on B-atom

(c) 

(i) $2p_\pi - 3d_\pi$ back bonding

(ii) Non-planar

(iii) Intra Lewis acid–base interaction.

(d) 

(i) $2p_\pi - 3d_\pi$ back bonding

(ii) Non-planar

(iii) Intra Lewis acid–base interaction

17. (a) p, r, s; (b) p, q, r; (c) p, t; (d) p, q, r, s

(a) B_2H_6

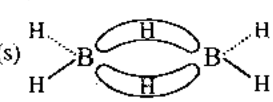
(p) B_2H_6 can act as Lewis acid

$B_2H_6(g) + 2NH_3 \xrightarrow{\Delta} [BH_2.2NH_3]^+.[BH_4]^-$

Lewis acid Lewis base

$\xrightarrow{\Delta} B_3N_3H_6$

Borazine

(s) 

Hybridization of each B: sp^3; hence non-planar.

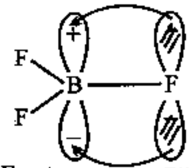
(r) As molecule is symmetrical; therefore $\mu_D = 0$.

(b) BF_3

(p) BF_3 can act as Lewis acid due to vacant orbital at B in spite of $p\pi$–$p\pi$ back bonding.

$BF_3 + \ddot{N}H_3 \rightarrow F_3B{\cdot}NH_3$

Lewis acid Lewis base Adduct

(q) 

Empty $2p$ orbital (Lewis acid) Filled $2p$ orbital (Lewis base)

Due to $p\pi$–$p\pi$ back bonding, intramolecular Lewis acid–base interaction occurs.

(s) BF_3: Planar

(r) μ_D of $BF_3 = 0$

(t) Does not undergo dimerization.

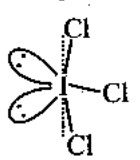
(c) ICl_3

(p) Due to vacant $5d$ orbitals at I atom, it can act as Lewis acid.

$$\underset{\text{Lewis acid}}{ICl_3} + \underset{\text{Lewis base}}{Cl^-} \rightarrow ICl_4^-$$

(q) Due to large size of I-atom, no back bonding is possible, i.e., no Lewis acid–base interaction internally occurs.

(s) Although ICl_3 exists in dimer form, but ICl_3 itself is planar.



Hybridization: sp^3d.
Shape: bent T shape

(r) μ_D of $ICl_3 = 0$

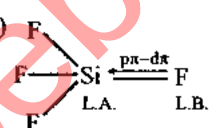
(t) It undergoes dimerization.

$$2ICl_3 \rightleftharpoons I_2Cl_6$$

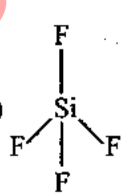
(d) SiF_4

(p) Can act as Lewis acid

$$\underset{\text{Lewis acid}}{SiF_4} + \underset{\text{Lewis base}}{2F^-} \rightarrow [SiF_6]^{2-}$$

(q) 

Due to $p\pi$–$p\pi$ back bonding in SiF_4 there is internal Lewis acid–base interaction.

(r) 

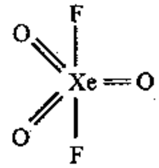
Hybridization of Si: sp^3

Shape: Regular tetrahedral; hence μ_D of $SiF_4 = 0$

(s) Non-planar

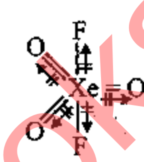
(t) Cannot undergo dimerization.

18. (a) s, t; (b) q, s; (c) p, q, r, s, t; (d) q, s, t

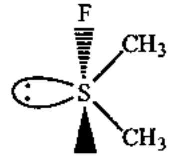
(a) 

(TBP)

Xe is sp^3d-hybridized and d used is d_{z^2}

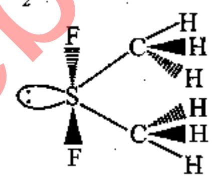


$\mu_{net} = 0$

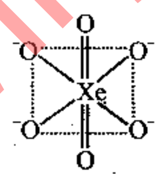
(b) 

See-saw

S is $sp^3\ d_{z^2}$ hybridized.

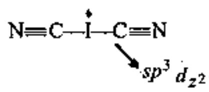


Bold atoms are lying in the same plane

(c) 

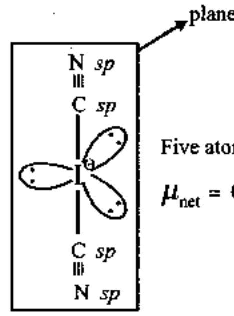
$sp^3\ d_{x^2-y^2}\ d_{z^2}$ or sp^3d^2-octahedral
5 atoms in plane.

$\mu_{net} = 0$, d used are $d_{x^2-y^2}$, d_{z^2}

(d) 

3 L.P.
2 B.P.

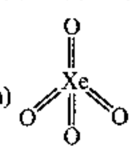
plane



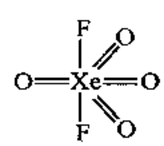
Five atoms are in plane

$\mu_{net} = 0$

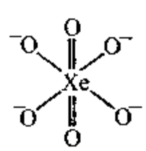
22. (a) q; (b) r; (c) s; (d) p

(a) 

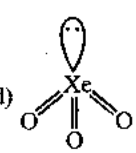
Tetrahedral

(b) 

Trigonal bipyramidal

(c) 

Octahedral

(d) 

Pyramidal

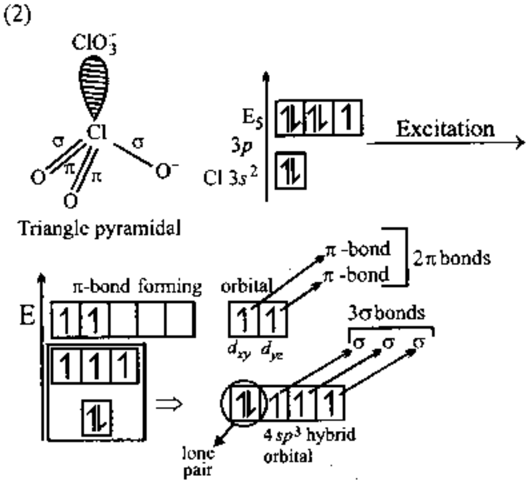
Integer Answer Type

3. (1)

$\Rightarrow$ pyrosilicate

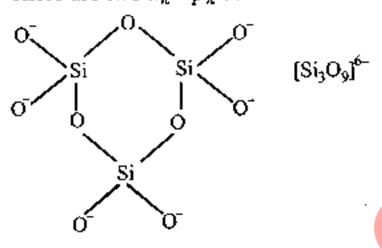
Number of corner shared per tetrahedron = 1

4. (2)



There are two $d_\pi - p_\pi$ bond.

9. (6)



$[Si_3O_9]^{6-}$

10. (3) 9σ and 2π-bonds

Butadiene is $CH_2 = CH - CH = CH_2$

18. (2) $Cl - Be - Cl$

No. of $2C - 2e^-$ bonds = 2 $\Rightarrow$ Total no. of $2C - 2e^-$ and $3C - 2e^-$ bonds = 2

No. of $3C - 4e^-$ bonds = 0

19. (2)

$SF_4 + 3H_2O \longrightarrow H_2SO_3 + 4HF$

Basicity = 2 Basicity = 1

28. (0) C_2 (solid) does not exist but C_2 (vapor) has 2π bonds according to M.O.T.

29. (1) B_2 has 1π bond, according to M.O.T.

30. (2) $B_2 = \sigma^2_{(1s)}\ \overset{*}{\sigma}{}^2_{(1s)}\ \sigma^2_{(2s)}\ \overset{*}{\sigma}{}^2_{(2s)}\ \pi^1_{2p_y} = \pi^1_{2p_z}$

$$\text{Ratio} = \frac{\text{Number of } \sigma \text{ bonding } e^-}{\text{Number of } \pi \text{ bonding } e^-} = \frac{4}{2} = 2$$

31. (3) $C_2 = \sigma^2(1s)\,\overset{*}{\sigma}{}^2(1s)\sigma^2(2s)\overset{*}{\sigma}{}^2(2s)\ \pi 2p_y^2 = \pi 2p_z^2$

$$\text{Ratio} = \frac{\text{Number of } \sigma \text{ bonding electrons}}{\text{Number of } \pi \text{ bonding electrons}} = \frac{4}{4} = 1$$

32. (6) $P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$

33. (2) $H_2S_2O_8 + 2H_2O \longrightarrow 2H_2SO_4 + H_2O_2$

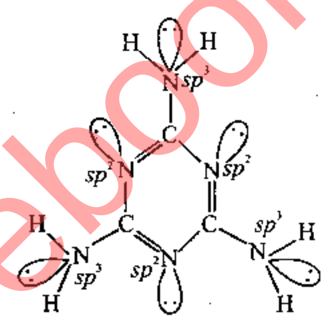
34. (4) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

35. (5) $SiCl_4 + 4H_2O \longrightarrow H_4SiO_4 + 4HCl$

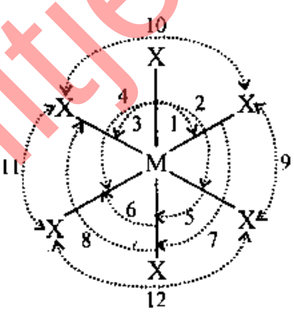
37. (2) $H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$

55. (3) $\frac{9}{3} = 3$

56. (1) $\frac{3}{3} = 1$



63. (12)



64. (1) $01 + 0 = 1$

69. (4) If vapor state of HF be $(HF)_n$

$P \times \text{Mol. wt.} = dRT$

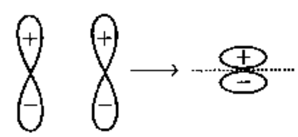
$1 \times \text{Mol. wt.} = 3.248 \times 0.0821 \times 300$

$n\,(20) = \text{Mol. wt.} = 79.9 \approx 80$

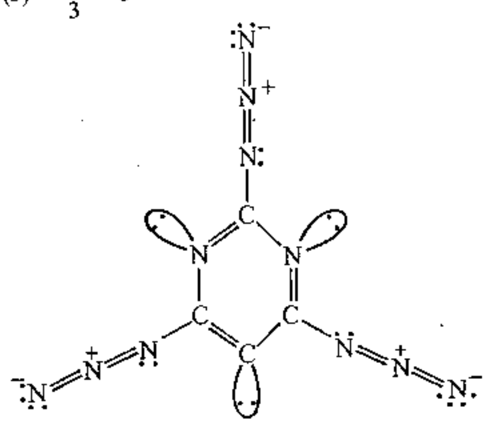
$n = 4$

Hence, vapor state is represented as $(HF)_4$

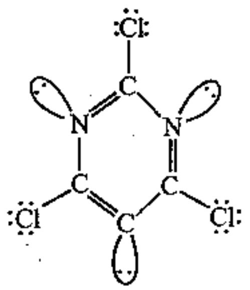
71. (1)



73. (5) $\frac{15}{3} = 5$



75. (1) $\frac{12}{12} = 1$

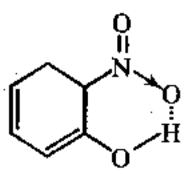


76. (3) $\frac{9}{3} = 3$

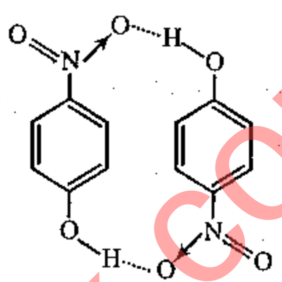
NCERT Exemplar Exercises

Short Answer Type

3.



(I)



(II)

(a) Compound (I) will form intramolecular hydrogen bond because NO_2 and OH group are close together in comparison to that in compound (II).

(b) Compound (II) will have higher melting point because it forms intermolecular hydrogen bonds. Thus, more and more molecules are joined together through hydrogen bond formation.

(c) Due to intramolecular hydrogen bonding compound (I) will not be able to form hydrogen bonds with water thus will be less soluble in it while compound (II) can form hydrogen bond with water more easily and will be soluble in water.

6. [**Hint:** Dimethyl ether will have larger bond angle. There will be more repulsion between bond pairs of CH_3 groups attached in ether than between bond pairs of hydrogen atoms attached to oxygen in water. The carbon of CH_3 in ether is attached to three hydrogen atoms through bonds and electron pairs of these bonds add to the electronic charge density on carbon atom. Hence, repulsion between two $-CH_3$ groups will be more than that between two hydrogen atoms.]

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b)

NH_3

No. of σ bond = 3

No. of lp = 1

No. of hybrid orbitals = 4

Bond angle nearly 109° 28'

BF_3

No. of σ bond = 3

No. of l-p = 0

No. of hybrid orbitals = 3

sp^2

Bond angle exactly 120°

BF_4^-

No. of σ bond = 4

No. of lp = 0

No. of hybrid orbitals = 4

sp^3 hybridization

Bond angle exactly 109° 28'

2. (b) Bond strength $\propto$ bond order

$O_2 \to \sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2}\sigma_{2pz}^2 < \pi_{2px}^{2} = \pi_{2py}^{2} < \pi_{2px}^{*1} = \pi_{2py}^{*1}$

$$BO = \frac{10-6}{2} = 2$$

$$O_2^+ \Rightarrow BO = \frac{10-5}{2} = 2.5$$

$$O_2^- \Rightarrow BO = \frac{10-7}{2} = 1.5$$

$$O_2^{2-} \Rightarrow BO = \frac{10-8}{2} = 1$$

3. (a)

AlH_4	AlH_4^-	H_2O
No. of σ bond = 3	No. of σ bond = 4	No. of σ bond = 2
No. of lp = 0	No. of lp = 0	No. of lp = 2
	No. of hybrid orbitals = 4	
sp^2	sp^3	sp^3
H_3O^+	**NH_3**	**NH_4^+**
No. of σ bond = 3	No. of σ bond = 3	No. of σ bond = 4

No. of $lp = 1$ No. of $lp = 1$ No. of $lp = 0$

sp^3 sp^3 sp^3

4. (c) Condition for hydrogen bonding

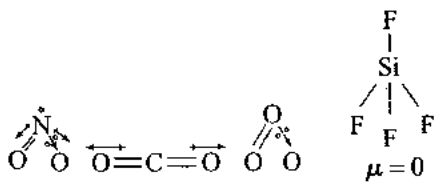
X—H-----Y

X = F, O, N

Y = F, O, N

In case of ether, there is no hydrogen bonding because hydrogen is directly attached with oxygen by covalent bond.

5. (b)



$\mu \neq 0$ $\mu = 0$ $\mu \neq 0$ $\mu = 0$ due to symm.

6. (b)

H_2O	(bond angle is 105°) sp^3
H_2S	(bond angle is 90°) no hybridization
NH_3	(bond angle is 107°) sp^3
SO_2	(bond angle is 120°) sp^2

7. (a)

XeF_2	**CO_2**	**BF_3**
No. of σ bond = 2	No. of σ bond = 2	No. of σ bond = 3
No. of $lp = 3$	No. of $lp = 0$	No. of $lp = 0$
sp^3d	sp	sp^3
Linear	Linear	Trigonal planar
PCl_3	**PF_5**	**IF_5**
No. of σ bond = 3	No. of σ bond = 5	No. of σ bond = 5
No. of $lp = 1$	No. of $lp = 0$	No. of $lp = 1$
sp^3	sp^3d	sp^3d^2
Trigonal pyramidal	Trigonal bipyramidal	Square pyramidal

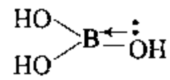
CF_4	**SF_4**
No. of σ bond = 4	No. of σ bond = 4
No. of $lp = 0$	No. of $lp = 1$
sp^3	sp^3d
Tetrahedral	See-Saw

8. (a)

H_2S	(Nearly 90°)
NH_3	(≈ 107°)
SiH_4	(109°28′)
BF_3	(120°)

9. (b) Bond length $\propto \dfrac{1}{\text{Bond order}}$

10. (b)

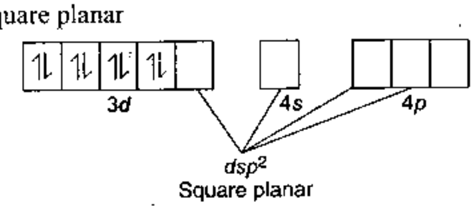


For boron	**For oxygen**
No. of σ bond = 3	No. of σ bond = 2
No. of $lp = 0$	No. of $lp = 1$
sp^2	sp^3

Because one lp involves in back bonding, so oxygen has sp^2 hybridisation.

11. (a)

BF_4^-	**SF_4**
[No. of σ bond = 4] sp^3	No. of σ bond = 4
No. of $lp = 0$	No. of $lp = 1$
All surrounding atoms are same	sp^3d
Perfect tetrahedral	See-Saw
XeF_4	**$[Ni(CN)_4]^{2-}$**
No. of σ bond = 4	$Ni \rightarrow 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^8\, 4s^2$
No. of $lp = 2$	$Ni^{+2} \rightarrow 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^8\, 4s^2$
sp^3d^2	CN^- S.F.L. Co. no. 4
Square planar	



12. (d)

dsp^2	squre planar	No. of 90° angles = 4
dsp^3/sp^3d	trigonal bipyramidal	No. of 90° angles = 6
sp^3d^2	square bipyramidal	No. of 90° angles = 12

13. (a) L.E. $\propto \dfrac{q_1 q_2}{d}$

q_1 and q_2 are magnitude of charge on the ions. d is the distance between ions.

14. (c)

N_2^+: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi 2px^{11} = \sigma 2py^{11} < \sigma 2pz^1$

O_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2a^2 < \sigma 2pz^2 < \pi 2px^{11} = \pi 2py^{11} < \pi^* 2px^1 = \pi^* 2py^1$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma 2pz^2 < \pi 2px^{\uparrow\downarrow}$
$= \pi 2py^{\uparrow\downarrow} < \sigma^* 2px^{\uparrow\downarrow} = \sigma^* 2py^{\uparrow\downarrow}$

B_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi 2px^1$
$= \pi 2py^1 < \sigma 2pz$

15. (d) **Note:** In sp^3d hybridization, all bond lengths are not equal. The three equatorial bonds are equivalent, while the two axial bonds are longer than equatorial bonds. This is due to the fact that the axial bond pairs suffer more repulsion as compared to equatorial bond pairs.

XeF_4	**BF_4^-**
No. of σ bond = 4	No. of σ bond = 4
No. of lp = 2	No. of lp = 0
sp^3d^2	sp^3
All bond lengths are equal	All bond lengths are equal
SF_4	**SiF_4**
No. of σ bond = 4	No. of σ bond = 4
No. of lp = 1	No. of lp = 0
sp^3d	sp^3
SF_4	**SiF_4**
See-Saw	All bond lengths are equal

Axial bond lengths are greater than equatorial.

16. (b) There is no hybridisation in SbH_3 due to Drago's rule.

17. (b) NO has 15 electrons; species having odd electrons are always paramagnetic.

O_2^+ has 15 electrons.

O_2: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{\uparrow\downarrow}$
$= \pi_{2px}^{\uparrow\downarrow} < \pi_{2px}^{*\uparrow} < \pi_{2py}^{*\uparrow}$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{\uparrow\downarrow}$
$= \pi_{2py}^{\uparrow\downarrow} < \pi_{2px}^{*\uparrow\downarrow} < \pi_{2py}^{*\uparrow\downarrow}$

18. (d) Smaller the cation and larger the positive charge on it more will be its polarizing power.

19. (c) N_2: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \pi_{2px}^{\uparrow\downarrow} = \pi_{2py}^{*\uparrow\downarrow} = \pi_{2pz}^2$

Diamagnetic BO $= \dfrac{10-4}{2} = 3$

N^{2+} paramagnetic BO $= \dfrac{9-4}{2} = 2.5$

C_2 diamagnetic BO $= \dfrac{8-4}{2} = 2.5$

C_2^+ paramagnetic BO $= \dfrac{7-4}{2} = 1.5$

NO: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{\uparrow\downarrow}$
$= \pi_{2py}^{*\uparrow} < \pi_{2px}^{*\uparrow} = \sigma_{2py}^*$

Paramagnetic BO $= \dfrac{10-5}{2} = 2.5$

NO^+ diamagnetic BO $= \dfrac{10-4}{2} = 3$

O_2 paramagnetic BO $= \dfrac{7-5}{2} = 2$

O_2^+ paramagnetic BO $= \dfrac{10-5}{2} = 2.5$

20. (c) Higher the electronegativity of atoms attached with H, more will the charge on H and the electronegative atom therefore, more will be electrostatic force of attraction.

21. (a)

CN^-	No. of electrons = 14	B – O = 3
NO^+	No. of electrons = 14	B – O = 3
CN^+	No. of electrons = 13	B – O = 2.5
O_2^-	No. of electrons = 17	B – O = 1.5

22. (b) BF_3 is a Lewis acid due to incomplete octet of boron. Among BF_3, BCl_3, BBr_3, and so on, BF_3 is the weakest Lewis acid due to back bonding of lp electron of F to vacant P-orbital of boron.

Therefore, the bond strength of B–F bond is stronger than single bond between boron and fluorine, that is, in BF_4^-

23. (d)

O_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{\uparrow\downarrow} = \pi 2py^{\uparrow\downarrow} < \pi^* 2px^1 = \pi^* 2py^1$

B.O. $= \dfrac{10-4}{2} = 2$

O_2^+: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{\uparrow\downarrow} = \pi 2py^{\uparrow\downarrow} < \pi^* 2px^1 = \pi^* 2py$

B.O. $= \dfrac{10-5}{2} = 2.5$

O_2^-: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{\uparrow\downarrow} = \pi 2py^{\uparrow\downarrow} < \pi^* 2px^{\uparrow\downarrow} = \pi^* 2py^1$

B.O. $= \dfrac{10-7}{2} = 1.5$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma 2pz^2 < \pi 2px^{\uparrow\downarrow}$
$= \pi 2py^{\uparrow\downarrow} < \pi^* 2px^{\uparrow\downarrow} = \pi^* 2py^{\uparrow\downarrow}$

$$B.O. = \frac{10-8}{2} = 1$$

$$\left[\text{Bond length} \propto \frac{1}{\text{Bond order}}\right]$$

24. (c) If the anion is same, then the ionic character or covalent character depends on the size and charge on cation. Smaller the size and larger the charge on cation, more will be its polarizing power.

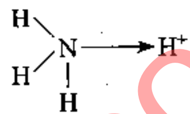
Fe^{2+} Sn^{+2} Al^{+3} Mg^{+2}

Polarizing power of Al^{+3} will be higher than other ions.

25. (b)

NO_3^- $O=N(\rightarrow O)-O^-$	NO_2^+ $O=\overset{+}{N}=O$
No. of σ bonds = 3	No. of σ bond = 2
No. of lp = 0	No. of lp = 0
No. of hybrid orbital = 3	No. of hybrid orbitals = 2
sp^2	sp

NH_4^+



No. of σ bond = 4

No. of lp = 0

No. of hybrid orbital = 4

sp^3

26. (d) IF_7

No. of σ bond = 7

No. of hybrid orbitals = 7

sp^3d^3

Pentagonal bipyramidal

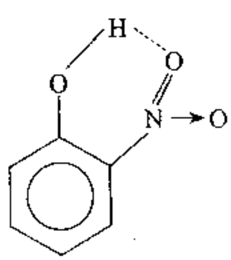
27. (d) $CaC_2 \Rightarrow Ca^{+2}\ C_2^{2-}$

$\bar{C} \equiv \bar{C}$

σ bond = 1

π bond = 2

28. (b)



In o-nitrophenol, there is intramolecular hydrogen bonding, whereas in *m*-nitrophenol and *p*-nitrophenol, there is no intramolecular hydrogen bonding. *o*-Nitrophenol has less tendency for hydrogen bonding with water than *m*- and *p*-nitrophenol

29. (c)

CO_3^{2-}	NO_3^-	PCl_4^+
$\bar{O}-C(=O)-\bar{O}$	$O-N(\rightarrow O)-\bar{O}$	
No. of σ bond = 3	No. of σ bond = 3	No. of σ bond = 4
No. of lp = 0	No. of lp = 0	No. of lp = 0
sp^2	sp^2	sp^3
Trigonal planar	Trigonal planar	Tetrahedral
$Si(CH_3)_4$	**PF_5**	**BrF_5**
No. of σ bond = 4	No. of σ bond = 5	No. of σ bond = 5
No. of lp = 0	No. of lp = 0	No. of lp = 1
sp^3	sp^3d	sp^3d^2
Tetrahedral	Trigonal bipyramidal	Square pyramidal
AlF_6^{3-}	**SF_6**	
No. of σ bond = 6	No. of σ bond = 6	
No. of lp = 0	No. of lp = 0	
sp^3d^2	sp^3d^2	
Octahedral	Octahedral	

30. (b) $C_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2 \begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases}$ (Diagmanetic)

$N_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2 \begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases} \sigma 2p_x^2$ (Diamagnetic)

$O_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases}, \begin{cases}\pi^* 2p_y^1 \\ \pi^* 2p_z^1\end{cases}$ (Paramagnetic)

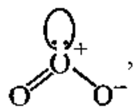
$S_2 = KK, LL, \sigma 3s^2, \sigma^* 3s^2, \begin{cases}\pi 3p_y^2 \\ \pi 3p_z^2\end{cases}, \begin{cases}\pi^* 3p_y^1 \\ \pi^* 3p_z^1\end{cases}$ (Paramagnetic)

C_2 and N_2 both are diamegnatic actully, but according to the language of question, **expected to be diamegnatic.**

If we consider energy leval diagram of C_2 and N_2 similar to O_2 then C_2 becomes paramagnetic and N_2 remains diamegnatic so best answer of question is N_2.

31. (a)

(i) Some times, two species having same valence shell electrons are considered as isolectronic species. Accordingly ONCl and ONO^- are isoelectronic to each other. **[Otherwise all four statements are correct and no answer is available in the given options].**

(ii)  , bent shaped

(iii) O_3 (g) = Blue

O_3 (l) = Dark blue

O_3 (s) = Violet-black

(iv) All electrons are paired in structure of O_3. Hence it is diamagnetic.

32. (c) According to M.O.T. species which has zero B.O., they do not exist.

Energy order of M.O. in H_2 and He_2 = $\sigma 1s$, σ^*_{1s}

$\Rightarrow$ H_2^{2+} have zero electron; B.O. = zero

$\Rightarrow$ He_2 have two bonding electron and two antibonding electrons; B.O. = zero

33. (b)

(i) I_2 is molecular solid in which I2 molecules are interacted by weak London forces.

(ii) Silicon exists in diamond like structure in which atoms of Si are bonded by covalent bond. Hence it is a covalent solid.

(iii) Sulphur is molecular solid in which S8 molecules are interacted by London force.

(iv) White phosphorous is a molecular solid in which P4 molecules are interacted by London force.

34. (b) Stability depends upon bond order

B.O. of Li_2, Li_2^+ and Li_2^- are 1, 0.5 and 0.5 respectively.

Hence $Li_2 > Li_2^+$

$Li_2 > Li_2^-$

while $Li_2^+ > Li_2^-$ due to higher interelectronic repulsion in Li_2^- which makes it least stable. Hence the order is $Li_2 > Li_2^+ > Li_2^-$

35. (c)

(1) $\underset{\text{(Colourless)}}{NO} + \underset{\text{(Air)}}{\frac{1}{2}O_2} \rightarrow \underset{\text{(Brown)}}{NO_2}$ (Correct statement)

(2) NO is odd e^- molecule which have B.O. = 2.5 (correct statement)

(3) NO has an unpaired e^- in its antibonding M.O. That is, it is paramagnatic compound (given statement in the question is incorrect)

(4) It is neutral towards litmus (correct statement)

36. (d) CsI_3 is an ionic compound and consisting of Cs^+ and I_3^-.

37. (c) Ca^{+2} $[C{\equiv}C]^{-2}$

38. (b) As the radius of halogen increase C—halogen bond length increased.

39. (a) O_2^- has one unpaired electron is π^* MO.

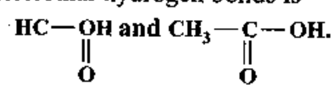
JEE (Advanced) Exercises

Fill in the Blanks Type

1. The angle between two covalent bonds is maximum in CO_2.

It is a linear molecule and has 180° angle.

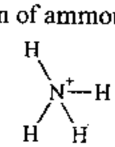
2. The pair of molecules which forms the strongest intermolecular hydrogen bonds is



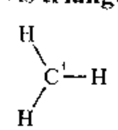
These are two carboxylic acids and form strong hydrogen bonds.

3. There are **two** π-bonds in a nitrogen molecule. There is a triple bond which has one σ-bond and two π-bonds.

4. sp^3-Hybrid orbitals of nitrogen atom are involved in the formation of ammonium ion.



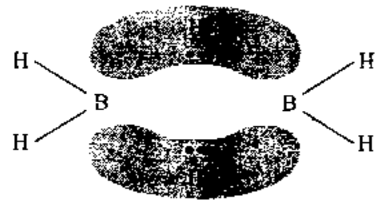
5. The shape of $[CH_3]^+$ is **triangular planar.**



CH_3^+, sp^2 carbon

In carbocations, carbon atom is sp^2-hybridized and they have a triangular planar shape.

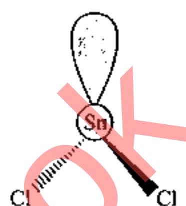
6. The two types of bonds present in B_2H_6 are covalent and **three-center two-electron bonds.**



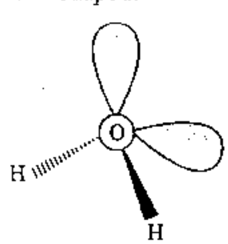
7. When N_2 goes to N_2^+, the N—N bond distance **increases**, and when O_2 goes to O_2^+, the O—O bond distance **decreases**.
   The electron is removed from a bonding molecular orbital in nitrogen and from an antibonding molecular orbital in oxygen.
8. Among N_2O, SO_2, $I_3^{\oplus}$, and $I_3^{\ominus}$, the linear species are **N_2O** and **I_3^-**.

True/False Type

1. **True.**
   The linear overlap of two atomic *p*-orbitals leads to a σ-bond.
2. **False.**
   All molecules with polar bonds do not have dipole moment. Sometimes due to regular shapes, dipole moment vectors cancel out each other and the molecule becomes non-polar.
3. **True.**
   $SnCl_2$ is a non-linear molecule. It is V-shaped.

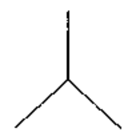


4. **False.**
   In benzene, carbon uses only two *p*-orbitals for hybridization because it is sp^2-hybridized.
5. **False.**
   sp^3-Hybrid orbitals have 25% *s* and 75% *p* characters.
6. **False.**
   All molecules with polar bonds do not have dipole moment. Sometimes due to regular shapes, dipole moment vectors cancel out each other and the molecule becomes non-polar.
7. **False.**
   H_2O molecule is V-shaped.

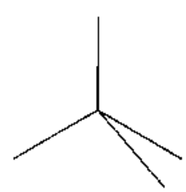


Single Correct Answer Type

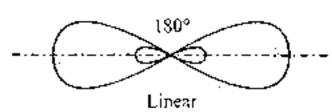
1. (d) In NO, the octet is not complete:
   $\cdot\ddot{N}::\ddot{\underset{\cdot\cdot}{O}}$
2. (c) $K^+[C\equiv N]^-$
   KCN consists of potassium ions and cyanide ions. In cyanide ion, there are also three covalent bonds.
3. (c) Six, because a triple covalent bond is formed between two nitrogen atoms.
4. (a) X^+Y^-
   Ionic bond is expected to be formed between a highly electropositive and a highly electronegative element.
5. (a) H_2 is a covalent compound because it is formed by the sharing of electrons or in other words when the difference in electronegativities is less, then covalent bond is formed as in H_2.
6. (c)



   Zero dipole moment means a triangular planar molecule is formed. And this shape is formed by sp^2-hybridization.
7. (a) In CO, there are 6 + 8 = 14 electrons.
   In CN^-, there are 6 + 7 + 1 = 14 electrons.
   CO is isoelectronic with CN^-.
8. (b)



   In carbon tetrachloride, there is regular tetrahedral shape. All the dipole moment vectors cancel each other so that the resultant dipole moment comes out to be zero.
9. (d) HCl does not form hydrogen bonds because chlorine is not electronegative enough, and it has larger size, so hydrogen bonds are not formed. They are generally formed with fluorine, oxygen, and nitrogen.
10. (b)



   Two *sp*-hybrid orbitals
11. (a) In NO, there are 7 + 8 = 15 electrons. Definitely it has an unpaired electron.

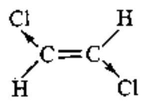
12. (c)

The sulphur atom in sulphur dioxide is sp^2-hybridized, and it is a V-shaped molecule.

13. (d) The bond between two identical non-metal atoms has a pair of electrons equally shared between them.

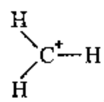
They form a covalent bond which is totally non-polar because of the similar electronegativity.

14. (c)



In *trans*-1,2-dichloroethylene, net dipole moment is zero because the two dipole moment vectors are equal and opposite, and they cancel each other as shown.

15. (c)



CH_3^+, sp^2 carbon

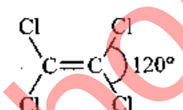
In carbocations, carbon atom is sp^2-hybridized and they have a triangular planar shape.

16. (a) CO_2 molecule is a linear molecule.

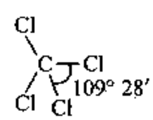
O═C═O

Central carbon is *sp*-hybridized.

17. (a)

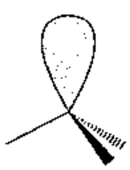


Tetrachloroethene
sp^2-hybridized carbon



Tetrachloromethane
sp^3-hybridized carbon

18. (a)



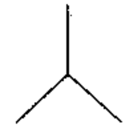
PCl_3 : sp^3-hybridization

Three bond pairs, one lone pair

Pyramidal shape

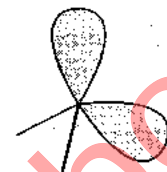
19. (a) O_2^- has 8 + 8 + 1 = 17 electrons. It must have at least one unpaired electron which makes it paramagnetic.

20. (b)



BF_3 is a triangular planar molecule where the resultant of three dipole moment vectors is equal to zero.

21. (a)

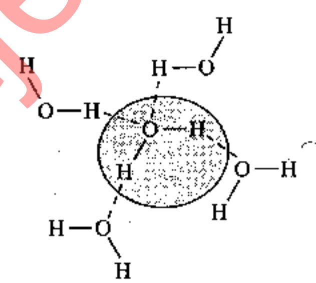


ClO_2^- : sp^3-hybridization

Two bond pairs, two lone pairs

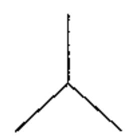
Angular shape, V-shaped

22. (b)



Every water molecule can form a maximum of four hydrogen bonds. Two hydrogen bonds are formed through oxygen atom and one each from the two hydrogen atoms.

23. (d)

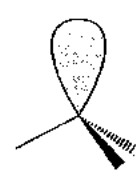


BF_3 has triangular planar molecule due to sp^2-hybridization.

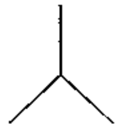
24. (b) $Ca^{2+}[C{\equiv}C]^{2-}$

There is a triple bond between two carbon atoms which means that there is one σ-bond and there are two π-bonds.

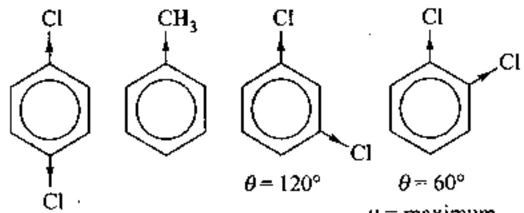
25. (c) NF_3 and H_3O^+ are pyramidal structures with three bond pairs and two lone pairs due to sp^3-hybridization.



NO_3^- are BF_3 triangular planar structures with three bond pairs and no lone pair due to sp^2-hybridization.



26. (b)



$\theta = 180°$
μ = zero

$\theta = 120°$

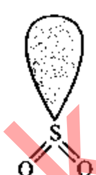
$\theta = 60°$
μ = maximum

p-Dichlorobenzene < Toluene < *m*-Dichlorobenzene < *o*-Dichlorobenzene

27. (b) The cyanide ions, CN^- and N_2 are isoelectronic, but in contrast to CN^-, N_2 is chemically inert because of the absence of polarity of bond.

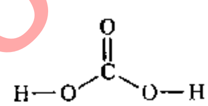
28. (c) KO_2 is potassium superoxide. It contains one unpaired electron due to the presence of superoxide ion (O_2^- ion) in it, which is paramagnetic.

29. (b)



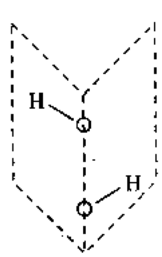
The sulphur atom in sulphur dioxide is sp^2-hybridized, and it is a V-shaped molecule.

30. (a)



H_2CO_3 is polar and the central carbon atom is sp^2-hybridized.

31. (c)



In hydrogen peroxide, O—O bond is non-polar, and O—H bonds are polar.

32. (d) Bond orders:

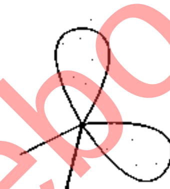
CO_3^{2-}:1.33

CO_2:2

CO:3

The higher the bond order, the lesser the bond length. So, the order of bond length of C—O is $CO < CO_2 < CO_3^{2-}$.

33. (a)



H_2S: sp^3-hybridization
Two bond pairs, two lone pairs
Angular shape, V-shaped

34. (d) $SF_4 \rightarrow sp^3d$, one lone pair, see-saw shape
$CF_4 \rightarrow sp^3$, no lone pair, tetrahedral
$XeF_4 \rightarrow sp^3d^2$, two lone pairs, square planar

35. (b) NO_2^+:

NO_2^+:
sp linear
Angle 180°

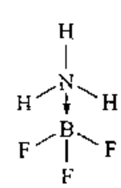
NO_3^-:
sp^2 triangular planar
Angle 120°

NH_4^+:
sp^3 tetrahedral
Angle 109°28′

36. (b) NH_3:sp^3; Pyramidal
$[PtCl_4]^{2-}$: dsp^2; Square planar
PCl_5: sp^3d; Trigonal bipyramidal
BCl_3: sp^2; Triangular planar

37. (a) CN^-, CO, and NO^+ have 14 electrons each, so they are isoelectronic.
Bond order in all of them is three according to molecular orbital theory.

38. (a)

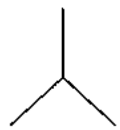


Both ammonia and BF_3 are tetrahedral and have sp^3-hybridization of the central atom.

39. (b) Be^-: $1s^2 2s^2 2p^1$ is the least stable of these ions.

40. (c) O_2^- has 8 + 8 + 1 = 17 electrons. It must have at least one unpaired electron which makes it paramagnetic.

41. (a)



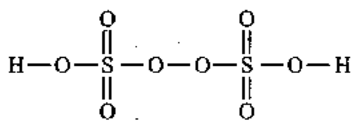
NO_3^{3-} and CO_3^{2-} ions are isoelectronic and isostructural.

CO_3^{2-}: 32 electrons

NO_3^-: 32 electrons

In both of these, the central atom is sp^2-hybridized with triangular planar shape.

42. (b)

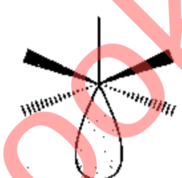


$H_2S_2O_8$

43. (a)

	O_2^{2-}	O_2^-	O_2	O_2^+
Bond order	1	1.5	2	2.5
	Dia	Para	Para	Para

44. (b)



$XeOF_4$

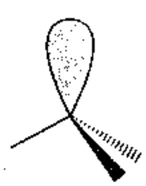
sp^3d^2 hybridization

Five bond pairs, one lone pair

Square pyramidal shape

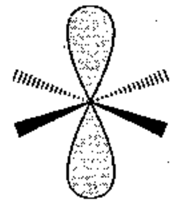
45. (d) ClO_3^-: sp^3

Three bond pairs, one lone pair



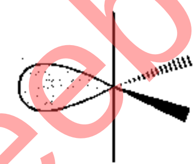
XeF_4: sp^3d^2

Four bond pairs, two lone pairs



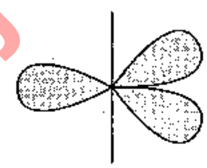
SF_4: sp^3d

Four bond pairs, one lone pair



I_3^-: sp^3d

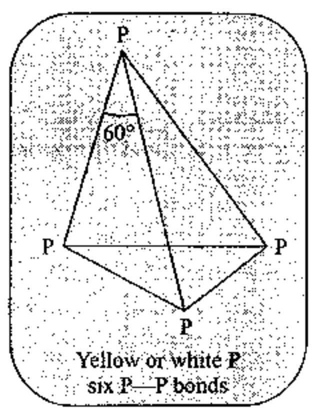
Two bond pairs, three lone pairs



46. (a) In NO^+, CN^-, and N_2, there are 14 electrons each, such as in CO, therefore the bond order would be similar (i.e., 3). In NO^-, there are 16 electrons and a different bond order, i.e., 2.

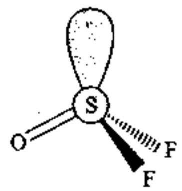
47. (d) KO_2 is potassium superoxide. It contains one unpaired electron due to the presence of superoxide ion, O_2^-, in it, which is paramagnetic.

48. (d)



sp^3-hybridization and 75% p-character.

49. (d)



OSF_2

sp^3-hybridization

Three bond pairs, one lone pair

Pyramidal shape

50. (b) $HNO_3 = +5$

$NO = +2$

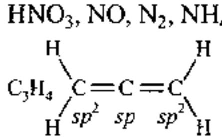
$NH_4Cl = -3$

$N_2 = 0$

So the correct order will be

HNO_3, NO, N_2, NH_4Cl

51. (b) C_3H_4



52. (c) If 2s–2p mixing is not operative, then the energy sequence of molecular orbitals is

$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_x} < \pi_{2p_y} = \pi_{2p_z} < \pi^*_{2p_y} = \pi^*_{2p_z} < \sigma^*_{2p_x}$

$Be_2(8e^-)$:	2	2	2	2			$\Rightarrow$	Diamagnetic
$B_2(10e^-)$:	2	2	2	2	2		$\Rightarrow$	Diamagnetic
$C_2(12e^-)$:	2	2	2	2	2	1	$\Rightarrow$	Paramagnetic
$N_2(14e^-)$:	2	2	2	2	2	2	$\Rightarrow$	Diamagnetic

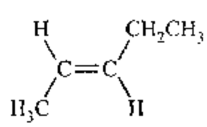
Multiple Correct Answers Type

1. (a), (b) Carbon dioxide is a linear molecule. $HgCl_2$ and C_2H_2 are linear molecules.

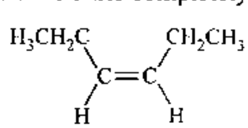
2. (b), (c), (d) $[O=N=O]^+$, $[N\equiv C-O]^-$, $S=C=S$

All these are linear molecules.

3. (b), (c)



trans-Pent-2-ene has dipole moment because on one side there is methyl group and on the other side there is ethyl group, so dipole moment vectors do not cancel out each other completely.

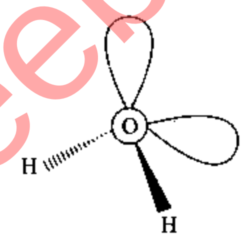


Hex-3-ene has dipole moment because dipole moment vectors do not cancel out each other.

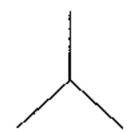
4. (a), (c) CN^- and NO^+ have 14 electrons each and an identical bond order of three.

5. (b), (d) H_3O^+, NH_3, and CH_3^- have 10 electrons each, so they are isoelectronic.

6. (c), (d) Critical temperature of water is higher than that of O_2 because H_2O molecule has dipole moment. Its two covalent bonds are at an angle to each other and the dipole moment vectors do not cancel each other.



7. (b)



BF_3 has triangular planar molecule due to sp^2-hybridization.

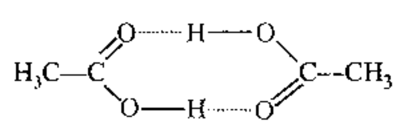
8. (a), (b), (c)

$N\equiv N \rightarrow O$

9. (b), (c), (d) **Hint:**

$\Rightarrow$ Ice floats in water due to the low density of ice as compare to water which is due to open cage like structure (formed by intermolecular H-bonding)

$\Rightarrow$ Dimerisation of acetic acid in benzene is due to intermolecular hydrogen bonding



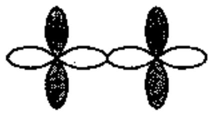
$\Rightarrow$ Basic strength of $RNH_2 > R_3N$ it also explained by hydrogen bonding.

Matching Column Type

1. (a) $\rightarrow$ (p, q, r, t); (b) $\rightarrow$ (q, r, s, t); (c) $\rightarrow$ (p, q, r); **(d)** $\rightarrow$ (p, q, r, s)

On the basis of molecular orbital theory, these conclusions can be made.

2. (c)

(a) 

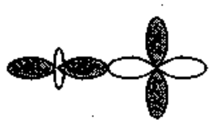
(1) d-d interaction produce bonding molecular orbital (due to addition of wave function)

(b) 

(2) Lateral overlapping produce π bonding molecular orbital (addition of wave function)

(c) 

(3) p-d interaction produce π antibonding molecular. Orbital (Substitution of wave function)

(d) 

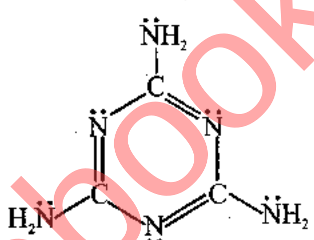
(4) d-d interaction produce antibonding molecular. Orbital (Substitution of wave function)

Integer Answer Type

1. (0)

2. (5)

3. (6) $C_3N_3(NH_2)_3$



Total six L.P.

4. (d) XeF_4, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[PtCl_4]^2$ are square planar

SF_4 – Sea-saw

SiF_4, BrF_4^-, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ are tetrahedral

Subjective Type

1. **Properties of covalent compounds:** When the difference in electronegativities of elements is lesser, covalent bond is formed.

Due to weaker forces of attraction, they have low melting and boiling points.

They are generally soft and waxy.

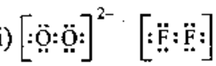
They are usually insoluble in polar solvents but soluble in non-polar solvents.

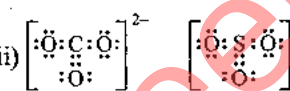
Properties of ionic compounds: When there is a large difference between the electronegativities of elements, then ionic bond is formed.

Due to stronger forces of attraction, they have high melting and boiling points

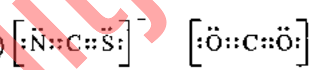
Generally they are hard and brittle.

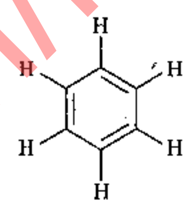
As they are polar molecules, so are easily soluble in polar solvents.

2. (i) 

(ii) 

(iii) 

(iv) 

3. 

12 σ- and 3 π-bonds

4. S < Cl < N < O < F

The larger the electronegativity, the stronger the hydrogen bonding. It decreases with increasing size of the atom. Sulphur does not form any hydrogen bonds.

5. In H_2O_2, the oxidation number of oxygen is –1, so it can be increased up to 0 and decreased up to –2. Hence, it acts as a reducing as well as an oxidizing agent.

As oxidizing agent:

$$H_2O_2 + 2e^- \rightarrow 2OH^-$$

$$2Cr(OH)_3 + 4NaOH + 3H_2O_2 \rightarrow 2Na_2CrO_4 + 8H_2O$$

The oxidation number of chromium increases from +3 to +6.

As reducing agent:

$$H_2O_2 + 2OH^- \rightarrow O_2 + 2H_2O + 2e^-$$

$$2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \rightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$$

The oxidation number of iron decreases from +3 to +2.

6. Assuming 100% ionic character in KCl:

Calculated dipole moment = $e \times d$

$$\mu_{cal} = 1.6\times10^{-19} \times 2.6\times10^{-10}\ \text{cm}$$
$$= 4.1\times10^{-29}\ \text{cm}$$

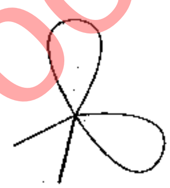
$$\text{Percentage ionic character} = \frac{\mu_{observed}}{\mu_{calculated}}\times100$$
$$= \frac{3.336\times10^{-29}\times100}{4.1\times10^{-29}}$$
$$= 81.36\%$$

7. According to Fajan rules, the larger the anion, the more the polarizability power and therefore more is the polarization of the bond. Hence, more is the covalent character. Iodide ion is larger than fluoride ion, so lithium iodide is more covalent than lithium fluoride.

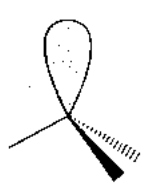
8. In OF_2, there are two lone pairs on oxygen atom and three lone pairs on each of the F atoms. Also, there are two bond pairs of electrons.

In OF_2, oxidation state of oxygen is +2, while the oxidation state of fluorine is −1. It is known as oxygen difluoride and not as oxide.

9.

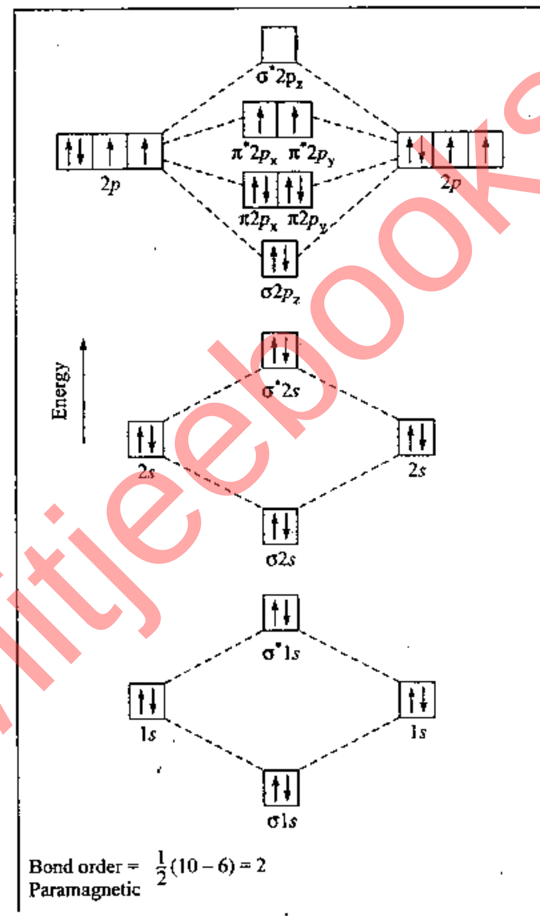


H_2S: Four electron pairs around central atom; two bond pairs and two lone pairs tetrahedrally arranged; angular shape, V-shaped.



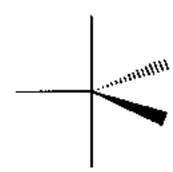
PCl_3: Four electron pairs around central atom; three bond pairs and one lone pair tetrahedrally arranged; pyramidal shaped.

10. Molecular orbital diagram for oxygen molecule

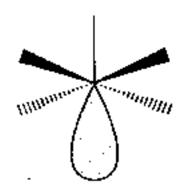


11. Anhydrous aluminium chloride is more soluble in diethyl ether because the oxygen atom of ether has lone pairs of electrons which can be donated into vacant p-orbitals of aluminium for interaction.

12.

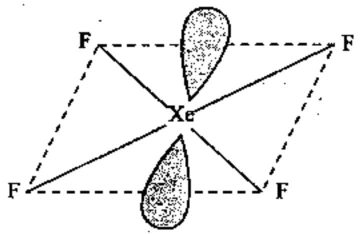


PCl_5: Five electron pairs around central atom; five bond pairs, no lone pairs; trigonal bipyramidal shape.



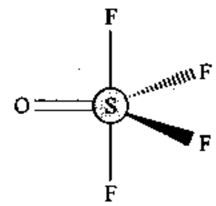
BrF_5: Six electron pairs around central atom; five bond pairs, one lone pair, octahedrally arranged; square pyramidal shape

13.



XeF_4: sp^3d^2-hybridization

Six electron pairs around central atom; four bond pairs, two lone pairs; square planar shape.



OSF_4: sp^3d-hybridized

Five electron pairs around central atom; four bond pairs, one lone pair; trigonal bipyramidal shape.

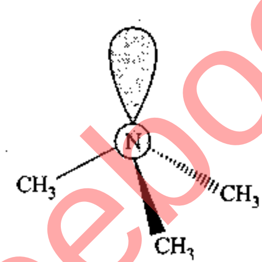
14.

	O_2^{2-}	O_2^-	O_2	O_2^+
Bond order	1	1.5	2	2.5
	Dia	Para	Para	Para

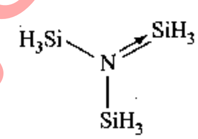
The larger the bond order, the smaller the bond length.

Therefore, $O_2^+[AsF_6]^- < O_2 < K^+O_2^-$

15.



$N(Me)_3$ is pyramidal in shape due to sp^3-hybridization.



$N(SiMe_3)_3$ is trigonal planar. Nitrogen atom shows sp^2-hybridization. The structure is stabilized by the donation of a lone pair of electrons from nitrogen into vacant d-orbitals of silicon.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	2. (b)	3. (a)	4. (b)	5. (b)	6. (a)	7. (d)	8. (b)	9. (b)	10. (d)
11. (c)	12. (a)	13. (d)	14. (c)	15. (a)	16. (c)	17. (a)	18. (d)	19. (c)	20. (b)
21. (d)	22. (b)	23. (d)	24. (d)	25. (c)	26. (d)	27. (a)	28. (d)	29. (d)	30. (b)
31. (b)	32. (d)	33. (d)	34. (d)	35. (c)	36. (d)	37. (a)	38. (c)	39. (d)	40. (c)
41. (c)	42. (b)	43. (b)	44. (a)	45. (b)	46. (a)	47. (c)	48. (d)	49. (d)	50. (d)
51. (a)	52. (b)	53. (a)	54. (b)	55. (a)	56. (a)	57. (a)	58. (b)	59. (b)	60. (a)
61. (c)	62. (d)	63. (b)	64. (c)	65. (a)	66. (d)	67. (b)	68. (b)	69. (c)	70. (c)
71. (a)	72. (b)	73. (a)	74. (b)	75. (c)	76. (a)	77. (a)	78. (a)	79. (a)	80. (d)
81. (b)	82. (d)	83. (b)	84. (c)	85. (d)	86. (c)	87. (d)	88. (c)	89. (b)	90. (d)
91. (a)	92. (d)	93. (c)	94. (b)	95. (b)	96. (c)	97. (d)	98. (d)	99. (c)	100. (c)
101. (b)	102. (b)	103. (d)							

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (c)	4. (d)	5. (c)	6. (a)	7. (a)	8. (b)	9. (a)	10. (a)

11. (c)	12. (c)	13. (b)	14. (a)	15. (c)	16. (a)	17. (a)	18. (c)	19. (c)	20. (c)
21. (a)	22. (c)	23. (b)	24. (c)	25. (b)	26. (a)	27. (a)	28. (b)	29. (a)	30. (c)
31. (c)	32. (b)	33. (c)	34. (b)	35. (a)	36. (c)	37. (a)	38. (b)	39. (a)	40. (d)
41. (c)	42. (c)	43. (a)	44. (b)	45. (b)	46. (c)	47. (b)	48. (d)	49. (b)	50. (c)
51. (c)	52. (a)	53. (b)	54. (a)	55. (b)	56. (a)	57. (a)	58. (c)	59. (b)	60. (b)
61. (b)	62. (b)	63. (b)	64. (b)	65. (b)	66. (b)	67. (b)	68. (a)	69. (c)	70. (c)
71. (a)	72. (d)	73. (b)	74. (b)	75. (a)	76. (c)	77. (c)	78. (c)	79. (c)	80. (b)
81. (a)	82. (b)	83. (b)	84. (d)	85. (b)	86. (b)	87. (a)	88. (b)	89. (b)	90. (b)
91. (d)	92. (a)	93. (d)	94. (d)	95. (a)	96. (d)	97. (a)	98. (a)	99. (a)	100. (b)
101. (c)	102. (b)	103. (d)							

Multiple Correct Answers Type

1. (a), (b)	2. (a), (b), (c)	3. (a), (b), (c)	4. (a), (b), (c)	5. (a), (b), (c)
6. (a), (b), (c), (d)	7. (a), (b), (c)	8. (a), (b)	9. (a), (b), (c)	10. (a), (c)
11. (a), (b)	12. (a), (b), (c), (d)	13. (a), (b), (d)	14. (a), (b), (c), (d)	15. (a), (b), (c)
16. (a), (b), (c), (d)	17. (a), (b)	18. (c), (d)	19. (a), (b), (c), (d)	20. (a), (b), (c), (d)
21. (a), (b), (c), (d)	22. (a), (b), (d)	23. (a), (b), (c), (d)	24. (b), (c)	25. (b), (c)
26. (a), (d)	27. (a), (b), (c)	28. (b), (d)	29. (b), (c)	30. (a), (b), (c), (d)
31. (a), (b), (d)	32. (a), (c), (d)	33. (a), (b), (c)	34. (c), (d)	35. (b), (c), (d)
36. (b), (c), (d)	37. (b), (c)	38. (a), (c)	39. (a), (b), (d)	40. (a), (b), (d)
41. (a), (c), (d)	42. (b), (c), (d)	43. (a), (b), (d)	44. (a), (c)	45. (b), (c)
46. (b), (c)	47. (a), (b), (c)	48. (a), (c), (d)	49. (b), (c)	50. (a), (b)
51. (a), (b), (c), (d)	52. (b), (d)	53. (a), (b), (c), (d)	54. (a), (b), (c), (d)	55. (a), (b), (c), (d)
56. (a), (b), (c), (d)	57. (a), (b), (d)	58. (a), (b), (c), (d)	59. (a), (b)	60. (b), (c), (d)
61. (a), (b), (c), (d)	62. (a), (b), (c), (d)	63. (c), (d)	64. (a), (d)	65. (a), (c)
66. (a), (b)	67. (a), (b), (c)	68. (a), (b)	69. (a), (b), (c)	70. (a), (b), (c), (d)
71. (b), (c), (d)	72. (b), (c)	73. (a), (b), (c)	74. (a), (c)	75. (a), (b), (d)
76. (a), (d)	77. (a), (b), (c)	78. (a), (b), (c)	79. (a), (b)	80. (a), (b), (c)
81. (b), (d)	82. (a), (c)	83. (a), (b)	84. (a), (b), (c)	85. (a), (d)
86. (a), (b)	87. (a), (b), (c)	88. (a), (b), (c)	89. (a), (b)	90. (a), (b), (c)
91. (a), (b), (c), (d)	92. (a), (b), (c), (d)	93. (a), (c)	94. (a), (b), (c)	95. (a), (b), (d)
96. (a), (b), (c)	97. (c), (d)	98. (a), (c), (d)	99. (a), (b), (c)	100. (c), (d)
101. (a), (b), (c), (d)	102. (a), (b), (c)	103. (a), (b), (c)	104. (b), (c), (d)	105. (b), (c)
106. (b), (c), (d)	107. (a), (d)	108. (a), (b)	109. (b), (c), (d)	110. (a), (c)
111. (a), (b), (c)	112. (a), (b), (c), (d)	113. (a), (b), (c), (d)	114. (a), (b), (c)	115. (a), (b)
116. (a), (b), (c), (d)	117. (b), (d)	118. (a), (d)	119. (a), (b), (c), (d)	120. (c), (d)
121. (a), (b), (c)	122. (a), (b), (c), (d)	123. (a), (b), (c), (d)	124. (a), (c), (d)	125. (a), (b), (c), (d)
126. (a), (b), (c), (d)	127. (a), (c)	128. (b), (c), (d)	129. (a), (b), (c), (d)	130. (a), (c), (d)
131. (a), (b), (c), (d)	132. (a), (b), (c), (d)	133. (a), (d)	134. (a), (d)	

Comprehension Type

Comprehension-1	1. (b)	2. (a)	
Comprehension-2	3. (b)	4. (b)	5. (a)
Comprehension-3	6. (d)	7. (b)	8. (a)

Comprehension-4	9. (d)	10. (d)	11. (a)	
Comprehension-5	12. (b)	13. (d)	14. (b)	
Comprehension-6	15. (b)	16. (d)	17. (a)	18. (d)
Comprehension-7	19. (c)	20. (d)	21. (d)	
Comprehension-8	22. (d)	23. (c)	24. (c)	
Comprehension-9	25. (a)	26. (c)	27. (b)	28. (b)
Comprehension-10	29. (c)	30. (a)	31. (b)	
Comprehension-11	32. (d)	33. (b)	34. (b)	
Comprehension-12	35. (c)	36. (a)	37. (a)	
Comprehension-13	38. (a)	39. (b)	40. (b)	
Comprehension-14	41. (a)	42. (a)	43. (b)	

Assertion-Reasoning Type

1. (a)	2. (c)	3. (b)	4. (a)	5. (d)	6. (b)	7. (b)	8. (c)	9. (b)	10. (d)
11. (a)	12. (b)	13. (a)	14. (a)	15. (a)	16. (a)	17. (a)	18. (a)	19. (d)	20. (d)
21. (b)	22. (d)	23. (d)	24. (a)	25. (a)	26. (a)	27. (a)	28. (d)	29. (a)	30. (a)
31. (b)	32. (a)	33. (d)	34. (a)						

Matching Column Type

1. (a) s; (b) p; (c) p, q; (d) p, q, r
2. (a) p, q, r, s, t; (b) p, q, r, s, t; (c) p, r, s, t; (d) p, r, s, t
3. (a) p, q; (b) q, r, s; (c) q, t; (d) q, r, s, t
4. (a) q, t; (b) p, t; (c) q, t; (d) p, r, s
5. (a) p, q, s, t; (b) p, s, t; (c) q, s, t; (d) r, s, t
6. (a) q, r, t; (b) r, s, t; (c) s; (d) p, s
7. (a) p, r, s; (b) q, r, t; (c) r; (d) q, r, t
8. (a) p, q; (b) s; (c) r; (d) t
9. (a) p, q, t; (b) p, r; (c) r; (d) p, s, t
10. (a) p, q, r, s; (b) q, r; (c) p, q, r, s
11. (a) s; (b) p; (c) q; (d) p
12. (a) p; (b) q; (c) r; (d) r
13. (a) s; (b) p; (c) r; (d) q, t
14. (a) q, r; (b) p, s; (c) p, q
15. (a) p, r, t; (b) q; (c) p, s; (d) p, s
16. (a) p, r, s, t; (b) r; (c) q, s, t; (d) p, r, s, t
17. (a) p, r, s; (b) p, q, r; (c) p, t; (d) p, q, r, s
18. (a) s, t; (b) q, s; (c) p, q, r, s, t; (d) q, s, t
19. (a) q; (b) r; (c) s; (d) p, q
20. (a) r, t; (b) q, s; (c) r, t; (d) p, t
21. (a) p, q, r, s, t; (b) p, r, s, t; (c) q; (d) p, q, r, s, t
22. (a) q; (b) r; (c) s; (d) p
23. (a) p, r, s; (b) p, r, t; (c) q, r, s; (d) q, r, s
24. (a) p, q, r, s; (b) q, r, s; (c) p, q; (d) p, q
25. (a) r; (b) q; (c) p; (d) s

Integer Answer Type

1. (4) 2. (7) 3. (1) 4. (2) 5. (8) 6. (3) 7. (4) 8. (4,4) 9. (6) 10. (3)
11. (4) 12. (5) 13. (3) 14. (9 and 2) 15. (4) 16. (3) 17. (1) 18. (2) 19. (2)
20. (4) 21. (0) 22. (2) 23. (2) 24. (3) 25. (1) 26. (1) 27. (3) 28. (0) 29. (1)
30. (2) 31. (1) 32. (6) 33. (2) 34. (4) 35. (5) 36. (1) 37. (2) 38. (2) 39. (4)
40. (3) 41. (5) 42. (3) 43. (3) 44. (3) 45. (4) 46. (0) 47. (4) 48. (1) 49. (4)
50. (1) 51. (1) 52. (4) 53. (2) 54. (0) 55. (3) 56. (1) 57. (5) 58. (4) 59. (5)
60. (6) 61. (6) 62. (4) 63. (12) 64. (1) 65. (2) 66. (5) 67. (3) 68. (3) 69. (4)
70. (2) 71. (1) 72. (2) 73. (5) 74. (2) 75. (1) 76. (3)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (c) 3. (b) 4. (b) 5. (b) 6. (d) 7. (a) 8. (c) 9. (c) 10. (b)
11. (d) 12. (b) 13. (a) 14. (b) 15. (d) 16. (b) 17. (a) 18. (b)

Multiple Correct Answers Type

1. (a), (b), (d) 2. (a), (b) 3. (c), (d) 4. (c), (d) 5. (a), (b)

Matching Column Type

1. (a) → (c); (b) → (a); (c) → (e); (d) → (d)
2. (a) → (e); (b) → (a); (c) → (b); (d) → (c)
3. (a) → (d); (b) → (e); (c) → (b); (d) → (a)
4. (a) → (c); (b) → (a); (c) → (b)

Assertion-Reasoning Type

1. (a) 2. (a) 3. (d)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) 2. (b) 3. (a) 4. (c) 5. (b) 6. (b) 7. (a) 8. (a) 9. (b) 10. (b)
11 (a) 12 (d) 13 (a) 14 (c) 15 (d) 16. (b) 17. (b) 18 (d) 19. (c) 20. (c)
21. (a) 22. (b) 23. (d) 24. (c) 25. (b) 26. (d) 27. (d) 28. (b) 29. (c) 30. (b)
31. (a) 32. (c) 33. (b) 34. (b) 35. (c) 36. (d) 37. (c) 38. (b) 39. (a)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (d) 2. (c) 3. (c) 4. (a) 5. (a) 6. (c) 7. (a) 8. (b) 9. (d) 10. (b)
11. (a) 12. (c) 13. (d) 14. (c) 15. (c) 16. (a) 17. (a) 18. (a) 19. (a) 20. (b)

21. (a) 22. (b) 23. (d) 24. (b) 25. (c) 26. (b) 27. (b) 28. (c) 29. (b) 30. (a)
31. (c) 32. (d) 33. (a) 34. (d) 35. (b) 36. (b) 37. (a) 38. (a) 39. (b) 40. (c)
41. (a) 42. (b) 43. (a) 44. (b) 45. (d) 46. (a) 47. (d) 48. (d) 49. (d) 50. (b)
51. (b) 52. (c)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (c), (d) 3. (b), (c) 4. (a), (c) 5. (b), (d)
6. (c), (d) 7. (b) 8. (a), (b), (c) 9. (a, b, d)

Matching Column Type

1. (a) → (p,q,r,t); (b) → (q,r,s,t); (c) → (p,q,r); (d) → (p,q,r,s) 2. (c)

Integer Answer Type

1. (8) 2. (5) 3. (6) 4. (d)

Coordination Compounds

JEE (Main) Exercises

Single Correct Answer Type

1. Ligand with two or more points of attachment to single metal atoms are called:
   (a) Monodentate ligand
   (b) Chelating ligand
   (c) Ambidentate ligand
   (d) None of these

2. Select the correct I.U.P.A.C. name for $[Cr(NH_3)_3Cl_3]$ complex:
   (a) Triamminetrichloridochromate(III)
   (b) Triamminetrichloridochromium(III)
   (c) Trichloridotriamminechromium(III)
   (d) Trichloridotriamminechromate(III)

3. Select the correct I.U.P.A.C. name for $[Cu(NH_3)_4][PtCl_4]$:
   (a) Tetraamminecopper(II) tetrachloridoplatinum(II)
   (b) Tetraamminecopper(II) tetrachloridoplatinum(IV)
   (c) Tetraamminecopper(II) tetrachloridoplatinate(II)
   (d) Tetraamminecuprate(II) tetrachloridoplatinate(II)

4. Select the correct I.U.P.A.C. name for $Cr(C_6H_6)(CO)_3$:
   (a) (η^6-benzene) tricarbonylchromate (0)
   (b) Tricarbonyl (η^6-benzene)chromate (0)
   (c) Tricarbonyl (η^6-benzene)chromium (0)
   (d) (η^6-benzene) tricarbonylchromium (0)

5. I.U.P.A.C. name for complex $[Mn(\pi\text{–}C_5H_5)(CO)_3]$:
   (a) Tricarbonyl (η^5–cyclopentadiene)manganese(I)
   (b) Tricarbonyl (η^5–cyclopentadiene)mangate(I)
   (c) Tricarbonyl (η^5-cyclopentadienyl)manganese(I)
   (d) (η^5-cyclopentadienyl) tricarbonyl manganese(I)

6. Select the correct order of E.A.N:
   (a) $[Cr(CO)_6] > [Cr(CO)_6]^{\ominus} > [Cr(CO)_6]^{\oplus}$
   (b) $[Cr\ (CO)_6]^+ > [Cr(CO)_6]^{\ominus} > [Cr(CO)_6]$
   (c) $[Cr(CO)_6]^{\ominus} > [Cr(CO)_6] > [Cr(CO)_6]^{\oplus}$
   (d) $[Cr(CO)_6]^{\ominus} = [Cr(CO)_6] > [Cr(CO)_6]^+$

7. Which of following complex has higher Δ_o value?
   (a) $[Fe(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
   (c) $[Fe(CN)_6]^{3-}$ (d) All have equal

8. Among the following ions which one has the highest paramagnetism?
   (a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
   (c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$

9. The calculated value of magnetic moment of $_{22}Ti^{3+}$ is:
   (a) 1.73 μ_B (b) 2.83 μ_B
   (c) 3.87 μ_B (d) 4.9 μ_B

10. The I.U.P.A.C. name for $[Fe(CN)_6]^{3-}$ ion is:
    (a) Hexacyanidoferrate(II) ion
    (b) Hexacyanidoferrate(III) ion
    (c) Hexacyanideiron(II) ion
    (d) Iron(III) hexacyanide ion

11. The I.U.P.A.C. name for $[Ni(CO)_4]$ is:
(a) Tetracarbonylnickel(II)
(b) Tetracarbonylnickel(0)
(c) Tetracarbonylnickelate(II)
(d) Tetracarbonylnickelate(0)

12. The number of ions produced by the complex $[Co(NH_3)_4Cl_2]Cl$ is:
(a) 2 (b) 3
(c) 4 (d) 6

13. The I.U.P.A.C. name for $[Ni(CN)_4]^{2-}$ is:
(a) Tetracyanidonickel (II) ion
(b) Tetracyanidonickel (0) ion
(c) Tetracyanidonickelate (II) ion
(d) Tetracyanidonickelate (0) ion

14. The I.U.P.A.C. name for $K_3[Co(NO_2)_6]$ is:
(a) Potassium(I) hexanitrocobaltate (II)
(b) Potassium(I) hexanitrocobaltate (IV)
(c) Potassium hexanitrocobalt (0)
(d) Potassium hexanitrocobaltate (III)

15. Which of the following complex is diamagnetic?
(a) $[CoF_6]^{3-}$ (b) $[NiCl_4]^{2-}$
(c) $[Ni(NH_3)_6]^{2+}$ (d) $[Ni(CN)_4]^{2-}$

16. Which of the following is a tridentate ligand?
(a) NO_2^- (b) Oxalate ion
(c) Glycinate ion (d) Dien

17. How many ions are produced from $[Co(NH_3)_6]Cl_3$ in the solution?
(a) 3 (b) 4
(c) 5 (d) 6

18. A complex involving dsp^2-hybridization has:
(a) A square planar geometry
(b) A tetrahedral geometry
(c) An octahedral geometry
(d) Trigonal planar geometry

19. A complex involving d^2sp^3-hybridization is:
(a) A square planar geometry
(b) A tetrahedral geometry
(c) An octahedral geometry
(d) Trigonal planar geometry

20. Zeise's salt is:
(a) $Fe(\eta^5 - C_5H_5)_2$
(b) $Cr(\eta^6 - C_6H_6)_2$
(c) $K[Pt(\eta^2 - C_2H_4)Cl_3]$
(d) $K[Pt(\eta^2 - C_2H_4)_2Cl_2]$

21. Which of the following complex ion possesses d^2sp^3 hybridization?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[CoF_6]^{3-}$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[FeF_6]^{3-}$

22. Which of the following complex ion possesses dsp^2 hybridization?
(a) $[Ni(CN)_4]^{2-}$ (b) $[Ni(CO)_4]$
(c) $[NiCl_4]^{2-}$ (d) $[Ni(PF_3)_4]$

23. Which of the following complex ion possesses sp^3d^2 hybridization?
(a) $[Cr(NH_3)_6]^{3+}$ (b) $[FeF_6]^{3-}$
(c) $[Co(NO_2)_6]^{3-}$ (d) $[TiF_6]^{3-}$

24. Which of the following complex is paramagnetic?
(a) $K_2[Ni(CN)_4]$ (b) $K_4[Fe(CN)_6]$
(c) $[Co(NH_3)_6]Cl_3$ (d) $[Cr(H_2O)_6]SO_4$

25. The color of a complex compound is due to:
(a) Promotion of 3*d*-electrons of the central atom/ion to 4*s*-orbital
(b) Promotion of 3*d*-electrons of the central atom/ion to 4*p*-orbitals
(c) Promotion of 3*d*-electrons of the central atom/ion within *d*-orbitals
(d) Promotion of 4*s*-electrons of the central atom/ion to 4*p*-orbitals

26. Relative to the average energy in the spherical crystal field, the t_{2g} orbitals in tetrahedral field is:
(a) Raised by $(2/5)\Delta_t$ (b) Lowered by $(2/5)\Delta_t$
(c) Raised by $(3/5)\Delta_t$ (d) Lowered by $(1/5)\Delta_t$

27. Which is the pair of ambident ligands?
(a) CN^-, NO_2^- (b) NO_3^-, SCN
(c) N_3^-, NO_2^- (d) NCS^-, $C_2O_4^{2-}$

28. The closed ring compounds formed by bidentate ligands, on binding to a metal or metal ions, are called:
(a) Monodentate (b) Chelates
(c) Ambidentate (d) None of these

29. Coordination number of Cu^{2+} is ...... in $CuSO_4 \cdot 5H_2O$:
(a) 5 (b) 4
(c) 3 (d) 2

30. Coordination number of calcium is six in:
(a) $[Ca(EDTA)]^{2-}$ (b) CaC_2O_4
(c) $[Ca(C_2O_4)_2]^{2-}$ (d) $CaSO_4 \cdot 4H_2O$

31. Increasing order of EAN of the metals in $[Ni(CN)_4]^{2-}$, $[Fe(CN)_6]^{3-}$ and $[Cu(CN)_4]^{3-}$ is:
(a) $[Ni(CN)_4]^{2-} < [Fe(CN)_6]^{3-} < [Cu(CN)_4]^{3-}$
(b) $[Ni(CN)_4]^{2-} < [Fe(CN)_6]^{3-} = [Cu(CN)_4]^{3-}$

(c) $[Ni(CN)_4]^{2-} < [Cu(CN)_4]^{3-} < [Fe(CN)_6]^{3-}$
(d) $[Cu(CN)_4]^{3-} < [Fe(CN)_6]^{3-} < [Ni(CN)_4]^{2-}$

32. $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ are:
(a) Linkage isomers (b) Ionization isomers
(c) Coordination isomers (d) None of these

33. The crystal field splitting energy for octahedral (Δ_o) and tetrahedral (Δ_t) complexes is related as:
(a) $\Delta_t = \frac{4}{9}\Delta_o$ (b) $\Delta_t = \frac{1}{2}\Delta_o$
(c) $\Delta_o = -2\Delta_t$ (d) $\Delta_o = -\frac{4}{9}\Delta_t$

34. Which has maximum coordinating (donor) points?
(a) DMG (b) EDTA
(c) en (d) py

35. Which is used in cancer chemotherapy?
(a) *cis*-platin (b) Zeisse's salt
(c) Both (a) and (b) (d) None of these

36. In which of the following compounds, transition metal may have zero oxidation state?
(a) $[Fe(CO)_5]$ (b) $[Ni(CN)_4]^{2-}$
(c) Fe_2O_3 (d) CrO_5

37. A square planar complex is formed by hybridization of which atomic orbitals?
(a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$
(c) s, p_x, p_y, d_{z^2} (d) s, p_y, p_z, d_{xy}

38. The type of isomerism present in pentaammine nitro chromium(III) chloride is:
(a) Optical (b) Linkage
(c) Hydrate (d) Polymerization

39. Which one of the following has the largest number of isomers?
(a) $[Co(en)_2Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$
(c) $[Ir(PR_3)_2H(CO)]^{2+}$ (d) $[Ru(NH_3)_4Cl_2]^+$

40. The correct order of magnetic moment (spin values in B.M.) is:
(Atomic no. Mn = 25, Fe = 26, Co = 27)
(a) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$
(b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$
(c) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$
(d) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

41. Which one of the following has the regular tetrahedral structure?
(a) $[Ni(CN)_4]^{2-}$ (b) SF_4
(c) BF_4^- (d) XeF_4

42. The I.U.P.A.C. name of the coordination compound $K_3[Fe(CN)_6]$ is:
(a) Potasssium hexacyanidoferrate(II)
(b) Potassium hexacyanidoferrate(III)
(c) Potassium hexacyanidoiron(II)
(d) Tripotassium hexacyanidoiron(II)

43. Which one of the following has the lowest value of paramagnetic behavior:
(a) $[Cr(CN)_6]^{3-}$ (b) $[Mn(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Co(CN)_6]^{3-}$

44. The species having tetrahedral shape is:
(a) $[PdCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$
(c) $[Pt(CN)_4]^2$ (d) $[NiCl_4]^{2-}$

45. $[Cr(H_2O)_6]Cl_3$ (atomic number of Cr = 24) has a magnetic moment of 3.83 B.M. The correct distribution of $3d$-electrons in the chromium present in the complex is:
(a) $3d^1_{xy}, 3d^1_{yz}, 3d^1_{zx}$ (b) $3d^1_{xy}, 3d^1_{yz}, 3d^1_{z^2}$
(c) $3d^1_{(x^2-y^2)}, 3d^1_{z^2}, 3d^1_{zx}$ (d) $3d^1_{xy}, 3d^1_{(x^2-y^2)}, 3d^1_{xz}$

46. A complex compound in which the oxidation number of metal is zero:
(a) $[Ni(CO)_4]$ (b) $[Pt(NH_3)_4]Cl_2$
(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

47. $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5ONO]Cl_2$ are related to each other as:
(a) Geometrical isomers
(b) Linkage isomers
(c) Coordination isomers
(d) Ionization isomers

48. Which one of the following will be able to show geometrical isomerism if complexes are square planar?
(a) Ma_4 (b) Ma_3b
(c) $Mabcd$ (d) $[M(AA)_2]$

49. $K_4[Fe(CN)_6]$ is called:
(a) Potassium hexacyanidoferrate(II)
(b) Potassium ferricyanate
(c) Potassium ferricyanide
(d) Prussian blue

50. Among the following ions which one has the highest paramagnetism?
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_4]^{2+}$

51. The number of geometrical isomers of $[Co(NH_3)_3(NO_3)_3]$ is:

(a) 0 (b) 2
(c) 3 (d) 4

52. Some salts, although containing two different metallic elements, give test for one of them in solution. Such salts are:
(a) Complex salt (b) Double salt
(c) Normal salt (d) None of these

53. Coordination number of Ni in $[Ni(C_2O_4)_3]^{4-}$ is:
(a) 3 (b) 6
(c) 4 (d) 5

54. Both geometrical and optical isomerisms are shown by:
(a) $[Co(en)_2Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$
(c) $[Co(NH_3)_4Cl_2]^+$ (d) $[Cr(OX)_3]^{3-}$

55. In $[Cr(C_2O_4)_3]^{3-}$, the isomerism shown is:
(a) Ligand (b) Optical
(c) Geometrical (d) Ionization

56. The hypothetical complex chlorido diaquatriammine cobalt (III) chloride can be represented as:
(a) $[Co(NH_3)_3(H_2O)_2Cl]Cl_2$
(b) $[Co(NH_3)_3H_2OCl_3]$
(c) $[Co(NH_3)_3(H_2O)Cl]$
(d) $[Co(NH_3)_3(H_2O)_3Cl_3]$

57. In the coordination compound $K_4[Ni(CN)_4]$, the oxidation state of Ni is:
(a) –1 (b) 0
(c) +1 (d) +2

58. Which of the following octahedral complex does not show geometrical isomerism (A and B are monodentate ligands)?
(a) $[MA_3B_3]$ (b) $[MA_4B_2]$
(c) $[MA_5B]$ (d) $[MA_2B_4]$

59. The geometry of $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ ions are:
(a) Tetrahedral (b) Square planar
(c) Square planar, tetrahedral, respectively
(d) Tetrahedral and square planar, respectively

60. The complex used as an anticancer agent is:
(a) *mer*-$[Co(NH_3)_3Cl_3]$ (b) *cis*-$[PtCl_2(NH_3)_2]$
(c) *cis*-$K_2[PtCl_2Br_2]$ (d) $Na_2[CoCl_4]$

61. The ligand called π-acid is:
(a) CO (b) NH_3
(c) $C_2O_4^{2-}$ (d) Ethylene diamine

62. The effective atomic number of cobalt in the complex $[Co(NH_3)_6]^{3+}$ is:
(a) 36 (b) 33
(c) 24 (d) 30

63. Facial-meridional isomers is associated with which one of the following complex? (M = central metal)
(a) $[M(AA)_2]$ (b) $[MA_3B_3]$
(c) $[M(AA)_3]$ (d) $[MABCD]$

64. Which one of the following is a tridenate ligand?
(a) NO_2^- (b) Oxalate ion
(c) Glycinate ion (d) Dien

65. Assign the hybridization, shape, and magnetic moment of $K_2[Cu(CN)_4]$ are:
(a) sp^3, tetrahedral, 1.73 B.M.
(b) dsp^2, square planar, 1.73 B.M.
(c) sp^3, tetrahedral, 2.44 B.M.
(d) dsp^2, square planar, 2.44 B.M.

66. Hardness of water is estimated by simple complex formation titration. Complex formed by cation in hard water during estimation of hardness is:
(a) $Na_2[Ca(PO_3)_6]$ (b) $Na_2[Mg(EDTA)]$
(c) $Na_2[Pb(EDTA)]$ (d) $[Ca(SO_4)_2]^{2-}$

67. The I.U.P.A.C. name for $[Ni(NH_3)_4][NiCl_4]$ is:
(a) Tetrachloridonickel(II)-tetraamminenickel(II)
(b) Tetraamminenickel (II)-tetrachloridonickel (II)
(c) Tetraamminenickel (II)-tetrachloridonickelate (II)
(d) Tetrachloridonickel (II)-tetraamminenickelate (II)

68. In which of the following coordination entities, the magnitude of Δ_0[CFSE in octahedral field] will be maximum?
(a) $[Co(CN)_6]^{3-}$ (b) $[Co(NO_2)_6]^{3-}$
(c) $[CoF_6]^{3-}$ (d) $[Co(NH_3)_6]^{3+}$

69. Hybridization, shape, and magnetic moment of $K_3[Co(CO_3)_3]$ are:
(a) d^2sp^3, octahedral, 4.9 B.M.
(b) sp^3d^2, octahedral, 4.9 B.M.
(c) dsp^2, square planar, 4.9 B.M.
(d) sp^3, tetrahedral, 4.9 B.M.

70. Geometry, hybridization, and magnetic moment of the ions $[Ni(CN)_4]^{2-}$, $[MnBr_4]^{2-}$ and $[FeF_6]^{3-}$, respectively are:
(a) Tetrahedral, square planar, octahedral: sp^3, dsp^2, sp^3d^2: 5.9, 0, 4.9
(b) Tetrahedral, square planar, octahedral: dsp^2, sp^3, sp^3d^2: 0, 5.9, 4.9
(c) Square planar, tetrahedral, octahedral: dsp^2, sp^3, d^2sp^3: 5.9, 4.9, 0
(d) Square planar, tetrahedral, octahedral: dsp^2, sp^3, sp^3d^2: 0, 5.9, 4.9

71. In Cu-ammonia complex, the state of hybridization of Cu^{2+} is:

(a) sp^3 (b) d^3s

(c) sp^2 (d) dsp^2

72. The total number of possible coordination isomer for the given compound $[Pt(NH_3)_4Cl_2][PtCl_4]$ is:

(a) 2 (b) 4

(c) 5 (d) 3

73. E.A.N. of $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ is:

(a) 86 (b) 78

(c) 84 (d) 34

74. Ag^+ forms many complexes, some of these are $[Ag(NH_3)_2]^+$, $[Ag(CN)_2]^-$, $[Ag(S_2O_3)_2]^{3-}$. Which of the following statements is true?

(a) In these complexes, Ag^+ is a Lewis base

(b) The hybridization of Ag^+ is sp^2

(c) The Ag^+ complexes are good reducing agents

(d) These complexes are all linear

75. The following complexes are given:

(1) *trans*-$[Co(NH_3)_4Cl_2]^+$ (2) *cis*-$[Co(NH_3)_2(en)_2]^{3+}$

(3) *trans*-$[Co(NH_3)_2(en)_2]^{3+}$

(4) $[NiCl_4]^{2-}$

(5) $[TiF_6]^{2-}$

(6) $[CoF_6]^{3-}$

Choose the correct code:

(a) 1, 2 are optically active; 3 optically inactive

(b) 2 is optically active; 1, 3 are optically inactive

(c) 4, 5 are colored; 6 is colorless

(d) 4 is colored; 5, 6 are colorless

76. The number of σ and π - bonds in $Fe_2(CO)_9$, respectively are:

(a) 22σ and 15π (b) 23σ and 15π

(c) 22σ and 16π (d) 15σ and 8π

77. In which of the following configurations will there be the possibility of both para and diamagnetism, depending on the nature of the ligands?

(a) d^7 (b) d^3

(c) d^6 (d) d^5

78. An aqueous solution of titanium chloride, when subjected to magnetic measurement, measured zero magnetic moment. Assuming the complex as octahedral in aqueous solution, the formula of the complex is:

(a) $[Ti(H_2O)_6]Cl_2$ (b) $[Ti(H_2O)_6]Cl_4$

(c) $[TiCl_6]^{3-}$ (d) $[Ti(H_2O)_4Cl_2]$

79. Which of the following statements is correct?

(a) With d^2sp^3 hybridization $[FeCl(CN)_4(O_2)]^{4-}$ complex is diamagnetic

(b) $[NiCl_4]^{2-}$ complex is more stable than $[Ni(dmg)_2]$ due to higher C.F.S.E. value

(c) $[V(CO)_6]$ is not very stable and easily reduces to $[V(CO)_6]^-$

(d) Ligands such as CO, CN^-, NO^+ are π e^- donor due to the presence of filled π-molecular orbital

80. Select the correct I.U.P.A.C. name for $[Pt(NH_3)_4][PtCl_4]$:

(a) Tetraammineplatinum(II) tetrachloridoplatinate(II)

(b) Tetraammineplatinate(II) tetrachloridoplatinate(II)

(c) Tetraammineplatinate(II) tetrachloridoplatinum(II)

(d) All are correct

81. Select the correct I.U.P.A.C. name for $[Co(NH_3)_6][Co(ONO)_6]$:

(a) Hexaamminecobalt(II) hexanitrito-O cobalt(II)

(b) Hexaamminecobalt(III) hexanitrito-N cobaltate(III)

(c) Hexaamminecobaltate(III) hexanitrito-O cobaltate(II)

(d) Hexaamminecobalt(III) hexanitrito-O cobaltate(III)

82. Select the correct I.U.P.A.C. name for $[PtCl_2(NH_3)_4][PtCl_4]$:

(a) Tetraamminedichloridoplatinate(IV) tetrachloridoplatinate(II)

(b) Tetraamminedichloridoplatinate(II) tetrachloridoplatinate(IV)

(c) Tetraamminedichloridoplatinum(IV) tetrachloridoplatinate(II)

(d) All are correct

83. Select the correct I.U.P.A.C. name for $Na[Co(CO)_4]$:

(a) Sodium tetracarbonylcobalt (–I)

(b) Sodium tetracarbonylcobalt (0)

(c) Sodium tetracarbonylcobaltate (0)

(d) Sodium tetracarbonylcobaltate (–I)

84. Select the correct I.U.P.A.C. name for $Fe(\pi\text{–}C_5H_5)_2$:

(a) bis(η^6-cyclopentadienyl) iron(II)

(b) bis(η^5-cyclopentadienyl) ferrate(II)

(c) bis(η^5-cyclopentadienyl) iron(0)

(d) bis(η^5-cyclopentadienyl) iron(II)

85. Select the correct I.U.P.A.C. name for $[Cr(C_6H_6)_2]$:

(a) bis(η^5-benzene) chromium(0)

(b) bis(η^6-benzene) chromate(0)

(c) bis(η^6-benzene) chromate(0)

(d) bis(η^6-benzene) chromium(0)

JEE (Advanced) Exercises

Single Correct Answer Type

1. Select the correct I.U.P.A.C. name for $[Co(CO)_3(\pi\text{-}C_3H_5)]$:
(a) (η^3-Allyl) tricarbonyl cobalt(I)
(b) (Tricrbonyl) (η^3-allyl) cobalt(I)
(c) Tricarbonyl (η^3-allyl) cobaltate(I)
(d) Tricarbonyl (η^3-allyl) tricarbonylcobalt(I)

2. E.A.N. of $[Fe(\eta^5\text{–}C_5H_5)(CO)_2Cl]$:
(a) 36 (b) 35
(c) 37 (d) 34

3. For Mn^{3+} ion, the electron pairing energy P is about 28,000 cm^{-1}, Δ_o values for the complexes $[Mn(H_2O)_6]^{3+}$ and $[Mn(CN)_6]^{3-}$ are 15,800 cm^{-1} and 38,500 cm^{-1}, respectively, which of the following complex is high spin:
(a) $[Mn(CN)_6]^{3-}$ (b) $[Mn(H_2O)_6]^{3+}$
(c) Both are high spin (d) None of these

4. If a transition-metal compound absorbs violet-indigo radiation in the visible region. Its color would be:
(a) Green (b) Yellow
(c) Orange (d) Blue

5. Transition metal compounds are usually colored. This is due to the electronic transition:
(a) From p-orbital to s-orbital
(b) From d-orbital to s-orbital
(c) From d-orbital to p-orbital
(d) Within the d-orbitals

6. A substance which is not paramagnetic is:
(a) $Cr(ClO_4)_3$ (b) $KMnO_4$
(c) $TiCl_3$ (d) $VOBr_2$

7. The following represents a pair of enantiomers:
(a) *trans*-$[CrCl_2\,en_2]^+$ (b) *cis*-$[CrCl_2\,en_2]^+$
(c) *trans*-$[CrCl_2(NH_3)_4]^+$ (d) *cis*-$[CrCl_2(NH_3)_4]^+$

8. The compound $[PtCl_2(NH_3)_2]$ can form:
(a) Geometrical isomers (b) Coordination isomers
(c) Linkage isomers (d) Optical isomers

9. The compound $[CoCl_2(NH_3)_2(en)]$ can form:
(a) Linkage isomers
(b) Coordination isomers
(c) Optical isomers
(d) Linkage as well as optical isomers

10. Which of the following complexes has magnetic moment of 2.83 Bohr magneton?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Ni(CN)_4]^{2-}$
(c) $TiCl_4$ (d) $[CoCl_6]$

11. According to crystal field theory, octahedral splitting and tetrahedral splitting of d orbitals caused by the same ligands are related through the expression:
(a) $\Delta_o = \Delta_t$ (b) $4\Delta_o = 9\Delta_t$
(c) $9\Delta_o = 4\Delta_t$ (d) $\Delta_o = 2\Delta_t$

12. Relative to the average energy in the spherical crystal field, the t_{2g} orbitals in octahedral field is:
(a) Raised by $(2/5)\Delta_o$ (b) Lowered by $(2/5)\Delta_o$
(c) Raised by $(1/5)\Delta_o$ (d) Lowered by $(3/5)\Delta_o$

13. Which of the following ligands are correctly represented in an spectrochemical series?
(a) $SCN^- < F^- < CN^-$ (b) $SCN^- < CN^- < F^-$
(c) $F^- < SCN^- < CN^-$ (d) $F^- < CN^- < SCN^-$

14. In the complex $[Pt(O_2)(en)_2(Br)]^{2+}$, coordination number and oxidation number of platinum are:
(a) 4, 3 (b) 4, 5
(c) 4, 6 (d) 6, 4

15. Coordination number of Cr is six. A complex with $C_2O_4^{2-}$, en and superoxide O_2^- will be in the ratio to make complex $[Cr(C_2O_4)_x(en)_y(O_2)_z]^-$:

	x	y	z
(a)	1	1	1
(b)	1	1	2
(c)	1	2	2
(d)	2	1	1

16. EAN of Fe is ... in $[Fe(C_2O_4)_3]^{3-}$:
(a) 27 (b) 24
(c) 35 (d) 29

17. EAN of cobalt is 36 in $[Co(NH_3)_2O_2(en)Cl]$. Thus, O_2 is:
(a) Dioxide (b) Superoxide ion
(c) Peroxide ion (d) Oxide

18. EAN of Mg is ... in $[Mg(EDTA)]^{2-}$:
(a) 16 (b) 20
(c) 22 (d) 18

19. Which has maximum EAN of the underlined atoms? (Cr = 24, Co = 27, Fe = 26, Ni = 28)
(a) $[\underline{Cr}(EDTA)]^-$ (b) $[\underline{Co}(en)_3]^{3+}$
(c) $[\underline{Fe}(C_2O_4)_3]^{3-}$ (d) $[\underline{Ni}(CN)_4]^{2-}$

20. Arrange the following in order of decreasing number of unpaired electrons:

I: $[Fe(H_2O)_6]^{2+}$ II: $[Fe(CN)_6]^{3-}$

III: $[Fe(CN)_6]^{4-}$ IV: $[Fe(H_2O)_6]^{3+}$

(a) IV, I, II, III (b) I, II, III, IV

(c) III, II, I, IV (d) II, III, I, IV

21. Among $[Ni(CO)_4]$, $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ species, the hybridization state of Ni atoms are respectively:

(a) sp^3, ds^2p, dsp^2 (b) sp^3, dsp^2, sp^3

(c) sp^3, sp^3, dsp^2 (d) dsp^2, sp^3, sp^3

22. The most stable ion is:

(a) $[Fe(C_2O_4)_3]^{3-}$ (b) $[Fe(Cl)_6]^{3-}$

(c) $[Fe(SCN)_6]^{3-}$ (d) $[Fe(H_2O)_6]^{3+}$

23. One mole of complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of $AgNO_3$ to yeild two moles of $AgCl_{(s)}$. The complex is:

(a) $[Co(NH_3)_4Cl_2]Cl \cdot NH_3$

(b) $[Co(NH_3)_4Cl]Cl_2 \cdot NH_3$

(c) $[Co(NH_3)_5Cl]Cl_2$ (d) $[Co(NH_3)_3Cl_3] \cdot 2NH_3$

24. Which of the following will show optical isomerism?

(a) $[Cu(NH_3)_4]^{2+}$ (b) $[ZnCl_4]^{2-}$

(c) $[Cr(C_2O_4)_3]^{3-}$ (d) $[Co(CN)_6]^{3-}$

25. The bond length of C—O bond in carbon monoxide is 1.128 Å. The C—O bond in $Fe(CO)_5$ is:

(a) 1.115 Å (b) 1.128 Å

(c) 1.178 Å (d) 1.150 Å

26. In which of the following pairs both the complexes show optical isomerism?

(a) *cis*-$[Cr(C_2O_4)_2Cl_2]^{3-}$, *cis*-$[Co(NH_3)_4Cl_2]$

(b) $[Co(en)_3]Cl_3$, *cis*-$[Co(en)_2Cl_2]Cl$

(c) $[Pt\,Cl\,(en)Cl]$, $[NiCl_2Br_2]^{2-}$

(d) $[Co(NO_3)_3(NH_3)_3]$, *cis*-$[Pt(en)_2Cl_2]$

27. The oxidation number of Pt in $[Pt(C_2H_4)Cl_3]^{\ominus}$ is:

(a) +1 (b) +2

(c) +3 (d) +4

28. Which of the following gives the maximum number of isomers?

(a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$

(c) $[Ni(C_2O_4)(en)_2]$ (d) $[Cr(SCN)_2(NH_3)_4]^{+}$

29. Consider the following complex:

$[Co(NH_3)_5CO_3]ClO_4$

the coordination number, oxidation number, number of *d*-electrons, and number of unpaired *d*-electrons of the metal are respectively:

(a) 6, 3, 6, 0 (b) 7, 2, 7, 1

(c) 7, 1, 6, 4 (d) 6, 2, 7, 3

30. The common features among the species CN^-, CO, and NO^+ are:

(a) Bond order three and isoelectronic

(b) Bond order three and weak field ligands

(c) Bond order two and π-acceptors

(d) Isoelectronic and weak field ligands

31. The possible number of optical isomers in $[Co(en)_2Cl_2]^+$ are:

(a) 2 (b) 3

(c) 4 (d) 6

32. Which of the following does not have optical isomers?

(a) $[Co(en)_3]Cl_3$ (b) $[Co(NH_3)_3Cl_3]$

(c) $[Co(en)_2Cl_2]Cl$ (d) $[Co(en)(NH_3)_2Cl_2]Cl$

33. Which of the following has a square planar geometry?

(a) $[PtCl_4]^{2-}$ (b) $[CoCl_4]^{2-}$

(c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

34. Which of the following will give a pair of enantiomorphs?

(a) $[Cr(NH_3)_6][Co(CN)_6]$ (b) $[Co(en)_2Cl_2]Cl$

(c) $[Pt(NH_3)_4][PtCl_6]$ (d) $[Co(NH_3)_4Cl_2]NO_2$

35. Both Co^{3+} and Pt^{4+} have a coordination number of 6. Which of the following pairs of complexes will show approximately the same electrical conductance for their 0.001M aqueous solutions?

(a) $CoCl_3{\cdot}4NH_3$ and $PtCl_4{\cdot}4NH_3$

(b) $CoCl_3{\cdot}3NH_3$ and $PtCl_4{\cdot}5NH_3$

(c) $CoCl_3{\cdot}6NH_3$ and $PtCl_4{\cdot}5NH_3$

(d) $CoCl_3{\cdot}5NH_3$ and $PtCl_4{\cdot}6NH_3$

36. The increasing order of the crystal field splitting power of some common ligands is:

(a) $H_2O < NO_2^- < \overset{\ominus}{C}N < NH_3$

(b) $NH_3 < NO_2^- < \overset{\ominus}{C}N < H_2O$

(c) $H_2O < NH_3 < NO_2^- < \overset{\ominus}{C}N$

(d) $H_2O < NH_3 < \overset{\ominus}{C}N < NO_2$

37. The EAN of Fe atom in $(CO)_3Fe(CO)_3\,Fe(CO)_3$ is:

(a) 34 (b) 35

(c) 36 (d) 37

38. Which of the pair of complex compounds are tetrahedral as well as diamagnetic?
(a) $[CoCl_4]^-$ and $[Co(CO)_4]^-$
(b) $[Ag(SCN)_4]^{2-}$ and $[NiCl_4]^{2-}$
(c) $[Co(CO)_4]^-$ and $[Ni(CN)_4]^{4-}$
(d) $[PdCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$

39. If H_x [Pt y_6], y is a monodentate negatively charged ligand then find out the value of x:
(a) 5 (b) 3
(c) 6 (d) None of these

40. Select the correct IUPAC name of $K_2[Cd(CN)_4]$:
(a) Potassium tetracyanidocadmate (II)
(b) Potassium tetracyanidocadmate (2–)
(c) Both (a) and (b) (d) None of these

41. Select the correct order of magnetic moment (in B.M.) from the following options:
(a) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$
(b) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$
(c) $[Fe(CN)_6]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$
(d) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$

42. When $K_4[Fe(CN)_6]$ is treated with $FeCl_3$, a blue color is obtained. It is due to the formation of:
(a) $Fe^{II}[Fe^{III}(CN)_6]^-$ (b) $Fe^{III}[Fe^{II}(CN)_6]^-$
(c) Both (a) and (b) (d) None of these

43. In isolated condition C—C bond length of C_2H_4 is x, than the bond length of C—C bond of C_2H_4 in Zeise's salt is:
(a) Greater than x (b) Less than x
(c) Equal to x (d) None of these

44. The correct I.U.P.A.C. name for $H_2[PtCl_6]$ complex:
(a) Hexachloridoplatinic(IV) acid
(b) Hexachloridoplatinate(IV) acid
(c) Hydrogenhexachloridoplatinate(IV)
(d) Di hydrogenhexachloridoplatinate(IV)

45. Select the correct I.U.P.A.C. name for $Fe_4[Fe(CN)_6]_3$:
(a) Iron(III) hexacyanidoferrate(II)
(b) Iron(III) hexacyanidoferrate(III)
(c) Iron(III) hexacyanidoiron(III)
(d) Iron(II) hexacyanidoiron(II)

46. Select the correct I.U.P.A.C. name for $[Ti(\pi-C_5H_5)_2(\sigma-C_5H_5)_2]$:
(a) Bis (cyclopentadienyl) bis (η^5 - cyclopentadienyl) titanate(IV)
(b) Bis (η^5-cyclopentadienyl) bis (cyclopentadienyl) titanium(IV)
(c) Bis (η^5-cyclopentadiene) bis (cyclopentadiene) titanium(IV)
(d) Bis (η^5-cyclopentadiene) bis (cyclopentadiene) titanate(IV)

47. Select the correct I.U.P.A.C name for $Mo(\sigma-C_3H_5)(\pi-C_5H_5)(CO)_3$:
(a) Allytricarbonyl (η^5 – cyclopentadiene) molybdenum(II)
(b) Allyltricarbonyl (η^5-cyclopentadienyl) molybdate(II)
(c) Tricarbonyl (η^5-cyclopentadienyl) allyl molybdate(II)
(d) Allyl tricarbonyl (η^5-cyclopentadienyl) molybdenum(II)

48. I.U.P.A.C. name for $Fe(CO)_2(\sigma-C_5H_5)(\pi-C_5H_5)$ complex:
(a) Dicarbonyl (η^5-cyclopentadienyl) (cyclopentadienyl)ferrate(II)
(b) Dicarbonyl (η^5-cyclopentadiene) (cyclopentodiencyl)iron(II)
(c) Dicarbonyl (η^5-cyclopentadienyl) (η^5-cyclopentadienyl)iron(II)
(d) Dicarbonyl (η^5-cyclopentadienyl) (cyclopentadienyl)iron(II)

49. Select the correct I.U.P.A.C. name for $[Pt(C_5H_5N)_4][PtCl_4]$:
(a) Tetrapyridineplatinate(II) tetrachloridoplatinate(II)
(b) Tetrapyridineplatinate(II) tetrachloridoplatinate(II)
(c) Tetrapyridineplatinate(II) tetrachloridoplatinum(II)
(d) Tetrapyridineplatinum(II) tetrachloridoplatinate(II)

50. Select the correct I.U.P.A.C. name for $C_4H_4Fe(CO)_3$ complex:
(a) η^4-cyclobutadiene tricarbonyliron(0)
(b) Tricarbonyl (η^4-cyclobutadienyl) iron(0)
(c) Tricarbonyl (η^4-cyclobutadiene) iron(I)
(d) Tricarbonyl (η^4-cyclobutadiene) iron(0)

51. Among the following, the lowest degree of paramagnetism per mole of the compound at 298 K will be shown by:
(a) $MnSO_4 \cdot 4H_2O$ (b) $FeSO_4 \cdot H_2O$
(c) $CuSO_4 \cdot 5H_2O$ (d) $NiSO_4 \cdot 6H_2O$

52. The color of Cu^+ compounds is:
(a) White (b) Blue
(c) Orange (d) Yellow

53. Dimethylglyoxime is coordinated to Ni^{2+} through:
(a) Two oxygen toms
(b) Two nitrogen atoms
(c) Two oxygen and one nitrogen atoms
(d) Two oxygen and two nitrogen atoms

54. Ferrocene is:
(a) $Fe(\eta^2\text{-}C_6H_5)_2$ (b) $Fe(\eta^5\text{-}C_5H_5)_2$
(c) $Fe(\eta^6\text{-}C_6H_6)_2$ (d) $Fe(\eta^3\text{-}C_3H_3)_2$

55. Relative to the average energy in the spherical crystal field, the e_g orbitals in octahedral field is:
(a) Raised by $(2/5)\Delta_o$ (b) Lowered by $(4/5)\Delta_o$
(c) Raised by $(3/5)\Delta_o$ (d) Lowered by $(3/5)\Delta_o$

56. Relative to the average energy in the spherical crystal field, the e_g orbitals in tetrahedral field is:
(a) Raised by $(2/5)\Delta_t$ (b) Lowered by $(4/5)\Delta_t$
(c) Raised by $(3/5)\Delta_t$ (d) Lowered by $(3/5)\Delta_t$

57. In the complex $[Pt(O_2)(en)_2(Br)]^{2+}$, nature of (O_2) is:
(a) Oxide ion (b) Peroxide ion
(c) Superoxide ion (d) Oxygen molecule

58. Among the properties (a) reducing, (b) oxidizing, (c) complexing, the set of properties shown by CN^- ion towards metal species is:
(a) *a, b, c* (b) *b, c*
(c) *c, a* (d) *a, b*

59. The value of "spin only" mgnetic moment for one of the following configuration is 2.84 B.M. The correct one is:
(a) d^4 (in strong field ligand)
(b) d^7 (in weak field ligand)
(c) d^3 (in weak as well as in strong field ligand)
(d) d^5 (in strong field ligand)

60. The complex ion which has no *d* electron in the central metal atom is:
(a) $[MnO_4]^-$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

61. The spin magnetic moment of cobalt in $Hg[Co(SCN)_4]$ is:
(a) $\sqrt{3}$ (b) $\sqrt{8}$
(c) $\sqrt{15}$ (d) $\sqrt{24}$

62. The pair in which both species have same magnetic moment (spin only value) is:
(a) $[Cr(H_2O)_6]^{2+}$, $[CoCl_4]^{2-}$
(b) $[Cr(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$
(c) $[Mn(H_2O)_6]^{2+}$, $[Cr(H_2O)_6]^{2+}$
(d) $[CoCl_4]^{2-}$, $[Fe(H_2O)_6]^{2+}$

63. Which of the following compound is not colored?
(a) $Na_2[CuCl_4]$ (b) $Na_2[CdCl_4]$
(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

64. What is the shape of $Fe(CO)_5$ molecule and which of the following *d*-orbitals involved in hybridization?
(a) Tetrahedral $d_{x^2-y^2}$
(b) Trigonal bipyramidal, $d_{x^2-y^2}$
(c) Trigonal bipyramidal, d_{z^2}
(d) Square pyramidal

65. Mg is an important component of which biomolecule occurring extensively in living world?
(a) Hemoglobin (b) Chlorophyll
(c) Florigen (d) ATP

66. Atomic numbers of Cr and Fe are, respectively, 24 and 26. Which of the following is paramagnetic with spin of electron?
(a) $Cr(CO)_6$ (b) $[Fe(CO)_5]$
(c) $[Fe(CN)_6]^{4-}$ (d) $[Cr(NH_3)_6]^{3+}$

67. Among the following, which is not the π-bonded organometallic compound?
(a) $(CH_3)_4Pb$ (b) $[Cr(\eta^6\text{-}C_6H_6)_2]$
(c) $[Fe(\eta^5\text{-}C_5H_5)_2]$ (d) $K[PtCl_3(\eta^2-C_2H_4)]$

68. According to the I.U.P.A.C. nomenclature, sodium nitroprusside is named as:
(a) Sodium nitro-ferrocyanide
(b) Sodium pentacyanidonitrosoniumferrate(II)
(c) Sodium nitroferricyanide
(d) Sodium pentacyanonitrosylferrate(III)

69. Which of the following is not considered as an organo-metallic compound?
(a) Ferrocene (b) *cis*-platin
(c) Zeise's salt (d) Grignard reagent

70. The *d*-electron configurations of Mn^{2+}, Fe^{2+}, Co^{3+}, and Ni^{2+} are $3d^5$, $3d^6$, $3d^6$, $3d^8$, respectively. Which of the following aqua complexes will exhibit the minimum paramagnetic behavior?
(a) $[Fe(H_2O)_6]^{2+}$ (b) $[Co(H_2O)_6]^{3+}$
(c) $[Ni(H_2O)_6]^{2+}$ (d) $[Mn(H_2O)_6]^{2+}$

71. The hybridization and geometry of $[Fe(CO)_4]^{2-}$ are:
(a) sp^3d, TBP (b) sp^3, tetrahedral
(c) dsp^2, square planar (d) sp^3, TBP

72. Which of the following statements is correct for the complex $K_4[Fe(CN)_5 O_2]$ having t_{2g}^6, e_g^0 electronic configuration?
(a) d^2sp^3 hybridized and diamagnetic
(b) sp^3d^2 hybridized and paramagnetic
(c) sp^3d^2 hybridized and diamagnetic
(d) d^2sp^3 hybridized and paramagnetic

73. Which of the following statements is correct for the $[Fe(H_2O)_5NO]SO_4$ complex?
(a) The E.A.N. value of Fe in this complex depends on the charge of NO ligand
(b) The E.A.N. value of Fe in this complex does not depend on the charge of NO ligand
(c) The hybridization of the central atom is d^2sp^3
(d) It is paramagnetic with $\mu = 1.73$ B.M.

74. Which of the following complex can act as an oxidizing agent as well as reducing agent?
(a) $Ti(CO)_6$ (b) $Mn(CO)_5$
(c) $Mn(CO)_6$ (d) None of these

75. Select the correct statement for $[M(AB)b_2cd]$:
(a) All geometrical isomers are optically active
(b) It has four *trans* isomer with respect to *b*
(c) It has seven geometrical isomers
(d) It has three *cis* and two *trans* isomers with respect to *b*

76. Which of the following complex is inner orbital as well as low spin complex?
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(CN)_6]^{3-}$
(c) $[Cu(CN)_4]^{3-}$ (d) $[Mn(NH_3)_6]^{2+}$

77. The magnetic moment of a certain complex (*A*) of Co was found to be 4.89 B.M. and the EAN as 36. Co also forms complex (*B*) with magnetic moment 3.87 B.M. and EAN 37, and complex (*C*) with EAN as 36 but diamagnetic. Which of the following statements is true regarding the above observation?
(a) The oxidation states of Co in (*A*), (*B*), and (*C*) are +3, +2, and +3, respectively
(b) Complexes (*A*) and (*B*) have sp^3d^2 hybridization state while (*C*) has dsp^3 hybridization state
(c) The spin multiplicities of Co in (*A*), (*B*), and (*C*) are 4, 3, and 1, respectively
(d) The oxidation states of Co in (*A*), (*B*), and (*C*) are +6, +8, and +1, respectively

78. Oxidation state of "V" in $Rb_4Na[HV_{10}O_{28}]$ is:
(a) +5 (b) +6
(c) $+\frac{7}{5}$ (d) +4

79. Which of the following organometallic compound is σ and π-bonded?
(a) $[Fe(\eta^5 - C_5H_5)_2]$ (b) $K[PtCl_3(\eta^2 - C_2H_4)]$
(c) $[Co(CO)_5NH_3]^{2+}$ (d) $Fe(CH_3)_3$

80. Spin only magnetic moments of a d^8 ion in octahedral, square planar, and tetrahedral complexes, respectively, are:
(a) 2.8 B.M., 0, and 2.8 B.M.
(b) 2.8, 2.8, and 2.8 B.M.
(c) 0, 0, and 0 B.M. (d) None of these

81. Compare C — C bond length (*x*) of C_2H_4 in Zeise's salt and C — C bond length (*y*) of $C_2(CN)_4$ in $K[PtCl_3C_2(CN)_4]$:
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

82. Select the correct order of C — O bond order in mixed phosphine carbonyl complex:
(a) $[(Ph_3P)_3Mo(CO)_3] > [(Ph_2PCl)_3 Mo(CO)_3] > (Ph PCl_2)_3 Mo (CO)_3]$
(b) $[(Ph_3P)_3Mo(CO)_3] < [(Ph_2PCl)_3 Mo(CO)_3] < (Ph PCl_2)_3 Mo (CO)_3]$
(c) $[(Ph_3P)_3Mo(CO)_3] = [(Ph_2PCl)_3 Mo(CO)_3] > (Ph PCl_2)_3 Mo (CO)_3]$
(d) $[(Ph_3P)_3Mo(CO)_3] < [(Ph_2PCl)_3 Mo(CO)_3] > (Ph PCl_2)_3 Mo (CO)_3]$

83. Which bond properties are consistent with one another?

	Bond order	Bond length	Vibrational frequency
(a)	Higher	shorter	higher
(b)	Higher	longer	lower
(c)	Lower	shorter	lower
(d)	Lower	longer	higher

84. Which of the following statement(s) is/are true or false?
S_1: In organometallic compounds, carbon is bonded to metals directly
S_2: Complexes having d^0 or d^{10} configuration of metal ions are always diamagnetic
S_3: Extra stability of metal carbonyls is explained by synergic bonding
S_4: In $Fe(CO)_5$, the Fe—C bond possesses both σ and π characteristics
(a) T T T T (b) T T F F
(c) F T F T (d) F T T T

85. Which of the following is **incorrect** about Wilkinson's catalyst?

(a) It is a non-ionic complex
(b) It is a diamagnetic complex
(c) It is a tetrahedral complex
(d) It is very effective for selective hydrogenation of organic molecule at room temperature and pressure

Multiple Correct Answers Type

1. Select the correct I.U.P.A.C. name from following:
(a) Diamminesilver(I) chloride: $[Ag(NH_3)_2]Cl$
(b) Potassium hexacyanidoferrate(III): $K_3[Fe(CN)_6]$
(c) Tetraamminecopper(II) sulphate: $[Cu(NH_3)_4]SO_4$
(d) Hexamminecobalt(III) chloride: $[Co(NH_3)_6]Cl_3$

2. Select the correct I.U.P.A.C. name for $[Pt(NH_3)_4]^{2+}$ complex ion:
(a) Tetraammineplatinum(II) ion
(b) Tetraammineplatinum(2+) ion
(c) Tetraammineplatinate(II) ion
(d) Tetraammineplatinate(2+) ion

3. Select the correct I.U.P.A.C. name for $[PtCl_4]^{2-}$:
(a) Tetrachloridoplatinum(II) ion
(b) Tetrachloridoplatinum(2–) ion
(c) Tetrachloridoplatinate(II) ion
(d) Tetrachloridoplatinate(2–) ion

4. Select the correct I.U.P.A.C. name for $[PtCl_6]^{2-}$:
(a) Hexachloridoplatinate(IV) ion
(b) Hexachloridoplatinum(II) ion
(c) Hexachloridoplatinate(2–) ion
(d) Hexachloridoplatinum(2–) ion

5. Select the correct statement(s) for double salt:
(a) Double salts are stable in solid state but loose their identity in aqueous solution
(b) In double salt the properties of constituent ions are not changed in their aqueous solution
(c) Double slats are stable in solid state and do not loose their identity in aqueous solution
(d) In double salt the properties of constituent ions are changed in their aqueous solution

6. Select the paramagentic complex compound:
(a) $K_4[Fe(CN)_5O_2]$ (b) $Fe(CO)_5$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Ni(CN)_6]^{4-}$

7. Which of the following ligand(s) is/are ambidentate?
(a) $NOS^{\ominus}$ (b) $\overset{\ominus}{S}CN$
(c) $NO_2^{\ominus}$ (d) $CH_3COO^{\ominus}$

8. Select the correct I.U.P.A.C. name for $[CoCl_2(en)_2]_2SO_4$:
(a) Dichloridobis (ethylenediamine)cobalt(III) sulphate
(b) Dichloridobis (ethane-1, 2-diamine) cobalt(III) sulphate
(c) bis{dichloridoethylenediaminecobalt(III)} sulphate
(d) bis{di(chlorido)ethylenediaminecobalt(III)} sulphate

9. Which of the following complex (s) is/are high spin?
(a) $[CoF_6]^{3-}$ (b) $[Co(H_2O)_3F_3]$
(c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(H_2O)_6]^{2+}$

10. Which of the following complex (s) is/are paramagnetic in nature?
(a) $K_2[NiF_6]$ (b) $K_3[CoF_6]$
(c) $K_3[Fe(CN)_6]$ (d) $[Co(H_2O)_6]^{3+}$

11. Which of the following complex ion(s) are paramagnetic?
(a) $[Ni(CN)_4]^{2-}$ (b) $[NiCl_4]^{2-}$
(c) $[CoF_6]^{3-}$ (d) $[Co(NH_3)_6]^{3+}$

12. Bidentate ligands are:
(a) $C_2O_4^{2-}$ (oxalate) (b) en (ethylenediamine)
(c) DMG (dimethyl glyoxime)
(d) Gly (glycine)

13. Which of the following complex(s) is/are having correct name?
(a) $K[Pt(NH_3)Cl_5]$ – Potassium amminepentachloridoplatinate(IV)
(b) $[Ag(CN)_2]^-$ – Dicyanidoargentate(I) ion
(c) $K_3[Cr(C_2O_4)_3]$ – Potassium trioxalatochromate(III)
(d) $Na_2[Ni(EDTA)]$–Sodium ethylenediaminetetraacetatonickel(II)

14. $d_{x^2-y^2}$ orbital is involved in which of the following hybridization?
(a) sp^3d (sq. pyramidal) (b) dsp^2
(c) sp^3d^2 (d) sp^3d^3

15. Which of the following statement(s) is/are correct?
(a) The stability constant of $[Co(NH_3)_6]^{3+}$ is larger than that of $[Co(NH_3)_6]^{2+}$
(b) The cyano complexes are more stable than those formed by halide ions
(c) The stability of halide complexes follows the order $I^- < Br^- < Cl^-$

(d) The stability constant of $[Cu(NH_3)_4]^{2+}$ is larger than that of $[CuCl_4]^{2-}$

16. The complexes $[CoNO_2(NH_3)_5]Cl_2$ and $[Co(ONO)(NH_3)_5]Cl_2$ are not the examples of:
(a) Geometrical isomers (b) Optical isomers
(c) Coordination isomers (d) Linkage isomers

17. The complexes $[Cr(NH_3)_6]\,[Co(CN)_6]$ and $[Co(NH_3)_6]\,[Cr(CN)_6]$ are not the examples of:
(a) Geometrical isomers (b) Optical isomers
(c) Coordination isomers (d) Linkage isomers

18. Which of the following statement(s) is/are true?
(a) $Ni(CO)_4$ is paramagnetic
(b) $[Fe(CN)_6]^{3-}$ contains one unpaired electron
(c) $[FeF_6]^{3-}$ involves sp^3d^2-hybridization
(d) $[Ni(CN)_4]^{2-}$ is square planar and diamagnetic

19. In the complex $[Fe(NH_3)_6]^{3+}$:
(a) Fe^{3+} is a Lewis acid (b) NH_3 is a Lewis base
(c) NH_3 is Lewis acid (d) Fe^{3+} is a Lewis base

20. Which can form chelates?
(a) Ethylene diamine (b) Oxalate
(c) Glycinate (d) Cyanide

21. In which case geometrical isomer *cis* possible with *M* as metal ion if complexes are square planar having C.N. = 4?
(a) MX_2Y_2 (b) MX_2Y_4
(c) $MX_2Y_2Z_2$ (d) Ma_4

22. Ethylenediamine is/are not an example of a .... ligand:
(a) Monodentate (b) Bidentate
(c) Tridentate (d) Hexadentate

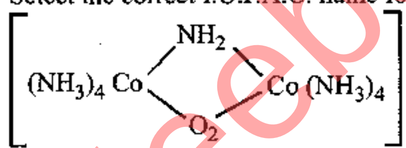
23. Which of the following statement(s) is/are correct?
(a) $Ni(CO)_4$—Tetrahedral, paramagnetic
(b) $[Ni(CN)_4]^{2-}$—Square planar, diamagnetic
(c) $[Ni(CO)_4]$—Tetrahedral, diamagnetic
(d) $[NiCl_4]^{2-}$—Tetrahedral, paramagnetic

24. Which of the following statements(s) is/are correct?
(a) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in state of hybridization of nickel
(b) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in geometry
(c) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in the magnetic properties
(d) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in primary valencies of nickel

25. Both geometrical and optical isomerisms are not shown by:
(a) dichlorobis (ethylenediamine) cobalt(III) ion
(b) triamminetrichloro cobalt(III) ion
(c) tetraamminedichloro cobalt(III) ion
(d) trioxalatochromate(III) ion

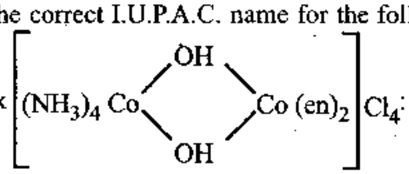
26. Which of the following moelcule(s) is/are showing optical isomerism?
(a) $[Co(NH_3)_3Cl_3]$ (b) $[Co(en)Cl_2(NH_3)_2]^+$
(c) $[Co(en)_3]^{3+}$ (d) $[Co(en)_2Cl_2]^+$

27. Select the correct I.U.P.A.C. name for the following


:

(a) Tetramminecobalt(III)-μ-amido-μ-superoxido-tetraamminecobalt(III) ion
(b) μ-Amido-μ-superoxidobis(tetraammine)dicobalt(III) ion
(c) μ-Amido-μ-superoxidobis(tetraamminecobalt(III)) ion
(d) μ-Amido-μ-superoxidooctaamminedicobalt(III) ion

28. Select the correct I.U.P.A.C. name for the following complex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(a) Tetraamminecobalt (III)-μ-dihydroxidobis (ethylenediamine)cobalt(III) chloride
(b) μ-Dihydroxidotetraamminebis(ethylenediamine) dicobalt(III) chloride
(c) Tetraammine cobalt (III)-μ-dihydroxidobis (ethane-1,2-diamine)cobalt(III) chloride
(d) Tetraamminecobalt (III)-μ-dihydroxidobis (ethylenediamine)cobalt(III) tetrachloride

29. Select the correct I.U.P.A.C. name for $Mn(CO)_5(\sigma\text{–}C_3H_5)$:
(a) Allylpentacarbonylmanganese(I)
(b) Cyclopropylpentacarbonylmanganese(I)
(c) Pentacarbonylcyclopropylmanganese(I)
(d) Pentacarbonyl allylmanganese(I)

30. Which of the following molecules have E.A.N. = 36?
(a) $[Fe(CO)_4]^{2-}$ (b) $[Co(\eta^5\text{-}C_5H_5)_2]^+$
(c) Co_2CO_8 (d) $Mn_2(CO)_{10}$

31. The aqueous solution of the following salts will be colored in the case of:

(a) $Zn(NO_3)_2$ (b) $LiNO_3$

(c) $Co(NO_3)_2$ (d) $CrCl_3$

32. In which of the following cases, the synergic bonding takes place at the π-orbital of the ligand?

(a) $[PtCl_3(C_2H_4)]^-$ (b) $[Ni(PF_3)_4]$

(c) $[Cr(C_6H_6)_2]$ (d) $[Fe(\pi\text{-}C_5H_5)_2]$

33. Which of the following complexes are diamagnetic:

(a) $[AuCl_4]$ (b) $[Co(H_2O)_6]^{3+}$

(c) $[CoF_6]^{3-}$ (d) $[Co(CO)_4]^-$

34. Which of the following is/are represent the correct sequence of indicated property?

(a) $Mn^{2+} < Ni^{2+} < Co^{2+} < Fe^{2+}$: magnetic moment

(b) $FeO > CoO > NiO$: basic character

(c) $Sc < Ti < Cr < Mn$: number of oxidation states

(d) 1.73 μ: one unpaired $e^{\ominus}$

35. Which of the following statement(s) is/are correct?

(a) Primary valency of the central metal of a complex is always satisfied by anions

(b) Secondary valency of the central metal of a complex may be satisfied by either negative ions or neutral molecules

(c) Species which show primary valencies in a complex compound can be precipitated out

(d) None of these

36. Select correct statements:

(a) $[Ni(en)_3]^{2+}$ is less stable than $[Ni(NH_3)_6]^{2+}$

(b) Increase in stability of the complexes due to the presence of multidentate cyclic ligand is called macro-cyclic effect

(c) $[Ni(en)_3]^{2+}$ is more stable than $[Ni(NH_3)_6]^{2+}$

(d) For a given ion and ligand, the greater the charge on the metal ion, the greater is the stability

37. The complex $[Fe(H_2O)_5NO]^{2+}$ is formed in the brown ring test for nitrates when freshly prepared $FeSO_4$ solution is added to aqueous solution of NO_3^- followed by addition of conc. H_2SO_4. Select correct statements about this complex:

(a) Color change is due to charge transfer

(b) It has iron in +1 oxidation state and nitrosyl as NO^+

(c) It has magnetic moment of 3.87 B.M. confirming three unpaired electrons in Fe

(d) In complex Fe has d^2sp^3 hybridization

38. Which of the following complex ion(s) is/are not expected to absorb visible light?

(a) $[Ti(en)_2(NH_3)_2]^{4+}$ (b) $[Cr(NH_3)_6]^{3+}$

(c) $[Zn(NH_3)_6]^{2+}$ (d) $[Sc(H_2O)_3(NH_3)_3]^{3+}$

39. Which of the following molecule(s) is/are not showing optical isomerism?

(a) $[Co(NH_3)_5Cl]^+$ (b) $[Co(en)(NH_3)_2]^{2+}$

(c) $[Co(H_2O)_4(en)]^{3+}$ (d) $[Co(en)_2(NH_3)_2]^{3+}$

40. Colorless, tetrahedral complexes among the following are:

(a) $K_3[Cu(CN)_4]$ (b) $Na_2[NiCl_4]$

(c) $K[BF_4]$ (d) $Ni(CO)_4$

41. Which of the following statement is correct regarding metal carbonyl?

(a) In $Mn_2(CO)_{10}$, bond order of Mn—Mn is 0

(b) In $Fe_2(CO)_9$, number of Fe—Fe bonds is 1

(c) In $Ni(CO)_4$, all bond length are same

(d) $Fe(CO)_5$ is diamagnetic

42. Select the correct I.U.P.A.C. name for $[(NH_3)_4Co(OH)(NH_2)Co(NH_3)_4]^{4+}$:

(a) μ-Amido-μ-hydroxidobis {tetraammine cobalt(4+)} ion

(b) μ-Amido-μ-hydroxidobis {tetraammine cobalt(III)} ion

(c) μ-Amido-μ-hydroxidobis {tetraammine cobaltate(4+)} ion

(d) μ-Amido-μ-hydroxidobis {tetraammine cobaltate(III)} ion

43. The compound(s) that exhibit(s) geometrical isomerism is(are):

(a) $[Pt(en)Cl_2]$ (b) $[Pt(en)_2]Cl_2$

(c) $[Pt(en)_2Cl_2]Cl_2$ (d) $[Pt(NH_3)_2Cl_2]$

44. Select the correct I.U.P.A.C. name for $[(C_6H_5)_3$ PCl Pd Cl_2 Pd $Cl(C_6H_5)_3P]$:

(a) Chloridotriphenylphosphinepalladium(II) μ-dichloridochloridotriphenylphosphinepalladium(II)

(b) μ-Dichloridodichloridobis(triphenylphosphine) dipalladium(II)

(c) μ-Dihloridobis(chloridotriphenylphosphinepalladium)(II)

(d) Bis (μ-chloridochloridotriphenylphosphinepalladium)(II)

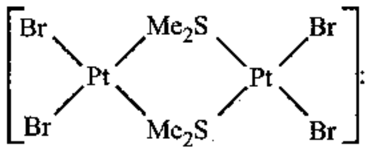
45. $[(Cl_3Sn)_2Rh\ Cl_2\ Rh\ (SnCl_3)_2]^{4-}$ as:

(a) Bis (trichlorostannito) rhodate(I)-μ-dichloridobis (trichlorostannito)rhodate(I) ion

(b) μ-Dichloridotetrakis (trichlorostannito) dirhodate(I)ion

(c) μ-Dichloridobis{bis (trichlorido stannito) rhodate(I)ion}

(d) μ-Dichloridotetrakis (trichloro stannito) dirnodium(I) ion

46. Select the correct I.U.P.A.C name for the following complex :

(a) Di bromidoplatinum(II) bis-μ-(dimethylthioether) dibromidoplatinum(II)

(b) Bis{μ (dimethylthioether) dibromidoplatinum(II)}

(c) Bis-μ-dimethylthioethertetrabromidodiplatinum(II)

(d) Bis-μ-dimethylthioethertetrabromidodiplatinate(II)

47. Select the correct I.U.P.A.C. name for $Na_2[Fe(CN)_5NO]$ complex:

(a) Sodiumpentacyanidonitrosoniumferrate(II)

(b) Sodiumpentacyanidonitrosyliumferrate(II)

(c) Sodiumpentacyanidonitrosyl ferrate(II)

(d) Sodiumpentacyanidonitrosyliron(II)

48. Select the correct I.U.P.A.C. name for $[Fe(H_2O)_5(NO)]SO_4$:

(a) Pentaaquanitrosonium iron(I) sulphate

(b) Pentaaquanitrosyliumiron(I) sulphate

(c) Pentaaquanitrosyliron(II) sulphate

(d) Pentaaquanitrosoniumferrate(II) sulphate

49. Select the correct I.U.P.A.C. name for $[(NH_3)_4CoNH_2NO_2Co(NH_3)_4](NO_3)_4$:

(a) Tetraamminecobalt(III)-μ-amido-μ-nitrito-*n* tetraamminecobalt(III) nitrate

(b) μ-Amido-μ-nitrito-N-octaamminedicobalt(III) nitrate

(c) μ-Amido-μ-nitrito-N-bis (tetraammine) dicobalt(III) nitrate

(d) μ-Amido-μ-nitrito-O-octaamminedicobaltate(III) nitrate

50. $[Co(H_2O)_6]^{3+}$ complex is:

(a) High spin complex

(b) Having d^2sp^3-hybridization

(c) Low spin complex

(d) Having octahedral structure

51. Select the correct statement:

(a) $[Co(H_2O)_6]^{3+}$ is Co(III), low spin, 0 unpaired electron, diamagnetic

(b) $[CoF_6]^{3-}$ is Co(III), high spin d^6, 4 unpaired electron, paramagnetic

(c) $[RhF_6]^{3-}$ is Rh(III), low spin d^6, 0 unpaired electrons diamagnetic

(d) $[Fe(CN)_6]^{4-}$ is high spin d^6, 0 unpaired electron diamagnetic

52. Which of the following is/are example(s) of σ-bonded organometallic compound?

(a) $Al_2(CH_3)_6$ (b) $Pb(CH_3)_4$

(c) $Zn(C_2H_5)_2$ (d) Ferrocene

53. Which of the following is an example of π-bonded organometallic complex?

(a) Ferrocene (b) Dibenzenechromium

(c) $Zn(C_2H_5)_2$ (d) $Pb(C_2H_5)_4$

54. Which of the following statement(s) is/are incorrect?

(a) Metal carbonyls are the examples of only σ-bonded organometallic complexes

(b) Metal carbonyls are the examples of only π-bonded organometallic complexes

(c) Metal carbonyls are the examples of organometallic complexes which involve both σ- and π-bonds between metal and carbon of the carbonyl group

(d) Metal carbonyls involve both σ- and π-bonds between metal and oxygen of the carbonyl group

55. The coordination number of a central metal atom in a complex(s) is/are not determined by:

(a) The number of only anionic ligands bonded to the metal ion

(b) The number of ligands around a metal ion bonded by π-bonds

(c) The number of ligands around a metal ion bonded by both σ and π-bonds

(d) The number of ligands around a metal ion bonded by σ-bonds

56. Which of the following complex(s) is/are an example of homoleptic complex?

(a) $[Co(NH_3)_6]^{3+}$ (b) $[Cr(H_2O)_6]^{3+}$

(c) $[Ni(NH_3)_6]^{2+}$ (d) $[Ni(NH_3)_4Cl_2]$

57. The complex $K_4[Zn(CN)_4(O_2)_2]$ is oxidized into $K_2[Zn(CN)_4(O_2)_2]$, then which of the following is/are correct:

(a) Zn(II) is oxidized into Zn(IV)

(b) Paramagnetic moment decreases

(c) O — O bond length decreases

(d) Paramagnetic moment increases

58. Which of the folloiwng is/are characteristic of a tetrahedral complex?

(a) $d_{x^2-y^2}$ and d_{z^2} orbitals are low energy orbitals

(b) Most tetrahedral complexes are high spin

(c) Crystal field splitting is found double in octahedral complexes

(d) Splitting pattern in tetrahedral complex is just opposite of that in octahedral complexes

59. A *d*-block element forms octahedral complex, but its spin magnetic moment remains same either in strong field or in weak field ligand. Which of the following is /are correct?

(a) Element always forms colorless compound

(b) Number of electrons in t_{2g} orbitals are higher than in e_g orbitals

(c) It can have either d^3 or d^8 configuration

(d) It can have either d^7 or d^8 configuration

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

(A) When $CuSO_4$ solution is treated with aqueous ammonia solution in 1 : 4 molar ratio, species formed, no longer, gives test of Cu^{2+}.

(B) When $FeSO_4$ solution is treated with $(NH_4)_2SO_4$ solution, species formed gives test of Fe^{2+}, NH_4^+, and SO_4^{2-}.

1. Species formed in experiment (A) does not give test of Cu^{2+}. It is due to the formation of:

(a) $[Cu(NH_3)_4]Cl$ (b) $[Cu(NH_3)_4]SO_4$

(c) $Cu(OH)_2$ (d) Cu

2. Species formed in experiment (B) is:

(a) Complex (b) Double salt

(c) Liquid crystal (d) None of these

3. EAN of copper formed in (A) is:

(a) 26 (b) 35

(c) 36 (d) 38

Comprehension-2: (Q. 4 to Q. 6)

One cationic complex has two isomers *A* and *B*. Each has one Co^{3+}, five NH_3, one Br^-, and one SO_4^{2-} stoichiometrically. *A* gives white ppt with $BaCl_2$ while *B* give yellow ppt with $AgNO_3$.

4. *A* can be:

(a) $[Co(NH_3)_5]BrSO_4$ (b) $[Co(NH_3)_5SO_4]Br$

(c) $[Co(NH_3)_5Br]SO_4$ (d) $[Co(NH_3)_4SO_4]Br\cdot NH_3$

5. *B* can be:

(a) $[Co(NH_3)_5SO_4]Br$ (b) $[Co(NH_3)_5Br]SO_4$

(c) $[Co(NH_3)_3Br(SO_4)] . 2NH_3$

(d) None of these

6. Complexes *A* and *B* have similarity in which type of isomerism?

(A) Hydrate (B) Ionization

(C) Linkage (D) Coordination

Comprehension-3: (Q. 7 and Q. 8)

The atoms or ions with available low-energy orbitals can attract loosely bonded pair of electrons from other molecules. A higher amount of positive charge on the side atom or ion makes its orbitals even more attractive for the loosely bonded electron pairs. The molecules with loosely bonded pairs also have different polarizabilities. The higher size of surrounding molecules and lower size of atom offering low energy orbitals increases crowding and diminishes the tendency of bonding.

7. Which is most stable?

(a) $[NiCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$

(c) $[Pd(CN)_4]^{2-}$ (d) $[Pt(CN)_4]^{2-}$

8. Which is strongest donor?

(a) Cl^- (b) ^-OH

(c) NH_3 (d) ^-CN

Comprehension-4: (Q. 9 to Q. 11)

A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms, (*X*) and (*Y*). The form (*X*) reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas (*Y*) gives a pale yellow precipitate soluble in concentrate ammonia.

9. Choose the true statement regarding compounds *X* and *Y*:

(a) Both compounds *X* and *Y* have different magnetic moment (spin only)

(b) Both complexes *X* and *Y* have same magnetic moment (spin only)

(c) Magnetic moment of both *X* and *Y* is calculated by assuming they are low-spin complex

(d) Both compounds *X* and *Y* have different primary valency

10. The hybridization of compound *X* and *Y* is respectively:
(a) sp^3d^2, d^2sp^3 (b) sp^3d^2, sp^3d^2
(c) d^2sp^3, d^2sp^3 (d) d^2sp^3, sp^3d^2

11. Choose the correct statement regarding the complexes *X* and *Y*:
(I) Both complexes have the same six geometrical isomer.
(II) Both complexes have nearly the same conductivity in H_2O.
(III) In both complexes, NH_3 is involved only to secondary valency.
(IV) In both complexes, electronic configuration of t_{2g} is same.
(a) I, II, and III (b) I, II, III, and IV
(c) II, III, and IV (d) I, III, and IV

Comprehension-5: (Q. 12 to Q. 14)

Square planar complexes are formed by d^8 ions with strong field ligands. The crystal field splitting Δ_o is larger for the second and third row transition elements and for more highly charged species. All the complexes having $4d^8$ and $5d^8$ configurations are mostly square planar including those with weak field ligands such as halide ions. Square planar complexes can show geometrical isomerism but they do not show optical isomerism due to the presence of plane of symmetry.

12. Which of the following complex is low spin?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Ni(CO)_4]$
(c) $[Pt(NH_3)_4]^{2+}$ (d) All are low spin complex

13. Among the following complex which has a square planar geometry?
(a) $[RhCl(CO)(PPh_3)_2]$ (b) $K_3[Cu(CN)_4]$
(c) $K_2[Zn(CN)_4]$ (d) $[Ni(CO)_4]$

14. Which of the following molecule has synergic bonding?
(a) $[Fe(Phen)_3]^{3+}$
(b) $[Fe(\pi\text{-}C_5H_5)_2]$
(c) $[RhCl(PPh_3)_3]$
(d) all are having synergic bonding

Comprehension-6: (Q. 15 to Q. 18)

The pi acceptor ligand are those which posses vacant π-orbitals in addition to the lone pairs of $e^{\ominus}$:

15. Which of the following complex/ion has highest C—O bond length?
(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$
(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

16. Which of the following complex/ion has lowest C—O bond order?
(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$
(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

17. Which of the following complex/ion has highest M—C bond order?
(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$
(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

18. Which of the following complex/ion has lowest M—C bond length?
(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$
(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

Comprehension-7: (Q. 19 to Q. 21)

The π acid ligands donate their lone pairs to the metal to form a normal σ bond with the latter in addition to it, the vacant orbitals accept $e^{\ominus}$ from the filled metal orbitals to form a type of π-bond which suppliments the σ bond.

19. Which of the following has lowest *M*—C bond order?
(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$
(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

20. Which of the following has lowest *M*—C bond length?
(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$
(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

21. Which of the following has lowest C—O bond length?
(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$
(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

Comprehension-8: (Q. 22 to Q. 24)

Most of the metal carbonyls obey inert gas rule which states that the compounds in which the central metal atom appears to have attained the configuration of a noble gas either by the sharing or by the transfernce of electrons tend to be more stable.

22. Which of the following has highest C—O bond length?
(a) $[Ni(CO)_4]$ (b) $[CoCO_4]^{\ominus}$
(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

23. Which of the following has lowest C—O bond order?
(a) $[Ni(CO)_4]$ (b) $[CoCO_4]^{\ominus}$
(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

24. Select the correct order of C—O bond length:

(a) $[M(CO)_3(PF_3)] < [M(CO)_3(PCl_3)] < [M(CO)_3(PMe_3)]$

(b) $[M(CO)_3(PF_3)] > [M(CO)_3(PCl_3)] > [M(CO)_3(PMe_3)]$

(c) $[M(CO)_3(PF_3)] = [M(CO)_3(PCl_3)] = [M(CO)_3(PMe_3)]$

(d) $[M(CO)_3(PF_3)] = [M(CO)_3(PCl_3)] > [M(CO)_3(PMe_3)]$

Comprehension-9: (Q. 25 to Q. 27)

The great scientist **LAXMI** isolated two complexes and in chemical abstract, she reported "A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms, (A) and (B). The form (A) reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas (B) gives a pale yellow precipitate soluble in concentrated ammonia.

25. Complexes A and B are respectively:

(a) $[Cr(NH_3)_4Cl_2]Br$, $[Cr(NH_3)_4Br]Cl_2$

(b) $[Cr(NH_3)_4Br]Cl_2$, $[Cr(NH_3)_4Cl_2]Br$

(c) $[Cr(NH_3)_4ClBr]Cl$, $[Cr(NH_3)_4Cl_2]Br$

(d) $[Cr(NH_3)_4Cl_2]Br$, $[Cr(NH_3)_4ClBr]Cl$

26. Cr atom is..............hybridized.

(a) sp^3d^2 in both complexes

(b) d^2sp^3 in both complexes

(c) sp^3d^2 in A and d^2sp^3 in B

(d) d^2sp^3 in A and sp^3d^2 in B

27. EAN and magnetic moment of Cr in A and B are:

(a) 33, $\sqrt{15}$ B.M. (b) 36, $\sqrt{15}$ B.M.

(c) 33, $\sqrt{24}$ (d) 36, $\sqrt{24}$ B.M.

Comprehension-10: (Q. 28 to Q. 30)

$Ni^{II}(NH_3)_4(NO_3)_2 \cdot 2H_2O$ molecule may have two unpaired electrons or zero unpaired electron and measurement of magnetic moment helps us to predict the geometry.

28. If magnetic moment value is zero, then the formula of the complex will be:

(a) $[Ni(NH_3)_4](NO_3)_2 \cdot 2H_2O$

(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2 \cdot 2NH_3$

(c) $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

(d) $[Ni(NO_3)_2(H_2O)_2] \cdot 4NH_3$

29. If the magnetic moment value is $2\sqrt{2}$ and conducts electricity, then the formula of the complex is:

(a) $[Ni(NH_3)_4](NO_3)_2 \cdot 2H_2O$

(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2 \cdot 2NH_3$

(c) $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

(d) $[Ni(NH_3)_4(NO_3)_2] \cdot 2H_2O$

30. The higher and lower values of magnetic moment of the given complex corresponds to the following geometries, respectively:

(a) Octahedron and Tetrahedron

(b) Octahedron and square planar

(c) Square planar and Octahedron

(d) Octahedron and Octahedron

Comprehension-11: (Q. 31 to Q. 34)

A, B, and C are three complexes of chromium(III) with the empirical formula $H_{12}O_6Cl_3Cr$. All the three complexes have water and chloride ions as ligands. Complex A does not react with concentrated H_2SO_4, whereas complex B and C lose 6.75% and 13.5% of their original weights respectively on treatment with concentrated H_2SO_4.

31. Complex A is:

(a) $[Cr(H_2O)_6]Cl_3$

(b) $[Cr(H_2O)_5Cl]Cl_2 . H_2O$

(c) $[Cr(H_2O)_4Cl_2]Cl . 2H_2O$

(d) None of these

32. Loss in weight on treatment with concentrated H_2SO_4 is due to:

(a) Cl^- is lost as HCl

(b) Cr^{3+} is lost as $Cr_2(SO_4)_3$

(c) H_2O is lost due to absorption

(d) Cl^- is lost as Cl_2

33. How many coordinated water molecule(s) is/are present in complex C?

(a) 4 (b) 5

(c) 6 (d) 3

34. Select the correct statement:

(a) Conductance in these complexes is in order $C < B < A$

(b) EAN of chromium is identical in each complex

(c) Non-reactivity of A with conc. H_2SO_4 is due to absence of water molecules outside coordinated sphere

(d) All of the above are correct

Comprehension-12: (Q. 35 to Q. 37)

If in the mixed carbonyl, the other ligand is also pi acceptor, it would compete with the ligand CO for gaining the metal d_π electron charge. The higher is the extent of back donation in CO, the lesser will be the stretching vibration frequency for C—O bond. If PF_3 is better π-acceptor than CO, then answer the following.

35. Select the correct order of M—C bond order in the following molecule and ions:

(a) $[Ni(CO)_4] > [Co(CO)_4]^{\ominus} > [Fe(CO)_4]^{2-}$

(b) $[Ni(CO)_4] = [Co(CO)_4]^{\ominus} = [Fe(CO)_4]^{2-}$

(c) $[Co(CO)_4]^{\ominus} > [Fe(CO)_4]^{2-} > [Ni(CO)_4]$

(d) $[Ni(CO)_4] < [Co(CO)_4]^{\ominus} < [Fe(CO)_4]^{2-}$

36. Select the correct order of stretching vibration frequency C—O bond in following molecules:

(a) $[Ni(CO)_4] > [Ni(PF_3)(CO)_3]$

(b) $[Ni(CO)_4] < [Ni(CO)_3(PF_3)]$

(c) $[Ni(CO)_4] = [Ni(PF_3)(CO)_3]$

(d) Cannot be predicted

37. Select the correct order of C—O bond length in the following molecules:

(a) $[Mo(CO)_3\ (PF_3)_3] > [Mo(CO)_3\ (PCl_3)_3] > [Mo(CO)_3\ (P(Me)_3)_3]$

(b) $[Mo(CO)_3\ (P(Me)_3)_3] > [Mo(CO)_3\ (PF_3)_3] > [Mo(CO)_3\ (PCl_3)_3]$

(c) $[Mo(CO)_3\ (PCl_3)_3] > [Mo(CO)_3\ (P(Me)_3)_3] > [Mo(CO)_3\ (PF_3)_3]$

(d) $[Mo(CO)_3\ (PF_3)_3] < [Mo(CO)_3\ (PCl_3)_3] < [Mo(CO)_3\ (P(Me)_3)_3]$

Comprehension-13: (Q. 38 and Q. 39)

In the manufacture of iron, a gas (A) is formed in the zone of combustion of the blast furnace. The gas (A) reacted with coke in the zone of fusion to form another gas (B). X moles of (B) reacts with iron at 200°C and 100 atm pressure to form a compound (C).

38. The magnetic moment and effective atomic number of the (C) respectively are:

(a) 4.93 and 36 (b) 0 and 36

(c) 0 and 34 (d) None

39. The d orbital(s) involved in the formation of the complex (C) will be:

(a) d_{z^2} (b) $d_{x^2-y^2}$ and d_{z^2}

(c) dxy and $d_{x^2-y^2}$ (d) $d_{x^2-y^2}$

Comprehension-14: (Q. 40 and Q. 41)

Valence bond theory describes the bonding in complexes in terms of coordinate–covalent bonds resulting from overlap of filled ligand orbitals with vacant metal hybrid orbitals. This theory explains magnetic behavior and geometrical shape of coordination compounds. Magnetic moment of a complex compound can be determined experimentally and theoretically by using spin only formula.

Magnetic moment = $\sqrt{n(n+2)}$ B.M. (where n = No. of unpaired electrons).

40. The value of spin only magnetic moment for octahedral complex of the following configuration is 2.84 B.M. The correct statement is:

(a) d^4 (in weak field ligand)

(b) d^2 (in weak field and in strong field ligand)

(c) d^3 (in weak field and in strong field ligand)

(d) d^6 (in strong field ligand)

41. Ni^{2+} cation combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiCl_4]^{2-}$. The number of unpaired electron(s) in central metal cation and geometry of this complex respectively are:

(a) One, tetrahedral (b) Two, tetrahedral

(c) One, square planar (d) Two, square planar

Assertion-Reasoning Type

1. **Statement-1:** Complexes containing three bidentate ligands do not show optical activity.

Statement-2: Octahedral complex $[Co(NH_3)_4Cl_2]Cl$ shows geometrical isomerism.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

2. **Statement-1:** $Ni(CO)_4$ complex has no unpaired electrons.

Statement-2: $4s$-electrons of Ni atom enter into the inner d-orbitals to facilitate the dsp^2-hybridization in Ni atom.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

3. **Statement-1:** A solution of $[Ni(H_2O)_6]^{2+}$ is green but a solution of $[Ni(CN)_4]^{2-}$ is colorless.

Statement-2: $[Ni(CN)_4]^{2-}$ is square planar complex.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

4. **Statement-1:** Cu^+ ion is unstable in aqueous solution, whereas Fe^{2+} ion is stable.

Statement-2: Cu^+ disproportionate in aqueous solution.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

5. **Statement-1:** Δ_o increases in the order of $[CrCl_6]^{3-} < [Cr(CN)_6]^{3-} < [Cr(C_2O_4)_3]^{3-}$.

Statement-2: The stronger the ligand field, the higher will be Δ_o value.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

6. **Statement-1:** NO^+ has lower π accepting tendency than the CO.

Statement-2: NO donate 3 electrons into the vacant orbital of metal cation or atom.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

7. **Statement-1:** Hybridization of $[AuCl_4]^{\ominus}$ is sp^3.

Statement-2: Hybridization of Au in above complex compound does not depend upon nature of ligand.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

8. **Statement-1:** The d_{C-O} in bridging carbonyl group is longer than that of terminal carbonyl group.

Statement-2: With increase in extent of synergic bonding, the C — O bond length increases.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

9. **Statement-1:** $[M(AA)_3]^{n+}$ is optically inactive.

Statement-2: Plane of symmetry is not present and center of symmetry is not present.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) $[Ag(NH_3)_2]^+$	(p) Octahedral
(b) $[Cu(NH_3)_4]^{2+}$	(q) Tetrahedral
(c) $[Cr(H_2O)_6]^{2+}$	(r) Trigonal bipyramidal
(d) $[Fe(CO)_5]$	(s) Square planar
	(t) Linear

2. Match the column:

List-I	List-II
(a) $[Ni(CN)_4]^{2-}$	(p) Tetrahedral
(b) $[ZnCl_4]^{2-}$	(q) Square planar
(c) $[Co(en)_3]^{3+}$	(r) Octahedral
(d) $[Zn(NH_3)_4]^{2+}$	(s) Square pyramidal

3. Match the column:

Column-I (Complex)	Column-II (Conductance)
(a) $[Pt(NH_3)_5Cl]Cl_3$	(p) 229
(b) $[Pt(NH_3)_3Cl_3]Cl$	(q) 97
(c) $[Pt(NH_3)_4Cl_2]Cl_2$	(r) 404
(d) $[Pt(NH_3)_6]Cl_4$	(s) 523

4. Match the column *(unitary match):*

Column-I (Complex ion)	**Column-II (Value charge on complex ion)**
(a) $[Hg(CN)_4]^x$	(p) 3–
(b) $[Co(NH_3)_2Cl_4]^x$	(q) 2–
(c) $[Fe(CN)_6]^x$	(r) 1–
	(s) 2+

5. Match the complex (in Column-I) with the hybridization of the central ion (in Column-II):

Column-I	**Column-II**
(a) $Ni(CO)_4$	(p) sp^3d^2
(b) $[Ni(CN)_4]^{2-}$	(q) sp^3
(c) $[Fe(CN)_6]^{4-}$	(r) d^2sp^3
(d) $[MnF_6]^{4-}$	(s) dsp^2

6. Match the complex (in Column-I) with the geometry (in Column-II):

Column-I	**Column-II**
(a) $[Ni(dmg)_2]$	(p) Tetrahedral
(b) $[ZnCl_4]^{2-}$	(q) Trigonal bipyramidal
(c) $[Fe(CO)_5]$	(r) Square planar
(d) $[Co(NO_2)_6]^{4-}$	(s) Square pyramidal
	(t) Octahedral

7. Match the complex (in Column-I) with the oxidation number of Co (in Column-II):

Column-I	**Column-II**
(a) $[Co(NCS)(NH_3)_5]SO_4$	(p) –1
(b) $Na[Co(CO)_4]$	(q) 0
(c) $Na_4[Co(S_2O_3)_3]$	(r) +1
(d) $Co_2(CO)_8$	(s) +2
	(t) +3

8. Match the complex (in Column-I) with the type of isomerism (in Column-II) *(unitary match):*

Column-I	**Column-II**
(a) $[Co(NH_3)_4Cl_2]$	(p) Optical
(b) *cis*$[Co(en)_2Cl_2]$	(q) Ionization
(c) $[Co(en)_2(NO_2)Cl]SCN$	(r) Coordination
(d) $[Co(NH_3)_6][Cr(CN)_6]$	(s) Geometrical

9. Match the complex (in Column-I) with the unpaired electron of the central ion (in Column-II)

Column-I	**Column-II**
(a) $[Fe(H_2O)_6]^{2+}$	(p) 0
(b) $[Fe(H_2O)_6]^{3+}$	(q) 1
(c) $[Fe(CN)_6]^{4-}$	(r) 2
(d) $[Fe(CN)_6]^{3-}$	(s) 3
(e) $[Ni(H_2O)_4]^{2+}$	(t) 4
	(u) 5

10. Match the geometry (given in Column-I) with the complexes (given in Column-II) in:

Column-I	**Column-II**
(a) Octahedral	(p) $[Ni(CN)_4]^-$
(b) Square planar	(q) $Ni(CO)_4$
(c) Tetrahedral	(r) $[Fe(CN)_6]^{4-}$
	(s) $[Ni(CN)_4]^{4-}$

11. Match the column:

Column-I	**Column-II**
(a) Hexabromido-platinate (2–)	(p) Monodentate ligand is present in complex/ion
(b) Potassium diammine-tetrabromidoco-baltate (III)	(q) Negative ligand is present in complex ion or molecule
(c) Tris(ethylenediamine) copper(II) sulphate	(r) Neutral ligand is present in complex ion/molecule
(d) Hexacarbonyl-manganese (I) perchlorate	(s) Central atom of complex or ion is a member of 3*d* transition series
	(t) Octahedral structure of complex ion/molecule

12. Match the column:

Column-I	**Column-II**
(a) $[Pt(NH_3)_2Cl_2]$	(p) Square planar complex
(b) $[Pt\ Cl_2\ (en)]$	(q) Central atom is a member of 3*d* transition series
(c) $[Pt(NH_3)(NO_2)(py)\ NH_2OH)]$	(r) Complex which shows geometrical isomerism
(d) $[Zn(gly)_2]$	(s) Non-planar complex
	(t) Both neutral as well as negative ligand are present in complex

13. Match the column:

Column-I	**Column-II**
(a) [Mabcd]	(p) Complex which shows geometrical isomerism
(b) $[M(AB)_2]$	(q) Two geometrical isomers

(c) $[M(AA)b_2]$ (r) Chelating ligand is present in complex

(d) $[M(AB)(CD)]$. (s) Complex in which ligand has two same donor atom

14. Match the column:

Column-I	Column-II
(a) $[Pt(NH_3)_2Cl_4]$	(p) Complex molecule/ion in which neutral ligand is present
(b) $[Cr(en)_2Cl_2]^+$	(q) Complex which shows geometrical isomerism
(c) $[Cr(gly)_3]$	(r) d^2sp^3-hybridization is present in central atom of complex molecule/ion
(d) $[Cr(en)_3]^{3+}$	(s) Two geometrical isomers
	(t) Complex in which only nitrogen atom acts as donor atom

15. Match the following:

Column-I	Column-II
(a) $[Cr(en)_2Cl_2]^+$	(p) Optical isomerism
(b) $[Fe(CN)_6]^{3-}$	(q) d^2sp^3-hybridization
(c) $[Ni(NH_3)_6]^{2+}$	(r) Paramagnetic
(d) $[CoF_6]^{3-}$	(s) sp^3d^2-hybridization

16. Match the column:

Column-I	Column-II
(a) Two unpaired electron	(p) $[Ni(en)_3]^{2+}$
(b) No unpaired electron	(q) $[VF_6]^{3-}$
(c) Optical isomerism	(r) $[NiCl_2(SCN)_4]^{4-}$
(d) Inner orbital complex	(s) $[Fe(CN)_6]^{4-}$

17. Match the Column:

Column-I	Column-II
(a) $[Cu(NH_3)_4]SO_4$	(p) dsp^2
(b) $[Pt(NH_3)_2Cl_2]$	(q) Octahedral
(c) $K_4[Fe(CN)_6]$	(r) sp^3d^2
(d) $[Fe(H_2O)_6]Cl_3$	(s) Square planar

18. Match the following:

Column-I	Column-II
(a) $[Ni(NH_3)_6]^{2+}$	(p) d^2sp^3 and diamagnetic
(b) $[Cr(NH_3)_6]^{3+}$	(q) sp^3d^2 and diamagnetic
(c) $[Co(NH_3)_6]^{3+}$	(r) sp^3d^2 and two unpaired electrons
(d) $[Zn(NH_3)_6]^{2+}$	(s) d^2sp^3 and three unpaired electrons

19. Match the column:

Column-I (Type of complex)	Column-II (The change in number of stereoisomer by the associated process with the given complex)
(a) $[M(AB)_2ab]^{n\pm} \xrightarrow{-a/+b}$	(p) 2
(b) $[Ma_2b_2c_2]^{n\pm} \xrightarrow{-b/+d}$	(q) 6
(c) $[M(AA)_2a_2]^{n\pm} \xrightarrow{-a/+c}$	(r) 3
(d) $[M(AB)a_3b]^{n\pm} \xrightarrow{-a/+b}$	(s) 5
	(t) 0

20. Match the column:

Column-I	Column-II
(a) $K_4[Fe(CN)_6]$	(p) d^2sp^3-hybridization
(b) $K_3[Fe(CN)_6]$	(q) Octahedral geometry
(c) $Fe_4[Fe(CN)_6]_3$	(r) Blue color due to charge transfer
(d) $[Co(NH_3)_6]^{3+}$	(s) Six electrons are present in t_{2g} orbitals
	(t) E.A.N is 36

21. Match the column:

Column-I	Column-II
(a) $[Pt(en)Cl_2]$	(p) Bidentate ligand present in complex moelcule/ion
(b) $[Pt(ox)_2]^{2-}$	(q) dsp^2-hybridization
(c) $[Fe(OH)_4]^{\ominus}$	(r) Only monodentate ligand is present in complex molecule/ion
(d) $[Pt(NH_3)_4]^{2+}$	(s) Planar
	(t) sp^3-hybridization

22. Match the column:

Column-I	Column-II
(a) $[M(AA)b_2cd]^{n+}$	(p) Four optically active isomer
(b) $[Ma_3bcd]^{n+}$	(q) Four geometrical isomer
(c) $[M(AB)b_2c_2]^{n\pm}$	(r) All geometrical isomers are optically active
(d) $[M(AB)_3]^{n\pm}$	(s) Two pair of enantiomer
	(t) Two optically inactive isomer.

Note: $\widehat{AA}$, $\widehat{AB}$ a,b,c,d are not having chiral center.

23. Match the column:

Column-I	Column-II
(a) $[Cr(H_2O)_5Br]^{2+}$	(p) Paramagnetic in nature
(b) $[Cu(NH_2CH_2CH_2NH_2)Cl_4]^{2-}$	(q) Geometrical isomerism is exhibited
(c) $[Pt(ox)_2]^{2-}$	(r) Optical isomerism is exhibited
(d) $[Fe(OH)_4]^{\ominus}$	(s) Do not follow Sidgwick E.A.N. rule
	(t) Complex having symmetrical bidentate ligand

24. Match the column:

Column-I	Column-II
(a) $[Be(gly)_2]$	(p) Complex which shows geometrical isomerism
(b) $[Ni(gly)_2]$	(q) Complex which shows optical isomerism
(c) $[Zn(gly)_2]$	(r) Complex which has dsp^2-hybridized central atom
(d) $[Pt(gly)_2]$	(s) Complex which has sp^3-hybridized central atom
	(t) Complex which has *s*-block element

25. Match the column:

Column-I	Column-II
(a) $[M(AA)_3]$	(p) Complex molecule which shows optical isomerism
(b) $[M(AA)_2b_2]$	(q) Only one *cis* and one *trans* isomer
(c) $[M(AA)b_2c_2]$	(r) Only one *cis* and two *trans* isomer
(d) $[M(AA)b_2cd]$	(s) Four geometrical isomer
	(t) Complex in which any *cis* isomer is optical active

26. Match the column:

Column-I	Column-II
(a) $[Cr(CN)_3(NO_2)_3]^{4-}$	(p) Outer orbital complex
(b) $[Co(C_2O_4)_3]^{3-}$	(q) Inner orbital complex
(c) $[Fe(EDTA)]^{-}$	(r) $\mu = 2\sqrt{2}$ B.M.
(d) $[Ni(en)_3](NO_3)_2$	(s) Shows optical activity

27. Match the following:

Column-I	Column-II
(a) $[Cr(en)_3]^{3+}$	(p) Paramagnetic
(b) $[Mn(CN)_6]^{3-}$	(q) $\mu_{spin} = \sqrt{15}$ B.M.
(c) $[Co(H_2O)_6]^{2+}$	(r) Two unpaired electrons
(d) $[Fe(CN)_6]^{3-}$	(s) Inner orbital complex

28. Match the column:

Column-I (Complex)	Column-II
(a) $[Ni(CO)_4]$	(p) sp^3-hybridization
(b) $[Co(CO)_4]^{\ominus}$	(q) Tetrahedral
(c) $[Fe(CO)_4]^{2-}$	(r) E.A.N is 36
(d) $[Fe(CO)_5]$	(s) Neutral complex compound
	(t) Central atom is a member of 3*d*-transition series

29. Match the column:

Column–I	Column–II
(a) MnO_4^-	(p) d^3s-hybridization
(b) CrO_4^{2-}	(q) Tetrahedral structure
(c) $Cr_2O_7^{2-}$	(r) Diamagnetic but colorful species
(d) CrO_2Cl_2	(s) +6 oxidation state on central atom
	(t) All X—O bonds are identical (where X is central atom)

30. Match the column:

Column-I	Column-II
(a) $[Fe(CO)_4]^{2-}$	(p) Complex having lowest bond length of CO ligand
(b) $[V(CO)_6]^{\ominus}$	(q) Follow Sidgwick's rule of E.A.N.
(c) $K[PtCl_3(C_2H_4)]$	(r) Synergic bonding is involved in complex/ion
(d) $[Fe(H_2O)_5NO]SO_4$	(s) Complex having highest bond length of CO ligand
	(t) Oragnometallic compound

31. Match the column:

Column-I	Column-II (Number of unpaired electron)	μ (B.M.)
(a) $[Fe(NH_3)_6]^{2+}$	(p) 0	0
(b) $[MnO_4]^-$	(q) 5	5.9
(c) $[Mn(NH_3)_6]^{2+}$	(r) 1	1.73
	(s) 4	4.90

32. Match the column:

Column-I	Column-II (Property which is different in given pair)
(a) $K_4[Ni(CN)_4]$ and $[Ni(en)_3]S_2O_3$	(p) Number of unpaired electrons
(b) $K_4[NiF_6]$ and $K_2[NiF_6]$	(q) Magnetic behavior (i.e., para/dia)
(c) $K_4[Co(NO_2)_6]$ and $[Fe(H_2O)_6]Cl_3$	(r) Hybridization
	(s) Geometry

33. Match the column:

Column-I	Column-II
(a) $[Ma_2b_2c_2]$	(p) Six geometrical *cis* isomers
(b) $[Ma_4bc]$	(q) Four *trans* geometrical isomers
(c) $[Ma_2b_2cd]$	(r) Octahedral complex compound
(d) $[Ma_2bcde]$	(s) Five geometrical isomers
	(t) Only two geometrical isomer

34. Match the column:

Column-I	Column-II
(a) $[Ma_3bcd]$	(p) The number of stereoisomers are two
(b) $[Ma_3b_3]$	(q) The number of pair of enantiomer is zero
(c) $[Mabcdef]$	(r) The number of stereoisomers are five
(d) $[Ma_2b_2c_2]$	(s) The pair of enantiomer is one
	(t) The pairs of enantiomers are fifteen

35. Match the column:

Column-I	Column-II
(a) $[M(AB)_3]$	(p) Zero pair of enantiomers
(b) $[M(AB)(CD)ef]$	(q) Ten pairs of enantiomers
(c) $[Ma_3b_2c]$	(r) Four number of stereoisomers
(d) $[Ma_4bc]$	(s) Two geometrical isomers

36. Match the following:

Column-I	Column-II
(a) $[Ni(CO)_4]$	(p) sp^3-hybridization
(b) $[AgF_4]^-$	(q) Diamagnetic
(c) $[Zn(CN)_4]^{2-}$	(r) dsp^2
(d) $[RhCl(PPh_3)_3]$	(s) Only unidentate ligand
	(t) Paramagnetic

Integer Answer Type

1. Find the number of ligands which are negative as well as flexidentate.

   CO_3^{2-}, CH_3COO^-, $X^{\ominus}$, $H^{\ominus}$

2. Find the number of ligands which are monodentate as well as ambidentate.

   $\overset{\ominus}{C}N$, $C_2O_2S_2^{2-}$, NO_2^-, $\overset{\ominus}{O}CN$

3. Find the number of ligand(s) in which donor atom is only N.

   $NH_2CH_2COO^{\ominus}$, en, dien, Py, EDTA

4. Find the number of non-classical ligand which are negative ligand.

   $\overset{\ominus}{C}N$, $S_2O_3^{2-}$ $C_3H_5^{\ominus}$, $C_5H_5^{\ominus}$

5. Find the number of *cis* isomer in $[Ma_2b_2]$.
6. Find the number of facial isomers in Ma_3b_3 complex.
7. Find the number of optical isomers are in Ma_3b_2c complex.
8. Find the ratio of stereoisomers and geometrical isomers in Ma_3b_2c.
9. Find the ratio of *cis* isomer and *trans* isomer in $[M(AB)b_2c_2]$.
10. How many ions are produced by $K_4[Fe(CN)_6]$ in an aqueous solution?
11. How many precipitated ions are produced by $CrCl_3 \cdot 5NH_3$ in an aqueous solution?
12. How many unpaired $e^{\ominus}$ are present in $[Ni(CN)_4]^{2-}$?
13. How many atomic orbitals are involved in hybridization of $[Co(NH_3)_6]^{2+}$?
14. How many maximum possible coordinated water molecules are present in $CrCl_3 \cdot 4H_2O$ complex compound?
15. Find the number of strong field ligand(s) from the following:

NH_3, en, $\overset{\ominus}{Cl}$, CH_3COO^-, $\overset{\ominus}{C}N$

16. Find the number of weak field ligand(s) from the following:

$\overset{\ominus}{Cl}$, H_2O, Py, $NO_2^{\ominus}$

17. How many unpaired $e^{\ominus}$ are present in t_{2g} orbital of $[Cr(NH_3)_6]^{3+}$?
18. How many minimum coordinated $Cl^{\ominus}$ ions are present in $CoCl_2 \cdot Br \cdot 4NH_3$ complex?
19. Find the ratio of *trans*-isomers in $[M(AA)\ b_2c_2]$ and $[Ma_4b_2]$, respectively.
20. Find the number of total possible ionization isomers in $[Pt(NH_3)_4Cl_2]Br_2$.
21. Find the number of total possible coordination isomers in $[Pt(NH_3)_4][Cu(Cl)_4]$.
22. How many donor atoms are present in EDTA?
23. What is the oxidation state of central atom in $[PtCl_3C_2H_4]^{\ominus}$ ion?
24. What is the coordination number of Cu in $[Cu(en)_2]^{2+}$?
25. What is the oxidation number of central atom in $[Co(NH_3)_2(NO_2)_4]^{\ominus}$?
26. How many geometrical isomer(s) is/are possible in $[Pt(NH_3)(NH_2OH)\ Py(NO_2)]^{+}$?
27. How many EDTA (ethylenediamine tetraacetate) molecule(s) is/are required to make an octahedral complex with Ca^{2+}?
28. In hexacyanidomanganate(II) ion the Mn atom assumes d^2sp^3-hybrid states. Then the number of unpaired electrons in the complex is:
29. Find the total number of possible structural isomers of the compound $[\overset{II}{Cu}(NH_3)_4][\overset{II}{Pt}Cl_4]$.
30. In the complex $Ni(CO)_x$, find the value of x.
31. In tris(ethylenediamine) cobalt(III) chloride, find the coordination number of cobalt.
32. Find the number of geometrical isomers of $[Co(NH_3)_3(NO_2)_3]$.
33. Find the number of unpaired electron(s) in the complex ion $[CoF_6]^{3-}$.
34. The sum of primary and secondary valencies of chromium in the complex $CrCl_3 \cdot 6NH_3$ is:
35. The complex $[Co(NH_3)_3Cl_3]$ when dissolved in water gives how many ions?
36. Find the number of isomeric forms in which $[Co(NH_3)_4Cl_2]^{+}$ ion can occur.
37. Find the number of ions formed when copper ammonium sulphate is dissolved in water.
38. Find the number of ions furnished per molecule of the complex $[Ni(NH_3)_4]Cl_2$.
39. Predict the number of unpaired electrons in a tetrahedral d^6 ion and in a square planar d^7 ion.

Note: [If answer is 1 and 2, then represent as 12.]

40. Find the number of unpaired electron present in the *d*-orbitals (whose lobes are present along the axis) for the complex $[Co(SCN)_4]^{2-}$.
41. Find the total number of possible isomers (*cis-trans* and optical) of $CrCl_2\,en_2^{+}$.
42. Find the total number of possible isomers of $[CrCl_3(NH_3)_3]$.
43. Find the total number of possible isomers of $[CrCl_2(CN)(NH_3)en]$.
44. Find the number of unpaired electrons calculated in $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$.
45. Find out the number of 3*d* electrons occupied in t_{2g} orbitals of hydrated Cr^{3+} ion (octahedral).
46. Find the number of ligand(s) which is/are chelating.

en, $C_2O_4^{2-}$, acac, DMG, gly

47. Find the number of ligand(s) which is/are polydentate ligand.

en, dmg, dien, EDTA

48. Find the number of geometrical isomer in $[Pt(gly)_2]$.
49. Find the number of geometrical isomer in $[M(AB)_3]$.
50. How many unpaired $e^{\ominus}$ are present in e_g orbital of MnO_4^-?
51. How many $e^{\ominus}$ are present in d_{z^2} orbital of $[Ni(gly)_2]$?
52. How many coordinated water molecule(s) is/are present in brown ring complex?
53. Find the ratio of geometrical isomers in $[M(AA)_2b_2]$ and optical isomers of $[M(AA)_3]$.
54. What is the value of x in $H_x[Cr(CO)_5]$?
55. Write the sum of geometrical isomer in $[Ma_2b_2c_2]$ complex and stereoisomers in $[M(AB)_3]$ complex.
56. If $AgNO_3$ solution is added in excess to 1 *M* solution of $CoCl_3 \cdot XNH_3$, one mole of AgCl is formed. What is the value of x?
57. Predict the number of unpaired electrons for each of the following:

(i) A tetrahedral d^6 ion (ii) $[Co(H_2O)_6]^{2+}$
(iii) $[Cr(H_2O)_6]^{3+}$ (iv) A square planar d^7 ion
(v) A coordination compound with magnetic moment of 5.92 B.M.

58. Find the values of highest oxidation state of chromium:

59. Find the number of t_{2g} and e_g electrons in $[NiF_6]^{2-}$.
Note: [If answer is 4 and 2 then represent as 42.]

60. Find total possible stereoisomer for the molecule $[Ma_2bcde]^{n\pm}$ (where *a,b,c,d,e* are simple monodentate ligand having no chiral center).

61. Write the sum of geometrical isomers in $[Pt(H_2N-CH(CH_3)-COO^-)_2]$ complex and stereoisomers of $[Pt(gly)_3]^+$ complex.

62. Find the coordination number and oxidation number of *X* in the given compound $[X(NH_3)_5(SO_4)]Cl$.

63. Find the magnetic moment of a salt containing Zn^{2+} ion.

64. Find the number of ligand(s) which is/are ambidentate and bidentate.

$$\overset{\ominus}{S}CN, \overset{\ominus}{O}CN, S_2O_3^{2}, C_2O_2S_2^{2-}$$

65. Find the number of ligand(s) which is/are non-classical ligand.

$$CO,\ NO,\ C_2H_4,\ C_3H_5^{\ominus},\ H^{\ominus}$$

66. Find the number of ligand(s) which are monodentate, neutral as well as non-classical ligand.

$$CO,\ \overset{\ominus}{C}N,\ S_2O_3^{2-},\ PF_3$$

67. Find the number of ligands which are non-classical ligand and π donor as well as π acceptor ligand.

$$CO,\ PH_3,\ PF_3,\ C_3H_5^{\ominus},\ C_5H_5^{\ominus}$$

68. Find the number of stereoisomer in $[Pt(NH_2-CH(CH_3)COO^-)_2]$.

69. Find the number of geometrical isomers in $[Co(en)(Pn)(NO_2)_2]$.

$$en = \begin{array}{cc} CH_2- & CH_2 \\ | & | \\ H_2N & NH_2 \end{array} \qquad Pn = \begin{array}{cccc} NH_2- & CH_2- & \overset{*}{C}H- & NH_2 \\ & & | & \\ & & CH_3 & \end{array}$$

70. How many unpaired $e^{\ominus}$ are present in $[NiF_6]^{2-}$?

71. How many $e^{\ominus}$ are present in *d*-orbitals which are present along the axis in $[Ti(H_2O)_6]^{3+}$?

72. If Hund's rule violated, then how many unpaired $e^{\ominus}$ are present in $[Cr(NH_3)_6]^{3+}$ complex ion?

73. How many *d*-orbital(s) is/are involved in hybridization of $[AuCl_4]^{\ominus}$?

74. Find the oxidation state of Co in its oxo-complex species $[Co_2O_4(C_2H_4)_2(H_2O)_2]^{2-}$.

75. Find the oxidation state of NO in the brown ring complex $[Fe(H_2O)_5NO]SO_4$.

76. Find the number of ions formed on dissolving one molecule of $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ in water.

77. How many pairs of enantiomers are possible for $[M(AA)(BC)de]$?

78. Find the total number of isomer of $[Be(gly)_2]$.

79. Number of pair of enantiomer of $[Ma_2b_2cd]$ is ________ .

80. Find the number of unpaired electrons in t_{2g}-set of *d*-orbitals in $[Co(H_2O)_3F_3]$ complex.

81. The number of total possible stereoisomers for $[Pd(NH_2-CH(CH_3)-CO_2^-)_2]^{\circ}$ is:

82. What are the values of *m* and *n* in the anionic species $[V(CO)_m]^{n-}$, if it is following Sidgwick E.A.N. rule and having octahedral shape?

83. Find the total number of possible isomers of $[ZnCl_2F_2]^{2-}$.

84. How many maximum atom(s) is/are present in same plane of $Cr(CO)_6$?

85. An alcoholic solution of dimethylglyoxime is added to an aqueous solution of nickel(II) chloride. Slow addition of ammonium hydroxide lead to the precipitation of a Rosy-red colored metal complex. Then find out the number of hydrogen bonds present in the structure of the complex.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Which of the following complexes formed by Cu^{2+} ions is most stable?
   (a) $Cu^{2+} + 4NH_3 \quad [Cu(NH_3)_4]^{2+}$, $\log K = 11.6$
   (b) $Cu^{2+} + 4CN^- \quad [Cu(CN)_4]^{2-}$, $\log K = 27.3$
   (c) $Cu^{2+} + 2en \quad [Cu(en)_2]^{2+}$, $\log K = 15.4$
   (d) $Cu^{2+} + 4H_2O \quad [Cu(H_2O)_4]^{2+}$, $\log K = 8.9$

2. The color of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[Co(NH_3)_6]^{3-}$, $[Co(CN)_6]^{3-}$, $[Co(H_2O)_6]^{3+}$:
   (a) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [[Co(H_2O)_6]^{3+}$
   (b) $[Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+} > [Co(CN)_6]^{3-}$
   (c) $[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$
   (d) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$

3. When 0.1 mol $CoCl_3(NH_3)_5$ is treated with excess of $AgNO_3$, 0.2 mol of AgCl are obtained. The conductivity of solution will correspond to
   (a) 1:3 electrolyte (b) 1:2 electrolyte
   (c) 1:1 electrolyte (d) 3:1 electrolyte

4. When 1 mol $CrCl_3 \cdot 6H_2O$ is treated with excess of $AgNO_3$, 3 mol of AgCl are obtained. The formula of the complex is:
   (a) $[CrCl_3(H_2O)_3] \cdot 3H_2O$
   (b) $[CrCl_2(H_2O)_4]Cl \cdot 2H_2O$
   (c) $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$
   (d) $[Cr(H_2O)_6]Cl_3$

5. The correct IUPAC name of $[Pt(NH_3)_2Cl_2]$ is:
   (a) Diamminedichloridoplatinum(II)
   (b) Diamminedichloridoplatinum(IV)
   (c) Diamminedichloridoplatinum(0)
   (d) Dichloridodiammineplatinum(IV)

6. The stabilization of coordination compounds due to chelation is called the chelate effect. Which of the following is the most stable complex species?
   (a) $[CoCl_6]^{-4}$ (b) $[Fe(SCN)_6]^{3-}$
   (c) $[Fe(C_2O_4)_3]^{3-}$ (d) $[Fe(H_2O)_6]^{3+}$

7. Indicate the complex ion which shows geometrical isomerism:
   (a) $[Cr(H_2O)_4Cl_2]^+$ (b) $[Pt(NH_3)_3Cl]^+$
   (c) $[Co(NH_3)_6]^{3+}$ (d) $[Co(CN)_5(NC)]^{3-}$

8. The CFSE for octahedral $[CoCl_6]^{4-}$ is 18,000 cm^{-1}. The CFSE for tetrahedral $[CoCl_4]^{2-}$ will be:
   (a) 18,000 cm^{-1} (b) 16000 cm^{-1}
   (c) 8000 cm^{-1} (d) 20000 cm^{-1}

9. Due to the presence of ambidentate ligands coordination compounds show isomerism. Palladium complexes of the type $[Pd(C_6H_5)_2(SCN)_2]$ and $[Pd(C_6H_5)_2(NCS)_2]$ are:
   (a) Linkage isomers
   (b) Coordination isomers
   (c) Ionization isomers
   (d) Geometrical isomers

10. The compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ represent:
   (a) Linkage isomerism
   (b) Ionization isomerism
   (c) Coordination isomerism
   (d) No isomerism

11. A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent?
   (a) Thiosulphato (b) Oxalato
   (c) Glycinato (d) Ethane-1,2-diamine

12. Which of the following species is not expected to be a ligand?
   (a) NO (B) NH_4^+
   (c) $NH_2CH_2CH_2NH_2$ (d) CO

13. What kind of isomerism exists between $[Cr(H_2O)_6]Cl_3$ (violet) and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ (greyish-green)?
   (a) Linkage isomerism
   (b) Solvate isomerism
   (c) Ionization isomerism
   (d) Coordination isomerism

14. IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is:
   (a) Platinum diaminechloronitrite
   (b) Chloronitrito-N-ammineplatinum(II)
   (c) Diamminechloridonitrito-N-platinum(II)
   (d) Diamminechloronitrito-N-platinate(II)

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. Atomic number of Mn, Fe, and Co are 25, 26, and 27 respectively. Which of the following inner orbital octahedral complex ions are diamagnetic?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^{3-}$
   (c) $[Fe(CN)_6]^{4-}$ (d) $[Fe(CN)_6]^{3-}$

2. Atomic number of Mn, Fe, Co, and Ni are 25, 26, 27, and 28 respectively. Which of the following outer orbital octahedral complexes have same number of unpaired electrons?
   (a) $[MnCl_6]^{3-}$ (b) $[FeF_6]^{3-}$
   (c) $[CoF_6]^{3-}$ (d) $[Ni(NH_3)_6]^{2+}$

3. Which of the following options are correct for $[Fe(CN)_6]^{3-}$ complex?
   (a) d^2sp^3 hybridization (b) sp^3d^2 hybridization
   (c) Paramagnetic (d) Diamagnetic

4. An aqueous pink solution of cobalt(II) chloride changes to deep blue on addition of excess of HCl. This is because ______.
   (a) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_6]^{4-}$
   (b) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$
   (c) Tetrahedral complexes have smaller crystal field splitting than octahedral complexes
   (d) Tetrahedral complexes have larger crystal field splitting than octahedral complex

5. Which of the following complexes are homoleptic?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Co(NH_3)_4Cl_2]^+$
   (c) $[Ni(CN)_4]^{2-}$ (d) $[Ni(NH_3)_4Cl_2]$

6. Which of the following complexes are heteroleptic?
   (a) $[Cr(NH_3)_6]^{3+}$ (b) $[Fe(NH_3)_4 Cl_2]^+$
   (c) $[Mn(CN)_6]^{4-}$ (d) $[Co(NH_3)_4Cl_2]$
7. Identify the optically active compounds from the following:
   (a) $[Co(en)_3]^{3+}$ (b) *trans*- $[Co(en)_2Cl_2]^+$
   (c) *cis*- $[Co(en)_2 Cl_2]^+$ (d) $[Cr (NH_3)_5Cl]$
8. Identify the correct statements for the behavior of ethane-1, 2-diamine as a ligand.
   (a) It is a neutral ligand
   (b) It is a didentate ligand
   (c) It is a chelating ligand
   (d) It is a unidentate ligand
9. Which of the following complexes show linkage isomerism?
   (a) $[Co(NH_3)_5 (NO_2)]^{2+}$ (b) $[Co(H_2O)_5CO]^{3+}$
   (c) $[Cr(NH_3)_5 SCN]^{2+}$ (d) $[Fe(en)_2Cl_2]^+$

Short Answer Type

1. Arrange the following complexes in the increasing order of conductivity of their solution: $[Co(NH_3)_3Cl_3]$, $[Co(NH_3)_4Cl_2]Cl$, $[Co(NH_3)_6]Cl_3$, $[Cr(NH_3)_5Cl]Cl_2$
2. A coordination compound $CrCl_3 \cdot 4H_2O$ precipitates silver chloride when treated with silver nitrate. The molar conductance of its solution corresponds to a total of two ions. Write structural formula of the compound and name it.
3. A complex of the type $[M(AA)_2X_2]^{+n}$ is known to be optically active. What does this indicate about the structure of the complex? Give one example of such complex.
4. Magnetic moment of $[MnCl_4]^{2-}$ is 5.92 BM. Explain giving reason.
5. On the basis of crystal field theory explain why Co(III) forms paramagnetic octahedral complex with weak field ligands whereas it forms diamagnetic octahedral complex with strong field ligands.
6. Why are low spin tetrahedral complexes not formed?
7. Give the electronic configuration of the following complexes on the basis of crystal field splitting theory. $[CoF_6]^{3-}$, $[Fe(CN)_6]^{4-}$ and $[Cu(NH_3)_6]^{2+}$.
8. Explain why $[Fe(H_2O)_6]^{3+}$ has magnetic moment value of 5.92 BM whereas $[Fe(CN)_6]^{3-}$ has a value of only 1.74 BM.
9. Arrange the following complex ions in increasing order of crystal field splitting energy (O): $[Cr(Cl)_6]^{3-}$, $[Cr(CN)_6]^{3-}$, $[Cr(NH_3)_6]^{3+}$.
10. Why do compounds having similar geometry have different magnetic moment?
11. $CuSO_4 \cdot 5H_2O$ is blue in color while $CuSO_4$ is colorless. Why?
12. Name the type of isomerism when ambidentate ligands are attached to central metal ion. Give two examples of ambidentate ligands.

Matching Column Type

Note: In the following questions match the items given in Columns I and II.

1. Match the complex ions given in Column-I with the colors given in Column-II and assign the correct code:

Column-I (Complex ion)	Column-II (Color)
(a) $[Co(NH_3)_6]^{3+}$	(p) Violet
(b) $[Ti(H_2O)_6]^{3+}$	(q) Green
(c) $[Ni(H_2O)_6]^{2+}$	(r) Pale blue
(d) $[Ni(H_2O)_4 (en)]^{2+}$ (aq)	(s) Yellowish orange
	(t) Blue

Code:
(a) a (p) b (q) c (s) d (t)
(b) a (s) b (r) c (q) d (p)
(c) a (r) b (q) c (s) d (p)
(d) a (s) b (p) c (q) d (r)

2. Match the coordination compounds given in Column-I with the central metal atoms given in Column-II and assign the correct code:

Column-I (Coordination compound)	Column-II (Central metal atom)
(a) Chlorophyll	(p) Rhodium
(b) Blood pigment	(q) Cobalt
(c) Wilkinson catalyst	(r) Calcium
(d) Vitamin B12	(s) Iron
	(t) Magnesium

Code:
(a) a (t) b (s) c (p) d (q)
(b) a (r) b (s) c (t) d (p)
(c) a (s) b (r) c (q) d (p)
(d) a (r) b (s) c (p) d (q)

3. Match the complex ions given in Column-I with the hybridization and number of unpaired electrons given in Column-II and assign the correct code:

Column-I (Complex ion)	Column-II (Hybridization, number of unpaired electrons)
(a) $[Cr(H_2O)_6]^{3+}$	(p) dsp^2, 1
(b) $[Co(CN)_4]^{2-}$	(q) sp^3d^2, 5
(c) $[Ni(NH_3)_6]^{2+}$	(r) d^2sp^3, 3
(d) $[MnF_6]^{4-}$	(s) sp^3, 4
	(t) sp^3d^2, 2

Code:

(a) a (r) b (p) c (t) d (q)

(b) a (s) b (r) c (q) d (p)

(c) a (r) b (q) c (s) d (p)

(d) a (s) b (p) c (q) d (r)

4. Match the complex species given in Column-I with the possible isomerism given in Column-II and assign the correct code:

Column-I (Complex species)	Column-II (Isomerism)
(a) $[Co(NH_3)_4Cl_2]^+$	(p) Optical
(b) cis-$[Co(en)_2Cl_2]^+$	(q) Ionization
(c) $[Co(NH_3)_5(NO_2)]Cl_2$	(r) Coordination
(d) $[Co(NH_3)_6][Cr(CN)_6]$	(s) Geometrical
	(t) Linkage

Code:

(a) a (p) b (q) c (s) d (t)

(b) a (s) b (r) c (q) d (p)

(c) a (s) b (p) c (t) d (r)

(d) a (s) b (p) c (q) d (r)

5. Match the compounds given in Column-I with the oxidation state of cobalt present in it (given in Column-II) and assign the correct code.

Column-I (Compound)	Column-II (Oxidation state of Co)
(a) $[Co(NCS)(NH_3)_5](SO_3)$	(p) + 4
(b) $[Co(NH_3)_4Cl_2]SO_4$	(q) 0
(c) $Na_4[Co(S_2O_3)_3]$	(r) + 1
(d) $[Co_2(CO)_8]$	(s) + 2
	(t) + 3

Code:

(a) a (p) b (q) c (s) d (t)

(b) a (s) b (r) c (q) d (p)

(c) a (t) b (p) c (s) d (q)

(d) a (s) b (p) c (q) d (r)

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are true, reason is correct explanation of assertion.

(b) Assertion and reason both are true but reason is not correct.

(c) Assertion is true, reason is false.

(d) Assertion is false, reason is true.

1. **Assertion:** Toxic metal ions are removed by the chelating ligands.

   Reason: Chelate complexes tend to be more stable.

2. **Assertion:** $[Cr(H_2O)_6]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are reducing in nature.

   Reason: Unpaired electrons are present in their d-orbitals.

3. **Assertion:** Linkage isomerism arises in coordination compounds containing ambidentate ligand.

   Reason: Ambidentate ligand has two different donor atoms.

4. **Assertion:** Complexes of MX_6 and MX_5L type (X and L are unidentate) do not show geometrical isomerism.

   Reason: Geometrical isomerism is not shown by complexes of coordination number 6.

5. **Assertion:** $[Fe(CN)_6]^{3-}$ ion shows magnetic moment corresponding to two unpaired electrons.

   Reason: Because it has d^2sp^3 type hybridization.

Long Answer Type

1. Using crystal field theory, draw energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value in the following:

   (i) $[CoF_6]^{3-}$, $[Co(H_2O)_6]^{2+}$, $[Co(CN)_6]^{3-}$

   (ii) $[FeF_6]^{3-}$, $[Fe(H_2O)_6]^{2+}$, $[Fe(CN)_6]^{4-}$

2. Using valence bond theory, explain the following in relation to the complexes given below: $[Mn(CN)_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $[Cr(H_2O)_6]^{3+}$, $[FeCl_6]^{4-}$

(i) Type of hybridization
(ii) Inner or outer orbital complex
(iii) Magnetic behavior.
(iv) Spin only magnetic moment value

3. $CoSO_4Cl_5NH_3$ exists in two isomeric forms 'A' and 'B'. Isomer 'A' reacts with $AgNO_3$ to give white precipitate, but does not react with $BaCl_2$. Isomer 'B' gives white precipitate with $BaCl_2$ but does not react with $AgNO_3$. Answer the following questions.
   (i) Identify 'A' and 'B' and write their structural formulas.
   (ii) Name the type of isomerism involved.
   (iii) Give the IUPAC name of 'A' and 'B'.

4. What is the relationship between observed color of the complex and the wavelength of light absorbed by the complex?

5. Why are different colors observed in octahedral and tetrahedral complexes for the same metal and same ligands?

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. A square planar complex is formed by hybridization of which atomic orbitals?
   (a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$
   (c) s, p_x, p_y, d_{y^2} (d) s, p_y, p_z, d_{xy}
   (AIEEE, 2002)

2. The type of isomerism present in nitropentamine chromium(III) chloride is:
   (a) Optical (b) Linkage
   (c) Ionization (d) Polymerization
   (AIEEE, 2002)

3. CH_3–Mg–Br is an organometallic compound due to:
   (a) Mg–Br bond (b) C–Mg bond
   (c) C–Br bond (d) C–H bond
   (AIEEE, 2002)

4. The most stable ion is:
   (a) $[Fe(OH)_3]^{3-}$ (b) $[Fe(Cl)_6]^{3-}$
   (c) $[Fe(CN)_6]^{3-}$ (d) $[Fe(H_2O)_6]^{3-}$
   (AIEEE, 2002)

5. Ammonia forms the complex ion $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solutions but not in acidic solutions. What is the reason for it?
   (a) In acidic solutions, protons coordinate with ammonia molecules forming NH_4^+ ions and NH_3 molecules are not available
   (b) In alkaline solutions, insoluble $Cu(OH)_2$ is precipitated which is soluble in excess of any alkali
   (c) Copper hydroxide is an amphoteric substance
   (d) In acidic solutions, hydration protects copper ions
   (AIEEE, 2003)

6. One mole of the complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of $AgNO_3$ solution to yield two moles of AgCl(s). The structure of the complex is:
   (a) $[Co(NH_3)_3Cl_3] \cdot 2NH_3$
   (b) $[Co(NH_3)_4Cl_2] \cdot 2NH_3$
   (c) $[Co(NH_3)_4Cl]Cl_2 \cdot NH_3$
   (d) $[Co(NH_3)_5Cl] \cdot Cl_2$
   (AIEEE, 2003)

7. In the coordination compound, $K_4[Ni(CN)_4]$, the oxidation state of nickel is:
   (a) 0 (b) +1
   (c) +2 (d) –1
   (AIEEE, 2003)

8. Among the properties (i) reducing, (ii) oxidizing, and (iii) complexing, the set of properties shown by CN^- ion towards metal species is:
   (a) (iii) and (i) (b) (ii) and (iii)
   (c) (i) and (ii) (d) (i), (ii), and (iii)
   (AIEEE, 2004)

9. The coordination number of a central metal atom in a complex is determined by:
   (a) The number of ligands around a metal ion bonded by both sigma and pi-bonds
   (b) The number of ligands around a metal ion bonded by pi-bonds
   (c) Number of ligands around a metal ion bonded by sigma bonds
   (d) The number of only anionic ligands bonded to the metal ion
   (AIEEE, 2004)

10. Which one of the following complexes is an outer orbital complex?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^4$
   (c) $[Fe(CN)_6]^{4-}$ (d) $[Ni(NH_3)_6]^{2+}$
   (AIEEE, 2004)

11. Coordination compounds have great importance in biological systems. In this context, which of the following statements is incorrect?
(a) Cyanocobalamin is B_{12} and contains cobalt
(b) Hemoglobin is the red pigment of blood and contains irons
(c) Chlorophylls are green pigments in plants and contain calcium
(d) Carboxypeptidase-A is an enzyme and contains zinc

(AIEEE, 2004)

12. Which one of the following has the largest number of isomers?
(a) $[Ir(PR_3)_2H(CO)]^{2+}$
(b) $[Co(NH_3)_5Cl]^{2+}$
(c) $[Ru(NH_3)_4Cl_2]^{+}$
(d) $[Co(en)_2Cl_2]^{+}$ (R = alkyl group, en = ethylenediamine)

(AIEEE, 2004)

13. The correct order of magnetic moments [spin only values in Bohr Magneton (B.M.)] among is:
(a) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$
(b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$
(c) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$
(d) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$

(AIEEE, 2004)

14. The oxidation state of Cr in $[Cr(NH_3)_4 Cl_2]^{+}$ is:
(a) 0 (b) +1
(c) +2 (d) +3

(AIEEE, 2005)

15. The IUPAC name of the coordination compound $K_3[Fe(CN)_6]$ is:
(a) Tripotassium hexacyanoiron(II)
(b) Potassium hexacyanoiron(II)
(c) Potassium hexacyanoferrate(III)
(d) Potassium hexacyanoferrate(II)

(AIEEE, 2005)

16. Which of the following compounds shows optical isomerism?
(a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
(c) $[ZnCl_4]^{2-}$ (d) $[Cu(NH_3)_4]^{2+}$

(AIEEE, 2005)

17. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behavior?
(a) $[Co(CN)_6]^{3-}$ (b) $[Fe(CN)_6]^{3-}$
(c) $[Mn(CN)_6]^{3}$ (d) $[Cr(CN)_6]^{3}$

(AIEEE, 2005)

18. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is:
(a) d^5 (in strong ligand field)
(b) d^3 (in weak as well as in strong fields)
(c) d^4 (in weak ligand fields)
(d) d^4 (in strong ligand fields)

(AIEEE, 2005)

19. The IUPAC name for the complex $[Co(NO_2)(NH_3)_5Cl_2]$ is:
(a) Pentaammine nitrito-N-cobalt(II) chloride
(b) Pentaammine nitrito-N-cobalt(III) chloride
(c) Nitrito-N-pentaamminecobalt(III) chloride
(d) Nitrito-N-pentaamminecobalt(II) chloride

(AIEEE, 2006)

20. A metal, M, forms chlorides in its +2 and +4 oxidation states. Which of the following statements about these chlorides is correct?
(a) MCl_2 is more ionic than MCl_4
(b) MCl_2 is more easily hydrolysed than MCl_4
(c) MCl_2 is more volatile than MCl_4
(d) MCl_2 is more soluble in anhydrous ethanol than MCl_4

(AIEEE, 2006)

21. Nickel (Z = 28) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiX_4]^{2-}$. The number of unpaired electron(s) in nickel and geometry of this complex ion are, respectively:
(a) One, square planar
(b) Two, square planar
(c) One, tetrahedral
(d) Two, tetrahedral

(AIEEE, 2006)

22. In $Fe(CO)_5$, the Fe–C bond possesses:
(a) Ionic character
(b) σ-character only
(c) π-character
(d) Both σ- and π-characters

(AIEEE, 2006)

23. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion?
(a) One (b) Two
(c) Six (d) Three

(AIEEE, 2006)

24. The 'spin-only' magnetic moment [in units of Bohr magneton, (m_B)] of Ni^{2+} in aqueous solution would be (atomic number of Ni = 28):
   (a) 6 (b) 1.73
   (c) 2.84 (d) 4.90
   (AIEEE, 2006)

25. Which of the following has a square planar geometry?
   (a) $[PtCl_4]^{2-}$ (b) $[(CoCl_4]^{2-}$
   (c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$
   (AIEEE, 2007)

26. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)]NO_2$, where (en) is ethylene diamine, are, respectively:
   (a) 6 and 2 (b) 4 and 2
   (c) 4 and 3 (d) 6 and 3
   (AIEEE, 2008)

27. In which of the following complexes of the Co (atomic no. = 27), will the magnitude of Δ_o be the highest?
   (a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
   (c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$
   (AIEEE, 2008)

28. Which of the following has an optical isomer?
   (a) $[Co(en)(NH_3)_2]^{2+}$
   (b) $[Co(H_2O)_4(en)]^{3+}$
   (c) $[Co(en)_2(NH_3)_2]^{3+}$
   (d) $[Co(NH_3)_3Cl]^{+}$

29. Which of the following pairs represent linkage isomers?
   (a) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
   (b) $[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
   (c) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
   (d) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$
   (AIEEE, 2009)

30. A solution containing 2.675 g of $CoCl_3 \cdot 6NH_3$ (molar mass = 267.5 g mol^{-1}) is passed through a cation exchanger. The chloride ions obtained in solution were treated with excess of $AgNO_3$ to give 4.78 g of AgCl (molar mass = 143.5 g mol^{-1}). The formula of the complex is:
   (a) $[Co(NH_3)_6]Cl_3$ (b) $[CoCl_2(NH_3)_4]Cl$
   (c) $[CoCl_3(NH_3)_3]$ (d) $[CoCl(NH_3)_5]Cl_2$
   (AIEEE, 2010)

31. Which one of the following has an optical isomer?
   (a) $[Zn(en)(NH_3)_2]^{2+}$ (b) $[Co(en)_3]^{3+}$
   (c) $[Co(H_2O)_4(en)]^{3+}$ (d) $[Zn(en)_2]^{2+}$
   (AIEEE, 2010)

32. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is wrong?
   (a) The complex involves d^2sp^3 hybridization and is octahedral in shape
   (b) The complex is paramagnetic
   (c) The complex is an outer orbital complex
   (d) The complex gives white precipitate with silver nitrate solution
   (AIEEE, 2011)

33. The magnetic moment (spin only) of $[NiCl_4]^{2-}$ is:
   (a) 1.82 BM (b) 5.46 BM
   (c) 2.82 BM (d) 1.41 BM
   (AIEEE, 2011)

34. Among the ligands NH_3, en, CN^-, and CO, the correct order of their increasing field strength is:
   (a) $NH_3 < en < CN^- < CO$
   (b) $CN^- < NH_3 < CO < en$
   (c) $en < CN^- < NH_3 < CO$
   (d) $CO < NH_3 < en < CN^-$
   (AIEEE, 2011)

35. Which one of the following complex ions has geometrical isomers?
   (a) $[Ni(NH_3)_5Br]^{+}$
   (b) $[Co(NH_3)_2(en)_2]^{3+}$
   (c) $[Cr(NH_3)_4(en)_2]^{3+}$
   (d) $[Co(en)_3]^{3+}$ (en = ethylenediamine)
   (AIEEE, 2011)

36. Which among the following will be named as dibromidobis (ethylene diamine) chromium(III) bromide?
   (a) $[Cr(en)_3]Br_3$ (b) $[Cr(en)_2Br_2]Br$
   (c) $[Cr(en)Br_4]^{-}$ (d) $[Cr(en)Br_2]Br$
   (AIEEE, 2012)

37. Which of the following complex species is not expected to exhibit optical isomerism?
   (a) $[Co(en)_3]^{3+}$ (b) $[Co(en)_2Cl_2]^{+}$
   (c) $[Co(NH_3)_3Cl_3]$ (d) $[Co(en)(NH_3)_2Cl_2]^{+}$
   (JEE Main, 2013)

38. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3, and L4 absorb wavelength in the region of red, green, yellow, and blue, respectively. The increasing order of ligand strength of the four ligands is:

(a) $L_3 < L_2 < L_4 < L_1$ (2) $L_1 < L_2 < L_4 < L_3$
(c) $L_4 < L_3 < L_2 < L_1$ (4) $L_1 < L_3 < L_2 < L_4$

(JEE Main, 2014)

39. The equation which is balanced and represents the correct product(s) is:

(a) $[Mg(H_2O)_6]^{2+} + (EDTA)^{4-} \xrightarrow{\text{excess NaOH}} [Mg(EDTA)]^{2+} + 6H_2O$
(b) $CuSO_4 + 4KCN \rightarrow K_2[Cu(CN)_4] + K_2SO_4$
(c) $Li_2O + 2KCl \rightarrow 2LiCl + K_2O$
(d) $[CoCl(NH_3)_5]^{+} + 5H^{+} \rightarrow Co^{2+} + 5NH_4^{+} + Cl^{-}$

(JEE Main, 2014)

40. The correct statement about the magnetic properties of $[Fe(CN)_6]^{3-}$ and $[FeF_6]^{3-}$ is: (Z = 26).

(a) $[Fe(CN)_6]^{3-}$ is paramagnetic, $[FeF_6]^{3-}$ is diamagnetic
(b) Both are diamagnetic
(c) $[Fe(CN)_6]^{3-}$ is diamagnetic, $[FeF_6]^{3-}$ is paramagnetic
(d) Both are paramagnetic

(JEE Main, 2014)

41. An octahedral complex of Co^{3+} is diamagnetic. The hybridization involved in the formation of the complex is:

(a) d^2sp^3 (b) dsp^3d
(c) dsp^2 (d) sp^3d^2

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. AgCl dissolves in excess of KCN solution to give the __________ complex compound.

(IIT-JEE, 1980)

2. The type of magnetism exhibited by $[Mn(H_2O)_6]^{2+}$ ion is __________.

(IIT-JEE, 1994)

3. The IUPAC name of $[Co(NH_3)_6]Cl_3$ is __________.

(IIT-JEE, 1994)

True/False Type

1. Both potassium ferrocyanide and potassium ferricyanide are diamagnetic.

(IIT-JEE, 1989)

Single Correct Answer Type

1. Among $Ni(CO)_4$, $[Ni(CN)_4]^{2-}$, and $NiCl_4^{2-}$

(a) $Ni(CO)_4$ and $NiCl_4^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic
(b) $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic
(c) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $NiCl_4^{2-}$ is paramagnetic
(d) $Ni(CO)_4$ is diamagnetic, and $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic

(IIT-JEE, 1991)

2. Among the following ions which has the highest paramagnetism?

(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$

(IIT-JEE, 1993)

3. Which of the following is formed when excess of KCN is added to an aqueous solution of copper sulphate?

(a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
(c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$

(IIT-JEE, 1996)

4. The geometries of $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are:

(a) Both square planar
(b) Tetrahedral and square planar, respectively
(c) Both tetrahedral
(d) Square planar and tetrahedral, respectively

(IIT-JEE, 1999)

5. Among the following, identify the species with an atom in +6 oxidation state:

(a) MnO_4^{-} (b) $Cr(CN)_6^{3-}$
(c) NiF_6^{2-} (d) CrO_2Cl_2

(IIT-JEE, 2000)

6. The complex ion which has no *d*-electrons in the central metal atom is:

(a) $[MnO_4]^{-}$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

(IIT-JEE, 2001)

7. The pair of compounds having metals in their highest oxidation state is:

(a) MnO_2, $FeCl_3$
(b) $[MnO_4]^{-}$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{3-}$, $[Co(CN)_6]^{3-}$
(d) $[NiCl_4]^{2-}$, $[CoCl_4]^{-}$

(IIT-JEE, 2004)

8. The compound having a tetrahedral geometry is:

(a) $[Ni(CN_4)]^{2-}$ (b) $[Pd(CN)_4]^{2-}$
(c) $[PdCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

(IIT-JEE, 2004)

9. Spin only magnetic moment of the compound $Hg[Co(SCN)_4]$ is:

(a) $\sqrt{3}$ (b) $\sqrt{15}$
(c) $\sqrt{24}$ (d) $\sqrt{8}$

(IIT-JEE, 2004)

10. Which kind of isomerism is exhibited by octahedral $Co(NH_3)_4Br_2Cl$?

(a) Geometrical and ionization
(b) Geometrical and optical
(c) Optical and ionization
(d) Geometrical only

(IIT-JEE, 2005)

11. If the bond length of the C—O bond in CO is 1.128 Å, what is the value of the bond length in $[Fe(CO)_5]$?

(a) 1.15 Å (b) 1.128 Å
(c) 1.72 Å (d) 1.118 Å

(IIT-JEE, 2006)

12. Among the following metal carbonyls, the C—O bond order is lowest in:

(a) $[Mn(CO)_6]^+$ (b) $[Fe(CO)_5]$
(c) $[Cr(CO)_6]$ (d) $[V(CO_6)]^-$

(IIT-JEE, 2007)

13. Both $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridizations of nickel in these complexes, respectively, are:

(a) sp^3, sp^3 (b) sp^3, dsp^2
(c) dsp^2, sp^3 (d) dsp^2, dsp^2

(IIT-JEE, 2008)

14. The IUPAC name of $[Ni(NH_3)_4][NiCl_4]$ is:

(a) Tetrachloronickel(II)-tetraaminenickel(II)
(b) Tetramminenickel(II)-tetrachloronickel(II)
(c) Tetraamminenickel(II)-tetrachloronickelate(II)
(d) Tetrachloronickel(II)-tetraaminenickelate(0)

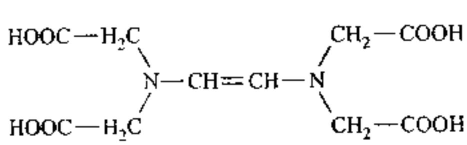
(IIT-JEE, 2008)

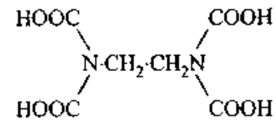
15. Among the following, the colored compound is:

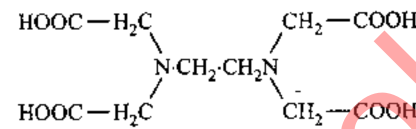
(a) CuCl (b) $K_3[Cu(CN)_4]$
(c) CuF_2 (d) $[Cu(CH_3CN)_4]BF_4$

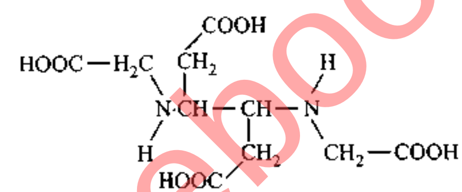
(IIT-JEE, 2008)

16. The correct structure of ethylenediaminetetraacetic acid (EDTA) is:

(a) 

(b) 

(c) 

(d) 

(IIT-JEE, 2010)

17. The ionization isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is:

(a) $[Cr(H_2O)_4(O_2N)]Cl_2$
(b) $[Cr(H_2O)_4Cl_2](NO_2)$
(c) $[Cr(H_2O)_4Cl(ONO)]Cl$
(d) $[Cr(H_2O)_4Cl_2(NO_2)]H_2O$ **(IIT-JEE, 2010)**

18. The complex showing a spin-magnetic moment of 2.82 B.M. is:

(a) $Ni(CO)_4$ (b) $[NiCl_4]^{2-}$
(c) $Ni(PPh_3)_4$ (d) $[Ni(CN)_4]^{2-}$

(IIT-JEE, 2010)

19. Geometrical shapes of the complexes formed by the rection of Ni_2^+ with Cl^-, CN^- and H_2O, respectively, are:

(a) Octahedral, tetrahedral and square planar
(b) Tetrahedral, square planar and octahedral
(c) Square planar, tetrahedral and octahedral
(d) Octahedral, square planar and octahedral

(IIT-JEE, 2011)

20. Among the following complexes (**K–P**)

$K_3[Fe(CN)_6]$ (**K**), $[Co(NH_3)_6]Cl_3$ (**L**),
$Na_3[Co(oxalate)_3]$ (**M**), $[Ni(H_2O)_6]Cl_2$ (**N**),
$K_2[Pt(CN)_4]$ (**O**) and $[Zn(H_2O)_6](NO_3)_2$ (**P**)

(a) K, L, M, N (b) K, M, O, P
(c) L, M, O, P (d) L, M, N, O

(IIT-JEE, 2011)

21. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is:

(a) Tetaaquadiaminecobalt(III) chloride
(b) Tetraaquadiamminecobalt(III) chloride
(c) Diaminetetraaquacoblat(III) chloride
(d) Diamminetetraaquacobalt(III) chloride

(IIT-JEE, 2012)

22. The color of light absorbed by an aqueous solution of $CuSO_4$ is:

(a) Organge-red (b) Blue-green
(c) Yellow (d) Violet

(IIT-JEE, 2012)

23. Consider the following complex ions P, Q, and R,

$P = [FeF_6]^{3-}$, $Q = [V(H_2O)_6]^{2+}$, and $R = [Fe(H_2O)_6]^{2+}$

The correct order of the complex ions, according to their spin-only magnetic moment values (in B.M.) is:

(a) $R < Q < P$ (b) $Q < R < P$
(c) $R < P < Q$ (d) $Q < P < R$

(JEE Advanced, 2013)

Multiple Correct Answers Type

1. The pair(s) of coordination complex/ion exhibiting the same kind of isomerism is(are):

(a) $[Cr(NH_3)_5Cl]Cl_2$ and $[Cr(NH_3)_4Cl_2]Cl$
(b) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)Cl]^+$
(c) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$
(d) $[Pt(NH_3)_3(NO_3)]$ Cl and $[Pt(NH_3)_3Cl]$ Br

(JEE Advanced, 2013)

Comprehension Type

For Problems 1–3

The coordination number of Ni^{2+} is 4.

$NiCl_2 + KCN(excess) \rightarrow A$ (Cyano complex)

$NiCl_2 + conc\ HCl(excess) \rightarrow B$ (Chloro complex)

1. The IUPAC name of *A* and *B* are:

(a) Potassium tetracyanonickelate(II), potassium tetrachloronickelate(II)
(b) Tetracyanopotassiumnickelate(II), tetrorachloropotassiumnickelate(II)
(c) Tetracyanonickel(II), tetrachloronickel(II).
(d) Potassium tetracyanonickel(II), potassium tetrachloronickel(II).

2. Predict the magnetic nature of *A* and *B*:

(a) Both are diamagnetic.
(b) *A* is diamagnetic and *B* is paramagnetic with one unpaired electron.
(c) *A* is diamagnetic and *B* is paramagnetic with two unpaired electrons.
(d) Both are paramagnetic.

3. The hybridization of *A* and *B* are:

(a) dsp^2, sp^3 (b) sp^3, sp^3
(c) dsp^2, dsp^2 (d) sp^3d^2, d^2sp^3

(IIT-JEE, 2006)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is also true; Statement-II is a correct explanation for Statement-I.
(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.
(c) Statement-I is true; Statement-II is false.
(d) Statement-I is false; Statement-II is true.

1. Statement-I: $[Fe(H_2O)_5NO]SO_4$ is paramagnetic.

Statement-II: The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons.

(IIT-JEE, 2008)

2. Statement-I: The geometrical isomer of the complex $[M(NH_3)_4Cl_2]$ are optically inactive.

Statement-II: Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry.

(IIT-JEE, 2008)

Matching Column Type

1. Match the complexes in Column-I with their properties listed in Column-II.

Column-I	Column-II
(a) $[Co(NH_3)_4(H_2O)_2]Cl_2$	(p) Geometrical isomers
(b) $[Pt(NH_3)_2Cl_2]$	(q) Paramagnetic
(c) $[Co(H_2O)_5Cl]Cl$	(r) Diamagnetic
(d) $[Ni(H_2O)_6]Cl_2$	(s) Metal ion with +2 oxidation state

(IIT-JEE, 2007)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements form List-I and List-II are given as options (a), (b), (c), and (d), out of which one is correct.

2. Match each coordination compound in List-I with an appropriate pair of characteristics from List-II and select the correct answer using the code given below the lists.

{en = $H_2NCH_2CH_2NH_2$ 'atomic numbers; Ti = 22; Cr = 24; Co = 27; Pt = 78}

List-I	List-II
(P) $[Cr(NH_3)_4Cl_2]Cl$	(1) Paramagnetic and exhibits ionization isomerism

(Q) $[Ti(H_2O)_5Cl](NO_3)_2$ (2) Dimagnetic and exhibits *cis-trans* isomerism

(R) $[Pt(en)(NH_3)Cl]NO_3$ (3) Paramagnetic and exhibits *cis-trans* isomerism

(S) $[Co(NH_3)_4(NO_3)_2]NO_3$ (4) Dimagnetic and exhibits ionization isomerism

Code:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	1	4	2
(c)	2	1	3	4
(d)	1	3	4	2

Integer Answer Type

1. $EDTA^{4-}$ is ethylenediaminetetraacetate ion. The total number of N–Co–O bond angles in $[Co(EDTA)]^{-1}$ complex ion is ______.
(JEE Advanced, 2013)

Subjective Type

1. Write the balanced chemical equations for the following:
"Potassium ferricyanide reacts with hydrogen peroxide in basic solution".
(IIT-JEE, 1989)

2. Give reasons in two or three sentences only for the following.
"The species $[CuCl_4]^{2-}$ exists, while $[CuI_4]^{2-}$ does not".
(IIT-JEE, 1992)

3. The acidic aqueous solution of ferrous ion forms a brown complex in the presence of NO_3^-, by the following two steps:
$$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \rightarrow \cdots + [Fe(H_2O)_6]^{3+} + H_2O$$
$$[Fe(H_2O)_6]^{2+} + \cdots \rightarrow \cdots + H_2O$$
Complete and balance the equations.
(IIT-JEE, 1993)

4. Identify the complexes which are expected to be colored. Explain.
(i) $[Ti(NO_3)_4]$ (ii) $[Cu(NCCH_3)]^+BF_4$
(iii) $[Cr(NH_3)_6]^{3+}3Cl^-$ (iv) $K_3[VF_6]$
(IIT-JEE, 1994)

5. Write the IUPAC names for the following compounds:
(i) $[Co(NH_3)_5ONO]Cl_2$
(ii) $K_3[Cr(CN)_6]$
(IIT-JEE, 1995)

6. Write the IUPAC name for $[Cr(NH_3)_5CO_3]Cl$.
(IIT-JEE, 1996)

7. Write a balanced equation for the reaction of argentite with KCN and name the products in the solution.
(IIT-JEE, 1996)

8. Write the formulae of the following complexes:
(i) Pentamminechlorocobalt(III) ion
(ii) Lithiumtetrahydridoaluminate(III)
(IIT-JEE, 1997)

9. *A*, *B*, and *C* are three complexes of chromium(III) with the empirical formula $H_{12}O_6C_{13}Cr$. All the three complexes have water and chloride ion as ligands. Complex *A* does not react with concentrated H_2SO_4, whereas complexes *B* and *C* lose 6.75% and 13.5% of their original mass, respectively, on treatment with concentrated H_2SO_4. Identify *A*, *B*, and *C*.
(IIT-JEE, 1999)

10. An aqueous solution containing 1 mol of HgI_2 and 2 mol of NaI, is orange in color. On addition of excess NaI the solution becomes colorless. The orange color reappears on subsequent addition of NaOCl. Explain with equations.
(IIT-JEE, 1999)

11. Draw the structures of $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_4]^{2-}$, and $[Ni(CO)_4]$. Write the hybridization of atomic orbitals of the transition metal in each case.
(IIT-JEE, 2000)

12. A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms *A* and *B*. The form *A* reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas *B* gives a pale-yellow precipitate soluble in concentrated ammonia. Write the formula of *A* and *B* and state the hybridization of chromium in each. Calculate their magnetic moments (spin-only value).
(IIT-JEE, 2001)

13. Deduce the structures of $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ considering the hybridization of the metal ion. Calculate the magnetic moment (spin only) of the species.
(IIT-JEE, 2002)

14. Write the IUPAC nomenclature of the given complex along with its hybridization and structure $K_2[Cr(NO)(NH_3)(CN)_4]$, $\mu = 1.73$.

(IIT-JEE, 2003)

15. $NiCl_2$ in the presence of dimethyl glyoxime (DMG) gives a complex which precipitates in the presence of NH_4OH, giving a bright red color.

(a) Draw its structure and show H bonding.

(b) Give the oxidation state of Ni and its hybridization.

(d) Predict whether it is paramagnetic or diamagnetic.

(IIT-JEE, 2004)

16. AlF_3 is insoluble in anhydrous HF but when little KF is added to the compound it becomes soluble. On addition of BF_3, AlF_3 is precipitated. Write the balanced chemical equations.

(IIT-JEE, 2004)

17. Write the balanced chemical equations for developing a black and white photographic film. Also, give the reason as to why the solution of sodium thiosulphate on acidification turns milky white and give the balanced chemical equation of this reaction.

(IIT-JEE, 2005)

18. $$Fe^{3+} \xrightarrow{SNC^- \text{(Excess)}} \underset{\text{Blood red}}{A} \xrightarrow{F^- \text{(Excess)}} \underset{\text{Colorless}}{B}$$

Identify A and B.

(a) Write the IUPAC names of A and B.

(b) Find out the spin only magnetic moment of B.

(IIT-JEE, 2005)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

20. (c) Zeise's salt is a metal–alkene complex $K[PtCl_3(C_2H_4)] \cdot H_2O$.

21. (a) $[Ni(NH_3)_6]^{2+}$, $[CoF_6]^{3-}$, and $[FeF_6]^{3-}$ involve sp^3d^2-hybridization, while $[Co(NH_3)_6]^{3+}$ involves d^2sp^3-hybridization.

22. (a) $[Ni(CN)_4]^{2-}$ involves dsp^2-hybridization, whereas $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, and $[Ni(PF_3)_4]$ involve sp^3-hybridization.

23. (b) The electronic configurations of Cr, Fe, Co, and Ti in the complexes are $(3d)^3$, $(3d)^5$, $(3d)^6$, and $(3d)^1$, respectively. These involve d^2sp^3, sp^3d^2, d^2sp^3, and d^2sp^3-hybridization, respectively.

24. (d) The electronic configurations of Ni, Fe, Co and Cr in the given complexes are $(3d)^8$, $(3d)^6$, $(3d)^6$ and $(3d)^4$, respectively. These involve dsp^2, d^2sp^3, d^2sp^3 and sp^3d^2-hybridization, respectively. The complex $[Cr(H_2O)_6]SO_4$ will be paramagnetic as Cr contains four unpaired electrons.

25. (c) The color of the complex compound is due to d–d electronic transition.

26. (a) t_{2g} orbitals have higher energy by $(2/5)\Delta_t$.

29. (b) Salt is represented as $[Cu(H_2O)_4]SO_4 \cdot H_2O$. Four H_2O molecules are coordinated to Cu^{2+} while remaining one H_2O molecule is H-bonded to SO_4^{2-}.

37. (b) dsp^2-hybridization gives square planar complex with $d_{x^2-y^2}$ orbitals involved in hybridization forming angles of 90°.

38. (b) The $-NO_2$ group can show $-NO_2$(nitro) or $-ONO$ (nitrito) linkage with metal.

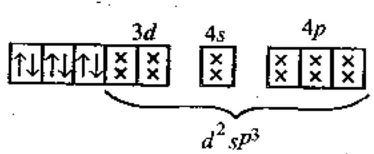
39. (a) $[Co(en)_2Cl_2]^+$ shows geometrical as well as optical isomerism.

40. (d) Mn^{2+}, Fe^{2+}, and Co^{2+} has $3d^5$, $3d^6$, and $3d^7$ configuration having 5, 0, and 3 unpaired electrons, respectively.

41. (c) B in BF_4^- has sp^3-hybridization leading to tetrahedral geometry.

43. (d) $[Co(CN)_6]^{3-}$ has d^2sp^3 hybridization and six d electrons are paired due to strong field ligand. Thus no unpaired electrons

Co^{3+}, Electronic configuration = [Ar] $3d^6$



[No unpaired electron paramagnetism = 0]

44. (d) The magnetic moment of $[NiCl_4]^{2-}$ reveals that the species is paramagnetic having two unpaired electrons i.e., Ni^{2+} is $3d^8$. The four electron pairs by Cl^- ligand leads to sp^3-hybridization in Ni^{2+} and do not disturb Ni^{2+} configuration to give tetrahedral geometry.

45. (a) Magnetic moment indicates that there are three unpaired electrons present in chromium. These must be present in lower energy orbitals which are $3d_{xy}$, $3d_{yz}$, and $3d_{xz}$.

50. (b) The larger the number of unpaired electrons, the more it has paramagnetism. The outer configurations are $Cr^{3+}: 3d^3$; $Fe^{2+}: 3d^6$; $Cu^{2+}: 3d^9$; $Zn: 3d^{10}$

56. (a) $[Co(NH_3)(H_2O)Cl]Cl_2$ {according to I.U.P.A.C. 2005]

72. (b) $\overset{+IV}{[PtCl_2(NH_3)_4]}^{2+}\overset{II}{[PtCl_4]}^{2-}$; $\overset{+IV}{[PtCl_3(NH_3)_3]}^{+}\overset{+II}{[PtCl_3(NH_3)]}^{-}$

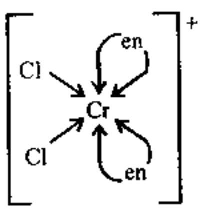
$\overset{+II}{[PtCl(NH_3)_3]}^{+}\overset{+IV}{[PtCl_5(NH_3)]}^{-}$; $\overset{II}{[Pt(NH_3)_4]}^{2+}\overset{IV}{[PtCl_6]}^{2-}$

73. (c) $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ E.A.N. of Pt $= 78 - 2 + 3 \times 2 + 2 = 84$

JEE (Advanced) Exercises

Single Correct Answer Type

7. (b) *cis*-$[CrCl_2 en_2]^+$ exists as a pair of enantiomers.



10. (a) 2.83 Bohr magneton implies two unpaired electrons according to the expression $\sqrt{n(n+2)}$ B.M. The species Cu, Ni, Ti, and Co in the given complexes have $(3d)^8$, $(3d)^8$, $(3d)^0$, and $(3d)^6$ electronic configurations, respectively. These involve sp^3, d^2, dsp^2, sp^3 and d^2sp^3-hybridization, respectively. Thus, the complex $[Ni(NH_3)_6]^{2+}$ has two unpaired electron.

11. (b) We have $4\Delta_0 = 9\Delta t$

12. (b) t_{2g} orbitals (d_{xy}, d_{xz}, d_{yz}) have lower energy by $(2/5)\Delta_0$.

13. (a) The order is $SCN^- < F^- < CN^-$.

15. (b) Sum of charges = net charges

16. (c) EAN = Z – oxidation number + 2 × coordination number $= 26 - 3 + 2 \times 6 = 35$.

18. (c) EDTA is hexadentate

21. (b) Ni shows sp^3, sp^3, and dsp^2-hybridization in $Ni(CO)_4 \cdot [NiCl_4]^{2-}$, and $[Ni(CN)_4]^{2-}$, respectively. CN^- being strong field ligand pairs up unpaired electron in Ni^{2+}.

22. (a) A more basic ligand and bidentate ligand form stable bond with metal ion due to chelation.

23. (c) $[Co(NH_3)_5Cl]Cl_2 \xrightarrow{H_2O} [Co(NH_3)_5Cl]^{2+} + 2Cl^-$

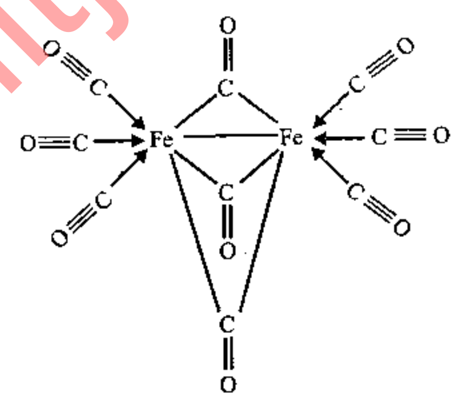
$2AgNO_3 + 2Cl^- \longrightarrow 2AgCl + 2NO_3^-$

24. (c) Optical isomerism is very common in octahedral complexes having general formula $[MA_2B_2C_2]^{n-}$, $[M(AA)_3]^{n-}$, $M(AA)_2b_2]^{n-}$, $[M(AA)_2AB]^{n-}$, and $[M(AB)_3]^{n-}$ where AA is symmetrical bidentate ligand such as COO^-–COO^- and AB is unsymmetrical bidentate ligand.

25. (d) The metal Fe makes the back bonding to CO. The metal to ligand bond creates a synergic effect which strengthens bond between CO and Fe which results in shortening of bond length.

30. (a) Each species has 14 electrons and bond order for each is three.

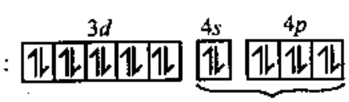
37. (c)



E.A.N. of Fe = 26 + 1 + 1 + 1 + 1 + 3 × 2 = 36

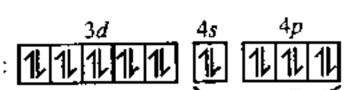
38. (c)

Co in $[Co(CO)_4]^-$:



Hybridization : sp^3, $\mu_{eff} = 0$

Ni in $[Ni(CN)_4]^{4-}$:



Hybridization : sp^3, $\mu_{eff} = 0$

39. (d) $H_x[Pt\,y_6]$

If coordination number of Pt = 6, then O.S. of Pt = + 4

$\therefore \quad x + 4 + 6 \times (-1) = 0$

$\therefore \quad x = 2$

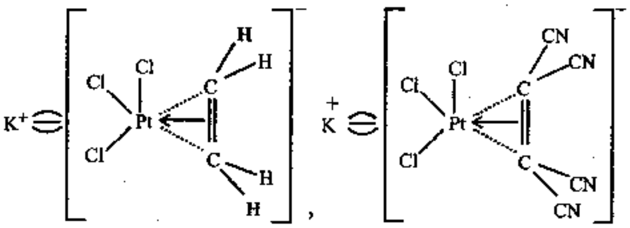
41. (a) $[MnCl_4]^{2-}$: $P > \Delta_t$; d^5-system $\mu_{eff} = 5.9$ B.M.

$[CoCl_4]^{2-}$: $P > \Delta_t$; d^7-system $\mu_{eff} = 3.89$ B.M.

$[Fe(CN)_6]^{4-}$: $P < \Delta_0$; d^6-system $\mu_{eff} = 0$ B.M.

42. (c) X-ray studies have established that Prussian blue and Turnbull's blue are identical. Fe^{3+} partially oxidizes $[Fe^{II}(CN)_6]^{4-}$ forming some $[Fe^{III}(CN)_6]^{3-}$. Thus, $Fe[Fe(CN)_6]^-$ is formed.

43. (a) Due to synergic bonding

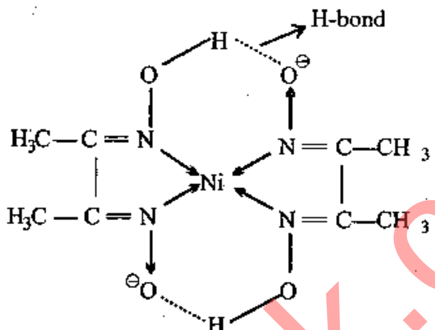


$\overset{\ominus}{C}N$ has $-I$ effect and hence it produces $+\delta$ charge on carbon atom. So carbon atom accept more electrons from metal cation.

With increase in synergic bonding, C—C bond length increases.

49. (d) NO in +1 state is proved by magnetic moment. Name of NO^+ = N nitrosonium or nitrosylium.

53. (b) Dimethylglyoxime is coordinated to Ni^{2+} through two nitrogen atoms.



54. (b) Ferrocene is $Fe(\eta^5\text{-}C_5H_5)_2$ complex.

55. (c) e_g orbitals $(d_{z^2}, d_{x^2-y^2})$ have higher energies by $(3/5)\Delta_o$.

56. (d) e_g orbitals have lower energies by $(3/5)\Delta_t$.

58. (c) $\overset{\ominus}{C}N$ acts as ligand and reducing agent.

59. (b) Magnetic moment = $\sqrt{n(n+2)}$ = 2.84.

60. (a) Co^{3+}, Fe^{3+}, and Cr^{3+} have 6, 5, and 3 d electrons, respectively.

61. (c) In $Hg[Co(SCN)_4]$, Co exists as Co^{2+}

$_{27}Co$: $3d^7, 4s^2$ or ↑↓ | ↑↓ | ↑ | ↑ | ↑   ↑↓

$_{27}Co^{2+}$: $3d^7$ or ↑↓ | ↑↓ | ↑ | ↑ | ↑

SCN^- ligand provides four electron pair to show sp^3-hybridization in $[Co(SCN)_4]^{2-}$ and thus three unpaired electron exists on Co^{2+}.

∴ Magnetic moment = $\sqrt{n(n+2)} = \sqrt{3(3+2)} = \sqrt{15}$

62. (b) Same magnetic moment = Same number of unpaired electrons

$\mu = \sqrt{n(n+2)}$

where n = number of unpaired electrons

$Co^{2+} = 3d^7$, 3 unpaired electrons;

$Cr^{2+} = 3d^4$, 4 unpaired electrons;

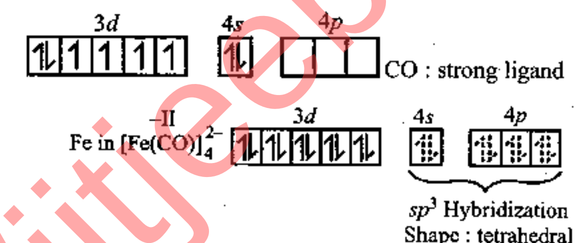
$Mn^{2+} = 3d^5$, 5 unpaired electrons;

$Fe^{2+} = 3d^6$, 4 unpaired electrons

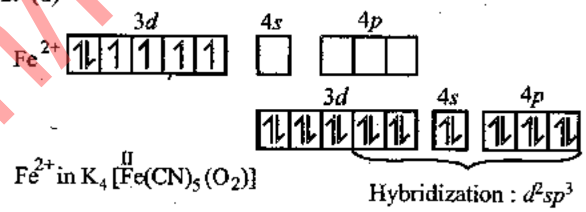
68. (b) In sodium nitroprusside, NO acts as positive ligand [nitrosonium]

70. (b) $[Co(H_2O)_6]^{3+} = d^2sp^3$, low spin, diamagnetic, zero B.M.

71. (b) Fe (in ground state)



72. (d)



Complex is paramagnetic due to presence of unpaired electron at O_2^- i.e., superoxide acting as ligand.

73. (b) $[Fe(H_2O)_5(\overset{+}{N}O)]^{2+}$ → Hybridization: sp^3d^2

→ μ_{eff}: 3.89 B.M.

→ In spite of electronic transition from NO to Fe^{2+}, total number of electrons remain conserved. Hence E.A.N. does not change.

74. (d) (a) $Ti(CO)_6$; E.A.N. of Ti = 22 – 0 + 6 × 2 = 34

Hence can only act as oxidizing agent.

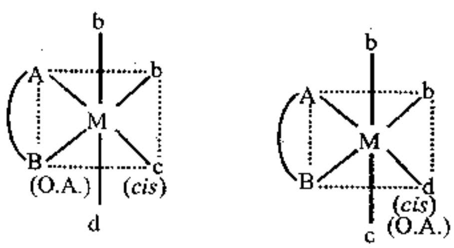
(b) $Mn(CO)_5$; E.A.N. of Mn = 25 – 0 + 5 × 2 = 35

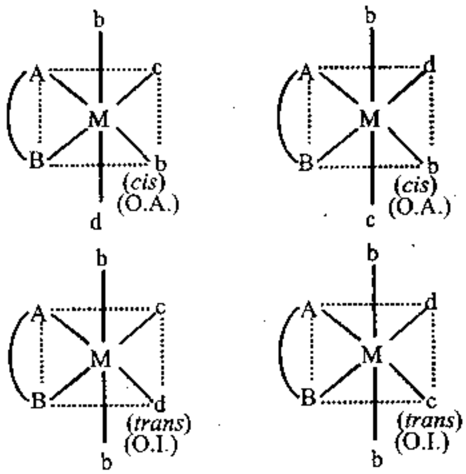
Hence can only act as oxidizing agent.

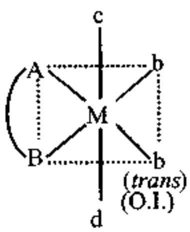
(c) $Mn(CO)_6$; E.A.N. of Mn = 25 – 0 + 6 × 2 = 37

Hence can only act as reducing agent.

75. (c)







→ Number of G.I. = 7

→ All *cis*: O.A. Optically active

→ One *trans*: O.A.

→ Two *trans*: O.I. (Optically inactive)

76. (b) $\overset{III}{[Cr(H_2O)_6]}^{3+}$; Hybridization: d^2sp^3, Inner orbital complex.

$\overset{+III}{[Fe(CN)_6]}^{3-}$; $P < \Delta_0$: Hybridization: d^2sp^3, Inner orbital / low spin / spin paired complex

$\overset{+I}{[Cu(CN)_4]}^{3-}$; Hybridization: sp^3

$[Mn(H_2O)_6]^{2+}$; $P < \Delta_0$: Hybridization: sp^3d^2: outer orbital / high spin / spin free complex

85. (c) Wilkinson's catalyst = $[RhCl(PPh_3)_3]$

Multiple Correct Answers Type

2. (a), (d)

The stock system puts the calculated oxidation number of the metal ion as a Roman numeral in parentheses after the name of the metal. This is the more common convention, although there are cases in which it is difficult to assign oxidation numbers.

The Ewing–Bassett system puts the charge on the coordination sphere in parentheses after the name of the metal. This convention is used by chemical abstracts and offers an unambiguous identification of the species.

13. (a), (b), (c)

Correct name for $Na_2[Ni(EDTA)]$ – Sodium ethylenediaminetetraacetatonickelate (II).

14. (a), (b), (c), (d)

$sp^3d \Rightarrow sp_xp_yp_z d_{x^2-y^2}$

$dsp^3 \Rightarrow d_{x^2-y^2}\, sp_xp_yp_z$

$sp^3d^2 \Rightarrow sp_xp_yp_z d_{x^2-y^2}\, d_{z^2}$

$sp^3d^3 \Rightarrow sp_xp_yp_z d_{x^2-y^2}\, d_{z^2}\, d_{xy}$

18. (b), (c), (d)

$Ni(CO)_4$ involves sp^3-hybridization with $(3d)^{10}$ electronic configuration of Ni. It is diamagnetic.

29. (a), (c)

σ–C_3H_5 can exist in two structures.

(i) $CH_2 = CH - \overset{\bullet\bullet}{\underset{\ominus}{C}}H_2$ (Allyl)

(ii) H_2C—$\overset{\ominus\bullet\bullet}{CH}$—$CH_2$ (Cyclopropyl)

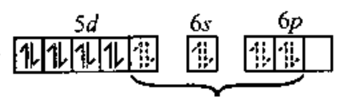
32. (a), (b), (c)

The species which show secondary valencies in a complex are Lewis base.

33. (a), (b), (d)

(a) $[AuCl_4]^-$, Au^{3+} : $5d^8$

Au^{3+} in $[AuCl_4]^-$



Hybridization : dsp^2, $\mu_{eff} = 0$

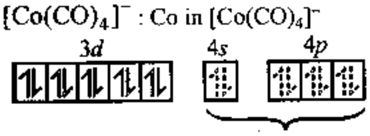
(b) $\overset{III}{[Co(H_2O)_6]}^{3+}$, $P < \Delta_0$,

Hence hybridization: d^2sp^3, $\mu_{eff} = 0$

(c) $\overset{III}{[CoF_6]}^{3-}$, $P < \Delta_0$,

Hence hybridization: sp^3d^2, $\mu_{eff} = 4.9$ B.M.

(d) $\overset{-I}{[Co(CO)_4]}^-$: Co in $[Co(CO)_4]^-$



Hybridization : sp^3, $\mu_{eff} = 0$

34. (b), (c), (d)

The number of unpaired electrons of the ions in the given choices are:

Mn^{2+} (n = 5); Ni^{2+} (n = 2), Co^{2+} (n = 3), and Fe^{2+} (n = 4)

The correct sequence of magnetic moment would be $Mn^{2+} > Fe^{2+} > Co^{2+} > Ni^{2+}$.

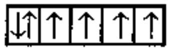
35. (a), (b), (c)

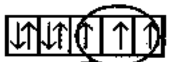
The species which show secondary valencies in a complex are Lewis base.

37. (a, b, c)

(a) Fe^{2+} changes to brown-colored ring complex

(b) $NO \longrightarrow NO^+ + e^-$ $\quad Fe^{2+} + e^- \longrightarrow Fe^+$

Fe^{2+} [Ar] $3d^6$ 

(c) Fe^{+} [Ar] $3d^7$ 

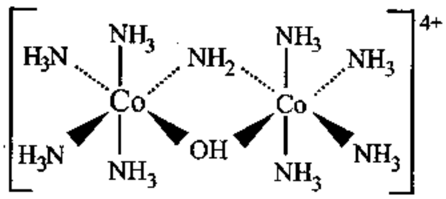
Three unpaired electrons

Magneticmoment $\sqrt{n(n+2)} = \sqrt{15} = 3.87$ BM

Thus, (a), (b), and (c) are true

(d) = sp^3d^2 hybridization.

42. (a), (b)



47. (a), (b)

NO in +1 state it is proved by magnetic moment. Name of NO^+ = nitrosonium or nitrosylium.

51. (a), (b), (c)

$\overset{II}{[Fe(CN)_6]}^{4-}$ Low spin complex, $\mu_{eff} = 0$.

54. (a), (b), (d)

The σ and π bondings are through C of CO.

Comprehension Type

3. (a) $[Cu(NH_3)_4]SO_4$

E.A.N = 29 – 2 + 2 × 4

= 27 + 8 = 35

29. (c) (a) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4](NO_3)_2{\cdot}2H_2O$

Complex conducts electricity

3d 4s 4p

Hybridization : dsp^2,

$\mu_{eff} = 0$

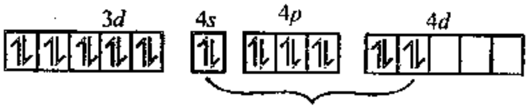
(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2{\cdot}2NH_3$

The complex will not exist due to the presence of ammoniates, i.e., NH_3 as solvent of crystallization because NH_3 cannot lie in voids of crystal lattice in the presence of H_2O.

(c) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

Complex conducts electricity due to ionic complex.

3d 4s 4p 4d



Hybridization : sp^3d^2,

$\mu_{eff} = 2.8$ B.M.

(d) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4(NO_3)_2]{\cdot}2H_2O$

3d 4s 4p 4d

Hybridization : sp^3d^2

$\mu_{eff} = 2.8$ B.M.

But complex does not conduct electricity due to neutral complex.

30. (d) Ni^{2+} ($3d^8$): For coordination number = 6,

$\mu_{eff} = 2.8$ B.M.

For coordination number = 4 (square planar), $\mu_{eff} = 0$

35. (d) $M \underset{\sigma}{\overset{\pi}{\rightleftarrows}} C{\equiv}O$

Higher the negative oxidation state of central metal, the higher will be back donation from $M \xrightarrow{\pi} C{\equiv}O$, hence $M - C$ bond order will increase.

36. (b) If PF_3 is a better π-acceptor ligand than CO, then extent of back donation from $M \xrightarrow{\pi} C{\equiv}O$ decreases, and hence bond order of CO will less decrease. Stretching frequency of C – O bond ∝ bond order of C≡O

Therefore, stretching frequency of $[Ni(PF_3)(CO)_3] > [Ni(CO)_4]$.

37. (d) C – O bond length $\propto \dfrac{1}{\text{CO bond order}}$

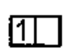
In the presence of PF_3 bond order of CO will be maximum due to better π-acceptor tendency of PF_3 in compansion to PCl_3 or PMe_3.

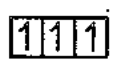
38. (a) $Fe + 5CO \xrightarrow[100\text{ atm}]{200°C} Fe(CO)_5$

Hybridization = dsp^3

d-orbital = d_{z^2}; Geometry = Trigonal bipyramidal

40. (b)

(a) e_g 

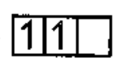
t_{2g} 

$p > \Delta_0$

d^4

μ_{eff} = 4·9 B.M.

(b) e_g 

t_{2g} 

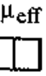
$p > \Delta_0$

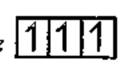
or

$p < \Delta_0$

d^2

μ_{eff} = 2·89 B.M.

(c) e_g 

t_{2g} 

$p > \Delta_0$

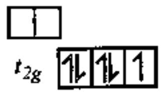
or

$p < \Delta_0$

d^3

μ_{eff} = 3.89 M.B

(d) e_g t_{2g}

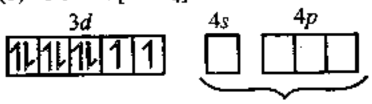


$\mu_{eff} = 1.73$ B.M.

$p > \Delta_0$

d^5

41. (b) Ni^{2+} in $[NiCl_4]^{2-}$



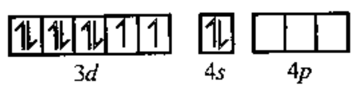
Hybridization : sp^3; Shape : Tetrahedral

$\mu_{eff} = 2.89$ B.M.

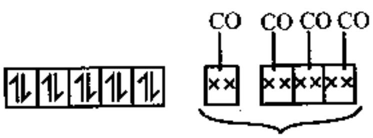
Assertion-Reasoning Type

2. (c) $Ni(CO)_4$ is tetrahedral complex and has no unpaired electron.

$Ni(CO)_4$ $\quad Ni \longrightarrow [Ar]\, 3d^8\, 4s^2\, 4p^0$



CO is a strong field ligand and it will pair up unpaired electrons and undergoes sp^3 hybridization.



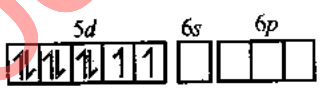
sp^3 Hybridization

5. (d) According to spectrochemical series, CN^- is a strong field ligand, so it has more Δ_0 value.

So correct order of Δ_0 for these complex ions is:
$[CrCl_6]^{3-} < [Cr(C_2O_4)_3]^{3-} < [Cr(CN)_6]^{3-}$

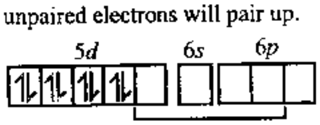
6. (d) Due to having positive charge the tendency of π-accepting property of NO^+ will be higher than that of CO.

7. (d) Au^{3+} (ground state)



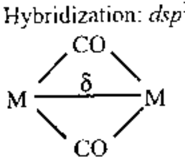
Although Cl^- is a weak ligand but due to high z_{eff} values of Au^{3+}, unpaired electrons will pair up.

Au^{3+} in $[AuCl_4^-]$



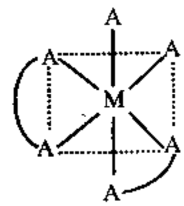
Hybridization: dsp^2; shape : square planar; $\mu_{eff} = 0$

8. (a)



In bridging carbonyl group, extent of $M \xrightarrow{\pi}$ CO bonding increases due to involvement of two metals for one CO group.

9. (d)



Asymmetric configuration due to the absence of plane of symmetry and center of symmetry; hence, it is optically active.

Matching Column Type

16. (a) p, q, r; (b) s; (c) p; (d) q, s

$[Ni(en)_3]^{2+}$: Type of hybridization – sp^3d^2 (outer orbital complex)
No. of unpaired electrons = 2 (paramagnetic)
Complex ion is optically active

$[VF_6]^{3-}$: Type of hybridization – d^2sp^3 (inner orbital complex)
No. of unpaired electrons = 2 (paramagnetic)

$[NiCl_2(SCN)_4]^{4-}$: Type of hybridization – sp^3d^2 (outer orbital complex)
No. of unpaired electrons = 2 (paramagnetic)

$[Fe(CN)_6]^{4-}$: Type of hybridization – d^2sp^3 (inner orbital complex)
No. of unpaired electrons = 0 (diamagnetic)

23. (a) p, s; (b) p, s, t; (c) s, t; (d) p, s

(a) $[\overset{III}{Cr}(H_2O)_5Br]^{2+}$ Hybridization d^2sp^3

$\mu_{eff} = 3.89$ B.M.

No geometrical, optical isomerism

E.A.N. = 24 – 3 + 12 = 33, does not follow E.A.N. rule

(b) $[\overset{II}{Cu}(NH_2CH_2CH_2NH_2)Cl_4]^{2-}$

Hybridization sp^3d^2

$\mu_{eff} = 1.732$ B.M.

No geometrical, Optical isomerism

E.A.N. = 29 – 2 + 12 = 39, does not follow E.A.N. rule

(c) $[\overset{II}{Pt}(OX)_2]^{2-}$ Hybridization dsp^2

$\mu_{eff} = 0$

No geometrical, optical isomerism

E.A.N. = 78 – 2 + 2 × 4 = 84, does not follow E.A.N. rule

(d) $[\overset{III}{Fe}(OH)_4]^-$ Hybridization sp^3

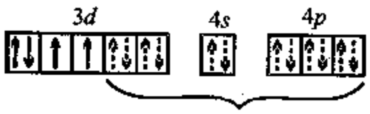
$\mu_{eff} = 5.9$ B.M.

No geometrical, optical isomerism

E.A.N. = 26 – 3 + 4 × 2 = 31 does not follow E.A.N. rule

26. (a) q, r; (b) q, s; (c) q, s; (d) p, r, s

(a) $[Cr(CN)_3(NO_2)_3]^{4-}$



Hybridization : d^2sp^3; octahedral

31. (a) s; (b) p; (c) q

(a) $[Fe(NH_3)_6]^{2+}$, $P > \Delta_0$, hybridization: sp^3d^2, $\mu_{eff} =$ 4.9 B.M., number of unpaired electrons = 4

(b) $[MnO_4]^-$, hybridization: d^3s, $\mu_{eff} = 0$, number of unpaired electrons = 0

(c) $[Mn(NH_3)_6]^{2+}$, $P > \Delta_o$, hybridization sp^3d^2, number of unpaired electrons = 5, $\mu_{eff} = 5.9$ B.M.

32. (a) p, q, r, s; (b) p, q, r; (c) p, r

(a) $K_4[Ni(CN)_4]$: Ni^0: Hybridization: sp^3, Shape: Tetrahedron, $\mu_{eff} = 0$

$K_2[NiCl_4]$: Ni^{2+}: Hybridization: sp^3, Shape: Tetrahedron, $\mu_{eff} = 2.8$ B.M.

(b) $K_4[\overset{+II}{Ni}F_6]$: Ni^{2+}: Hybridization: sp^3d^2, Shape: Octahedron, $\mu_{eff} = 2.8$ B.M.

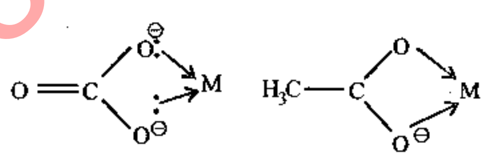
$K_2[\overset{+IV}{Ni}F_6]$: $\overset{+IV}{Ni}$ $(P < \Delta_0)$, Hybridization d^2sp^3, Shape: Octahedron, $\mu_{eff} = 0$

(c) $K_4[Co(NO_2)_6]$: Co^{2+} : d^7, Hybridization: d^2sp^3, Shape: Octahedron, $\mu_{eff} = 1.73$ B.M.

$[Fe(H_2O)_6]Cl_3$: Fe^{3+} : d^5 : Hybridization: sp^3d^2, Shape: Octahedron, $\mu_{eff} = 5.9$ B.M.

Integer Answer Type

1. (2)

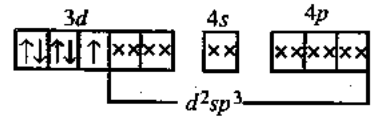


CH_3COO^-, CO_3^{2-} are negative ligand as well as flexidentate ligand.

19. (2) $\frac{2}{1} = 2$

27. (1) As EDTA is hexadentate ligand.

28. (1) $[Mn(CN)_6]^{4-}$ has configuration:



× × Electron pair donated by CN^-.

29. (4) The four isomers are $[Cu(NH_3)_4][PtCl_4]$, $[Cu(NH_3)_3Cl][PtCl_3(NH_3)]$, $[Pt(NH_3)_3Cl][CuCl_3(NH_3)]$, and $[Pt(NH_3)_4][CuCl_4]$.

30. (4) Monomeric form of nickel carbonyl is $Ni(CO)_4$.

31. (6) *Tris*(ethylenediamine)cobalt(III) chloride is $[Co(NH_2CH_2CH_2NH_2)_3]Cl_3$; $NH_2CH_2CH_2NH_2$ is bidentate ligand and thus coordination no. = 3 × 2 = 6.

32. (2) Two *fac* and *mer* forms.

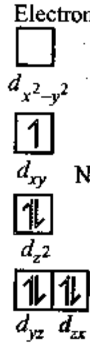
35. (0) $[Co(NH_3)_3Cl_3]$ is not ionized on dissolution.

37. (2) $[Cu(NH_3)_4]SO_4 \rightleftharpoons [Cu(NH_3)_4]^{2+} + SO_4^{2-}$

39. (41) Electronic distribution in a tetrahedral d^6 ion

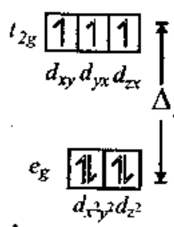
Δ_t Number of unpaired electrons = 4

Electronic distribution in square planar d^7 ion



Number of unpaired electrons = 1

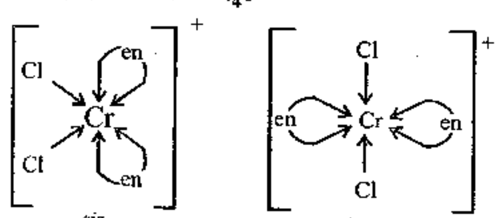
40. (0) $[\overset{II}{Co}(SCN)_4]^{2-}$



No. of unpaired electron present in d-orbitals whose lobes are present along axis = 0

$Co^{2+}(d^7)$ in $[\overset{II}{Co}(SCN)_4]^{2-}$

41. (3)



cis optical active — *trans* optical inactive

42. (2) $[CrCl_3(NH_3)_3]$ has plane of symmetry. Hence it is optically inactive.

43. (8) There are four geometrical isomers: two isomers of *cis*-dichloro and two isomers of *trans*-dichloro. All the two *cis* isomers are optically active. Hence, there are six isomers.

53. (1) $\frac{2}{2} = 1$

54. (1) Effective atomic number = 36

$\therefore$ 36 = 24 — (—x) +10

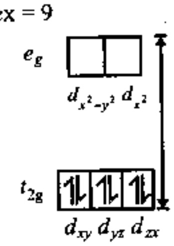
$\therefore$ X = 2 $\therefore$ Formula is $H_2[Cr(CO)_5]$

55. (9) Total number of geometrical isomer in $Ma_2b_2c_2 = 5$

Total number of stereo isomers in $M(AB)_3 = 4$

Sum of geometrical isomer and stereo isomer of given complex = 9

59. (60)



Ni^{4+} in $[\overset{+IV}{Ni}F]_6^{2-}$

60. (15) $[Ma_2bcde]$ Total geometrical isomers = 9

(6 *cis*, 3 *trans*)

Optical = 15 (12 optical active, 3 optical inactive)

Steroisomers = 15

61. (8) Total number of geometrical isomers in $[Pt(H_2N–CH(CH_3)–COO^–)_2] = 4$

Total number of stereo isomers in $[Pt(gly)_3]^+ = 4$

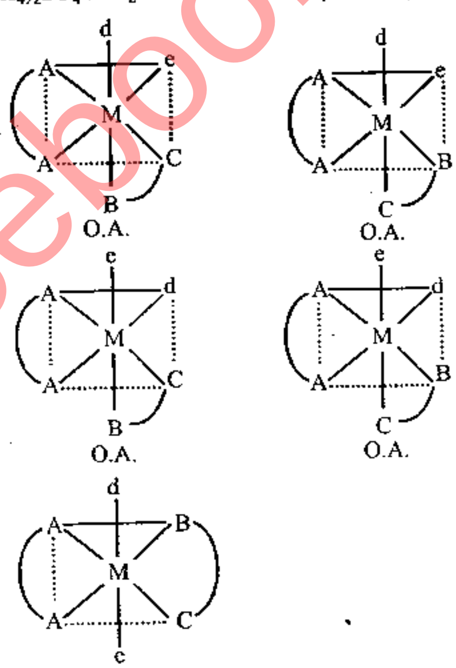
Sum of geometrical isomers and stereo isomers of given complexes = 8

74. (3) $2 \times x + 4 \times (-2) + 2 \times 0 + 2 \times 0 = -2 \therefore x = +3.$

76. (5) It is a double salt:

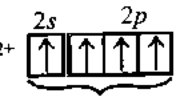
$FeSO_4.(NH_4)_2SO_4 . 6H_2O \longrightarrow Fe^{2+} + 2SO_4^{2-} + 2NH_4^+ + 6H_2O$

77. (5)



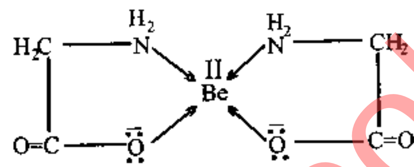
Five pairs of enantiomers are possible.

78. (2) As. Be^{2+}



(Tetrahedral)

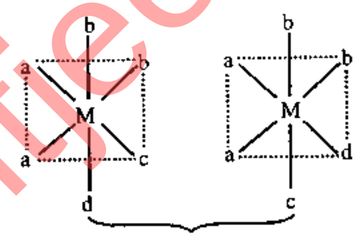
Hybridization : sp^3



(optically active)

Asymmetric configuration due to absence of plane of symmetry, hence optically active. Therefore, number of space/stereoisomers = 2

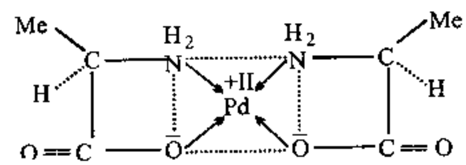
79. (2) Only *cis*- isomers are optically active. Their number = 2



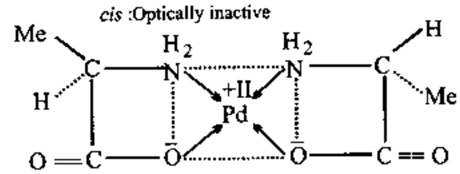
Optically active

80. (2) $[Co(H_2O)_3F_3]$: Overall ligand field will be weak.

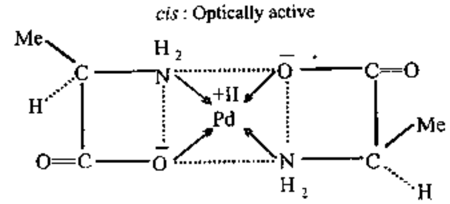
81. (6)



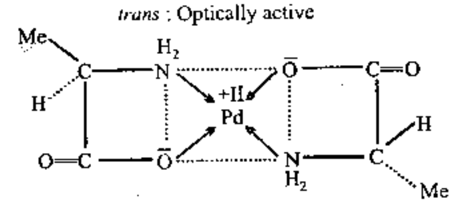
cis :Optically inactive



cis : Optically active



trans : Optically active



trans : Optically inactive due to center of symmetry.

Total number of space isomers = 6

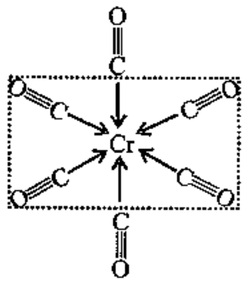
82. (61) $\Rightarrow [V(CO)_m]^{n-}$

$\Rightarrow$ For octahedral shape of complex; $m = 6$

$\Rightarrow$ E.A.N. of V = 36 = 22 + n + 6 × 2n = 1

83. (2) There are only two isomers *d* and *l*.

85. (9)



9 atoms are present in same plane.

NCERT Exemplar Exercises

Short Answer Type

1. $[Co(NH_3)_3Cl_3] < [Cr(NH_3)_4Cl_2]Cl < [Co(NH_3)_5Cl]Cl_2 < [Co(NH_3)_6]Cl_3$
2. $[Co(H_2O)_4Cl_2]Cl$ (tetraaquadichloridocobalt(III) chloride)
3. An optically active complex of the type $[M(AA)_2X_2]^{+n}$ indicates *cis*-octahedral structure, e.g. *cis*-$[Pt(en)_2Cl_2]^{2+}$ or *cis*- $[Cr(en)_2Cl_2]^+$
4. The magnetic moment of 5.92 BM corresponds to the presence of five unpaired electrons in the *d*-orbitals of Mn^{2+} ion. As a result the hybridization involved is sp^3 rather than dsp^2. Thus tetrahedral structure of $[MnCl_4]^{2-}$ complex will show 5.92 BM magnetic moment value.
5. With weak field ligands; $\Delta_0 < p$, the electronic configuration of Co(III) will be $t_{2g}^4 e_g^2$ and it has 4 unpaired electrons and is paramagnetic. With strong field ligands, $\Delta_0 < p$, the electronic configuration will be $t_{2g}^6 e_g^0$. It has no unpaired electrons and is diamagnetic.
6. Because for tetrahedral complexes, the crystal field stabilization energy is lower than pairing energy.
7. $[CoF_6]^{3-}$, $Co^{3+}(d^6)$ $t_{2g}^4 e_g^2$,
   $[Fe(CN)_6]^{4-}$, $Fe^{2+}(d^6) t_{2g}^6 e_g^0$,
   $[Cu(NH_3)_6]^{2+}$, Cu^{2+} $(d^9) t_{2g}^6 e_g^3$,
8. $[Fe(CN)_6]^{3-}$ involves d^2sp^3 hybridization with one unpaired electron and $[Fe(H_2O)_6]^{3+}$ involves sp^3d^2 hybridization with five unpaired electrons. This difference is due to the presence of strong ligand CN^- and weak ligand H_2O in these complexes.
9. Crystal field splitting energy increases in the order $[Cr(Cl)_6]^{3-} < [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$
10. It is due to the presence of weak and strong ligands in complexes, if CFSE is high, the complex will show low value of magnetic moment and vice versa, e.g. $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$, the former is paramagnetic and the latter is diamagnetic.
11. In $CuSO_4 \cdot 5H_2O$, water acts as ligand as a result it causes crystal field splitting. Hence *d—d* transition is possible in $CuSO_4 \cdot 5H_2O$ and shows color. In the anhydrous $CuSO_4$ due to the absence of water (ligand), crystal field splitting is not possible and hence no color.
12. Linkage isomerism

    (i) $M \leftarrow NO_2$ (N bonded to two O)

    (ii) $M \leftarrow SCN$ thiocyanato-S $M \leftarrow NCS$ thiocyanato-N

Long Answer Type

3. (i) A-$[Co(NH_3)_5SO_4]Cl$ B-$[Co(NH_3)_5Cl]SO_4$
   (ii) Ionization isomerism
   (iii) (A), Pentaamminesulphatocobalt(III) chloride
   (iv) (B), Pentaamminechlorocobalt(III) sulphate.
4. When white light falls on the complex, some part of it is absorbed. Higher the crystal field splitting, lower will be the wavelength absorbed by the complex. The observed color of complex is the color generated from the wavelength left over.
5. $\Delta_t = \left(\frac{4}{9}\right)\Delta_0$, So lower wavelength is absorbed in octahedral complex than tetrahedral complex for 9 same metal and ligands.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) Square planar complex is formed by hybridization of $d_{x^2-y^2}, s, p_x, p_y$.
2. (b) Nitropentammine chromium(III) chloride is $[Cr(NH_3)_5(NO)_2]Cl_2$. It will show linkage isomerism because it contains NO_2 ligand, which is an ambidentate ligand.
3. (b) Organometallic compounds are those in which positively charged metals are directly bonded to negatively charged carbon. The answer is C–Mg bond.
4. (c) Stability of $[Fe(CN)_6]$ is more due to presence of strong field ligand CN^-.
5. (a) NH_3 can act as ligand but NH_4^+ cannot act as ligand.

6. (d) Total 3 moles of ions are generated on dissolution in water, that is, one complex ion and two simple ions.

$$[Co(NH_3)_5Cl]\cdot Cl_2 \xrightarrow{H_2O} [Co(NH_3)_5^{\oplus}Cl] + 2Cl^{\ominus}$$

$$[Co(NH_3)_5Cl]\cdot Cl_2 \xrightarrow{AgNO_3} [Co(NH_3)_5Cl]\,NO_3 + 2AgCl\downarrow$$

One mole of complex reacts with two moles of $AgNO_3$; thus, it must have 2 Cl atoms bonded by ionic linkage. Coordination number of Co is 6.

7. (a) Let the oxidation state of Ni be x.

then

$$4(+1) + x + 4(-1) = 0$$

$$\Rightarrow \quad x = 0$$

8. (a) $CN^{\ominus}$ forms complexes with several metal ions, for example, metal species.

$$Fe^{2+} + 4\,CN^- \rightarrow [Fe(CN)_6]^{4-}$$

CN^- can also act as a reducing agent for metal species, for example,

$$Cu^{2+} + CN^- \rightarrow \underset{\text{White ppt.}}{Cu(CN)\downarrow} + \underset{\text{Cyanogen gas}}{(CN)_2\uparrow}$$

However, there is no example of CN^- acting as oxidizing agent on metal ions or species.

9. (c) The coordination number of the central atom or ion is determined by the number of sigma bonds between the ligands and the central atom or ion. Pi-bonds, if any, between the ligating atom and the central atom or ion are not considered for the determination of coordination number.

10. (d) Ni^{+2} coordination number is 6 and always forms outer orbital complex.

11. (c) The correct statement should be chlorophylls are green pigments in plants and contain magnesium.

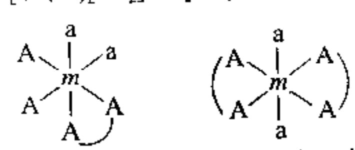
12. (d)

(a) $[Ir(PR_3)_2H(CO)]^{2+}$ will show two geometrical isomers.

(b) $[Co(NH_3)_5Cl]^{2+}$ will not show any geometrical and optical isomerism.

(c) $[Ru(NH_3)_4Cl_2]^+$ will show two geometrical isomerism.

(d) $[Co(en)_2Cl_2]^+ \equiv [M(\overline{AA})_2a_2]$



optically active optically inactive

13. (c) $[Fe(CN)_6]^{4-}$

Fe^{2+} $3d^64s^0$ $\boxed{}\boxed{}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$

M.M = 0 B.M.

$[MnCl_4]^{2-}$.

Mn^{2+} $3d^54s^0$ $\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ $\boxed{\uparrow}\boxed{\uparrow}$

M.M = $\sqrt{35}$ B.M.

$[CoCl_4]^{2-}$

Co^{+2} $3d^74s^0$ $\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$

M.M = $\sqrt{15}$ B.M.

14. (d) Let the oxidation state of Cr is x.

Oxidation state of NH_3 is zero and of Cl is -1.

Thus, $x + 4(0) + 2(-1) = +1$

$\Rightarrow \quad x = +3$

16. (b)

(a) $[Co(CN)_6]^{3-} \equiv [Ma_6]^{3-}$

It will not show geometrical and optical isomerism.

(b) $[Co(C_2O_4)_3]^{3-} \equiv [M(\overline{AA})_3]^{3-}$

It will not show geometrical isomerism but it is optically active.

(c) $[ZnCl_4]^{2-}$

It will not show geometrical and optical isomerism.

(d) $[Cu(NA_3)_4]^{2+}$

It will not show geometrical and optical isomerism.

17. (a)

$[CoCN_6]^{3-}$ Co^{+3} $3d^64s^0$ $\boxed{}$

M.M. = 0 B.M. $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$

$2Hg_2Cl_2 + 2NH_4OH \rightarrow 2Hg(NH_2)Cl + 2Hg + 2H_2O + 2HCl$

$[Fe(CN)_6]^{3-}$ Fe^{+3} $3d^54s^0$ $\boxed{}\boxed{}$

M.M. = $\sqrt{3}$ B.M. $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}$

$[Mn(CN)_6]^{3-}$ Mn^{+3} $3d^44s^0$ $\boxed{}\boxed{}$

M.M. = $\sqrt{8}$ B.M. [⇅][↑][↑]

$[Cr(CN)_6]^{3-}$ Cr^{+3} $3d^3 4s^0$ [ ][ ]

M.M. = $\sqrt{15}$ B.M. [↑][↑][↑]

18. (d) M.M. = 2.84 B.M. $\rightarrow$ No. of unpaired electron is 2

d^5(in strong ligand field) [ ][ ]

[⇅][⇅][↑]

d^3(in weak as well as in stron field ligand fields) [ ][ ]

[↑][↑][↑]

d^4(in weak ligand fields) [↑][ ]

[↑][↑][↑]

d^4(in strong ligand fields) [ ][ ]

[⇅][↑][↑]

20. (a) As per Fajan's rule, with increase in charge density on the cation, the covalent character in the compound increases.

21. (d) Ni: in $[NiX_4]^2$ is Ni^{2+}.

Ni electronic configuration: $3d^8\ 4s^2$

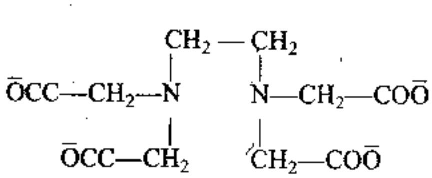
Ni^{2+} electronic configuration: $3d^8\ 4s^0$

[⇅][⇅][⇅][↑][↑]

As the complex is paramagnetic, thus, the two unpaired electrons will remain unpaired. Hence, the hybridization should be sp^3 and geometry, thus is tetrahedral.

22. (b) $Fe(CO)_5$, has synergic bonding.

23. (a) $EDTA^{4-}$ is a hexadentate ligand in which donor atoms are N (two) and oxygen (four).



(decimal to get the impaired electrons)

24. (c) $m = \sqrt{n(n+2)}$

In Ni^{2+}, unpaired electron is 2.

$\therefore \quad m = \sqrt{2(2+2)} = \sqrt{8}$

$= 2.828$

$= 2.84$

25. (a)

$[PtCl_4]^{2-}$ Pt^{+2} $5d^8 6s^0$

[⇅][⇅][⇅][⇅][ ] [ ][ ][ ][ ]

dsp^2

Others are tetrahedral complex.

26. (d) $[E(en)_2(C_2O_4)]NO_2$

$E + 2(0) + (-2) + (-1) = 0$

$E = +3$

27. (a) Other factors are same. The complex having strong field ligand has the highest magnitude of Δ_0.

28. (c) $[Co(en)_2 (NH_3)_2]^{3+} \equiv [M(\overline{AA})_2\, a_2]^{3+}$

It has to geometrical isomers. Its *cis* isomer is optically active.

29. (a) Linkage isomers contain ambidentate ligand $NC\bar{S}$ and $SC\bar{N}$.

30. (a) AgCl obtained is 4.78 g, that is, $\frac{4.78}{143.5}$ moles.

Thus, in $\frac{2.675}{267.5}$ moles of complex, $\frac{4.78}{143.5}$ moles of Cl^- ions were isonizable.

That is, Ii 10^{-2} moles of complex, $\frac{1}{30}$ moles Cl^- are produced.

$\therefore$ 1 mole of complex $\rightarrow \frac{1}{30} \times 10^{-2}$ moles of Cl^-

$= \frac{100}{30} = 3.3$ moles

Thus, the formula of complex should be $[Co(NH_3)_6]Cl_3$.

31. (b)

(a) $[Zn(en)(NH_3)_2]^{2+}$

It has no geometrical and optical isomers.

(b) $[Co(en)_3]^{3+}$

It has no geometrical isomers, but it is optically active.

(c) $[Co(H_2O)_3(en)]^{3+}$

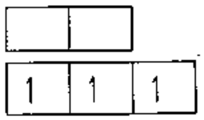
It has no geometrical and optical isomers.

(d) $[Zn(en)_2]^{2+}$

It has no geometrical and optical isomers.

32. (c)

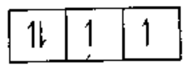
$[Cr(NH_3)_6]Cl_3$ Cr^{+3} $3d^3 4s^0$



d^2sp^3 and paramagnetic

33. (d)

$[NiCl_4]^{2-}$



Ni^{+2} $3d^8 4s^0$

M.M. = $\sqrt{8}$ = 2.82 B.M.

34. (a) Increasing order of field strength is $NH_3 < en < CN^- < CO$.

In general, field strength order is Halogen Family < Oxygen Family < Nitrogen Family < Carbon Family.

35. (b)

(a) $[Ni(NH_3)_5Br]^+$

It has no geometrical and optical isomers.

(b) $[Co(NH_3)_2(en)_2]^{3+}$

It has two geometrical isomers.

(c) $[Cr(NH_3)_4(en)_2]^{3+}$

It has no geometrical isomers.

(d) $[Co(en)_3]^{3+}$

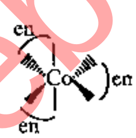
It has no geometrical isomers, but it is optically active.

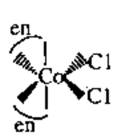
36. (b)

(a) We first name cation and then anion.

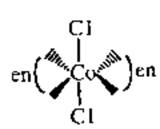
(b) If cation is complex, then we first name ligand in alphabetical order and then central atom with oxidation state remain numeral in common brackets.

37. (c)

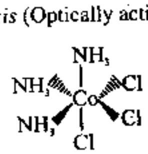
(a)  (Optically active)

(b) 

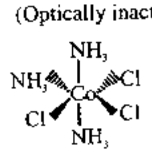
cis (Optically active)



trans (Optically inactive)

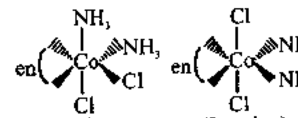
(c) 

fac (Optically inactive)

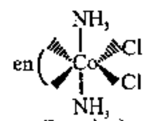


Mer (Optically inactive)

(d) Exist in three G.I.



(Active) (Inactive)



(Inactive)

38. (d) The frequency order of given absorbed light is:

Blue > Green > Yellow > Red.

Respective ligands L_4 L_2 L_3 L_1

Hence the ligand strength order is $L_4 > L_2 > L_3 > L_1$.

Because strong field ligand causes higher splitting gap for octahedral-complex and absorbs high frequency light for *d-d* transition.

Hence the answer is (d).

39. (d)

(a) $[Mg(H_2O)_6]^{+2} + (EDTA)^{-4} \xrightarrow[\text{of NaOH}]{\text{excess}} [Mg(EDTA)]^{-2} + 6H_2O$

(b) $CuSO_4 + 5KCN \rightarrow K_3[Cu(CN_4) + K_2SO_4 + \frac{1}{2}(CN)_2$

(c) $2LiCl + K_2O \rightarrow Li_2O + 2KCl$

backward reaction of given equation is correct

(d) $[CoCl(NH_3)_5]^+ + 5H^+ \rightarrow Co^{+2} + 5NH_4^+ + Cl^-$

Hence NH_3 gets protonated and makes Co^{+2} ion free in solution.

40. (d) In $[FeF_6]^{3-}$, 5 unpaired electron present is In $[Fe(CN)_6]^{3-}$ 1 unpaired electron present.

41. (a) Co^{+3} is diamagnetic and having d^6 by configuration under SFL.

JEE (Advanced) Exercises

Fill in the Blanks Type

1. AgCl dissolves in excess of KCN solution to give the **K[Ag(CN)$_2$]** complex compound.

   $AgCl + 2KCN \rightarrow K[Ag(CN)_2] + KCl$

2. The type of magnetism exhibited by $[Mn(H_2O)_6]^{2+}$ ion is **paramagnetism**.

3. The IUPAC name of $[Co(NH_3)_6]Cl_3$ is **hexamminecobalt(III) chloride**.

True/False Type

1. **False.**
Potassium ferrocyanide is diamagnetic but potassium ferricyanide is paramagnetic.

Single Correct Answer Type

1. (c)

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing.

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

$[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing.

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons so, the complex is diamagnetic.

Spin magnetic moment = zero

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

2. (b) $[Cr(H_2O)_6]^{3+}$

The oxidation number of Cr is +3.

Atomic number = 24

$Cr = [Ar]3d^5 4s^1$

$Cr^{3+} = [Ar]3d^3 4s^0$

3d					4s	4p		
↑	↑	↑						

There are three unpaired electrons.

$[Fe(H_2O)_6]^{2+}$

The oxidation number of Fe is +2.

Atomic number = 26

$Fe = [Ar]3d^6 4s^2$

$Fe^{2+} = [Ar]3d^6 4s^0$

3d					4s	4p		
↑↓	↑	↑	↑	↑				

There are four unpaired electrons.

$[Cu(H_2O)_6]^{2+}$

The oxidation number of Cu is +2.

Atomic number = 29

$Cu = [Ar]3d^{10} 4s^1$

$Cu^{2+} = [Ar]3d^9 4s^0$

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑				

There is one unpaired electron.

$[Zn(H_2O)_6]^{2+}$

The oxidation number of Zn is +2.

Atomic number = 30

$Zn = [Ar]3d^{10}\,4s^2$

$Zn^{2+} = [Ar]3d^{10}\,4s^0$

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑↓				

There are no unpaired electrons.

$[Fe(H_2O)_6]^{2+}$ has the maximum number of unpaired electrons; therefore, the highest degree of paramagnetism.

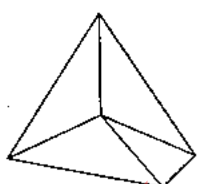
3. (d) When excess of KCN is added to an aqueous solution of copper sulphate, $K_3[Cu(CN)_4]$ is formed.

$CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$

$2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + (CN)_2$

$Cu_2(CN)_2 + 6KCN \rightarrow 2K_3[Cu(CN)_4]$

4. (c)



$Ni(CO)_4$

Oxidation number = 0

$Ni = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8, 4s^2$

$Ni^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$

3d					4s	4p		
↓↑	↓↑	↓↑	↓↑	↓↑				

sp^3-Hybridization

Geometry of $Ni(CO)_4$ is tetrahedral.

$Ni(PPh_3)_2Cl_2$

Oxidation number = +2

$Ni^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8$

$3d^8$					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization

Geometry of $Ni(PPh_3)_2Cl_2$ is tetrahedral.

5. (d) $MnO_4^- : Mn(+7)$

$Cr(CN)_6^{3-} : Cr(+3)$

$NiF_6^{2-} : Ni(+4)$

$CrO_2Cl_2 : Cr(+6)$

6. (a) $MnO_4^- : Mn(+7)$

Mn ($z = 25$)

$[Ar]3d^5\,4s^2$

$Mn^{+7} : [Ar]$

No d electrons left.

7. (b) $MnO_2(+4)$ and $FeCl_3(+3)$

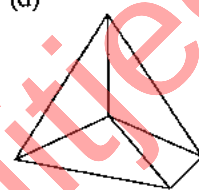
MnO_4^- (+7) and $CrO_2Cl_2(+6)$

$[Fe(CN)_6]^{3-}$ (+3) and $[Co(CN)_6]^{3-}$ (+3)

$[NiCl_4]^{2-}$ and $[CoCl_4](+3)$

For manganese, +7 is the maximum oxidation state and for chromium, +6 is the maximum oxidation state.

8. (d)



$[Ni(Cl)_4]^{2-}$

The oxidation state of Ni is +2.

The atomic number of Nickel is 28.

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization, tetrahedral shape.

9. (b) $Hg[Co(SCN)_4]$,

Co is present as Co^{2+}.

The atomic number of cobalt is 27.

$Co = [Ar]3d^7\,4s^2$

$Co^{2+} = [Ar]3d^7$

↑↓	↑↓	↑	↑	↑				

Unpaired electrons, $n = 3$

Magnetic moment = $\sqrt{n(n+2)}$

$= \sqrt{3(3+2)} = \sqrt{15}$ BM

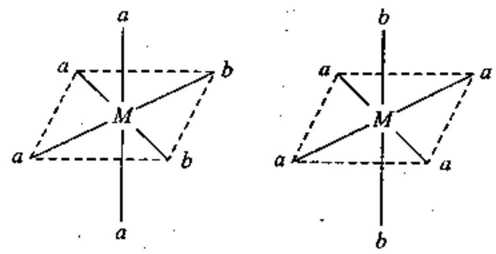
10. (a) $Co(NH_3)_4Br_2Cl$ is octahedral in shape.

It shows ionization and geometrical isomerism.

$[Co(NH_3)_4Br_2]Cl \rightleftharpoons [Co(NH_3)_4Br_2]^+ + Cl^-$

$[Co(NH_3)_4BrCl]Br \rightleftharpoons [Co(NH_3)_4BrCl]^+ + Br^-$

The above two structures are geometrical isomers because they furnish different ions on dissociation. $Co(NH_3)_4Br_2Cl$ is of Ma_4b_2 type, and it shows geometrical isomerism as shown here.



cis trans

Ma_4b_2

11. (d) The overlap of a lone pair on the C atom with the empty hybrid metal orbital forms a metal-to-carbon σ-bond. The transition metal atom in a metal carbonyl fills the non-bonding *d*-orbitals which are of proper symmetry to overlap with the anti-bonding orbitals of CO. The electronic charge is transferred from the filled non-bonding orbitals of the metals to π^*-orbitals of the ligand CO. This reduces the bond order of CO. The π back-bonding strengthens the M—C bond order, it weakens the C—O bond order. So the bond length increases slightly.

12. (d) The overlap of a lone pair on the C atom with the empty hybrid metal orbital forms a metal-to-carbon σ-bond. The transition metal atom in a metal carbonyl fills the non-bonding *d*-orbitals which are of proper symmetry to overlap with the anti-bonding orbitals of CO. The electronic charge is transferred from the filled non-bonding orbitals of the metals to π^*-orbitals of the ligand CO. This reduces the bond order of CO. The π back-bonding strengthens the M—C bond order and weakens the C—O bond order.

CO is a strong ligand, it causes pairing of electrons.

Mn^+: $(z = 25)$

$[Ar]3d^5 4s^1 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

Fe^0: $(z = 26)$

$[Ar]3d^6 4s^2 \Rightarrow [Ar]3d^8$

Four lone pairs are available for back-bonding with vacant orbital of C in CO.

Cr^0: $(z = 24)$

$[Ar]3d^5 4s^1 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

V^-: $(z = 23)$

$[Ar]3d^4 4s^2 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

Minimum back-bonding is possible in $[V(CO)_6]^{-1}$, so the M—C bond order is the lowest.

13. (b)

	$[Ni(CN)_4]^{2-}$	$[NiCl_4]^{2-}$
Oxidation number	+2	+2
Coordination number	4	4
Hybridization	dsp^2	sp^3
Shape	Square planar	Tetrahedral
Unpaired electrons	0	2
Magnetic moment	0	$\sqrt{8}$ BM

CN^- is a strong field ligand, hence it causes the pairing of 3*d*-electrons, whereas Cl^- is a weak field ligand and it does not cause pairing.

14. (c) $[Ni(NH_3)_4][NiCl_4]$

In both cation and anion, oxidation state of nickel is +2.

The IUPAC name is tetraaminenickel(II) tetra-chloridonickelate(II).

15. (c) CuF_2 is blue colored.

In CuF_2, Cu^{2+} ions are present.

In all the other given options, the oxidation number of copper is +1.

$Cu = [Ar]3d^{10} 4s^1$

$Cu^{2+} = [Ar]3d^9$

Unpaired electron present

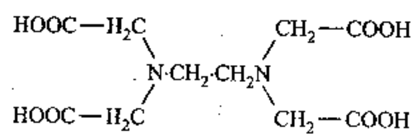
Colored

$Cu^+ = [Ar]3d^{10}$

No unpaired electron

Colorless

16. (c)



is the correct structure of ethylenediaminetetraacetatic acid. It is a hexa-dentate ligand.

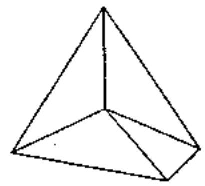
17. (b) The ionization isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is $[Cr(H_2O)_4Cl_2](NO_2)$.

$$[Cr(H_2O)_4Cl(NO_2)]Cl \rightarrow [Cr(H_2O)_4Cl(NO_2)]^+ + Cl^-$$

$$[Cr(H_2O)_4Cl_2](NO_2) \rightarrow [Cr(H_2O)_4Cl_2]^+ + NO_2^-$$

Both of them give different ions on dissociation.

18. (d)



$[Ni(Cl)_4]^{2-}$

The oxidation state of Ni is +2.

The atomic number of nickel is 28.

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d   4s   4p

↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization, tetrahedral shape.

There are two unpaired electrons.

Spin magnetic moment $= \sqrt{n(n+2)}$

$= \sqrt{2(2+2)} = \sqrt{8}$ BM

≈ 2.82 BM

19. (b) $Ni^{2+} + Cl^- \rightarrow NiCl_4$; tetrahedral

$Ni^{2+} + CN^- \rightarrow Ni(CN)_4$; square planar

$Ni^{2+} + H_2O \rightarrow [Ni(H_2O)_6]^{+2}$; octahedral

20. (c) K: $K_3[Fe(CN_6)] \rightarrow Fe^{3+} \equiv 3D^5$ (odd electrons)

It is paramagnetic.

L: $[Co(NH_3)_6]Cl_3 \rightarrow CO^{3+} \equiv 3d^6$

NH_3 a strong field ligand and hence back pairing

⇅	⇅	⇅		

$\underbrace{\quad}_{d^6}$

It is diamagnetic.

M: $Na_3[Co(OX)_3] \rightarrow Co^{3+} \equiv 3d^6$

21. (d) $[Co(H_2O)_4(NH_3)_2]Cl_3$

= Diaminetet raaqua cobalt(III) chloride

22. (a) $CuSO_4$ will be absorbing orange-red color and hence will be of blue color.

23. (b) spin only magnetic moment $= \sqrt{n(n+2)}$ B.M.

$n \rightarrow$ number of unpaired electrons

P: $[FeF_6]^{3-}$

$F^- \rightarrow$ (weak field ligand)

$\Delta_0 < P$

Fe^{3+} [Ar] $3d^5$ — e_g: | 1 | 1 |; t_{2g}: | 1 | 1 | 1 |

number of unpaired electron = 5

$\mu = \sqrt{5(5+2)} = \sqrt{35}$

Q: $[V(H_2O)_6]^{2+}$

$H_2O \rightarrow$ (weak field ligand)

$\Delta_0 < P$

$V^{2+} \rightarrow [Ar]\,3d^3$ — e_g: | | |; t_{2g}: | 1 | 1 | 1 |

number of unpaired electron = 3

$\mu = \sqrt{3(3+2)} = \sqrt{15}$

R: $[Fe(H_2O)_6]^{2+}$

$H_2O \rightarrow$ (weak field ligand)

$\Delta_0 < P$

Fe^{2+}; [Ar] $3d^6$ — e_g: | 1 | 1 |; t_{2g}: | ⇅ | 1 | 1 |

number of unpaired electron = 4

$\mu = \sqrt{4(4+2)} = \sqrt{24}$

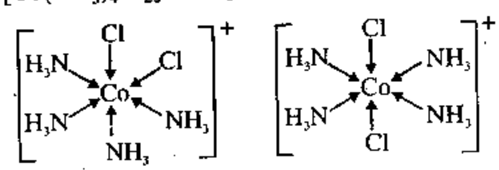
Hence, Q < R < P

Multiple Correct Answers Type

1. (b), (d)

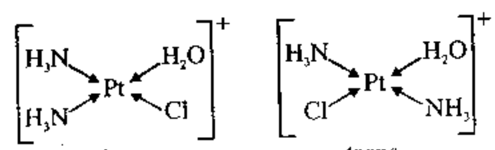
(a) $[Cr(NH_3)_5Cl]Cl_2$ does not show any isomerism while $[Cr(NH_3)_4Cl_2]Cl$ shows geometrical isomerism

(b) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)(Cl)]^+$



cis   *trans*

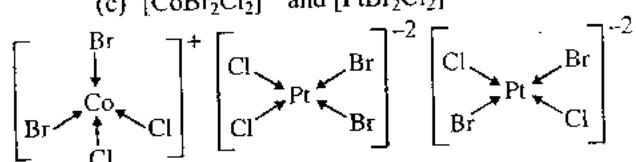
hence, $[Co(NH_3)_4Cl_2]^+$ ion shows geometrical isomerism. $[Pt(NH_3)_2(H_2O)(Cl)]^+$



cis   *trans*

hence, $[Pt(NH_3)_2(H_2O)(Cl)]^+$ ion shows geometrical isomerism

(c) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$



tetrahedral does not show any isomerism   *cis*   *trans*   square planar and shows geometrical isomerism

does not show any isomerism   square planar and shows geometrical isomerism

(d) $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$

$\left.\begin{matrix}[Pt(NH_3)_3(No_3)]Cl \\ [Pt(NH_3)_3Cl]NO_3\end{matrix}\right\}$ show ionization isomerism

$\left.\begin{matrix}[Pt(NH_3)_3Cl]Br \\ [Pt(NH_3)_3Br]Cl\end{matrix}\right\}$ show ionization isomerism

Hence, answer is (b), (d)

Comprehension Type

1. (a) $NiCl_2 + 4KCN \rightarrow K_2[Ni(CN)_4] + 2KCl$

A is $K_2[Ni(CN)_4]$

Potassium tetracyanonickelate(II)

$K_2[Ni(CN)_4] + 4HCl(conc) \rightarrow K_2[Ni(CN)_4] + 4HCN$

B is $K_2[NiCl_4]$

Potassium tetrachloridonickelate(II)

2. (c) $[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\ 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\ 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing.

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

3. (a)

$K_2[Ni(CN)_4]$: dsp^2-hybridization

$K_2[NiCl_4]$: sp^3-hybridization

Assertion-Reasoning Type

1. (a) $[Fe(H_2O)_5NO]SO_4$

NO has charge equal to +1 in this complex. Therefore, the oxidation number of Fe in the complex becomes +1.

$Fe^+ = [Ar]3d^6 4s^2$

$Fe^+ = [Ar]3d^6 4s^1$

3d					4s	4p		
↑↓	↑	↑	↑	↑	↑			

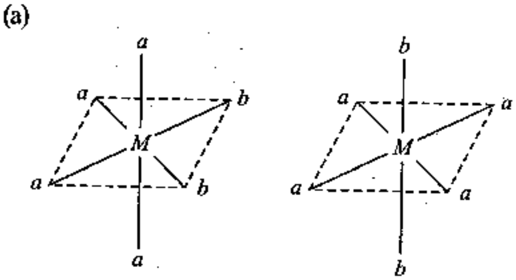
After pairing

3d					4s	4p		
↑↓	↑↓	↑	↑	↑				

NO^+ causes pairing of 4s electron inside.

Thus, the configuration is $3d^7$ and the number of unpaired electrons is 3.

2. (a)



cis trans

Ma_4b_2

The *cis* and *trans* forms of the complex $[M(NH_3)_4Cl_2]$ are optically inactive. Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry.

Matching Column Type

1. (a) → (p, q, s); (b) → (p, r, s); (c) → (q, s); (d) → (q, s)

In all the given complexes, the metal is in +2 oxidation state.

$[Co(NH_3)_4(H_2O)_2]Cl_2$ can show geometrical isomerism, it is an octahedral complex of Ma_4b_2 type.

$[Pt(NH_3)_2Cl_2]$ can show geometrical isomerism, it is a tetrahedral complex of Ma_2b_2 type.

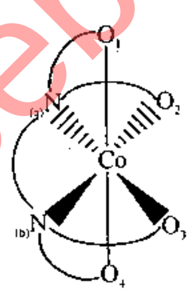
$[Co(NH_3)_4(H_2O)_2]Cl_2$ is paramagnetic, it has three unpaired electrons.
$[Pt(NH_3)_2Cl_2]$ is diamagnetic. It does not have any unpaired electrons.
$[Co(H_2O)_5Cl]Cl$ is paramagnetic. It has three unpaired electrons.
$[Ni(H_2O)_6]Cl_2$ is paramagnetic. It has two unpaired electrons.

2. (b)

(P) $[Cr^{III}(NH_3)_4Cl_2]Cl$ (3 upaired electrons)	(1) Complex given in (P) is paramagnetic and shows two geometrical isomerism (*cis* and *trans*) (does not show ionization isomer)
(Q) $[Ti^{III}(H_2O)_5Cl](NO_3)_2$ (1 unpaired electrons)	(2) Complex given in (Q) is paramagnetic and shows ionization isomerism
(R) $[Pt^{II}(en)(NH_3)Cl]NO_3$ (1 unpaired electrons)	(3) Complex given in (R) is diamagnetic and shows ionization isomerism
(S) $[Co^{III}(NH_3)_4(NO_3)_2]NO_3$ (0 unpaired electrons)	(4) Complex given in (S) is diamagnetic and does not show ionization isomerism (show geometrical isomerism)

Integer Answer Type

1. (8)



$= [Co^{III}(EDTA)]^-$

Total 8 N–Co–O bond angles

$_{(a)}$N–Co–O_1	$_{(b)}$N–Co–O_1
$_{(a)}$N–Co–O_2	$_{(b)}$N–Co–O_2
$_{(a)}$N–Co–O_3	$_{(b)}$N–Co–O_3
$_{(a)}$N–Co–O_4	$_{(b)}$N–Co–O_4

Subjective Type

1. Potassium ferricyanide is reduced to potassium ferrocyanide as follows:

$$2K_3Fe(CN)_6 + H_2O_2 + 2KOH \rightarrow 2K_4Fe(CN)_6 + 2H_2O + O_2$$

2. "The species $[CuCl_4]^{2-}$ exists, while $[CuI_4]^{2-}$ does not."

$$2CuI_2 \rightarrow Cu_2I_2 + I_2$$

Iodide ion reduces Cu^{2+} to cuprous iodide and I_2. So $[CuI_4]^{2-}$ does not exist.

3. $$3[Fe(H_2O)_6]^{2+} + NO_3^- + 4H^+ \rightarrow NO + 3[Fe(H_2O)_6]^{3+} + 2H_2O$$

$$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$$

4. $[Ti(NO_3)_4]$

The oxidation state of Ti is +4.
The atomic number of titanium is 22.

$Ti = [Ar]3d^2 4s^2$

$Ti^{4+} = [Ar]$

Incomplete *d*-orbital is not there, so it is colorless.

$[Cu(NCCH_3)]^+ BF_4^-$

The oxidation state of Cu is +1.
The atomic number of copper is 28.

$Cu = [Ar]3d^{10} 4s^1$

$Cu^+ = [Ar]3d^9$

Incomplete *d*-orbital is not there, so it is colorless.

$[Cr(NH_3)_6]^{3+} 3Cl^-$

The oxidation state of Cr is +23.
The atomic number of chromium is 24.

$Cr = [Ar]3d^{10} 4s^1$

$Cr^{3+} = [Ar]3d^8$

Incomplete *d*-orbitals are there, so it is colored.

$K_3[VF_6]$

The oxidation state of V is +3.
The atomic number of vanadium is +3.

$V = [Ar]3d^3 4s^2$

$V^{3+} = [Ar]3d^3$

Incomplete *d*-orbitals are there, so it is colored.

5. **(i)** $[Co(NH_3)_5ONO]Cl_2$

Pentamminenitritocobalt(II) chloride

(ii) $K_3[Cr(CN)_6]$

Potassiumhexacyanochromate(III)

6. $[Cr(NH_3)_5CO_3]Cl$

Pentaamminecarbonatochromium(III) chloride

7. Argentite is the sulphide ore of silver.

$$Ag_2S + 4KCN \rightarrow 2K[Ag(CN)_2] + K_2S$$

8. (i) Pentaamminechlorocobalt(III) ion

$[Co(NH_3)_5Cl]^{2+}$

(ii) Lithiumtetrahydrogenaluminate(III)
$Li[AlH_4]$

9. A, B, and C are three complexes of chromium(III) with the empirical formula $H_{12}O_6C_{13}Cr$. All the three complexes have water and chloride ion as ligands.
Complex A does not react with concentrated H_2SO_4.

A is $[Cr(H_2O)_6]Cl_3$.

$$[Cr(H_2O)_6]Cl_3 + H_2SO_4 \rightarrow \text{No reaction}$$

Water molecules inside the coordination sphere are not removed by sulphuric acid.
Complex B loses 6.75% of its original mass on treatment with concentrated H_2SO_4.

B is $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

One mole of H_2O which is outside the coordination sphere is removed with sulphuric acid.
Molecular weight of the complex = 266.5

$$\text{Percentage loss in mass} = \frac{18}{266.5} \times 100 = 6.75\%$$

Complex C loses 13.5% of its original mass on treatment with concentrated H_2SO_4.

C is $[Cr(H_2O)_4Cl_2] \cdot Cl \cdot 2H_2O$

Two moles of H_2O are removed which are outside the coordination sphere.

$$\text{Percentage loss in mass} = 2 \times \frac{18}{266.5} \times 100 = 13.50\%$$

10. HgI_2 has orange/scarlet color.
It dissolves in sodium iodide due to the formation of a complex.

$$HgI_2 + 2NaI \rightarrow Na_2HgI_4$$

With NaOCl, again a precipitate of HgI_2 is formed.

$$3Na_2HgI_4 + 2NaOCl + 2H_2O \rightarrow 3HgI_2 + 2NaI_3 + 4NaOH + 2NaCl$$

11. $[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero

$[Ni(CO)_4]$

The oxidation number of Ni is 0.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑	↑↓			

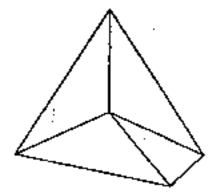
CO is a strong field ligand, it causes pairing.

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑↓				

sp^3-Hybridization (tetrahedral)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero



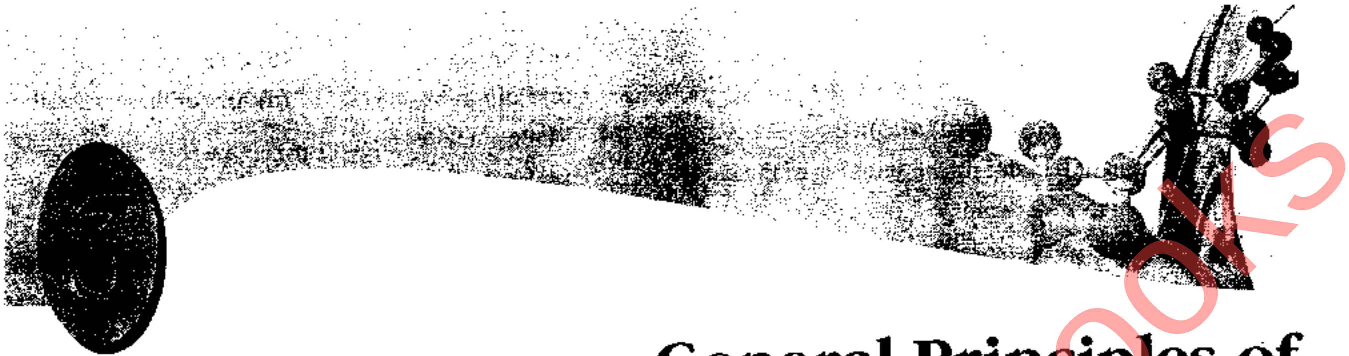
$[Co(NH_3)_6]^{3+}$

The oxidation number of Co is +3.

Atomic number = 27

$Co = [Ar]3d^7 4s^2$

$Co^{3+} = [Ar]3d^6 4s^0$



General Principles of Extraction of Metals

JEE (Main) Exercises

Single Correct Answer Type

1. Froth floatation process is used for the:
   (a) Oxide ores (b) Sulphide ores
   (c) Chloride ores (d) All of these

2. In the froth floatation process, for the benefication of ores, the ore particles float because:
   (a) They are light
   (b) Their surface is not easily wetted by water
   (c) They bear electrostatic charge
   (d) They are insoluble

3. Zone refining is a method to obtain:
   (a) Very high temperature (b) Ultrapure Al
   (c) Ultrapure metals (d) Ultrapure oxides

4. Cassiterite is an ore of:
   (a) Mn (b) Ni
   (c) Sb (d) Sn

5. Cryolite is:
   (a) Na_3AlF_6 and is used in the electrolysis of alumina for decreasing electrical conductivity
   (b) Na_3AlF_6 and is used in the electrolysis of alumina for lowering the melting point of alumina
   (c) Na_3AlF_6 and is used in the electrolytic purification of alumina
   (d) Na_3AlF_6 and is used in the electrolysis of alumina

6. The process of converting hydrated alumina into anhydrous alumina is called:
   (a) Roasting (b) Smelting
   (c) Dressing (d) Calcination

7. Pyrolusite is a/an:
   (a) Oxide ore (b) Sulphide ore
   (c) Carbide ore (d) Not an ore

8. Composition of azurite mineral is:
   (a) $CuCO_3{\cdot}CuO$ (b) $Cu(HCO_3)_2{\cdot}Cu(OH)_2$
   (c) $2CuCO_3{\cdot}Cu(OH)_2$ (d) $CuCO_3{\cdot}2Cu(OH)_2$

9. Which of the following metal is not manufactured by electrolysis?
   (a) Na (b) Mg
   (c) Al (d) Fe

10. Poling process is used:
    (a) For the removal of Cu_2O from Cu
    (b) For the removal of Al_2O_3 from Al
    (c) For the removal of Fe_2O_3 from Fe
    (d) All of these

11. The pyrometallurgical operations involve the use of:
    (a) High temperature (b) Sulphide ores
    (c) Electrolysis (d) Complexation

12. Aluminium is extracted by the electrolysis of:
    (a) Bauxite
    (b) Alumina
    (c) Alumina mixed with molten cryolite
    (d) Molten cryolite

13. Which of the following ores is best concentrated by froth floatation process?
(a) Malachite (b) Cassiterite
(c) Galena (d) Magnetite

14. The function of flux during the smelting of the ore is:
(a) To make the ore porous
(b) To remove gangue
(c) To facilitate reduction (d) To facilitate oxidation

15. Complex formation method is used for the extraction of:
(a) Zn (b) Ag
(c) Hg (d) Cu

16. Heating of pyrites in presence of air to remove sulphur is called:
(a) Roasting (b) Calcination
(c) Smelting (d) Fluxing

17. The acidic refractory material is:
(a) CaO (b) P_2O_5
(c) SiO_2 (d) MgO

18. The incorrect statement is:
(a) Calamine and siderite are carbonates
(b) Argentite and cuprite are oxides
(c) Zinc blende and iron pyrites are sulphides
(d) Malachite and azurite are ores of copper

19. Composition of malachite mineral is:
(a) $CuCO_3 \cdot CuO$ (b) $Cu(HCO_3)_2 \cdot Cu(OH)_2$
(c) $2CuCO_3 \cdot Cu(OH)_2$ (d) $CuCO_3 \cdot Cu(OH)_2$

20. Select the correct statement:
(a) Calcination and roasting take place in reverberatory furnace and small roasting takes place in small blast furnace
(b) Calcination and roasting take place only in small blast furnace
(c) Calcination and roasting take place only in reverberatory furnace
(d) All are correct

21. Bauxite is extracted by:
(a) Hall's process (b) Baeyer's process
(c) Serpek's process (d) All of these

22. Tin is extracted from its ore, cassiterite, by:
(a) Electrolytic reduction
(b) Carbon-monoxide reduction
(c) Carbon reduction
(d) The aluminothermic process

23. Tin is not refined by:
(a) Liquation (b) Zone refining
(c) Poling (d) Any of these

24. Matte contains:
(a) Cu_2S, FeS, and silica
(b) Cu_2S, FeO, and silica
(c) Cu_2S, CuO, and silica
(d) Cu_2S, Cu_2O, and silica

25. The ore that is concentrated by froth floatation process is:
(a) Cinnabar (b) Bauxite
(c) Malachite (d) Zincite

26. Hydro-metallurgical process of extraction of metals is based on:
(a) Complex formation (b) Hydrolysis
(c) Dehydration (d) Dehydrogenation

27. In alumino-thermic process, aluminium is used as:
(a) Oxidizing agent (b) Reducing agent
(c) Dehydrating agent
(d) Complex formation agent

28. Which of the following metals are found in native state?
Ag, Pt, C, Si, N, O, Mg, Na, Pb.
(a) Ag, Pt, C, N, O (b) Ag, Pt, Mg
(c) Ag, Pt, Pb, Mg (d) Ag, Pt

29. Most abundant metal in earth crust is:
(a) Al (b) O
(c) Fe (d) Si

30. $CaS_2 + \frac{3}{2}O_2 \longrightarrow CaS_2O_3$

What is the difference in average oxidation number of sulphur in product and in reactant in the above given reaction?
(a) 1 (b) 2
(c) 3 (d) 4

31. Ellingham diagram represents:
(a) Change of ΔG with temperature
(b) Change of ΔH with temperature
(c) Change of ΔG with pressure
(d) Change of $(\Delta G - T\Delta S)$ with temperature

32. To carry out a reduction process, select a temperature so as to make:
(a) ΔG negative (b) ΔG positive
(c) ΔH negative (d) ΔH positive

33. Self-reduction of the sulphide ore takes place during:
(a) Roasting (b) Smelting
(c) Calcination (d) Cupellation

34. Corundum is .... mineral of Al:
(a) Silicate (b) Oxide
(c) Double salt (d) Sulphate

35. Purest form of iron is:
(a) Cast iron (b) Wrought iron
(c) Pig iron (d) None of these

36. Cementite is:
(a) Predominant content of cement
(b) A mineral of calcium
(c) A carbide of iron in steel
(d) None of these

37. Iron obtained from blast furnace is:
(a) Wrought iron (b) Cast iron
(c) Pig iron (d) Steel

38. In the extraction of nickel by Mond's process, the metal is obtained by:
(a) Electrochemical reduction
(b) Thermal decomposition
(c) Chemical reduction by aluminium
(d) Reduction by carbon

39. Iron obtained from reduction zone of the blast furnace is:
(a) Wrought iron (b) Cast iron
(c) Spongy iron (d) Steel

40. Refining of silver is done by:
(a) Liquation (b) Poling
(c) Cupellation (d) Van Arkel method

41. Bessemerization is carried out for
I: Fe, II: Cu, III: Al, IV: silver
(a) I, II (b) II, III
(c) III, IV (d) I, III

42. Calcination is the process of heating the ore:
(a) In inert gas
(b) In the presence of air
(c) In the absence of air or limited supply of air
(d) In the presence of CaO and MgO

43. $Ag_2S + NaCN + Zn \longrightarrow Ag$
This method of extraction of Ag by complex formation and then its displacement is called:
(a) Parke's method
(b) Mac Arthur–Forest method
(c) Serpek method
(d) Hall's method

44. The slag obtained during the extraction of copper from copper pyrites is composed of:
(a) Cu_2S (b) $CuSiO_3$
(c) $FeSiO_3$ (d) SiO_2

45. In zone-refining method, the molten zone:
(a) Consists of impurities only
(b) Contains more impurity than the original metal
(c) Contains the purified metal only
(d) Moves to either side

46. Out of Cu_2S, HgS, and ZnS, roasting is used to convert the minerals into metal in case of:
(a) Cu_2S, ZnS (b) HgS, ZnS
(c) Cu_2S (d) HgS

47. During smelting, an additional substance is added which combines with impurities to form a fusible mass. The additional substance is called:
(a) Flux (b) Slag
(c) Gangue (d) Ore

48. The process of isolation of metals by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called:
(a) Electrometallurgy (b) Hydrometallurgy
(c) Electro-refining (d) Zone-refining

49. Smelting involves reduction of metal oxide with:
(a) Carbon (b) Self-reduction
(c) Magnesium (d) Aluminium

50. Zone-refining has been employed for preparing ultra-pure samples of:
(a) Cu (b) Zn
(c) Ge (d) Ag

51. In the aluminothermite process, aluminium acts as:
(a) An oxidizing agent (b) A flux
(c) A reducing agent (d) A solder

52. In which of the following minerals, is aluminium not present?
(a) Cryolite (b) Mica
(c) Feldspar (d) Fluorspar

53. Which of the following metals is obtained by leaching the ore with dilute cyanide solution?
(a) Silver (b) Titanium
(c) Vanadium (d) Zinc

54. Which method of purification is represented by the equations:

$$\underset{\text{(Impure)}}{Ti} + 2I_2 \xrightarrow{500\ K} TiI_4 \xrightarrow{1675\ K} \underset{\text{(Pure)}}{Ti} + 2I_2$$

(a) Cupellation (b) Poling
(c) Van Arkel (d) Zone refining

55. Which of the following benefication processes is used for the mineral, $Al_2O_3 \cdot 2H_2O$?
(a) Froth floatation (b) Leaching
(c) Liquation (d) Magnetic separation

56. Malachite is an ore of:
(a) Iron (b) Zinc
(c) Copper (d) Mercury

57. Heating of pyrites to remove sulphur is called:
(a) Smelting (b) Calcination
(c) Liquation (d) Roasting

58. In the metallurgy of which of the following, is cupellation process used?
(a) Copper (b) Silver
(c) Iron (d) Aluminium

59. The methods chiefly used for the extraction of lead and tin from their ores are, respectively:
(a) Self-reduction and carbon reduction
(b) Self-reduction and electrolytic reduction
(c) Carbon reduction and self-reduction
(d) Cyanide process and carbon reduction

60. Vapor phase refining of nickel is carried out using:
(a) I_2 (b) Cl_2
(c) HCl (d) CO

61. Complexes formed in the following methods are:
(I) Mond's process for purification of nickel
(II) Removal of lead poisoning from the body
(III) Cyanide process for extraction of silver
(IV) Froth floatation process for separation of ZnS from galena ore by using depressant

	I	II	III	IV
(a)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_2]$
(b)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_4]^{2-}$
(c)	$Ni(CO)_6$	$[Pb(EDTA)]^{4-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_6]^{4-}$
(d)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_4]^{3-}$	$[Zn(CN)_4]^{2-}$

62. Silver is obtained from $Na[Ag(CN)_2]$ by reaction with:
(a) Fe (b) Na
(c) Zn (d) Au

63. Which of the following reactions taking place in the blast furnace during extraction of iron is endothermic?
(a) $CaCO_3 \longrightarrow CaO + CO_2$
(b) $2C + O_2 \longrightarrow 2CO$
(c) $C + O_2 \longrightarrow CO_2$
(d) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

64. Casseterite ore consists of magnetic impurity named as:
(a) Chromite (b) Wolframite
(c) Magnetite (d) Limonite

65. $A + 3O_2 \longrightarrow 2ZnO + 2SO_2$
Find the formula of A
(a) $ZnCO_3$ (b) ZnS
(c) $ZnSO_4$ (d) $ZnCO_3 \cdot 3Zn(OH)_2$

66. Which of the following term is not related to Al-extraction?
(a) Serpek's process (b) Hall–Heroult process
(c) Thermite process (d) Hoop's process

67. Which of the following is not the ore of Fe?
(a) Siderite (b) Limonite
(c) Magnetite (d) Anthracite

68. Gold is extracted by hydrometallurgical process based on its property:
(a) Of being electropositive
(b) To form complexes which are water soluble
(c) Of being less reactive
(d) To form salts which are water soluble

JEE (Advanced) Exercises

Single Correct Answer Type

1. Van Arkel method of purification of metals involves converting the metal to a:
(a) Volatile enough stable compund
(b) Volatile unstable compound
(c) Non-volatile stable compound
(d) None of these

2. When an aqueous solution of sodium chloride is electrolyzed using platinum electrodes, the ions discharged at the electrodes are:
(a) Sodium and hydrogen (b) Sodium and chloride
(c) Hydrogen and chloride
(d) Hydroxyl and chloride

3. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of:
(a) Nitrogen (b) Oxygen
(c) Carbon dioxide (d) Argon

4. Extraction of zinc from zinc blende is achieved by:
(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

5. The metal oxide which cannot be reduced to metal by carbon is;
   (a) ZnO (b) Fe_2O_3
   (c) PbO (d) Al_2O_3
6. The actual reducing agent of haematite in blast furnace is:
   (a) C (b) CO
   (c) Al (d) CO_2
7. In the cyanide process for extraction of gold and silver from ores, the cyanide solution acts as a:
   (a) Reducing agent to reduce the gold and silver compounds present in the ores into the metallic states
   (b) Leaching agent to bring the gold and silver into solution as cyanide complexes and thus separate these metals from the ores
   (c) Leaching agent to dissolve all the other constituents of the ores leaving the gold and silver as metals
   (d) Leaching agent to bring the ores into solution
8. During the process of electrorefining of Cu, some metals present as impurity settle as anode mud. These are:
   (a) Sn and Ag (b) Pb and Zn
   (c) Ag and Au (d) Fe and Ni
9. Electrolytic reduction process is used for the extraction of:
   (a) Alkali metals (b) Alkaline earth metals
   (c) Aluminium (d) All of these
10. Choose the correct code regarding roasting process:
   (I) It is the process of heating ore in air to obtain the oxide
   (II) It is an exothermic process
   (III) It is used for hydrated oxide and oxysalt ore
   (IV) It is used after the concentration of ore
   (a) I, II, and III (b) I, II, and IV
   (c) I, III, and IV (d) I, II, III, and IV
11. The ignition mixture in "alumino thermite" process consists of a mixture of:
   (a) Magnesium powder and BaO_2 or $KClO_3$
   (b) Magnesium powder, aluminium, and $BaO_2/KClO_3$
   (c) Magnesium and aluminium powder
   (d) Magnesium and aluminium oxides
12. Metal sulphides occur mainly in rocks and metal halides in lakes and seas because:
   (a) Metal sulphides are soluble in water while metal chlorides are insoluble in water
   (b) Metal sulphides are insoluble in water while metal chlorides are soluble in water
   (c) Metal sulphide and metal chlorides both are soluble
   (d) Metal sulphides and metal chlorides both are insoluble
13. From which of the following reaction is blister copper obtained?
   (a) $Cu_2S + FeO \longrightarrow 2Cu + FeO$
   (b) $Cu_2S + FeS \longrightarrow 2Cu + FeS_2$
   (c) $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$
   (d) $Cu^{2+} + Fe \longrightarrow Fe^{2+} + Cu$
14. During the extraction of copper from chalcopyrites, iron is removed as:
   (a) $Fe_3(PO_4)_2$ (b) Fe_2O_3
   (c) $Fe_2(SiO_3)_3$ (d) $FeSiO_3$
15. Blister copper is:
   (a) Electrolytically refined copper
   (b) A mixture of impure copper and silver
   (c) Copper containing 2% impurity
   (d) Present in the anode mud in an electrolytic process
16. In the electrolytic refining of silver, the anode mud obtained contains:
   (a) Zn, Ag, and Au (b) Zu, Cu, Ag, and Au
   (c) Au (d) Cu, Ag, and Au
17. ΔG^o vs T plot in Ellingham diagram slopes downward for the reaction:
   (a) $Mg + 1/2\ O_2 \longrightarrow MgO$
   (b) $2Ag + 1/2O_2 \longrightarrow Ag_2O$
   (c) $C + 1/2\ O_2 \longrightarrow CO$
   (d) $CO + 1/2\ O_2 \longrightarrow CO_2$
18. Self-reduction of CuS to Cu can be carried out in:
   (a) Bessemer converter (b) Blast furnace
   (c) Both (a) and (b) (d) None of these
19. When alloy of silver and lead is rich in silver:
   (a) Cupellation process is used
   (b) Parke's method is used
   (c) Bett's method is used
   (d) Any of these methods can be used
20. Phosphorus separates, in the extraction of iron, as:
   (a) Slag, $Ca_3(PO_4)_2$ (b) Volatile P_2O_5
   (c) Slag, $Mg_3(PO_4)_2$ (d) Ca_3P_2
21. In the metallurgy of iron, when $CaCO_3$ is added to the blast furnace, calcium ion appears as:
   (a) CaO (b) Metallic Ca
   (c) Gangue (d) Slag

22. The method not used for the extraction of Al is:
(a) Van Arkel (b) Serpek's
(c) Baeyer (d) Hall–Heroult

23. Four metals and their methods of refinement are given
(i) Ni, Cu, Zr, Ga
(ii) Electrolysis, Van Arkel process, zone refining, Mond's process
Choose the right method for each:
(a) Ni: Electrolysis, Cu: Van Arkel process, Zr: Zone refining, Ga: Mond's process
(b) Ni: Mond's process, Cu: Electrolysis, Zr: Van Arkel process, Ga: Zone refining
(c) Ni: Mond's process, Cu: Van Arkel process, Zr: Zone refining, Ga: Electrolysis
(d) Ni: Electrolysis, Cu: Zone refining, Zr: Van Arkel process, Ga: Mond's process

24. Extraction of aluminium from aluminium oxide (Al_2O_3) is best done by:
(a) Electrolytic reduction of Al_2O_3
(b) Reduction of Al_2O_3 with carbon
(c) Reduction of Al_2O_3 with sodium
(d) Reduction of Al_2O_3 with CO

25. Chemical leaching is useful in the concentration of:
(a) Copper pyrites (b) Bauxite
(c) Galena (d) Cassiterite

26. Which one of the following is not a method of concentration of metals?
(a) Gravity separation
(b) Froth floatation process
(c) Electromagnetic separation
(d) Smelting

27. $Ag_2S + NaCN \longrightarrow (A)$, $(A) + Zn \longrightarrow (B)$
(B) is a metal. Hence, (A) and (B) are:
(a) $Na_2[Zn(CN)_4]$, Zn (b) $Na[Ag(CN)_2]$, Ag
(c) $Na_2[Ag(CN)_4]$, Ag (d) $Na_3[Ag(CN)_4]$, Ag

28. Which of the following does not contain Mg?
(a) Magnetite (b) Magnesite
(c) Epsom (d) Carnallite

29. Annealing of steel is the process of heating steel:
(a) To a bright red hot and then cooling it slowly
(b) To a bright red hot and then cooling it suddenly
(c) To a temperature much below redness and cooling it slowly
(d) None of the above

30. Which of the following process is not a physical process of separation?
(a) Levigation (b) Magnetic separation
(c) Leaching (d) Froth floatation

31. The process of concentrating Au and Ag ores is based upon their solubility in:
(a) NH_3 (b) HNO_3
(c) HCl (d) KCN

32. Which of the following metal is sometimes found native in nature?
(a) Aluminium (b) Copper
(c) Iron (d) Magnesium

33. In the Parke's process of Ag-extraction, Zn is removed from (Zn–Ag) alloy by using
(a) Cupellation (b) Electrolytic refining
(c) Distillation (d) Fractional crystallization

34. In the extraction of copper from its sulphide ore, the metal is formed by reduction of Cu_2O with:
(a) FeS (b) CO
(c) Cu_2S (d) SO_2

35. In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$$
$$[X] + Zn \longrightarrow [Y] + Au$$

(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{2-}$, $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

36. Carbon cannot be used to produce magnesium by chemical reduction of MgO because:
(a) Carbon is not a powerful reducing agent
(b) Magnesium reacts with carbon to form carbides
(c) Carbon does not react with magnesium
(d) Carbon is a non-metal

37. The ore haivng two different metal atoms is:
(a) Hematite (b) Galena
(c) Magnetite (d) Copper pyrites

38. Which of the following statement is correct regarding Cu-extraction?
(a) In the smelting step, carbon reduction takes places
(b) During roasting, Cu_2S remains almost unaffected
(c) In Bessemer converter, only self-reduction occurs, not slag formation
(d) Blister formed in the blister Cu is due to dissolved CO_2

39. Which of the following process is not involved in the extraction of Fe?
(a) Gravity separation (b) Leaching
(c) Roasting (d) Carbon reduction

40. Carbon reduction process is not commerically applicable for which of the following set of oxides to extract the respective metal?
(I) ZnO (II) Fe_2O_3
(III) Al_2O_3 (IV) SnO_2
(V) MgO
(a) ZnO, Fe_2O_3, SnO_2 (b) ZnO, SnO_2, MgO
(c) MgO, Al_2O_3 (d) MgO, SnO_2, Al_2O_3

41. Which of the following metal can be reduced by carbon reduction as well as self-reduction?
(a) Fe (b) Al
(c) Pb (d) None of these

42. Which of the following metal is leached by cyanide process?
(a) Ag (b) Na
(c) Al (d) Cu

43. Which one of the following ore is not concentrated by froth floatation process?
(a) Copper pyrites (b) Cinnabar
(c) Pyrolusite (d) Zinc blende

44. Sulphide ores of metals are usually concentrated by froth floatation process. Which one of the following sulphide ores offers an exception and is concentrated by chemical leaching?
(a) Galena (b) Copper pyrite
(c) Sphalerite (d) Argentite

45. Among the metals Cr, Fe, Mn, Ti, Ba, and Mg, the one that cannot be obtained by reduction of its metal oxide by aluminium is:
(a) Cr (b) Fe
(c) Mn (d) Ba

46. Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly?
(a) CO_2 is more volatile than CS_2
(b) Metal sulphides are thermodynamically more stable than CS_2
(c) CO_2 is thermodynamically more stable than CS_2
(d) Metal sulphides are less stable than the corresponding oxides

47. The method not used in metallurgy to refine the impure metal is:
(a) Mond's process (b) Van-Arkel process
(c) Liquation (d) All are used

48. Chalcogens are:
(a) Hydrocarbons (b) Ore forming elements
(c) Oxide forming elements
(d) Those having ability to catenate

49. The oxidation state of Cu and Fe in Chalcopyrite is, respectively:
(a) +2, +2 (b) +1, +2
(c) +1, +3 (d) +2, +1

50. Extraction of zinc from zinc blende is achieved by:
(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

51. Copper can be extracted by hydrometallurgy but not zinc because:
(a) Copper is comparatively less active metal as its reduction potential is high. It can be displaced from solutions of Cu^{2+} ion by more active metals
(b) Zn displaced from solution of Zn^{2+} ion, a more reactive metal than it, but then readily react with water forming their corresponding ions and evolve hydrogen gas
(c) Both (a) and (b) are correct
(d) Copper can never be extracted by hydrometallurgy

52. Consider the following reactions at 1000°C:
(i) $Zn_{(s)} + 1/2\ O_{2(g)} \longrightarrow ZnO_{(s)}$
$\Delta G^\circ = -360$ kJ mol^{-1}
(ii) $C_{(s)} + 1/2\ O_{2(g)} \longrightarrow CO_{(g)}$
$\Delta G^\circ = -460$ kJ mol^{-1}
Choose the correct statement at 1000°C:
(a) Zinc can be oxidized by CO
(b) Zinc oxide can be reduced by C
(c) Both statements (i) and (ii) are true
(d) Both statements (i) and (ii) are false

53. Formation of $Ni(CO)_4$ and subsequently its decomposition into Ni and CO (recycled) make the basis of Mond's process:
$$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$$
T_1 and T_2 are:
(a) 100°C, 50°C (b) 50°C, 100°C
(c) 50°C, 230°C (d) 230°C, 50°C

54. Oxides of the various metals are converted into metal by heating but not in:

(a) Ag_2O (b) CuO
(c) HgO (d) All of these

55. When $FeCr_2O_4$ (chromite) is reduced with Al:

(a) Cr and Fe_2O_3 are formed
(b) Fe and Cr_2O_3 are formed
(c) Fe and Cr (ferrochrome) are formed
(d) $FeCrO_4$ is formed

56. Boron can be obtained by various methods but not by:

(a) Pyrolysis of BI_3 (Van Arkel)
(b) Reducing BCl_3 with H_2
(c) Electrolysis of fused BCl_3
(d) Oxidation of B_2O_3

57. Which of the following statement is correct?

(a) Roasting is unnecessarily done for Fe-extraction because there is no sulphide ore
(b) In the smelting step of Cu-extraction, reduction of the ore takes place
(c) Ores may not be mineral
(d) Sphalerite is the ore of zinc

58. Consider the following metallurgical processes:

1. Heating impure metal with CO and distilling the resulting volatile carbonyl (b.pt. 43°C) and finally decomposing at 150°C to 230°C to get the pure metal
2. Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged sulphide
3. Electrolyzing the molten electrolyte containing $CaCl_2$ to obtain the metal

The processes used for obtaining sodium, nickel, and copper are, respectively,

(a) 1, 2, and 3 (b) 2, 3, and 1
(c) 3, 1, and 2 (d) 2, 1, and 3

59. Consider the following statements:

Roasting is carried out to

1. Convert sulphide to oxide and sulphate
2. Remove water of hydration
3. Melt the ore
4. Remove arsenic and sulphur impurities

Of these statements:

(a) 1, 2, and 3 are correct
(b) 1 and 4 are correct
(c) 1, 2, 4 are correct
(d) 2, 3, and 4 are correct

60. The element which could be extracted by electrolytic reduction of its oxide dissolved in a high temperature melt is:

(a) Sodium (b) Magnesium
(c) Fluorine (d) Aluminium

61. In which of the following isolations is no reducing agent required?

(a) Iron from haematite
(b) Tin from tin oxide
(c) Mercury from cinnabar
(d) Zinc from zinc blende

62. The following are the extraction process of silver but not:

(a) As a side product in electrolytic refining of copper
(b) Parke's process in which Zn is used to extract silver by solvent extraction from molten lead
(c) By reaction of silver sulphide with KCN and then reaction of soluble complex with Zn
(d) By heating $Na[Ag(CN)_2]$

63. Reduction of a metal oxide by excess carbon at high temperature is a method for the commercial preparation of some metals. This method can be successfully applied in the case of:

(a) BeO and Al_2O_3 (b) ZnO and Fe_2O_3
(c) CaO and Cr_2O_3 (d) BaO and U_3O_8

64. The salt which is least likely to be found in minerals is:

(a) Chloride (b) Sulphate
(c) Sulphide (d) Nitrate

65. Which of the following statement is correct?

(a) Froth floatation method can only be used for sulphide ore
(b) Tin stone consists of wolframite as non-magnetic impurity
(c) In cyanide process for the extraction of silver, Zn is used as leaching agent
(d) Bessemerization process is used in the extraction of copper from copper pyrite

66. A solution containing 1 mol L^{-1} each of $Cu(NO_3)_2$, $AgNO_3$, $Hg_2(NO_3)_2$, and $Mg(NO_3)_2$ is electrolyzed using inert electrodes; with increasing potential difference applied across the electrodes, the sequence of deposition of metals on the cathode will be:

$$\left(E^\circ_{Ag^+|Ag} = 0.80\,V, E^\circ_{Hg^{+2}|Hg} = 0.79\,V, E^\circ_{Cu^{+2}/Cu} = 0.34\,V, E^\circ_{Mg^{+2}|Mg} = -2.37\,V\right)$$

(a) Ag, Hg, Cu, Mg (b) Mg, Ag, Cu, Hg

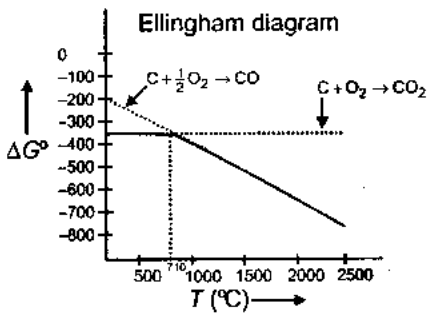
(c) Ag, Hg, Cu (d) Cu, Hg, Ag

67. Thermite reduction is not used for commercial extraction of the respective metal from which of the following oxides?

(a) Mn_3O_4 (b) TiO_2

(c) Fe_2O_3 (d) Cr_2O_3

68.



Which of the following is incorrect on the basis of the above Ellingham diagram for carbon?

(a) Up to 710°C, the reaction of formation of CO_2 is energetically more favorable, but above 710°C, the formation of CO is preferred

(b) In principle, carbon can be used to reduce any metal oxide at a sufficiently high temperature

(c) $\Delta S\ (C_{(s)} + 1/2\ O_{2(g)} \longrightarrow CO_{(g)}) < \Delta S\ (C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)})$

(d) Carbon reduces many oxides at elevated temperature because $\Delta G°$ vs temperature line has a negative slope

Multiple Correct Answers Type

1. $Ca_3(PO_4)_2$ is:

(a) Thomas slag

(b) Formed in manufacturing of steel iron

(c) Used in manufacture of phosphorus fertilizer

(d) Used as a refractory material

2. Which of the following ores is/are oxide ore(s)?

(a) Cassiterite (b) Bauxite

(c) Cryolite (d) Haematite

3. Select the correct statement(s):

(a) Gravity separation method is used in concentration of oxide ore and carbonate ore

(b) Magnetic separation method is used for separation of non-magnetic rutile and magnetic impurity of chlorapatite

(c) Fe_3O_4 is magnetic and impurities non-magnetic

(d) MnO_2 is non-magnetic and impurities magnetic

4. Auto-reduction process is used for the extraction of:

(a) Cu (b) Hg

(c) Pb (d) Al

5. Which of following reaction is not an example of thermite reaction?

(a) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

(b) $3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9\ Mn$

(c) $2HgO + HgS \longrightarrow 3Hg + SO_2$

(d) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

6. Which represent incorrect matching of metals with their ores?

	Mg	Na	Cu	Al
(a)	Chloride	chloride	sulphide	silicate
(b)	Carbonate	chloride	sulphide	oxide
(c)	Carbonate	carbonate	oxide	phosphate
(d)	Oxide	chloride	sulphide	oxide

7. Which of the following reactions represent correct method?

(a) $NaCl_{(molten)} \longrightarrow Na^+ + Cl^{\ominus}$: Down cell

(b) $Ni(CO)_4 \longrightarrow Ni + 4CO$: Mond process

(c) $Ag_2CO_3 \longrightarrow 2Ag + CO_2 + 1/2\ O_2$: Van Arkel method

(d) $ZrI_4 \longrightarrow Zr + 2I_2$: Van Arkel method

8. For the pyrometallurgical method used for the extraction of copper from sulphide ore, which statement(s) is/are correct?

(a) Pyrometallurgy is a dry method

(b) It involves concentration by leaching the sulphide ore with dil. H_2SO_4

(c) It involves concentration of the sulphide ore by froth floatation process

(d) It involves concentration by leaching for every ore

9. Blister copper is:

(a) Impure copper

(b) Obtained in self-reduction process during bassemerization

(c) Obtained in carbon reduction process during bassemerization

(d) None is correct

10. Froth floatation process used for the concentration of sulphide ore:

(a) Is based on the difference in wettability of different minerals

(b) Uses sodium ethyl xanthate, $C_2H_5OCS_2Na$, as collector

(c) Uses NaCN as depressant in the mixture of ZnS and PbS when ZnS forms soluble complex and PbS forms froth

(d) Uses pine oil as frothing agent

11. Mg can be obtained:

(a) By heating $MgCl_2$ (anhydrous) with Na in the atmosphere of coal gas

(b) By electrolysis of fused carnallite

(c) By electrolysis of aqueous solution of carnallite

(d) None of the above

12. NaCl and $CaCl_2$ are also added to fused $MgCl_2$ in the electrolysis of $MgCl_2$. Select the incorrect statement(s) for this solution:

(a) Melting point is decreased and conductivity is increased

(b) Melting point is increased and conductivity is decreased

(c) Melting point and conductivity both are decreased

(d) Melting point and conductivity both are increased

13. SnO_2 is reduced to metallic Sn on smelting oxide with anthracite and lime. In this, the function of lime is:

(a) It acts as a flux

(b) It removes acidic impurities as slag

(c) It removes basic impurities as slag

(d) It acts as a slag

14. Poling process:

(a) Reduces SnO_2 to Sn

(b) Oxidizes impurities like iron; removes as scum

(c) Uses green poles

(d) Uses brown poles

15. Refining of tin can be done by:

(a) Cupellation (b) Liquation

(c) Poling (d) Electrorefining

16. Which is the correct process–mineral matching in metallurgical extraction?

(a) Leaching : Ag

(b) Zone-refining : Sn

(c) Liquation : Sn

(d) Van Arkel : Zr

17. Tempering of steel:

(a) Is heating the steel to appropriate temperature and then cooling it slowly

(b) Increases mechanical strength

(c) Changes ratio of iron in steel

(d) Decreases mechanical strength

18. Of the following reduction processes:

(i) $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

(ii) $ZnO + C \longrightarrow Zn + CO$

(iii) $Cu_2O + C \longrightarrow 2Cu + CO$

(iv) $PbO + C \longrightarrow Pb + CO$

correct process is/are:

(a) (i) (b) (ii)

(c) (iii) (d) (iv)

19. Reaction(s) involved in thermite process is/are:

(a) $3Mn_3O_4 + 8Al \longrightarrow 9Mn + 4Al_2O_3$

(b) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

(c) $2Fe + Al_2O_3 \longrightarrow 2Al + Fe_2O_3$

(d) $B_2O_3 + 2Al \longrightarrow 2B + Al_2O_3$

20. Which of the following compounds are not called Thomas slag?

(a) Calcium silicate (b) Calcium phosphate

(c) Barium phosphate (d) Strontium silicate

21. Out of the following metals, that can be obtained by electrolysis of the aqueous solution of their salts is/are:

(a) Ag (b) Au

(c) Cu (d) Mg

22. Mond's process is not used for:

(a) Ni (b) Al

(c) Fe (d) Cu

23. The metal(s) which cannot be obtained by electrolysis of aqueous solution of their salts is/are:

(a) Ag (b) Mg

(c) Cu (d) Al

24. The anodic mud obtained during electrorefining of Cu contains:

(a) Ag (b) Fe

(c) Au (d) Zn

25. In Fe-extraction, the roasting is carried out because:

(a) All FeO are to be converted to Fe_2O_3

(b) The formation of $FeSiO_3$ slag is prevented

(c) Fe_2O_3 does not react with SiO_2 to form slag

(d) The formation of slag ($CaSiO_3$) is enhanced

26. Brine solution on electrolysis will give:

(a) NaOH (b) O_2

(c) Cl_2 (d) H_2

27. The extraction of metals from oxide ores involve(s):

(a) Reduction with carbon

(b) Reduction with aluminium

(c) Electrolytic reduction

(d) Reduction with CO

28. Select the correct statement(s):

(a) When temperature is raised, a point will be reached where the graph crosses the $\Delta G = 0$ line. Below this temperature, the free energy of formatin of the oxide is negative, so the oxide is stable

(b) When temperature is raised, a point will be reached where the graph crosses the $\Delta G = 0$ line. Above this temperature, the free energy of formation of the oxide is positive, and the oxide becomes unstable, and should decompose into the metal and dioxygen

(c) Theoretically, all oxides can be decomposed to give the metal and dioxygen if a sufficiently high temperature can be attained

(d) Theoretically, all oxides cannot be decomposed to give the metal and dioxygen if a sufficiently high temperature can be attained

29. Metals which can be extracted by smelting process is/are:

(a) Sn (b) Cu

(c) Zn (d) Al

30. Which of the following steps is/are involved in roasting?

(a) Remove water of hydration

(b) Remove arsenic and sulphur impurities

(c) Convert sulphide to oxide and sulphate

(d) None of these

31. Which of the following ores is/are sulphide ore(s)?

(a) Galena (b) Cinnabar

(c) Tinstone (d) Copper pyrites

32. In the commerical extraction of iron, roasting is adopted becuase:

(a) It removes impurities of S, As, and Sb in the form of their elemental vapor.

(b) It prevents slag formation by Fe_2O_3.

(c) It prevents slag formation by FeO.

(d) Limonite is converted into its anhydrous form.

33. Select the correct statement(s):

(a) In hydrometallurgy, Zn is used as oxidizing agent in the purification of Ag from $[Ag(CN)_2]^{\ominus}$

(b) When pine oil or eucalyptus oil is added into the water, it lowers down the surface tension by which froth is formed

(c) Sodium ethyl xanthate is used as collector

(d) Basic copper carbonate or $PbSO_4$ is concentrated by froth floatation method by using an activator

34. Select the correct statement(s) for calcination:

(a) Carbonate ore is converted in oxide ore

(b) Hydrated oxide ore is converted into its oxide ore

(c) Oxidizable volatile impurties are removed by calcination process

(d) Only calcination occurs for carbonate or oxide ore.

35. H_2 is not widely used as the reducing agent in metallurgic process because:

(a) Many metals react with H_2 at elevated temperature forming hydrides

(b) There is a risk of explosion from H_2 and O_2 present in the air

(c) $\Delta G^\circ/T$ line for $2H_2 + O_2 \rightarrow 2H_2O$ has positive slop, and runs parallel to many metal oxide lines so, reducing power of H_2 does not increase with temperature

(d) $\Delta G^\circ/T$ line for $2H_2 + O_2 \rightarrow 2H_2O$ has positive slop, and runs parallel to many metal oxide lines, so reducing power of H_2 increase with temperature

36. Which is/are correct statement(s)?

(a) Casseterite, chromite, and pitchblende are concentrated by hydraulic washing (tabling)

(b) Pure Al_2O_3 is obtained from the bauxite ore by leaching in the Baeyer's process

(c) Sulphide ore is concentrated by calcination method

(d) Roasting can convert sulphide into oxide or sulphate and part of sulphide may also act as a reducing agent

37. Which is/are the correct method–metal matching for refining of crude metals?

(a) Distillation: zinc and mercury

(b) Liquation: tin

(c) Van Arkel: zirconium

(d) Mond process: lead

38. Select the correct reduction process:

(a) $2[Ag(CN)_2] + Zn \dashrightarrow [Zn(CN)_4]^{2-} + 2Ag$

(b) $CuO + H_2 \longrightarrow Cu + H_2O$

(c) $Al_2O_3 + 3Zn \longrightarrow 2Al + 3ZnO$

(d) $MgO + C \xrightarrow[\text{temp.}]{\text{high}} Mg + CO$

39. Select the incorrect meaning of softening of lead:

(a) Melting pure lead at high temperature

(b) Removal of impurities, except silver, present in commerical lead

(c) Formation of lead alloy

(d) Formation of 100% pure lead

40. Softened lead is not desilverized by:

(a) Parke's method (b) Roasting method

(c) Calcination (d) Electrolysis

41. Select the correct statement(s):

(a) When the lead–silver alloy is rich in silver, lead is removed by the cupellation process

(b) When the lead–silver alloy is rich in lead, silver is removed by Parke's or Pattinson's process

(c) Zinc forms an alloy with lead, from which lead is separated

(d) Zinc forms an alloy with silver, from which zinc is separated by distillation

42. In the leaching of Ag_2S with NaCN, a stream of air is also passed. It is because of:

(a) Reversible nature of reaction between Ag_2S and NaCN

(b) Oxidized Na_2S formed into Na_2SO_4.

(c) Irreversible nature of reaction between Ag_2S and NaCN

(d) None of the above

43. $(Ag + Pb)$ alloy $\xrightarrow[\text{is added}]{\text{melt and zinc}}$ $(Ag + Pb + Zn)$ melt $\xrightarrow{\text{cool}}$ $\dfrac{\text{Layer } X}{\text{Layer } Y}$

Select the correct statement(s) based on above scheme:

(a) Layer X contains zinc and silver

(b) Layer Y contains lead and silver but amount of silver in this layer is smaller than in the layer X.

(c) X and Y are immiscible layers

(d) X and Y are miscible layers

44. Which mineral has/have been named correctly?

(a) Bauxite : $Al_2O_3 \cdot 2H_2O$

(b) Corundum : Al_2O_3

(c) Cryolite : $3NaF \cdot AlF_3$

(d) Galena : HgS

45. Chemical leaching is not useful in the concentration of:

(a) Copper pyrites (b) Bauxite

(c) Galena (d) Cassiterite

46. In the equation,

$$4M + 8\,CN^- + 2\,H_2O + O_2 \longrightarrow 4\,[M(CN)_2]^- + 4\,OH^-,$$

the metal M is:

(a) Copper (b) Silver

(c) Gold (d) Zinc

47. Which of the following statements are correct regarding metallurgy of iron?

(a) Coke reduces FeO to Fe above 710°C

(b) CO reduces Fe_2O_3 to FeO below 710°C

(c) Coke reduces Fe_2O_3 to FeO below 710°C

(d) CO reduces Fe_2O_3 to FeO above 710°C

48. The major role of fluorspar which is added in small amount in the electrolytic reduction of Al_2O_3 dissolved in fused cryolite is:

(a) As a catalyst

(b) To make the fused mixture very conducting

(c) To lower the fusion temperature of the melt

(d) To decreases the rate of oxidation of carbon at the anode

49. Select the correct statements for Ellingham diagram:

(a) Any metal will reduce the oxide of other metals which lie above it in the Ellingham diagram

(b) According to Ellingham diagram, Al will not reduce MgO at temperature below 1350°C

(c) According to Ellingham diagram, Al will reduce MgO at temperature below 1350°C

(d) Any metal will not reduce the oxide of other metals which lie above it in the Ellingham diagram

50. The extraction of metals from sulphide ore involves:

(a) Reduction with carbon (b) Froth floatation

(c) Reduction with Al (d) Electrolytic reduction

51. Find the correct match:

	Column-I	Column-II
(a)	Azurite	$CuCO_3 \cdot 2Cu(OH)_2$
(b)	Malachite	$Cu(OH)_2 \cdot CuCO_3$
(c)	Anglesite	$PbSO_4$
(d)	Chalcocite	Cu_2S

52. Which of the following statements are correct?

(a) The process of producing a hard coating of iron nitride on the surface of steel is called nitriding

(b) The process of producing a thin coating of iron carbide on the surface of mild steel is called case-hardening

(c) Quenched steel is produced by heating steel to redness and allowing it to cool slowly

(d) Stainless steel is produced by heating wrought iron in molten chromium

53. Carbon can be used to reduce a number of oxides and other compounds, and because of the low cost and availability of coke, this method is widely used, but the disadvantages are that:

(a) High temperature is needed, which is expensive

(b) Many metals combine with carbon to form carbides

(c) Low temperature is needed, which is expensive

(d) Many metal combine with carbon and do not form carbides

54. Select the correct statement(s):

(a) Based on reactivity series, occurrence of certain elements takes place in native state

(b) Due to the basic nature of oxides of alkaline earth elements, they combine with atmospheric acidic oxides giving salts

(c) Based on reactivity series, occurence of certain elements takes place in atomic state

(d) None is correct

55. The reduction of an oxide by aluminium is not called:

(a) Ellingham process

(b) Goldschmidt's aluminothermite process

(c) Kroll's process (d) Van Arkel process

56. Which of the following steps are involved in hydro-metallurgical process?

(a) $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

(b) $CuFeS_2 + 2H_2SO_4 \longrightarrow CuSO_4 + FeSO_4 + 2H_2S$

(c) $Ag_2S + 2NaCN \longrightarrow [Ag(CN)_2]^- + Na_2S$

(d) $CuCO_3 + H_2SO_4 \longrightarrow CuSO_4 + H_2O + CO_2$

57. Which are not sulphate ore of Mg?

(a) Dolomite (b) Carnallite

(c) Magnesite (d) Kieserite

58. In the Baeyer's process, which of the following statements are incorrect?

(a) Al_2O_3 goes into solution as soluble $Al(OH)_4^-$ while other basic oxides as TiO_2 and Fe_2O_3 remain insoluble.

(b) Al_2O_3 changes to AlN which in turn is decomposed by H_2O

(c) Al_2O_3 changes to $Al_2(CO_3)_3$ which changes to $AlCl_3$

(d) Al_2O_3 changes to $Al_2(SO_4)_3$ which changes to Al_2S_3

59. $$\boxed{\text{Bauxite}} \xrightarrow[\uparrow N_2]{+C} \overset{\overset{CO}{\uparrow}}{\boxed{AlN}} \xrightarrow{H_2O} Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$$

This flow-sheet is not for:

(a) Baeyer's process (b) Serpek's process

(c) Hall's process (d) Kroll's process

60. Silver containing lead as an impurity is not purified by:

(a) Poling (b) Cupellation

(c) Levigation (d) Distillation

61. Which of the following oxides cannot be reduced to metal by carbon?

(a) ZnO (b) Al_2O_3

(c) CuO (d) CaO

62. Select the correct statements for Ellingham diagram:

(a) The slope of the curves of the formation of metal oxide is +ve because ΔG° becomes less negative or increases with the rise in temperature

(b) Each curve is a straight line except when some change takes place in phase ($s \to l$ or $l \to g$)

(c) Each curve is not a straight line except when some change takes place in phase ($s \to l$ or $l \to g$)

(d) The slope of the curves of the formation of metal oxide is –ve because ΔG° becomes less negative or increases with the rise in temperature

63. Which of the following metal oxides are reduced by self-reduction method?

(a) Cu_2O (b) PbO

(c) HgO (d) CaO

64. Which of the following pair consists of ore of the same metal?

(a) Magnesite, cerussite

(b) Chalcocite, copper pyrites

(c) Bauxite, corundum

(d) Anglesite, cerussite

65. Which of the following statement(s) is/are correct?

(a) The chemical processes in the production of steel from haematite ore involve reduction followed by oxidation

(b) In Hall–Heroult process, the electrolyte used is a molten mixture of alumina and cryolite or fluorspar

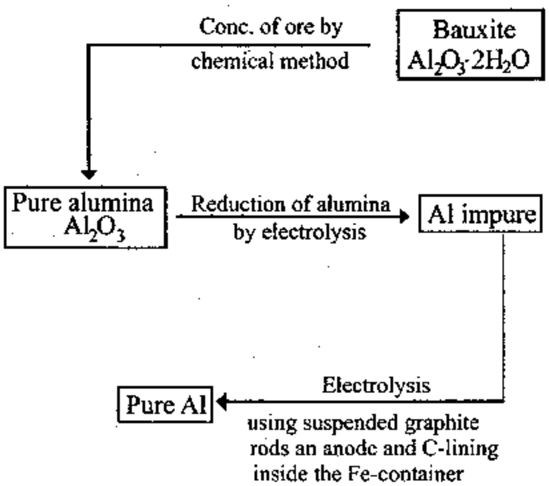
(c) Lead is extracted from its chief ore galena by both carbon reduction as well as self-reduction

(d) Haematitie, cassiterite, and argentite are oxide ores

Comprehension Type

Comprehension-1: (Q. 1 to Q. 4)

Extraction of aluminium can be understood by:



Electrolytic reduction of Al_2O_3:

Electrolyte : $(Al_2O_3 + \text{Cryolite} + CaF_2)$

Cathode : Carbon inside the Fe-container

Anode : Graphite rods

1. The purpose of adding cryolite is:

(a) To decrease the electrical conductivity of pure aluminium

(b) To lower the melting point of Al_2O_3

(c) To remove the impurities as slag

(d) To increase the Al percentage in the yield

2. Coke powder is spread over the molten electrolyte to:

(a) Prevent the heat radiation from the surface

(b) Prevent the corrosion of graphite anode

(c) Prevent the oxidation of molten aluminium by air

(d) Both (a) and (b)

3. The function of fluorspar (CaF_2) is:

(a) To increase the melting point of electrolyte

(b) To increase electrolytic conductivity power

(c) To remove the impurities as slag

(d) All of these

4. The molten electrolytes contain Na^+, Al^{3+}, and Ca^{2+} but only Al gets deposited at cathode because:

(a) Standard reduction potential of Al is more than that of Na and Ca

(b) Standard oxidation potential of Al is more than that of Na and Ca

(c) Discharge potential of Al^{3+} is higher than Na^+ and Ca^{2+}

(d) Graphite reacts only with Al^{3+} and not with Na^+ and Ca^{2+}

Comprehension-2: (Q. 5 to Q. 7)

Roasting is a process in which the ore (mostly sulphide) is heated strongly in the presence of excess of air. The heating should be done at a temperature below the melting point of the ore.

5. Select the correct statement:

(a) Roasting also removes easily oxidizable volatile impurties like arsenic as As_2O_3, antimony as Sb_2O_3, and sulphur as SO_2

(b) The release of SO_2 (in roasting process) has been a serious air pollution problem

(c) In roasting process, if temperature is fairly low (about 500°C) and the concentration of SO_2 in the gaseous environment is more, sulphate may be produced, that is stable, and high temperature is needed to decompose it

(d) All are correct

6. $2PbS + 3O_2 \longrightarrow A + 2SO_2$

The name of A is:

(a) Litharge (b) Galena

(c) Sesquioxide (d) None of these

7. Sometimes roasting may not bring about complete oxidation:

$$2CuFeS_2 + 4O_2 \longrightarrow A + 2FeO + 3SO_2$$

Find out A:

(a) Cu_2O (b) CuO

(c) Cu_2S (d) CuS

Comprehension-3: (Q. 8 to Q. 11)

Lead obtained from galena ore (PbS) by air reduction or carbon reduction process contains base metal (Cu, Bi, Sn, As) as impurities; it is due to the presence of these impurites that lead becomes hard and brittle.

8. Parke's process is also called:

(a) Softening process (b) Desilverisation method

(c) Cupellation (d) None of these

9. Zn–Ag alloy formed in the upper layer of molten lead is skimmed off from the surface of the molten lead by perforated ladles. This alloy contains lead as impurity. This impurity of Pb is removed by:

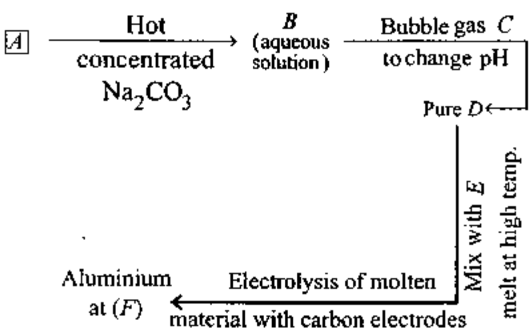
(a) Distillation process (b) Cupellation

(c) Liquation (d) Bett's electrolysis

10. Ag can be obtained from purified Zn–Ag alloy by:
(a) Distillation (b) Poling
(c) Liquation (d) Reduction

11. Cupellation is used for purification of:
(a) Pb (b) Ag
(c) Zn (d) Fe

Comprehension-4: (Q. 12 to Q. 16)



12. Find out A:
(a) $CuFeS_2$ (b) $MgCl_2 \cdot 6H_2O$
(c) $Al_2O_3 \cdot 2H_2O$ (d) Fe_2O_3

13. Find out B:
(a) $Na[Al(OH)_4]$ (b) NaOH
(c) H_2SO_4 (d) Al_2O_3

14. Find out C:
(a) CO_2 (b) SO_2
(c) SO_3 (d) NO_2

15. Find out E:
(a) Na_3GeF_6 (b) Na_3AlF_6
(c) Al_2O_3 (d) None of these

16. Find out F:
(a) Cathode (b) Anode
(c) Electrolyte (d) None of these

Comprehension-5: (Q. 17 and Q. 18)

All minerals are not the ore but all ores are minerals. The extraction of a particular metal depends upon several factors and overall it has to be convenient and economical.

17. $\underset{\text{(Sulphide ore)}}{A} + NaCN \underset{}{\overset{\text{air}}{\rightleftharpoons}} \underset{\text{(complex)}}{B} + Na_2S \xrightarrow{O_2} Na_2SO_4$

Then B is:
(a) Ferromagnetic
(b) Paramagnetic
(c) Linear complex
(d) Coordination number of central atom is 4

18. Which of the following statement is true?
(a) Na-ethyl xanthate is used as frother exclusively
(b) Levigation cannot be applied for sulphide in any condition
(c) Froth floatation can be applied for non-sulphide ore also using suitable activator
(d) Impurities like S and As are removed as elemental vapor in roasting

Comprehension-6: (Q. 19 to Q. 21)

Lead obtained from galena ore (PbS) by air reduction or carbon reduction process contains base metal (Cu, Bi, As, Sn, Zn) as impurities.

19. The removal of the impurity of Ag from the commercial lead is called:
(a) Desilverization of lead
(b) Softening process
(c) Bett's electrolysis
(d) Cupellation

20. Which of the following electrolyte is used for electrolysis of Pb?
(a) $PbSO_4 + H_2SO_4$ (b) $PbCl_2 + HCl$
(c) $PbSiF_6 + H_2SiF_6$ (d) None of these

21. Gelatin acts as addition agent in electrolysis of Pb; in the presence of gelatin, Pb becomes:
(a) Hard and brittle (b) Soft and useless
(c) Smooth and uniform (d) Only brittle

Comprehension-7: (Q. 22 to Q. 24)

Calcination is a process in which the ore is heated strongly in the absence of air to remove volatile impurities. It thermally decomposes the carbonate.

22. $A \xrightarrow{\text{Calcination}} CaO + MgO + 2CO_2$

Find out A:
(a) $CaCO_3$ (b) $MgCO_3$
(c) $CaCO_3 \cdot MgCO_3$ (d) $CaSO_4 \cdot MgCO_3$

23. $2Fe_2O_3 \cdot 3H_2O \xrightarrow{\text{Calcination}} A + 3H_2O$

Find out A:
(a) 2FeO (b) $2Fe_3O_4$
(c) $2Fe_2O_3$ (d) $FeO \cdot FeCO_3$

24. $Al_2O_3 \cdot 2H_2O \xrightarrow{\text{Calcination}} B + 2H_2O$

The name of product B is:
(a) Corundum (b) Bauxite
(c) Aluminum hydroxide (d) None of these

Comprehension-8: (Q. 25 to Q. 27)

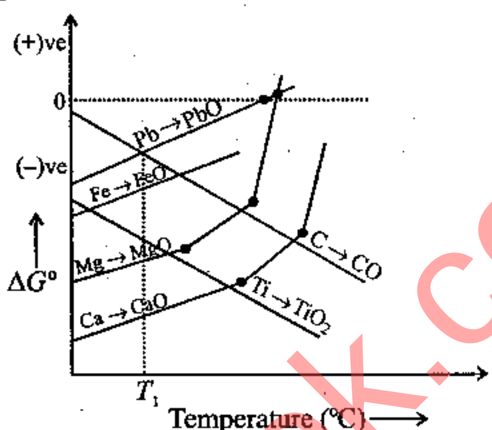
Pb is a very important element of carbon family. It forms a number of compounds which are very useful in industries.

25. Which of the following electrolysis process is used for purification of Pb?
(a) Hall process (b) Parke's process
(c) Bett's electrolysis process
(d) None of these

26. The removal of impurity of Ag from the commercial lead is called:
(a) Softening process (b) Liquation
(c) Parke's process (d) Cupellation

27. The process of removal of base metals (Cu, Sn, Bi, As) from lead is called:
(a) Softening process (b) Liquation
(c) Parke's process (d) Cupellation

Comprehension-9: (Q. 28 to Q. 30)

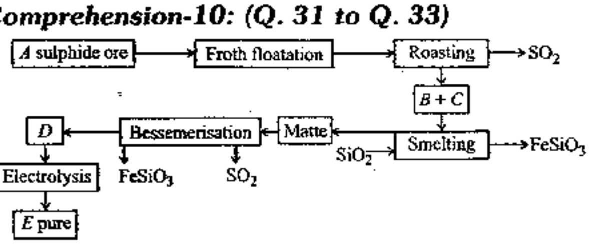


28. Which in the above curve is wrongly presented?
(a) $C \rightarrow CO_2$ (b) $Ti \rightarrow TiO_2$
(c) $Pb \rightarrow PbO$ (d) $Mg \rightarrow MgO$

29. Which of the given metal oxides is having minimum thermal decomposition temperature?
(a) CaO (b) FeO
(c) PbO (d) MgO

30. Which of the following metal's oxide can be reduced by Fe as reducing agent at temperature T_1?
(a) Pb (b) Ca
(c) Mg (d) None of these

Comprehension-10: (Q. 31 to Q. 33)



31. Find out A:
(a) Cu_2S (b) $CuFeS_2$
(c) FeS_2 (d) Fe_3O_4

32. Find out B and C:
(a) FeS + FeO (b) $Cu_2O + Cu_2S$
(c) Cu_2O + FeS (d) Cu_2S + FeO

33. Find out D:
(a) Pig iron (b) FeO
(c) Blister Cu (d) Wrought iron

Comprehension-11: (Q. 34 to Q. 36)

$$(A + Ag) + Zn \longrightarrow (A + Ag + Zn) \xrightarrow{\text{Cooling}} \frac{x \text{ layer}}{y \text{ layer}}$$

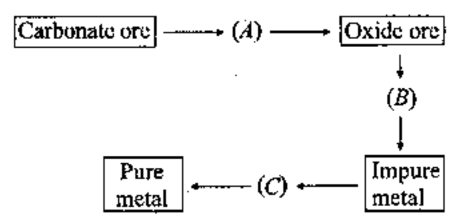
x layer-solid alloy y layer-molten metal

34. Molten metal is purified by:
(a) Hall-Heroult process (b) Hoop method
(c) Baeyer's process
(d) Bett's electrolysis process

35. Metal A is:
(a) Cu (b) Sn
(c) Fe (d) Pb

36. Layer x contains:
(a) Zn + Pb alloy (b) Zn + Ag alloy
(c) Only Ag (d) Only Pb

Comprehension-12: (Q. 37 to Q. 39)



37. A metal is in combined state as carbonate; find out process A:
(a) Roasting (b) Calcination
(c) Smelting (d) Reduction

38. Find out process B:
(a) Roasting (b) Reduction
(c) Van Arkel (d) Smelting

39. Find out process C:
(a) Electrolysis (b) Reduction
(c) Smelting (d) Roasting

Comprehension-13: (Q. 40 to Q. 44)

Copper is extracted from copper pyrites. After roasting, the ore is mixed with silica and coke and then smelted in a blast furnace. The matte obtained from the blast furance is charged into a silica lined converter. Some silica is also added and a hot air blast is thrown into the mixture to obtain blister copper which is purified by electrorefining.

40. The chemical formula for copper pyrites is:

(a) $CuFeS_2$ (b) Cu_2S

(c) Cu_2O (d) $CuCO_3 \cdot Cu(OH)_2$

41. During roasting, copper pyrites are ultimately converted into a mixture of:

(a) $FeS + Cu_2S$ (b) $FeS + Cu_2O$

(c) $FeO + Cu_2S$

(d) $FeS + Cu_2S + FeO + Cu_2O$

42. Coke is added during smelting:

(a) To reduce FeO to Fe

(b) To reduce Cu_2O to Cu

(c) To check the oxidation of FeO to Fe_2O_3

(d) To check the oxidation of Cu_2O to CuO

43. The chemical composition of the slag formed during smelting process is:

(a) $CuSiO_3$ (b) $FeSiO_3$

(c) $CaSiO_3$ (d) $Cu_2O \cdot SiO_2$

44. Matte is a mixture of:

(a) $Cu_2S + FeS$ (small amount)

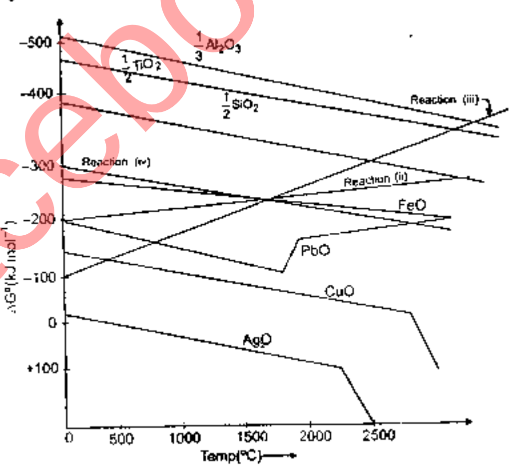
(b) $FeS + Cu_2S$ (small amount)

(c) $Cu_2O + FeO$ (small amount)

(d) $FeO + Cu_2O$ (small amount)

Comprehension-14: (Q. 45 to Q. 47)

These equilibria can be discussed in terms of thermodynamic functions.



For the reactions:

(i) $M_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow MO_{(s)}$

(ii) $\frac{1}{2}C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow \frac{1}{2}CO_{2(g)}$

(iii) $C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{(g)}$

(iv) $CO_{(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{2(g)}$

The temperature dependence of ΔG° of reaction (i) to (iv) is shown in the given diagram. This is known as Ellingham diagram. With the help of Ellingham diagram, one can easily predict the most suitable reducing agent for the reduction of metal oxides.

45. A metal oxide $MO_{(s)}$ can be reduced by carbon or carbon monoxide successfully when the line in Ellingham diagram for reaction (i):

(a) Lies above the line for one of the reactions (ii) to (iv)

(b) Intersects the line for one of the reactions (ii) to (iv)

(c) Lies below the line for one of the reactions (ii) to (iv)

(d) May lie above or below the line for one of the reactions (ii) to (iv) depending upon the temperature

46. CuO can be reduced to Cu conveniently by using C or CO at any temperature:

(a) Approximately equal to room temperature

(b) Above room temperature

(c) Below room temperature

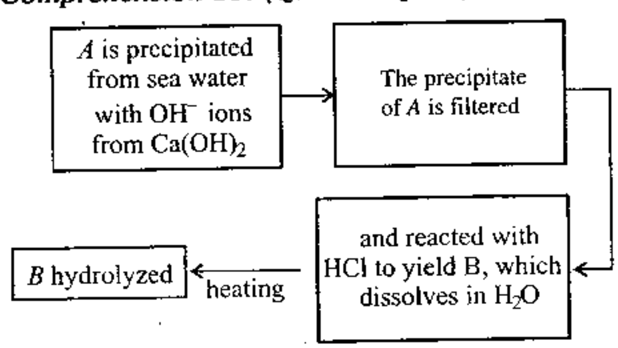
(d) At all temperature

47. Al_2O_3 can be reduced by carbon at a temperature of:

(a) 30°C (b) 500°C

(c) 2000°C (d) > 2500°C

Comprehension-15: (Q. 48 to Q. 50)



48. Find out *A*:

(a) Mg cation (b) $MgCl_2$

(c) $Mg(OH)_2$ (d) Ca cation

49. The compound *B* is:

(a) Anhy. $MgCl_2$ (b) $Mg(OH)_2$

(c) $Ca(OH)_2$ (d) $MgCl_2 \cdot 6H_2O$

50. When B is hydrolyzed, then which of the following compound is formed?

(a) Anhy. $MgCl_2$ (b) MgO

(c) $Mg(OH)_2$ (d) $MgCl_2 \cdot 6H_2O$

Comprehension-16: (Q. 51 to Q. 53)

In many extraction processes, an oxide is added deliberately to combine with other impurities and form a stable molten phase immiscible with molten metal called a slag. The process is termed smelting.

51. The principle of slag formation is essentially the following:

$$\text{Non-metal oxide} + \text{Metal oxide} \longrightarrow X$$

Find out X.

(a) Non-fusible (easily melted) slag

(b) Fusible (easily melted) slag

(c) Solid phase miscible with molten metal

(d) Solid phase immiscible with molten metal

52. In the extraction of iron, which of the following flux is used for the formation of slag:

(a) $MgCO_3$ (b) $ZnCO_3$

(c) SiO_2 (d) $CaCO_3$

53. FeO is the impurity in the extraction of Cu from copper pyrite. Which of the following flux is used for the removal of impurity?

(a) CaO (b) MgO

(c) SiO_2 (d) $FeSiO_3$

Assertion-Reasoning Type

1. **Statement-1:** Reduction of Fe_2O_3 with CO is done below 710°C.

Statement-2: ΔG is negative at this temperature; thus, process is spontaneous.

(a) Statement-1 is true, statement-2 is true; statement -2 is a correct explanation for statement -1.

(b) Statement-1 is true, statement-2 is true; statement -2 is NOT a correct explanation for statement -2.

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** Silver may be prepared by using silver coins; in this process, coins are treated with HNO_3 and then treated with HCl to get AgCl, but directly coins are not treated with HCl.

Statement-2: HCl is not a good oxidizing agent.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

3. **Statement-1:** Graphite is used as anode but diamond is not.

Statement-2: There exist free electrons between two parallel sheets of graphite; hence, it helps in electron conduction.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true but statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

4. **Statement-1:** Copper and zinc are obtained by electrolysis of aqueous solution of their sulphates.

Statement-2: Elements that react with water are often extracted from fused melts of their ionic salts.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true but statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I (Metal)	Column-II (Purification method)
(a) Hg	(p) Zone refining method
(b) Ag	(q) Liquation
(c) Ga	(r) $\overset{\ominus}{C}N$ process
(d) Pb	(s) Distillation

2. Match the column:

Column-I	Column-II
(a) Roasting	(p) Process in which volatile impurities are removed

(b) Calcination	(q) Process in which hydrated water is removed
(c) Concentration	(r) Magnetic impurities removed
	(s) Sulphide ore converted into its oxide ore

3. Match the column:

Column-I	Column-II
(a) Flux	(p) SiO_2
(b) Slag	(q) CaO
(c) Acidic flux	(r) $CaSiO_3$
(d) Basic flux	(s) MgO
	(t) $FeSiO_3$

4. Match the column (for electrolytic refining of Cu):

Column-I	Column-II
(a) Anode	(p) Thin sheets of pure Cu
(b) Cathode	(q) An aqueous solution of copper sulphate containing H_2SO_4
(c) Electrolyte	(r) Ag, Au
(d) Anode mud	(s) Impure metal of Cu

5. Match Column-I with Column-II.

Column-I	Column-II
(a) Cyanide process	(p) Ultrapure Ge
(b) Floatation process	(q) Pine oil
(c) Electrolytic reduction	(r) Extraction of Al
(d) Zone refining	(s) Extraction of Au

6. Match the column:

Column-I	Column-II
(a) Van Arkel method	(p) Manufacture of caustic soda
(b) Cupellation	(q) Purification of titanium
(c) Poling	(r) Purification of copper
	(s) Refining of silver

7. Match the column:

Column - I	Column - II
(a) Vapor phase refining process	(p) Cu
(b) Thermite process	(q) Fe
(c) Self-reduction	(r) B
(d) Bessemerization	(s) Al
	(t) Ni

8. Match the column:

Column-I	Column-II
(a) Van Arkel method	(p) Manufacture of Mg
(b) Dow's sea-water process	(q) Purification of titanium
(c) Cupellation	(r) Manufacture of Na
(d) Poling	(s) Purification of Cu
	(t) Refining of silver

9. Match the column:

Column-I	Column-II
(a) Bauxite ore	(p) Roasting
(b) SnO_2 ore	(q) Calcination
(c) Native silver ore	(r) Leaching
(d) $CuFeS_2$ ore	(s) Electrolysis

10. Match the following:

Column-I	Column-II
(a) Slag formation	(p) Extraction of copper from copper pyrites
(b) Froth-floatation	(q) Extraction of iron from haematite
(c) Leaching	(r) Extraction of tin from cassiterite
(d) Roasting	(s) Extraction of lead from galena
	(t) Extraction of gold from its native ore

11. Match the column:

Column-I	Column-II
(a) Anglesite	(p) Sulphate ore
(b) Galena	(q) Sulphide ore
(c) Cerussite	(r) Ore of Pb
(d) Cinnabar	(s) Carbonate ore
	(t) Ore of Hg

12. Match the commercial extraction process listed in Column-I with metals listed in Column-II:

Column-I	Column-II
(a) Self-reduction	(p) Lead
(b) Carbon reduction	(q) Silver
(c) Complex formation and displacement by metal	(r) Copper
(d) Decomposition of iodide	(s) Boron

13. Match the column:

Column-I	Column-II
(a) Ni	(p) Van Arkel de boer process
(b) Zr	(q) Zone refining process
(c) Si	(r) Mond's process
(d) Fe	(s) Bessemerization
	(t) Reduction in blast furnace

14. Match the column:

Column-I	Column-II
(a) Froth floatation	(p) Pb ore
(b) Self-reduction	(q) Cu ore
(c) Roasting	(r) Fe ore
(d) Pyrometallurgy	(s) Sn ore
	(t) Zn ore

15. Match the column:

Column-I	Column-II
(a) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$	(p) Roasting
(b) $Ni(CO)_4 \xrightarrow{230°C} Ni + 4CO$	(q) Calcination
(c) $Fe_2O_3 . 3H_2O \xrightarrow{\Delta} 2Fe_2O_3 + 3H_2O$	(r) Vapor phase refining process
(d) $PbS + 2O_2 \longrightarrow PbO + SO_2$	(s) Thermite reaction

16. Match the column:

Column-I	Column-II
(a) Poling	(p) Sn
(b) Cupellation	(q) Ag
(c) Zone refining	(r) Cu
(d) Parke's process	(s) Ge
	(t) Si

17. Match the column:

Column-I	Column-II
(a) Ni	(p) A solution of lead silico fluoride $PbSiF_6$ containing 8–10% of H_2SiF_6 is used as electrolyte for
(b) Pb	(q) Complex formation reaction is involved in extraction of
(c) Cu	(r) Self-reduction
(d) Hg	(s) Carbon monoxide is used for extraction of
	(t) *d*-block element

18. Match the column:

Column-I (Processes involved)	Column-II (Related to)
(a) Serpeck's process	(p) Purification of aluminium
(b) Dow's sea-water process	(q) Purification of alumina
(c) Hall–Heroult process	(r) Preparation of hydrated $MgCl_2$
(d) Hoop's process	(s) Purification of tin
	(t) Reduction of alumina

19. Match the column:

Column-I	Column-II
(a) Magnetic separation	(p) $CuFeS_2$
(b) Froth floation	(q) Fe_3O_4
(c) Gravity separation	(r) $ZnCO_3$
(d) *p*-block metal is present in the ore	(s) PbS
	(t) Ag_2S

20. Match the column:

Column-I (Conversion processes)	Column-II (Involves which of the following operation/s)
(a) Auriferrous rock $\longrightarrow$ Au	(p) Roasting
(b) Haemetite containing siderite and magnetite $\longrightarrow$ Fe	(q) Smelting
(c) Bauxite $\longrightarrow$ Al	(r) Leaching
(d) Galena $\longrightarrow$ Pb	(s) Electrolytic reduction
	(t) Froth floatation

Integer Answer Type

1. How many ores are sulphide ores from the given ores?

Azurite, Chalcocite, Iron pyrites, Limonite

2. How many metals are commercially purified by Van Arkel method from the given metals?

Ti, B, Zr, Pb, Hg

3. How many metals are commercially purified by electrolysis method from the given metals?

Na, Al, Pb, Ni

4. Find the number of following reactions which are involved in roasting process:

(i) $S_8 + 8O_2 \xrightarrow{\Delta} 8SO_2\uparrow$

(ii) $4Sb + 3O_2 \xrightarrow{\Delta} 2Sb_2O_3\uparrow$

(iii) $4As + 3O_2 \xrightarrow{\Delta} 2As_2O_3\uparrow$

(iv) $2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$

(v) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2\uparrow$

5. Find the number of reaction from the given reactions which can show calcination process:

(i) $CaCO_3{\cdot}MgCO_3 \xrightarrow{\Delta} CaO + MgO + CO_2$

(ii) $CuCO_3{\cdot}Cu(OH)_2 \xrightarrow{\Delta} 2CuO + H_2O + CO_2$

(iii) $Al_2O_3{\cdot}2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$

(iv) $2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2$

6. Find the number of basic flux from the given compounds:

SiO_2, MgO, CaO, FeO, B_2O_3, $CaCO_3{\cdot}MgCO_3$

7. Find the number of metal oxides which are decomposed on normal heating from the given oxides:

Na_2O, Al_2O_3, PbO, Ag_2O, HgO

8. How many metallic ores are concentrated by magnetic separation method from the given ores?

Cassiterite, Pyrolusite, Rutile, Magnetite, Galena, Cinnabar

9. Find the number of metals from the given metals which can be commercially purified by zone refining methods:

Si, Ge, Ga, Al, Ti, Zr

10. How many metals are commercially extracted by pyrometallurgy from the given metals?

Cu, Fe, Sn, Au, K, Na

11. Find the number of acidic flux from the given compounds:

$CaCO_3$, $Na_2B_4O_7$, $MgSiO_3$, $FeSiO_3$, SiO_2

12. How many metals are commercially reduced by Goldschmidt alumino-thermic process from the given metals?

Na, Pb, Al, Mn, Cr, Sn

13. Find the number of metals which are commercially reduced by self-reduction from the given metals:

Fe, Al, Zn, Sn, Pb, Hg, Cu

14. Find the number of metals which are commercially reduced by carbon reduction method from the given metals:

Ag, Cr, Mn, Sn, Zn, Fe

15. How many metals are commercially extracted by hydrometallurgy from the given metals?

Ag, Mn, In, Cr, Pb, Au

16. How many metals are commercially extracted by electrometallurgy from the given metals?

Al, Mg, Na, K, Ag, Hg, Ti, Th, Zr, B

17. How many reactions can show slag formation process from the given reactions?

(i) $SiO_2 + CaO \longrightarrow CaSiO_3$

(ii) $FeO + SiO_2 \longrightarrow FeSiO_3$

(iii) $CaO + P_2O_5 \longrightarrow Ca_3(PO_4)_2$

(iv) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

(v) $MgCO_3 + SiO_2 \longrightarrow MgSiO_3 + CO_2$

NCERT Exemplar Exercises

Single Correct Answer Type

1. In the extraction of chlorine by electrolysis of brine ______.
   (a) Oxidation of Cl^- ion to chlorine gas occurs
   (b) Reduction of Cl^- ion to chlorine gas occurs
   (c) For overall reaction ΔG has negative value
   (d) A displacement reaction takes place

2. When copper ore is mixed with silica in a reverberatory furnace, copper matte is produced. The copper matte contains ______.
   (a) Sulphides of copper (II) and iron (II)
   (b) Sulphides of copper (II) and iron (III)
   (c) Sulphides of copper (I) and iron (II)
   (d) Sulphides of copper (I) and iron (III)

3. Which of the following reactions is an example of autoreduction?
   (a) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$
   (b) $Cu_2O + C \rightarrow 2Cu + CO$
   (c) $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$
   (d) $Cu_2O + \frac{1}{2}Cu_2S \rightarrow 3Cu + \frac{1}{2}SO_2$

4. A number of elements are available in earth's crust but most abundant elements are ______.
   (a) Al and Fe (b) Al and Cu
   (c) Fe and Cu (d) Cu and Ag

5. Zone refining is based on the principle that ______.
   (a) Impurities of low boiling metals can be separated by distillation
   (b) Impurities are more soluble in molten metal than in solid metal
   (c) Different components of a mixture are differently adsorbed on an adosrbent
   (d) Vapors of volatile compound can be decomposed in pure metal

6. In the extraction of copper from its sulphide ore, the metal is formed by the reduction of Cu_2O with:
   (a) FeS (b) CO
   (c) Cu_2S (d) SO_2

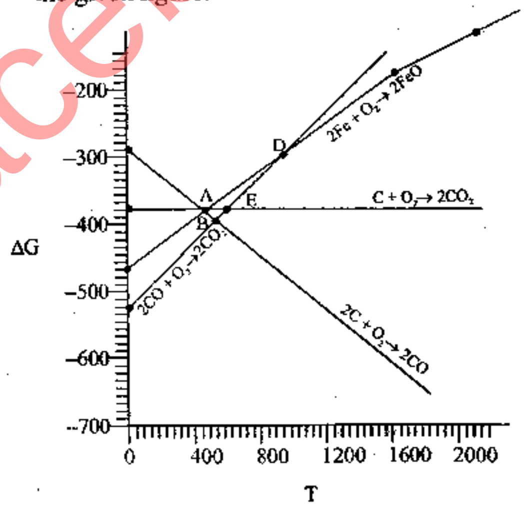
7. Brine is electrolyzed by using inert electrodes. The reaction at anode is _______.
   (a) $Cl^-(aq.) \rightarrow \frac{1}{2} Cl_2(g) + e^-$; $E^\circ_{cell} = 1.36$ V
   (b) $2H_2O(l) \rightarrow O_2(g) + 4H^+ + 4e^-$; $E^\circ_{cell} = 1.23$ V
   (c) $Na^+(aq.) + e^- \rightarrow Na(s)$; $E^\circ_{cell} = 2.71$ V
   (d) $H^+(aq.) + e^- \rightarrow \frac{1}{2}H_2(g)$; $E^\circ_{cell} = 0.00$ V

8. In the metallurgy of aluminium _______.
   (a) Al^{3+} is oxidized to Al (s)
   (b) Graphite anode is oxidized to carbon monoxide and carbon dioxide
   (c) Oxidation state of oxygen changes in the reaction at anode
   (d) Oxidation state of oxygen changes in the overall reaction involved in the process

9. Electrolytic refining is used to purify which of the following metals?
   (a) Cu and Zn (b) Ge and Si
   (c) Zr and Ti (d) Zn and Hg

10. Extraction of gold and silver involves leaching the metal with CN^- ion. The metal is recovered by _______.
   (a) Displacement of metal by some other metal from the complex ion
   (b) Roasting of metal complex
   (c) Calcination followed by roasting
   (d) Thermal decomposition of metal complex

Note: Answer the questions 11–13 on the basis of the given figure.



11. Choose the correct option of temperature at which carbon reduces FeO to iron and produces CO.
   (a) Below temperature at point A
   (b) Approximately at the temperature corresponding to point A
   (c) Above temperature at point A but below temperature at point D
   (d) Above temperature at point A

12. Below point 'A' FeO can _______.
   (a) Be reduced by carbon monoxide only
   (b) Be reduced by both carbon monoxide and carbon
   (c) Be reduced by carbon only
   (d) Not be reduced by both carbon and carbon monoxide

13. For the reduction of FeO at the temperature corresponding to point D, which of the following statements is correct?
   (a) ΔG value for the overall reduction reaction with carbon monoxide is zero
   (b) ΔG value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive
   (c) ΔG value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive
   (d) ΔG value for the overall reduction reaction with carbon monoxide is negative

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. At the temperature corresponding to which of the points in the figure given in Q. 10, FeO will be reduced to Fe by coupling the reaction $2FeO \rightarrow 2Fe + O_2$ with all of the following reactions?
   (i) $C + O_2 \rightarrow CO_2$ (ii) $2C + O_2 \rightarrow 2CO$ and (iii) $2CO + O_2 \rightarrow 2CO_2$
   (a) Point A (b) Point B
   (c) Point D (d) Point E

2. Which of the following options are correct?
   (a) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast
   (b) In extraction of silver, silver is extracted as cationic complex
   (c) Nickel is purified by zone refining
   (d) Zr and Ti are purified by Van Arkel method

3. In the extraction of aluminium by Hall-Heroult process, purified Al_2O_3 is mixed with CaF_2 to:
   (a) Lower the melting point of Al_2O_3
   (b) Increase the conductivity of molten mixture
   (c) Reduce Al^{3+} into Al(s)
   (d) Acts as catalyst

4. Which of the following statements is correct about the role of substances added in the froth floatation process?
   (a) Collectors enhance the non-wettability of the mineral particles
   (b) Collectors enhance the wettability of gangue particles
   (c) By using depressants in the process two sulphide ores can be separated
   (d) Froth stabilizers decrease wettability of gangue

5. In the froth floatation process, zinc sulphide and lead sulphide can be separated by ______.
   (a) Using collectors
   (b) Adjusting the proportion of oil to water
   (c) Using depressant
   (d) Using froth stabilizers

6. Common impurities present in bauxite are ______.
   (a) CuO (b) ZnO
   (c) Fe_2O_3 (d) SiO_2

7. Which of the following ores are concentrated by froth floatation?
   (a) Haematite (b) Galena
   (c) Copper pyrites (d) Magnetite

8. Which of the following reactions occur during calcination?
   (a) $CaCO_3 \rightarrow CaO + CO_2$
   (b) $2FeS_2 + \frac{11}{2}O_2 \rightarrow Fe_2O_3 + 4SO_2$
   (c) $Al_2O_3 \cdot x\,H_2O \rightarrow Al_2O_3 + x\,H_2O$
   (d) $ZnS + \frac{3}{2}O_2 \rightarrow ZnO + SO_2$

9. For the metallurgical process of which of the ores calcined ore can be reduced by carbon?
   (a) Haematite (b) Calamine
   (c) Iron pyrites (d) Sphalerite

10. The main reactions occurring in blast furnace during extraction of iron from haematite are ______.
   (a) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
   (b) $FeO + SiO_2 \rightarrow FeSiO_3$
   (c) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$
   (d) $CaO + SiO_2 \rightarrow CaSiO_3$

11. In which of the following method of purification, metal is converted to its volatile compound which is decomposed to give pure metal?
   (a) Heating with stream of carbon monoxide
   (b) Heating with iodine
   (c) Liquation
   (d) Distillation

12. Which of the following statements are correct?
   (a) A depressant prevents certain type of particle to come to the froth
   (b) Copper matte contains Cu_2S and ZnS
   (c) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction
   (d) Zinc can be extracted by self-reduction

13. In the extraction of chlorine from brine ______.
   (a) $\Delta G^{\ominus}$ for the overall reaction is negative
   (b) $\Delta G^{\ominus}$ for the overall reaction is positive
   (c) $E^{\ominus}$ for overall reaction has negative value
   (d) $E^{\ominus}$ for overall reaction has positive value

Short Answer Type

1. Why is an external emf of more than 2.2 V required for the extraction of Cl_2 from brine?
2. At temperatures above 1073 K coke can be used to reduce FeO to Fe. How can you justify this reduction with Ellingham diagram?
3. Wrought iron is the purest form of iron. Write a reaction used for the preparation of wrought iron from cast iron. How can the impurities of sulphur, silicon and phosphorus be removed from cast iron?
4. How is copper extracted from low grade copper ores?
5. Write two basic requirements for refining of a metal by Mond process and by Van Arkel Method.
6. Although carbon and hydrogen are better reducing agents but they are not used to reduce metallic oxides at high temperatures. Why?
7. How do we separate two sulphide ores by froth floatation method? Explain with an example.
8. The purest form of iron is prepared by oxidising impurities from cast iron in a reverberatory furnace.

   Which iron ore is used to line the furnace? Explain by giving reaction.

9. The mixture of compounds A and B is passed through a column of Al_2O_3 by using alcohol as eluant. Compound A is eluted in preference to compound B.

   Which of the compounds A or B, is more readily adsorbed on the column?

10. Why is sulphide ore of copper heated in a furnace after mixing with silica?

11. Why are sulphide ores converted to oxide before reduction?

12. Which method is used for refining Zr and Ti? Explain with equation.

13. What should be the considerations during the extraction of metals by electrochemical method?

14. What is the role of flux in metallurgical processes?

15. How are metals used as semiconductors refined? What is the principle of the method used?

16. Write down the reactions taking place in Blast furnace related to the metallurgy of iron in the temperature range 500–800 K.

17. Give two requirements for vapour phase refining.

18. Write the chemical reactions involved in the extraction of gold by cyanide process. Also give the role of zinc in the extraction.

Matching Column Type

Note: Match the items given in Column-I and Column-II in the following questions.

1. Match the items of Column-I with items of Column-II and assign the correct code:

Column-I	Column-II
(a) Pendulum	(p) Chrome steel
(b) Malachite	(q) Nickel steel
(c) Calamine	(r) Na_3AlF_6
(d) Cryolite	(s) $CuCO_3 \cdot Cu(OH)_2$
	(t) $ZnCO_3$

Code:

(a) a (p) b (q) c (r) d (s)

(b) a (q) b (s) c (t) d (r)

(c) a (q) b (r) c (s) d (t)

(d) a (s) b (t) c (r) d (q)

2. Match the items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Colored bands	(p) Zone refining
(b) Impure metal to volatile complex	(q) Fractional distillation
(c) Purification of Ge and Si	(r) Mond Process
(d) Purification of mercury	(s) Chromatography
	(t) Liquation

Code:

(a) a (p) b (q) c (s) d (t)

(b) a (s) b (r) c (p) d (q)

(c) a (r) b (s) c (q) d (p)

(d) a (t) b (s) c (r) d (q)

3. Match items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Cyanide process	(p) Ultrapure Ge
(b) Froth floatation Process	(q) Dressing of ZnS
(c) Electrolytic reduction	(r) Extraction of Al
(d) Zone refining	(s) Extraction of Au
	(t) Purification of Ni

Code:

(a) a (s) b (q) c (r) d (p)

(b) a (q) b (r) c (p) d (t)

(c) a (p) b (q) c (r) d (s)

(d) a (r) b (s) c (t) d (p)

4. Match the items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Sapphire	(p) Al_2O_3
(b) Sphalerite	(q) NaCN
(c) Depressant	(r) Co
(d) Corundum	(s) ZnS
	(t) Fe_2O_3

Code:

(a) a (r) b (s) c (q) d (p)

(b) a (t) b (s) c (r) d (q)

(c) a (q) b (r) c (s) d (t)

(d) a (p) b (q) c (r) d (s)

5. Match the items of Column-I with items of Column-II and assign the correct code:

Column-I	Column-II
(a) Blistered Cu	(p) Aluminium
(b) Blast furnace	(q) $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

(c) Reverberatory furnace	(r) Iron
(d) Hall-Heroult process	(s) $FeO + SiO_2 \rightarrow FeSiO_3$
	(t) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

Code:

(a) a (q) b (r) c (s) d (p)
(b) a (p) b (q) c (r) d (t)
(c) a (t) b (s) c (r) d (q)
(d) a (s) b (t) c (r) d (q)

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.
(e) Assertion and reason both are wrong.

1. **Assertion:** Nickel can be purified by Mond process.

   Reason: Ni $(CO)_4$ is a volatile compound which decomposes at 460 K to give pure Ni.

2. **Assertion:** Zirconium can be purificed by Van Arkel method.

   Reason: ZrI_4 is volatile and decomposes at 1800 K.

3. **Assertion:** Sulphide ores are concentrated by Froth Flotation method.

   Reason: Cresols stabilize the froth in froth flotation method.

4. **Assertion:** Zone refining method is very useful for producing semiconductors.

   Reason: Semiconductors are of high purity.

5. **Assertion:** Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation by a more electropositive metal.

   Reason: Copper is extracted by hydrometallurgy.

Long Answer Type

1. Explain the following:

   (a) CO_2 is a better reducing agent below 710 K whereas CO is a better reducing agent above 710 K.

   (b) Generally sulphide ores are converted into oxides before reduction.

   (c) Silica is added to the sulphide ore of copper in the reverberatory furnace.

   (d) Carbon and hydrogen are not used as reducing agents at high temperatures.

   (e) Vapour phase refining method is used for the purification of Ti.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Aluminium is extracted by the electrolysis of:
   (a) Bauxite
   (b) Alumina
   (c) Alumina mixed with molten cryolite
   (d) Molten cryolite **(AIEEE, 2002)**

2. The metal extracted by leaching with a cyanide is:
   (a) Mg (b) Ag
   (c) Cu (d) Na **(AIEEE, 2002)**

3. Which one of the following ores is best concentrated by froth-flotation method?
   (a) Galena (b) Cassiterite
   (c) Magnetite (d) Malachite
   (AIEEE, 2004)

4. During the process of electrolytic refining of copper, some metals present as impurity settle as 'anode mud'. These are:
   (a) Fe and Ni (b) Ag and Au
   (c) Pb and Zn (d) Sn and Ag
   (AIEEE, 2005)

5. Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly?
   (a) Metal sulphides are thermodynamically more stable than CS_2
   (b) CO_2 is thermodynamically more stable than CS_2
   (c) Metal sulphides are less stable than the corresponding oxides
   (d) CO_2 is more volatile than CS_2
   (AIEEE, 2008)

6. Which method of purification is represented by the following equation?

$$Ti(s) + 2I_2(g) \xrightarrow{523\,K} TiI_4(g) \xrightarrow{1700\,K} Ti(s) + 2I_2(g)$$

(a) Zone refining (b) Cupellation
(c) Polling (d) Van Arkel

(AIEEE, 2012)

7. The form of iron obtained from blast furnace is:

(a) Steel (b) Wrought iron
(c) Cast iron (d) Pig iron

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of ________. The slag formed consists of ________.
(IIT-JEE, 1980)

2. In the thermite process, ________ is used as a reducing agent. **(IIT-JEE, 1980)**

3. Cassiterite is an ore of ________. **(IIT-JEE, 1980)**

4. In extractive metallurgy of zinc, partial fusion of ZnO with coke is called ________ and reduction of the ore to molten metal is called ________ (smelting, calcining, roasting, sintering).
(IIT-JEE, 1988)

Single Correct Answer Type

1. In the aluminothermite process, aluminium is:

(a) An oxidizing agent
(b) A flux
(c) A reducing agent
(d) A solder

(IIT-JEE, 1983)

2. The major role of fluorspar (CaF_2) which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is:

(a) As a catalyst
(b) To make the fused mixture very conducting
(c) To increase the temperature of the melt
(d) To decrease the rate of oxidation of carbon at the anode

(IIT-JEE, 1993)

3. In the commercial electrochemical process for aluminium extraction, the electrolyte used is:

(a) $Al(OH)_3$ in NaOH solution
(b) An aqueous solution of $Al_2(SO_4)_3$
(c) A molten mixture of Al_2O_3 and Na_3AlF_6
(d) A molten mixture of AlO(OH) and $Al(OH)_3$

(IIT-JEE, 1999)

4. The chemical process in the production of steel from haematite ore involves:

(a) Reduction
(b) Oxidation
(c) Reduction followed by oxidation
(d) Oxidation followed by reduction

(IIT-JEE, 2000)

5. Electrolytic reduction of alumina to aluminium by Hall–Heroult process is carried out:

(a) In the presence of NaCl
(b) In the presence of fluorite
(c) In the presence of cryolite which forms a melt with lower melting temperature
(d) In the pressure of cryolite which forms a melt with higher melting temperature

(IIT-JEE, 2000)

6. The chemical composition of slag formed during the smelting process in the extraction of copper is:

(a) $Cu_2O + FeS$ (b) $FeSiO_3$
(c) $CuFeS_2$ (d) $Cu_2S + FeO$

(IIT-JEE, 2001)

7. Which of the following processes is used in extractive metallurgy of magnesium?

(a) Fused salt electrolysis
(b) Self-reduction
(c) Aqueous solution electrolysis
(d) Thermite reduction **(IIT-JEE, 2002)**

8. In the process of extraction of gold,

Roasted gold ore + $CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$

$[X] + Zn \rightarrow [Y] + Au$

Identify the complexes $[X]$ and $[Y]$:

(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{3-}$, $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

(IIT-JEE, 2003)

9. The methods chiefly used for the extraction of lead and tin from their ores, respectively, are:

(a) Self-reduction and carbon reduction

(b) Self-reduction and electrolytic reduction
(c) Carbon reduction and self-reduction
(d) Cyanide process and carbon reduction

(IIT-JEE, 2004)

10. Which ore contains both iron and copper?
(a) Cuprite (b) Chalcocite
(c) Chalcopyrite (d) Malachite

(IIT-JEE, 2005)

11. Extraction of zinc from zinc blende is achieved by:
(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

(IIT-JEE, 2007)

12. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of:
(a) Nitrogen (b) Oxygen
(c) Carbon dioxide (d) Argon

(IIT-JEE, 2008)

13. In the cyanide extraction process of silver from argentite ore, the oxidizing and reducing agents used are:
(a) O_2 and CO, respectively
(b) O_2 and Zn dust, respectively
(c) HNO_3 and Zn dust, respectively
(d) HNO_3 and CO, respectively

(IIT-JEE, 2012)

14. Sulfide ores are common for the metals:
(a) Ag, Cu and Pb (b) Ag, Cu and Sn
(c) Ag, Mg and Pb (d) Al, Cu and Pb

(JEE Advanced, 2013)

Multiple Correct Answers Type

1. In the electrolysis of alumina, cryolite is added to:
(a) Lower the melting point of alumina
(b) Increase the electrical conductivity
(c) Minimize the anode effect
(d) Remove the impurities from alumina

(IIT-JEE, 1988)

2. Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are:
(a) Ag (b) Mg
(c) Cu (d) Al
(e) Cr

(IIT-JEE, 1990)

3. Extraction of metal from the ore cassiterite involves:
(a) Carbon reduction of an oxide ore
(b) Self-reduction of a sulphide ore
(c) Removal of copper impurity
(d) Removal of iron impurity

(IIT-JEE, 2011)

4. Oxidation states of the metal in the minerals hematite and magnetite, respectively, are:
(a) II, III in hematite and III in Magnetite
(b) II, III in hematite and II in Magnetite
(c) II in hematite and II, III in Magnetite
(d) III in hematite and II, III in Magnetite

(IIT-JEE, 2011)

5. The carbon-based reduction method is **NOT** used for the extraction of:
(a) Tin from SnO_2
(b) Iron from Fe_2O_3
(c) Aluminium from Al_2O_3
(d) Magnesium from $MgCO_3.CaCO_3$

(JEE Advanced, 2013)

6. Upon heating with Cu_2S, the reagent(s) that give copper metal is/are:
(a) $CuFeS_2$ (b) CuO
(c) Cu_2O (d) $CuSO_4$

(JEE Advanced, 2014)

Comprehension Type

For Problems 1–3

Copper is the most noble of the first row transition elements. It occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4 \cdot 5H_2O$), atacamite [$Cu_2Cl(OH)_3$], cuprite (Cu_2O), copper glance (Cu_2S), and malachite [$Cu_2(OH)_2CO_3$]. However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). Extraction of copper from chalcopyrite includes roasting, iron removal, and self-reduction.

1. Partial roasting of chalcopyrite produces:
(a) Cu_2S and FeO (b) Cu_2O and FeO
(c) CuS and Fe_2O_3 (d) Cu_2O and Fe_2O_3

2. Iron is removed from chalcopyrite as:
(a) FeO (b) FeS
(c) Fe_2O_3 (d) $FeSiO_3$

3. In self-reduction, the reducing species is:
(a) S (b) O^{2-}
(c) S^{2-} (d) SO_2

(IIT-JEE, 2010)

Matching Column Type

1. Match the following metals listed in Column-I with extraction processes listed in Column-II.

Column-I	Column-II
(a) Silver	(p) Fused salt electrolysis
(b) Calcium	(q) Carbon reduction
(c) Zinc	(r) Carbon monoxide reduction
(d) Iron	(s) Amalgamation
(e) Copper	(t) Self-reduction

(IIT-JEE, 1979)

2. Match the following choosing one item from Column-I and the appropriate item from Column-II.

Column-I	Column-II
(a) Al	(p) Calamine
(b) Cu	(q) Cryolite
(c) Mg	(r) Malachite
(d) Zn	(s) Carnallite

(IIT-JEE, 1983)

3. Match the extraction processes listed in Column-I with the metals listed in Column-II.

Column-I	Column-II
(a) Self-reduction	(p) Lead
(b) Carbon reduction	(q) Silver
(c) Complex formation and displacement by metal	(r) Copper
(d) Decomposition of iodide	(s) Boron

(IIT-JEE, 2006)

4. Match the conversions in Column-I with the type(s) of reaction(s) given in Column-II.

Column-I	Column-II
(a) $PbS \rightarrow PbO$	(p) Roasting
(b) $CaCO_3 \rightarrow CaO$	(q) Calcination
(c) $ZnS \rightarrow Zn$	(r) Carbon reduction
(d) $Cu_2S \rightarrow Cu$	(s) Self-reduction

(IIT-JEE, 2008)

Subjective Type

1. Write the chemical equations involved in the extraction of lead from galena by self-reduction process. **(IIT-JEE, 1979)**

2. State the conditions under which the preparation of alumina from aluminium is carried out. Give the necessary equations which need not be balanced. **(IIT-JEE, 1983)**

3. Each of the following statements is true only under some specific conditions. Write the condition for each sub-question in not more than two sentences.

(i) Metals can be recovered from their ores by chemical methods.

(ii) High purity metals can be obtained by zone refining method. **(IIT-JEE, 1984)**

4. Write balanced chemical equations for the following: "Gold is dissolved in aquaregia." **(IIT-JEE, 1987)**

5. Answer the following questions briefly.

(i) What is the actual reducing agent of haematite in blast furnace?

(ii) Give the equations for the recovery of lead from galena by air reduction.

(iii) Why is sodium chloride added during electrolysis of fused anhydrous magnesium chloride?

(iv) Zinc, not copper, is used for the recovery of metallic silver from the complex $[Ag(CN)_2]^-$, explain.

(v) Why is chalcocite roasted and not calcinated during recovery of copper? **(IIT-JEE, 1987)**

6. Give balanced equations for the following: "Extraction of silver from silver glance by cyanide process" **(IIT-JEE, 1988)**

7. Write balanced equations for "the extraction of copper from copper pyrites by self-reduction." **(IIT-JEE, 1990)**

8. Give briefly the isolation of magnesium from sea water. Give equations for the steps involved. **(IIT-JEE, 1993)**

9. Given reasons for the following: "Although aluminium is above hydrogen in the electrochemical series, it is stable in air and water." **(IIT-JEE, 1994)**

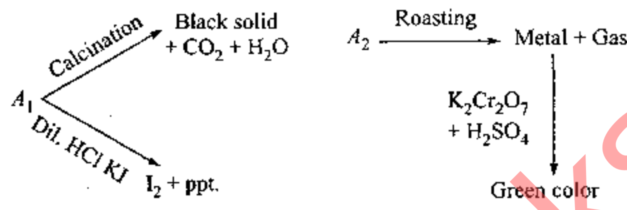
10. When the ore haematite is burnt in air with coke around 2000 K along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. **(IIT-JEE, 1998)**

11. Write the chemical reactions involved in the extraction of metallic silver from argentite. **(IIT-JEE, 2000)**

12. How is boron obtained from borax? Give chemical equations with reaction conditions. Write the structure of B_2H_6 and its reaction with HCl. **(IIT-JEE, 2002)**

13. Write down the reactions involved in the extraction of Pb. What is the oxidation number of lead in litharge? **(IIT-JEE, 2003)**

14. A_1 and A_2 are two ores of metal M. A_1 on calcination gives a black precipitate, CO_2, and water. Identify A_1 and A_2. **(IIT-JEE, 2004)**



Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

61. (b)

I Mond's porcess:

$$\underset{\text{Impure}}{Ni} + 4CO\uparrow \xrightarrow{50^\circ C} \underset{\text{Volatile complex}}{[Ni(CO)_4]} \xrightarrow{230^\circ C} \underset{\text{Pure}}{Ni} + 4CO\uparrow$$

II Removal of unreacted AgBr from photographic plate:

$$AgBr + 2Na_2S_2O_3 \rightleftharpoons Na_3[Ag(S_2O_3)_2] + NaBr$$

III Removal of lead poisoning:

$$Pb^{2+} + EDTA^{4-} \rightleftharpoons [Pb(EDTA)]^{2-}$$

IV Cyanide process:

$$2Ag + 4NaCN + H_2O + \frac{1}{2}O_2 \rightleftharpoons 2Na[Ag(CN)_2] + 2NaOH \text{ Native Ore}$$

V Separation of ZnS from PbS:

$$ZnS + CN \rightleftharpoons [Zn(CN)_4]^{2-}$$

64. (b) Cassiterite (SnO_2) is diamagnetic, while wolframite ($MnWO_4 + FeWO_4$) is paramagnetic.

66. (c) Thermite process is related to Goldschmidt thermite reduction or welding where aluminium is used in powdered form (thermite) as reducing agent.

67. (d) Anthracite is the purest form of coal.

JEE (Advanced) Exercises

Single Correct Answer Type

3. (b) $4Ag + 8NaCN + 2H_2O + O_2 \longrightarrow 4Na[Ag(CN)_2] + 4NaOH$

4. (b) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$;

$$ZnO + C \xrightarrow{>1270\text{ K}} Zn + CO$$

10. (b)

(I) $M_2S + O_2 \longrightarrow M_2O$; $\Delta H = -$ ve

(II) Roasting is always exothermic

11. (a) BaO_2 or $KClO_3$ provides oxygen to burn Mg.

33. (c) As zinc is volatile at 920°C while Ag is not, hence on heating (Zn + Ag) alloy, zinc goes into vapor phase and Ag remains at the bottom of the vessel.

36. (b) $2Mg + 3C \xrightarrow{2000^\circ C} Mg_2C_3$

38. (b) In Bessemer converter, slag of $FeSiO_3$ is also formed. Blister appearance is due to escape of SO_2 gas from molten copper.

39. (b) Leaching is required for hydrometallurgy or to purify or concentrate ore for electrolytic reduction.

40. (c) $MgO + C \xrightarrow[2000^\circ C]{\text{at high temp.}} Mg + CO$

It is possible at high temperature; so it is not used for commerical purpose.

41. (c) A $\rightarrow$ Fe: by carbon reduction.

B $\rightarrow$ Al: by electrolytic reduction.

46. (a) The reduction process is on the thermodynamic stability of the products and not on their volatility.

49. (b) $2CuFeS_2$ ($Cu_2S + FeS + FeS_2$)

55. (c) Cr–Fe alloy: Ferrochrome is made similarily by the reduction of the ore chromite, $FeCr_2O_4$, with Al.

Multiple Correct Answers Type

23. (c), (d)

(a) During roasting S, As, and Sb will be oxidized into their volatile oxides SO_2, As_2O_3, and Sb_2O_3, respectively.

(c) During roasting, FeO is oxidized into Fe_2O_3 which does not form slag with silica.

(d) $Fe_2O_3 \cdot 3H_2O \xrightarrow{\Delta} Fe_2O_3 + 3H_2O\uparrow$

51. (b),(c),(d)

Azurite: $Cu(OH)_2 \cdot 2CuCO_3$

Comprehension Type

17. (c) If ore is Ag_2S, then

$$Ag_2S + 4NaCN \overset{\text{air}}{\rightleftharpoons} \underset{\text{(complex)}}{2Na[Ag(CN)_2]} + NaS_2 \xrightarrow{O_2} Na_2SO_4$$

Complex $[Ag(CN)_2]^-$ is linear and diamagnetic.

18. (c)
   (a) Sodium ethylxanthate acts as collector.
   (b) Levigation can be used for sulphide ore to remove majority of gangue when density difference in high.
   (c) Froth floatation can also be used for non-sulphide ores having sulphide impurities, and the ore is recovered by using suitable activator.
   (d) During roasting, impurities such as S and As are removed as their volatile oxides SO_2 and As_2O_3, respectively.

22. (c) $CaCO_3 \cdot MgCO_3 \xrightarrow{\text{Calcination}} CaO + MgO + 2CO_2$

28. (b) $Ti\,(s) + 1/2\,O_2(g) \xrightarrow{\Delta} TiO_2\,(s)$
   By increasing temperature according to $\Delta G = \Delta H - T\Delta S$, ΔG for formation of TiO_2 will move toward +ve value.

29. (c) ΔG_f of PbO is touching the zero value of ΔG° first.

30. (a) At T_1 temperature, ΔG_f of FeO is more negative than that of PbO.

Assertion-Reasoning Type

3. (a) Free electrons exist along layers of graphite.

Integer Answer Type

1. Azurite = $2\,CuCO_3 \cdot Cu(OH)_2$
   Chalcocite = Cu_2S
   Iron pyrites = FeS_2
   Limonite = $Fe_2O_3 \cdot 3H_2O$

NCERT Exemplar Exercises

Short Answer Type

1. For the reaction

   $2Cl^-\,(aq) + 2H_2O\,(l) \rightarrow 2OH^-\,(aq) + H_2(g) + Cl_2\,(g)$

   Value of $\Delta G^\ominus$ is + 422 kJ. Using the equation $\Delta G^\ominus = -nFE^\ominus$ the value of $E^\ominus$ comes out to be –2.2 V. Therefore extraction of Cl_2 from brine will require an external emf of greater than 2.2 V.

2. As per Ellingham diagram at temperatures greater than 1073 K

   ΔG (C, CO) < ΔG (Fe, FeO). Hence coke can reduce FeO to Fe.

3. $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

   Limestone is added as flux and sulphur, silicon and phosphorus change to their oxides and pass into the slag.

4. Copper is extracted by hydrometallurgy from low grade copper ores. It is leached out using acid or bacteria. The solution containing Cu^{2+} is treated with scrap iron, Zn or H_2.

   $2\,Cu^{2+}\,(aq) + H_2(g) \rightarrow 2Cu(s) + 2H^+(aq)$

   $Cu^{2+} + Fe(s) \rightarrow Fe^{2+}\,(aq) + Cu(s)$

5. Basic requirements for both processes are:
   (i) The metal should form a volatile compound with an available reagent.
   (ii) The volatile compound should be easily decomposable, so that recovery of metal is easy.

6. It is because at high temperature carbon and hydrogen react with metals to form carbides and hydrides respectively.

7. Two sulphide ores can be separated by adjusting proportion of oil to water or by using depressants. For example, in the case of an ore containing ZnS and PbS, the depressant NaCN is used. It forms complex with ZnS and prevents it from coming with froth but PbS remains with froth.

8. Haematite

   $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

9. Since compound 'A' comes out before compound 'B', the compound 'B' is more readily adsorbed on column.

10. Iron oxide present as impurity in sulphide ore of copper forms slag which is iron silicate and copper is produced in the form of copper matte.

    $FeO + SiO_2 \rightarrow FeSiO_3$

11. Sulphides are not reduced easily but oxides are easily reduced.

12. Van Arkel method is used for refining Zr and Ti. In this method crude metal is heated with iodine.

    $Zr + 2I_2 \longrightarrow ZrI_4$

    $ZrI_4 \xrightarrow{1800K} Zr + 2I_2$

13. Generally two things are considered so that proper precautions can be taken:
    (i) reactivity of metal produced
    (ii) suitability of electrodes

14. Flux is used for making the molten mass more conducting.

15. Semiconducting metal is produced by zone refining method which is based on the principle that the impurities are more soluble in melt than in the solid state of metals.

16. $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$

$Fe_2O_3 + CO \rightarrow 2FeO + CO_2$

17. (i) The metal should form a volatile compound with available reagent.

(ii) The volatile compound should be easily decomposable so that the recovery is easy.

18. $4Au(s) + 8CN^-(aq) + 2H_2O(aq) + O_2(g) \rightarrow 4[Au(CN)_2]^-(aq) + 4OH^-(aq)$

$2[Au(CN)_2]^-(aq) + Zn(s) \rightarrow 2Au(s) + [Zn(CN)_4]^{2-}(aq)$

In this reaction zinc acts as a reducing agent.

Long Answer Type

1. (a) **Hint:** Use Ellingham diagram.

(b) **Hint:** Oxides are easier to reduce. See Ellingham diagram.

(c) **Hint:** Sulphide ore of copper contains iron as impurity which is removed as iron silicate (slag)

$$FeO + SiO_2 \rightarrow \underset{(Slag)}{FeSiO_3}$$

(d) **Hint:** Carbon and hydrogen react with metals at high temperature to form carbides and hydrides respectively.

(e) **Hint:** Ti reacts with iodine to form volatile TiI_4 which decomposes at high temperature to give extra pure titanium.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) Aluminium is extracted by the electrolysis of purified Al_2O_3, which is mixed with Na_3AlF_6 or CaF_2, which lowers the melting point of the mixture and brings conductivity. Steel cathode and graphite anode are used. The graphite anode is useful here for reduction to metal. The overall reaction may be taken as

$$Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$$

The process of electrolysis is widely known as Hall–Heroult process.

2. (b) Leaching is often used if the ore is soluble in some suitable solvent. In the metallurgy of silver and that of gold, the respective metal is leached with a dilute solution of NaCN or KCN in the presence of air (for O_2) from which the metal is obtained later by replacement.

$4M(s) + 8CN^-(aq) + 2H_2O(aq) + O_2(g) \rightarrow 4[M(CN)_2]^-(aq) + 4OH^-(aq)$ (M = Ag or Au)

$2[M(CN)_2]^-(aq) + Zn(s) \rightarrow [Zn(CN)_4]^{2-}(aq) + 2M(s)$

3. (a) Froth-floatation method is used for removing gangue from sulphide ores.

Galena is PbS, Cassiterite is SnO_2, Magnetite is Fe_3O_4, and Malachite is $CuCO_3 \cdot Cu(OH)_2$.

4. (b) In electrolytic refining, the impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

5. (a)

(a) $PbS + C \rightarrow Pb + CS_2$

This reaction in non-spontaneous on the basis that PbS is more stable than CS_2.

(b) Carbon or CO is used as a reducing agent and they get converted to CO_2 rather than CS_2 because CO_2 is thermodynamically more stable than CS_2.

(c) $PbS + O_2 \rightarrow PbO + SO_2$

$PbS + PbO \rightarrow Pb + SO_2$

(d) Boiling point × Molecular mass

Both CO_2 and CS_2 are non-polar molecular.

6. (d) Van Arkel method is vapor phase refining method.

7. (d) Iron obtained in blast furnace is known as pig iron.

JEE (Advanced) Exercises

Fill in the Blanks Type

1. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of **lime**. The slag formed consists of **$Ca_3(PO_4)_2$**. Phosphorous is oxidized to P_4O_{10} which reacts with lime to form slag.

   $P_4 + 5O_2 \rightarrow P_4O_{10}$

   $6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$

2. In the thermite process **aluminium** is used as a reducing agent.

   A mixture of concentrated oxide ore and **aluminium** powder, commonly called as thermite, is taken in a steel crucible placed in a bed of sand.

   $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$

   $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$

   A large amount of heat energy is released during reduction, which fuses both the alumina and the metal. Aluminium acts as a reducing agent and is itself oxidized.

3. Cassiterite is an ore of **tin**.

   Tin is extracted from oxide ore cassiterite by reduction with carbon in a reverberatory furnace.

   $SnO_2 + 2C \rightarrow Sn + 2CO$

4. In extractive metallurgy of zinc, partial fusion of ZnO with coke is called **sintering** and reduction of the ore to molten metal is called **smelting**.

Single Correct Answer Type

1. (c) A mixture of concentrated oxide ore and aluminium powder, commonly called as thermite, is taken in a steel crucible placed in a bed of sand.

   $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$

   $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$

   A large amount of heat energy is released during reduction, which fuses both the alumina and the metal. Aluminium acts as a reducing agent and is itself oxidized.

2. (b) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when electrolysis is carried out on the fused mass, the metal formed vaporizes, as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

3. (c) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

4. (d) First, by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

   $4FeO + O_2 \rightarrow 2Fe_2O_3$

   $Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

   $Fe_2O_3 + CO \rightarrow FeO + CO_2$

   $FeO + CO \rightarrow Fe + CO_2$

5. (c) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

6. (b) When smelting is done in the blast furnace, most of the ferrous oxide is converted into ferric oxide. With silica, it forms ferrous silicate which is the slag.

   $FeO + SiO_2 \rightarrow FeSiO_3$

7. (a) Anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride.

   The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity.

8. (a) $Au + 4CN^- + H_2O + \frac{1}{2}O_2 \rightarrow 2[Au(CN)_2]^- + 2OH^-$

   $2[Au(CN)_2]^- + Zn \rightarrow [Zn(Cn)_4]^{2-} + 2Au$

9. (a) The methods chiefly used for the extraction of lead and tin from their ores are self-reduction and carbon reduction, respectively.

Tin is extracted from oxide ore cassiterite by reduction with carbon in a reverberatory furnace.

$SnO_2 + 2C \rightarrow Sn + 2CO$

Lead is mainly extracted from sulphide ore called galena. Self-reduction finally takes place.

$2PbO + PbS \rightarrow 3Pb + SO_2$

$PbSO_4 + PbS \rightarrow 2Pb + 2SO_2$

10. (c) Chalcopyrite is $CuFeS_2$.

11. (b) When zinc blende is used, the powdered ore is concentrated by froth floatation process. The concentrated ore is heated in excess of oxygen at about 900°C. Zinc sulphide is oxidized to zinc oxide. If some of the ore is oxidized to zinc sulphate, it also decomposes at 900°C into ZnO. This is roasting. It is followed by reduction. The reaction that takes place during reduction is the conversion of the oxide into metal with the help of carbon.

$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$

$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$

$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$

12. (b) Native silver metal forms a water-soluble complex with a dilute aqueous solution of NaCN in the presence of oxygen as follows:

$4Ag + 8NaCN + 2H_2O + O_2 \rightarrow 4Na[Ag(CN)_2] + 4NaOH$

13. (b) In the extraction of silver, Ag_2S is leached with KCN in the presence of air:

$Ag_2S + NaCN + O_2 \rightleftharpoons Na[Ag(CN)_2] + Na_2S_2O_3$

Thus, O_2 is oxidant.

$2Ag(CN)_2^- + Zn \longrightarrow [Zn(CN_4)]^{2-} + 2Ag\downarrow$

14. (a) Sulphide ores are common for Ag, Cu and Pb

i.e. Ag_2S (Silver glance)

Cu_2S (Copper glance or chalcocite)

$CuFeS_2$ (Chalcopyrite)

PbS (Galena)

While SnO_2 (Cassiterite)

$KCl.MgCl_2.6H_2O$ (Carnalite)

$Al_2O_3.2H_2O$ (Bauxite)

Multiple Correct Answers Type

1. (a), (b) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

2. (b), (d) Magnesium and aluminium lie above hydrogen in electrochemical series. Their standard reduction potentials are lower than that of hydrogen. When their salts are electrolyzed in aqueous solutions, hydrogen gas is liberated at the cathode.

3. (a), (c), (d) Cassiterite ore: SnO_2

$$\left.\begin{array}{l} SnO_2 + C \longrightarrow SnO + CO \\ SnO_2 + C \longrightarrow Sn + CO \end{array}\right\} \text{Carbon reduction}$$

Also iron is present as impurity in this ore.

4. (d) Hematite: Fe_2O_3: Iron (III)

Magnetite: $Fe_3O_4 \equiv FeO_4 : Fe_2O_3$: Iron (II, III)

5. (c), (d)

(a) $\boxed{SnO_2 \xrightarrow[\text{Reduction}]{\text{Carbon}} Sn}$

$SnO_2 + 2C \rightarrow Sn + 2CO\uparrow$

$SnO_2 + 2CO \rightarrow Sn + 2CO_2\uparrow$

(b) $\boxed{Fe_2O_3 \xrightarrow[\text{Reduction}]{\text{Carbon}} 2Fe}$

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO\uparrow$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2\uparrow$

(c)

$\boxed{Al_2O_3 \xrightarrow[\text{Reduction}]{\text{Electrolytic}} 2Al}$

$\underbrace{Al_2O_3 + Na_3AlF_6 + CaF_2}_{\text{Molten Electrolyte}} \xrightarrow{\text{Electrolysis}} Al_{(\ell)}$ (at cathode)

(d)

$MgCO_3.CaCO_3 \xrightarrow{\text{Calcination}} MgO.CaO$

(i) Fe–Si Alloy $\longrightarrow$ Mg-metal

(ii) HCl $\longrightarrow [MgCl_2 + CaCl_2] \xrightarrow[\text{Reduction}]{\text{Electrolytic}}$ Mg-metal

In no process carbon is used as reducing agent.

6. (b), (c), (d) $Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6\,Cu + SO_2$

Comprehension Type

1. (a) Partial roasting:

$$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$$
$$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$$

2. (d) Removal of iron:

$$FeO + SiO_2 \rightarrow FeSiO_3(slag)$$

3. (c) Self-reduction:

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

The oxidation number of sulphur increases from −1 to +4. Therefore, S^{2-} is the reducing species.

Matching Column Type

1. (a) → (s); (b) → (p); (c) → (q, r); (d) → (t)

Silver metal is extracted by amalgamation process:

$$Ag + Hg \rightarrow (Hg) \xrightarrow{Distil} Ag\downarrow + Hg\uparrow$$

Calcium is extracted by the electrolysis of fused mixture of $CaCl_2$ and CaF_2.

When zinc blende is used, the powdered ore is concentrated by froth floatation process. The concentrated ore is heated in excess of oxygen at about 900°C. Zinc sulphide is oxidized to zinc oxide. If some of the ore is oxidized to zinc sulphate, it also decomposes at 900°C into ZnO. This is roasting. It is followed by reduction. The reaction that takes place during reduction is the conversion of the oxide into metal with the help of carbon.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$
$$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$$
$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$$

For iron, first by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

Copper is extracted by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

2. (a) → (q); (b) → (r); (c) → (s); (d) → (p)

Al	Cryolite	Na_3AlF_6
Cu	Malachite	$CuCO_3{\cdot}Cu(OH)_2$
Mg	Carnallite	$KCl{\cdot}MgCl_2{\cdot}6H_2O$
Zn	Calamine	$ZnCO_3$

3. (a) → (p, r); (b) → (p); (c) → (q); (d) → (s)

Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbO + PbS \rightarrow 3Pb + SO_2$$
$$PbSO_4 + PbS \rightarrow 2Pb + 2SO_2$$

Copper is extracted by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

In silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{Soluble}{Na_2[Zn(CN)_4]} + \underset{Ppt.}{2Ag\downarrow}$$

By decomposition of iodide, boron metal is isolated.

4. (a) → (p); (b) → (q); (c) → (p, r); (d) → (p, s)

For PbS → PbO, roasting is done.

For $CaCO_3$ → CaO, calcination is done in the absence of air.

For ZnS → Zn, there is roasting followed by reduction.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$
$$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$$
$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$$

For Cu_2S → Cu, roasting is done followed by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

Subjective Type

1. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbS + 3O_2 \rightarrow 2PbO + SO_2$$
$$PbS + 2O_2 \rightarrow PbSO_4$$
$$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$$
$$PbS + 2PbO \rightarrow 3Pb + SO_2$$

2. $Al + NaOH \xrightarrow{\text{Aqueous}} NaAlO_2 + H_2O$

$NaAlO_2 \xrightarrow{CO_2} Al(OH)_3 + Na_2CO_3$

$Al(OH)_3 \xrightarrow{\Delta} \underset{\text{Alumina}}{Al_2O_3} + H_2O$

3. (i) Many metals occur in nature as oxides, carbonates, sulphides which can be calcined or roasted. Then, they can be further treated chemically to get the metal.

(ii) Elements such as Si, Ge, Ga, etc., which are used as semiconductors, are refined by zone refining method. Highly pure metals are obtained. The method is based on the difference in solubility of impurities in molten and solid state of the metal. A movable heater is fitted around a rod of the impure metal. The heater is slowly moved across the rod. The metal melts at the point of heating and as the heater moves on from one end of the rod to the other end, the pure metal crystallizes, while the impurities pass on to the adjacent molten zone.

4. Aquaregia is three parts conc. HCl and one part conc. HNO_3. Aquaregia forms nascent chlorine which attacks gold.

$HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl$

$Au + 3Cl \rightarrow AuCl_3$

$AuCl_3 + HCl \rightarrow HAuCl_4$

5. (i) For iron, first by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$4FeO + O_2 \rightarrow 2Fe_2O_3$

$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_2O_3 + CO \rightarrow FeO + CO_2$

$FeO + CO \rightarrow Fe + CO_2$

Carbon monoxide is the actual reducing agent of hematite in the blast furnace.

(ii) Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$2PbS + 3O_2 \rightarrow 2PbO + SO_2$

$PbS + 2O_2 \rightarrow PbSO_4$

$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$

$PbS + 2PbO \rightarrow 3Pb + SO_2$

(iii) The anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride. The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at the cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity. Sodium chloride prevents the hydrolysis of magnesium chloride.

(iv) Zinc is more reducing and cheaper than copper.

(v) Chalcocite is a sulphide ore of copper; therefore, it must be roasted in the presence of air to get oxide.

6. In case of silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{Ppt.}}{2Ag\downarrow}$

7. Roasting:

$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 3SO_2$

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$

Smelting:

$FeO + SiO_2 \rightarrow FeSiO_3(Slag)$

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Bessemerization:

Self-reduction

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

8. In sea water, $MgCl_2$ is present.

$MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCl_2$

$Mg(OH)_2 \xrightarrow[\text{Dry}]{\Delta} MgO + H_2O$

$MgO + C + Cl_2 \xrightarrow{\Delta} MgCl_2 + CO\uparrow$

The anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride. The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at the cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity. Sodium chloride prevents the hydrolysis of magnesium chloride.

At anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

At cathode: $Mg^{2+} + 2e^- \rightarrow Mg$

9. When Al is exposed to air, it forms a thin invisible continuous resistant protective film of Al_2O_3.

10. First, by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of lime. The slag formed consists of $Ca_3(PO_4)_2$. Phosphorous is oxidized to P_4O_{10} which reacts with lime to form slag.

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$
$$6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$$

11. Silver is extracted from argentite ore by cyanide process. In case of silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{Ppt.}}{2Ag\downarrow}$$

12. Finely ground borax is heated with concentrated hydrochloric acid or concentrated sulphuric acid when sparingly soluble orthoboric acid separates out.

$$Na_2B_4O_7 + 2HCl \rightarrow 2NaCl + H_2B_4O_7$$
$$Na_2B_4O_7 + H_2SO_4 \rightarrow Na_2SO_4 + H_2B_4O_7$$
$$H_2B_4O_7 + 5H_2O \rightarrow 4H_3BO_3$$

Orthoboric acid is strongly heated to get B_2O_3.

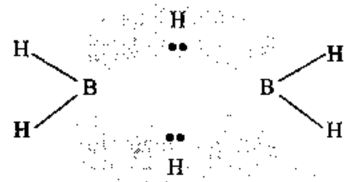
$$2H_3BO_3 \rightarrow B_2O_3 + 3H_2O$$

The reduction of boric anhydride (B_2O_3) can be done with sodium, potassium, or magnesium.

$$B_2O_3 + 6K \rightarrow 2B + 3K_2O$$
$$B_2O_3 + 3Mg \rightarrow 2B + 3MgO$$

Boron is obtained these days by the electrolysis of a fused mixture containing boric anhydride, magnesium oxide, and magnesium fluoride. The electrolysis is done in carbon crucible which acts as the anode and iron rod is used as the cathode. The magnesium discharged at the cathode reduces B_2O_3 to boron.

The structure of diborane is given below:



There are two types of hydrogen atoms. Four hydrogen atoms are terminal hydrogens. The other two hydrogen atoms are known as bridged hydrogens. The two boron atoms and the four terminal H atoms lie in the same plane, while the two bridging H atoms are in the plane perpendicular to the rest of the molecule. The four terminal hydrogens are bonded by normal covalent bonds. The bridged hydrogens are bonded by three-center electron pair bonds which involve two electrons but bind three atoms. There are two such types of bonds in diborane. The boron atom undergoes sp^3-hybridization. Two hybrid orbitals of each B atom overlaps with 1*s* orbitals of two H atoms. The hybrid orbital containing an unpaired electron of one B atom and the vacant hybrid orbital of the second B atom overlaps simultaneously with 1*s* orbital of an H atom to form B—H—B bridge bond. This B—H—B bond is called three-center electron pair bonds. It is also called banana bond.

$$B_2H_6 + HCl \rightarrow \underset{\text{Chlorodiborane}}{B_2H_5Cl} + H_2$$

13. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbS + 3O_2 \rightarrow 2PbO + SO_2$$
$$PbS + 2O_2 \rightarrow PbSO_4$$
$$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$$
$$PbS + 2PbO \rightarrow 3Pb + SO_2$$

Litharge is chemically PbO, and the oxidation state of lead is +2.

14. A_1 is malachite $CuCO_3 \cdot Cu(OH)_2$

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2\uparrow + H_2O$$

CuO is the black solid.

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\text{Dil. HCl}} CuCl_2 + CO_2 + H_2O$$

$$CuCl_2 \xrightarrow{KI} Cu_2I_2 + KCl + I_2$$

A_2 is copper glance Cu_2S, a sulphide ore.

$$Cu_2S \xrightarrow[\Delta]{O_2} Cu_2O + SO_2$$

$$Cu_2S + Cu_2O \rightarrow Cu + SO_2$$

The gas SO_2 gives green color with acidified $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + 4H_2O$$

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	**2.** (b)	**3.** (c)	**4.** (d)	**5.** (b)	**6.** (d)	**7.** (a)	**8.** (c)	**9.** (d)	**10.** (a)
11. (a)	**12.** (c)	**13.** (c)	**14.** (b)	**15.** (b)	**16.** (a)	**17.** (c)	**18.** (b)	**19.** (d)	**20.** (a)
21. (d)	**22.** (c)	**23.** (b)	**24.** (a)	**25.** (a)	**26.** (a)	**27.** (b)	**28.** (d)	**29.** (a)	**30.** (c)
31. (a)	**32.** (a)	**33.** (a)	**34.** (b)	**35.** (b)	**36.** (c)	**37.** (c)	**38.** (b)	**39.** (c)	**40.** (c)
41. (a)	**42.** (c)	**43.** (b)	**44.** (c)	**45.** (b)	**46.** (d)	**47.** (a)	**48.** (b)	**49.** (a)	**50.** (c)
51. (c)	**52.** (d)	**53.** (a)	**54.** (c)	**55.** (b)	**56.** (c)	**57.** (d)	**58.** (b)	**59.** (a)	**60.** (d)
61. (b)	**62.** (c)	**63.** (a)	**64.** (b)	**65.** (b)	**66.** (c)	**67.** (d)	**68.** (b)		

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	**2.** (c)	**3.** (b)	**4.** (b)	**5.** (d)	**6.** (b)	**7.** (b)	**8.** (c)	**9.** (d)	**10.** (b)
11. (a)	**12.** (b)	**13.** (c)	**14.** (d)	**15.** (c)	**16.** (c)	**17.** (c)	**18.** (a)	**19.** (a)	**20.** (a)
21. (d)	**22.** (a)	**23.** (b)	**24.** (a)	**25.** (b)	**26.** (d)	**27.** (b)	**28.** (a)	**29.** (a)	**30.** (c)
31. (d)	**32.** (b)	**33.** (c)	**34.** (c)	**35.** (a)	**36.** (b)	**37.** (d)	**38.** (b)	**39.** (b)	**40.** (c)
41. (c)	**42.** (a)	**43.** (c)	**44.** (d)	**45.** (d)	**46.** (a)	**47.** (d)	**48.** (b)	**49.** (b)	**50.** (b)
51. (c)	**52.** (b)	**53.** (c)	**54.** (b)	**55.** (c)	**56.** (d)	**57.** (d)	**58.** (c)	**59.** (c)	**60.** (d)
61. (c)	**62.** (d)	**63.** (b)	**64.** (d)	**65.** (d)	**66.** (a)	**67.** (c)	**68.** (c)		

Multiple Correct Answers Type

1. (a), (b), (c)	**2.** (a), (b), (d)	**3.** (a), (c)	**4.** (a), (b), (c)	**5.** (c), (d)
6. (a), (c), (d)	**7.** (a), (b), (d)	**8.** (a), (c)	**9.** (a), (b)	**10.** (a), (b), (c), (d)
11. (a), (b)	**12.** (b), (c), (d)	**13.** (a), (b)	**14.** (a), (b), (c)	**15.** (b), (c), (d)
16. (a), (c), (d)	**17.** (a), (b)	**18.** (a), (b), (c), (d)	**19.** (a), (b), (d)	**20.** (a), (c), (d)
21. (a), (b), (c)	**22.** (b), (c), (d)	**23.** (c), (d)	**24.** (a), (c)	**25.** (a), (b), (c)
26. (a), (c), (d)	**27.** (a), (b), (c), (d)	**28.** (a), (b), (c)	**29.** (a), (b), (c)	**30.** (a), (b), (c)
31. (a), (b), (d)	**32.** (c), (d)	**33.** (b), (c), (d)	**34.** (a), (b)	**35.** (a), (b), (c)
36. (a), (b), (d)	**37.** (a), (c), (b)	**38.** (a), (b), (d)	**39.** (a), (c), (d)	**40.** (b), (c), (d)
41. (a), (b), (d)	**42.** (a), (b)	**43.** (a), (b), (c)	**44.** (a), (b), (c)	**45.** (a), (c), (d)
46. (b), (c)	**47.** (a), (b)	**48.** (b), (c)	**49.** (a), (b)	**50.** (a), (b)
51. (b), (c), (d)	**52.** (a), (b)	**53.** (a), (b)	**54.** (a), (b)	**55.** (a), (c), (d)
56. (b), (c), (d)	**57.** (a), (b), (c)	**58.** (b), (c), (d)	**59.** (a), (c), (d)	**60.** (a), (c), (d)
61. (b), (d)	**62.** (a), (b)	**63.** (a), (b), (c)	**64.** (b), (c), (d)	**65.** (a), (b), (c)

Comprehension Type

Comprehension-1	1. (b)	2. (d)	3. (b)	4. (a)	
Comprehension-2	5. (d)	6. (a)	7. (c)		
Comprehension-3	8. (b)	9. (c)	10. (a)	11. (b)	
Comprehension-4	12. (c)	13. (a)	14. (a)	15. (b)	16. (a)
Comprehension-5	17. (c)	18. (c)			
Comprehension-6	19. (a)	20. (c)	21. (c)		
Comprehension-7	22. (c)	23. (c)	24. (a)		
Comprehension-8	25. (c)	26. (c)	27. (a)		
Comprehension-9	28. (b)	29. (c)	30. (a)		
Comprehension-10	31. (b)	32. (d)	33. (c)		
Comprehension-11	34. (d)	35. (d)	36. (b)		
Comprehension-12	37. (b)	38. (b)	39. (a)		
Comprehension-13	40. (a)	41. (d)	42. (c)	43. (b)	44. (a)
Comprehension-14	45. (c)	46. (b)	47. (d)		
Comprehension-15	48. (a)	49. (d)	50. (b)		
Comprehension-16	51. (b)	52. (d)	53. (c)		

Assertion-Reasoning Type

1. (a) 2. (a)
3. (a) 4. (b)

Matching Column Type

1. (a) s; (b) r; (c) p; (d) q
2. (a) p, q, s; (b) p,q; (c) r
3. (a) p, q, s; (b) r, t; (c) p; (d) q, s
4. (a) s; (b) p; (c) q; (d) r
5. (a) s; (b) q; (c) r; (d) p
6. (a) q; (b) s; (c) r
7. (a) r, t; (b) s; (c) p; (d) p, q
8. (a) q; (b) p; (c) t; (d) s
9. (a) q, r, s; (b) p, r, s; (c) r, s; (d) p, s
10. (a) p, q, r, s ; (b) p, s; (c) r, t; (d) p, q, r, s
11. (a) p, r; (b) q, r; (c) r, s; (d) q, t
12. (a) p, r; (b) p; (c) q; (d) s
13. (a) r; (b) p; (c) q; (d) s, t
14. (a) p, q, t; (b) p, q; (c) p, q, r, s, t; (d) p, q, r, s, t
15. (a) s; (b) r; (c) q; (d) p
16. (a) p, r; (b) q; (c) s, t; (d) q
17. (a) q, s, t; (b) p, r; (c) r, t; (d) r, t
18. (a) q; (b) r; (c) t; (d) p
19. (a) q; (b) p, s, t; (c) r; (d) s
20. (a) r; (b) p, q; (c) r, s; (d) p, q, t

Integer Answer Type

1. (2) 2. (3) 3. (2) 4. (4) 5. (3) 6. (4) 7. (2) 8. (4) 9. (3) 10. (3)
11. (2) 12. (2) 13. (3) 14. (3) 15. (2) 16. (4) 17. (4)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (d) 4. (a) 5. (b) 6. (c) 7. (a) 8. (b) 9. (a) 10. (a)
11. (d) 12. (a) 13. (a)

Multiple Correct Answers Type

1. (b), (d) 2. (a), (d) 3. (a), (b) 4. (a), (c) 5. (b), (c) 6. (c), (d)
7. (b), (c) 8. (a), (c) 9. (a), (b) 10. (a), (d) 11. (a), (b) 12. (a), (c)
13. (b), (c)

Matching Column Type

1. (b) 2. (b) 3. (a) 4. (a) 5. (a)

Assertion-Reasoning Type

1. (a) 2. (a) 3. (b) 4. (b) 5. (b)

Archives

JEE (Main) Exercises

1. (c) 2. (b) 3. (a) 4. (b) 5. (a) 6. (d) 7. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) 2. (b) 3. (c) 4. (d) 5. (c) 6. (b) 7. (a) 8. (a) 9. (a) 10. (c)
11. (b) 12. (b) 13. (b) 14. (a)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (d) 3. (a), (c), (d) 4. (d) 5. (c), (d) 6. (b), (c), (d)

Comprehension Type

1. (a) 2. (d) 3. (c)

Matching Column Type

1. (a) → (s); (b) → (p); (c) → (q, r); (d) → (t)
2. (a) → (q); (b) → (r); (c) → (s); (d) → (p)
3. (a) → (p, r); (b) → (p); (c) → (q); (d) → (s)
4. (a) → (p); (b) → (q); (c) → (p, r); (d) → (p, s)

Qualitative Inorganic Analysis

JEE (Main) Exercises

Single Correct Answer Type

1. An aqueous solution of gas (X) turns red litmus blue; then gas will be:
   (a) SO_2 (b) SO_3
   (c) NH_3 (d) None of these

2. To aqueous solution of X on adding $CuSO_4$ a brown precipitate is obtained which turns white on adding of excess of $Na_2S_2O_3$ solution; on addition of Ag^+ ion solution, a yellow curdy precipitate is obtained which is insoluble in NH_4OH; then X will be:
   (a) $Cu_2I_2 + I_3^{\ominus}$ (b) CuI_2
   (c) Cu_2I_2 (d) KI

3. A imparts green color to the flame. Its solution does not give a precipitate on passing H_2S. When it is heated with solid $K_2Cr_2O_7$ and conc. H_2SO_4, reddish brown gas is evolved. The gas when passed in an aqueous solution of NaOH turns it yellow. Find out A:
   (a) $HgCl_2$ (b) $BaCl_2$
   (c) Both (a) and (b) (d) None of these

4. Which of the following anions will give same color of gas?
   (a) $NO_2^-, NO_3^-, I^{\ominus}$ (b) $NO_2^-, NO_3^-, CH_3COO^-$
   (c) $NO_2^-, Br^{\ominus}, I^{\ominus}$ (d) $NO_2^-, NO_3^-, Br^{\ominus}$

5. Which of the following anion exist in equilibrium condition with other anion depending upon the pH of the solution?
   (a) CrO_4^{2-} (b) SO_4^{2-}
   (c) CO_3^{2-} (d) SO_3^{2-}

6. $A \xrightarrow{\text{Conc. } H_2SO_4} B_{(g)} + C_{(g)} \longrightarrow$ (Gas B and gas C both have same color.)
   A: (Mixture of two anions)
   $B_{(g)} \xrightarrow{H_2O}$ Brown color to the solution
   $C_{(g)} \xrightarrow{H_2O}$ No color

   Find out (A):
   (a) $I^{\ominus}, Br^{\ominus}$ (b) Br , NO
   (c) $C_2O_4^{2-}, NO_3^-$ (d) NO_3^-, NO_2^-

7. Select the correct statement:
   (a) Cation and anion are also called acidic or basic radicals, respectively
   (b) Classification of anion is systematic as that of cation
   (c) All the anions are deducted by soda extract solution without any exception
   (d) None of these

8. Which of the following anions are identified by dil. H_2SO_4?
   (i) CO_3^{2-} (ii) SO_3^{2-} (iii) $S_2O_3^{2-}$ (iv) NO_3^-
   (v) $I^{\ominus}$ (vi) $C_2O_4^{2-}$
   (a) $CO_3^{2-}, SO_3^{2-}, NO_3^-, S_2O_3^{2-}$
   (b) $SO_3^{2-}, S_2O_3^{2-}, I^{\ominus}, NO_3^-$
   (c) $CO_3^{2-}, SO_3^{2-}, S_2O_3^{2-}$
   (d) $CO_3^{2-}, SO_3^{2-}, NO_3^-, C_2O_4^{2-}$

9. Which of the following pair of anions will give same gas on treatment with acid?
(a) CO_3^{2-}, HCO_3^- (b) $SO_3^{2-}, S_2O_3^{2-}$
(c) NO_2^-, NO_3^- (d) All are having same gas

10. When a mixture (A) of unknown gases is passed into the dichromate solution, then orange color turns to green; when the solution is boiled and gas passed into lime water, then lime water turns milky. Find out (A).
(a) CO_2, Cl_2 (b) H_2S, CO_2
(c) Both (a) and (b) (d) None of these

11. $A \xrightarrow{\Delta} B_{(s)} + C_{(g)}$
(Used as a flux in metallurgy)
$B \xrightarrow{H_2O} D$
$D \xrightarrow{C_{(g)}}$ Milky solution
Find out (A).
(a) $Ca(HCO_3)_2$ (b) $CaCO_3$
(c) Both (a) and (b) (d) Na_2CO_3

12. Which of the following metal will give redox reaction with steam water only?
(a) Zn (b) Mg
(c) Fe (d) Ag

13. Which of the following acid is non-oxidizing acid?
(a) Conc. H_2SO_4 (b) Conc. H_3PO_4
(c) Conc. HNO_3 (d) None of these

14. When Ag reacts with conc. HCl, then products will be:
(a) AgCl, Cl_2 (b) AgCl, H_2
(c) AgCl, H_2, Cl_2 (d) None of these

15. Which of the following metal will form NH_4NO_3 with dil. HNO_3 (20%)?
(a) Zn (b) Sn
(c) Ag (d) None of these

16. $\underset{\text{Mixture of two anions}}{A} \xrightarrow[\text{BaCl2}]{\text{Cold excess of}}$ White ppt. $\xrightarrow{\text{Filtered}}$
Filtrate ppt. $\xrightarrow{\text{Boil}}$ White ppt.
Find out A:
(a) CO_3^-, HSO_3^- (b) CO_3^{2-}, HCO_3^-
(c) SO_3^{2-}, HSO_3^- (d) SO_3^{2-}, CO_3^{2-}

17. $A \xrightarrow{\text{Boil}} B$ (White ppt.)
(White ppt.)
$C \xrightarrow{\text{Boil}} D$ (Black ppt.)
(White ppt.)
A and C both have sulphur containing anion; then identify A and C:
(a) $CaSO_3$, CaS_2O_3 (b) $PbSO_3$, PbS_2O_3
(c) $BaSO_3$, BaS_2O_3 (d) $PbSO_3$, BaS_2O_3

18. White ppt. of silver gives brown ppt. on boiling, but when it is heated (> 300°C), then a metallic black ppt. is obtained. Identify the compound of silver having white ppt:
(a) Ag_2SO_3 (b) $Ag_2S_2O_3$
(c) Ag_2CO_3 (d) AgCl

19. Which of the following complex of silver is not allowed on stand?
(a) $[Ag(NH_3)_4]^{\oplus}$ (b) $[Ag(CN)_2]^{\ominus}$
(c) $[Ag(NH_3)_2]^+$ (d) $Ag_2S_2O_3$

20. When $HgCl_2$ reacts with CO_3^{2-} anion, then:
(a) Reddish brown precipitate of $HgCO_3{\cdot}2HgO$ is formed
(b) Brownish red precipitate of $HgCO_3{\cdot}3HgO$ is formed
(c) Reddish brown precipitate of $HgCO_3{\cdot}3HgO$ is formed
(d) Blue ppt. of $Hg_4O_4CO_3$ is formed

21. $A \xrightarrow{\Delta} B + C_{(g)} + D_{\text{(Liquid at room temp.)}}$
$B \xrightarrow{\text{Dil. HCl}} C_{(g)}$
(Sparingly soluble in water) $B \xrightarrow{\Delta}$ Melt
$C_{(g)} \xrightarrow{\text{Baryta water}}$ White turbidity
Find out A, B, C, and D.
(a) Na_2CO_3, $NaHCO_3$, CO_2, H_2O
(b) $NaHCO_3$, Na_2O, CO_2, H_2O
(c) $NaHCO_3$, Na_2CO_3, CO_2, H_2O
(d) $KHCO_3$, K_2CO_3, CO_2, H_2O

22. $\underset{\text{(Mixture of two anions)}}{A} \xrightarrow[\text{BaCl}_2]{\text{Cold excess of}}$ White ppt. $\xrightarrow{\text{filtered}}$
filtrate $\xrightarrow{\text{boil}}$ White ppt.
Find out (A).
(a) SO_3^{2-}, HSO_3^- (b) CO_3^{2-}, SO_3^{2-}
(c) $SO_3^{2-}, HCO_3^{\ominus}$ (d) None of these

23. A salt is made of bivalent ions X and Y, each of which is capable of decolorizing acidified $KMnO_4$ solution. The salt is likely to be:
(a) Stannic chloride (b) Ferric sulphate
(c) Ferrous sulphate (d) Ferrous oxalate

24. Which of the following salt will evolve sulphur dioxide gas along with formation of yellowish turbidity when treated with dilute H_2SO_4?
(a) Sodium sulphide (b) Sodium sulphite
(c) Sodium thiosulphate (d) Sodium sulphate

25. A colorless salt gives white precipitate with $CaCl_2$ solution. The salt also decolorizes acidified MnO_4^- with effervescence. On reaction with conc. H_2SO_4, the salt gives a colorless gaseous mixture containing:
(a) CO, CO_2 (b) CO_2, SO_2
(c) CO_2, H_2S (d) None of these

26. Aqueous solution of a salt + $MgSO_4$ solution $\longrightarrow$ no ppt. in cold $\xrightarrow{\text{Heating}}$ White ppt. appears
The salt contains the acidic radical:
(a) CO_3^{2-} (b) HCO_3^-
(c) SO_3^{2-} (d) $C_2O_4^{2-}$

27. Which of the following compound is formed when CO_2 gas is passed through an aqueous solution of sodium chromate?
(a) $Cr(OH)_3$ is precipitated
(b) Yellow solution of $Cr_2(CO_3)_2$ is formed
(c) Orange solution of $Na_2Cr_2O_7$ is formed
(d) No reaction

28. Which of the following ion gives a suffocating gas when treated with dilute HCl?
(a) Carbonate (b) Sulphite
(c) Sulphate (d) Borate

29. The acidic solution of a salt produces blue color with KI starch solution. The salt may be:
(a) Sulphite (b) Bromide
(c) Nitrite (d) Chloride

30. Sulphite on treatment with dil. H_2SO_4 liberates a gas which:
(a) Turns lead acetate paper black
(b) Burns with blue flame
(c) Smells like vinegar
(d) Turns acidified $K_2Cr_2O_7$ paper green

31. Violet vapors are given out when .... is treated with conc. H_2SO_4.
(a) Bromide (b) Iodide
(c) Chloride (d) Nitrate

32. The color developed when sodium sulphide is added to sodium nitroprusside is:
(a) Purple (b) Yellow
(c) Red (d) Black

33. Which of the following compound does not gives ppt. with dil HCl?
(a) $AgNO_3$ (b) $Pb(NO_3)_2$
(c) $Hg_2(NO_3)_2$ (d) $Cu(NO_3)_2$

34. A gas is obtained by addition of dil. H_2SO_4 to a mixture which turns lead acetate paper black. It is:
(a) SO_2 (b) CO_2
(c) H_2S (d) NO_2

35. A mixture when rubbed with organic acid smells like vinegar. It contains:
(a) Sulphite (b) Nitrate
(c) Nitrite (d) Acetate

36. Soda extract is prepared by:
(a) Fusing soda and mixture and then extracting with water
(b) Dissolving $NaHCO_3$ and mixture in dil. HCl
(c) Boiling Na_2CO_3 and mixture, in dil. HCl
(d) Boiling Na_2CO_3 and mixture, in distilled water

37. For the tests of halides, the soda extract is acidified with:
(a) Conc. H_2SO_4 (b) Dil. HNO_3
(c) Dil. HCl (d) Any of the three

38. When an aqueous solution of gas (*X*) is added to $FeCl_3$ solution, a brown precipitate is obtained which is soluble in dil. HNO_3; gas (*X*) will give white fumes with HCl, then gas (*X*) is:
(a) SO_2 (b) Cl_2
(c) CO_2 (d) NH_3

39. A white solid is first heated with dilute H_2SO_4 and then with concentrated H_2SO_4. No action is observed in either case. The solid contains:
(a) Sulphide (b) Sulphite
(c) Sulphate (d) Thiosulphate

40. A precipitate of calcium oxalate will not dissolve in:
(a) Acetic acid (b) HCl
(c) HNO_3 (d) Aqua-regia

41. The brown ring test is performed for the qualitative detection of:
(a) Bromides (b) Iodides
(c) Nitrates (d) Phosphates

42. Which compound does not dissolve in hot dil. HNO_3?
(a) HgS (b) PbS
(c) CuS (d) CdS

43. Which one is not the interfering radical?
(a) PO_4^{3-} (b) BO_3^{3-}
(c) F^- (d) SO_4^{2-}

44. In the test for iodine, I_2 is treated with sodium thiosulphate ($Na_2S_2O_3$):

$$Na_2S_2O_3 + I_2 \longrightarrow NaI + ...$$

(a) $Na_2S_4O_6$ (b) Na_2SO_4
(c) Na_2S (d) Na_3ISO_4

45. Which of the following sulphides is yellow in color?
(a) CuS (b) CdS
(c) ZnS (d) CoS

46. Brown ring in the test of NO_3^- is formed due to the formation of:
(a) $FeSO_4{\cdot}NO$ (b) $[Fe(SO_4)_2{\cdot}HO]{\cdot}H_2O$
(c) $Fe_2(SO_4)_3{\cdot}NO$ (d) None of these

47. The brown ring test for nitrates depends on:
(a) The reduction of nitrate to nitric oxide
(b) Oxidation of nitric oxide to nitrogen dioxide
(c) Reduction of ferrous sulphate to iron
(d) Oxidizing action of sulphuric acid

48. A sodium salt of unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is:
(a) SO_4^{2-} (b) HCO_3^-
(c) CO_3^{2-} (d) NO_3^-

49. In the brown ring test, the brown color of the ring is due to:
(a) A mixture to NO and NO_2
(b) Nitrosoferrous sulphate
(c) Ferrous nitrate (d) Ferric nitrate

50. S^{2-} and SO_3^{2-} can be distinguished by using:
(a) $(CH_3COO)_2Pb$ (b) $Na_2[Fe(CN)_5NO]$
(c) Both (a) and (b) (d) None of these

51. An aqueous solution containing Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+} ions will give precipitates of .... with HCl.
(a) Hg_2Cl_2 only (b) $PbCl_2$ only
(c) Hg_2Cl_2 and $PbCl_2$ (d) $HgCl_2$ and $PbCl_2$

52. Which one of the following pairs of ions cannot be separated by H_2S in dilute HCl?
(a) Bi^{3+}, Sn^{4+} (b) Al^{3+}, Hg^{2+}
(c) Cu^{2+}, Zn^{2+} (d) Ni^{2+}, Cu^{2+}

53. In qualitative analysis, Cd is under:
(a) I group (b) II group
(c) III group (d) IV group

54. Which compound does not dissolve in hot dil. HNO_3?
(a) HgS (b) PbS
(c) CuS (d) CdS

55. Which of the following metal sulphides has maximum solubility in water?
(a) HgS, $K_{sp} = 10^{-54}$ (b) CdS, $K_{sp} = 10^{-30}$
(c) FeS, $K_{sp} = 10^{-20}$ (d) ZnS, $K_{sp} = 10^{-22}$

56. The compound formed in the borax-bead test of Cu^{2+} ion in oxidizing flame is:
(a) Cu (b) $CuBO_2$
(c) $Cu(BO_2)_2$ (d) None of these

57. Identify the correct order of solubility of Na_2S, CuS, and ZnS in aqueous medium:
(a) $CuS > ZnS > Na_2S$ (b) $ZnS > Na_2S > CuS$
(c) $Na_2S > CuS > ZnS$ (d) $Na_2S > ZnS > CuS$

58. Potassium chromate solution is added to an aqueous solution of a metal chloride. The precipitates thus obtained are insoluble in acetic acid. These are subjected to flame test; the color of the flame is:
(a) Lilac (b) Apple green
(c) Crimson red (d) Golden yellow

59. Consider the following observation:

$M^{n+} + HCl \longrightarrow$ White precipitate $\xrightarrow{\Delta}$ Water soluble

The metal ion M^{n+} will be:
(a) Hg^{2+} (b) Ag^+
(c) Pb^{2+} (d) Sn^{2+}

60. When H_2S is passed through Hg_2^{2+}, we get:
(a) HgS (b) $HgS + Hg_2S$
(c) $HgS + Hg$ (d) Hg_2S

61. In Nessler's reagent for detection of ammonia, the active species is:
(a) Hg_2Cl_2 (b) Hg^{2+}
(c) Hg_2I_2 (d) HgI_4^{2-}

62. Precipitation of IV group cations takes place when H_2S passed is:
(a) Less ionized (b) Highly ionized
(c) Not ionized (d) None of these

63. Nessler's reagent is:
(a) $NaHgCl_4$ (b) K_2HgI_4/OH^-
(c) $Hg(NH_3)_2Cl$ (d) K_2HgI_4

64. To a metal nitrate, when KI solution is added, a black precipitate is produced at first; on adding excess of KI, orange solution is produced. Identify the metal ion:
(a) Hg^{2+} (b) Bi^{3+}
(c) Cu^{2+} (d) Pb^{2+}

65. The formula of the compound which gives violet color in Lassaigne's test for sulphur with sodium nitroprusside is:

(a) $Na_4[Fe(CN)_6S]$ (b) $Na_4[Fe(CN)_5NCS]$
(c) $Na_4[Fe(CN)_5NOS]$ (d) $Na_2[Fe(CN)_5NOS]$

66. When H_2S gas is passed through HCl containing aqueous solution of $CuCl_2$, $HgCl_2$, $BiCl_3$, and $CoCl_2$, it does not precipitate out:
(a) CuS (b) HgS
(c) Bi_2S_3 (d) CoS

67. Yellow color solution of $FeCl_3$ changes to light green when:
(a) $SnCl_2$ is added (b) Zn is added
(c) H_2S gas is passed (d) All are true

68. $Fe(OH)_3$ and $Cr(OH)_3$ ppt. are separated by:
(a) aq. NH_3 (b) HCl
(c) $NaOH / H_2O_2$ (d) H_2SO_4

69. Turnbull's blue and Prussian's blue, respectively, are:
$Fe^{II}[Fe^{II}(CN)_6]^{2-}$ (I) $Fe^{III}[Fe^{III}(CN)_6]$ (II)
$Fe^{II}[Fe^{III}(CN)_6]^{3-}$ (III) $Fe^{III}[Fe^{II}(CN)_6]^{4-}$ (IV)
(a) I, II (b) I, III
(c) III, IV (d) IV, III

70. Ferric alum gives red color with NH_4SCN due to formation of:
(a) $Al(SCN)_3$ (b) $FeSO_4$
(c) $Fe(SCN)_3$ (d) $Fe(SCN)_2$

71. H_2S would separate the following at pH < 7:
(a) Zn^{2+}, Co^{2+} (b) Cu^{2+}, Cd^{2+}
(c) Cu^{2+}, Cr^{3+} (d) Cu^{2+}, As^{3+}

72. Solution of (X) in dil. HCl + $H_2O \longrightarrow$ White turbidity
$(X) \xrightarrow{H_2S/HCl}$ Brown ppt. (Y)
X is:
(a) Bi^{3+} (b) Pb^{2+}
(c) Cd^{2+} (d) Cu^{2+}

73. $AgNO_3$ gives white ppt. with hypo changing to black after some-time. Black ppt. is of:
(a) $Ag_2S_2O_3$ (b) Ag_2SO_4
(c) $Ag_2S_4O_6$ (d) Ag_2S

74. Ag_2S is soluble in NaCN due to formation of:
(a) $Na[Ag(CN)_2]$ (b) $Ag(CN)_2$
(c) $Na_2[Ag(CN)_3]$ (d) $Na_2[Ag(CN)_2]$

75. Cu^{2+} and Ag^+ are both present in the same solution. To precipitate one of the ions and leave the other in solution, add:
(a) $H_2S_{(aq)}$ (b) $HCl_{(aq)}$
(c) $HNO_{3(aq)}$ (d) $NH_4NO_{3(aq)}$

76. Of the following solutions, the one that is acidic is:
(a) $ZnSO_{4(aq)}$ (b) $NaAl(OH)_{4(aq)}$
(c) $NaHCO_{3(aq)}$ (d) $KNO_{3(aq)}$

77. With MnO, color of the bead in sodium carbonate-bead test is:
(a) Pink (b) Black
(c) Yellow (d) Green

78. With Cr_2O_3, color of the bead in sodium carbonate-bead test is:
(a) Red (b) Blue
(c) Yellow (d) Green

79. KI gives precipitate with all the cations given:
(a) Ag^+, Hg_2^{2+}, Pb^{2+} (b) Cu^{2+}, Zn^{2+}, Ni^{2+}
(c) Na^+, Ca^{2+}, Mg^{2+} (d) Ag^+, Ca^{2+}, Sr^{2+}

80. Aq. $(A) + K_2CrO_4 \longrightarrow \underset{\text{(Red ppt.)}}{(B)} \xrightarrow{\text{aq. } NH_3} \underset{\text{(Black)}}{(C)}$
A is:
(a) $AgNO_3$ (b) $Pb(NO_3)_2$
(c) $Hg_2(NO_3)_2$ (d) $Ca(NO_3)_2$

81. The ion most difficult to remove as a precipitate is:
(a) Ag^+ (b) NH_4^+
(c) Fe^{3+} (d) Cu^{2+}

82. A colorless gas is dissolved in water and the resulting solution turns red litmus blue; the gas may have been which one of the following?
(a) HCl (b) H_2S
(c) SO_2 (d) NH_3

83. What would you observe if you add with shaking, excess dil. NaOH solution to $ZnCl_2$ solution?
(a) A white ppt.
(b) A white ppt. which later dissolves
(c) A green ppt.
(d) A green ppt. which later dissolves

84. A mixture is known to contain NO_3^- and NO_2^-. Before performing ring test for NO_3^-, the aqueous solution should be made free of NO_2^-. This is done by heating aqueous extract with:
(a) Conc. HNO_3 (b) Dil. HNO_3
(c) Urea (d) Zinc dust

85. A suspension containing insoluble substances HgS and FeS is treated with 2*M* HCl. On filtering, the filtrate contained appreciable amounts of which one of the following?
(a) Mercury, iron (b) Only iron
(c) Only mercury (d) None of these

86. In the separation of Cu^{2+} and Cd^{2+} in 2nd group of qualitative analysis of cations, tetrammine copper(II) sulphate and tetraammine cadmium(II) sulphate react with KCN to form the corresponding cyanide complexes; which one of the following pairs of the complexes and their relative stabilities enables the separation of Cu^{2+} and Cd^{2+}?

(a) $K_3[Cu(CN)_4]$: less stable and $K_2[Cd(CN)_4]$: more stable

(b) $K_3[Cu(CN)_4]$: more stable and $K_2[Cd(CN)_4]$: less stable

(c) $K_2[Cu(CN)_4]$: less stable and $K_2[Cd(CN)_4]$: more stable

(d) $K_2[Cu(CN)_4]$: more stable and $K_2[Cd(CN)_4]$: less stable

87. Which reagent is used to remove SO_4^{2-} or Cl^- from water?

(a) NaOH (b) $Pb(NO_3)_2$
(c) $BaSO_4$ (d) KOH

88. AgCl with NH_3 forms a complex:

(a) $Ag(NH_3)_2Cl$ (b) $AgNO_3$
(c) $AgNH_2Cl$ (d) Ag mirror

89. Acidic solution of a salt produced deep blue color with starch and KI. The salt is:

(a) Chloride (b) Nitrite
(c) Acetate (d) Bromide

90. $CuSO_4$ reacts with NH_4OH to give deep blue complex of:

(a) Copperammonium sulphate
(b) Copperammonium hydroxide
(c) Both (a) and (b)
(d) None of these

91. Prussian blue is formed when:

(a) Ferrous sulphate reacts with $FeCl_3$
(b) Ferric sulphate reacts with $K_4[Fe(CN)_6]$
(c) Ferrous ammonium sulphate reacts with $FeCl_3$
(d) Ammonium sulphate reacts with $FeCl_3$

92. Which compound will not give positive chromyl chloride test?

(a) Copper chloride, $CuCl_2$
(b) Mercuric chloride, $HgCl_2$
(c) Zinc chloride, $ZnCl_2$
(d) Anilinium chloride, $C_6H_5NH_3^+Cl^-$

93. A metal salt solution forms a yellow precipitate with potassium chromate in acetic acid, a white precipitate with dil. sulphuric acid, but gives no precipitate with sodium chloride or iodide. The white precipitate obtained when sodium carbonate is added to the metal salt solution consists of:

(a) Lead carbonate (b) Basic lead carbonate
(c) Barium carbonate (d) Strontium carbonate

94. An inorganic salt solution gives a yellow precipitate with silver nitrate. The precipitate dissolves in dil. nitric acid as well as in ammonium hydroxide. The solution contains:

(a) Bromide (b) Iodide
(c) Phosphate (d) Chromate

95. Which cation is detected by the flame test?

(a) NH_4^+ (b) K^+
(c) Mg^{2+} (d) Al^{3+}

96. Strongly acidified solution of barium nitrate gives a white precipitate with.........which did not dissolve even after large addition of water:

(a) Sodium phosphate (b) Sodium carbonate
(c) Sodium sulphate (d) Sodium chloride

97. A substance on treatment with dil. H_2SO_4 liberates a colorless gas which produces (i) turbidity with baryta water and (ii) turns acidified dichromate solution green. The reaction indicates the presence of:

(a) CO_3^{2-} (b) S^{2-}
(c) SO_3^{2-} (d) NO_2^-

98. Ca, Ba, and Sr ions are precipitated in fifth group as their:

(a) Oxides (b) Sulphates
(c) Carbonates (d) Sulphides

99. Conc. H_2SO_4 on addition to dry KNO_3 gives brown fumes of:

(a) SO_2 (b) SO_3
(c) NO (d) NO_2

100. Ferric ion forms a prussian blue colored ppt. due to the formation of:

(a) $K_4[Fe(CN)_6]$ (b) $Fe_4[Fe(CN)_6]_3$
(c) $KMnO_4$ (d) $Fe(OH)_3$

101. In the precipitation of the iron group in qualitative anlaysis, ammonium chloride is added before adding ammonium hydroxide to:

(a) Decrease concentration of OH^- ions
(b) Prevent interference by phosphate ions
(c) Increase concentration of Cl^- ions
(d) Increase concentration of NH_4^+ ions

102. H_2S gas, on passing through an alkaline solution, forms a white precipitate. The solution contains ions of:
(a) Pb (b) Zn
(c) Cu (d) Ni

103. Which gives violet color with borax?
(a) Fe (b) Pb
(c) Co (d) Mn

104. Yellow ammonium sulphide solution is a suitable reagent used for the separation of:
(a) HgS and PbS (b) PbS and Bi_2S_3
(c) Bi_2S_3 and CuS (d) CdS and As_2S_3

105. An orange red precipitate obtained by passing H_2S through an acidified solution of an inorganic salt indicates the presence of:
(a) Cadmium (b) Tin
(c) Antimony (d) Bismuth

106. The presence of NH_4^+ radical in solution can be detected by:
(a) Fehling's solution (b) Benedict's solution
(c) Schiff's reagent (d) Nessler's reagent

107. Excess of concentrated sodium hydroxide can separate a mixture of:
(a) Al^{3+} and Cr^{3+} (b) Cr^{3+} and Fe^{3+}
(c) Al^{3+} and Zn^{3+} (d) Zn^{2+} and Pb^{2+}

108. Potassium thiocyanate solution reacts with ferric chloride to give:
(a) Pink color (b) Deep blue color
(c) Green color (d) Blood-red color

109. A green mass is formed in the charcoal cavity test when a colorless salt (*X*) is fused with cobalt nitrate. (*X*) may contain:
(a) Aluminium (b) Copper
(c) Barium (d) Zinc

110. Which of the following sulphides has the maximum solubility product?
(a) HgS (b) PbS
(c) CuS (d) MnS

111. A white metal sulphide soluble in water is:
(a) CuS (b) Na_2S
(c) PbS (d) ZnS

112. Lead has been placed in qualitative group analysis 1st and 2nd because:
(a) It shows the valency one and two
(b) It forms insoluble $PbCl_2$
(c) It forms lead sulphide
(d) $PbCl_2$ is partially soluble in water

113. As_2S_3 is:
(a) Black (b) Yellow
(c) Orange (d) White

114. A black sulphide is formed by the action of H_2S on:
(a) $CuCl_2$ (b) $CdCl_2$
(c) $ZnCl_2$ (d) NaCl

115. $Pb(CH_3COO)_2$ gives........color with H_2S:
(a) Black (b) White
(c) Red (d) Orange

116. Acidified $K_2Cr_2O_7$ turns green by:
(a) CO_2 (b) SO_3
(c) SO_2 (d) HNO_3

117. Chemical volcano is produced on heating:
(a) $K_2Cr_2O_7$ (b) $(NH_4)_2Cr_2O_7$
(c) $ZnCr_2O_7$ (d) K_2CrO_4

118. Which gives blood red color with ammonium thiocyanate?
(a) Fe^{3+} (b) Fe^{2+}
(c) Cu^{2+} (d) Cd^{2+}

119. A salt having BO_3^{3-} on burning with alcohol and conc. H_2SO_4 gives ...... edge flame:
(a) Green (b) Yellow
(c) Red (d) White

120. Carbonates of Ba, Sr, and Ca are:
(a) White (b) Blue
(c) Green (d) Yellow

121. The II group precipitates soluble in yellow ammonium sulphide may be:
(a) As, Sb, Sn (b) Cu, Hg, Bi, Cd
(c) Both (a) and (b) (d) None of these

122. CaC_2O_4 is ......in water:
(a) Insoluble (b) Soluble
(c) Complex (d) None of these

123. Nitric acid is generally not used for preparation of original solution in analysis of basic radicals, because it:
(a) Is oxidizing agent (b) Is reducing agent
(c) Forms insoluble nitrates
(d) Forms soluble nitrates

124. When dimethyl glyoxime solution is added to an aqueous solution of nickel chloride in presence of ammonium hydroxide:
(a) A black ppt. is formed
(b) A blue ppt. is formed
(c) A rose red ppt. is formed
(d) No ppt. is formed

125. A white salt soluble in NH_4OH but insoluble in water is:
(a) $BaSO_4$ (b) $CuSO_4$
(c) $PbSO_4$ (d) AgCl

126. The sulphide not soluble in hot dilute nitric acid is:
(a) CuS (b) ZnS
(c) CdS (d) HgS

127. KBr, on reaction with conc. H_2SO_4, gives reddish-brown gas:
(a) Bromine
(b) Mixture of bromine and HBr
(c) HBr (d) NO_2

128. Formation of a green-edged flame on igniting the vapors evolved by heating a given inorganic salt with a few mL of ethyl alcohol and conc. H_2SO_4 indicates the presence of a:
(a) Tartrate (b) Oxalate
(c) Acetate (d) Borate

129. The compound which turns black with NH_4OH is:
(a) Lead chloride (b) Mercurous chloride
(c) Mercuric chloride (d) Silver chloride

130. Formation of a rosy-red precipitate when a slightly alkaline solution of an inorganic salt is treated with dimethyl glyoxime confirms the presence of:
(a) Cobalt (b) Zinc
(c) Iron (d) Nickel

131. The metal that does not give the borax bead test is:
(a) Cr (b) Ni
(c) Pb (d) Mn

132. H_2S will precipitate the sulphides of all the metals from the solution of chlorides of Cu, Zn, and Cd if:
(a) The solution is aqueous
(b) The solution is acidic
(c) The solution is dilute acidic
(d) Any of the above solutions is present

133. To a solution of a substance, gradual addition of ammonium hydroxide results in a black precipitate which does not dissolve in excess of NH_4OH. However, when HCl is added to the original solution, a white precipitate is formed. The solution contained:
(a) Lead salt (b) Silver salt
(c) Mercurous salt (d) Copper salt

134. A compound is soluble in water. If ammonia is added to aqueous solution of the compound, a brown precipitate appears which is soluble in dil. HCl. The compound has:
(a) Aluminium (b) Zinc
(c) Iron (d) Cadmium

135. A light green colored salt soluble in water gives black precipitate on passing H_2S which dissolves readily in HCl. The metal ion present is:
(a) Co^{2+} (b) Fe^{2+}
(c) Ni^{2+} (d) Ag^+

136. An inorganic salt when heated evolves colored gas which bleaches moist litmus paper. The evolved gas is:
(a) NO_2 (b) SO_2
(c) N_2O (d) I_2

137. All ammonium salts liberate ammonia when:
(a) Heated with HCl (b) Heated with caustic soda
(c) Heated with H_2SO_4 (d) Heated with $NaNO_2$

138. Silver, mercury, and lead are grouped together in a scheme of qualitative analysis because they form:
(a) Nitrates
(b) Carbonates which dissolve in dil. HNO_3
(c) Insoluble chlorides (d) Colorless compounds

139. Manganese salt + PbO_2 + conc. $HNO_3 \longrightarrow$ The solution has purple color.
The color is due to:
(a) $HMnO_4$ (b) A lead salt
(c) $Mn(NO_3)_2$ (d) H_2MnO_4

140. An orange precipitate of II group is dissolved in conc. HCl; the solution when treated with excess of water turns milky due to formation of:
(a) Sn(OH)Cl (b) $Sb(OH)Cl_2$
(c) SbOCl (d) $Sb(OH)_2Cl$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which of the following sulphide is not soluble in dil. HNO_3?
(a) PbS (b) HgS
(c) ZnS (d) Bi_2S_3

2. Which of the following solutions gives precipitate with $Pb(NO_3)_2$ but not with $Ba(NO_3)_2$?
(a) Sodium chloride (b) Sodium sulphate
(c) Sodium nitrate
(d) Sodium hydrogen phosphate

3. The color developed when sodium sulphide is added to sodium nitroprusside is:
(a) Violet (b) Yellow
(c) Red (d) Black

4. A white powder when strongly heated gives off brown fumes. A solution of this powder gives a yellow precipitate with a solution of KI. When a solution of barium chloride is added to a solution of powder, a white precipitate results. This white powder may be:
(a) A soluble sulphate (b) KBr or NaBr
(c) $Ba(NO_3)_2$ (d) $AgNO_3$

5. In qualitative analysis, Cd^{2+} is under:
(a) I group (b) II group
(c) III group (d) IV group

6. The ion that cannot be precipitated by both HCl and H_2S is:
(a) Pb^{2+} (b) Ba^{2+}
(c) Ag^+ (d) Sn^{2+}

7. Which sulphide is insoluble in dilute acids but soluble in alkalies:
(a) PbS (b) CdS
(c) FeS (d) As_2S_3

8. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a/an:
(a) Hg_2^{2+} salt (b) Cu^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt

9. When $S_2O_3^{2-}$ ion reacts with X cation, then first redox reaction takes place and after this ppt. reaction; then X may be:
(a) Cu^{2+} (b) Fe^{3+}
(c) Hg^{2+} (d) Bi^{3+}

10. Which is soluble in water?
(a) AgF (b) AgCl
(c) AgBr (d) AgI

11. Using dil. HCl, which of the following radical cannot be confirmed:
(a) S^{2-} (b) $S_2O_3^{2-}$
(c) CO_3^{2-} (d) NO_2^-

12. When $K_2Cr_2O_7$ is heated with conc. H_2SO_4 and soluble chloride such as KCl:
(a) Red vapors of CrO_2Cl_2 are evolved
(b) Cl^- ion is oxidized to Cl_2 gas
(c) $CrCl_3$ is formed
(d) $Cr_2O_7^{2-}$ ion is reduced to green Cr^{3+} ion

13. A salt on heating with dilute H_2SO_4 and subsequently treatment with a few drops of dilute $K_2Cr_2O_7$ turns into green solution. The salt may be a:
(a) Sulphate (b) Nitrate
(c) Sulphide (d) Chromate

14. The reagents NH_4Cl and aqueous NH_3 will precipitate:
(a) Ca^{2+} (b) Al^{3+}
(c) Mg^{2+} (d) Zn^{2+}

15. In a mixture of PbS, ZnS, and FeS_2, each component is separated from the other by using the reagents in which of the following sequence in froth floatation process?
(a) Potassium ethyl xanthate, KCN, NaOH, copper sulphate, acid
(b) KCN, $CuSO_4$, acid
(c) Potasssium ethyl xanthate, KCN
(d) None of these

16. A doctor by mistake administers a $Ba(NO_3)_2$ solution to a patient for radiography investigations. Which of the following should be given as the best to prevent the absorption of soluble barium?
(a) Na_2SO_4 (b) NaCl
(c) NH_4Cl (d) Na_2CO_3

17. Which of these is the correct group reagent for group cations?
(a) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; dil. HCl
(b) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $NH_4Cl + NH_4OH + H_2S$
(c) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $NH_4Cl + NH_4OH$
(d) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $HCl + H_2S$

18. A white solid imparts a violet color to a Bunsen flame. On being heated with concentrated H_2SO_4, the solid gives violet vapors that turn starch paper blue. The salt may be:
(a) KI (b) NaI
(c) MgI_2 (d) $CaBr_2$

19. Thenard blue is:
(a) $Cu(NH_3)_4\,SO_4$ (b) $CoAl_2O_4$
(c) $K_2Fe[Fe(CN)_6]$ (d) $Fe_4[Fe(CN)_6]_3$

20. The chocolate colored precipitate is:
(a) $[Fe(H_2O)_5(NO)]\,SO_4$ (b) $Fe_2[Fe(CN)_6]$
(c) $Cu_2[Fe(CN)_6]$ (d) $HgSO_4$

21. Among the species A ($CrCl_3$), B (CuS), C ($AlCl_3$), D ($ZnCl_2$), which will be soluble in excess of NaOH?

(a) A, C, and D (b) C and D only
(c) B and C only (d) A and D only

22. $2Ag^+ \text{(excess)} + S_2O_3^{2-} \longrightarrow Ag_2S_2O_3 \xrightarrow[\Delta]{H_2O} X + H_2SO_4$

$2\,NO_2^- + 2I^- \xrightarrow{\text{acidic medium}} Y + I_2 + 2H_2O$

Suggest the formula of the products X and Y.

(a) $X = Ag_2O$, $Y = N_2$ (b) $X = Ag_2S$, $Y = N_2$
(c) $X = Ag_2O$, $Y = 2NO_2$ (d) $X = Ag_2S$, $Y = 2NO$

23.

$$A \text{ (Colorless salt)} \xrightarrow{\Delta} \underbrace{B + C}_{\text{Gas}} + D, \quad C \xrightarrow{H_2O} E$$

Gas (C) turns solution (E) milky. (B) burns with blue flame. (A) also decolorizes MnO_4^-/H^+.

Thus (A), (B), (C), (D), and (E) are:

(a) $A = CaC_2O_4$, $B = CO_2$, $C = CO$, $D = CaO$, $E = Ca(OH)_2$
(b) $A = CaCO_3$, $B = CaO$, $C = CO$, $D = CO_2$, $E = Ca(OH)_2$
(c) $A = CaCl_2$, $B = Cl_2$, $C = O_2$, $D = CaO$, $E = Ca(OH)_2$
(d) $A = CaC_2O_4$, $B = CO$, $C = CO_2$, $D = CaO$, $E = Ca(OH)_2$

24. Which acid forms salts of any metal usually water soluble?

(a) $HClO_4$ (b) CH_3COOH
(c) HNO_3 (d) H_2CO_3

25. During the presence of SO_3^{2-} and S^{2-} in a mixture, with addition of dil. H_2SO_4, one can notice:

(a) SO_2 and H_2S are not formed
(b) SO_2 and H_2S formed undergo a redox change forming colloidal sulphur and thus no smell
(c) A smell of rotten egg
(d) A smell of burning sulphur

26. Which of the following is not a protonic acid?

(a) $PO(OH)_3$ (b) $B(OH)_3$
(c) $SO(OH)_2$ (d) $SO_2(OH)_2$

27. Which of the following will be precipitates when H_2S gas is passed through their solutions at pH = 10.0?

(a) Na^+ (b) Ba^{2+}
(c) Zn^{2+} (d) Ca^{2+}

28. $\underset{\text{(Solid)}}{A} \xrightarrow{\Delta} \underset{\text{(Brown residue)}}{B} + C_{(g)} + D_{(g)}$

$A \xrightarrow{\text{Aqueous NaOH}} E$ (dirty green precipitate) $\xrightarrow[\text{to air}]{\text{on exposure}} F$

Find out A.

(a) $FeCl_3$ (b) $Fe_2(SO_4)_3$
(c) $FeSO_4$ (d) All are correct

29. $\underset{\text{white ppt.}}{(D)} \xleftarrow[\text{presence of HCl}]{BaCl_2 \text{ in}} \underset{\substack{\text{(Light green)} \\ \text{crystalline compound}}}{(A)} \xrightarrow[\text{with } K_2HgI_4]{\text{aq.solution}} \underset{\text{Brown ppt.}}{(B)}$

$(A) \xrightarrow{\text{Aqueous solution with } K_3[Fe(CN)_6]} (C)$ Blue

Find out (A):

(a) $FeSO_4$ (b) $(NH_4)_2SO_4$
(c) $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$
(d) None of these

30. $Fe + \underset{(> 80\%)}{\text{conc. } HNO_3} \longrightarrow X$

Then X will be:

(a) Fe_2O_3 (b) FeO
(c) Fe_3O_4 (d) None of these

31. Select the incorrect statement:

(a) When SO_3^{2-} reacts with $Pb(NO_3)_2$, then a white ppt. is formed; on boiling, the precipitate is oxidized by atmospheric oxygen and lead sulphate is formed.
(b) White ppt. of $PbSO_3$ is soluble in dil. HNO_3, and excess of NaOH solution.
(c) When white ppt. of Ag_2SO_3 is boiled, then brown and metallic black ppt. is formed
(d) Ag_2SO_3 is insoluble in excess of Na_2SO_3 solution

32. When an aqueous solution of gas (X) is added in excess to a copper sulphate solution, a deep blue color is obtained; then gas is:

(a) CH_3COOH (b) NH_3
(c) SO_2 (d) None of these

33. When a mixture containing phosphate is heated with conc. HNO_3 and ammonium molybdate solution, a canary yellow precipitate is formed. The formula of the yellow precipitate is:

(a) $(NH_4)_3PO_4$ (b) $(NH_4)_3PO_4 \cdot 12MoO_4$
(c) $(NH_4)_3PO_4 \cdot 12MoO_3$
(d) $(NH_4)_3PO_4 \cdot (NH_4)_2 \cdot MoO_4$

34. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess of KI to give a colorless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II)thiocyanate gives rise to deep blue crystalline precipitate. The metal ion is:

(a) Pb^{2+} (b) Hg^{2+}

(c) Cu^{2+} (d) Co^{2+}

35. $[X] + \text{dil. } H_2SO_4 \longrightarrow [Y]$ colorless gas with suffocating smell

$[Y] + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ green solution

$[X]$ and $[Y]$ are:

(a) SO_3^{2-} and SO_2 (b) Cl^- and HCl

(c) S^{2-} and H_2S (d) CO_3^{2-} and CO_2

36. A colorless salt $A \xrightarrow{MnO_4^-/H^+}$ Decolorization of permanganate sol. occurs

$A \xrightarrow{\text{Heat}} \underbrace{X + Y + Z}_{\text{Gases}}$

$Z \xrightarrow{H_2O} B$

Gas $Y + B \longrightarrow$ milkiness

Gas X burns with blue flame. Mark the correct choice.

	A	X	Y	Z	B
(a)	$CaCO_3$	CO	CO_2	CaO	$Ca(OH)_2$
(b)	CaC_2O_4	CO	CO_2	CaO	$Ca(OH)_2$
(c)	CaC_2O_4	CO_2	CO	CaO	$Ca(OH)_2$
(d)	$CaOCl_2$	Cl_2	O_2	CaO	$Ca(OH)_2$

37. Colorless salt A

$\xrightarrow{\text{Conc. } H_2SO_4}$ Brown fumes

$\xrightarrow{\text{Cu}}$ Blue solution + metal C

$\xrightarrow{\text{HCl}}$ White ppt. soluble in NH_4OH

The salt A is:

(a) $Cu(NO_3)_2$ (b) $Pb(NO_3)_2$

(c) $AgNO_3$ (d) $Zn(NO_3)_2$

38. $NaCl + K_2Cr_2O_7 + \text{conc. } H_2SO_4 \xrightarrow{\text{Heat}}$ Red colored gas $\xrightarrow[\text{NaOH solution}]{\text{Dilute}}$ Yellow solution $\xrightarrow[Pb(CH_3COO)_2]{CH_3COOH} X$

The formula and color of X is:

(a) CrO_2Cl_2, red (b) $Cr_2(SO_4)_3$, green

(c) PbO, yellow (d) $PbCrO_4$, yellow

39. $[C] \xleftarrow{CaCl_2} \underset{\text{Colorless salt}}{[A]} \xrightarrow[\Delta]{KOH} \underset{\text{Gas, giving white fumes with HCl}}{[B]}$

White ppt. $[C]$ decolorizes pink color of acidified $KMnO_4$, then $[A]$ is:

(a) NH_4ClO_4 (b) NH_4NO_2

(c) $(NH_4)_2C_2O_4$ (d) $(NH_4)_2SO_4$

40. A colorless salt A decolorizes the brown color of $I_3^{\ominus}$. Solution of A on treatment with $AgNO_3$ gives white precipitate. The compound A turns $FeCl_3$ solution (yellow) to $FeCl_2$ solution (green). Identify A:

(a) Na_2S (b) $Na_2S_2O_3$

(c) Na_2CO_3 (d) Na_2SO_4

41. A gas X is passed through water to form saturated solution. The aqueous solution on treatment with $AgNO_3$ gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colorless gas Y. Identify X and Y:

(a) $X = CO_2$, $Y = Cl_2$ (b) $X = Cl_2$, $Y = CO_2$

(c) $X = Cl_2$, $Y = H_2$ (d) $X = H_2$, $Y = Cl_2$

42. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?

(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$

(c) $MgCl_2 \cdot MgSO4$ (d) $MgSO_4$

43. $KCl + \text{conc. } H_2SO_4 + K_2Cr_2O_7 \xrightarrow{\Delta} (X) \xrightarrow{NaOH} (Y)$

(X) is reddish brown colored gas soluble in NaOH forming (Y). (X) and (Y) are:

(a) Cr_2OCl_2, Na_2CrO_3 (b) $Cr_2O_2Cl_2$, Na_2CrO_3

(c) CrO_2Cl, Na_2CrO_4 (d) CrO_2Cl_2, Na_2CrO_4

44. $K_2Cr_2O_7$ + conc. H_2SO_4 + H_2O_2 + ether $\longrightarrow$ blue perchromic anhydride (in ethereal layer)

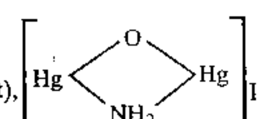
Blue color is due to:

(a) CrO_3 (b) H_2CrO_4

(c) $H_2Cr_2O_3$ (d) CrO_5

45. $HgCl_2$ + excess of KI $\longrightarrow (A) \xrightarrow{NH_3/NaOH} (B)$.

(A) and (B), respectively, are:

(a) K_2HgI_4 (Nessler's reagent), 

(Brown ppt.)

(Iodide of Millon's base) (Y)

(b) (Y), (X)

(c) Both (X) (d) Both (Y)

46. To increase significantly the concentration of free Zn^{2+} ion in a solution of the complex ion $[Zn(NH_3)_4]^{2+}$,

$Zn^{2+}_{(aq)} + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+}_{(aq)}$

add to the solution some:

(a) H_2O (b) $HCl_{(aq)}$

(c) $NH_{3(aq)}$ (d) $NH_4Cl_{(aq)}$

47. Three test tubes *A*, *B*, *C* contain Pb^{2+}, Hg_2^{2+}, and Ag^+ (but unknown). To each, aqueous solution NaOH is added in excess. Following changes occur.

A: Black ppt. *B*: Brown ppt

C: White ppt. but dissolves in excess of NaOH

A, *B*, and *C* contain, respectively:

(a) Pb^{2+}, Hg_2^{2+}, Ag^+ (b) Hg_2^{2+}, Ag^+, Pb^{2+}
(c) Ag^+, Pb^{2+}, Hg_2^{2+} (d) Ag^+, Hg_2^{2+}, Pb^{2+}

48. Consider the following equilibrium:

$$AgCl\downarrow + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+ + Cl^-$$

Soluble

White ppt. of AgCl appears on adding:

(a) NH_3 (b) Aq. NaBr
(c) Aq. HNO_3 (d) Aq. NH_4I

49. Borax on heating strongly above its melting point melts to a liquid, which then solidifies to a transparent mass commonly known as borax-bead. The transparent glassy mass consists of:

(a) Sodium pyroborate
(b) Boric anhydride
(c) Sodium meta-borate
(d) Boric anhydride and sodium metaborate

50. If CO_2 gas is passed into aq. Na_2CrO_4 yellow solution:

(a) Aq. $Na_2Cr_2O_7$ (orange) solution is formed
(b) Aq. $Cr_2(CO_3)_2$ is formed
(c) $Cr(OH)_3$ is precipitated
(d) No action

51. Four test tubes contain dil. HCl, $BaCl_2$, $CdCl_2$, and KNO_3 solution. Which of the following will identify $BaCl_2$?

(a) Dil. HCl (b) K_2CrO_4
(c) NaF (d) $AgNO_3$

52. A yellow solid known to be a single compound is completely insoluble in hot water but dissolves in hot dilute HCl to give an orange solution. When this solution is cooled, a white crystalline ppt. is formed. This white ppt. redissolves on heating the solution. The compound is:

(a) $Fe(OH)_3$ (b) $PbCrO_4$
(c) K_2CrO_4 (d) $Co(OH)_2$

53. A mixture upon adding conc. H_2SO_4 gives orange red fumes. It may contain the anion pair:

(a) $CrO_4^{2-} + Cl^-$ (b) $Br^- + Cl^-$
(c) $NO_3^- + Cl^-$ (d) $CrO_4^{2-} + NO_3^-$

54. $AgNO_{3(aq.)}$ gives yellow ppt. with:

(a) $KIO_{3(aq.)}$ (b) $KI_{(aq.)}$
(c) CHI_3 (d) CH_2I_2

55. The solution of a chemical compound *X* reacts with $AgNO_3$ solution to form a white precipitate of *Y* which dissolves in NH_4OH to give a complex *Z*. When *Z* is treated with dil. HNO_3, *Y* reappears. The chemical compound *X* can be:

(a) NaCl (b) CH_3Cl
(c) NaBr (d) NaI

56. The presence of magnesium is confirmed in the qualitative analysis by the formation of a white crystalline precipitate of:

(a) $Mg(HCO_3)_2$ (b) $MgNH_4PO_4$
(c) $MgNH_4(HCO_3)_3$ (d) $MgCO_3$

57. In qualitative inorganic analysis, phosphate, if present, is to be eliminated in the appropriate group in order to detect the radical:

(a) Pb^{2+} (b) As^{3+}
(c) Ca^{2+} (d) Cd^{2+}

58. Al^{3+}, Fe^{3+}, and Cr^{3+}, are grouped together for qualitative analysis because their:

(a) Carbonates are insoluble in NH_3
(b) Hydroxides are insoluble in NH_3
(c) Sulphides are soluble in acid
(d) None of these

59. SnS is:

(a) Black (b) Brown
(c) Orange (d) Yellow

60. Na_2CO_3 cannot be used in place of $(NH_4)_2CO_3$ for the precipitation of V group because:

(a) Na^+ interferes in the detection of V group
(b) Conc. of CO_3^{2-} is very low
(c) Na will react with acid radicals
(d) Mg will be precipitated

61. $CoCl_2$ is:

(a) Pink (b) Black
(c) Green (d) Colorless

62. Which on mixing gives deep brown color?

(a) $N_2O + O_2$ (b) $NO + O_2$
(c) $N_2O_3 + O_2$ (d) None of these

63. NaCl, NaBr, NaI mixture on adding conc. H_2SO_4 gives gases, respectively:

(a) HCl, Br_2, I_2 (b) HCl, HBr, HI
(c) Cl_2, Br_2, I_2 (d) None of these

64. Sodium nitroprusside when added to an alkaline solution of sulphide ions produces purple coloration due to the formation of:
(a) $Na_4[Fe(SCN)_5NOS]$ (b) $Na_3[Fe(CN)_5NOS]$
(c) $Na_2[Fe(CN)_5NOS]$ (d) $Na_4[Fe(CN)_5NOS]$

65. H_2S on passing through ammonical solution gives white ppt. The white ppt. is of:
(a) CoS (b) NiS
(c) MnS (d) ZnS

66. Preparation of Na_2CO_3 extract is made for acid radical analysis because:
(a) All anions react with Na to give water soluble compound
(b) Na is more reactive
(c) Na_2CO_3 is water soluble
(d) None of the above

67. H_2S and SO_2 can be distinguished by:
(a) Litmus paper (b) MnO_4^-
(c) $Pb(CH_3COO)_2$ (d) HCl

68. On passing CrO_2Cl_2 in water and then adding $(CH_3COO)_2$ Pb, the ppt. formed is:,
(a) $PbCrO_4$ (b) $PbCl_2$
(c) $CrCl_3$ (d) None of these

69. A solution on treatment with NH_3 turns blue; it contains:
(a) Cu^{2+} (b) Ca^{2+}
(c) Co^{2+} (d) Mn^{2+}

70. When solution of ZnS in dil. HCl is treated with NaOH solution, a white ppt. is formed which dissolves in excess of NaOH due to formation of:
(a) $ZnCl_2$ (b) $Zn(OH)Cl$
(c) Na_2ZnO_2 (d) None of these

71. Disodium hydrogen phosphate is used to test:
(a) Mg^{2+} (b) Na^+
(c) Ca^{2+} (d) All of these

72. Reddish-brown (chocolate) ppt. is formed with:
(a) Cu^{2+} and $Fe(CN)_6^{4-}$ (b) Ba^{2+} and SO_4^{2-}
(c) Pb^{2+} and I^- (d) None of these

73. Addition of KI to Pb salt in water gives .... ppt:
(a) Yellow (b) Black
(c) White (d) Red

74. Which radicals are precipitated in $(NH_4)_2CO_3$ in presence of NH_4Cl and NH_4OH?
(a) Ca, Ba, Sr (b) Mg
(c) Both (a) and (b) (d) None of these

75. Addition of $SnCl_2$ to $HgCl_2$ gives ppt.:
(a) White turning to grey (b) Black turning to white
(c) White turning to red (d) None of these

76. If HCl is not added before passing H_2S in the second group, it may result in the:
(a) Incomplete precipitation of second group sulphide
(b) Precipitation of sulphides of cations belonging to subsequent groups
(c) Precipitation of sulphur
(d) Precipitation of lead as lead sulphide

77. Which metal gives blue ash when its salt is heated with Na_2CO_3 solid and $Co(NO_3)_2$ on a charcoal piece?
(a) Cu (b) Mg
(c) Al (d) Zn

78. To avoid the precipitation of hydroxides of Ni^{2+}, Co^{2+}, Zn^{2+}, and Mn^{2+} along with those of Fe^{3+}, Al^{3+}, and Cr^{3+} the third group solution should be:
(a) Heated with a few drops of conc. HNO_3
(b) Treated with excess of NH_4Cl
(c) Concentrated (d) None of these

79. Which gives a white precipitate with a solution of $AgNO_3$, a white precipitate with dil. H_2SO_4, and a green flame test?
(a) Copper chloride (b) Copper nitrate
(c) Lead nitrate (d) Barium chloride

80. In qualitative inorganic analysis of basic radicals, hydrochloric acid is preferred to nitric acid for preparing a solution of given substance. This is because:
(a) Nitrates are not decomposed to sulphides
(b) Nitric acid contains nitrogen
(c) Hydrochloric acid is not an oxidizing agent
(d) Chlorides are easily converted to sulphides

81. Addition of solution of oxalate to an aqueous solution of mixture of Ba^{2+}, Sr^{2+}, and Ca^{2+} will precipitate:
(a) Ca^{2+} (b) Ca^{2+} and Sr^{2+}
(c) Ba^{2+} and Sr^{2+} (d) All the three

82. Group reagent for the precipitation of group II basic radicals for the qualitative analysis is:
(a) Dil. HCl + H_2S
(b) NH_4Cl (solid) + NH_4OH (solution) + H_2S
(c) $(NH_4)_2CO_3$ solution (d) None of these

83. In the second group of qualitative analysis, H_2S is passed through a solution acidified with HCl in order to:
(a) Limit the concentration of S^{2-} ions

(b) Increase the solubility of H_2S

(c) Increase the concentration of S^{2-} ions

(d) Add the Cl^- ions

84. Few drops of a salt solution are shaken with chloroform, chlorine water. Chloroform layer becomes violet. Solution contains:

(a) NO_2^- ion (b) NO_3^- ion
(c) Br^- ion (d) I^- ion

85. The reagent that distinguishes between silver and lead salt is:

(a) H_2S gas

(b) Dil. HCl solution added after this dissolved in hot water

(c) NH_4Cl (solid) + NH_4OH (solution)

(d) NH_4Cl (solid) + $(NH_4)_2CO_3$ solution

86. Sulphide ions react with $Na_2[Fe(NO)(CN)_5]$ to form a purple colored compound $Na_4[Fe(CN)_5(NOS)]$. In the reaction, the oxidation state of iron:

(a) Changes from +2 to +3

(b) Changes from +3 to +2

(c) Changes from +2 to +4

(d) Does not change

87. Two test tubes containing a nitrate and a bromide are treated separately with H_2SO_4; brown fumes evolved are passed in water. The water will be colored by vapors evolved from the test tube containing:

(a) Nitrate (b) Bromide
(c) Both (a) and (b) (d) None of these

88. A minute quantity of cupric salt is heated on borax bead in reducing flame of Bunsen burner; the color of bead after cooling will be:

(a) Blue (b) Red
(c) Colorless (d) Green

89. A solution of white crystals gives a yellow precipitate with $AgNO_3$ but no precipitate with a solution of Na_2CO_3. The action of conc. H_2SO_4 on the crystals yields a brown gas. The crystals are of:

(a) $NaNO_3$ (b) KCl
(c) $Ca(ON_3)_2$ (d) NaBr

90. A white precipitate insoluble in conc. HNO_3 is formed when the aqueous solution of x in NaOH is treated with barium chloride and bromine water:

(a) SO_3 (b) SO_2
(c) CO_2 (d) None of these

91. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 water gives:

(a) $Na_2S_4O_4$ (b) Na_2SO_4
(c) $Na_2S_4O_6$ (d) NaOH

92. The product of reaction of an aq. solution of Bi^{3+} salt with sodium thiosulphate gives:

(a) BiS (b) $Bi_2(S_2O_3)_3$
(c) $Na[Bi(S_2O_3)_2]$ (d) $[Bi_2(S_2O_3)_2]Cl_2$

93. When CS_2 layer containing both Br_2 and I_2 is shaken with excess of Cl_2 water, the violet color due to I_2 disappears and a pale yellow color appears in the solution. The disappearance of violet color and appearance of pale yellow color is due to the formation of:

(a) I_3^- and Br_2, respectively

(b) HIO_3 and BrCl, respectively

(c) ICl and BrCl, respectively

(d) I^- and Br^-, respectively

94.
$$\begin{tikzcd} \underset{\text{(Mix. of two cation)}}{A} + HClO_4 \arrow[r] & \underset{\text{White ppt.}}{B} + C\ \text{(Filtrate)} \arrow[d, "NaOH"] \\ \text{Brown ppt.} & D \arrow[l, "K_2HgI_4/OH^-"] \end{tikzcd}$$

The cations present in A are:

(a) K^+ and Na^+ (b) K^+ and NH_4^+
(c) NH_4^+ and Fe^{2+} (d) Mg^{2+} and Na^+

95. Which of the following pair of acid radicals can be distinguished by using dil. H_2SO_4?

(a) $C_2O_4^{2-}$ and NO_3^- (b) NO_3^- and NO_2^-
(c) Cl^- and Br^- (d) HCO_3^- and CO_3^{2-}

96. A white colored salt forms white sublimate in dry heating test and also gives ammonia on heating with caustic soda solution. Which of the following test will be shown positive by the salt?

(a) It will give greenish yellow gas on reaction with conc. H_2SO_4

(b) It will give red gas by heating with $K_2Cr_2O_7$ and conc. H_2SO_4

(c) It will give colorless gas with dil. H_2SO_4

(d) It will give ring test

97. $Zn + \text{conc. } HNO_3 \longrightarrow Zn^{2+} + NO_2$

$Ag + \text{conc. } HNO_3 \longrightarrow Ag^+ + NO_2$

Which of the following cation has highest percentage in above reactions?

(a) Zn^{2+} (b) Ag^+

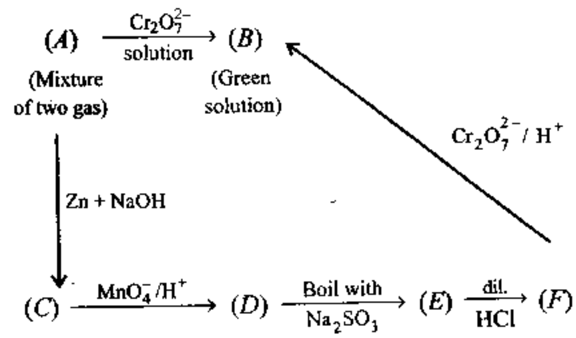
(c) Both have equal percentage

(d) None of these

98. When Au reacts with very dil. HNO_3 (6%), then product will be:

(a) $AuNO_3$, NH_4NO_3 (b) $AuNO_3$, NO
(c) $AuNO_3$, NO_2 (d) None of these

99.



Then A may have:

(a) SO_2, NO_2 (b) H_2S, SO_2
(c) Br_2, SO_2 (d) CO_2, SO_2

100. A red solid is insoluble in water. However, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets of a metal appear on cooler part of the test tube. The red solid is:

(a) Pb_3O_4 (b) HgI_2
(c) HgO (d) $(NH_4)_2Cr_2O_7$

101. When KI is added to acidified solution of sodium nitrite:

(a) NO gas is liberated and I_2 is set free
(b) N_2 gas is liberated and HI is produced
(c) N_2O gas is liberated and I_2 is set free
(d) N_2 gas is liberated and HOI is produced

102. A hydrated metallic salt (A), light green in color, gives a white anhydrous residue (B) after being heated gradually. (B) is soluble in water and its aqueous solution reacts with NO to give a dark brown compound (C). (B) on strong heating gives a brown residue (D) and a mixture of two gases (E) and (F). The gaseous mixture, when passed through acidified permanganate, discharges the pink color:

(a) $ZnSO_4 \cdot 7H_2O$ (b) $MgSO_4 \cdot 7H_2O$
(c) $FeSO_4 \cdot 7H_2O$ (d) $CuSO_4 \cdot 5H_2O$

103. A gas X occupies 22.4 liter at S.T.P. The gas turns acidified $K_2Cr_2O_7$ green and decolorizes acidified $KMnO_4$ solution. White turbidity appears when H_2S gas is passed through aqueous solution of gas; then X will be:

(a) H_2S (b) NO_2
(c) SO_2 (d) None of these

104. An aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:

(a) A colorless filtrate and a green residue
(b) A yellow filtrate and a green residue
(c) A yellow filtrate and a brown residue
(d) A green filtrate and a brown residue

105. The only cations present in a slightly acidic solution are Fe^{3+}, Zn^{2+}, and Cu^{2+}. The reagent which when added in excess of this solution would identify the separate Fe^{3+} in one step is:

(a) 2MHCl (b) 6$M$$NH_3$
(c) 6MNaOH (d) H_2S gas

106. The phenomenon in which white transparent crystal changes into white powder is called:

(a) Deliquescence (b) Efflorescence
(c) Allotropy (d) Sublimation

107. If Fe^{3+} and Cr^{3+} both are present in group III of qualitative analysis, then distinction can be made by:

(a) Addition of NH_4OH in presence of NH_4Cl, when only $Fe(OH)_3$ is precipitated
(b) Addition of NH_4OH in presence of NH_4Cl, when $Cr(OH)_3$ and $Fe(OH)_3$ both are precipitated; and on adding Br_2 water and NaOH, $Cr(OH)_3$ dissolves
(c) Precipitates of $Cr(OH)_3$ and $Fe(OH)_3$ as obtained in (b) are treated with conc. HCl when only $Fe(OH)_3$ dissolves
(d) Both (b) and (c) are correct

108. When calomel reacts with NH_4OH solution, the compound formed is:

(a) $NH_2(Hg)Cl$ (b) $Hg_2Cl_2NH_3$
(c) $Hg(NH_3)_2Cl_2$ (d) $HgCl_2NH_3$

109. A solution when diluted with water and boiled, gives a white precipitate. On addition of excess of NH_4Cl/NH_4OH, the volume of precipitate decreases leaving behind a white gelatinous precipitate. Identify the precipitate which dissolves in NH_4OH/NH_4Cl:

(a) $Zn(OH)_2$ (b) $Al(OH)_3$
(c) $Mg(OH)_2$ (d) $Ca(OH)_2$

110. SO_2 and CO_2 both turn lime water (A) milky, SO_2 also turns $K_2Cr_2O_7/H^+$ (B) green while O_2 is soluble in pyrogallol (C) turning it black. These gases are to be detected in order by using these reagents. The order is:

(a) (A), (B), (C) (b) (B), (C), (A)
(c) (B), (A), (C) (d) (A), (C), (B)

111. NH_4SCN can be used to test one or more out of Fe^{3+}, Co^{2+}, Cu^{2+}:

(a) Fe^{3+} only (b) Co^{2+}, Cu^{2+}

(c) Fe^{3+}, Cu^{2+} (d) All of these

112. A mixture contains Cu^{2+}, Al^{3+}, and Ni^{2+}. Following steps have been adopted but written in disorder:

I: Filter, boil off H_2S gas, and add NH_4Cl; heat and add NH_4OH.

II: Filter, add NH_4OH and pass H_2S gas.

III: Pass H_2S gas into acidified solution of mixture.

Steps will be used in the following order:

(a) I, II, III (b) III, I, II

(c) III, II, I (d) I, III, II

113. *A* is a colorless substance. Aq. solution of *A* gives reddish-orange ppt. with KI; ppt. dissolves in excess of KI forming a colorless solution. If NH_4Cl and NaOH solution is added to this colorless solution, reddish brown ppt. is formed. Substance *A* is:

(a) Epsom salt (b) Mohr's salt

(c) Calomel (d) Corrosive sublimate

114. Sb_2S_3 is:

(a) Black (b) Yellow

(c) Orange–red (d) None of these

115. Few drops of HNO_3 are added to II group before proceeding to III group in order to:

(a) Convert Fe^{2+} to Fe^{3+} (b) Convert Fe^{3+} to Fe^{2+}

(c) ppt. III group (d) None of these

116. The aqueous solution of salt gives white ppt. with lead acetate solution which is insoluble in hot water and nitric acid. The salt contains:

(a) Cl^- (b) Ba^{2+}

(c) CO_3^{2-} (d) SO_4^{2-}

117. Some pale-green crystals are strongly heated. The gases given off are passed into a container surrounded by ice and then through a solution of acidified $KMnO_4$. The $KMnO_4$ is decolorized, a waxy white solid is formed in the ice container; this is dissolved in water. The solution will:

(a) Give a precipitate with silver nitrate solution

(b) Given a precipitate with barium chloride solution

(c) Turn red litmus blue

(d) Give blue color with starch solution

118. For testing sodium carbonate solution for the presence of sulphate ions as impurities one should add:

(a) Excess hydrochloric acid and silver nitrate solution

(b) Excess sulphuric acid and silver nitrate solution

(c) Excess nitric acid and silver nitrate solution

(d) Excess hydrochloric acid and barium chloride solution

119. A reddish-pink substance on heating gives off a vapor which condenses on the sides of the test tube and the substance turns blue. If on cooling water is added to the residue, it turns to its original color. The substance is:

(a) Iodine crystals (b) Copper sulphate crystals

(c) Cobalt chloride crystals

(d) Zinc oxide

120. An inorganic Lewis acid (*X*) fumes in moist air, and intensity of fumes increases when a rod dipped in NH_4OH is brought near to it. An acidic solution of (*X*) on addition of NH_4Cl and NH_4OH gives a precipitate which dissolves in NaOH solution. An acidic solution of (*X*) does not give precipitate with H_2S. Hence, the compound (*X*) is:

(a) $FeCl_3$ (b) $AlCl_3$

(c) $SnCl_2$ (d) $ZnCl_2$

121. Aqueous solution of a salt (*Y*) is alkaline to litmus. On strong heating, it swells-up to give a glassy material. When conc. H_2SO_4 is added to a hot concentrated solution of (*Y*), white crystals of a weak acid separate out. Hence, the compound (*Y*) is:

(a) $Na_2SO_4{\cdot}10H_2O$ (b) $Ca_2P_6O_{11}{\cdot}10H_2O$

(c) $Na_2B_6O_{11}$ (d) $Na_2B_4O_7{\cdot}10H_2O$

122. A colorless salt (*X*) is soluble in water and also in alcohol and amines. On strong heating, (*X*) gives a brown gas (*Y*) and a grey residue. (*X*) dissolves in ammonia to give a solution (*Z*) which gives silver mirror with aldehydes. A solution of (*X*) is easily reduced by iron (II) sulphate. A solution of (*X*) also gives a brick red precipitate with potassium dichromate solution. Hence, choose the correct alternative:

	X	*Y*	*Z*
(a)	$Pb(NO_3)_2$	NO_2	Ag_2O
(b)	$AgNO_3$	NO	$[Ag(NH_3)_2]^+$
(c)	$AgNO_3$	NO_2	Ag_2O
(d)	$AgNO_3$	NO_2	$[Ag(NH_3)_2]^+$

123. Salt-*A* $\xrightarrow{\text{Layer test}}$ If reddish-brown layers comes first, then:

(a) Br^- present (b) $Br^{\ominus}$ absent

(c) Cl^- present (d) I^- present

124. Salt mixture $\xrightarrow{\text{Dil. HCl}}$ White ppt.

Heated and filtered under hot condition $\rightarrow$ Filtrate $\xrightarrow{\text{cooled}}$ White needle like crystal

Heated and filtered under hot condition $\rightarrow$ Residue $\xrightarrow{\text{NH}_3\text{ sol.}}$ Clear solution

Salt is consisting of cations:

(a) Pb^{2+} and Hg^{2+} (b) Pb^{2+} and Hg_2^{2+}
(c) Pb^{2+} and Ag^+ (d) Pb^{2+}, Hg_2^{2+}, and Ag^+

125. $CaCO_3(s) + AcOH \xrightarrow{Na_2C_2O_4 \text{ solution}} ?$
Comment on the product of this reaction?
(a) No reaction
(b) White ppt. of $Ca(OAc)_2$ is obtained
(c) White ppt. of CaC_2O_4 is formed
(d) No ppt. is obtained but not the no reaction

126. $Hg(NO_3)_2 \longrightarrow W + X + O_2$

$X + H_2O \longrightarrow HNO_2 + HNO_3$

$W + HNO_3 \longrightarrow Y + NO + H_2O$

$Y + Na_2S_2O_3 \text{ (excess)} \longrightarrow Z + NaNO_3$

(a) $W = Hg$, $X = N_2O$, $Y = Hg(NO_3)_2$, $Z = Na_2[Hg(S_2O_3)_2]$
(b) $W = HgO$, $X = NO$, $Y = Hg(NO_3)_2$, $Z = Na[Hg(S_2O_3)_2]$
(c) $W = Hg$, $X = NO_2$, $Y = Hg(NO_3)_2$, $Z = Na_2[Hg(S_2O_3)_2]$
(d) $W = Hg$, $X = N_2O_3$, $Y = Hg(NO_3)_2$, $Z = Na_3[Hg(S_2O_3)_2]$

127. A metal hydroxide is precipitated as a white gelatinous substance when NH_4OH is added to the solution (after previously removing acid insoluble sulphides with H_2S). The metal in metal hydroxide is:
(a) Cr (b) Fe
(c) Al (d) Zn

128. A pale green crystalline metal salt of (*X*) dissolves freely in water. It gives a brown precipitate on the addition of aq. NaOH. The metal salt solution also gives a black precipitate on bubbling H_2S in aqueous medium. An aqueous solution of the metal salt decolorizes the pink color of the permangnetic solution. The metal in the metal salt solution is:
(a) Fe (b) Pb
(c) Cu (d) Al

129. When a reagent (*X*) reacts with Fe^{3+}, the solution turns red due to the formation of a compound (*Y*). This reagent causes no change in color with Fe^{2+} in the pure state. Here (*X*) and (*Y*) are, respectively:
(a) NH_4SCN and $[Fe(SCN)_3]$
(b) $K_4[Fe(CN)_6]$ and $Fe_4[Fe(CN)_6]_3$
(c) Na_2HPO_4 and $FeSO_4$
(d) $K_3[Fe(CN)_6]$ and $K_2\,Fe[Fe(CN)_6]$

130. Two different salts (*A*) [zinc nitrate] and (*B*) [potassium bromide] were separately warmed with conc. H_2SO_4. Which of them will produce reddish brown fumes that dissolve in CS_2 giving yellow solution?
(a) Both (*A*) and (*B*) (b) Only (*A*)
(c) Only (*B*) (d) Neither (*A*) nor (*B*)

131. A red solid is insoluble in water, however, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets. Metal appears on the cooler parts of the test tube. The red solid is:
(a) Pb_3O_4 (b) HgO
(c) $(NH_4)_2\,Cr_2O_7$ (d) HgI_2

132. A green colored water soluble substance, (*A*), forms a greenish precipitate (*B*) with NH_4OH in presence of NH_4Cl (excess). When (*B*) is oxidized with a little sodium bismuthate in presence of H_2SO_4, a orange solution is obtained. If now a little solid Na_2O_2 is added, an intensely blue-colored compound is formed, extractable with ether. (*A*) yields a bulky white precipitate with $BaCl_2$ solution. Suggest the nature of the compound (*A*):
(a) Nickel (II) sulphate (b) Copper (II) sulphate
(c) Chromium (III) sulphate
(d) Ferrous sulphate

133. A certain pale-green substance (*A*) becomes dark brown on adding $NaNO_2$ in presence of dil. H_2SO_4. Its aqueous solution gives precipitates with (I) $BaCl_2$ and (II) NaOH in separate tests.
The latter precipitate, (*B*), gradually changes color from green to brown on exposure to air. What is *A*?
(a) $NiSO_4$ (b) $FeSO_4$
(c) $CuSO_4$ (d) $Cr_2(SO_4)_3$

134. Which of the following reaction(s) are not relevant to the microcosmic salt bead test?
I. $Cr_2O_3 + 3B_2O_3 \longrightarrow 2Cr(BO_2)_3$
II. $CoO + ZnO \longrightarrow CoZnO_2$
III. $CoO + NaPO_3 \longrightarrow NaCoPO_4$
IV. $Al_2(SO_4)_3 + 3Na_2CO_3 \longrightarrow Al_2O_3 + 3Na_2SO_4 + 3CO_2$
(a) I, III, and IV (b) I, II, and IV
(c) II, III, and IV (d) II and IV only

135. Identify (P) to (R):

$$(P) \xrightarrow{KOH} \underset{\substack{\text{(gas turns red} \\ \text{litmus blue)}}}{(Q)} + (R) \xrightarrow{Zn + KOH} (Q) \text{ gas}$$

$$(P) \xrightarrow{\Delta} \text{Gas (does not support combustion)}$$

(a) $P = (NH_4)_2SO_4$, $Q = NH_3$, $R = K_2SO_4$
(b) $P = NH_4NO_3$, $Q = NH_3$, $R = KNO_3$
(c) $P = NH_4NO_2$, $Q = NH_3$, $R = KNO_2$
(d) $P = (NH_4)_2Cr_2O_7$, $Q = NH_3$, $R = Cr_2O_3$

136. In the following reactions,

$$CaCO_3\,(s) \xrightarrow[\Delta]{} A(s) + B(g)$$

$$A(s) + \text{carbon} \xrightarrow[\Delta]{} C(s) + D(g)$$

$$C(s) + H_2O \xrightarrow[\Delta]{} E(g)$$

the compound E is:

(a) CO (b) CH_4
(c) H_2 (d) C_2H_2

137. Consider the following reactions:

I. $Na_2S_2O_3 + \text{dil. HCl} \xrightarrow{\Delta}$
II. $Na_2S_2O_3 + Cl_2 \text{ water} \xrightarrow{\Delta}$
III. $SO_2 + 2H_2S \xrightarrow{\Delta}$
IV. $H_2S + H_2O_2 \xrightarrow{\Delta}$

The reactions which gives yellow turbidity are:

(a) II, III, and IV (b) III and IV only
(c) I, III, and IV (d) I, II, III, and IV

138. The compound of a metal M, $M_x(NO_3)_y$, when treated with hydrogen sulphide in neutral or dilute acidic medium forms a black precipitate of M and its sulphide. Identify the metal and its sulphide.

(a) M – Cd, M_2S – CdS (b) M – Hg, MS – HgS
(c) M – Pb, MS – PbS (d) M – Cu, M_2S – Cu_2S

139. What is the magnetic moment (spin only) and hybridization of central atom in the brown ring complex $[Fe(H_2O)_5NO]SO_4$?

(a) $\sqrt{\ }$ B.M., d^2sp^3 (b) $\sqrt{\ }$ B.M., sp^3d^2
(c) $\sqrt{15}$ B.M., sp^3d^2 (d) $\sqrt{15}$ B.M., d^2sp^3

140. Consider the given sequence of reaction and identify P and Q:

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} P + NaBO_2 + H_2O\uparrow + \xrightarrow[\Delta]{Cr_2O_3}$$

Q (Green colored)

(a) $P = Na_3BO_3$, $Q = Cr(BO_2)_3$
(b) $P = B_2O_3$, $Q = CrBO_3$
(c) $P = Na_2B_4O_7$, $Q = Cr(BO_2)_3$
(d) $P = B_2O_3$, $Q = Cr(BO_2)_3$

Multiple Correct Answers Type

1. Which of the following anions may be identified by their ppt. reaction in aqueous solution?

(a) CrO_4^{2-} (b) SO_4^{2-}
(c) PO_4^{3-} (d) MnO_4^-

2. Which of the following anion (s) is/are interfering radicals?

(a) BO_3^{3-} (b) $F^{\ominus}$
(c) PO_4^{3-} (d) none of these

3. When Zn reacts with conc. HNO_3, then $Zn(NO_3)_2$ and NO_2 are formed; reaction(s) involved in this process is/are:

(a) Redox reaction (b) Acid–base reaction
(c) Ion-exchange reaction (d) None of these

4. Select the correct statement(s):

(a) $NaHCO_3$ is sparingly soluble in water because it has massive H-bonding
(b) When $BaCl_2$ reacts with bicarbonate, then white ppt. of $BaCO_3$ is formed
(c) $HgCl_2$ is poisonous
(d) Phenolphthalein is turned pink by soluble carbonate and colorless by soluble hydrogen carbonate

5. Select the correct statement(s):

(a) When $HgCl_2$ reacts with carbonate ion, then basic mercury (II) carbonate is formed
(b) When $HgCl_2$ reacts with carbonate ion, then pH of solution highly increases
(c) The excess of carbonate acts as buffer reacting with the hydrogen ions formed in the reaction

$$CO_3^{2-} + 2H^+ \longrightarrow CO_2\uparrow + H_2O$$

(d) White ppt. of $MgCO_3$ soluble in dil. H_2SO_4

6. Select the correct statement(s):

(a) White ppt. of $BaSO_3$ and $CaSO_3$ is soluble in dil. HNO_3, dil. HCl, and CH_3COOH
(b) On standing, the precipitate $BaSO_3$ is slowly oxidized to sulphate and then becomes insoluble in dilute mineral acids
(c) When excess of SO_2 gas is passed into the solution of $BaSO_3$ and $CaSO_3$, then white turbidity disappears
(d) The hydrogen carbonates of alkali metals are soluble in water, but are less soluble than the corresponding normal carbonates

7. Which of the following carbonates do not give metal oxide on heating?
(a) $CuCO_3$ (b) K_2CO_3
(c) Na_2CO_3 (d) $MgCO_3$

8. The ions which can be precipitated with both HCl and H_2S are:
(a) Pb^{2+} (b) Cu^{2+}
(c) Ag^+ (d) Sn^{2+}

9. Which of the following compounds are soluble in water?
(a) CaC_2O_4 (b) $SrSO_4$
(c) $BaCl_2$ (d) $(NH_4)_2C_2O_4$

10. Which of the following halides are not soluble in water?
(a) AgCl (b) AgBr
(c) $PbCl_2$ (d) AgF

11. When dimethyl glyoxime solution is added to an aqueous solution of nickel(II) chloride followed by ammonium hydroxide, then which of the following statements are incorrect?
(a) No precipitate is obtained
(b) A blue colored ppt. is obtained
(c) A rosy red colored ppt. is obtained
(d) A black colored ppt. is obtained

12. The brown ring test is performed for the qualitative detection of:
(a) Bromides (b) Iodides
(c) Nitrates (d) Nitrite

13. Which of the following respond to borax bead test?
(a) Nickel salts (b) Copper salts
(c) Cobalt salts (d) Aluminium salts

14. Concentrated aqueous sodium hydroxide cannot separate a mixture of:
(a) Al^{3+} and Sn^{2+} (b) Al^{3+} and Fe^{3+}
(c) Al^{3+} and Zn^{2+} (d) Zn^{2+} and Pb^{2+}

15. The metal ion(s) which is/are not precipitated when H_2S is passed with HCl is/are:
(a) Zn^{2+} (b) Ni^{2+}
(c) Cd^{2+} (d) Mn^{2+}

16. An aqueous solution of a substance gives a white precipitate on treatment with dil. HCl which dissolves on heating. When H_2S is passed through the hot acidic solution, a black precipitate is obtained. The substances are not:
(a) Hg_2^{2+} salt (b) Cu^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt

17. When H_2S gas is passed through HCl containing aqueous solution of $CuCl_2$, $HgCl_2$, $BiCl_3$, and $CoCl_2$, then which of the following precipitate out?
(a) CuS (b) HgS
(c) Bi_2S_3 (d) CoS

18. In broax bead test, which compound(s) is/are not formed?
(a) Orthoborate (b) Metaborate
(c) Double oxide (d) Tetraborate

19. Mark the correct statement(s):
(a) I group basic radicals precipitate as chlorides
(b) IV group basic radicals precipitate as sulphides
(c) V group basic radicals precipitate as carbonates
(d) V group basic radicals precipitate as hydroxide

20. Which of the following sulphides is/are not yellow in color?
(a) CuS (b) CdS
(c) ZnS (d) CoS

21. Which of the following basic radicals will be precipitated by H_2S gas in the presence of NH_3?
(a) Mn^{2+} (b) Ni^{2+}
(c) Cd^{2+} (d) Ca^{2+}

22. Which of the following is/are soluble in NaOH?
(a) $Fe(OH)_3$ (b) $Zn(OH)_2$
(c) $Al(OH)_3$ (d) $Sn(OH)_2$

23. Which of the following is/are soluble in excess of NaOH? (*X*): $Pb(OH)_2$; (*Y*): CuS; (*Z*): $Al(OH)_3$
(a) *X* (b) *Y*
(c) *Z* (d) None of these

24. Aqueous solution contains $Zn(CH_3COO)_2$, $Cd(CH_3COO)_2$, and $Cu(CH_3COO)_2$. On passing H_2S gas, there is a precipitation of .... as sulphide:
(a) Zn^{2+} (b) Cd^{2+}
(c) Cu^{2+} (d) None of these

25. Which of the following salt does give positive test for nitrate ion?
(a) KNO_3 (b) $NaNO_3$
(c) $Mg(NO_3)_2$ (d) None of these

26. Which of the following oxides is/are soluble in $NaOH_{(aq)}$:
(a) ZnO (b) Al_2O_3
(c) Fe_2O_3 (d) SnO_2

27. Ag_2CrO_4 ppt. is soluble in:
(a) Dil. HNO_3 (b) Aq. NH_3
(c) AgCl solution (d) None of these

28. Which of the following pairs can be separated by H_2S in dil. HCl?

(a) Cu^{2+} and Cd^{2+} (b) Cu^{2+} and Ni^{2+}
(c) Cu^{2+} and Zn^{2+} (d) Hg^{2+} and Al^{3+}

29. An inorganic salt solution on treatment with HCl will not give a white precipitate of which metal ions?

(a) Hg_2^{2+} (b) Hg^{2+}
(c) Zn^{2+} (d) Al^{3+}

30. Ammonium molybdate is used to test the radical:

(a) PO_4^{3-} (b) AsO_4^{3-}
(c) Cu^{2+} (d) Ag^+

31. Which of the following anions are easily removed from aqueous solution by precipitation?

(a) Cl^- (b) SO_4^{2-}
(c) NO_3^- (d) CO_3^{2-}

32. Which of the following chlorides are water soluble?

(a) AgCl (b) Hg_2Cl_2
(c) $HgCl_2$ (d) NaCl

33. Which of the following metal sulphide is soluble in hot and dil. HNO_3?

(a) Ag_2S (b) PbS
(c) CdS (d) HgS

34. Which of the following ppt. is soluble in dil. HNO_3 and NH_3 solution?

(a) $Ag_2S_2O_3$ (b) Ag_2CO_3
(c) Ag_2SO_3 (d) AgI

35. Which of the following ppt. is insoluble in NH_3 solution?

(a) AgI (b) Ag_2S
(c) AgCl (d) AgBr

36. Which of the following metals are present in Devarda alloy?

(a) Cu (b) Al
(c) Zn (d) Ag

37. Which of the following reactions is/are ppt. reaction(s)?

(a) $BaS + Na_2SO_4 \longrightarrow BaSO_4 + Na_2S$
(b) $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$
(c) $2NaNO_3 + MgCl_2 \longrightarrow 2NaCl + Mg(NO_3)_2$
(d) $MgCl_2 + Na_2SO_4 \longrightarrow 2NaCl + MgSO_4$

38. Which of the following compound(s) give(s) N_2 gas on heating?

(a) NH_4ClO_3 (b) NH_4ClO_4
(c) NH_4NO_3 (d) NH_4Cl

39. Which of the following compound(s) give(s) NH_3 gas on heating?

(a) NH_4Cl (b) CH_3COONH_4
(c) $(NH_4)_2CO_3$ (d) NH_4NO_2

40. Which of the following reaction(s) is/are example(s) of intra-redox reaction?

(a) $(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3 + H_2CO_3$
(b) $(NH_4)_2S \xrightarrow{\Delta} 2NH_3 + H_2S$
(c) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} 2N_2 + Cr_2O_3 + H_2O$
(d) $NH_4IO_3 \longrightarrow N_2 + I_2 + 4H_2O + O_2$

41. Which of the following metal(s) will give same gas on reaction with cold or warm water?

(a) Na (b) Mg
(c) Au (d) Fe

42. Which of the following metal(s) will produce NO_2 gas on reaction with conc. HNO_3(70%)?

(a) Ag (b) Zn
(c) Cu (d) None of these

43. Which of the following metal(s) will produce NO gas on reaction with dil. HNO_3 (20%)?

(a) Cu (b) Ag
(c) Zn (d) Fe

44. A white ppt. is obtained when:

(a) A solution of $BaCl_2$ is treated with Na_2CO_3
(b) A solution of $CaCl_2$ is treated with Na_2SO_3
(c) A solution of $ZnSO_4$ is treated with Na_2S
(d) A solution of $Pb(NO_3)_2$ is treated with Na_2CrO_4

45. Which of the following cation(s) will turn blue in oxidizing flame?

(a) Co^{2+} (b) Cr^{3+}
(c) Ni^{2+} (d) Cu^{2+}

46. Which of the following substances are green?

(a) $Fe(BO_2)_2$ (b) Cu
(c) $Cr(BO_2)_3$ (d) $Co(BO_2)_2$

47. Which pair would not be expected to form precipitate when solutions are mixed?

(a) K^+, SO_4^{2-} (b) Na^+, S^{2-}
(c) Ag^+, NO_3^- (d) Al^{3+}, OH^-

48. Borax bead test is given by:

(a) Co^{2+} (b) Zn^{2+}
(c) Cu^{2+} (d) Ni^{2+}

49. Reddish-brown gas is obtained when the following are treated with conc. H_2SO_4:

(a) $Br^{\ominus}$ (b) NO_2^-
(c) NO_3^- (d) SO_3^{2-}

50. Which of the following will be completely or partially dissolved in NH_4OH?

(a) AgCl (b) AgBr
(c) $BaSO_4$ (d) AgI

51. Which of the following cations are present in III group?

(a) Al^{3+} (b) Fe^{3+}
(c) Cr^{3+} (d) Cu^{2+}

52. Which of the following metal produces N_2O gas with 20% HNO_3.

(a) Fe (b) Cu
(c) Zn (d) Sn

53. Black sulphides are formed by:

(a) Cu^{2+} (b) Sb^{3+}
(c) Pb^{2+} (d) Ag^{+}

54. Interfering radicals interfere the test of:

(a) III group radicals only
(b) III group radicals or downward
(c) Cations which are present in II group filtrate
(d) None of the above

55. Which of the following metal(s) form NO with dil. HNO_3(20%)?

(a) Ag (b) Pb
(c) Cu (d) None of these

56. Select the correct statement(s):

(a) Normal and polysulphides of alkali metals are soluble in water
(b) The sulphides of aluminium chromium, and magnesium can only be prepared under dry conditions as they are completely hydrolyzed by water
(c) When filter paper is moistened with a solution of sodium nitroprusside made alkaline with sodium hydroxide or ammonia solution, a purple coloration is produced with free hydrogen sulphide
(d) Thiosulphate salts of Pb, Ag, and Ba are insoluble and dissolve in excess of sodium thiosulphate solution forming thiosulphate

57. $\underset{\text{(Mixture of two anions)}}{A} \xrightarrow[\text{BaCl}_2]{\text{Cold}} \underset{\text{ppt.}}{\text{White}} \xrightarrow{\text{Filtered}} \text{Filtrate}$

$\xrightarrow{H_2O_2}$ Blue litmus turns red

Mixture of A contains:

(a) CO_3^{2-}, HCO_3^- anions (b) CO_3^{2-}, HSO_3^- anions
(c) SO_3^{2-}, HSO_3^- anions (d) None of these

58. Which of the following statement(s) is/are incorrect?

(a) Manganese salts give a violet borax bead test in reducing flame
(b) From a mixed precipitate of AgCl and AgI, ammonia solution dissolves only AgCl
(c) Ferric ions give a deep green precipitate on adding potassium ferrocyanide solution
(d) On boiling the solution having K^+, Ca^{2+}, and HCO_3^- ions, we get a precipitate of $K_2Ca(CO_3)_2$

59. When H_2S gas is passed in a metal sulphate solution in presence of NH_4OH, a white precipitate is produced. The metal is/are not identified as:

(a) Zn (b) Fe
(c) Pb (d) Hg

60. In which of the following is NH_3 used?

(a) Nessler's reagent
(b) Group reagent for analysis of IV group basic radicals
(c) Group reagent for analysis of III group basic radicals
(d) Tollen's reagent

61. The correct statement(s) is/are, with respect to chromyl chloride test:

(a) Formation of lead chromate
(b) Formation of chromyl chloride
(c) Liberation of chloride
(d) Formation of reddish-brown vapors

62. Aqueous solution of $BaBr_2$ gives yellow ppt. with:

(a) K_2CrO_4 (b) $AgNO_3$
(c) $PbCl_2$ (d) None of these

63. $\underset{\text{orange}}{Cr_2O_7^{2-}} \underset{pH = Y}{\overset{pH = X}{\rightleftharpoons}} \underset{\text{green}}{CrO_4^{2-}}$

This change is based on change in pH. Probable values of X and Y cannot be:

(a) 8, 6 (b) 8, 10
(c) 4, 6
(d) Change is independent of pH

64. Nitrite (NO_2^-) interferes in the "ring-test" of nitrate (NO_3^-). Some of the following reagents can be used for the removal of nitrite.

(a) AgF (b) $(NH_2)_2CS$ (thiourea)
(c) NH_2SO_3H (sulphamic acid)
(d) None of these

65. Which of the following is/are correct for potassium ferrocyanide?

(a) It gives a brown precipitate with Cu^{2+} ions

(b) It gives a red precipitate of mixed salt with Cd^{2+} ions

(c) It in excess gives a white precipitate with Zn^{2+}

(d) It develps a deep red coloration with Fe^{3+}

66. Which of the following statements is not correct?

(a) Lead(II) chloride is soluble in hot water and reappears on cooling

(b) In dilute HCl, the solubility of $PbCl_2$ is high than the hot water

(c) In concentrated HCl, $PbCl_2$ is insoluble

(d) Lead(II) chloride forms the complex with conc. HCl

67. Sulphuric acid is not used for preparation of original solution in analysis of basic radicals because:

(a) It is a reducing agent

(b) It forms insoluble sulphate with certain basic radicals

(c) It forms a soluble complex

(d) It is oxidizing in nature

68. If (*X*) turns lime water milky, then *X* may be:

(a) CO_2 (b) SO_2

(c) NO_2 (d) O_2

69. If (*X*) turns acidified $K_2Cr_2O_7$ solution green, then *X* may be:

(a) SO_2 (b) CO_2

(c) NO_2^- (d) Fe^{2+}

70. If (*X*) decolorizes acidified $KMnO_4$ solution, then *X* may be:

(a) S^{2-} (b) SO_3^{2-}

(c) Fe^{2+} (d) SO_2

71. If (*X*) gives white turbidity when H_2S is passed through its aqueous solution, then *X* may be:

(a) SO_2 (b) Fe^{3+}

(c) Mn^{2+} (d) Sn^{2+}

72. A solution of colorless salt H on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colorless salt(s) H is (are):

(a) NH_4NO_3 (b) NH_4NO_2

(c) NH_4Cl (d) $(NH_4)_2SO_4$

73. Which of the following statements is/are not true?

(a) $Fe^{2+}{}_{(aq)}$ gives brown color with NH_4SCN

(b) $Fe^{3+}{}_{(aq)}$ gives blood red color with NH_4SCN

(c) $Fe^{2+}{}_{(aq)}$ yields orange color with $K_3Fe(CN)_6$

(d) Ag^+ reacts with CO_3^{2-}; then black ppt. is formed

74. Which of the following react with dil. H_2SO_4?

(a) $CaCO_3$ (b) KNO_2

(c) Na_2S (d) $BaCl_2$

75. Conc. H_2SO_4 will not give any gas with:

(a) $ZnSO_4$ (b) Barium phosphate

(c) Magnesium borate (d) Sodium oxalate

76. The reagents, ammonium chloride and aqueous ammonia will precipitate:

(a) Bi^{3+} (b) Pb^{2+}

(c) Mg^{2+} (d) Fe^{3+}

77. Which of the following ppt.(s) of sulphite ion have white color?

(a) Ag_2SO_3 (b) $PbSO_3$

(c) $CaSO_3$ (d) $BaSO_3$

78. Which of the following gases have brown color?

(a) Br_2 (b) NO_2

(c) CO_2 (d) I_2

79. Which of the following compounds are having white ppt?

(a) $K_2Fe[Fe(CN)_6]$ (b) $[Fe(H_2O)_5(SCN)]^{2+}$

(c) ZnS (d) $Zn(OH)_2$

80. Which of the following compounds do not have white color in the form of ppt.?

(a) Bi_2S_3 (b) $Co[Hg(SCN)_4]$

(c) CdS (d) BiI_3

81. Select the correct statement(s):

(a) All carbonate salts are soluble except carbonate salts of alkali metals and $(NH_4)_2CO_3$

(b) All bicarbonate salts are soluble except $NaHCO_3$ which is sparingly soluble

(c) All sulphite salts are insoluble except sulphite salts of alkali metals and $(NH_4)_2SO_3$

(d) All MnO_4^- salts are insoluble

82. Select the correct statement(s):

(a) White ppt. of $BaCO_3$ and $CaCO_3$ is soluble in dil. HNO_3, dil HCl, CH_3COOH, and soda water

(b) White ppt. of $PbCO_3$ is soluble in dil. HNO_3, dil. HCl, excess of NaOH, and CH_3COOH

(c) White ppt. of Ag_2CO_3 is soluble in dil. HNO_3 and excess NH_3 solution

(d) HCN and H_3BO_3 are stronger acids than H_2CO_3

83. Select the correct statement(s):

(a) HCl is not used as acid for titration of SO_2

(b) Soda extract solution is very useful when any insoluble salt is present in a given mixture

(c) SO_2 gas is identified by a filter paper moistened with potassium iodate and starch solution.

(d) When zinc and sulphuric acid react with sulphite, then hydrogen sulphide gas is evolved which may be detected by holding lead acetate paper to the mouth of the test tube

84. The salt used for performing "bead test" in qualitative inorganic analysis is:

(a) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(b) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

(c) $Na(NH_4)HPO_4 \cdot 4H_2O$

(d) $Na_2B_4O_7 \cdot 10H_2O$

85. S^{2-} and SO_3^{2-} can be distinguished by using:

(a) $(CH_3COO)_2Pb$ (b) $Na_2[Fe(CN)_5NO]$

(c) $Cr_2O_7^{2-}$ solution (d) $CaCl_2$

86. Out of Cu^{2+}, Ni^{2+}, Co^{2+}, and Mn^{2+}, of those that dissolve in dil. HCl, only one gives a precipitate when H_2S is passed. Identify the corresponding other which do not gives precipitation:

(a) Ni^{2+} (b) Cu^{2+}

(c) Co^{2+} (d) Mn^{2+}

87.

Colorless salt $(X) \xrightarrow{\Delta} (Y) \xrightarrow{Cu^{2+},\ \Delta}$ Colored bead (Z)

(X) can be:

(a) Borax (b) Microcosmic salt

(c) Copper sulphate (d) None of these

88. Consider the following reaction,

Nitrite + acetic acid + thiourea $\longrightarrow N_2 + SCN^- + 2H_2O$

Formation of the product in the above reaction cannot be identified by:

(a) $FeCl_3$/dil. HCl when blood-red color appears

(b) $FeCl_3$/dil. HCl when blue color appears

(c) $K_2Cr_2O_7$/HCl when green color appears

(d) $KMnO_4$/HCl when colorless solution is formed

89. Select the correct statement(s):

(a) $Ag_2S_2O_3$ appears as white precipitate when $Na_2S_2O_3$ reacts with $AgNO_3$

(b) $Ag_2S_2O_3$ is unstable turning black on standing due to formation of Ag_2S

(c) $S_2O_3^{2-}$ can form soluble complex $[Ag(S_2O_3)_2]^{3-}$ with Ag^+

(d) $Na_2S_2O_3$ is used in photography

90. Which of the following sulphides are soluble only in aqua-regia?

(a) NiS (b) CoS

(c) HgS (d) CdS

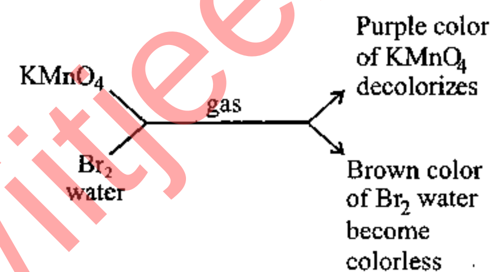
91. Aqueous solution of $X \xrightarrow{NaHC_4H_4O_6}$ White ppt

The cation(s) present in X is/are:

(a) Na^+ (b) Mg^{2+}

(c) NH_4^+ (d) K^+

92.



The gas will be:

(a) CO_2 (b) SO_2

(c) H_2S (d) SO_3

93. Which of the following combinations in an aqueous medium will give a yellow ppt.?

(a) $AgNO_3 + NaBr$

(b) $Pb(CH_3COO)_2 + Na_2CrO_4$

(c) $Fe^{3+} + \overset{\ominus}{S}CN$ (d) None of these

94. Which of the following nitrates are water soluble?

(a) $NaNO_3$ (b) $AgNO_3$

(c) $Hg(NO_3)_2$ (d) $LiNO_3$

95. Which of the following complex(s) will have blue color solution or ppt.?

(a) $[Cu(NH_3)_4]SO_4$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $Co[Hg(SCN)_4]$ (d) $K_3[Co(NO_2)_6]$

96. Which of the following combination will give black ppt.?

(a) $Pb(CH_3COO)_2 + H_2S$ (b) $Cd(CH_3COO)_2 + H_2S$

(c) $Ag_2S_2O_3$ + Heat (d) $AgNO_3 + Na_2S$

97. Which of the following statement(s) is(are) true?

(a) Soluble bicarbonates gives white precipitate with $MgCl_2$ in cold

(b) Soluble calcium bicarbonate gives white precipitate with dilute ammonia solution followed by $MgSO_4$

(c) Bicarbonates are generally soluble in water

(d) Hg(II) chloride forms a reddish-brown precipitate in a solution of soluble carbonate

98. Which of the following statement(s) is(are) correct?
   (a) Soluble sulphide gives black precipitate with $AgNO_3$ solution which is soluble in hot dilute nitric acid
   (b) Soluble sulphide produces a yellow precipitate with a suspension of cadmium carbonate
   (c) Sulphide ion reacts with sodium nitroprusside and gives a purple coloration
   (d) Free H_2S gas forms white precipitate with tetrahydroxido plumbate(II) solution

99. Which of the following reagents can be use to distinguish between SO_2 and CO_2?
   (a) Lime water
   (b) Zinc nitroprusside paste in water
   (c) Potassium iodate and starch
   (d) Acidified potassium dichromate solution

100. Each of these solutions is added to a mixture of aqueous solutions of iodide and chloroform ($CHCl_3$) separately. Which will give a positive test for iodine when the solutions are vigorously mixed?
   (a) NaCl solution (b) NaBr solution
   (c) Chlorine water (d) Bromine water

101. Which of the following statement(s) is(are) incorrect?
   (a) In thiourea test for nitrite, a green colored solution is obtained
   (b) It is not necessary to carry out the chromyl chloride test in a dry test tube
   (c) In $PbNO_3$, the brown ring test can be performed with its water extract
   (d) Suspension of $CdCO_3$ gives black ppt. with sodium sulphide solution

102. Which of the following is(are) correct?
   (a) $[Al(OH)_4]^-_{(aq)} + NH_4^+{}_{(aq)} \xrightarrow{\text{Slightly heat}}$ White precipitate and liberation of ammonia
   (b) $Pb^{2+}{}_{(aq)} + 2Br^-{}_{(aq)} \longrightarrow$ Red precipitate
   (c) BiI_3 (black precipitate) + H_2O (l) $\xrightarrow{\Delta}$ Orange turbidity
   (d) $Fe^{3+}{}_{(aq)} + K_4[Fe(CN)_6]_{(aq)} \longrightarrow$ Blue precipitate

103. Pick out the correct statement(s):
   (a) Golden yellow PbI_2 dissolves in hot water to give a colorless solution
   (b) Ba^{2+} and Ca^{2+} ions can be separated by adding SO_4^{2-} ion in acetic acid medium
   (c) Salts of calcium, copper, and nickel give a green flame color
   (d) The sulphide ion gives with alkaline sodium nitroprusside, a violet color

104. Which of the following statement(s) is(are) true?
   (a) Cu^{2+} salts form soluble complex with excess KCN
   (b) Cu^{2+} salts form soluble complex with aqueous ammonia
   (c) Cu^{2+} salts form soluble complex with KI
   (d) A piece of iron or zinc when placed in Cu^{2+} salt solution, precipitates copper

105. Which of the following statement(s) is/are true?
   (a) In a mixture of Sr^{2+} and Ca^{2+}, ammonium sulphate precipitates only Sr^{2+} as $SrSO_4$ but $CaSO_4$ dissolves in ammonium sulphate forming a soluble complex
   (b) Barium chromate is insoluble in dilute acetic acid
   (c) $Cr(OH)_3$ is soluble in NaOH and Br_2 water while $Fe(OH)_3$ is insoluble
   (d) Cu and Cd separation is based upon the fact that in presence of excess KCN, only Cd is precipitated as sulphide on passing H_2S

106. $\underset{\text{(Ion)}}{X}$ + dil. HCl $\longrightarrow$ $\underset{\text{(White turbidity)}}{Y}$ + $SO_2\uparrow$

$X \xrightarrow{\text{reagent}}$ White ppt. $\xrightarrow[\text{aq. suspension}]{\text{Heat}}$ Black ppt.

Which of the following cation may be present in white ppt.?
   (a) Pb^{2+} (b) Hg^{2+}
   (c) Ag^+ (d) Bi^{3+}

107. For the lime water test, if the observations are positive for the unknown sample, then which of the following conclusion(s) is/are incorrect?
   (a) Sample has only NO_2
   (b) Sample has only SO_3
   (c) Sample has CO_2 and SO_2
   (d) Sample has H_2S

108. $CaCO_3 \xrightarrow{\Delta} A + B\text{(gas)}$

$A + H_2O \longrightarrow C$

$C + B \longrightarrow \underset{\text{(White ppt.)}}{D} + H_2O$

$D + B\text{(gas)} \longrightarrow \underset{\text{(Water soluble)}}{E} \xrightarrow[BaCl_2]{\text{Boil}} \underset{\text{(White ppt.)}}{F}$

Select the correct option(s) for white ppt. shown in the above reactions:
   (a) $CaCO_3$ (b) $MgCO_3$
   (c) $BaCO_3$ (d) Na_2CO_3

109. Which of the following statement(s) is/are correct?

(a) In $S_2O_3^{2-}$, both sulphur are different in nature

(b) Sodium acetate and lead acetate on heating giving same type of product, whereas Mn, Sn, Fe oxalate salt giving different type of products

(c) Aqueous solution OCl^-, S^{2-}, and CO_3^{2-} basic in nature

(d) NO_2^- oxidizes I^- whereas Br_2 and Cl_2 oxidizes NO_2^-

110. In reactions,

(I) $FeSO_4 + NO + H_2O \longrightarrow X$

(II) Sodium nitroprusside + $Na_2S \longrightarrow Y$

Then select the correct option(s) for X and Y:

(a) Products X and Y both are paramagnetic.

(b) In reaction (I) change of oxidation state of central metal occurs, while in reaction (II), there is no change in oxidation state.

(c) Hybridization of central metal in reaction (II) is not changed.

(d) Magnetic moment of compound X is $\sqrt{15}$ B.M.

111. Which of the following is/are correct process for the separation of given ions?

(a) Cu^{2+} from the mixture of Cu^{2+} and Cd^{2+} in aqueous solution,

$Cu^{2+} + Cd^{2+} \xrightarrow[\text{KCN}]{\text{Add excess}} \xrightarrow[\text{and filter}]{\text{Pass } HS_2} Cu^{2+}$ in the filtrate

(b) Cu^{2+} from the mixture of Cu^{2+} and Cd^{2+} in aqueous solution,

$Cu^{2+} + Cd^{2+} \xrightarrow[\text{KCN}]{\text{Add excess}} \xrightarrow[\text{and filter}]{\text{Pass } HS_2} Cu^{2+}$ in the precipitate

(c) Zn^{2+} from the mixture of Zn^{2+} and Cu^{2+} in aqueous solution,

$Zn^{2+} + Cu^{2+} \xrightarrow{H_2S + \text{dil HCl}} \xrightarrow{\text{Filter}} Zn^{2+}$ in the precipitate

(d) Fe^{3+} from the mixture of Fe^{2+} and Fe^{3+} in aqueous solution,

$Fe^{2+} + Fe^{3+} \xrightarrow{NH_4Cl + NH_3 \text{ solution and filter}} Fe^{3+}$ in the precipitate

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

(Mixture of two anions)

$A \xrightarrow{\text{Dil HCl}} B$ (Acidic gas) $\xrightarrow{Cr_2O_7^{2-}/H^+} C$ (Green)

$\downarrow CaCl_2$

K (White ppt.) + E (Filtrate) $\xrightarrow{BaCl_2} S$ (White) $\xrightarrow{\text{Dil HCl}} G$ Yellow turbidity

$\xrightarrow[\text{Boil}]{Na_2SO_3} H \xrightarrow{FeCl_3} I$

$H \xrightarrow{Pb(NO_3)_2} J \xrightarrow{\text{Warming}} V$ (Black)

1. Find out V, J:

(a) ZnS, $Ag_2S_2O_3$ (b) Ag_2S, $Ag_2S_2O_3$

(c) $Pb_2S_2O_3$, PbS (d) None of these

2. Find out V, K, B:

(a) ZnS, H_2S, Cr^{3+} (b) Ag_2S, $CaSO_3$, H_2S

(c) $Pb_2S_2O_3$, $CaSO_3$, SO_2 (d) None of these

3. Find out S, B:

(a) $BaSO_3$, SO_2 (b) $BaSO_3$, H_2S

(c) BaS_2O_3, SO_2 (d) None of these

Comprehension-2: (Q. 4 to Q. 8)

(E) White ppt. $\xleftarrow{Na_2CO_3} (A) \xrightarrow{KI_{(aq.)}} (B)$ Yellow precipitate $\xrightarrow{BaCl_{2(aq.)}}$

$(E) \xrightarrow{\text{aqueous suspension}}$ Brown ppt.

(C) White precipitate $\xrightarrow{NH_4OH \text{ excess}}$ Solution of (D)

Answer the following questions:

4. Compound (A) is:

(a) $CuSO_4$ (b) $AgNO_3$

(c) $Pb(NO_3)_2$ (d) $Ca(NO_3)_2$

5. Yellow precipitate (B) is:

(a) AgI (b) PbI_2

(c) CaI_2 (d) CH_3I

6. White precipitate (C) obtained on treatment with aqueous solution of $BaCl_2$ is:

(a) $BaSO_4$ (b) $AgCl$

(c) $PbCl_2$ (d) $CaCl_2$

7. The compound (D) obtained when (C) dissolves in excess of NH_4OH will be:

(a) $AgOH$ (b) $[Ag(NH_3)_2]Cl$

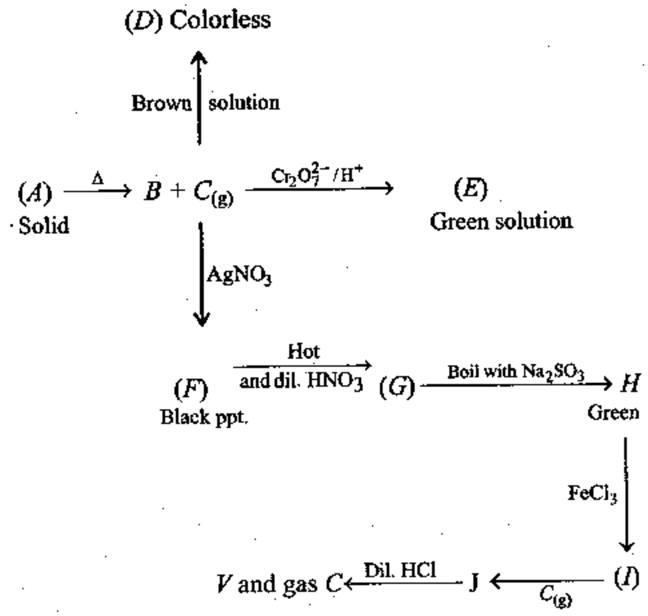
(c) Ag_2O (d) $AgNO_3$

8. Molecular formula of the compound E is:

(a) Ag_2O (b) $Pb(OH)_2$

(c) $AgOH$ (d) Ag_2CO_3

Comprehension-3: (Q. 9 to Q. 11)



9. Find out V, J:

(a) Ag_2S, Cr^{3+} solution (b) $FeSO_4$, $FeCl_2$

(c) $FeCl_2$, FeS (d) None of these

10. Find out V, B:

(a) FeS, Fe^{2+} (b) FeS, Cr^{3+}

(c) $FeCl_2$, Cr^{3+} (d) None of these

11. Find out A, B:

(a) $(NH_4)_2SO_4$, NH_3 (b) $(NH_4)_2S$, NH_3

(c) $(NH_4)_2CO_3$, CO_2 (d) None of these

Comprehension-4: (Q. 12 to Q. 14)

A colorless solid (A) dissolves in water to a yellowish-brown solution. The solution gives a white ppt. with $BaCl_2$ solution, the white ppt. is insoluble in HCl or HNO_3. When NH_4OH or NaOH is added to a solution of (A), a brown ppt. is formed which does not dissolve in NaOH solution. The brown ppt. dissolves in conc. HCl to give a reddish brown solution which gives a blue ppt. with $[K_4Fe(CN)_6]$ solution. When solid (A) is heated, a colorless gas is evolved and a brown residue is left.

12. Identify A:

(a) $FeSO_4$ (b) $Fe_2(SO_4)_3$

(c) $FeSO_4$ (d) FeO

13. What is the formula of brown ppt?

(a) $Fe(OH)_3$ (b) $Fe(OH)_2$

(c) $FeCl_3$ (d) None of these

14. Which of the following complex is formed when A reacts with $K_4[(Fe(CN)_6]$:

(a) Prussian blue (b) Turnbull's blue

(c) Brown ring complex (d) Sodium nitroprusside

Comprehension-5: (Q. 15 to Q. 18)

A dark brown solid (A) liberates a brown gas (B) on treatment with conc. H_2SO_4. A solution of (A) gives a red-brown precipitate (C) with dilute NaOH or NH_4OH insoluble in an excess of either reagent. A solution of (A) gives a cream-colored (light yellow) precipitate (D) with $AgNO_3$ that is insoluble in dilute HNO_3.

15. Identify A:

(a) $Fe(NO_2)_3$ (b) $ZnBr_2$

(c) $FeBr_3$ (d) $ZnCl_2$

16. Identify B:

(a) Cl_2 (b) Br_2

(c) NO_2 (d) I_2

17. Identify C:

(a) $Fe(OH)_3$ (b) Fe_2O_3

(c) FeO (d) FeS

18. Identify D:

(a) AgCl (b) AgF

(c) AgBr (d) None of these

Comprehension-6: (Q. 19 to Q. 22)

An aqueous green solution (A) is treated with NH_4OH when a greenish ppt. (B) is formed which is treated with Na_2O_2 when a yellow solution (C) results. Acidification causes the color of the solution to change from yellow to orange. Addition of dilute aqueous $Pb(NO_3)_2$ to the orange solution after addition of base produces a bright yellow ppt. (D).

19. Identify A:

(a) $AlCl_3$ (b) $Cr(OH)_3$

(c) $CrCl_3$ (d) None of these

20. Identify B:

(a) $CrCl_3$ (b) $Cr(OH)_3$

(c) $Mn(OH)_2$ (d) CrO_4^{2-}

21. Identify C:

(a) $Na_2Cr_2O_7$ (b) Na_2CrO_4

(c) Na_2MnO_4 (d) $NaMnO_4$

22. Identify D:

(a) PbS (b) PbI_2

(c) $PbCrO_4$ (d) $Zn(OH)_2$

Comprehension-7: (Q. 23 to Q. 26)

A white water insoluble solid (*A*) turns yellow on heating and becomes white on cooling. Solid (*A*) gives a clear solution (*B*) when treated with HCl solution or treatment with excess NaOH solution (*C*). When H_2S is bubbled through *B* nothing is obtained; however if *B* is made neutral, H_2S causes the precipitation of white compound *D*.

23. Identify *A*:

(a) ZnS (b) ZnO
(c) MnO (d) FeO

24. Identify *B*:

(a) $FeCl_2$ (b) $NiCl_2$
(c) $ZnCl_2$ (d) $FeCl_3$

25. Identify *C*:

(a) Na_2ZnO_2 (b) $Zn(OH)_2$
(c) $Fe(OH)_3$ (d) $Fe(OH)_2$

26. Identify *D*:

(a) ZnO (b) ZnS
(c) FeO (d) FeS

Comprehension-8: (Q. 27 to Q. 30)

(i) $(A) \xrightarrow{\Delta}$ glassy transparent bead (*B*) on platinum wire $(B) + CuSO_4 \longrightarrow$ colored bead (*C*)

(ii) (A) + conc. H_2SO_4 + $CH_3CH_2OH \xrightarrow{\text{ignite}}$ green flame (*D*)

(iii) Aqueous solution of (*A*) is alkaline

27. Identify *A*:

(a) $NaNH_4HPO_4 . 4H_2O$ (b) $Na_2B_4O_7 . 10H_2O$
(c) $CuSO_4 . 5H_2O$ (d) None of these

28. What is the formula of glassy bead (*B*)?

(a) $NaPO_3$ (b) $NaBO_2$
(c) $NaBO_2 + B_2O_3$ (d) None of these

29. Identify *C*:

(a) $Cu_3(PO_4)_2$ (b) $CuSO_4$
(c) $Cu(BO_2)_2$ (d) None of these

30. Identify *D*:

(a) $(CH_3)_3BO_3$ (b) $(C_2H_5)_3BO_3$
(c) H_3BO_3 (d) none of these

Comprehension-9: (Q. 31 to Q. 33)

A colorless mixture of two salts (*A*) and (*B*) [excess] is soluble in H_2O. (*A*) turns blue litmus red and (*B*) turns red litmus blue. (*A*) gives white ppt with (*B*) which dissolves in excess of (*B*) forming (*C*). (*A*) when placed in atmosphere gives fumes and can form dimer. (*A*) gives white ppt with NH_4Cl, and NH_4OH soluble in (*B*).

31. Identify *A*:

(a) $AlCl_3$ (b) $ZnCl_2$
(c) $FeCl_3$ (d) None of these

32. Identify *B*:

(a) $Al(OH)_3$ (b) $Zn(OH)_2$
(c) NaOH (d) None of these

33. Identify *C*:

(a) Na_2ZnO_2 (b) $NaAlO_2$
(c) Na_2SnO_2 (d) None of these

Comprehension-10: (Q. 34 to Q. 36)

For the purpose of systematic qualitative analysis, cations are classified into various groups on the basis of their behavior against some reagents. The group reagents used for the classification of most common cations are hydrochloric acid, hydrogen sulphide, ammonium hydroxide, and ammonium carbonate. Classification is based on whether a cation reacts with these reagents by the formation of precipitates or not.

34. Which one among the following pairs of ions cannot be separated by H_2S in the presence of dilute hydrochloric acid?

(a) Bi^{3+}, Cd^{2+} (b) Al^{3+}, Hg^{2+}
(c) Zn^{2+}, Cu^{2+} (d) Ni^{2+}, Cu^{2+}

35. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+}. The addition of 2 M HCl will precipitate:

(a) $HgCl_2$ only (b) $PbCl_2$ only
(c) $PbCl_2$ and Hg_2Cl_2 (d) $PbCl_2$ and $CdCl_2$

36. An aqueous solution which is slightly acidic contain cations Fe^{3+}, Zn^{2+}, and Cu^{2+}. The reagent that when added in excess to this solution would identify the separate Fe^{3+} ion in one step is:

(a) 2M HCl (b) 6M NH_3
(c) 6M NaOH (d) H_2S gas

Comprehension-11: (Q. 37 to Q. 39)

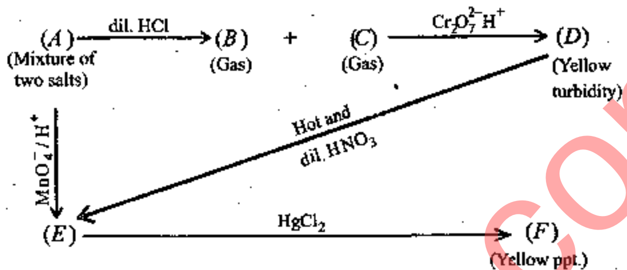
The reagents like silver nitrate, potassium ferrocyanide, potassium thiocyanate, potassium iodide, potassium chromate, Nessler's reagent, etc., find extensive and very important application in qualitative analysis because these reagents form different types of products with different cations. For example, potassium iodide forms yellow precipitate with Pb^{2+} but it forms red precipitate with Hg^{2+}. Hence, these reagents are widely used in the qualitative analysis of inorganic salts:

37. Which of the following is not correctly matched?
(a) $Ag^+ + S_2O_3^{2-} \longrightarrow$ White ppt.
(b) Pb^{2+} (aq) + $2\,Cl^{\ominus}$ (aq) $\longrightarrow$ Black precipitate
(c) BiI_3 (black precipitate) + H_2O (l) $\xrightarrow{\Delta}$ Orange turbidity
(d) Ca^{2+} (aq) + $K_4[Fe(CN)_6]$(aq) $\longrightarrow$ White precipitate

38. Which of the following cations (i.e., basic radicals) forms colored (not white) precipitates with aqueous solution of potassium iodide but precipitate does not dissolve in excess of reagent?
(a) Hg^{2+} (b) Hg_2^{2+}
(c) Bi^{3+} (d) Cu^{2+}

39. Which of the following hydroxide does not dissolve in ammonia solution but dissolves in sodium hydroxide?
(a) $Zn(OH)_2$ (b) $Cd(OH)_3$
(c) $Cu(OH)_2$ (d) $Al(OH)_3$

Comprehension-12: (Q. 40 to Q. 42)



40. Find the anion(s):
(a) SO_3^{2-} (b) SO_3^{2-}, S^{2-}
(c) SO_3^{2-}, CO_3^{2-} (d) $S_2O_3^{2-}$

41. Find out (*E*):
(a) S^{2-} (b) CO_3^{2-}
(c) $S_2O_3^{2-}$ (d) SO_4^{2-}

42. Find out (*F*):
(a) $HgSO_4{\cdot}2HgO$ (b) $HgSO_4{\cdot}3HgO$
(c) $HgSO_4$ (d) $Hg_2SO_4{\cdot}3HgO$

Comprehension-13: (Q. 43 to Q. 45)

A black colored (insoluble in H_2O) solid *A* does not dissolve in HNO_3. Aquaregia can dissolve *A* forming *B*. *B* gives yellow precipitate *C* with NaOH. *B* also gives orange ppt. *D* with KI. *D* dissolves in excess of KI forming *E*. *E* gives brown ppt. with NH_4^+ salt in presence of NaOH. *A* is precipitated if H_2S gas is passed into the solution of *B* in dil. HCl.

43. The compound *A* is:
(a) HgS (b) CuS
(c) $PbCl_2$ (d) FeS

44. The compound *C* is:
(a) $HgCl_2$ (b) $PbCl_2$
(c) HgO (d) PbO

45. The compound *E* is:
(a) PbI_2 (b) FeI_3
(c) K_2HgI_4 (d) HgI_2

Comprehension-14: (Q. 46 and Q. 47)

Cation and anion are called basic and acidic radicals, respectively, because during salt formation cation comes from base and anion comes from acid.

46. Cu^{2+} ions will be reduced to Cu^+ ions by the addition of an aqueous solution of:
(a) KI (b) KCl
(c) KSCN (d) Both (a) and (c)

47. $K_4[Fe(CN)_6]$ can be used to detect one or more out of $Fe^{2+}, Fe^{3+}, Zn^{2+}, Cu^{2+}, Cd^{2+}$:
(a) Fe^{2+}, Fe^{3+} only (b) $Fe^{3+}, Zn^{2+}, Cu^{2+}$ only
(c) All but not Cd^{2+} (d) All of these

Comprehension-15: (Q. 48 to Q. 52)

A colorless solid *A*, when placed in water, produces a heavy white turbidity *B*. Solid *A* gives a clear solution in conc. HCl. When HCl solution is added to large amount of water, *B* forms again. *B* dissolves in dilute HCl. When H_2S is passed through a suspension of *A* or *B*, a black precipitate *C* forms. Conc. H_2SO_4 added to solid *A* liberates gas *D*. Gas *D* is water-soluble and gives white precipitate *E* with a solution of mercurous salts but not with mercuric salts.

48. Identify *A*:
(a) BiOCl (b) Bi_2S_3
(c) $BiCl_3$ (d) $BaSO_4$

49. Identify *B*:
(a) BiOCl (b) BaS
(c) $BiCl_3$ (d) None of these

50. Identify *C*:
(a) BiOCl (b) Bi_2S_3
(c) $BiCl_3$ (d) H_2S

51. Identify *D*:
(a) Br_2 (b) HCl
(c) I_2 (d) Cl_2

52. Identify *E*:
(a) $Hg_2(NO_3)_2$ (b) HCl
(c) Hg_2Cl_2 (d) HNO_3

Comprehension-16: (Q. 53 to Q. 55)

An aqueous solution of an inorganic compound (*X*) gives the following reactions:
(i) With an aqueous solution of $BaCl_2$, a precipitate insoluble in dilute HCl is obtained.

(ii) Addition of excess of KI gives a brown precipitate which turns white on addition of excess hypo solution

(iii) With an aqueous solution of potassium ferrocyanide a chocolate colored ppt. is obtained.

53. Identify *X*:

(a) $CuSO_4$ (b) $BaSO_4$
(c) $BaCl_2$ (d) NaI

54. What is the formula of choclate colored ppt.?

(a) $Fe_4[Fe(CN)_6]$ (b) $Cu_2[Fe(CN)_6]$
(c) $Cu_2[Fe(CN)_4]$ (d) $Cu(CN)_2$

55. What is the formula of brown ppt.?

(a) Cu_2I_2 (b) $Cu_2I_2 + I_3^{\ominus}$
(c) CuI_2 (d) $CuSO_4$

Comprehension-17: (Q. 56 to Q. 59)

Compound (*A*) is a greenish crystalline salt which gives the following results when tested:

(a) Addition of $BaCl_2$ solution to a solution of (*A*) results in the formation of a white precipitate (*B*) which is insoluble in dilute HCl.

(b) On heating, water vapor and two gases *C* and *D* are liberated, leaving a red brown residue *E*.

(c) *E* dissolves in conc. HCl to give a yellow solution *F*.

(d) With H_2S, the solution *F* yields a yellow-white ppt. *G* which when filtrated, leaves a greenish filtrate *H*.

(e) The solution *F* gives a green solution with $SnCl_2$, and when reacted with $K_4[Fe(CN)_6]$ gives a blue ppt.

56. Identify compound *A*:

(a) $ZnSO_4{\cdot}7H_2O$ (b) $FeSO_4{\cdot}7H_2SO_4$
(c) $MgSO_4{\cdot}7H_2O$ (d) $CuSO_4{\cdot}5H_2O$

57. Gases *C* and *D* are:

(a) SO_2, SO_3 (b) SO_3, CO_2
(c) NO_2, MgO (d) ZnO, SO_3

58. Identify yellow solution *F*:

(a) Fe_2O_3 (b) $FeCl_3$
(c) $ZnCl_2$ (d) CuCl

59. Identify *G*:

(a) SO_2 (b) ZnS
(c) S (d) FeS

Comprehension-18: (Q. 60 to Q. 62)

(*A*) greenish salt soluble in water gives a greenish ppt. with NH_4OH. When this ppt. is boiled with caustic soda and bromine water (with Na_2O_2), a yellow solution is obtained. On addition of lead acetate and acetic acid to the yellow solution, a yellow ppt. is formed.

60. The formula of greenish salt is:

(a) $Cr_2(SO_4)_3$ (b) $Al_2(SO_4)_3$
(c) $FeSO_4$ (d) None of these

61. Cationic part of (*A*) greenish salt is a:

(a) I group cation (b) II group cation
(c) III group cation (d) IV group cation

62. Which of the following group reagent is used for identification of cationic part of (*A*)?

(a) $NH_4Cl + NaOH$ (b) $NH_4Cl + NH_4OH$
(c) H_2S gas in basic medium
(d) None of these

Comprehension-19: (Q. 63 to Q. 65)

A hydrate metallic salt *A*, light green in color, on careful heating, gives a white anhydrous residue *B*. *B* is soluble in water and its aqueous solution reacts with NO to give a dark brown compound *C*. *B* on strong heating gives a brown residue *D* and a mixture of two gases *E* and *F*. The gaseous mixture when passed through acidified $KMnO_4$ discharges the pink color and when passed through $BaCl_2$ solution gives a white precipitate.

63. Identify *C*:

(a) $[Fe(H_2O)_5NO]SO_4$ (b) Na_2SO_4
(c) $Na_2[Fe(CN)_5NO]$ (d) $Fe_4[Fe(CN)_6]_3$

64. Identify *B*:

(a) $ZnSO_4$ (b) $CuSO_4$
(c) $MgSO_4$ (d) $FeSO_4$

65. Identify *D*:

(a) ZnO (b) FeO
(c) Fe_2O_3 (d) CuO

Comprehension-20: (Q. 66 to Q. 69)

(*A*), an important laboratory reagent, turns red litmus blue, imparts golden yellow color in flame, and is a good precipitating agent. (*A*) reacts with Zn or Al forming H_2 gas. (*A*) gives white ppt with $ZnCl_2$ or $AlCl_3$ but ppt. dissolves in excess of (*A*).

66. Which of the following reagent is *A*?

(a) Na_2SO_4 (b) $NaNO_3$
(c) NaOH (d) KOH

67. What is the nature of *A*?

(a) Acidic (b) Basic
(c) Amphoteric (d) None of these

68. What is the formula of white ppt. When does *A* react with $ZnCl_2$?

(a) ZnS (b) $[Zn(OH)_4]^{2-}$
(c) $Zn(OH)_2$ (d) None of these

69. What is the formula of compound when *A* reacts with $AlCl_3$ in excess amount?

(a) $Al(OH)_3$ (b) Al_2O_3
(c) $Na[Al(OH)_4]$ (d) None of these

Comprehension-21: (Q. 70 to Q. 72)

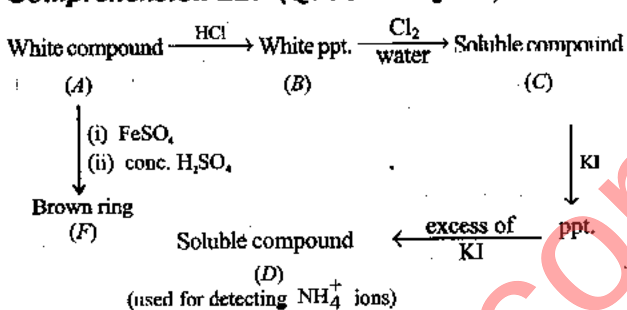
Silver nitrate gives a white recipitate (*A*) with aqueous sodium thiosulphate (*B*); the precipitate dissolves in excess of thiosulphate. If the precipitate is heated with water, it turns black (*C*), and the upper layer liquid then gives a white precipitate (*D*) with acidified barium nitrate solution.

70. What is the formula of white ppt. (*A*)?
(a) Ag_2S (b) AgS_2O_3
(c) $Ag_2S_2O_3$ (d) $AgNO_3$

71. What is the formula of black ppt. *C*?
(a) HgS (b) PbS
(c) Ag_2S (d) Ag_2CrO_4

72. What is the formula of (*D*)?
(a) BaS (b) $BaCl_2$
(c) $BaSO_4$ (d) $Ba(NO_3)_2$

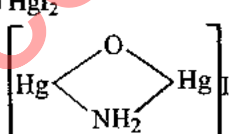
Comprehension-22: (Q. 73 to Q. 76)



73. Compound (*A*) is:
(a) HgI_2 (b) K_2HgI_4
(c) $Hg(NO_3)_2$ (d) $Hg_2(NO_3)_2$

74. Oxidation state of Fe in compound (*F*) is:
(a) +1 (b) +2
(c) +3 (d) +4

75. $(D) + (NH_4)_2SO_4 \xrightarrow[\text{in basic medium}]{} $ brown ppt. (*G*)

Hence, compound (*G*) is:
(a) HgI_2 (b) NH_4I
(c) 

(d) $Hg(NH_2)I$

76. White ppt. $(B) + NH_3 \longrightarrow$ Black ppt. (*H*)
Hence, (*H*) is due to the formation of:
(a) $Hg(NH_2)Cl$ (b) Hg
(c) $Hg(NH_2)Cl + Hg$ (d) $Hg(NH_2)$

Comprehension-23: (Q. 77 to Q. 80)

A black colored compound (*A*) on reaction with dil. H_2SO_4 gives a gas (*B*) which on passing in a solution of an acid (*C*) gives a white turbidity (*D*). Gas (*B*) when passed in an acidified solution of a compound (*E*) gives a black precipitate (*F*) which is soluble in hot concentrated (*C*). After boiling this solution when excess of ammonia solution is added, a blue colored compound (*G*) is formed. To the solution of (*E*), on addition of acetic acid and aqueous potassium ferrocyanide, a chocolate brown precipitate (*H*) is formed. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of (*E*), white precipitate insoluble in HNO_3 is obtained.

77. Black colored compound (*A*) is:
(a) PbS (b) CuS
(c) Ag_2S (d) All of these

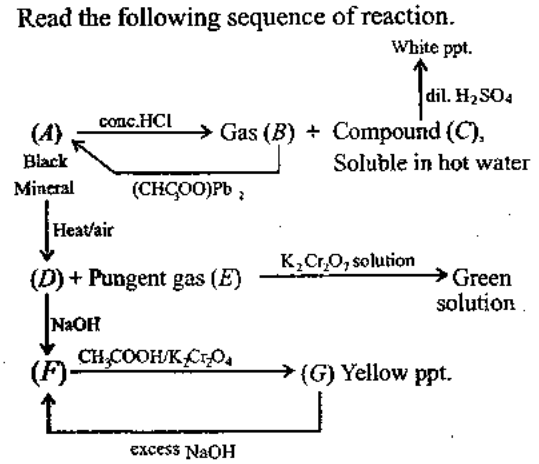
78. The gas (*B*) on passing through an acid (*C*) gives a white turbidity (*D*) because:
(a) Gas (*B*) acts as an oxidizing agent
(b) Gas (*B*) acts as an reducing agent
(c) Acid (*C*) acts as an oxidizing agent
(d) Both (b) and (c)

79. To which of the following property, will the compound(*E*) respond?
(a) It gives white precipitate with $(CH_3COO)_2Pb$ solution soluble in ammonium acetate
(b) It gives dirty white precipitate with KI
(c) Its hydrated salt effloresces
(d) All of these

80. When a piece of iron or zinc is added to the solution of compound (*F*) in hot concentrated (*C*) acid:
(a) A reddish brown precipitate is formed
(b) A white precipitate is formed
(c) A black precipitate is formed
(d) None of these

Comprehension-24: (Q. 81 to Q. 83)

Read the following sequence of reaction.



81. Gas (*B*) on passing through $CdSO_4$ solution will give:

(a) Black ppt. (b) Yellow ppt.
(c) Orange ppt. (d) No ppt.

82. Compound (*A*), (*B*), and (*E*) are, respectively:

(a) CuS, H_2S, SO_2 (b) PbS, H_2S, SO_2
(c) PbS, H_2S, SO_3 (d) ZnS, H_2S, SO_2

83. Compound (*C*) and (*D*) are, respectively:

(a) $PbO, PbCl_2$ (b) $PbCl_2, PbO$
(c) PbO, PbO_2 (d) PbS, PbO

Comprehension-25: (Q. 84 to Q. 86)

A certain metal (*A*) is boiled in dil HNO_3 to give a salt (*B*) and oxide of nitrogen (*C*). An aqueous solution of *B* with brine solution gives a ppt. (*D*) which is soluble in NH_4OH. On adding aqueous solution of (*B*) to hypo solution a white ppt. (*E*) is obtained. *E* turns black on long standing.

84. Compound *B* on strong heating gives:

(a) Hg_2O, NO_2, O_2 (b) Hg, NO_2, O_2
(c) Ag, NO_2, O_2 (d) Ag_2O, NO_2, O_2

85. Compound *D* is insoluble in water but soluble in KCN give:

(a) $[Hg(CN)_2]^-$ (b) $[Hg(CN)_4]^{2-}$
(c) $[Ag(CN)_2]^-$ (d) AgCN

86. Compound *E* on long standing slowly converts into yellow, brown, and finally black to the formation of:

(a) Hg_2S (b) Ag_2S
(c) HgS (d) $Hg(NH_2)Cl + Hg$

Comprehension-26 [Paragraph for Q. 87 to Q. 89 (more than one correct)]

A great scientist "PHUNSUKH WANGDU" collected four sample solution in different test tube for a new discovery to achieve "Nobel Prize" (Chemistry) in the year of 2010. But his very close friend "CHATUR" all of a sudden appeared in the laboratory and kicked off a bottle of amonia solution on all these samples, which caused precipitation from all samples and spoiled the experiments. But "PHUNSUKH WANGDU" told himself "ALL IS WELL" and has not lost his enthusiasm at all and found the following observation about the precipitates:

(a) White ppt. which is soluble in excess of NH_3 solution
(b) On heating white ppt. obtained from (a) produces a compound which is white in cold but yellow on heating
(c) The cation present in (b) form white ppt. with hypo solution which gives black ppt. on heating
(d) The cation present in (c) form soluble complex with excess of NH_3 solution

87. White ppts. in (a), (b), and (c), respectively, obtained are:

(a) $Zn(OH)_2, Zn(OH)_2, HgO.Hg(NH_2)NO_3$
(b) $Cd(OH)_2, Zn(OH)_2, HgO.Hg(NH_2)NO_3$
(c) $HgO.Hg(NH_2)NO_3, Zn(OH)_2, Cd(OH)_2$
(d) $Al(OH)_3, Zn(OH)_2, Pb(OH)_2$

88. The solution initially present in (a) + H_2S (basic medium) gives ppt., then (a) may have:

(a) Zn^{2+} (b) Cd^{2+}
(c) Co^{2+} (d) Ni^{2+}

89. White ppt. in (c) and the soluble complex formed from white ppt. with the hypo solution is/are:

(a) $Pb(OH)_2, [Pb(S_2O_3)_2]^{2-}$
(b) $Ag_2O, [Ag(S_2O_3)_2]^{3-}$
(c) $HgO.Hg(NH_2)NO_3, [Hg(S_2O_3)_2]^{2-}$
(d) None of these

Comprehension-27: (Q. 90 to Q. 97)

A black colored compound (*A*) on reaction with dilute H_2SO_4 gives a gas (*B*) which on passing in a solution of an acid (*C*) gives a white turbidity (*D*). Gas (*B*) when placed in an acidified solution of a compound (*E*) gives a precipitate (*F*) soluble in dilute HNO_3. After boiling this solution, when an excess of NH_4OH is added, blue colored compound (G) is formed. To this solution on addition of CH_3COOH and aqueous $K_4[Fe(CN)_6]$, a chocolate precipitate (*H*) is obtained. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of *E*, a white ppt insoluble in HNO_3 is obtained.

90. Identify *A*:

(a) $FeCl_2$ (b) $FeCl_3$
(c) FeS (d) $FeSO_4$

91. Identify *B*:

(a) CO_2 (b) H_2S
(c) SO_2 (d) SO_3

92. Identify *C*:

(a) CH_3COOH (b) HNO_3
(c) H_2S (d) CuS

93. Identify *D*:

(a) $CuSO_4$ (b) CuS
(c) S (d) H_2S

94. Identify *E*:

(a) $CuSO_4$ (b) $BaCl_2$
(c) $Cu(OH)_2$ (d) NH_3

95. Identify *F*:

(a) $CuSO_4$ (b) $BaSO_4$

(c) CuS (d) H_2S

96. Identify *G*:

(a) $K_4[Fe(CN)_6]$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $K_3[Fe(CN)_6]$ (d) None of these

97. Identify *H*:

(a) $Cu_2[Fe(CN)_6]$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $BaSO_4$ (d) $Fe_4[Fe(CN)_6]_3$

Comprehension-28: (Q. 98 to Q. 100)

A colorless water insoluble solid (*A*) decomposes on heating to give a residue (*B*) with evolution of a colorless gas which turns lime water milky. (*B*) turns yellow on heating and white on cooling. When (*B*) is heated with cobalt oxide or cobalt nitrate solution on charcoal cavity, a green mass is left on the cavity.

98. Identify *A*:

(a) $ZnSO_4$ (b) $ZnCO_3$

(c) $Zn(OH)_2$ (d) None of these

99. Identify colorless gas *B*:

(a) SO_2 (b) CO_2

(c) SO_3 (d) NO_2

100. Identify the formula of green mass:

(a) $Al_2O_3 \cdot CoO$ (b) $SnO \cdot CoO$

(c) $ZnO \cdot CoO$ (d) $MgO \cdot CoO$

Comprehension-29: (Q. 101 to Q. 103)

(i) $(A) \xrightarrow[\Delta]{NaOH} (B)(g) \xrightarrow{HCl}$ White fumes.

(ii) After (*B*) is expelled completely, resultant alkaline solution again gives gas (*B*) on heating with zinc.

(iii) $(A) \xrightarrow{\Delta} N_2O + H_2O$.

101. Identify *A*:

(a) NH_4NO_2 (b) NH_4NO_3

(c) HCl (d) Na_2SO_4

102. Identify *B*:

(a) SO_2 (b) NH_3

(c) N_2O (d) NO_2

103. What is the formula of white fumes?

(a) NH_4NO_3 (b) NH_4Cl

(c) NH_4NO_2 (d) NH_3

Comprehension-30: (Q. 104 to Q. 108)

Identification of cations can also be done using a dry test called sodium carbonate-bead test which is similar to borax-bead test.

$$Na_2CO_3 \xrightarrow[\text{oxidizing flame}]{KNO_3 \text{ fuse and heat in}} \begin{cases} \xrightarrow{\text{with MnO}} A \xrightarrow{Cl_2} B \\ \xrightarrow{\text{with } Cr_2O_3} C \xrightarrow{H_2SO_4} D \end{cases}$$

104. Identify *A*, and what is the hybridization of *A*?

(a) Na_2MnO_4, d^3s (b) $NaMnO_4$, sp^3

(c) Mn_2O_7, d^3s (d) $Na_2Cr_2O_7$, d^3s

105. Identify *B*, and what is the hybridization of *B*?

(a) Na_2MnO_4, d^3s (b) $NaMnO_4$, sp^3

(c) $Nn_2Cr_2O_7$, d^3s (d) $NaMnO_4$, d^3s

106. Identify *C* and color of *C*:

(a) Na_2CrO_4, orange (b) $Na_2Cr_2O_7$ (orange)

(c) $Na_2Cr_2O_7$, (yellow) (d) Na_2CrO_4, yellow

107. Identify D, and how many unpaired $e^{\ominus}$ are present in *D*?

(a) Na_2CO_3, 1 (b) $NaMnO_4$, 2

(c) $Na_2Cr_2O_7$, zero (d) Na_2CrO_4, zero

108. What is the color of compound *A*?

(a) Yellow (b) Green

(c) Orange (d) Brown

Comprehension-31: (Q. 109 to Q. 111)

A colorless solid (*A*) when placed into water produces a heavy white turbidity to (*B*). Solid (*A*) gives a clear solution in conc. HCl when HCl solution is added to large amounts of water, (*B*) forms again. (*B*) dissolves in dilute HCl. When H_2S is passed through a suspension of (*A*) or (*B*), a black precipitate (*C*) forms, (*C*) is insoluble in yellow ammonium sulphide $(NH_4)_2S$. Conc. H_2SO_4 added to solid (*A*) liberates gas (*D*). Gas (*D*) is water-soluble and gives white precipitate with mercuric salts (*E*) and not mercuric salts. The black precipitate (*C*) dissolves in HNO_3 (1 : 1) to give a solution to which H_2SO_4 is added followed by addition of NH_4OH when a white precipitate (*F*) is formed. (*E*) gives a black ppt. (*G*) with solution of sodium stannite.

109. When compound *E* reacts with NH_4OH, then product is a:

(a) White ppt. (b) Black ppt.

(c) Yellow ppt. (d) Green ppt.

110. Compound *C* is also formed by the following reaction:

(a) $Ba^{2+} + S_2O_3^{2-} \longrightarrow E$

(b) $Bi^{3+} + S_2O_3^{2-} \longrightarrow E$

(c) $Bi_2S_2O_3 \xrightarrow{\Delta} E$ (d) None of these

111. Compound B is not soluble in:

(a) Tartaric acid (b) HCl

(c) HNO_3 (d) H_2SO_4

Comprehension-32: (Q. 112 to Q. 114)

(A) is a colorless solid; if melts when heated and gives off a colorless gas (B) which is supporter of combustion. If heating is continued, the whole of the solid disappears. When (A) is heated with an aqueous NaOH solution, an alkaline gas (C) is evolved. When gas (B) is heated with sodamine, a colorless solid (D) is formed. When (D) is heated with dil. H_2SO_4, a colorless liquid (E) is formed.

112. The compound E has:

(a) Linear structure (b) Bent structure

(c) Tetrahedral structure (d) None of these

113. The name of compound E is:

(a) Ammonia (b) Hydrazoic acid

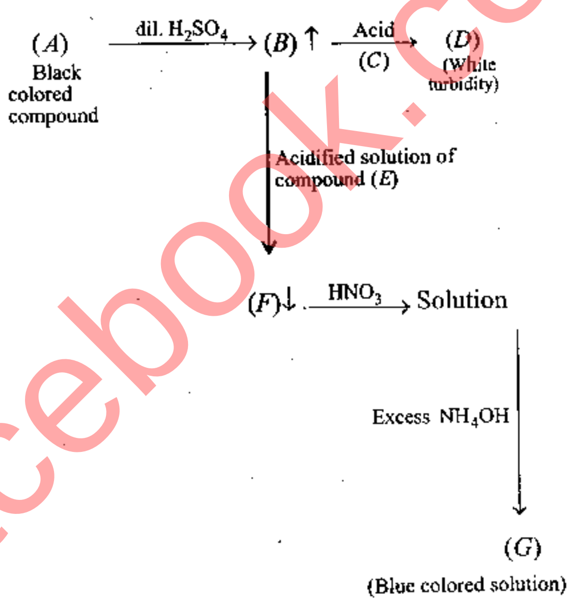
(c) Hydrogen amide (d) None of these

114. The compound C has:

(a) Linear geometry (b) Pyramidal

(c) Tetrahedral (d) None of these

Comprehension-33: (Q. 115 to Q. 117)



$(G) \xrightarrow[K_4Fe(CN)_6]{CH_3COOH} (H)$ (Chocolate ppt.)

Compound (E) (aq. solution) $\xrightarrow[\text{aq. solution}]{BaCl_2}$ White ppt. insoluble in HNO_3.

115. Compound (A) is:

(a) FeS (b) CuS

(c) NiS (d) All of these

116. Compound (G) is:

(a) $Cu(NH_3)_4(NO_3)_2$ (b) $Ni(NH_3)_4(NO_3)_2$

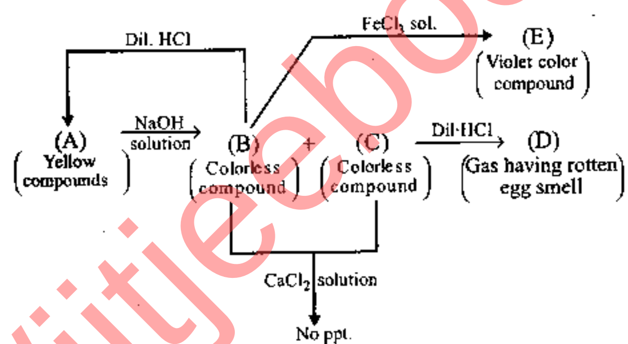
(c) $Cu(NH_3)_3NO_2$ (d) $Fe(NH_3)_2(NO_2)_2$

117. Compound (H) is:

(a) $Cu[Fe_4(CN)_6]$ (b) $Cu_2[Fe(CN)_6]$

(c) $Fe_4[Fe(CN)_6]_3$ (d) $Ni[Fe(CN)_5]$

Comprehension-34: (Q. 118 to Q. 120)



118. Compound (B) on strong heating produces compound(s) which has/have:

(a) Chain structure

(b) Tetrahedral structure

(c) Both (a) and (b)

(d) None of these

119. Which of the following statements is/are correct for gas (D)?

(I) It has the state of hybridization sp^3.

(II) Gas can be identified by $CaCl_2$ solution.

(III) Gas can be identified by $Pb(OAc)_2$ solution.

(IV) Gas can be identified by passing through sodium nitroprusside solution.

(a) I, IV (b) I, III

(c) III only (d) I, II, IV

120. Compound (B) on reaction with $[Ni(en)_3](NO_3)_2$ gives a colored complex exhibiting:

(a) Optical isomerism

(b) Geometrical isomerism

(c) Linkage isomerism

(d) No isomerism

Assertion-Reasoning Type

1. Statement-1: A solution of AgCl in NH_4OH gives a white precipitate with HNO_3.

Statement-2: $[Ag(NH_3)_2]^+$ decomposes in the presence of HNO_3.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** The solubility of $Zn(OH)_2$ is enhanced in acidic as well as in basic medium as compared to water.

Statement-2: $Zn(OH)_2$ is an amphoteric hydroxide.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Fe^{2+} react with $K_3[Fe(CN)_6]$	(p) Cherry red ppt.
(b) Fe^{3+} react with $K_4[Fe(CN)_6]$	(q) Turn bull's blue
(c) Ni^{2+} react with DMG	(r) Prussian blue
(d) Cu^{2+} react with NH_3 solution	(s) Blue solution

2. Match the column:

Column-I	Column-II
(a) Ag^+	(p) Zero group radical
(b) Pb^{2+}	(q) I group radical
(c) Fe^{3+}	(r) II group radical
(d) NH_4^+	(s) III group radical
	(t) IV group radical

3. Match the column:

Column-I	Column-II
(a) $PbSO_4$	(p) Water insoluble
(b) $BaSO_4$	(q) Water soluble
(c) AgCl	(r) Blue colored
(d) $CuSO_4$	(s) White ppt.
	(t) Compound having *d*-block cation

4. Match the column:

Column-I (Radical)	Column-II (Group reagent)
(a) Ag^+	(p) dil. HCl
(b) Al^{3+}	(q) H_2S gas in acidic medium
(c) Zn^{2+}	(r) NH_4OH in presence of NH_4Cl
(d) Cu^{2+}	(s) H_2S gas in basic medium
	(t) $(NH_4)_2CO_3$

5. There are certain chemical reagents which are used in the qualitative analysis of specific acid, i.e., anionic radicals. Match the reagent listed in column-I with acid radicals listed in column-II:

Column-I (Reagent)	Column-II (Anion)
(a) Silver nitrate solution	(p) CO_3^{2-}
(b) Barium chloride solution	(q) SO_3^{2-}
(c) Lead nitrate solution	(r) S^{2-}
(d) Acidified potassium permangnate solution	(s) NO_2^-

6. Match the salts listed in column (I) with the color of the precipitate and reagent(s) listed in column (II):

Column-I	Column-II
(a) $FeSO_4$	(p) Brown precipitate with NaOH
(b) $Bi(NO_3)_3$	(q) White precipitate with $Pb(NO_3)_2$
(c) $AgNO_3$	(r) Yellow precipitate with NH_4NO_2 and CH_3COOH on warming
(d) $CoCl_2$	(s) Black precipitate with H_2S

7. Match the precipitates of the compounds listed in column-I with the solvent(s) listed in column-II.

Column-I	Column-II
(a) $Zn(OH)_2$ precipitate dissolves in	(p) Potassium cyanide
(b) $Cr(OH)_3$ precipitate dissolves in	(q) Ammonia solution
(c) AgCl precipitate dissolves in	(r) Sodium hydroxide
(d) CuS precipitate dissolves in	(s) Sodium peroxide

8. Match the column:

Column-I	Column-II
(a) White ppt.	(p) $Fe^{3+} + SO_2 \longrightarrow$
(b) Black ppt.	(q) $Pb^{2+} + Na_2S \longrightarrow$
(c) Yellow ppt.	(r) $SO_3^{2-} + Pb(NO_3)_2 \longrightarrow$
(d) Green colouration	(s) $PbSO_3 + O_2 \xrightarrow{\text{boil}}$
	(t) $Cd^{2+} + Na_2S \longrightarrow$

9. Match the column:

Column-I	Column-II
(a) Violet color gas	(p) SO_2
(b) Rotten egg smell	(q) NO_2
(c) Brown color	(r) I_2
(d) Suffocating smell	(s) H_2S
	(t) Br_2

10. Match the column:

Column-I	Column-II
(a) PbO_2	(p) Soluble in excess alkali solution
(b) ZnO	(q) Form blue color hydroxide with alkali solution
(c) $HgCl_2$	(r) Reacts with NaOH to form colored ppt.
(d) $CuSO_4$	(s) Yellow on heating

11. Match the column:

Column-I	Column-II
(a) $NH^+_{4(aq)}\ [Co(NO_2)6]^{3-}_{(aq)} \longrightarrow$ complex	(p) Colorless water soluble complex
(b) $Cr(OH)_3\downarrow + NH_{3(aq)} \longrightarrow$ complex	(q) Yellow colored water insoluble complex
(c) $Fe(SCN)_{3(aq)} + F^-_{(aq)} \longrightarrow$ complex	(r) Value of oxidation state of metal ion and number of unpaired electrons are same
(d) $Ni(OH)_2\downarrow + NH_{3(aq)} \longrightarrow$ complex	(s) d^2sp^3-hybridization
	(t) sp^3d^2-hybridization

12. Match the substances given in column-II based on reactions given in column-I and select correct answer from the alternate:

Column-I	Column-II
(a) A white, waxy solid, normally stored under water because it spontaneously inflames in air	(p) HNO_3
(b) A viscous liquid that reacts with $BaCl_2$, giving a white ppt.	(q) Cl_2
(c) An acid that reacts with copper metal, releasing brown fumes	(r) P
(d) A pale greenish yellow gas that dissolves in aqueous NaOH to give a solution used as a bleach	(s) H_2SO_4

13. Match the column:

Column-I	Column-II
(a) HgS	(p) Black ppt.
(b) PbS	(q) White ppt.
(c) Ag_2S	(r) ppt. of II group cation
(d) ZnS	(s) Salt having *p* block cation
	(t) Salt having *d* block cation

14. Match the column

Column–I	Column–II
(a) Pb^{2+}	(p) 1st group
(b) Cu^{2+}	(q) zero group
(c) NH_4^+	(r) 3rd group
(d) Al^{3+}	(s) 2nd group

15. Column (I) contains some reagents which when taken in excess produce precipitate with radical(s) given in column (II). Accordingly match column (I) with column (II):

Column–I (Reagent)	Column–II (Radical)
(a) KCN (aq)	(p) Pb^{2+}
(b) NaOH (aq)	(q) Ag^+
(c) KI (aq)	(r) Hg_2^{2+}
(d) K_2CrO_4 (aq)	(s) Cu^{2+}

16. Match the column:

Column-I	Column-II
(a) Green coloration	(p) $HCO_3^- + BaCl_2 \xrightarrow{\text{boil}}$
(b) White ppt.	(q) $SO_3^{2-} + BaCl_2 \longrightarrow$
(c) Black ppt.	(r) $SO_2 + Cr_2O_7^{2-} \longrightarrow$
	(s) $Na_2S + Ag^+ \longrightarrow$

17. Match the column:

Column-I	Column-II
(a) Deep blue color	(p) $[Cu(NH_3)_4]SO_4$
(b) Yellow ppt.	(q) $[Cu(NH_3)_4](OH)_2$
(c) Blue ppt.	(r) $Co[Hg(SCN)_4]$
	(s) $K_3[Co(NO_2)_6]$

18. Match the column:

Column-I	Column-II
(a) White ppt.	(p) $HgSO_4{\cdot}2HgO$
(b) Yellow ppt.	(q) Ag_2CrO_4
(c) Brick red ppt.	(r) $(NH_4)_3\ P(Mo_3O_{10})_4$
(d) Blue color	(s) $MgNH_4PO_4$
	(t) CrO_5

19. Match the column:

Column-I (Reagents)	Column-II (Observation)
(a) $K_4[Fe(CN)_6]$	(p) Produces deep blue solution with $CuSO_4$ solution

(b) $(NH_4)_2S$	(q) Produces deep blue ppt. with $FeSO_4$ solution
(c) NH_4OH(excess)	(r) Produces deep blue ppt. with $FeCl_3$ solution
(d) NaOH(excess)	(s) Produces colorless solution or white ppt. with $ZnSO_4$ solution
	(t) Produces chocolate brown ppt. with $CuSO_4$ solution

20. Match the column:

Column-I (Reaction)	Column-II (Precipitate obtained as one of the products)
(a) $Hg^{2+}_{(aq)} + I^-_{(aq)} \longrightarrow$	(p) Yellow precipitate
(b) $Cu^{2+}_{(aq)} + [Fe(CN)_6]^{4-}_{(aq)} \longrightarrow$	(q) Brown precipitate
(c) $Mg^{2+}_{(aq)} + NH_{3(aq)} + HPO_4^{2-}{}_{(aq)} \longrightarrow$	(r) White precipitate
(d) $Pb^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)} \longrightarrow$	(s) Red precipitate

21. Match the column:

Column-I	Column-II
(a) Chromyl chloride test	(p) H_2S
(b) Rotten egg smell	(q) SO_2
(c) Suffocating smell	(r) $K_4[Fe(CN)_6]$
(d) Brown chocolate test of Cu^{2+}	(s) CrO_2Cl_2
	(t) $K_2Cr_2O_7$

22. Match the column:

Column–I	Column–II
(a) Canary yellow with ammonium molybdate	(p) PO_4^{3-}
(b) Brown ring test	(q) AsO_4^{3-}
(c) Acid radical decomposed by dil. H_2SO_4	(r) NO_3^-
(d) Acid radical decomposed by conc. H_2SO_4	(s) NO_2^-

23. Match the reactions listed in column (I) with the color of the precipitate(s) listed in column (II):

Column–I	Column–II
(a) $Cu^{2+}_{(aq)} + 2SCN^-_{(aq)} \xrightarrow{\text{allow to stand for sometime}}$	(p) Brown
(b) $Pb^{2+} + CrO_4^{2-} \longrightarrow$	(q) Reddish brown ppt.
(c) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow$	(r) Yellow
(d) $Mn^{2+}_{(aq)} + 2OH^-_{(aq)} \xrightarrow{\text{air}}$	(s) White

24. Match the color of precipitates listed in column (I) with the reagent(s) listed in column (II):

Column–I	Column–II
(a) Bi^{3+} gives black precipitate with	(p) Saturated solution of H_2S in water
(b) Cu^{2+} gives black precipitate with	(q) Potassium thiocyanate solution
(c) Zn^{2+} gives white precipitate with	(r) Potassium iodide solution
(d) Ag^+ gives white precipitate with	(s) Potassium ferrocyanide solution

25. Match the column:

Column-I	Column-II
(a) White ppt.	(p) $CO_3^{2-} + BaCl_2 \longrightarrow$
(b) Brown ppt.	(q) $CO_3^{2-} + Pb(NO_3)_2 \longrightarrow$
(c) Reddish-brown ppt.	(r) $Ag_2CO_3 \xrightarrow{\Delta} Ag_2O$
	(s) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow$

26. Match the column:

Column-I	Column-II
(a) White turbidity	(p) $IO_3^- + SO_2 +$ starch $\longrightarrow$
(b) Rotten egg smell	(q) $SO_2 + MnO_4^- \longrightarrow$
(c) Colorless solution	(r) $Zn + NaOH + SO_2 \longrightarrow$
(d) Blue color	(s) $SO_2 + Br_2 \longrightarrow$
	(t) $CO_2 + Ca(OH)_2 \longrightarrow$

27. Match the column:

Column-I	Column-II
(a) Pale green solution	(p) $Na_2S + Hg(NO_3)_2 \longrightarrow$
(b) Black ppt.	(q) $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$
(c) Finally purple color	(r) $Na_2S_2O_3 + BaCl_2 \longrightarrow$
(d) White ppt.	(s) $Na_2S_2O_3 + Pb(NO_3)_2 \longrightarrow$
	(t) $Fe^{3+} + S_2O_3^{2-} \longrightarrow$

28. Match the column:

Column-I	Column-II
(a) $3Fe^{3+} + 6CH_3COO^- \xrightarrow{\text{boil}}$	(p) White ppt.
(b) $S_2O_3^{2-} + [Ni(en)_3](NO_3)_2 \longrightarrow$	(q) Blood red color

(c) $Fe^{3+} + \overset{\ominus}{S}CN \longrightarrow$ — (r) Violet ppt.

(d) $CH_3COO^- + AgNO_3 \longrightarrow$ — (s) Brownish red ppt.

29. Match the column:

Column-I	Column-II
(a) $NH_3 + NaOCl \xrightarrow{\Delta}$	(p) N_2O
(b) $NH_4NO_2 + NaOH \longrightarrow$	(q) N_2
(c) $NH_4NO_3 \xrightarrow{\Delta}$	(r) NH_3
(d) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta}$	(s) H_2O

Integer Answer Type

1. Find the number of ions which are identified by dil HCl from the following:

(I) CO_3^{2-} (II) SO_3^{2-} (III) SO_4^{2-}

2. $\underset{\text{few drops}}{NaCl} + \text{Solid } K_2Cr_2O_7 + \text{conc. } H_2SO_4 \longrightarrow \underset{\text{(Reddish-brown fumes)}}{X}$

(i) How many axial d-orbitals are involved in hybridization of X?

(ii) How many s-orbital involved in hybridization of X?

(iii) Find the number of unpaired $e^{\ominus}$ in axial d-orbitals of X?

(iv) How many non axial d-orbitals are involved in hybridization of X?

(v) Find the value of magnetic moment of X?

(vi) What is the formula of X if

1. represents CrO_4^{2-} 2. represents CrO_5

3. represents $Cr_2O_7^{2-}$ 4. represents CrO_2Cl_2

3. Find the number of donor atoms in thionitro ligand $(NO\overset{\ominus}{S})$.

4. Find the number of reducing agents from the following: H_2S, SO_3, CrO_4^{2-}, Fe^{2+}, MnO_4^-.

5. Find the number of compounds which have yellow color ppt. from the given compounds:

Ag_2CrO_4, $PbCrO_4$, Hg_2CrO_4, $BaCrO_4$

6. $Na_2S + X \longrightarrow \underset{\text{purple color}}{Na_4[Fe(CN)_5(NOS)]}$

(i) The name of X is .... if –

1. represents sodium thiosulphate
2. represents brown ring complex
3. represents sodium nitroprusside
4. represents prussian blue

(ii) Find the value of magnetic moment of X.

(iii) The reason of color of X is .... if –

1. represents d–d transition
2. represents charge transfer
3. represents colorless compound

(iv) Find the number of $e^{\ominus}$(s) in non-axial d-orbitals.

7. Na_2SO_3, $NaCl$, $Na_2C_2O_4$, Na_2HPO_4, Na_2CrO_4, $NaNO_2$, CH_3CO_2Na are separately treated with $AgNO_3$ solution. In how many cases is/are white ppt. obtained?

8. How many water moelcule(s) is/are present in micro cosmic salt?

9. When aqueous solution of borax forms a complex compound, then what is the coordination number in that particular complex?

10. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+}. Out of these, how many ions will produce white precipitate with dilute HCl?

11. How many water of crystallization is(are) present in the ore carnallite?

12. The oxidation number of Cr in the product of alkaline oxidative fusion of $FeCr_2O_4$ is:

13. How many compounds liberate NH_3 on heating from the following?

$(NH_4)_2SO_4$, $(NH_4)_2CO_3$, NH_4Cl, NH_4NO_3, $(NH_4)_2Cr_2O_7$

14. $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow X$ (purple color)

(i) How many ligands are present in compound X?

(ii) Find the number of type of ambidentate ligands in X.

(iii) How many d-orbitals are involved in hybridization of X?

(iv) Find the value of magnetic moment of X.

(v) How many axial d-orbitals are involved in hybridization of X?

(vi) Find the number of total possible linkage isomer of X. Ambident behaviour of CN^- is not considered.

(vii) What is the formula of X? if –

1. represents $Fe_4[Fe(CN)_6]$
2. represents $[Fe(H_2O)_5NO]SO_4$
3. represents $[Fe(H_2O)_5NO]SO_4$
4. represents $Na_4[Fe(CN)_5(NOS)]$

15. $Ag_2S + 2NaCN \underset{}{\overset{\text{air}}{\rightleftharpoons}} X + Na_2S$

(i) How many d orbitals are involved in hybridization of X?

(ii) Predict the geometry of compound X; if –

1. represents linear geometry
2. represents tetrahedral geometry
3. represents octahedral geometry
4. represents square planar geometry

(iii) Find the value of magnetic moment of *X*.

16. $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow X + 6K_2SO_4$

(i) How many *d*-orbitals are involved in hybridization?

(ii) The reason of color of *X*; if –
1. represents *d–d* transition
2. represents charge transfer
3. represents colorless compound

(iii) What is the color of *X*? if –
1. represents brown color
2. represents green color
3. represents blue color
4. represents yellow color

(iv) What is the name of *X*? if –
1. represents brown ring complex
2. represents sodium nitroprusside
3. represents prussian blue
4. represents chromyl chloride

17. What will be the *n*-factor of the reactant in the following reaction?

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$$

18. $BO_3^{3-} + \text{conc. } H_2SO_4 + CH_3-CH_2-OH \xrightarrow{\text{ignite}} (A)$ Green flame

What is the oxidation number of central atom that is responsible for green flame in compound (*A*)?

19. Na_2SO_3, $Na_2S_2O_3$, Na_2CO_3, Na_2CrO_4 are separately treated with $AgNO_3$ solution. In how many cases is/are red ppt. obtained?

20. How many water moelcule(s) is/are present in compound which is used in borax bead test?

21. A solution of Hg^{2+} ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. Then the coordination number of mercury in the deep blue colored compound is:

22. In how many of the following reactions, one of the products is obtained as a yellow precipitate?

$$Ba^{2+} + CrO_4^{2-} \longrightarrow \text{Product}$$
$$Hg^{2+} + Co^{2+} + SCN^- \longrightarrow \text{Product}$$
$$NH_4^+ + [PtCl_6]^{2-} \longrightarrow \text{Product}$$
$$Ag^+ + CrO_4^{2-} \longrightarrow \text{Product}$$
$$NH_4^+ + [Co(NO_2)_6]^{3-} \longrightarrow \text{Product}$$

23. $Fe^{2+}(aq) + NO_3^-(aq) + H_2SO_4(conc) \longrightarrow$ Brown ring.

The oxidation number of iron in brown ring complex is:

24. $Cr_2O_7^{2-} + 4H_2O_2 + 2H^+ \xrightarrow[\text{solvent}]{\text{organic}} X + 5H_2O$

(i) How many peroxy linkage(s) is/are present in *X*?

(ii) How many *d*-orbitals are involved in hybridization of CrO_4^{2-}?

(iii) Find the value of magnetic moment of *X*.

(iv) What is the color of *X*? if–
1. represents green color
2. represents blue color
3. represents red color
4. represents brown color

25. When white ppt. of Ag_2CO_3 is dissolved in NH_3 solution, then compound *X* is formed.

(i) How many *d*-orbitals are involved in hybridization of *X*?

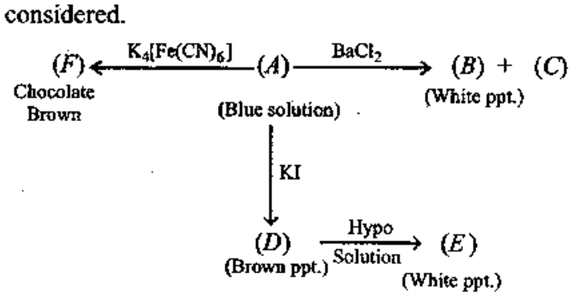
(ii) Predict the geometry of compound *X*; if –
1. represents linear geometry
2. represents tetrahedral geometry
3. represents octahedral geometry
4. represents square planar geometry

(iii) Find the value of magnetic moment of *X*.

26. $S^{2-} + Na_2[Fe(CN)_5NO] \rightarrow$ Complex is having violet/purple coloration (*X*).

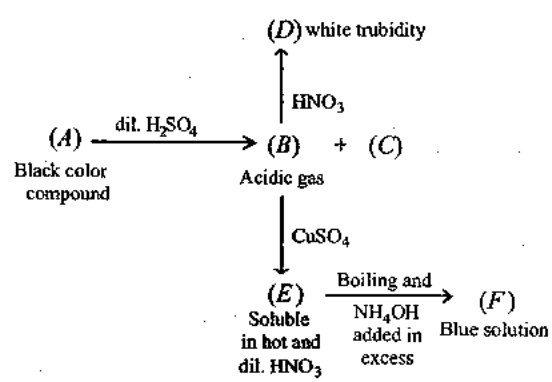
The total number of possible isomers for complex *X* is .... provided the ambident behavior of CN^- is not considered.

27.



(*A*) .... (*B*) .... (*C*) ....
(*D*) .... (*E*) .... (*F*) ....

28.



(*A*) .... (*B*) .... (*C*) ....
(*D*) .... (*E*) .... (*F*) ....

29. (A) Dissolves in water (Colorless solid)

$(A) \xrightarrow[\Delta]{Co(NO_3)_2} (D)$ (Blue mass)

$(A) \xrightarrow{NH_4OH} (B)$ Dissolves in dil. NaOH but insoluble in excess of NH_4OH

$(A) \xrightarrow{BaCl_2} (C)$ (White ppt.) (Insoluble in dil. HCl)

(A) .... (B) .... (C) ....

(D) ....

30. (A) (Colorless Solid) $\xrightarrow[\text{in water}]{\text{Dissolves}} (B)$ Yellow solution $\xrightarrow{BaCl_2} (C)$ (Insoluble in dil. HCl or HNO_3)

$(A) \xrightarrow{\Delta} (H)$ (Brown residue) $+ (I)$ (Colorless gas)

$(B) \xrightarrow{NH_4OH \text{ or } NaOH} (D)$ (Reddish-brown ppt.) (insoluble in NaOH)

$(D) \xrightarrow{\text{Conc. HCl}} (E)$

$(E) \xrightarrow{K_4Fe(CN)_6} (F)$ Blue ppt.

$(E) \xrightarrow{\overset{\ominus}{S}CN}$ Blood red color (G)

(A) .... (B) .... (C) ....

(D) .... (E) .... (F) ....

(G) .... (H) .... (I) ....

31. (A) (Greenish crystalline salt) $\xrightarrow[\text{added to a solution of } A]{BaCl_2} (B)$ (White ppt.) (Insoluble in dil. HCl)

$(A) \xrightarrow{\Delta} (E) + (D) + (C)$ (Brown residue)

$(C) \xrightarrow[\text{HCl}]{\text{Conc.}} (F) \xrightarrow{H_2S} (G)$

(A) .... (B) .... (C) ....

(D) .... (E) .... (F) ....

(G) ....

32. (D) (Brown ppt.) (Insoluble in excess of NaOH) $\xleftarrow[NH_4OH]{\text{NaOH or}} (A) \xrightarrow{AgNO_3} (B)$ (Yellow ppt.) (Insoluble in dil. HNO_3)

$(A) \xrightarrow[H_2SO_4]{\text{Conc.}} (C)$ (Brown gas)

(A) .... (B) .... (C) ....

(D) ....

33. (A) (Green solution) $\xrightarrow{NH_4OH} (B)$ (Green ppt.) $\xrightarrow{Na_2O_2} (C)$ (Yellow solution)

$(C) \xrightarrow{\text{Acidified solution}} (D)$ (Orange solution)

$(D) \xrightarrow{Pb(NO_3)_2} (E)$ (Bright yellow ppt.)

(A) .... (B) .... (C) ....

(D) .... (E) ....

34. (A) (Hydrated metallic) (Salt A light green in color) $\xrightarrow[\text{Gentle heating}]{\Delta} (B) + (C)$

$(B) + (C) \xrightarrow{\text{React with NO}} (D)$ (Brown color)

$(B) + (C) \xrightarrow{\Delta} (E)$ (Brown residue) $+ \underbrace{(F) + (G)}_{\text{Gas mixture}}$

Gas mixture $\xrightarrow{Cr_2O_7^{2-}/H^+} (H)$ (Green color)

(A) .... (B) .... (C) ....

(D) .... (E) .... (F) ....

(G) .... (H) ....

35. (A) (white ppt.) water insoluble solid turns yellow on heating and becomes white on cooling

$(A) \xrightarrow{HCl} (B) \xrightarrow{\text{Excess of NaOH}} (C)$ (Clear solution)

$(B) \xrightarrow{H_2S}$ No ppt.

(A) .... (B) .... (C) ....

36. (A) Colorless water soluble compund $\xrightarrow{\Delta} (B)$ (Brown gas) $+ (C)$ (Yellow residue) (On cooling it turns white)

$(A) \xrightarrow{NH_4OH \text{ and } H_2S} (D)$ (White ppt.)

37. In how many of the following reactions one of the products is obtained as a black precipitate?

(i) $Bi(OH)_3\downarrow + [Sn(OH)_4]^{2-}$ (aq) $\longrightarrow$ Products

(ii) Bi^{3+} (aq) + I^- (aq) (not in excess) $\longrightarrow$ Products

(iii) Ag^+ (aq) + H_2S (g) $\xrightarrow{H^+}$ Products

(iv) $[BiI_4]^-$ (aq) + H_2O (l) $\xrightarrow{\text{Dilution}}$ Products

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. When H_2S is passed through Hg_2S, we get:

(a) HgS (b) $HgS + Hg_2S$
(c) $Hg_2S + Hg$ (d) None of these

(AIEEE, 2002)

2. How do we differentiate between Fe^{3+} and Cr^{3+} in group III?

(a) By taking excess of NH_4OH solution
(b) By increasing NH_4^+ ion concentration
(c) By decreasing OH^- ion concentration
(d) Both (b) and (c)

(AIEEE, 2002)

3. Which one of the following statements is correct?

(a) From a mixed precipitate of AgCl and AgI, ammonia solution dissolves only AgCl
(b) Ferric ions give a deep green precipitate on adding potassium ferrocyanide solution
(c) On boiling a solution having K^+, Ca^{2+}, and HCO_3^- ions, we get a precipitate of $K_2Ca(CO_3)_2$
(d) Manganese salts give a violet borax bead test in the reducing flame

(AIEEE, 2003)

4. The compound formed in the positive test for nitrogen with the Lassaigne solution of an organic compound is

(a) $Fe_4[Fe(CN)_6]_3$ (b) $Na_3[Fe(CN)_6]$
(c) $Fe(CN)_3$ (d) $Na_4[Fe(CN)_5NOS]$

(AIEEE, 2004)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. If metal ions of group III are precipitated by NH_4Cl and NH_4OH without prior oxidation by concentrated HNO_3, ________ is not completely precipitated.

(IIT-JEE, 1984)

2. The formula of the deep-red liquid formed on warming dichromate with KCl in concentrated sulphuric acid is ________.

(IIT-JEE, 1993)

True/False Type

1. The addition of ammonium chloride to a solution containing ferric and magnesium ions is essential for selective precipitation of ferric hydroxide by aqueous ammonia.

(IIT-JEE, 1985)

2. From the solution containing copper (+2) and zinc (+2) ions, copper can be selectively precipitated using sodium sulphide.

(IIT-JEE, 1987)

Single Correct Answer Type

1. The ion that cannot be precipitated by both HCl and H_2S is:

(a) Pb^{2+} (b) Cu^+
(c) Ag^+ (d) Sn^{2+}

(IIT-JEE, 1982)

2. The pair of compounds which cannot exist together in solution is:

(a) $NaHCO_3$ and NaOH
(b) Na_2CO_3 and $NaHCO_3$
(c) Na_2CO_3 and NaOH
(d) $NaHCO_3$ and NaCl

(IIT-JEE, 1986)

3. The compound insoluble in acetic acid is:

(a) Calcium oxide (b) Calcium carbonate
(c) Calcium oxalate (d) Calcium hydroxide

(IIT-JEE, 1986)

4. Which of the following pairs of ions cannot be separated by H_2S in dilute HCl?

(a) Bi^{3+}, Sn^{4+} (b) Al^{3+}, Hg^{2+}
(c) Zn^{2+}, Cu^{2+} (d) Ni^{2+}, Cu^{2+}

(IIT-JEE, 1986)

5. Which compound is formed when excess of KCN is added to an aqueous solution of copper sulphate?

(a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
(c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$

(IIT-JEE, 1995)

6. An aqueous solution of $FeSO_4{\cdot}Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:

(a) A colorless filtrate and a green residue

(b) A yellow filtrate and a green residue

(c) A yellow filtrate and a brown residue

(d) A green filtrate and a brown residue

(IIT-JEE, 1996)

7. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a:

(a) Hg_2^{+} salt (b) Cr^{2+} salt

(c) Ag^{+} salt (d) Pb^{2+} salt

(IIT-JEE, 2000)

8. A gas X is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with the evolution of a colorless gas Y. Identify X and Y:

(a) $X = CO_2$, $Y = Cl_2$ (b) $X = Cl_2$, $Y = CO_2$

(c) $X = Cl_2$, $Y = H_2$ (d) $X = H_2$, $Y = Cl_2$

(IIT-JEE, 2002)

9. $[X] + H_2SO_4 \rightarrow [Y]$ Colorless gas with irritating smell

$[Y] + H_2SO_4 + K_2Cr_2O_7 \rightarrow$ Green solution

$[X]$ and $[Y]$ are:

(a) SO_3^{2-}, SO_2 (b) Cl^-, HCl

(c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2

(IIT-JEE, 2003)

10. A sodium salt of an unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is:

(a) SO_4^{2-} (b) HCO_3^-

(c) CO_3^{2-} (d) NO_3^-

(IIT-JEE, 2004)

11. A metal nitrate reacts with KI to give a black precipitate which on addition of excess of KI converts to an orange color solution. The cation of metal nitrate is:

(a) Hg^{2+} (b) Bi^{3+}

(c) Pb^{2+} (d) Cu^{+}

(IIT-JEE, 2005)

12. $CuSO_4$ decolorizes on addition of KCN; the product is:

(a) $[Cu(CN)_4]^{2-}$

(b) Cu^{2+} get reduced to form $[Cu(CN)_4]^{3-}$

(c) $Cu(CN)_2$

(d) $CuCN$

(IIT-JEE, 2006)

13. A solution when diluted with H_2O and boiled, gives a white precipitate. On the addition of excess NH_4Cl/NH_4OH, the volume of the precipitate decreases leaving behind a white gelatinous precipitate. Identify the precipitate which dissolves in NH_4OH/NH_4Cl:

(a) $Zn(OH)_2$ (b) $Al(OH)_3$

(c) $Mg(OH)_2$ (d) $Ca(OH)_2$

(IIT-JEE, 2006)

14. The species present in the solution when CO_2 is dissolved in water are:

(a) CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}

(b) H_2CO_3, CO_3^{2-}

(c) CO_3^{2-}, HCO_3^- (d) CO_2, H_2CO_3

(IIT-JEE, 2006)

15. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colorless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep-blue crystalline precipitate. The metal ion is:

(a) Pb^{2+} (b) Hg^{2+}

(c) Cu^{2+} (d) CO^{2}

(IIT-JEE, 2007)

16. Upon treatment with ammonical H_2S, the metal ion that precipitates as a sulfide is:

(a) Fe(III) (b) Al(III)

(c) Mg(II) (d) Zn (II)

(JEE Advanced, 2013)

17. Consider the following list of reagents:

Acidified $K_2Cr_2O_7$, alkaline $KMnO_4$, $CuSO_4$, H_2O_2, Cl_2, O_3, $FeCl_3$, HNO_3 and $Na_2S_2O_3$. The total number of reagents that can oxidize aqueous iodide to iodine is.

(JEE Advanced, 2014)

Multiple Correct Answers Type

1. The reagents NH_4Cl and aqueous NH_3 will precipitate:

(a) Ca^{2+} (b) Al^{3+}

(c) Bi^{3+} (d) Mg^{2+}

(e) Zn^{2+}

(IIT-JEE, 1991)

2. Which of the following statements is/are correct with reference to the ferrous and ferric ions?

(a) Fe^{3+} gives brown color with potassium ferricyanide

(b) Fe^{2+} gives blue precipitate with potassium ferricyanide

(c) Fe^{3+} gives red color with potassium thiocyanate

(d) Fe^{2+} gives brown color with ammonium thiocyanate

(IIT-JEE, 1998)

3. A solution of colorless salt *H* on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colorless salt(s) *H* is/are:

(a) NH_4NO_3 (b) NH_4NO_2

(c) NH_4Cl (d) $(NH_4)_2SO_4$

(IIT-JEE, 2008)

4. For the given aqueous reaction, which of the statement(s) is(are) true?

$$\text{Excess KI} + K_3[Fe(CN)_6] \xrightarrow{\text{dilute } H_2SO_4} \text{brownish-yellow solution}$$

$$\downarrow ZnSO_4$$

$$\text{(white precipitate + brownish-yellow filtrate)}$$

$$\downarrow Na_4S_2O_3$$

$$\text{colorless solution}$$

(a) The first reaction is a redox reaction

(b) White precipitate is $Zn_3[Fe(CN)_6]_2$

(c) Addition of filtrate to starch solution gives blue color

(d) White precipitate is soluble in NaOH solution

(IIT-JEE, 2012)

Comprehension Type

Paragraph for Questions 1 and 2

An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl, gave a precipitate (P) and a filtrate (Q). The precipitate P was found to dissolve in hot water. The filtrate (Q) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (R) with H_2S in an ammoniacal medium. The precipitate R gave a colored solution (S), when treated with H_2O_2 in an aqueous NaOH medium.

1. The colored solution S contains:

(a) $Fe_2(SO_4)_3$ (b) $CuSO_4$

(c) $ZnSO_4$ (d) Na_2CrO_4

(JEE Advanced, 2013)

2. The precipitate P contains:

(a) Pb^{2+} (b) Hg_2^{2+}

(c) Ag^+ (d) Hg^{2+}

(JEE Advanced, 2013)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is also true; Statement-II is the correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** A very dilute acidic solution of Cd^{2+} and Ni^{2+} gives yellow precipitate of CdS on passing H_2S.

Statement-II: The solubility product of CdS is more than that of NiS.

(IIT-JEE, 1989)

2. **Statement-I:** Sulphate is estimated as $BaSO_4$, not as $MgSO_4$.

Statement-II: Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.

(IIT-JEE, 1998)

Integer Answer Type

1. Among PbS, CuS, HgS, MnS, Ag_2S, NiS, CoS, Bi_2S_3, and SnS_2 the total number of **BLACK** coloured sulphides is.

(JEE Advanced, 2014)

Subjective Type

1. The precipitation of second group sulphides in qualitative analysis is carried out with hydrogensulphide in the presence of hydrochloric acid but not with nitric acid. Explain.

(IIT-JEE, 1979)

2. A white amorphous powder *A* on heating yields a colorless, non-combustible gas *B* and a solid *C*. The latter compound assumes a yellow color on heating and changes to white on cooling. *C* dissolves in dilute hydrochloric acid and the resulting solution gives a white precipitate with $K_4Fe(CN)_6$ solution. *A* dissolves in dilute HCl with the evolution of gas, which is identical in all respect with *B*. The

gas B turns lime water milky, but the milkiness disappears with the continuous passage of gas. The solution of A as obtained above gives a white precipitate D on the addition of excess of NH_4OH and passing H_2S. Another portion of the solution gives initially a white precipitate E on the addition of NaOH solution, which dissolves on further addition of base. Identify the compounds A, B, C, D, and E.

(IIT-JEE, 1979)

3. Explain the following in not more than two sentences:
"A solution of $FeCl_3$ in water gives a brown precipitate on standing."

(IIT-JEE, 1980)

4. Compound A is a light-green crystalline solid. It gives the following tests:
   (i) It dissolves in dilute sulphuric acid. No gas is produced.
   (ii) A drop of $KMnO_4$ is added to the above solution. The pink color disappears.
   (iii) Compound A is heated strongly. Gases B and C, with pungent smell, come out. A brown residue D is left behind.
   (iv) The gas mixture (B and C) is passed into a dichromate solution. The solution turns green.
   (v) The green solution from step (iv) gives a white precipitate E with a solution of barium nitrate.
   (vi) Residue D from step (iii) is heated on charcoal in a reducing flame. It gives a magnetic substance.

   Name the compounds A, B, C, D, and E.

(IIT-JEE, 1980)

5. When 16.8 g of white solid X was heated, 4.4 g of acid gas A that turned lime water milky was driven off together with 1.8 g of a gas B which condensed to a colorless liquid. The solid that remained, Y, dissolved in water to give an alkaline solution, which with excess barium chloride solution gave a white precipitate Z. The precipitate effervesced with acid giving carbon dioxide. Identify A, B, and Y, and write the equations for the thermal decomposition of X.

(IIT-JEE, 1984)

6. What happens when
   (i) Hydrogen sulphide is bubbled through an aqueous solution of sulphur dioxide.
   (ii) Aqueous ammonia is added dropwise to a solution of copper sulphate till it is in excess.
   (iii) Tin is treated with concentrated nitric acid.
   (iv) $CrCl_3$ solution is treated with sodium hydroxide and then with hydrogen peroxide.
   (v) Pb_3O_4 is treated with nitric acid.

(IIT-JEE, 1985)

7. Write the balanced equations for the reactions, when "a mixture of potassium chlorate, oxalic acid, and sulphuric acid is heated."

(IIT-JEE, 1985)

8. Mention the products formed in the following:
   (i) Zinc oxide is treated with excess of sodium hydroxide solution.
   (ii) Iodine is added to a solution of stannous chloride.
   (iii) Sulphur dioxide gas, water vapor, and air are passed over heated sodium chloride.

(IIT-JEE, 1986)

9. Write the balanced equation for the following. "Potassium permanganate is reacted with warm solution of oxalic acid in the presence of sulphuric acid."

(IIT-JEE, 1987)

10. A mixture of two salts was treated as follows:
    (i) The mixture was heated with manganese dioxide and concentrated sulphuric acid, when a yellowish-green gas was liberated.
    (ii) The mixture on heating with sodium hydroxide solution gave a gas which turned red litmus blue.
    (iii) Its solution in water gave a blue precipitate with potassium ferricyanide and red coloration with ammonium thiocyanate.
    (iv) The mixture was boiled with potassium hydroxide and the liberated gas was bubbled through an alkaline solution of K_2HgI_4 to give a brown precipitate.

    Identify the two salts. Give ionic equations for the reactions involved in the tests (i), (ii), and (iii).

(IIT-JEE, 1988)

11. Write the balanced chemical equations for the following:
    (i) Silver chloride is treated with aqueous sodium cyanide and the product thus formed is allowed to react with zinc in an alkaline medium.
    (ii) Cobalt(II) solution reacts with KNO_2 in acetic acid medium.

(IIT-JEE, 1989)

12. The gas liberated, on heating a mixture of two salts with NaOH, gives a reddish-brown precipitate

with an alkaline solution of K_2HgI_4. The aqueous solution of the mixture on treatment with $BaCl_2$ gives a white precipitate which is sparingly soluble in concentrated HCl. On heating the mixture with $K_2Cr_2O_7$ and concentrated H_2SO_4, red vapors of *A* are produced. The aqueous solution of the mixture gives a deep-blue coloration *B* with potassium ferricyanide solution. Identify the radicals in the given mixture and write the balanced equations for the formation of *A* and *B*.

(IIT-JEE, 1991)

13. Give reason in one or two sentences for the following:
"The hydroxides of aluminium and iron are insoluble in water. However, NaOH is used to separate one from the other."

(IIT-JEE, 1991)

14. In the following reaction, identify the compounds/reaction conditions represented by *A* and *B*.
$$PbS \xrightarrow[\text{air}]{\text{Heat in}} A + PbS \xrightarrow{B} Pb + SO_2$$

(IIT-JEE, 1991)

15. A light bluish-green crystalline compound responds to the following tests:
(i) Its aqueous solution gives a brown precipitate or coloration with alkaline $K_2[HgI_4]$ solution.
(ii) Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution.
(iii) Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution.
Identify the ions present and suggest the formula of the compound.

(IIT-JEE, 1992)

16. The acidic aqueous solution of ferrous ion forms a brown complex in the presence of NO_3^- by the following two steps:
$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \rightarrow \cdots + [Fe(H_2O)_6]^{3+} + H_2O$
$[Fe(H_2O)_6]^{2+} + \cdots \rightarrow \cdots + H_2O$
Complete and balance the equations.

(IIT-JEE, 1993)

17. An orange solid *A* on heating gave a green residue *B*, a colorless gas *C*, and water vapor. The dry gas *C* on passing over heated Mg gave a white solid *D*. *D* on reaction with water gave a gas *E* which formed dense white fumes with HCl. Identify *A* to *E* and give the reactions involved.

(IIT-JEE, 1993)

18. A scarlet compound *A* is treated with concentrated HNO_3 to give a chocolate-brown precipitate *B*. The precipitate is filtered and the filtrate is neutralized with NaOH. Addition of KI to the resulting solution gives a yellow precipitate *C*. The brown precipitate *B* on warming with concentrated HNO_3 in the presence of $Mn(NO_3)_2$ produces a pink colored solution due to the formation of *D*. Identify *A*, *B*, *C*, and *D*. Write the reaction sequence.

(IIT-JEE, 1995)

19. The gradual addition of KI solution to $Bi(NO_3)_3$ solution initially produces a dark brown precipitate which dissolves in excess of KI to give a yellow solution. Write the chemical equations for the above reactions.

(IIT-JEE, 1996)

20. Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas *A* and an alkaline solution. The solution on exposure to air produces a thin solid layer of *B* on the surface. Identify the compounds *A* and *B*.

(IIT-JEE, 1996)

21. A colorless inorganic salt *A* decomposes completely at about 250°C to give only two products *B* and *C*, leaving no residue. The oxide *C* is a liquid at room temperature and neutral to moist litmus paper, while the gas *B* is a neutral oxide. White phosphorus burns in excess of *B* to produce a strong white dehydrating agent. Write the balanced equations for the reactions involved in the above process.

(IIT-JEE, 1996)

22. Element *A* burns in nitrogen to give an ionic compound *B*. Compound *B* reacts with water to give *C* and *D*. A solution of *C* becomes 'milky' on bubbling carbon dioxide. Identify *A*, *B*, *C*, and *D*.

(IIT-JEE, 1997)

23. During the qualitative analysis of a mixture containing Cu^{2+} and Zn^{2+} ions, H_2S gas is passed through an acidified solution containing these ions in order to test Cu^{2+} alone. Explain.

(IIT-JEE, 1998)

24. An aqueous solution containing 1 mol of HgI_2 and 2 mol of NaI is orange in color. On addition of excess NaI, the solution becomes colorless. The orange color reappears on subsequent addition of NaOCl.

(IIT-JEE, 1999)

25. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid.

(i) Identify the substance and explain with balanced equations.

(ii) Explain what would happen to the red litmus if the white solid were the other compound.

(IIT-JEE, 1999)

26. Write the chemical reactions associated with the "brown ring test."

(IIT-JEE, 2000)

27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate A which is insoluble in warm aqueous solution of KOH. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate B. Identify the transition metal ion. Write the chemical reactions involved in the formation of A and B.

(IIT-JEE, 2000)

28. Write the chemical reactions associated with the "borax beat test" of cobalt(II) oxide.

(IIT-JEE, 2000)

29. A white substance A reacts with dilute H_2SO_4 to produce a colorless gas B and a colorless solution C. The reaction between B and acidified $K_2Cr_2O_7$ solution produces a green solution and a slightly colored precipitate D. The substance D burns in air to produce a gas E which reacts with B to yield D and a colorless liquid. Anhydrous copper sulphate is turned blue on addition of this colorless liquid. Addition of aqueous NH_3 of NaOH to C produces first a precipitate which dissolves in the excess of the respective reagent to produce a clear solution in each case. Identify A, B, C, D, and E. Write the equations of the reactions involved.

(IIT-JEE, 2001)

30. When a white crystalline compound X is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas A is evolved. On passing A into caustic soda solution, a yellow-colored solution B is obtained. Neutralizing the solution of B with acetic acid and on subsequent addition of lead acetate, a yellow precipitate C is obtained. When X is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate D is formed. Identify A, B, C, D, and X. Write the equations of the reactions involved.

(IIT-JEE, 2002)

31. Identify the following:

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow{\text{Elemental S}} C \xrightarrow{I_2} D$$

Also, mention the oxidation state of S in all the compounds.

(IIT-JEE, 2003)

32. A mixture consists A (yellow solid) and B (colorless solid) which gives lilac color in flame.

(a) The mixture gives black precipitate C on passing H_2S gas.

(b) C is soluble in aquaregia and on evaporation of aquaregia and adding $SnCl_2$ gives greyish-black precipitate D.

(c) The salt solution with NH_4OH gives a brown precipitate.

(i) The sodium extract of the salt with CCl_4/$FeCl_3$ gives a violet layer.

(ii) The sodium extract gives yellow precipitate with $AgNO_3$ solution which is insoluble in NH_3.

Identify A and B and the precipitates C and D.

(IIT-JEE, 2003)

33. AlF_3 is insoluble in anhydrous HF but when little KF is added to the compound it becomes soluble. On addition of BF_3, AlF_3 is precipitated. Write the balanced chemical equations.

(IIT-JEE, 2004)

34.

$$\underset{\text{(White fumes having smell)}}{B} \xleftarrow{\text{Moist air}} \underset{M = \text{(Transition element colorless)}}{MCl_4} \xrightarrow{Zn} \underset{\text{(Purple color)}}{A}$$

Identify the metal M and hence MCl_4. Explain the difference in colors of MCl_4 and A.

(IIT-JEE, 2005)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

68. (a) $MgSO_4 + NH_4OH + Na_2HPO_4 \longrightarrow \underset{\text{(white ppt)}}{Mg(NH_4)PO_4} + Na_2SO_4 + H_2O$

69. (a) $Zn^{2+} + 4NH_4OH \longrightarrow [Zn(NH_3)_4]^{2+} + 4H_2O$

87. (b) $PbSO_4$ and $PbCl_2$ are insoluble in cold water.

88. (a) $AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$

89. (b) $2KNO_2 + H_2SO_4 \longrightarrow K_2SO_4 + 2HNO_2$

$2KI + H_2SO_4 \longrightarrow K_2SO_4 + 2HI$

$2HNO_2 + 2HI \longrightarrow 2H_2O + I_2 + 2NO$

I_2 + Starch $\longrightarrow$ Blue color

90. (a) $CuSO_4 + 4NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

91. (b) $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 6K_2SO_4.$

92. (b) Chromyl chloride test fails in case of chlorides of Hg, Sn, Ag, Pb, and Sb.

93. (c) $BaCrO_4$ is yellow; $BaSO_4$ is white.

94. (a) These are characteristics of bromide ion.

95. (b) K^+ imparts violet flame color.

96. (c) $BaSO_4$ is insoluble in acidic medium.

97. (c) $BaSO_3 + 2HCl\text{ (dil.)} \longrightarrow 2NaCl + H_2O + SO_2;$

$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O.$

98. (c) Group reagent for V group is ammonium carbonate in the presence of NH_4Cl and NH_4OH.

99. (d) $KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3;$

$4HNO_3 \longrightarrow 2H_2O + \underset{\text{(Brown)}}{4NO_2} + O_2.$

100. (b) $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 6K_2SO_4.$

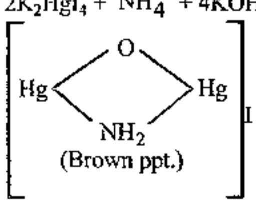
101. (a) So that only Fe, Cr, and Al are precipitated as their hydroxides.

102. (b) ZnS is white.

104. (d) As_2S_3 is soluble in yellow ammonium sulphide.

105. (c) Sb_2S_3 is orange.

106. (d) $2K_2HgI_4 + NH_4^+ + 4KOH \longrightarrow$



$I + 7HI + K^+ + 3H_2O.$

107. (b) Al^{3+}, Zn^{2+}, and Cr^{3+} form a soluble complex with excess of NaOH, whereas Fe^{3+} does not.

108. (d) $Fe(SCN)_3$ is formed which is red.

109. (d) Follow cobalt nitrate charcoal test.

$ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4;$

$ZnCO_3 \longrightarrow ZnO + CO_2;$

$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2;$

$CoO + ZnO \longrightarrow \underset{\text{(Green)}}{CoZnO_2}$

110. (d) The more is K_{sp}, the higher is solubility. Also in the presence of HCl, H_2S gives less $[S^{2-}]$ which is sufficient only to cross over the K_{sp} of II group sulphide.

111. (b) Alkali metal salts are water soluble.

112. (d) Pb forms $PbCl_2$ in I group and PbS in II group. Lead salts are partially soluble in water.

114. (a) $CuCl_2 + H_2S \longrightarrow \underset{\text{(Black)}}{CuS} + 2HCl.$

115. (a) $(CH_3COO)_2Pb + H_2S \longrightarrow 2CH_3COOH + \underset{\text{(Black)}}{PbS}$

116. (c) $PbCrO_4$, a yellow precipitate, is formed. This is chromyl chloride test.

117. (b) On heating $(NH_4)_2Cr_2O_7$, N_2 is given out with Cr_2O_3 powder at higher rate, giving a look of artificial volcano.

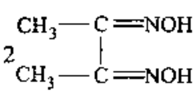
118. (a) $Fe(SCN)_3$ is a red salt soluble in water.

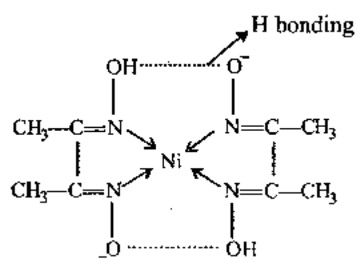
119. (a) $2Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3;$

$H_3BO_3 + 3C_2H_5OH \longrightarrow \underset{\text{Burns with green edge flame}}{(C_2H_5)_3BO_3} + 3H_2O.$

120. (a) All are white in color.

121. (a) Yellow ammonium sulphide is a solvent for As, Sb, Sn sulphides.

124. (c) $NiCl_2 + 2$  $+ 2NH_4OH \longrightarrow$



(Rosy red ppt.)

125. (d) AgCl forms soluble complex $[Ag(NH_3)_2]Cl$ with NH_3.

126. (d) HgS is insoluble in conc. HNO_3. It is soluble in aquaregia.

127. (a) $KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr,$

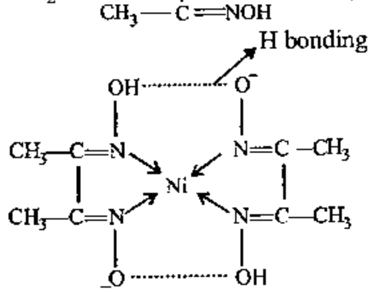
$2HBr + H_2SO_4 \longrightarrow Br_2 + 2H_2O + SO_2$

128. (a) $2Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3;$

$H_3BO_3 + 3C_2H_5OH \longrightarrow \underset{\text{Burns with green edge flame}}{(C_2H_5)_3BO_3} + 3H_2O.$

129. (b) $Hg_2Cl_2 + 2NH_4OH \longrightarrow \underbrace{Hg + HgO.Hg(NH_2)Cl}_{\text{Black}} + NH_4Cl + 2H_2O$

130. (d) $NiCl_2 + 2 \begin{array}{l} CH_3—C{=}NOH \\ \quad\;\; | \\ CH_3—C{=}NOH \end{array} + 2NH_4OH \longrightarrow$



(Rosy red ppt.)

132. (a) H_2S in neutral medium provides sufficient S^{2-} to precipitate Cu, Cd, Zn, and Mn as sulphide.

133. (c) Hg_2Cl_2 is white insoluble salt.

$Hg_2Cl_2 + 2NH_4OH \longrightarrow \underbrace{Hg + HgO.Hg(NH_2)Cl}_{\text{Black}} + NH_4Cl + 2H_2O$

134. (c) $Fe(OH)_3$ is brown.

135. (b) FeS is soluble in HCl. Also Fe^{2+} salts are green.

136. (a) Some nitrates on heating give NO_2 which bleaches most litmus paper due to its oxidizing nature.

137. (b) Any ammonium salt on heating with any alkali loses NH_3.

138. (c) It is a reason for the given fact.

139. (a) Mn^{2+} is oxidized to Mn^{7+} forming $HMnO_4$.

140. (c) $Sb_2S_3 + 6HCl \longrightarrow 2SbCl_3 + 3H_2S$;

$SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$.

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b) It is a fact. HgS is soluble in aquaregia.

2. (a) $PbCl_2$ is insoluble in cold water but soluble in hot water.

3. (a) $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow \underset{\text{(Violet)}}{Na_4[Fe(CN)_5NOS]}$

4. (d) $AgNO_3 \longrightarrow Ag + NO_2 + \frac{1}{2}O_2$;

$AgNO_3 + KI \longrightarrow AgI + KNO_3$;

$BaCl_2 + 2AgNO_3 \longrightarrow 2AgCl + Ba(NO_3)_2$

6. (b) Cu^+ disproportionates in the aqueous solution to a very large extent.

$2Cu^+ \rightleftharpoons Cu^{2+} + Cu$

$K = \frac{[Cu^{2+}]}{[Cu^+]^2} = 1.6 \times 10^6$

Thus, the concentration of Cu^+ ion is very small, and hence it cannot be precipitated.

7. (d) $As_2S_3 + 4NaOH \longrightarrow NaAsO_2 + \underset{\text{(Brick red)}}{3NaAsS_2} + 2H_2O$

8. (d) $Pb^{2+} + 2HCl \longrightarrow \underset{\text{White ppt. dissolves on boiling}}{PbCl_2\downarrow} \xrightarrow{H_2S} \underset{\text{Black ppt}}{PbS\downarrow}$

10. (a) Solubility order: AgF > AgCl > AgBr > AgI.

11. (c) $S^{2-} + 2HCl \xrightarrow{\Delta} H_2S\downarrow + 2Cl^-$

Rotten egg smell (Specific smell)

$S_2O_3^{2-} + 2HCl \xrightarrow{\Delta} \underset{\text{Suffocating smell of burning sulphur}}{SO_2\uparrow} + 2Cl^- + \underset{\text{Yellow turbidity or white turbidity}}{S\downarrow} + H_2O$

$CO_3^{2-} + 2HCl \xrightarrow[\text{or cold}]{\Delta} CO_2\uparrow + H_2O + 2Cl^-$

Odorless gas evolves with brisk effervescences

HCO_3^- also behave similarly

$NO_2^- + HCl \xrightarrow{\Delta} HNO_2 + Cl^-$

$\downarrow$

NO $\uparrow$ (colourless)

$\downarrow$ atmospheric air

$NO_2\uparrow$ (Brown color gas)

28. (c) A = $FeSO_4$; B = Fe_2O_3; C = SO_2; D = SO_3; E = $Fe(OH)_2$; F = Fe $(OH)_3$

54. (b) $AgNO_{3(aq.)} + KI_{(aq.)} \longrightarrow \underset{\text{(Yellow ppt.)}}{AgI} + KNO_3$

55. (a) $NaCl + AgNO_3 \longrightarrow \underset{\text{(White)}}{AgCl}$; CH_3Cl does not give ppt.

56. (b) $MgCl_2 + Na_2HPO_4 + NH_4OH \longrightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4} + 2NaCl + H_2O$.

57. (c) Phosphate interferes in the usual inorganic analysis after II group.

58. (b) III group radicals are precipitated as hydroxides.

60. (d) Na_2CO_3 furnishes appreciable $[CO_3^{2-}]$ to precipitate Mg.

61. (a) $CoCl_2$ is pink in color.

62. (b) $2NO + O_2 \longrightarrow 2NO_2$ (Brown).

63. (a) HBr and HI are strong reducing agents and are oxidized by H_2SO_4 to Br_2 and I_2, respectively.

64. (d) $\underset{\text{Sodium nitroprusside}}{Na_2[Fe(CN)_5NO]} + Na_2S \longrightarrow \underset{\text{Sodium thio nitroprusside (Purple)}}{Na_4[Fe(CN)_5NOS]}$

67. (c) H_2S reacts with lead acetate to give black PbS.

68. (a) Pb CrO_4, a yellow precipitate is formed.

69. (a) $[Cu(NH_3)_4]^{2+}$ is blue in color.

70. (c) $ZnS + 2HCl \longrightarrow ZnCl_2 + H_2S$;

$ZnCl_2 + 2NaOH \longrightarrow Zn(OH)_2 + 2NaCl$;

$Zn(OH)_2 + 2NaOH \longrightarrow \underset{\text{(soluble)}}{Na_2ZnO_2} + 2H_2O$

71. (a) $MgCl_2 + Na_2HPO_4 + NH_4OH \longrightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4} + 2NaCl + H_2O.$

72. (a) $Cu_2[Fe(CN)_6]$ is chocolate color insoluble compound.

73. (a) PbI_2 is yellow insoluble solid.

74. (a) $(NH_4)_2CO_3$ is group reagent for V group radicals in presence of NH_4Cl and NH_4OH.

75. (a) Hg_2Cl_2 formed is white which later on turns to Hg grey due to further reduction.

76. (b) H_2S, although weak electrolyte, furnishes appreciable $[S^{2-}]$ to precipitate subsequent group radicals as sulphides.

77. (c) $CoAlO_2$ is formed which is blue. Follow cobalt nitrate–charcoal test.

78. (b) The presence of NH_4Cl in excess reduces degree of dissociation of NH_4OH to a considerable amount, and thus, $[OH^-]$ is just sufficient to cross over the ionic concentration product of hydroxides of III group elements to their K_{sp}.

79. (d) Ba gives green falme. AgCl and $BaSO_4$ are white ppt. formed respectively.

80. (c) HNO_3 is an oxidizing agent but HCl is not.

81. (d) Oxalate of these metals are insoluble.

82. (a) In II group, sulphides are precipitated in acidic medium.

83. (a) The dissociation of H_2S is suppressed in the presence of HCl due to common ion effect, and thus, only II group radicals are precipitated.

84. (d) $2KI + Cl_2 \longrightarrow 2KCl + I_2;$

$I_2 + CCl_4 \longrightarrow$ Violet solution.

85. (b) $PbCl_2$ is insoluble in cold water but soluble in hot water, whereas AgCl is insoluble in both states.

86. (d) No change in oxidation number of Fe.

87. (b) $Br_2 + H_2O \longrightarrow$ Brown color;

$NO_2 + H_2O \longrightarrow$ Colorless.

Br_2 impart brown color to the aqueous solution while NO_2 does not.

88. (d) These are characteristics of NaBr. Br_2 is given out with H_2SO_4.

90. (b) $SO_2 + 2NaOH \longrightarrow Na_2SO_3 + H_2O$

$Na_2SO_3 + BaCl_2 \longrightarrow BaSO_3 + 2NaCl$

$Br_2 + H_2O \longrightarrow 2HBr + [O]$

$BaSO_3 + [O] \longrightarrow BaSO_4$

white ppt.

(Insoluble in conc. HNO_3)

91. (b) $S_2O_3^{2-} + 4Cl_2 + 5H_2O \longrightarrow S + SO_4^{2-} + Cl^{\ominus}$

92. (b) $3Na_2S_2O_3 + 2BiCl_3 \longrightarrow Bi_2(S_2O_3)_3 + 6NaCl$

$Bi_2(S_2O_3)_3 + 3H_2O \longrightarrow Bi_2S_3 + 3H_2SO_4$

94. (b) $\underset{\text{Mixture of two cations }(A)}{(K^+ + NH_4^+)} \xrightarrow{HClO_4} \underset{\substack{\text{White}\\(B)}}{KClO_4\downarrow} + \underset{(C)}{NH_4^+}$

$NH_4^+ \xrightarrow[\Delta]{NaOH} \underset{(D)}{NH_3\uparrow}$

$NH_3 \xrightarrow[KOH]{K_2[HgI_4]} \underset{\text{(Brown ppt.)}}{HgO\cdot Hg(NH_2)I\downarrow}$

95. (b) (a): $\rightarrow C_2O_4^{2-} + 2H^+ \xrightarrow{\text{dil. } H_2SO_4}$ No vapors or gas is evolved

$\rightarrow NO_3^-$: No reaction with dil. H_2SO_4

(b): $\rightarrow NO_3^-$: No reaction with dil. H_2SO_4

$\rightarrow NO_2^- + H^+ \xrightarrow{\text{dil. } H_2SO_4} HNO_2$

$HNO_2 \xrightarrow{\text{disproportionation}} HNO_3 + NO\uparrow$

$NO \xrightarrow{\text{atm. air}} NO_2\uparrow$ Light brown

Hence, distinction is possible.

(c) Both Cl^- and Br^- have no reaction with dil. H_2SO_4.

(d) Both HCO_3^- and CO_3^{2-} produce $CO_2\uparrow$ which evolves with effervescences.

115. (a) Fe^{2+} is oxidized to Fe^{3+} in order to precipitate $Fe(OH)_3$.

116. (d) $PbSO_4$ is white and insoluble in HNO_3 and hot water.

117. (b) Assume green crystal of $FeSO_4$

$FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

$SO_2 + MnO_4^- \longrightarrow Mn^{2+} + SO_4^{2-}$

SO_3 forms waxy white solid (H_2SO_4) in ice container which is dissolved in water and gives SO_4^{2-} ion. When $BaCl_2$ reacts with SO_4^{2-} ion, it forms white ppt. of $BaSO_4$.

118. (d) $SO_4^{2-} + BaCl_2 \longrightarrow \underset{\text{(White ppt.)}}{BaSO_4} + 2Cl^-$.

119. (c) It is a property of $COCl_2$.

120. (b) (X) is $AlCl_3$

$\underset{\text{(moisture)}}{AlCl_3 + 3H_2O} \longrightarrow Al(OH)_3\downarrow + \underset{\text{(fumes)}}{3HCl}$

$AlCl_3 + 3NH_4OH \longrightarrow Al(OH)_3\downarrow + 3NH_4Cl$

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

$AlCl_3 + H_2S + H^+ \longrightarrow$ No ppt.

121. (d) $Na_2B_4O_7 + 7H_2O \longrightarrow \underbrace{\underset{\text{Strong base}}{2NaOH} + \underset{\text{Weak acid}}{4H_3BO_3}}_{\text{Alkaline}}$

$$Na_2B_4O_7 \xrightarrow{\Delta} \underbrace{2NaBO_2 + B_2O_3}_{\text{Glassy-bead}}$$

$Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow Na_2SO_4 + 4H_3BO_3$
(white crystals)

122. (d) $\underset{(X)}{AgNO_3} \xrightarrow{\Delta} \underset{\text{(grey residue)}}{2Ag\downarrow} + 2NO_2\uparrow + \underset{(Y)}{O_2\uparrow}$

$AgNO_3 + NH_4OH \longrightarrow [Ag(NH_3)_2]^+$

$2[Ag(NH_3)_2]^+ + CH_3CHO + H_2O \longrightarrow 2Ag\downarrow + CH_3COO^- + 3NH_4^+ + NH_3$

$Ag^+ + Fe^{2+} \longrightarrow Ag\downarrow + Fe^{3+}$

$2AgNO_3 + K_2CrO_4 \longrightarrow \underset{\text{(Brick red)}}{Ag_2CrO_4\downarrow} + 2KNO_3$

123. (a) $2Br^- \xrightarrow[\text{water}]{Cl_2} Br_2$; CCl_4 layer becomes red or reddish-brown.
I^- ion is oxidized preferebly compared to Br^-. Hence I^- is absent.

124. (c)

$\underbrace{Pb^{2+}, Ag^+}$
Salt mixture
↓ dil. HCl
$\underbrace{AgCl, PbCl_2}$
White ppt.
↓ Heated with distilled water and filter in hot

- ppt. AgCl
  ↓ Excess NH_3 solution
  $[Ag(NH_3)_2]^+$
  Clear solution
- Filtrate $PbCl_2$
  ↓ Cooled
  $PbCl_2\downarrow$
  (W) Needle like crystals

125. (c) $CaCO_3 \xrightarrow{AcOH} Ca^{2+} + CO_2\uparrow$
Soluble
↓ $Na_2C_2O_4$
No dissolution of ppt. $\xleftarrow{AcOH}$ $CaC_2O_4\downarrow$

126. (c) $Hg(NO_3)_2 \xrightarrow{\Delta} \underset{(W)}{Hg(l)} + \underset{(X)}{NO_2\uparrow} + O_2\uparrow$

$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$

$\underset{(W)}{Hg} + \underset{\text{(dil.)}}{4HNO_3} \xrightarrow{\Delta} \underset{(Y)}{Hg(NO_3)_2} + 2NO\uparrow + 2H_2O$

$Hg(NO_3)_2 + Na_2S_2O_3 \longrightarrow \underset{\text{Soluble}}{Na_2[Hg(S_2O_3)_2]} + 2NaNO_3$

Multiple Correct Answers Type

28. (b), (c), (d)
Both Cu^{2+} and Cd^{2+} are precipitated in II group by H_2S in dil. HCl.

29. (b), (c), (d)
Hg_2Cl_2 is insoluble.

30. (a), (b)
Both PO_4^{3-} and AsO_4^{3-} give yellow ppt. with ammonium molybdate.

31. (a), (b), (d)
Nitrates of all the metals are water soluble and cannot be precipitated.

47. (a), (b), (c)
$Al(OH)_3$ is insoluble in water.

48. (a), (c), (d)
White salts or ions giving colorless beads do not give borax bead test.

49. (a), (b), (c)
Br^- gives $Br_2 \cdot NO_3^-$ and NO_3^- gives NO_2 gas which are brown in color.

50. (a), (b)
AgCl is completely soluble while AgBr is partially soluble in NH_4OH.

52. (a), (c)
$M + \underset{(20\%)}{\text{dil. } HNO_3} \longrightarrow M(NO_3)_2 + N_2O$
where M is metals which are more electropositive than hydrogen except Sn and Pb.
$Sn + \underset{(20\%)}{\text{dil. } HNO_3} \longrightarrow Sn(NO_3)_2 + NH_4NO_3$

66. (b), (c)
The solubility of $PbCl_2$ is already very low in water and is suppressed appreciably in the presence of dil. HCl.
$PbCl_2 + \text{conc. HCl} \rightleftharpoons \underset{\text{soluble complex}}{[PbCl_4]^{2-}}$

67. (b), (d)
It is a reason for the given fact.

72. (a), (b)
$NH_4NO_3 + NaOH \longrightarrow NH_3 + NaNO_3 + H_2O$
$7NaOH + NaNO_3 + 4Zn \longrightarrow 4Na_2ZnO_2 + NH_3 + 2H_2O$
$NH_4NO_2 + NaOH \longrightarrow NaNO_2 + NH_3 + H_2O$
$3Zn + 5NaOH + NaNO_2 \longrightarrow 3Na_2ZnO_2 + NH_3 + H_2O$

74. (a), (b), (c), (d)
All these salts react with dil. H_2SO_4.

75. (a), (b), (c)

SO_4^{2-}, PO_4^{3-}, and BO_3^{3-} do not react with conc. H_2SO_4.

76. (a), (b), (d)

(a) $Bi^{3+} + 3NH_4OH \longrightarrow Bi(OH)_3\downarrow$ (white) + $3NH_4^+$

(b) $Pb^{2+} + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow$ (white) + $2NH_4^+$

(c) Due to common ion effect of NH_4^+, the OH^- ion concentration is not excess enough to precipitate Mg^{2+} as $Mg(OH)_2$ because of its high solubility product.

(d) $Fe^{3+} + 3NH_4OH \longrightarrow Fe(OH)_3\downarrow$ (reddish-brown) + $3NH_4^+$

90. (a), (b), (c)

These are soluble in aquaregia only.

97. (b), (c), (d)

(a) $2HCO_3^- + Mg^{2+} \xrightarrow{\text{Cold}} Mg(HCO_3)_2$(soluble) $\xrightarrow{\Delta} MgCO_3\downarrow + CO_2 + 2H_2O$

(b) $Ca(HCO_3)_2 + 2NH_3 \longrightarrow (NH_4)_2CO_3 + CaCO_3\downarrow$

(c) True statement.

(d) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3\downarrow$ (reddish-brown) + $6H^+$

or

$HgCO_3{\cdot}3HgO$

Basic mercury(II) carbonate

98. (a), (b), (c)

(a) $S^{2-} + Ag^+ \longrightarrow Ag_2S; Ag_2S + HNO_3 \longrightarrow AgNO_3 + S + NO + H_2O$

(b) $S^{2-} + Cd^{2+} \longrightarrow CdS\downarrow$ (yellow)

(c) $S^{2-} + Na_2[\overset{II}{Fe}(CN)_5NO^+] \longrightarrow Na_4[\overset{II}{Fe}(CN)_5NOS]$

(d) $[Pb(OH)_4]^{2-} + H_2S \longrightarrow PbS\downarrow$ (black) + $2OH^- + 2H_2O$

99. (b), (c), (d)

(b) Red color compound of unknown composition is formed when moist SO_2 is brought in contact with $Zn[Fe(CN)_5NO]$ (salmon color) paste in water. No color change with CO_2.

(c) $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$; I_2 + starch $\longrightarrow$ blue color.

No color change observed with CO_2.

(d) $3SO_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}$(green solution) + $3SO_4^{2-} + H_2O$.

No color change observed with CO_2.

100. (c), (d)

$2I^- + Cl_2 \longrightarrow I_2$ (purple/violet)

$2I^- + Br_2 \longrightarrow I_2$ (purple/violet).

101. (a), (b), (c), (d)

(a) It is deep red coloration due to the formation of $Fe(SCN)_3$.

(b) In presence of moisture, following reaction will occur: $CrO_2Cl_2 + H_2O \longrightarrow H_2CrO_4 + HCl$; so test is carried out only in dry test tube.

(c) White precipitate of $PbSO_4$ is formed and hence brown ring is not visible.

(d) Gives yellow precipitate of CdS.

102. (a), (c), (d)

(a) $[Al(OH)_4]^- + NH_4^+ \longrightarrow Al(OH)_3$ (white) + $NH_3\uparrow + H_2O$

(b) $Pb^{2+}{}_{(aq)} + 2Br^-{}_{(aq)} \longrightarrow PbBr_2\uparrow$ (white)

(c) $BiI_3\downarrow$ (black precipitate) + $H_2O \xrightarrow{\Delta} BiOI\downarrow$ (orange)

(d) $4Fe^{3+} + 3K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3\downarrow$ blue + $12K^+$

104. (a), (b), (d)

(c) is incorrect as with KI, Cu^{2+} salts form a brown precipitate of Cu_2I_2 and $I_3^{\ominus}$.

105. (a), (b), (c), (d)

(a) $CaSO_4 + (NH_4)_2SO_4 \longrightarrow (NH_4)_2[Ca(SO_4)_2]$ (soluble)

(b) $BaCrO_4$ is insoluble in dilute acetic acid and thus gets precipitated with K_2CrO_4 (low K_{sp} in K_2CrO_4 solution in acetic acid).

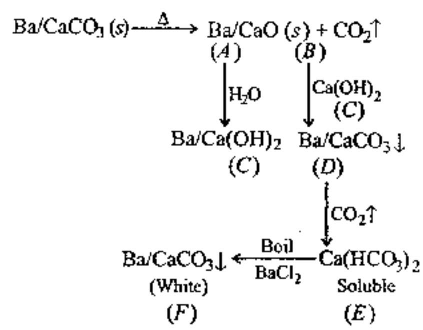
(c) $Cr(OH)_3$ is soluble in NaOH and Br_2 water forming sodium chromate while $Fe(OH)_3$ is insoluble.

(d) $[Cu(CN)_4]^{3-}$ is more stable than $[Cd(CN)_4]^{2-}$; so $[Cd(CN)_4]^{2-}$ gives yellow precipitate with H_2S.

107. (a), (b), (d)

Either CO_2 or SO_2 or $(CO_2 + SO_2)$ can give lime water test.

108. (a), (c)



Comprehension Type

Comprehension-4:

12–14. $Fe_2(SO_4)_3 \xrightarrow{\Delta} Fe_2O_3 + 3SO_3$
(A)

$Fe_2(SO_4)_3 + 3NH_4OH \longrightarrow 2Fe(OH)_3\downarrow + 3(NH_4)_2SO_4$
Reddish-brown ppt.

$2Fe(OH)_3 + 6HCl \longrightarrow 2FeCl_3 + 3H_2O$
reddish brown solution

$4FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow Fe_4[Fe(CN)_6] + 12KCl$
Prussian blue

Comprehension-5:

15–17.

$FeBr_3 + 3AgNO_3 \longrightarrow Fe(NO_3)_3 + 3AgBr\downarrow$ (light yellow ppt.)
(A) (D)

$2FeBr_3 + 3H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 3Br_2$
(B)

$FeBr_3 + 3NH_4OH \longrightarrow Fe(OH)_3\downarrow + 3NH_4Br$
(C)

Comprehension-6:

18–22. $CrCl_3 + 3NH_4OH \longrightarrow Cr(OH)_3\downarrow + 3NH_4Cl$
Green solution — Greenish ppt.

$Na_2O_2 + H_2O \longrightarrow 2NaOH + [O] \times 3$

$2Cr(OH)_3 + 4NaOH + 3[O] \longrightarrow 2Na_2CrO_4 + 5H_2O$

$2Cr(OH)_3 + 3Na_2O_2 \longrightarrow 2Na_2CrO_4 + 2NaOH + 2H_2O$
Yellow solution

$2CrO_4^{2-} + 2H^+ \longrightarrow Cr_2O_7^{2-} + H_2O$
Yellow — Orange

$Cr_2O_7^{2-} + 2OH^- + 2Pb^{2+} \longrightarrow 2PbCrO_4 + H_2O$
(Bright yellow ppt.)

Note: $CrBr_3$ (greenish black) and chromic iodide (red) are crystalline solids.

Comprehension-7:

23–26. Zinc oxide turns yellow on heating and white on cooling. (A) is ZnO which is not soluble in water. ZnO is called Chinese white, zincite, Philosopher's wool.

$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$
(B)

$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$
(C)

ZnO is amphoteric.

$ZnCl_2 + H_2S \longrightarrow$ no ppt.
(B)

This is because ZnS is precipitated in basic medium with sufficient $[S^{2-}]$ concentration.

$ZnCl_2 + H_2S \xrightarrow{NH_4OH} ZnS\downarrow + 2HCl$
(Neutral or basic solution) (D)

Comprehension-8:

27–30. (i) (A) forms glassy transparent bead which is characteristic property of borax.

$\Rightarrow$ (A) is borax $(Na_2B_4O_7 \cdot 10H_2O)$

$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} \underbrace{NaBO_2 + B_2O_3}_{(B)\ \text{Glassy bead}} + 10H_2O$

$B_2O_3 + CuSO_4 \xrightarrow{\Delta} Cu(BO_2)_2 + SO_3\uparrow$
Colored bead (C)

(ii) $Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow Na_2SO_4 + 4H_3BO_3$

$H_3BO_3 + 3C_2H_5OH \longrightarrow (C_2H_5)_3BO_3 + 3H_2O$
Green flame (on ignition)
(D)

(iii) $Na_2B_4O_7 + 5H_2O \longrightarrow 2H_3BO_3 + 2Na[B(OH)_4]$
Weak acid

$Na[B(OH)_4]$ reacts with acid (HCl); hence aqueous solution of (A) is alkaline.

Comprehension-9:

31–33. (A) gives white ppt. with NH_4Cl and NH_4OH

(A) is Al^{3+}

ppt. is of $Al(OH)_3$

$Al(OH)_3$ is soluble in (B) $\Rightarrow$ (B) is NaOH

(C) is $NaAlO_2$ (sodium meta-aluminate)

(A) forms dimer indicating (A) is electron-deficient, which is the possible case of $AlCl_3$.

(A) is thus $AlCl_3$ (acidic due to hydrolysis, turns blue litmus red)

(B) is NaOH (alkaline, turns red litmus blue)

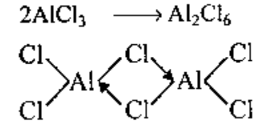
$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 + 3NaCl$
(A) (B) White ppt.

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + H_2O$
(Excess) Soluble (C)

$AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl\uparrow$ (fumes)

$AlCl_3 + 3NH_4OH \xrightarrow{NH_4Cl} Al(OH)_3\downarrow + 3NH_4Cl$

$2AlCl_3 \longrightarrow Al_2Cl_6$



Comprehension-10:

34. (a) Both Bi^{3+} and Cd^{2+} will be precipitated as Bi_2S_3 (black) and CdS (yellow) by H_2S as both have low values of K_{sp} than Al^{3+}, Zn^{2+}, and Ni^{2+} (as sulphides).

35. (c) 2*M* HCl is group reagent for group I cations. $PbCl_2$ and Hg_2Cl_2 will get precipitated, as their solubility products (K_{sp}) are less than that of other radical.

36. (b) $Fe^{3+} + 3NH_4OH \longrightarrow Fe(OH)_3\downarrow$ (reddish-brown) + $3NH_4^+$

$Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$ (blue color soluble complex)

$Zn^{2+} + 4NH_3 \longrightarrow [Zn(NH_3)_4]^{2+}$ (colorless soluble complex)

Comprehension-11:

37. (b)

(a) $Ag^+ + S_2O_3^{2-} \longrightarrow Ag_2S_2O_3$ (White ppt.)

(b) $Pb^{2+}_{(aq)} + 2Cl^{\ominus}_{(aq)} \longrightarrow PbCl_2\downarrow$

(c) $BiI_3\downarrow$ (black precipitate) $+ H_2O \xrightarrow{\Delta} BiOI\downarrow$ (orange)

(d) $Ca^{2+} + 2K^+ + [Fe(CN)_6]^{4-} \longrightarrow K_2Ca[Fe(CN)_6]\downarrow$ (white)

38. (b)

(a) $Hg^{2+} + 2I^- \longrightarrow HgI_2\downarrow$ (red / scarlet)

$HgI_2 + 2I^- \longrightarrow [HgI_4]^{2-}$ (soluble complex)

(b) $Hg_2^{2+} + 2I^- \longrightarrow Hg_2I_2\downarrow$ (green)

$Hg_2I_2 + 2I^- \longrightarrow [HgI_4]^{2-} + Hg\downarrow$ (black)

(c) $Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black)

$BiI_3\downarrow + I^- \longrightarrow [BiI_4]^-$ (orange color soluble complex)

(d) $2Cu^{2+} + 5I^- \longrightarrow 2CuI\downarrow$ (white) $+ I_3^-$

39. (d) (a) $Zn(OH)_2$ dissolves in both NaOH and NH_3 forming $[Zn(OH)_4]^{2-}$ and $[Zn(NH_3)_4]^{2+}$ respectively.

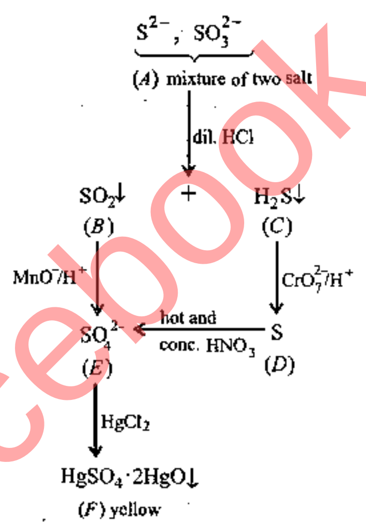
(b) $Cd(OH)_2$ dissolves in ammonia but does not dissolve in NaOH.

(c) $Cu(OH)_2 + NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$, which is a soluble complex but does not dissolve in NaOH.

(d) $Al(OH)_3 + OH^- \longrightarrow [Al(OH)_4]^-$, which is a soluble complex but does not dissolve in NH_3.

Comprehension-12:

40–42.



Comprehension-15:

48–52. $BiCl_3 + H_2O \longrightarrow BiOCl\downarrow + 2HCl$

(A) White ppt. (B) (Redissolves in HCl)

$2BiCl_3 + 3H_2S \longrightarrow Bi_2S_3 + 6HCl$

black ppt. (C)

$\underset{(A)}{2BiCl_3} + 3H_2SO_4 \xrightarrow{\Delta} \underset{(D)}{Bi_2(SO_4)_3} + 6HCl$

$Hg_2(NO_3)_2 + 2HCl \longrightarrow \underset{(E)}{Hg_2Cl_2\downarrow} + 2HNO_3$

Comprehension-16:

53–55.

(i) $CuSO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$

(ii) $2CuSO_4 + 4KI \longrightarrow 2K_2SO_4 + \underset{\text{White ppt.}}{CuI_2\downarrow} + I_2\downarrow$

$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

(iii) $2Cu^{2+} + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6] + 4K^+$

Red-brown (chocolate) ppt.

Comprehension-17:

56–59. (*A*) is $FeSO_4\cdot 7H_2O$

$FeSO_4 + BaCl_2 \longrightarrow \underset{(B)}{BaSO_4\downarrow} + FeCl_2$

$2FeSO_4 \xrightarrow{\Delta} \underset{(E)}{Fe_2O_3} + \underset{(C)}{SO_2} + \underset{(D)}{SO_3}$

$Fe_2O_3 + 6HCl \longrightarrow \underset{(F)}{2FeCl_3} + 3H_2O$

$2FeCl_3 + H_2S \longrightarrow \underset{(H)}{2FeCl_2} + 2HCl + \underset{(G)}{S}$

$2FeCl_3 + SnCl_2 \longrightarrow 2FeCl_2 + SnCl_4$

$4FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12KCl$

Note: $FeCl_3$ gives blood red coloration with thiocyanate ion:

$FeCl_3 + \underset{\text{Potassium thiocyanate}}{3KSCN} \longrightarrow \underset{\text{Blood red coloration}}{Fe(SCN)_3} + 3KCl$

Comprehension-18:

60–62. $\underset{\text{Greenish salt}}{Cr_2(SO_4)_3} + 6NH_4OH \longrightarrow \underset{\text{Greenish ppt.}}{2Cr(OH)_3} + 3(NH_4)_2SO_4$

$Br_2 + 2NaOH \longrightarrow NaBr + NaBrO + H_2O$

$NaBrO \longrightarrow NaBr + O$

$2Cr(OH)_3 + 4NaOH + 3[O] \longrightarrow 2Na_2CrO_4 + 5H_2O$

or $2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2$

$2Cr(OH)_3 + 4NaOH + [O] \longrightarrow \underset{\text{Yellow solution}}{2Na_2CrO_4} + 5H_2O$

$Na_2CrO_4 + (CH_3COO)_2Pb \xrightarrow{CH_3COOH} \underset{\text{Yellow ppt.}}{PbCrO_4\downarrow} + 2CH_3COONa$

Comprehension-19:

63–65. (*A*) is $FeSO_4\cdot 7H_2O$

$\underset{\substack{\text{Light green}\\(A)}}{FeSO_4\cdot 7H_2O} \xrightarrow{\text{Gentle heating}} \underset{\substack{\text{Colourless}\\(B)}}{FeSO_4} + 7H_2O$

$$FeSO_4 + NO \longrightarrow \underset{\text{Brown }(C)}{FeSO_4.NO}$$

$$2FeSO_4 \xrightarrow{\Delta} \underset{(D)}{Fe_2O_3} + \underset{(E)}{SO_2} + \underset{(F)}{SO_3}$$

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$SO_2 + H_2O + O \longrightarrow [H_2SO_4] \times 5$$

$$\underset{\text{(Pink)}}{2KMnO_4} + 2H_2O + 5SO_2 \longrightarrow K_2SO_4 + \underset{\text{(Almost colorless)}}{2MnSO_4} + 2H_2SO_4$$

$$SO_3 + H_2O \longrightarrow H_2SO_4;\ H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$$

Comprehension-20:

66–69. (A) turns blue litmus red $\Rightarrow$ (A) is basic in nature.

(A) imparts golden yellow color in flame $\Rightarrow$ (A) has Na^+.

(A) gives H_2 gas with Zn or Al $\Rightarrow$ (A) is NaOH.

Explanation:

$$2NaOH + Zn \longrightarrow Na_2ZnO_2 + H_2\uparrow$$
$$2NaOH + 2H_2O + 2Al \longrightarrow 2NaAlO_2 + 3H_2\uparrow$$
$$ZnCl_2 + 2NaOH \longrightarrow \underset{\text{White ppt.}}{Zn(OH)_2\downarrow} + 2NaCl$$
$$Zn(OH)_2 + 2NaOH \longrightarrow Na_2[Zn(OH)_4] \text{ or } \underset{\text{Sodium zincate}}{Na_2ZnO_2}$$
$$AlCl_3 + 3NaOH \longrightarrow \underset{\text{White ppt.}}{Al(OH)_3\downarrow} + 3NaCl$$
$$Al(OH)_3 + NaOH \longrightarrow Na[Al(OH)_4] \text{ or } \underset{\text{Sodium meta-aluminate}}{NaAlO_2}$$

Comprehension-21:

70–72. $$\underset{(B)}{2AgNO_3 + Na_2S_2O_3} \longrightarrow \underset{\text{White ppt. }(A)}{Ag_2S_2O_3\downarrow} + 2NaNO_3$$

White ppt. dissolves in excess of (B) forming a complex.

$$Ag_2S_2O_3 + 3Na_2S_2O_3 \longrightarrow \underset{\text{Soluble}}{2Na_3[Ag(S_2O_3)_2]}$$

When (A) is heated with water, there is disproportionation of $S_2O_3^{2-}$ to SO_4^{2-} and S^{2-}

$$Ag_2S_2O_3 + H_2O \longrightarrow \underset{(C)\text{ Black ppt.}}{Ag_2S\downarrow} + \underset{\text{Soluble}}{H_2SO_4}$$

H_2SO_4 remains in the upper layer and gives white ppt. (D) with a $Ba(NO_3)_2$ solution.

$$H_2SO_4 + Ba(NO_3)_2 \longrightarrow \underset{(D)}{BaSO_4\downarrow} + 2HNO_3$$

Comprehension-23:

77. (d) All are black and give gas with dil. H_2SO_4.

$$S^{2-} + 2H^+ \longrightarrow H_2S\uparrow$$

78. (d) (c) $2H\overset{+5}{N}O_3 \longrightarrow H_2O + 2\overset{+4}{N}O_2 + [O]$;

(b) $H_2\overset{-2}{S} + [O] \longrightarrow H_2O + \overset{0}{S}\downarrow$

79. (d) (a) $SO_4^{2-} + (CH_3COO)_2Pb \longrightarrow PbSO_4\downarrow + 2CH_3COO^-$

(b) $2CuSO_4 + 4KI \longrightarrow 2K_2SO_4 + Cu_2I_2\downarrow + I_2$

(c) $CuSO_4\cdot 5H_2O \xrightarrow[-2H_2O]{} CuSO_4\cdot 3H_2O$

80. (a) $$\underset{(A)}{Ag_2S, FeS, CuS \text{ or } PbS} + H_2SO_4 \longrightarrow FeSO_4 + \underset{(B)}{H_2S}$$

$$H_2S + 2HNO_3 \longrightarrow \underset{(C)}{2NO_2} + 2H_2O + \underset{(D)}{S}$$

$$\underset{(E)}{CuSO_4} + BaCl_2 \longrightarrow CuCl_2 + BaSO_4\downarrow\text{(white)}$$

$$CuSO_4 + H_2S \longrightarrow \underset{(F)}{CuS\downarrow\text{(black)}} + H_2SO_4$$

$$3CuS\downarrow + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$$

$$Cu^{2+} + 4NH_3 \longrightarrow \underset{(G)}{[Cu(NH_3)_4]^{2+}}\text{ (blue color soluble complex)}$$

$$Cu^{2+} + [Fe(CN)_6]^{4-} \longrightarrow \underset{(H)}{Cu_2[Fe(CN)_6]\downarrow}\text{ (chocolate brown)}$$

$$Cu(NO_3)_2 + Zn \longrightarrow Zn(NO_3)_2 + Cu\downarrow\text{ (reddish-brown)}$$

Comprehension-24:

81–83.

$$\underset{(A)}{PbS} \xrightarrow{\text{Conc. HCl}} \underset{(B)}{H_2S\uparrow} + \underset{(C)}{PbCl_2\downarrow}\text{ (soluble in hot water)}$$

$$\underset{(C)}{PbCl_2} \xrightarrow{\text{dil. }H_2SO_4} PbSO_4\text{(White ppt.)}$$

$$\underset{(A)}{PbS} \xrightarrow{\Delta\ \text{Air}} \underset{(D)}{PbO} + \underset{(E)}{SO_2}$$

$$\underset{(E)}{SO_2} \xrightarrow[\text{dil.}H_2SO_4]{K_2Cr_2O_7} \underset{\text{(Green sol.)}}{Cr^{3+}}$$

$$\underset{(D)}{PbO} \xrightarrow{NaOH} \underset{(F)}{[Pb(OH)_4]^{2-}} \xrightarrow[K_2Cr_2O_7]{AcOH/} \underset{(G)\text{ (Yellow ppt.)}}{PbCrO_4\downarrow}$$

$$\underset{(G)}{PbCrO_4} \xrightarrow{\text{Excess of NaOH}} \underset{(F)}{[Pb(OH)_4]^{2-}}$$

Comprehension-26:

89. (a), (c)

For test tube "a"

- If it contains Cd^{2+} then

$$Cd^{2+} \xrightarrow[\text{Solution}]{NH_3} \underset{(W)}{Cd(OH)_2\downarrow} \xrightarrow{\text{Excess of }NH_3\text{ solution}} \underset{\text{Colorless solution}}{[Cd(NH_3)_4]^{2+}}$$

- If it contains Zn^{2+} then

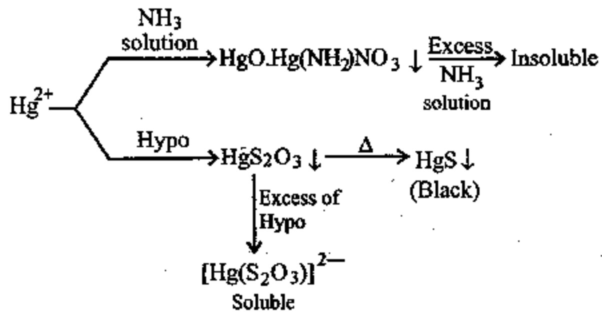
$$Zn^{2+} \xrightarrow[\text{Solution}]{NH_3} Zn(OH)_2 \xrightarrow[\text{of }NH_3\text{ solution}]{\text{Excess}} \underset{\text{(colorless solution)}}{[Zn(NH_3)_4]^{2+}}$$

For test tube "b"

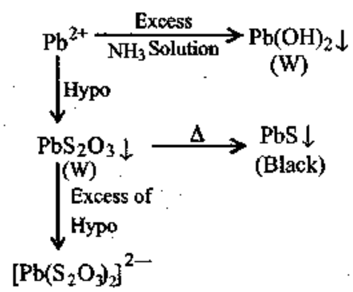
$$Zn^{2+} \xrightarrow[\text{Solution}]{NH_3} \underset{\text{(white)}}{Zn(OH)_2\downarrow} \xrightarrow{\Delta} \underset{\text{(White : cold) (Yellow : Hot)}}{ZnO}$$

For test tube "c"

- If it contains Hg^{2+} then



- If this test contains Pb^{2+}, then



Comprehension-27:

90–97.

$$\underset{(A)}{FeS} + H_2SO_4 \longrightarrow FeSO_4 + \underset{(B)}{H_2S}$$

$$\underset{(C)}{2HNO_3} + 3H_2S \longrightarrow 2NO + \underset{(D)}{3S\downarrow} + 4H_2O$$

$$\underset{(E)}{CuSO_4} + \underset{(B)}{H_2S} \longrightarrow \underset{(F)}{CuS\downarrow} + H_2SO_4$$

$$3CuS + 8HNO_3 \longrightarrow 2Cu(NO_3)_3 + 2NO + 3S$$

$$Cu(NO_3)_2 + 2NH_4OH \longrightarrow Cu(OH)_2 + 2NH_4NO_3$$

$$Cu(OH)_2 + 4NH_3 \longrightarrow \underset{\substack{\text{(Blue complex solution)}\\(G)}}{[Cu(NH_3)_4]\,(OH)_2}$$

$$2Cu^{2+} + K_4Fe(CN)_6 \longrightarrow \underset{(H)}{Cu_2\,[Fe\,(CN)_6]} + 4K^+$$

$$BaCl_2 + CuSO_4 \longrightarrow BaSO_4\downarrow + CuCl_2$$

Comprehension-28:

98–100. (A) is $ZnCO_3$ and (B) is ZnO

$$\underset{(A)}{ZnCO_3} \longrightarrow \underset{(B)}{ZnO} + CO_2$$

$$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$$

$$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2$$

$$ZnO + CoO \xrightarrow[\text{cavity}]{\text{On charcoal}} ZnO \cdot CoO$$

Comprehension-29:

101–103. By (iii) (A) gives $N_2O + 2H_2O$ on heating, hence (A) is NH_4NO_3

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$$

(i) $$NH_4NO_3 + NaOH \xrightarrow{\Delta} NaNO_3 + \underset{(B)}{NH_3} + H_2O$$

$$NH_3 + HCl \longrightarrow \underset{\text{White fumes}}{NH_4Cl} + H_2O$$

(ii) $$2NaOH + Zn \xrightarrow{\Delta} Na_2ZnO_2 + 2H$$

$$NaNO_3 + 8H \xrightarrow{\Delta} NaOH + \underset{(B)}{NH_3} + 2H_2O$$

(NH_3 gas is obtained due to reduction of NO_3^-.)

Comprehension-30:

104–108. $$Na_2CO_3 + O_2\,(\text{from } KNO_3) + MnO \longrightarrow \underset{A\ \text{(Green)}}{Na_2MnO_4} + CO_2$$

$$\underset{A}{2Na_2MnO_4} + Cl_2 \longrightarrow \underset{B\ \text{(Purple)}}{2NaMnO_4} + 2NaCl$$

$$2Cr_2O_3 + 4Na_2CO_3 + 3O_2 \longrightarrow \underset{C\ \text{(Yellow)}}{4Na_2CrO_4} + 4CO_2$$

$$\underset{(C)}{2Na_2CrO_4} + H_2SO_4 \longrightarrow \underset{D\ \text{(Orange)}}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

Comprehension-31:

109–111. $$\underset{(A)}{BiCl_3} + H_2O \longrightarrow \underset{\text{white ppt. }(B)}{BiOCl\downarrow} + 2HCl$$

$$\underset{(B)}{BiOCl} + 2HCl \longrightarrow \underset{(A)}{BiCl_3} + H_2O$$

$$2BiCl_3 + 3H_2S \longrightarrow \underset{\substack{\text{brown-black ppt.}\\(C)}}{Bi_2S_3\downarrow} + 6HCl$$

$$Bi_2S_3 + 8HNO_3 \longrightarrow 2Bi(NO_3)_3 + 3S\downarrow + 2NO + 4H_2O$$

$$2Bi(NO_3)_3 + 3H_2SO_4 \longrightarrow Bi_2(SO_4)_3 + 6HNO_3$$

$$Bi_2(SO_4)_3 + 6NH_4OH \longrightarrow \underset{\substack{\text{white ppt.}\\(F)}}{2Bi(OH)_3\downarrow} + 3(NH_4)_2SO_4$$

$$2Bi(OH)_3 + 3Na_2SnO_2 \longrightarrow \underset{\substack{(G)\\\text{black ppt.}}}{2Bi} + 3Na_2SnO_3 + H_2O$$

$$2BiCl_3 + 3H_2SO_4 \longrightarrow \underset{(D)}{Bi_2(SO_4)_3} + 6HCl$$

$$Hg_2(NO_3)_2 + 2HCl \longrightarrow \underset{\substack{\text{white ppt.}\\(E)}}{Hg_2Cl_2\downarrow} + 2HNO_3$$

Comprehension-32:

112–114. (A) is NH_4NO_3, reactions are:

(i) $$\underset{(A)}{NH_4NO_3} \xrightarrow{\Delta} \underset{(B)}{N_2O} + 2H_2O$$

$$N_2O + Mg \longrightarrow MgO + N_2$$

(ii) $$NH_4NO_3 + NaOH \xrightarrow{\text{heat}} \underset{(C)}{NH_3\uparrow} + NaNO_3 + H_2O$$

(iii) $$\underset{(B)}{N_2O} + NaNH_2 \longrightarrow \underset{\text{Sod. azide }(D)}{NaN_3} + H_2O$$

$$NaN_3 + H_2SO_4 \longrightarrow NaHSO_4 + \underset{(E)\ \text{hydrazoic acid}}{HN_3}$$

$Pb(N_3)_2$, AgN_3 (azides) are explosive.

Matching Column Type

5. (a) p, q, r, s; (b) p, q; (c) p, q, r, (d) q, r, s

(a) $Ag_2CO_3\downarrow$ (white), $Ag_2SO_3\downarrow$ (white), $Ag_2S\downarrow$ (black), $AgNO_2\downarrow$ (white)

(b) $BaCO_3\downarrow$ (white), $BaSO_3\downarrow$ (white), BaS (soluble), $Ba(NO_2)_2$ (soluble)

(c) $PbCO_3\downarrow$ (white), $PbSO_3\downarrow$ (white), $PbS\downarrow$ (black), $Pb(NO_2)_2$ (soluble)

(d) No reaction; other decolorizes pink color of $KMnO_4$

6. (a) p, q, s; (b) s; (c) z, p, s; (d) r, s

(a) $Fe(OH)_2\downarrow$ green; $PbSO_4\downarrow$ white; $FeS\downarrow$ black.

(b) $Bi_2S_3\downarrow$ black

(c) Ag_2O brown, Ag_2S(black)

(d) $(NH_4)_3[Co(NO_2)_6]\downarrow$ yellow; $CoS\downarrow$ black.

7. (a) p, q, s; (b) r, s; (c) p, q; (d) p, s

(a) $Zn(OH)_2\downarrow + 4KCN \longrightarrow K_2[Zn(CN)_4] + 2KOH$

Colorless soluble complex

$Zn(OH)_2\downarrow + 4NH_3 \longrightarrow [Zn(NH_3)_4](OH)_2$

Colorless soluble complex

$Zn(OH)_2\downarrow 2NaOH \longrightarrow Na_2[Zn(OH)_4]$

Colorless soluble complex

(b) It is slightly soluble in cold

$Cr(OH)_3\downarrow + 6NH_3 \longrightarrow [Cr(NH_3)_6]^{3+} + 3OH^-$

(Pink or violet soluble complex)

$Cr(OH)_3\downarrow + OH^- \longrightarrow [Cr(OH)_4]^-$

Green soluble complex

$2Cr(OH)_3\downarrow + 3Na_2O_2 \longrightarrow 2Na_2CrO_4 + 2NaOH + 2H_2O$

Yellow solution

(c) $AgCl\downarrow + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$

$AgCl + 2CN^- \longrightarrow [Ag(CN)_2]^- + Cl^-$

r, s $\longrightarrow$ No

(d) $2CuS\downarrow + 8CN^- \longrightarrow 2[Cu(CN)_4]^{3-} + S_2^{2-}$ colorless soluble complex (Redox reaction).

$CuS + Na_2O_2 \xrightarrow{H_2O} CuSO_4 + NaOH$

$CuS\downarrow + H_2O \longrightarrow CuSO_4$ soluble compound

15. (a) p, r; (b) q, r, s; (c) q, r, s; (d) p, q, r

(a) $Pb(CN)_2\downarrow$ (white), not soluble in excess of reagent.

$AgCN\downarrow$ (white), soluble in excess of reagent

$Hg + Hg(CN)_2\downarrow$ (black), not soluble in excess reagent.

$Cu(CN)_2\downarrow$ (yellow) $\xrightarrow{\text{Excess}} K_3[Cu(CN)_4]$ soluble.

(b) $Pb(OH)_2\downarrow$ white $\xrightarrow{\text{Excess}} Na_2[Pb(OH)_4]$ soluble.

$Ag_2O\downarrow$ brown, $Hg_2O\downarrow$ black, $Cu(OH)_2\downarrow$ blue

(c) $PbI_2\downarrow$ yellow $\xrightarrow{\text{Excess}} [PbI_4]^{2-}$ soluble complex only with concentrated solution of KI(4M).

$AgI\downarrow$ yellow $\xrightarrow{\text{Excess}}$ No reaction

$Hg_2I_2\downarrow$ green $\xrightarrow{\text{Excess}} [HgI_4]^- + Hg\downarrow$ black.

$\underbrace{CuI\downarrow \text{ white} + I_3^-}$ $\longrightarrow$ White ppt in brown colored solution.

(d) $PbCrO_4\downarrow$ yellow

$Ag_2CrO_4\downarrow$ (brick red/brownish red)

$Hg_2CrO_4\downarrow$ red (with hot solution of K_2CrO_4)

In cold, brown precipitate is obtained.

19. (a) r, s, t; (b) s; (c) p, s; (d) s

(a) $4Fe^{3+} + 3[Fe(CN)_6]^{4-} \longrightarrow \overset{III}{Fe_4}[\overset{II}{Fe}(CN)_6]_3\downarrow$

Blue ppt. (Prussian blue)

$3Zn^{2+} + 2K_4[Fe(CN)_6] \longrightarrow K_2Zn_3[Fe(CN)_6]_2\downarrow + 6K^+$

(white)

$Cu^{2+} + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6]\downarrow$

(Chocolate brown)

(b) $(NH_4)_2S + ZnSO_4 \longrightarrow ZnS\downarrow + (NH_4)_2SO_4$

(White)

(c) $Cu^{2+} + 2NH_4OH \longrightarrow Cu(OH)_2\downarrow + 2NH_4^+$

(Blue)

$\downarrow$ Excess of NH_3 solution

$[Cu(NH_3)_4]^{2+}$

Deep blue solution

$Zn^{2+} + 2NH_4OH \xrightarrow[\text{of } NH_4Cl]{\text{Absence}} Zn(OH)_2\downarrow + 2NH_4^+$

(White)

$\xrightarrow[\text{of } NH_3 \text{ solution}]{\text{Excess}} [Zn(NH_3)_4]^{2+}$

colorless solution

(d) $Zn^{2+} + 2NaOH \longrightarrow Zn(OH)_2\downarrow$

white

$\downarrow$ Excess

$[Zn(OH)_4]^{2-}$

colorless solution

23. (a) s; (b) r; (c) q; (d) p

(a) $Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2\downarrow$ (black)

$2Cu(SCN)_2\downarrow \longrightarrow 2CuSCN\downarrow$ (white) + $(SCN)_2\uparrow$

(b) $Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4$(yellow)

(c) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3\downarrow + 6H^+$

Reddish brown

(d) $Mn^{2+}(aq.) + 2OH^-(aq.) \longrightarrow Mn(OH)_2\downarrow$ (white)

$Mn(OH)_2\downarrow + O_2 \longrightarrow 2MnO(OH)_2\downarrow$ (brown)

24. (a) p, r; (b) p; (c) p, s; (d) q, s

(a) $2Bi^{3+} + 3H_2S \longrightarrow Bi_2S_3\downarrow$ Black + $6H^+$

$Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ Black

(b) $Cu^{2+} + H_2S \longrightarrow CuS\downarrow$ Black + $2H^+$

$Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2\downarrow$ Black

Which on standing slowly changes to white

$$2Cu(SCN)_2 \longrightarrow 2Cu(SCN)\downarrow \text{ white} + (SCN)_2$$

Cu_2I_2 is white precipitate, and $Cu_2[Fe(CN)_6]$ brown precipitate.

(c) $Zn^{2+} + H_2S \longrightarrow ZnS\downarrow \text{ white} + 2H^+$

$$2K^+ + 2[Fe(CN)_6]^{4-} + 3Zn^{2+} \longrightarrow K_2Zn_3[Fe(CN)_6]_2\downarrow$$
white

$ZnI_2 \longrightarrow$ soluble

(d) $4Ag^+ + [Fe(CN)_6]^{4-} \longrightarrow Ag_4[Fe(CN)_6]\downarrow$ white

$Ag^+ + SCN^- \longrightarrow AgSCN\downarrow$ white

$Ag_2S\downarrow$ black; $AgI\downarrow$ yellow

Integer Answer Type

9. (4)

$$Na_2B_4O_7 + 5H_2O \longrightarrow 2H_3BO_3 + 2Na[B(OH)_4]$$

18. (3)

$B(OCH_2{-}CH_3)_3$

23. (1)

Oxidation number of iron is one $[Fe(H_2O)_5(NO)]SO_4$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) $Hg_2S + H_2S \rightleftharpoons Hg + HgS$
2. (b) $Cr_3 + NH_4^{\oplus} \rightarrow \underset{\text{Violet or pink solution}}{[Cr_3(NH_3)_6]^{3+}}$

   $Fe^{3+} + NH_4^{\oplus} \rightarrow \underset{\text{Reddish brown gelatinous ppt}}{Fe(OH)_3\downarrow}$
3. (a) $AgCl + NH_3 \rightarrow \underset{\text{Soluble Complex}}{[Ag(NH_3)_2]^+}$

   $AgI + NH_3 \rightarrow$ Insoluble
4. (a) $Na + C + N \xrightarrow{\Delta} NaCN$

   $CN^- + Fe^{2+} \rightarrow [Fe(CN)_6]^{4-}$

   $Fe^{3+} + [Fe(CN)_6]^{4-} \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3\,xH_2O}$

JEE (Advanced) Exercises

Fill in the Blanks Type

1. If metal ions of group III are precipitated by NH_4Cl and NH_4OH without prior oxidation by concentrated HNO_3, **ferric ion not completely** precipitated. Nitric oxide oxidizes ferrous to ferric ions.
2. The formula of the deep-red liquid formed on warming dichromate with KCl in concentrated sulphuric acid is **chromyl chloride**.

   $K_2CrO_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$

   $KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

   $CrO_3 + 2HCl \rightarrow \underset{\text{Orange-red vapors}}{CrO_2Cl_2} + H_2O$

True/False Type

1. **True.**

   The addition of ammonium chloride to a solution containing ferric and magnesium ions is essential for selective precipitation of ferric hydroxide by aqueous ammonia.
2. **True.**

   From the solution containing copper (+2) and zinc (+2) ions, copper can be selectively precipitated using sodium sulphide.

Single Correct Answer Type

1. (c) Sn^{2+} cannot be precipitated by HCl, but is precipitated by H_2S as a chocolate-colored precipitate of SnS, soluble in yellow ammonium sulphide.
2. (a) $NaHCO_3$ and NaOH cannot coexist in solution because $NaHCO_3$ is an acid salt. It reacts with the base NaOH as follows:

   $NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$
3. (c) Acetic acid, being an acid, reacts with calcium oxide, hydroxide, and calcium carbonate. No reaction with calcium oxalate.
4. (a) In the presence of HCl, both the ions are precipitated by H_2S.

   $Bi^{3+} + H_2S \xrightarrow{HCl} \underset{\text{Brown}}{Bi_2S_3\downarrow}$

   $Sn^{4+} + H_2S \xrightarrow{HCl} \underset{\text{Yellow}}{SnS_2\downarrow}$
5. (d) $2CuSO_4 + 10KCN$

   $\rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2$

   First, $Cu(CN)_2$ is formed which decomposes to form $(CN)_2$ and $Cu_2(CN)_2$. $Cu_2(CN)_2$ then combines with KCN to form $K_3[Cu(CN)_4]$.
6. (c) In the presence of peroxide, chromium ions are oxidized to chromate ions which give a yellow filtrate. Ferric ions form brown precipitate of $Fe(OH)_3$.

7. (d) A white precipitate which is soluble in hot water is lead chloride.

$$Pb^{2+} + 2HCl \rightarrow \underset{\text{White}}{PbCl_2} \downarrow + 2H^+$$

$$\underset{\text{Hot solution}}{PbCl_2} + H_2S \xrightarrow{H^+} \underset{\text{Black}}{PbS} \downarrow + 2HCl$$

8. (c) The first gas is chlorine and the second gas is hydrogen.

$Cl_2 + H_2O \rightarrow HCl + HOCl$

$$HCl + AgNO_3 \rightarrow \underset{\text{White}}{AgCl} \downarrow + HNO_3$$

$$Mg + 2HCl + \rightarrow MgCl_2 + H_2 \uparrow$$

9. (a) $[X] + H_2SO_4 \rightarrow [Y]$ colorless gas with irritating smell

$[Y] + H_2SO_4 + K_2Cr_2O_7 \rightarrow$ Green solution

Sulphite ions give sulphur dioxide gas with sulphuric acid, which turns acidified potassium dichromate to green.

$$SO_3^{2-} + H_2SO_4 \rightarrow SO_2 + H_2O + SO_4^{2-}$$

$$3SO_2 + K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O$$

10. (b) It must be a bicarbonate ion because first magnesium bicarbonate is formed which is soluble, then on heating, magnesium carbonate is formed which is insoluble and forms a precipitate.

$$MgCl_2 + 2NaHCO_3 \rightarrow \underset{\text{Soluble}}{Mg(HCO_3)_2} + 2NaCl$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} \underset{\text{White}}{MgCO_3} \downarrow + H_2O + CO_2$$

11. (b) $Bi^{3+} + 3KI \rightarrow \underset{\text{Black}}{BiI_3} \downarrow + 3K^+$

$$BiI_3 + KI \rightarrow \underset{\text{Orange solution}}{K[BiI_4]}$$

12. (d) $2CuSO_4 + 10KCN \rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2$

First, $Cu(CN)_2$ is formed which decomposes to form $(CN)_2$ and $Cu_2(CN)_2$. $Cu_2(CN)_2$ then combines with KCN to form $K_3[Cu(CN)_4]$.

13. (a) $Zn^{2+} + 2H_2O \rightarrow \underset{\text{White}}{Zn(OH)_2} \downarrow + 2H^+$

$$Zn(OH)_2 + 2NH_4Cl + 2NH_4OH \rightarrow \underset{\text{(Soluble)}}{[Zn(NH_3)_4]Cl_2} + 4H_2O$$

$Zn(OH)_2$ precipitate dissolves in excess of NH_4OH in the presence of NH_4Cl to form tetrammine soluble complex.

14. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3$

$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

15. (b) $Hg^{2+} + 2I^- \rightarrow HgI_2 \downarrow$ (Scarlet red precipitate)

$HgI_2 + 2I^- \rightarrow [HgI_4]^{2-}$

$$Hg^{2+} + Co(SCN)_2 \rightarrow \underset{\text{Deep blue crystalline}}{Hg(SCN)_2} \downarrow + Co^{2+}$$

16. (d) Only Zn^{2+} gives white ppt. of ZnS with ammonical H_2S, while

$2Fe^{3+} + S^{2-} \longrightarrow 2Fe^{2+} + S \downarrow$

$Fe^{2+} + S^{2-} \longrightarrow FeS \downarrow$

Here the sulphide of Fe^{3+} is not obtained

$Al^{3+} + S^{2-} + H_2O \longrightarrow Al(OH)_3 \downarrow + S^-$ white ppt.

$Mg^{2+} + S^{2-} \longrightarrow$ No reaction

17. Acidified $K_2Cr_2O_7$, $CuSO_4$, H_2O_2, Cl_2, O_3 $FeCl_3$, HNO_3 oxidize aq. iodide to iodine. Alkaline $KMnO_4$ oxidize aq. iodide to IO_3^-

No reaction between iodine and $Na_2S_2O_3$

Multiple Correct Answers Type

1. (b), (c) Al^{3+}, and Bi^{3+} are precipitated as their hydroxides [$Al(OH)_3$, $Bi(OH)_3$] with ammonium hydroxide in the presence of ammonium chloride.

2. (b), (c)

$$Fe^{2+} + K_3[Fe(CN)_6] \rightarrow KFe^{II}[Fe^{III}(CN)_6] + 2K^+$$

Turnbull's blue is formed.

$Fe^{3+} + 3KCNS \rightarrow [Fe(CNS)_3] + 3K^+$

Blood-red color is formed.

3. (a), (b) The gas is ammonia, and the salt can be nitrate or nitrite as suggested by the following reactions:

$NH_4NO_3 + NaOH \rightarrow NaNO_3 + NH_3 + H_2O$

$NaNO_3 + 8[H] \rightarrow NaOH + NH_3 + 2H_2O$

$NH_4NO_2 + NaOH \rightarrow NaNO_2 + NH_3 + H_2O$

$NaNO_2 + 6[H] \rightarrow NaOH + NH_3 + H_2O$

4. (a), (c), (d)

$$KI_{(aq)} + K_3[Fe(CN)_6]_{(aq)} \longrightarrow \underset{\text{Brownish yellow}}{KI_{3(aq)}} + K_4[Fe(CN)_{6(aq)}]$$

$$\downarrow$$

$$\underset{\text{white ppt}}{K_2Zn_3[Fe(CN)_6]_2} \downarrow + KI_{3(aq)}$$

OR

$\{K_2Zn[Fe(CN)_6] \downarrow\}$

$$KI_{3(aq)} \xrightarrow{Na_2S_2O_3} \underset{\text{colorless}}{I^-_{(aq)} + S_4O_{6\,(aq)}^{2-}}$$

Comprehension Type

1. (d) According to the options given the cation present in filtrate Q may be Fe^{+2} or Cu^{+2} or Zn^{+2} or Cr^{+3} because Q remains unchanged with H_2S in dil. mineral acid medium but gives ppt with alk. H_2S, the cation can not be Cu^{+2}

Hence $\quad Fe^{+2} \rightarrow FeS\downarrow$

$\qquad\quad Zn^{+2} \rightarrow ZnS\downarrow$

$\qquad\quad Cr^{+3} \rightarrow Cr(OH)_3\downarrow$

Among these three ppt. only $Cr(OH)_3$ gives colored solution with H_2O_2 in alk. medium,

i.e. $Cr(OH)_3\downarrow + OH^{\ominus} \rightarrow [Cr(OH)_4]^{\ominus}$

$$[Cr(OH)_4]^{\ominus} + H_2O_2 \rightarrow \underset{\text{yellow solution}}{CrO_4^{-2}} + H_2O$$

Note: (i) Zn^{+2} cannot produce any colored solution due to d^{10} configuration.

(ii) FeS may be oxidized by H_2O_2 in basic medium into Fe^{3+} and SO_4^{2-} and Fe^{3+} must give raddish brown ppt. of $Fe(OH)_3$, not colored solution.

2. (a) (Unknown salt) + dil HCl $\rightarrow \underset{\text{(ppt.)}}{P} + \underset{\text{(filtrate)}}{Q}$

ppt. (P) is $PbCl_2$ because it is insoluble in cold water but soluble in hot water.

Assertion-Reasoning Type

1. (c) In qualitative analysis of basic radicals, cation Cd^{2+} belongs to group II and Ni^{2+} belongs to group IV. Group II radicals are precipitated by passing H_2S in acidic solution. They have low values of solubility products. But that of group IV are precipitated by passing H_2S in alkaline solution, and have high values of solubility products. Therefore, on passing H_2S in acidic solution a yellow precipitate of CdS is formed.

2. (b) Sulphate is estimated as $BaSO_4$, not as $MgSO_4$ because $MgSO_4$ is soluble in water and does not form a precipitate. The ionic radius of Mg^{2+} is smaller than that of Ba^{2+} because on moving down in a group ionic radii increase.

Integer Answer Type

1. (6, 7) PbS, CuS, HgS, Ag_2S, NiS, CoS are black

MnS – dirty pink/Buff

SnS_2 – yellow

Bi_2S_3 – brown/black (brownish black)

Subjective Type

1. The precipitation of second group sulphides in qualitative analysis is carried out with hydrogen sulphide in the presence of hydrochloric acid but not in nitric acid.

Nitric acid is a strong oxidizing agent and oxidizes H_2S into S. So it cannot be used in the reactions involving hydrogen sulphide.

2. *A*: $ZnCO_3$

B: CO_2

C: ZnO

D: ZnS

E: $Zn(OH)_2$

The solid that is yellow when hot and white when cold is zinc oxide. The gas is carbon dioxide, from its behavior towards lime water. In alkaline medium, zinc sulphide is precipitated by hydrogen sulphide gas. The precipitate of zinc hydroxide is soluble in excess of sodium hydroxide due to the formation of sodium zincate.

$$A \xrightarrow{\Delta} ZnO + B$$

$$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$$

$$2ZnCl_2 + K_4[Fe(CN)_6] \rightarrow 4KCl + Zn_2[Fe(CN)_6]\downarrow$$

$$CO_2 + Ca(OH)_2 \rightarrow H_2O + \underset{\text{Milkiness}}{CaCO_3\downarrow}$$

$$CaCO_3 + CO_2 + H_2O \rightarrow \underset{\text{Soluble}}{Ca(HCO_3)_2}$$

$$ZnCO_3 + HCl \rightarrow CO_2\uparrow + ZnCl_2$$

$$ZnCl_2 + H_2S \xrightarrow{NH_4OH} 2HCl + ZnS\downarrow$$

$$ZnCl_2 + NaOH \rightarrow Zn(OH)_2\downarrow + 2NaCl$$

$$Zn(OH)_2 \xrightarrow{NaOH} NaZnO_2(\text{soluble})$$

3. A brown precipitate of ferric hydroxide is formed due to hydrolysis.

$$FeCl_3 + H_2O \rightleftharpoons Fe(OH)_3\downarrow + HCl$$

4. *A*: $FeSO_4$

B: SO_2

C: SO_3

D: Fe_2O_3

E: $BaSO_4$

A light-green crystalline solid is expected to be ferrous sulphate. There is no reaction with dilute sulphuric acid. With potassium permanganate, ferrous sulphate is oxidized to ferric sulphate and the pink color disappears. On strong heating, it gives two gases which are two oxides of sulphur, along with a brown residue, ferric oxide. When gases are passed through acidified potassium dichromate, it is reduced by sulphur dioxide to give a green solution of chromium sulphate. On adding barium sulphate, the green solution of sulphate gives a white precipitate of barium sulphate. In charcoal cavity test, ferric oxide is reduced to iron which is magnetic.

$FeSO_4 + \text{dil. } H_2SO_4 \rightarrow \text{No reaction}$

$FeSO_4 + \underset{\text{(Pink)}}{KMnO_4} \xrightarrow{H_2SO_4} Fe_2(SO_4)_3 + \underset{\text{(Colorless)}}{Mn^{2+}}$

$FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2\uparrow + SO_3\uparrow$

$K_2Cr_2O_7 + SO_2 \xrightarrow{H_2SO_4} \underset{\text{Green}}{Cr_2(SO_4)_3}$

$H_2O + SO_3 \rightarrow H_2SO_4$

$H_2SO_4 + Ba(NO_3)_2 \rightarrow 2HNO_3 + \underset{\text{White}}{BaSO_4\downarrow}$

5. X: $NaHCO_3$
Y: Na_2CO_3
A: CO_2
B: H_2O

$2MHCO_3 \xrightarrow{\Delta} M_2CO_3 + CO_2 + H_2O$

The gas A is carbon dioxide coming from a bicarbonate along with water B.
4.4 g CO_2 comes from 16.8 g of salt.
Then, 44 g (1 mol) CO_2 must be coming from

$\frac{16.8}{4.4} \times 44 = 168$ g of salt.

So the molecular mass of the salt is 168/2 = 84.
Accordingly, M should be sodium.

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

$CO_2 + Ca(OH)_2 \rightarrow \underset{\text{Milkiness}}{CaCO_3\downarrow} + H_2O$

$Na_2CO_3 + BaCl_2 \rightarrow \underset{\text{White}}{BaCO_3\downarrow} + NaCl$

$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$

6. (i) Sulphur is precipitated.
$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$

(ii) Ammonia gives deep-blue color with copper sulphate due to the formation of a complex.
$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2SO_4$
$Cu(OH)_2 + 2NH_4OH + (NH_4)_2SO_4 \rightarrow \underset{\text{Blue}}{[Cu(NH_3)_4]SO_4} + 4H_2O$

(iii) Metastannic acid is formed.
$Sn + 3HNO_3\text{ (conc.)} \rightarrow H_2SnO_3 + 4NO_2 + H_2O$

(iv) A yellow solution of sodium chromate is produced.
$H_2O_2 \rightarrow H_2O + O$
$2CrCl_3 + 10NaOH + 3[O] \rightarrow 2NaCrO_4 + 6NaCl + 3H_2O$

(v) Lead dioxide is precipitated.
$Pb_3O_4 + 4HNO_3 \rightarrow 2Pb(NO_3)_2 + 2H_2O + PbO_2\downarrow$

7. $3KClO_3 + 3H_2SO_4\text{ (conc.)} \xrightarrow{\Delta} 3KHSO_4 + HClO_4 + 2ClO_2 + H_2O$

$(COOH)_2 \xrightarrow{\text{conc } H_2SO_4} CO + CO_2 + H_2O$

8. (i) Sodium zincate is formed.
$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

(ii) Stannous chloride is a good reducing agent. It reduces iodine to iodide.
$SnCl_2 + 2HCl + I_2 \rightarrow SnCl_4 + 2HI$

(iii) Sodium sulphate is formed.
$SO_2 + H_2O + \underset{\text{Air}}{\frac{1}{2}O_2} + 2NaCl \rightarrow Na_2SO_4 + 2HCl$

9. $2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$
$[(COOH)_2 + [O] \rightarrow 2CO_2 + H_2O] \times 5$

$2KMnO_4 + 3H_2SO_4 + 5(COOH)_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO_2$

10. The mixture contains Fe^{2+}, NH_4^+, and Cl^- ions (with an impurity of Fe^{3+} ions).

(i) The mixture was heated with manganese dioxide and concentrated sulphuric acid, when a yellowish-green gas was liberated. This gas must be chlorine, suggesting chloride.

$2Cl^- + MnO_2 + H_2SO_4 + 2H^+ \rightarrow MnSO_4 + Cl_2\uparrow + 2H_2O$

(ii) The mixture on heating with sodium hydroxide solution gave a gas which turned red litmus blue. This alkaline gas must be ammonia coming from an ammonium salt.

$NH_4^+ + NaOH \xrightarrow{\Delta} NH_3 + H_2O + Na^+$

(iii) Its solution in water gave a blue precipitate with potassium ferricyanide. This is due to the presence of ferrous ions.
$3Fe^{2+} + 2[Fe(CN)_6]^{3-} \rightarrow Fe_3[Fe(CN)_6]_2$
Red coloration with ammonium thiocyanate indicates ferric ions, probably formed by oxidation of ferrous.

(iv) The mixture was boiled with potassium hydroxide and the liberated gas was bubbled through an alkaline solution of K_2HgI_4 to give a brown precipitate. The gas is ammonia which gives a brown precipitate with Nessler's reagent.

11. (i) Silver goes into the complex, and then it is displaced with zinc.

$AgCl + 2NaCN \rightarrow NaCl + Na[Ag(CN)_2]$

$2Na[Ag(CN)]_2 + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$

(ii) A yellow precipitate is formed.

$KNO_2 + CH_3COOH \rightarrow CH_3COOK + HNO_2$

$CoCl_2 + 2KNO_2 \rightarrow Co(NO_2)_2 + 2KCl$

$Co(NO_2)_2 + 2HNO_2 \rightarrow Co(NO_2)_3 + NO + H_2O$

$Co(NO_2)_3 + 3KNO_2 + K_3[Co(NO_2)_6]$

12. The gas liberated on heating a mixture of two salts with NaOH gives a reddish-brown precipitate with an alkaline solution of K_2HgI_4. This must be ammonia gas coming from an ammonium salt.

The aqueous solution of the mixture on treatment with $BaCl_2$ gives a white precipitate which is sparingly soluble in concentrated HCl. This must be barium sulphate suggesting sulphate ions.

On heating the mixture with K_2Cr_2O and concentrated H_2SO_4, red vapors A are produced. These are chromyl chloride vapors suggesting chloride ions.

The aqueous solution of the mixture gives a deep-blue coloration B with potassium ferricyanide solution. This suggests ferric ions.

$NH_4^+ + NaOH \rightarrow Na^+ + NH_3 + H_2O$

$NH_3 + K_2HgI_4 \rightarrow I—Hg—O—Hg—NH_2$

Brown iodide of Millon's base

$$SO_4^{2-} + BaCl_2 \rightarrow \underset{\text{White}}{BaSO_4\downarrow} + 2Cl^-$$

$$K_2Cr_2O_7 + 4Cl^- + \underset{\text{(Conc.)}}{6H_2SO_4} \rightarrow 2CrO_2Cl_2 + 2KHSO_4 + 4HSO_4^- + 3H_2O$$

$$Fe^{2+} + [Fe(CN)_6]^{3-} \rightarrow \underset{\text{Blue}}{Fe_4[Fe(CN)_6]_3}$$

13. In NaOH, the hydroxide of Al becomes soluble due to the formation of sodium meta-aluminate.

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

Hydroxide of iron does not dissolve in NaOH.

14. $PbS \xrightarrow{\text{Heat in air}} PbO + PbS$

$PbO + PbS \xrightarrow{\text{Heat in the absence of air}} Pb + SO_2$

15. Its aqueous solution gives a brown precipitate or coloration with alkaline $K_2[HgI_4]$ solution. This suggests ammonium ions.

Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution. This suggests ferrous ions.

Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution. This suggests sulphate ions. The formula of the compound can be $FeSO_4{\cdot}(NH_4)_2SO_4{\cdot}6H_2O$ (Mohr's salt).

16. $3[Fe(H_2O)_6]^{2+} + NO_3^- + 4H^+ \rightarrow NO + 3[Fe(H_2O)_6]^{3+} + 2H_2O$

$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$

17. The gas E must be ammonia, so D is magnesium nitride, and gas C is nitrogen. It is expected that the orange solid A is ammonium dichromate. The green residue B is Cr_2O_3.

$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$

$N_2 + 3Mg \rightarrow Mg_3N_2$

$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

$NH_3 + HCl \rightarrow NH_4Cl$ (Dense white fumes)

18. A: Pb_3O_4

B: PbO_2

C: PbI_2

D: $Pb(MnO_4)_2$

The pink-colored compound is permanganate salt which is formed by the oxidation of manganese salt with lead dioxide. The yellow precipitate is of lead iodide. This shows the original compound to be red lead.

$$Pb_3O_4 + 4HNO_3 \rightarrow PbO_2\downarrow + \underset{\text{Filtrate}}{2Pb(NO_3)_2} + 2H_2O$$

$$Pb(NO_3)_2 + 2KI \rightarrow \underset{\text{Yellow}}{PbI_2\downarrow} + 2KNO_3$$

$$5PbO_2 + 2Mn(NO_3)_2 + 4HNO_3 \rightarrow Pb(MnO_4)_2 + 4Pb(NO_3)_2 + 2H_2O$$

19. The gradual addition of KI solution of $Bi(NO_3)_3$ solution initially produces a dark-brown precipitate which dissolves in excess of KI to give a yellow solution. Iodide is oxidized to iodine which dissolves in KI to give a yellow solution of KI_3.

$Bi^{3+} + H_2O \rightleftharpoons Bi(OH)^{2+} + H^+$

$[NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O] \times 2$

$[2I^- \rightarrow I_2 + 2e^-] \times 3$

$2NO_3^- + 8H^+ + 6I^- \rightarrow 2NO + 4H_2O + 3I_2$

$KI + I_2 \rightarrow KI_3$

20. A is ammonia and B is calcium carbonate.

$Ca + N_2 \rightarrow Ca_3N_2$

$Ca_3N_2 + H_2O \rightarrow Ca(OH)_2 + NH$

$Ca(OH)_2 \xrightarrow{CO_2} CaCO_3 + H_2O$

21. A colorless inorganic salt A decomposes completely at about 250°C to give only two products B and C, leaving no residue. The oxide C is a liquid at room temperature and neutral to moist litmus paper; hence, it must be water. Gas B is a neutral oxide; it must be nitrous oxide. So, A must be ammonium nitrate. White phosphorus burns in excess of nitrous oxide to produce a strong white dehydrating agent, phosphorous pentoxide.

$$NH_4NO_3 \xrightarrow{250^\circ C} N_2O\uparrow + 2H_2O\uparrow$$

No residue left.

$$P_4 + 10N_2O \rightarrow P_4O_{10} + 10N_2$$

22. The given data suggest the following reactions:
$3Ca + N_2 \rightarrow Ca_3N_2$
$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
It is given that a solution of C becomes "milky" on bubbling carbon dioxide. Therefore, it must be calcium or barium hydroxide which is more soluble than magnesium hydroxide.

23. $H_2S \rightleftharpoons 2H^+ + S^{2-}$

$HCl \rightarrow H^+ + Cl^-$

K_{sp} (solubility product) of CuS is less than K_{sp} of ZnS. Due to common ion effect, the ionization of H_2S is suppressed and the S^{2-} concentration decreases.
Only those metal sulphides get precipitated which have low K_{sp}. So, ZnS is not precipitated.

24. HgI_2 is having orange/scarlet color.
It dissolves in sodium iodide due to the formation of a complex.
$HgI_2 + 2NaI \rightarrow Na_2HgI_4$
With NaOCl, again a precipitate of HgI_2 is formed.

$$3Na_2HgI_4 + 2NaOCl + 2H_2O \rightarrow 3HgI_2 + 2NaI_3 + 4NaOH + 2NaCl$$

25. $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$
$H_2O_2 \rightarrow H_2O + [O]$
H_2O_2 turns the color of red litmus paper to white due to its bleaching action by oxidation.
Therefore, the given substance is Na_2O_2.

26. Brown ring test is done for the detection of nitrates. To a solution containing the salt and freshly prepared ferrous sulphate, concentrated sulphuric acid is added gradually along the sides of the tube. A brown ring appears at the junction of the two liquids.
$2NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$
$2HNO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$
$FeSO_4 + NO \rightarrow [Fe(NO)SO_4]$ (Brown ring)

27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate A which is insoluble in warm aqueous solution of KOH. It must be a black precipitate of CuS because copper sulphate is blue colored also. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate B. In this reaction, cupric iodide is formed first which decomposes to give white cuprous iodide and iodine.

$$CuSO_4 + H_2S \xrightarrow{\text{Acidic medium}} \underset{\text{Black}}{CuS\downarrow} + H_2SO_4$$

$$CuSO_4 + 2KI \rightarrow CuI_2 + K_2SO_4$$

$$2CuI_2 \rightarrow Cu_2I_2\downarrow + I_2$$

28. When borax is heated, a colorless glassy bead is formed of the following composition:

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

$$Co(II)\text{salt} \xrightarrow{\Delta} CoO + \text{Some gas}$$

$$CoO + B_2O_3 \xrightarrow{\Delta} Co(BO_2)_2$$

A blue-colored bead of cobalt metaborate is formed.

29. A = ZnS

$B = H_2S$

$C = ZnSO_4$

D = S

$E = SO_2$

A white substance A reacts with dilute H_2SO_4 to produce a colorless gas B and a colorless solution C. The reaction between B and acidified $K_2Cr_2O_7$ solution produces a green solution and a slightly colored precipitate D. This precipitate must be sulphur. So gas B must be hydrogen sulphide, and the white substance A must be some metal sulphide. Sulphur burns in air to produce sulphur dioxide (gas) which reacts with hydrogen sulphide to yield sulphur again and a colorless liquid water. Anhydrous copper sulphate is turned blue on addition of water. Addition of aqueous NH_3 or NaOH to C produces, first, a precipitate which dissolves in excess of the respective reagent to produce a clear solution in each case. This suggests that C must be sulphate of either zinc or aluminium. So, A may be zinc sulphide.
$ZnS + H_2SO_4 \rightarrow H_2S + ZnSO_4$
$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

$[H_2S + (O) \rightarrow H_2O + S] \times 3$

$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S$

$\rightarrow K_2SO_4 + \underset{\text{Green solution}}{Cr_2(SO_4)_3} + 7H_2O + 3S\downarrow$

$S + O_2 \rightarrow SO_2$

$SO_2 + 2H_2S \rightarrow 2H_2O + 3S$

$ZnSO_4 + 2NaOH \rightarrow \underset{\text{White}}{Zn(OH)_2}\downarrow + Na_2SO_4$

$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$

30. X: NH_4Cl

A: CrO_2Cl_2

B: Na_2CrO_4

C: $PbCrO_4$

D: $H_2N—Hg—O—Hg—I$

When a white crystalline compound X is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas A is evolved. This must be chromyl chloride coming from a chloride salt. On passing A into caustic soda solution, a yellow-colored solution B is obtained. This is sodium chromate. Neutralizing the solution of B with acetic acid and on subsequent addition of lead acetate, a yellow precipitate C is obtained. This is lead chromate. When X is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate D is formed. The gas is ammonia, so A is ammonium chloride. D is iodide of Millon's base.

$K_2Cr_2O_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$

$NH_4Cl + H_2SO_4 \rightarrow NH_4HSO_4 + HCl$

$CrO_3 + 2HCl \rightarrow \underset{\text{Orange-red vapors}}{CrO_2Cl_2} + H_2O$

$NaOH + CrO_2Cl_2 \rightarrow \underset{\text{Yellow solution}}{Na_2CrO_4} + NaCl + H_2O$

$Pb(CH_3COO)_2 + Na_2CrO_4$

$\rightarrow \underset{\text{Yellow ppt.}}{PbCrO_4}\downarrow + CH_3COONa$

$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$

$2K_2HgI_4 + NH_3 + 3KOH$

$\rightarrow H_2N—Hg—O—Hg—I + 7KI + 2H_2O$

$H_2N—Hg—O—Hg—I$ is brown colored iodide of Millon's base.

31. $Na_2CO_3 + 2SO_2 + H_2O \rightarrow 2NaHSO_3 + CO_2$

$2NaHSO_3 + Na_2CO_3 \rightarrow 2Na_2SO_3 + H_2O + CO_2$

$Na_2SO_3 + S \rightarrow Na_2S_2O_3$

$2Na_2S_2O_3 + I_2 \xrightarrow{\Delta} Na_2S_4O_6 + 2NaI$

Oxidation states of sulphur:

$NaHSO_3$ (+6)

Na_2SO_3 (+6)

$Na_2S_2O_3$ (+2) or (+5 and −1)

$Na_2S_4O_6$ (+2) or (+5 and 0)

32. A: KI

B: HgI_2

C: HgS

D: Hg

A mixture consists of A (yellow solid) and B (colorless solid) which gives lilac color in flame. Lilac color comes from potassium ions. Mixture gives black precipitate C on passing H_2S gas. C is soluble in aquaregia, and hence, it must be HgS. On evaporation of aquaregia and adding $SnCl_2$, it gives a greyish-black precipitate D. This must be mercury.

The salt solution with NH_4OH gives a brown precipitate. It must be iodide of Millon's base, and the salt mixture must be potassium iodide and mercuric iodide. The sodium extract of the salt with $CCl_4/FeCl_3$ gives a violet layer. This confirms iodide. The sodium extract gives a yellow precipitate with $AgNO_3$ solution which is insoluble in NH_3. This also confirms iodide.

$HgI_2 + H_2S \longrightarrow \underset{\text{Black}}{HgS}\downarrow + 2HI$

$HgS \xrightarrow{\text{Aquaregia}} HgCl_2 \text{(Soluble)}$

$HgCl_2 \xrightarrow{SnCl_2} SnCl_4 + \underset{\text{Black}}{Hg}$

$2KI + HgI_2 \rightarrow K_2HgI_4$

Nessler's reagent

$K_2HgI_4 \xrightarrow{NH_3} H_2N—Hg—O—Hg—I$

Iodide of Millon's base

With sodium extract:

$2NaI + 2Fe^{3+} \xrightarrow{CCl_4} I_2 + 2Na^+ + Fe^{2+}$

$AgNO_3 + NaI \rightarrow AgI\downarrow + NaNO_3$

AgI is the yellow precipitate insoluble in ammonium hydroxide.

33. Anhydrous HF is stabilized due to intermolecular H bonding and is less dissociated. AlF_3 is soluble in HF in the presence of KF due to the formation of $[AlF_6]^{3-}$.

$3KF + AlF_3 \rightarrow K_3[AlF_6]$

BF_3 displaces out F^- from $[AlF_6]^{3-}$ because it is more acidic than AlF_3.

$K_3[AlF_6] + BF_3 \rightarrow AlF_3\downarrow + 3KBF_4$

34. $\underset{\text{(White fumes having smell)}}{B} \xleftarrow{\text{Moist air}} \underset{\text{M = (transition element colorless)}}{MCl_4} \xrightarrow{Zn} \underset{\text{(Purple color)}}{A}$

$M = Ti$, $MCl_4 = TiCl_4$

$A = [Ti(H_2O)_6]^{3+}$

$B = TiO_2$

Ti (IV) ion contains no d-electron, so it is colorless.

Ti (III) ion contains one d-electron, so it is colored.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	2. (d)	3. (b)	4. (d)	5. (a)	6. (b)	7. (d)	8. (c)	9. (d)	10. (b)
11. (b)	12. (c)	13. (b)	14. (d)	15. (b)	16. (b)	17. (b)	18. (c)	19. (c)	20. (c)
21. (c)	22. (c)	23. (d)	24. (c)	25. (a)	26. (b)	27. (c)	28. (b)	29. (c)	30. (d)
31. (b)	32. (a)	33. (d)	34. (c)	35. (d)	36. (d)	37. (b)	38. (d)	39. (c)	40. (a)
41. (c)	42. (a)	43. (d)	44. (a)	45. (b)	46. (a)	47. (a)	48. (b)	49. (b)	50. (c)
51. (c)	52. (a)	53. (b)	54. (a)	55. (c)	56. (c)	57. (d)	58. (b)	59. (c)	60. (c)
61. (d)	62. (b)	63. (b)	64. (b)	65. (c)	66. (d)	67. (d)	68. (a)	69. (a)	70. (c)
71. (c)	72. (a)	73. (d)	74. (a)	75. (b)	76. (a)	77. (d)	78. (c)	79. (a)	80. (c)
81. (b)	82. (d)	83. (b)	84. (c)	85. (b)	86. (b)	87. (b)	88. (a)	89. (b)	90. (a)
91. (b)	92. (b)	93. (c)	94. (c)	95. (b)	96. (c)	97. (c)	98. (c)	99. (d)	100. (b)
101. (a)	102. (b)	103. (d)	104. (d)	105. (c)	106. (d)	107. (b)	108. (d)	109. (d)	110. (d)
111. (b)	112. (d)	113. (b)	114. (a)	115. (a)	116. (c)	117. (b)	118. (a)	119. (a)	120. (a)
121. (a)	122. (a)	123. (a)	124. (c)	125. (d)	126. (d)	127. (a)	128. (a)	129. (b)	130. (d)
131. (c)	132. (a)	133. (c)	134. (c)	135. (b)	136. (a)	137. (b)	138. (c)	139. (a)	140. (c)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (a)	4. (d)	5. (b)	6. (b)	7. (d)	8. (d)	9. (a)	10. (a)
11. (c)	12. (a)	13. (c)	14. (b)	15. (a)	16. (a)	17. (b)	18. (a)	19. (b)	20. (c)
21. (a)	22. (d)	23. (d)	24. (c)	25. (b)	26. (b)	27. (c)	28. (c)	29. (c)	30. (c)
31. (d)	32. (b)	33. (c)	34. (b)	35. (a)	36. (b)	37. (c)	38. (d)	39. (c)	40. (b)
41. (c)	42. (a)	43. (d)	44. (d)	45. (a)	46. (b)	47. (b)	48. (c)	49. (d)	50. (a)
51. (b)	52. (b)	53. (a)	54. (b)	55. (a)	56. (b)	57. (c)	58. (b)	59. (b)	60. (d)
61. (a)	62. (b)	63. (a)	64. (d)	65. (d)	66. (a)	67. (c)	68. (a)	69. (a)	70. (c)
71. (a)	72. (a)	73. (a)	74. (a)	75. (a)	76. (b)	77. (c)	78. (b)	79. (d)	80. (c)
81. (d)	82. (a)	83. (a)	84. (d)	85. (b)	86. (d)	87. (b)	88. (d)	89. (d)	90. (b)
91. (b)	92. (b)	93. (b)	94. (b)	95. (b)	96. (b)	97. (b)	98. (d)	99. (b)	100. (b)
101. (a)	102. (c)	103. (c)	104. (c)	105. (b)	106. (b)	107. (b)	108. (a)	109. (a)	110. (c)
111. (d)	112. (b)	113. (d)	114. (c)	115. (a)	116. (d)	117. (b)	118. (d)	119. (c)	120. (b)
121. (d)	122. (d)	123. (a)	124. (c)	125. (c)	126. (c)	127. (c)	128. (a)	129. (a)	130. (c)
131. (d)	132. (c)	133. (b)	134. (b)	135. (c)	136. (d)	137. (d)	138. (b)	139. (c)	140. (d)

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (c)	3. (a), (b)	4. (a), (c), (d)	5. (a), (c), (d)
6. (b), (c), (d)	7. (b), (c)	8. (a), (c)	9. (c), (d)	10. (a), (b), (c)
11. (a), (b), (d)	12. (c), (d)	13. (a), (b), (c)	14. (a), (c), (d)	15. (a), (b), (d)

16. (a), (b), (c)	17. (a), (b), (c)	18. (a), (c), (d)	19. (a), (b), (c)	20. (a), (c), (d)
21. (a), (b), (c)	22. (b), (c), (d)	23. (a), (c)	24. (a), (b), (c)	25. (a), (b), (c)
26. (a), (b), (d)	27. (a), (b)	28. (b), (c), (d)	29. (b), (c), (d)	30. (a), (b)
31. (a), (b), (d)	32. (c), (d)	33. (a), (b), (c)	34. (a), (b), (c)	35. (a), (b)
36. (a), (b), (c)	37. (a), (b)	38. (a), (b)	39. (a), (b), (c)	40. (c), (d)
41. (a), (b)	42. (a), (b), (c)	43. (a), (b)	44. (a), (b), (c)	45. (a), (d)
46. (a), (c)	47. (a), (b), (c)	48. (a), (c), (d)	49. (a), (b), (c)	50. (a), (b)
51. (a), (b), (c)	52. (a), (c)	53. (a), (c), (d)	54. (b), (c)	55. (a), (b), (c)
56. (a), (b), (c), (d)	57. (b), (c)	58. (a), (c), (d)	59. (b), (c), (d)	60. (b), (c), (d)
61. (a), (b), (d)	62. (a), (b),c)	63. (b), (c), (d)	64. (a), (b), (c)	65. (a), (c)
66. (b), (c)	67. (b), (d)	68. (a), (b)	69. (a), (c), (d)	70. (a), (b), (c), (d)
71. (a), (b)	72. (a), (b)	73. (a), (c),d)	74. (a), (b), (c), (d)	75. (a), (b), (c)
76. (a), (b), (d)	77. (a), (b), (c), (d)	78. (a), (b)	79. (a), (c), (d)	80. (a), (b), (c), (d)
81. (b), (c)	82. (a), (c)	83. (a), (b), (c), (d)	84. (c), (d)	85. (a), (b), (d)
86. (a), (c), (d)	87. (a), (b)	88. (b), (c), (d)	89. (a), (b), (c), (d)	90. (a), (b), (c)
91. (c), (d)	92. (b), (c)	93. (a), (b)	94. (a), (b), (c), (d)	95. (a), (b), (c)
96. (a), (c), (d)	97. (b), (c), (d)	98. (a), (b), (c)	99. (b), (c), (d)	100. (c), (d)
101. (a), (b), (c), (d)	102. (a), (c), (d)	103. (a), (b), (d)	104. (a), (b), (d)	105. (a), (b), (c), (d)
106. (a), (b), (c)	107. (a), (b), (d)	108. (a), (c)	109. (a), (c), (d)	111. (b), (c), (d)
111. (a), (d)				

Comprehension Type

Comprehension-1	1. (d)	2. (d)	3. (c)						
Comprehension-2	4. (b)	5. (a)	6. (b)	7. (b)	8. (d)				
Comprehension-3	9. (c)	10. (d)	11. (b)						
Comprehension-4	12. (b)	13. (a)	14. (a)						
Comprehension-5	15. (c)	16. (b)	17. (a)						
Comprehension-6	18. (c)	19. (c)	20. (b)	21. (b)	22. (c)				
Comprehension-7	23. (b)	24. (c)	25. (a)	26. (b)					
Comprehension-8	27. (b)	28. (c)	29. (c)	30. (b)					
Comprehension-9	31. (a)	32. (c)	33. (b)						
Comprehension-10	34. (a)	35. (c)	36. (b)						
Comprehension-11	37. (b)	38. (b)	39. (d)						
Comprehension-12	40. (b)	41. (d)	42. (a)						
Comprehension-13	43. (a)	44. (c)	45. (c)						
Comprehension-14	46. (d)	47. (d)							
Comprehension-15	48. (c)	49. (a)	50. (b)	51. (b)	52. (c)				
Comprehension-16	53. (a)	54. (b)	55. (b)						
Comprehension-17	56. (b)	57. (a)	58. (b)	59. (c)					
Comprehension-18	60. (a)	61. (c)	62. (b)						
Comprehension-19	63. (a)	64. (d)	65. (c)						
Comprehension-20	66. (c)	67. (b)	68. (c)	69. (c)					
Comprehension-21	70. (c)	71. (c)	72. (c)						
Comprehension-22	73. (d)	74. (a)	75. (c)	76. (c)					
Comprehension-23	77. (d)	78. (d)	79. (d)	80. (a)					
Comprehension-24	81. (b)	82. (b)	83. (b)						
Comprehension-25	84. (c)	85. (c)	86. (b)						
Comprehension-26	87. (a), (b)	88. (a), (b)	89. (a), (c)						
Comprehension-27	90. (c)	91. (b)	92. (b)	93. (c)	94. (a)	95. (c)	96. (b)	97. (a)	
Comprehension-28	98. (b)	99. (b)	100. (c)						
Comprehension-29	101. (b)	102. (b)	103. (b)						

Comprehension-30 **104.** (a) **105.** (d) **106.** (d) **107.** (c) **108.** (b)
Comprehension-31 **109.** (b) **110.** (c) **111.** (a)
Comprehension-32 **112.** (b) **113.** (b) **114.** (b)
Comprehension-33 **115.** (a) **116.** (a) **117.** (b)
Comprehension-34 **118.** (c) **119.** (c) **120.** (a)

Assertion-Reasoning Type

1. (a) **2.** (a)

Matching Column Type

1. (a) q; (b) r; (c) p; (d) s
2. (a) q; (b) q, r; (c) s; (d) p
3. (a) p, s; (b) p, s; (c) p, s, t; (d) q, r, t
4. (a) p; (b) r; (c) s; (d) q
5. (a) p, q, r, s; (b) p, q; (c) p, q, r; (d) q, r, s
6. (a) p, q, s; (b) s; (c) p, s; (d) r, s
7. (a) p, q, r; (b) r, s; (c) p, q; (d) p, s
8. (a) r, s; (b) q; (c) t; (d) p
9. (a) r; (b) s; (c) q, t; (d) p
10. (a) p; (b) p, s; (c) r; (d) q, r
11. (a) q, s; (b) r, s; (c) p, t; (d) r, t
12. (a) r; (b) s; (c) p; (d) q
13. (a) p, r, t; (b) p, r, s; (c) p ,t; (d) q, t
14. (a) p, s; (b) s; (c) q; (d) r
15. (a) p, r; (b) q, r, s; (c) q, r, s; (d) p, q, r
16. (a) r; (b) p, q; (c) s
17. (a) p, q; (b) s; (c) r
18. (a) s; (b) p, r; (c) q; (d) t
19. (a) r, s, t; (b) s; (c) p, s; (d) s
20. (a) s; (b) q; (c) r; (d) p
21. (a) s, t; (b) p; (c) q; (d) r
22. (a) p, q; (b) r, s; (c) s; (d) r, s
23. (a) s; (b) r; (c) q; (d) p
24. (a) p, r; (b) p; (c) p, s; (d) q, s
25. (a) p, q; (b) r; (c) s
26. (a) t; (b) r; (c) q, s; (d) p
27. (a) t; (b) p; (c) q; (d) r, s
28. (a) s; (b) r; (c) q; (d) p
29. (a) q, s; (b) r, s; (c) p, s; (d) q, s

Integer Answer Type

1. 2 **2.** (i) 0, (ii) 1 (iii) 0, (iv) 3, (v) 0, (vi) 4 **3.** 3 **4.** 2 **5.** 2
6. (i) 3, (ii) 0, (iii) 2, (iv) 6 **7.** 5 **8.** 4 **9.** 4 **10.** 2 **11.** 6 **12.** 6 **13.** 3
14. (i) 6, (ii) 2, (iii) 2, (iv) 0, (v) 2, (vi) 3, (vii) 4 **15.** (i) 0, (ii) 1, (iii) 0 **16.** (i) 2, (ii) 2, (iii) 3, (iv) 3
17. 6 **18.** 3 **19.** 1 **20.** 10 **21.** 4 **22.** 3 **23.** 1
24. (i) 2, (ii) 3, (iii) 0 (iv) 2 **25.** (i) 0, (ii) 1, (iii) 0 **26.** 3
27. (*A*) $CuSO_4$ (*B*) $BaSO_4$ (*C*) HCl (*D*) ($Cu_2I_2 + I_3^-$) (*E*) $Cu_2I_2 + I^- + S_4O_6^{2-}$ (*F*) $Cu_2[Fe(CN)_6]$
28. (*A*) FeS (*B*) H_2S (*C*) $FeSO_4$ (*D*) S (*E*) CuS (*F*) $[Cu(NH_3)_4](OH)_2$
29. (*A*) $Al_2(SO_4)_3$ (*B*) $Al(OH)_3$ (*C*) $BaSO_4$ (*D*) CoO. Al_2O_3
30. (*A*) $Fe_2(SO_4)_3$ (*B*) $Fe_2(SO_4)_3$ solution (*C*) $BaSO_4$ (*D*) $Fe(OH)_3$
(*E*) $FeCl_3$ (*F*) $Fe_4[Fe(CN)_6]_3$ (*G*) $Fe(SCN)_3$ (*H*) Fe_2O_3
(*I*) SO_3
31. (*A*) $FeSO_4$ (*B*) $BaSO_4$ (*C*) Fe_2O_3 (*D*) SO_2
(*E*) SO_3 (*F*) $FeCl_3$ (*G*) S
32. (*A*) $FeBr_3$ (*B*) AgBr (*C*) Br_2 (*D*) $Fe(OH)_3$
33. (*A*) $CrCl_3$ (*B*) $Cr(OH)_3$ (*C*) Na_2CrO_4 (*D*) $Na_2Cr_2O_7$
(*E*) $PbCrO_4$
34. (*A*) $FeSO_4.7H_2O$ (*B*) $FeSO_4$ (*C*) $7H_2O$ (*D*) $Fe[(H_2O)_5NO]SO_4$
(*E*) Fe_2O_3 (*F*) SO_2 (*G*) SO_3 (*H*) Cr^{3+} solution
35. (*A*) ZnO (*B*) $ZnCl_2$ (*C*) Na_2ZnO_2
36. (*A*) $Zn(NO_3)_2$ (*B*) NO_2 (*C*) ZnO (*D*) ZnS
37. 3

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) **2.** (b) **3.** (a) **4.** (a)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) **2.** (a) **3.** (c) **4.** (a) **5.** (d) **6.** (c) **7.** (d) **8.** (c) **9.** (a) **10.** (b)
11. (b) **12.** (d) **13.** (a) **14.** (a) **15.** (b) **16.** (d) **17.** (7)

Multiple Correct Answers Type

1. (b), (c) **2.** (b), (c) **3.** (a), (b) **4.** (a), (c), (d)

Comprehension Type

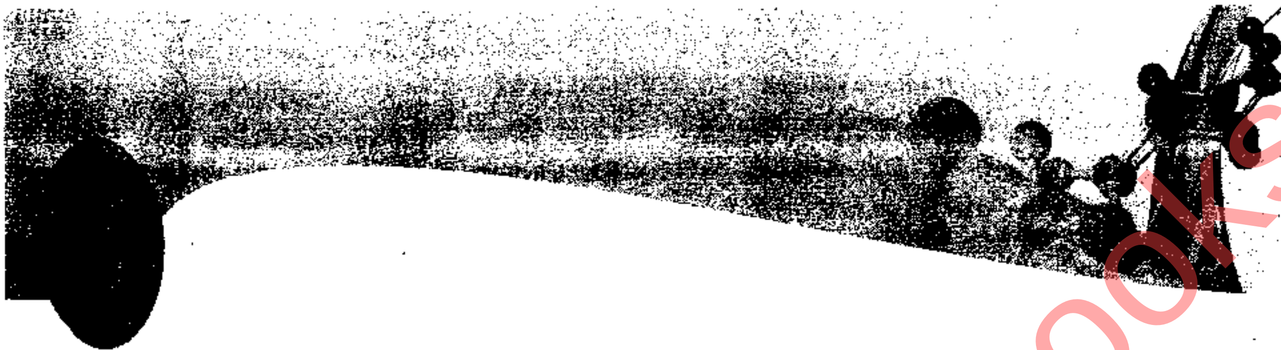
1. (d) **2.** (a)

Assertion-Reasoning Type

1. (c) **2.** (b)

Integer Answer Type

1. (6, 7)



s-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Electrolysis of fused NaCl will give:
   (a) Na (b) NaOH
   (c) NaClO (d) $NaClO_3$
2. Chile saltpetre is the ore of:
   (a) Iodine (b) Bromine
   (c) Sodium (d) Magnesium
3. In view of their low ionization energies, the alkali metals are:
   (a) Weak oxidizing agents
   (b) Strong reducing agents
   (c) Strong oxidizing agents
   (d) Weak reducing agents
4. Which of the following has lowest melting point?
   (a) Li (b) Na
   (c) K (d) Cs
5. Smallest among these species is:
   (a) Hydrogen (b) Helium
   (c) Lithium (d) Lithium ion
6. Which one of the following electrolytes used in Down's process of extracting sodium metal?
   (a) NaCl + KCl + KF (b) NaCl
   (c) NaOH + KCl + KF (d) NaCl + NaOH
7. Shine at freshly cut sodium is because of:
   (a) Due to oscillations of free electrons
   (b) Due to weak metallic bonding
   (c) Due to absorption of light in crystal lattice
   (d) Due to the presence of free valency at the surface
8. The solubility of alkali metal hydroxides follows the order:
   (a) LiOH < NaOH < KOH < RbOH < CsOH
   (b) LiOH > NaOH > KOH > RbOH < CsOH
   (c) LiOH > CsOH > RbOH > NaOH > KOH
   (d) None of these
9. Which of the following carbonate(s) decompose readily?
   (a) Li_2CO_3 (b) Na_2CO_3
   (c) K_2CO_3 (d) Rb_2CO_3
10. The sequence of ionic mobility in aqueous solution is:
   (a) $Rb^+ > K^+ > Cs^+ > Na^+$
   (b) $Na^+ > K^+ > Rb^+ > Cs^+$
   (c) $K^+ > Na^+ > Rb^+ > Cs^+$
   (d) $Cs^+ > Rb^+ > K^+ > Na^+$
11. Sodium peroxide which is a yellow solid, when exposed to air becomes white due to formation of:
   (a) H_2O_2 (b) Na_2O
   (c) Na_2O and O_3 (d) NaOH and Na_2CO_3
12. Among the alkali metals Cs is the most reactive because:
   (a) Its incomplete shell is nearest to the nucleus
   (b) It has a single electron in the valence shell
   (c) It is the heaviest alkali metal
   (d) Its outermost electron is more loosely bound than the outermost electron of the other alkali metals

13. Sodium hydride (NaH) when dissolved in water produces:

(a) Acidic solution (b) Basic solution
(c) Neutral solution (d) Cannot be predicted

14. The correct order of stability for the following superoxides is:

(a) $KO_2 > RbO_2 > CsO_2$ (b) $RbO_2 > CsO_2 > KO_2$
(c) $CsO_2 > RbO_2 > KO_2$ (d) $KO_2 > CsO_2 > RbO_2$

15. In the case of alkali metals, the covalent character decreases in the order:

(a) $MF > MCl > MBr > MI$
(b) $MF > MCl > MI > MBr$
(c) $MI > MBr > MCl > MF$
(d) $MCl > MI > MBr > MF$

16. The oxide of an element whose electronic configuration is $1s^2 2s^2 2p^6 3s^1$ is:

(a) Amphoteric (b) Basic
(c) Acidic (d) Neutral

17. The characteristic not related to alkali metals is:

(a) Their ions are isoelectronic with noble gases
(b) Metallic character
(c) Low electronegativity (d) High ionization energy

18. The electronic configuration of the outermost orbit in the case of alkaline earth metals is:

(a) ns^2 (b) $ns^2\ np^1$
(c) ns^1 (d) $ns^2\ np^4$

19. Plaster of Paris is:

(a) $CaSO_4$ (b) $CaSO_4 \cdot H_2O$
(c) $2CaSO_4 \cdot H_2O$ (d) $CaSO_4 \cdot 2H_2O$

20. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order:

K_2CO_3(I), $MgCO_3$(II), $CaCO_3$(III), $BeCO_3$ (IV)

(a) I < II < III < IV (b) IV < II < III < I
(c) IV < II < I < III (d) II < IV < III < I

21. Silica reacts with magnesium to form a magnesium compound X, X reacts with dilute HCl and forms Y. Y is:

(a) MgO (b) $MgSiO_3$
(c) $SiCl_4$ (d) $MgCl_2$

22. Among the following hydroxides, the one which has the lowest value of K_{sp} at ordinary temperature is:

(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Ba(OH)_2$ (d) $Be(OH)_2$

23. The first ionization potentials (eV) of Be and B respectively are:

(a) 8.29, 9.32 (b) 9.32, 9.32
(c) 8.29, 8.29 (d) 9.32, 8.29

24. Among the alkaline earth metals, the element forming predominantly covalent compound is:

(a) Ba (b) Sr
(c) Ca (d) Be

25. Chemical A is used for water softening to remove temporary hardness. A reacts with Na_2CO_3 to generate caustic soda. When CO_2 is bubbled through A, it turns cloudy. What is the chemical formula of A?

(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

26. The set representing the correct order of the first ionization potential is:

(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

27. Aluminium is not present in which of the following minerals?

(a) Cryolite (b) Mica
(c) Feldspar (d) Fluorspar

28. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:

(a) Sodium hydride (b) Sodium amide
(c) Sodium (d) Solvated electrons

29. The compound insoluble in acetic acid is:

(a) Calcium oxide (b) Calcium carbonate
(c) Calcium oxalate (d) Calcium hydroxide

30. KOH is preferably used to absorb CO_2 gas because:

(a) $KHCO_3$ is soluble in water and $NaHCO_3$ is sparingly soluble in water
(b) KOH is cheaper than NaOH
(c) KOH is more soluble than NaOH in water
(d) KOH is stronger base than NaOH

31. Which of the following is correct statement?

(I) Ca^{2+} ions are important in blood clotting
(II) $Ca_3(PO_4)_2$ is a part of bones
(III) $3Ca_3(PO_4) \cdot CaF_2$ is a part of enamel of teeth

(a) (I) and (II) (b) (II) and (III)
(c) (I) and (III) (d) (I), (II), and (III)

32. Consider the following statements:

(I) Cs^+ ion is more highly hydrated than other alkali metal ions.
(II) Among the alkali metals Li, Na, K, and Rb, Li has the higher melting point.
(III) Among the alkali metals, only Li forms a stable nitride by direct combination.

(a) (I) and (III) are correct

(b) (II) and (III) are correct

(c) (I), (II), and (III) are correct

(d) (I) and (II) are correct

33. Which of the following changes occurs when excess of CO_2 gas is passed into a clear solution of lime water?

(a) A white precipitate containing both $CaCO_3$ and $Ca(HCO_3)_2$ is formed

(b) Initially a white precipitate of $CaCO_3$ is formed which changes into soluble $Ca(HCO_3)_2$ on passing excess CO_2 gas

(c) A white precipitate of $Ca(HCO_3)_2$ is formed

(d) A white precipitate of $CaCO_3$ is formed

34. In the following sequence of reactions. Identify (E):

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow (A) \xrightarrow{\Delta,\, ZnCl_2} (B) \xrightarrow{\Delta} (C) + (D)\uparrow \xrightarrow{NaOH} (E)$$

(a) $NaHCO_3$ (b) Na_2O_2

(c) Na_2ZnO_2 (d) $ZnCO_3$

35. The decomposition temperatures of alkaline earth metal carbonates are given below:

$BeCO_3$	$MgCO_3$	$CaCO_3$	$SrCO_3$	$BaCO_3$
< 100°C	<	< 900°C	<	< 1300°C

The decomposition temperatures of $MgCO_3$ and $SrCO_3$ are respectively:

(a) 1290°C, 1200°C (b) 1290°C, 540°C

(c) 540°C, 1290°C (d) 540°C, 800°C

36. Aluminium is more reactive than iron because its standard reduction potential is higher. Still aluminium is less easily corroded than iron because:

(a) Al reacts with atmospheric carbon dioxide to form a self-protective layer of Al_2O_3

(b) It has higher reducing power and forms a self-protective layer of Al_2O_3

(c) It has higher reducing power and does not react with oxygen so easily

(d) Both (a) and (b)

37. Which one of the following statements is true for all the alkali metals?

(a) Their nitrates decompose on heating to give NO_2 and O_2

(b) Their carbonates decompose on heating to given CO_2 and normal oxide

(c) They react with halogens to given the halides of the type, MX

(d) They react with oxygen to give mainly the oxide, M_2O

38. Select correct statement:

(a) Oxides (M_2O) and peroxides (M_2O_2) of alkali metals are diamagnetic and colorless

(b) Superoxides (MO_2) of alkali metals are paramagnetic

(c) Li and Na do not form superoxides

(d) All are correct

39. Which of the following salts does not form any precipitate with excess of NaOH?

(a) $ZnCl_2$ (b) $FeCl_3$

(c) $CrCl_3$ (d) $CuSO_4$

40. Which of the following is best CO_2 absorber as well as source of O_2 in space capsule?

(a) KO_2 (b) K_2O_2

(c) KOH (d) LiOH

41. The aqueous solutions of lithium salts are poor conductor of electricity rather than other alkali metals because of:

(a) High ionization energy

(b) High electronegativity

(c) Lower ability of Li^+ ions to polarize water molecules

(d) Higher degree of hydration of Li^+ ions

42. A soft metal (A) gives violet flame test. When burnt in excess O_2, (A) gives chrome yellow powder (B) which on reaction with water gives alkaline solution C and O_2. Identify A and B:

(a) Na, Na_2O_2 (b) K, K_2O_2

(c) K, KO_2 (d) Li, Li_2O_2

43. (X), (Y), (Z) are elements in the third period. Oxide of (X) is ionic, that of (Y) is amphoteric, and of (Z) a giant molecule. (X), (Y) and (Z) will have atomic numbers in the order:

(a) $(X) < (Y) < (Z)$ (b) $(Z) < (Y) < (X)$

(c) $(X) < (Z) < (Y)$ (d) $(Y) < (X) < (Z)$

44. The inside surface of glass bottle containing caustic soda becomes dull because:

(a) Silica is present in glass. It does not dissolves in NaOH and hence forms soluble sodium silicate and thus inside surface becomes dull

(b) Silica is present in glass. It dissolves in NaOH slowly and forms soluble sodium silicate and thus inside surface becomes dull

(c) Both (a) and (b)

(d) None of the above

45. Potash alum is represented by the formula:

(a) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(b) $K \cdot Al(SO_4)_2 \cdot 12\,H_2O$

(c) Both (a) and (b)

(d) None of these

46. Among of alkali metals, the metal with highest ionization potential is:

(a) Li (b) Na
(c) K (d) Rb

47. What is the oxidation state of K in KO_2?

(a) –1 (b) –2
(c) +1 (d) Zero

48. A metal from period IV is added to water and a vigorous reaction takes place with the evolution of a gas. Which statements are correct?

1. Oxygen is evolved.
2. Hydrogen is evolved.
3. The resulting solution is acidic.
4. The resulting solution is basic.

(a) 1 and 3 only (b) 2 and 3 only
(c) 2 and 4 only (d) 1 and 4 only

49. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:

(a) Sodium atoms (b) Sodium hydride
(c) Sodium amide (d) Solvated electrons

50. Sodium reacts with water more vigorously than lithium because it:

(a) Has higher atomic weight
(b) Is a metal
(c) Is more electropositive
(d) More electronegative

51. The hydration energy of Mg^{2+} is greater than that of:

(a) Al^{3+} (b) Na^+
(c) Be^{2+} (d) Mg^{3+}

52. Among KO_2, AlO_2^-, BaO_2, and NO_2^+ unpaired electron is present in:

(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-
(c) KO_2 only (d) BaO_2 only

53. A metal *M* readily forms water-soluble sulphate MSO_4, water insoluble hydroxide $M(OH)_2$ and oxide MO which becomes inert on heating. The hydroxide is soluble in NaOH. The metal *M* is:

(a) Be (b) Mg
(c) Ca (d) Sr

54. The paramagnetic species is:

(a) KO_2 (b) SiO_2
(c) TiO_2 (d) BaO_2

55. On dissolving moderate amount of sodium metal in liquid NH_3 at low temperature, which one of the following does not occur?

(a) Blue colored solution is obtained
(b) Na^+ ions reformed in the solution
(c) Liquid ammonia becomes good conductor of electricity
(d) Liquid ammonia remains diamagnetic

56. $Na_2S_2O_3 \cdot 5H_2O$ is used in photography to:

(a) Reduce AgBr to metallic Ag
(b) Remove reduced Ag
(c) Remove undecomposed AgBr as a soluble complex
(d) Convert metallic Ag to silver salt

57. Among LiCl, RbCl, $BeCl_2$, and $MgCl_2$ the compounds with greatest and least ionic character, respectively are:

(a) LiCl, RbCl (b) RbCl, $BeCl_2$
(c) RbCl, $MgCl_2$ (d) $MgCl_2$, $BeCl_2$

58. Thermal stability of hydrides of first group elements follows the order:

(a) LiH > NaH > KH > RbH
(b) LiH > KH > NaH > RbH
(c) LiH > RbH > KH > NaH
(d) LiH > KH > RbH > NaH

59. When sodium is treated with sufficient oxygen/air, the product obtained is:

(a) Na_2O (b) Na_2O_2
(c) NaO_2 (d) NaO

60. KO_2 (potassium superoxide) is used in oxygen cylinders in space and submarines because it:

(a) Decomposes to give oxygen
(b) Eliminates moisture
(c) Absorbs CO_2
(d) Produces ozone

61. The magnetic moment of KO_2 at room temperature is .... B.M.

(a) 1.41 (b) 1.73
(c) 2.23 (d) 2.64

62. The reaction that takes place when Cl_2 gas is passed through conc. NaOH solution is:

(a) Oxidation (b) Reduction
(c) Displacement (d) Disproportionation

63. Calcium is extracted by the electrolysis of:

(a) Fused mixture of $CaCl_2$ and CaF_2
(b) $CaCl_2$ solution
(c) Fused mixture of $CaCl_2$ and NaF
(d) $Ca_3(PO_4)_2$ solution

JEE (Advanced) Exercises

Single Correct Answer Type

1. When CaC_2 is heated in atmospheric nitrogen in an electric furnace, the compound formed is:
   (a) $Ca(CN)_2$ (b) $CaNCN$
   (c) Ca_3N_2 (d) $CaNC_2$
2. Which of the following represents calcium chlorite?
   (a) $CaClO_2$ (b) $Ca(ClO_4)_2$
   (c) $Ca(ClO_3)_2$ (d) $Ca(ClO_2)_2$
3. The most electropositive element among the alkaline earth metals is:
   (a) Be (b) Mg
   (c) Ca (d) Ba
4. The right order of the solubility of sulphates of alkaline earth metals is:
   (a) Be > Ca > Mg > Ba > Sr
   (b) Mg > Be > Ba > Ca > Sr
   (c) Be > Mg > Ca > Sr > Ba
   (d) Mg > Ca > Ba > Be > Sr
5. The compound which is insoluble in dil. HCl is:
   (a) MnS (b) ZnS
   (c) $BaCO_3$ (d) $BaSO_4$
6. The first ionization energies of alkaline earth metals are higher than those of the alkali metals. This is because:
   (a) There is increase in the nuclear charge of the alkaline earth metal
   (b) There is decrease in the nuclear charge of the alkaline earth metal
   (c) There is no change in the nuclear charge
   (d) None of the above
7. Which of the following has maximum ionization energy?
   (a) $Ba \longrightarrow Ba^+ + e^-$ (b) $Be \longrightarrow Be^+ + e^-$
   (c) $Ca \longrightarrow Ca^{2+} + 2e^-$ (d) $Mg \longrightarrow Mg^{2+} + 2e^-$
8. As the alkaline earth metals (except Be) tend to lose their valence electrons readily. They act as:
   (a) Weak oxidizing agents
   (b) Weak reducing agents
   (c) Strong oxidizing agents
   (d) Strong reducing agents
9. The reaction of Cl_2 with X gives bleaching powder. X is:
   (a) CaO (b) $Ca(OH)_2$
   (c) $Ca(OCl_2)$ (d) $Ca(ClO_3)_2$
10. Which of the following carbides produces propyne on reaction with water?
    (a) CaC_2 (b) Be_2C
    (c) Al_4C_3 (d) Mg_2C_3
11. KO_2 (potassium superoxide) is used in oxygen cylinders in space and submarines because it:
    (a) Produces ozone (b) Absorbs CO_2
    (c) Absorbs CO_2 and increase O_2 contents
    (d) Eliminates moisture
12. Which of the following compounds transforms baking soda into baking powder?
    (a) $KHCO_3$ (b) $NaHCO_3$
    (c) $KHC_4H_4O_6$ (d) KCl
13. Baking powder used to make cake is a mixture of starch, $NaHCO_3$, and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is:
    (a) Being acidic in nature and gives CO_2 when moistened with $NaHCO_3$
    (b) To slow down the release of CO_2 gas
    (c) To act as a filler
    (d) None of these
14. The alkali metals form salt-like hydrides by the direct synthesis at elevated temperature. The thermal stability of these hydrides decreases in which of the following orders?
    (a) NaH > LiH > KH > RbH > CsS
    (b) LiH > NaH > KH > RbH > CsH
    (c) CsH > RbH > KH > NaH > LiH
    (d) KH > NaH > LiH > CsH > RbH
15. Which one of the following reactions is not associated with the Solvay process of manufacture of sodium carbonate?
    (a) $NaCl + NH_4HCO_3 \longrightarrow NaHCO_3 + NH_4Cl$
    (b) $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$
    (c) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$
    (d) $NH_3 + H_2CO_3 \longrightarrow NH_4HCO_3$
16. In the following reactions, (X) and (Y) are respectively:
    $BaC_2 + N_2 \xrightarrow{\Delta} (X)$ $CaC_2 + N_2 \xrightarrow{\Delta} (Y)$
    (a) $Na(CN)_2$ and $Ca(CN)_2$
    (b) $Ba(CN)_2$ and $CaCN_2$
    (c) $BaCN_2$ and $CaCN_2$ (d) None of these
17. In the reaction: $K_4[Fe(CN)_6] + K_2CO_3 \longrightarrow$ the product formed is:
    (a) $FeCO_3$ (b) KCN
    (c) $KFeCO_3$ (d) $K_3[Fe(CN)_6]$

18. $CO_2 + NH_3 + H_2O \longrightarrow X$
$X + NaCl \longrightarrow Y + NH_4Cl$
$2Y \longrightarrow Z + H_2O + CO_2$. '$Z$' is:
(a) Na_2CO_3 (b) $(NH_4)_2CO_3$
(c) NH_4HCO_3 (d) $NaHCO_3$

19. The aqueous solution of an inorganic compound (X) gives white precipitate with NH_4OH which does not dissolve in excess of NH_4OH. This aqueous solution also gives white precipitate with $AgNO_3$ and the precipitate is soluble in dilute HNO_3. Here, (X) is:
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlN (d) $Al_2(SO_4)_3$

20. A compound (X) imparts a golden yellow flame and shows the following reactions:
Zn powder when boiled with a concentrated aqueous solution of (X) dissolves and H_2 is evolved. What is X?
(a) KOH (b) NaOH
(c) $Mg(OH)$ (d) $Ca(OH)_2$

21. For two ionic solids CaO and KI, identify the wrong statement among the following?
(a) Lattice energy of CaO is much higher than that of KI
(b) KI is soluble in benzene
(c) CaO has high m.pt.
(d) KI has high m.pt.

22. Photoelectric effect is maximum in:
(a) Cs (b) Na
(c) K (d) Li

23. Which of the following metals has most stable carbonate?
(a) Na (b) Mg
(c) Al (d) Si

24. A sodium salt of unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is:
(a) SO_4^{2-} (b) HCO_3^-
(c) CO_3^{2-} (d) NO_3^-

25. A solid compound 'X' on heating gives CO_2 gas and a residue. The residue mixed with water forms 'Y'. On passing an excess of CO_2 through 'Y' in water, a clear solution 'Z' is obtained. On boiling 'Z', compound 'X' is reformed. The compound 'X' is:
(a) $Ca(HCO_3)_2$ (b) $CaCO_3$
(c) Na_2CO_3 (d) K_2CO_3

26. One mole of magnesium nitride on reaction with an excess of water gives:
(a) One mole of ammonia
(b) One mole of nitric acid
(c) Two moles of ammonia
(d) Two moles of nitric acid

27. In certain matters, lithium differs from other alkali metals; the main reason for this is:
(a) Small size of lithium atom and Li^+
(b) Extremely high electropositivity of Li
(c) Greater hardness of Li
(d) Hydration of Li^+ ion

28. The stability of the following alkali metal chlorides follows the order:
(a) LiCl > KCl > NaCl > CsCl
(b) CsCl > KCl > NaCl > LiCl
(c) NaCl > KCl > LiCl > CsCl
(d) LiCl > NaCl > KCl > CsCl

29. Which of the following has the highest melting point?
(a) NaCl (b) NaF
(c) NaBr (d) NaI

30. Oxone is:
(a) CaO (b) N_2O
(c) Na_2O_2 (d) $NaBO_3$

31. Which of the following has the least ionization potential among these metals?
(a) Li (b) He
(c) N (d) Zn

32. Sodium carbonate on heating gives:
(a) CO_2 (b) Water vapors
(c) Carbon dioxide + water vapor
(d) None of these

33. The sodium is made by electrolysis of a molten mixture of 40% NaCl and 60% $CaCl_2$ because:
(a) $CaCl_2$ helps in the conduction of electricity
(b) Ca^{2+} can reduce NaCl to Na
(c) Ca^{2+} can displace Na from NaCl
(d) This mixture has a lower melting point than NaCl

34. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame, no distinctive color is noticed. Which one is cation?
(a) Mg^{2+} (b) Ba^{2+}
(c) Na^+ (d) Ca^{2+}

35. Alkaline earth metal salt are:

(a) Paramagnetic (b) Diamagnetic

(c) Ferromagnetic (d) All of these

36. Halides of alkaline earth metals from hydrates such as $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$, and $SrCl_2 \cdot 2H_2O$. This shows that halides of group II elements:

(a) Are hygroscopic in nature

(b) Act as dehydrating agents

(c) Can absorbs moisture from air

(d) Cannot absorbs moisture from air

37. Which of the following gives propyne on hydrolysis?

(a) Al_4C_3 (b) Mg_2C_3

(c) B_4C (d) La_4C_3

38. A metal X on heating in nitrogen gas gives Y. Y on treatment with H_2O gives a colorless gas which when passed through $CuSO_4$ solution gives a blue color. Y is:

(a) $Mg(NO_3)_2$ (b) Mg_3N_2

(c) NH_3 (d) MgO

39. As the nuclear charge increases from neon to calcium, the orbital energies:

(a) Increase (b) Increase very rapidly

(c) Increase very slowly (d) Fall

40. Ripening of fruits can be carried out in the presence of:

(a) Na_2SO_4 (b) NaCl

(c) $CaCl_2$ (d) CaC_2

41. What are the products formed when an aqueous solution of magnesium bicarbonate is boiled?

(a) $MgCO_3$, H_2O, CO_2 (b) $Mg(HCO_3)_2$, H_2O

(c) $Mg(OH)_2$, H_2O (d) $Mg(HO)_2$, CO_2

42. The substance not likely to contain $CaCO_3$ is:

(a) Dolamite (b) Sea shell

(c) Calcined gypsum (d) Marble statue

43. Bleaching powder is obtained by treating Cl_2 with:

(a) $Ca(OH)_2$ (b) CaO

(c) $CaCO_3$ (d) $CaCl_2$

44. Dead burnt plaster is:

(a) $CaSO_4 \cdot 2H_2O$ (b) $MgSO_4 \cdot 7H_2O$

(c) $CaSO_4 \cdot 1/2\ H_2O$ (d) $CaSO_4$

45. Correct order of stability of group IIA metal carbonates is:

(a) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$

(b) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$

(c) $SrCO_3 > BaCO_3 > CaCO_3 > MgCO_3$

(d) $CaCO_3 > MgCO_3 > BaCO_3 > SrCO_3$

46. Which of the following carbides produces propyne on reaction with water?

(a) CaC_2 (b) Be_2C

(c) Al_4C_3 (d) Mg_2C_3

47. Which one of the following processes will produce hard water?

(a) Saturation of water with $CaCO_3$

(b) Addition of Na_2SO_4 to water.

(c) Saturation of water with $MgCO_3$

(d) Saturation of water with $CaSO_4$

48. Which of the following statements about anhydrous aluminium chloride is correct?

(a) It sublimes at 100°C under vacuum

(b) It exists as $AlCl_3$ molecules

(c) It is a strong Lewis base

(d) It is not easily hydrolyzed

49. The oxidation states of the most electronegative element in the products of the reaction BaO_2 with dil. H_2SO_4 are:

(a) 0 and –1 (b) –1 and –2

(c) –2 and 0 (d) –2 and +1

50. Calcium imide on hydrolysis gives gas (P) which on oxidation by bleaching powder gives gas (Q). Gas (Q) on reaction with magnesium gives compound (R) which on hydrolysis again gives gas (P). Identify (P), (Q), and (R):

(a) N_2, NH_3, MgNH (b) NH_3, N_2, Mg_3N_2

(c) NH_3, NO_2, $Mg(NO_2)_2$ (d) N_2, N_2O_5, $Mg(NO_3)_2$

51. In the electrolysis of aqueous NaCl solution, side reactions taking place are:

(I) $2OH^- + Cl_2 \longrightarrow 2OCl^- + H_2O$

(II) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

(III) $4OH^- \longrightarrow O_2 + 2H_2 + 4e^-$

Select the correct alternate:

(a) (I) and (III) (b) (II) and (III)

(c) (I) and (II) (d) (I), (II), and (III)

52. Salt $(P) + (Q) \longrightarrow (R) \xrightarrow[\text{White ppt.}]{BaCl_2}$

(P) is paramagnetic in nature and contains about 55% K, so (P) is:

(a) KO_2 (b) K_2O

(c) K_2SO_4 (d) K_2O_2

53. $(P) + H_2O \longrightarrow NaOH$

$(P) \xrightarrow{O_2\ 400°C} (Q) \xrightarrow{H_2O,\ at\ 25°C} NaOH + O_2$

(Q) is used for oxygenating in submarine. (P) and (Q) are:

(a) Na_2O_2 and O_2 (b) Na_2O and O_2

(c) Na_2O_2 and Na_2O (d) Na_2O and Na_2O_2

54. Which of the following equations is correct?

(a) $3LiNO_3 \xrightarrow{\text{heat}} 2LiNO_2 + O_2$

(b) $NaNO_3 + NaNH_2 \xrightarrow{80°\text{-}90°C} 2NaOH + N_2O$

(c) Potassium formate is heated with free exposure to air. $2HCOOK + O_2 \longrightarrow K_2CO_3 + H_2O + CO_2$

(d) Solid $KBrO_3$ is heated with powdered charcoal. $2KBrO_3 + 3C \longrightarrow 2KBr + 3CO_2$

55. In the reaction: $Al_2(SO_4)_3 \cdot 18H_2O \xrightarrow[-18H_2O]{\text{heat}} A \xrightarrow{800°C} B + C$. The product A, B and C are respectively:

(a) $Al_2(SO_4)_3$, Al_2O_3, SO_3 (b) Al_2O_3, $Al_2(SO_4)_3$, SO_3

(c) Al_2SO_4, Al_2O_3, SO_3

(d) $Al_2(SO_4)_3$, Al_2O_3, SO_2

56. Which of the following reaction/s are correct here?

(I) $B + NaOH \longrightarrow 2Na_3BO_3 + H_2$

(II) $P_4 + NaOH + H_2O \longrightarrow NaH_2PO_2 + PH_3$

(III) $S + NaOH \longrightarrow Na_2S_2O_3 + Na_2S + H_2O$

(a) I only (b) III only

(c) II and III (d) I, II, and III

57. In the following sequence of reactions, identify the end product (D).

$Na_2CO_3 \xrightarrow{SO_2} (A) \xrightarrow{Na_2CO_3} (B) \xrightarrow{\text{Elemental } S,\ \Delta} (C) \xrightarrow{I_2} (D)$

(a) Na_2SO_4 (b) $Na_2S_4O_6$

(c) Na_2S (d) $Na_2S_2O_3$

58. Consider the following reactions:

$X + HCl \xrightarrow[\text{(addition)}]{\text{anhyd. AlCl}_3} C_2H_5Cl \xrightarrow[\text{(substitution)}]{\text{anhyd. ZnCl}_2/\text{HCl}} Y$

Y can be converted to X on heating with .... at .... temperature:

(a) Cu, 300°C (b) Al_2O_3, 350°C

(c) $NaOH/I_2$, 60°C (d) $Ca(OH)_2 + CaOCl_2$, 60°C

59. Consider the following reactions:

I. $2Na + 2H_2O \longrightarrow 2NaOH + H_2$;

II. $2NaOH + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$;

III. $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

IV. $2Cl^- \longrightarrow Cl_2 + 2e^-$

In the diaphragm cell used for the electrolysis of brine, the reactions that occur would include:

(a) 2, 3, 4 (b) 1, 3, 4

(c) 1, 2, 3 (d) 1, 2, 4

60. A soft metal (A) gives violet flame test. When burnt in O_2, (A) gives chrome yellow powder (B) which on reaction with water gives alkaline solution (C) and O_2. Identify the metal:

(a) Na (b) Mg

(c) K (d) Ca

61. A hydrated colorless solid (A) is water soluble and finds use in medicine as a purgative. When a solution of (A) is treated with ammonium phosphate, a white precipitate is formed. (A) gives a pink mass is cobalt nitrate test. What is (A)?

(a) $FeSO_4 \cdot 7H_2O$ (b) $Na_2SO_4 \cdot 10H_2$

(c) $MgSO_4 \cdot 7H_2O$ (d) $CaSO_4 \cdot 2H_2O$

62. Select the correct basic character:

(a) $NiO < MgO < SrO < K_2O < Cs_2O$

(b) $NiO < MgO < K_2O < BrO < Cs_2O$

(c) $MgO < NiO < SrO < K_2O < Cs_2O$

(d) $SrO < NiO < MgO < K_2O < Cs_2O$

63. Calcium is obtained by the:

(a) Roasting of limestone

(b) Electrolysis of a solution of calcium chloride in H_2O

(c) Reduction of calcium chloride with carbon

(d) Electrolysis of molten anhydrous calcium chloride

Multiple Correct Answers Type

1. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because:

(a) The hydration energy of Na_2SO_4 is more than its lattice energy

(b) The lattice energy of $BaSO_4$ is more than its hydration energy

(c) The lattice energy has no role to play in solubility

(d) The lattice energy of Na_2SO_4 is more than its hydration energy

2. Be and Al have following resemblance due to diagonal relationship:

(a) Have nearly equal electronegativity

(b) Form amphoteric oxides

(c) Have same charge/radius ratio

(d) Both form dimeric halides

3. The correct statement(s) is/are:

(a) $BeCl_2$ is a covalent compound

(b) $BeCl_2$ can form dimer

(c) $BeCl_2$ is an electron deficient molecule

(d) The hybrid state of Be in $BeCl_2$ is sp^2

4. Among the following, the diamagnetic compound is/are:
   (a) Na_2O_2 (b) O_3
   (c) N_2O (d) KO_2

5. The carbonate that will decompose on heating is/are:
   (a) Na_2CO_3 (b) $CaCO_3$
   (c) $BaCO_3$ (d) $SrCO_3$

6. Highly pure dilute solution of sodium in liquid ammonia:
   (a) Shows blue color
   (b) Exhibits electrical conductivity
   (c) Produces sodium amide
   (d) Produces hydrogen gas

7. Identify the incorrect statement:
   (a) Gypsum contains a lower percentage of calcium than Plaster of Paris
   (b) Gypsum is obtained by heating Plaster of Paris
   (c) Plaster of Paris is obtained by hydration of gypsum
   (d) Plaster of Paris is obtained by partial oxidation of gypsum

8. Which one of the following processes is/are not used for the manufacture of calcium?
   (a) Reduction of CaO with carbon
   (b) Reduction of CaO with hydrogen
   (c) Electrolysis of a mixture of anhydrous $CaCl_2$
   (d) Electrolysis of molten $Ca(OH)_2$

9. Select the incorrect statement(s):
   (a) Lattice energy $\propto \frac{1}{r^2}$. {where r is the interionic distance}
   (b) Lattice energy $\propto q_1q_2$. {where q_1 and q_2 are the charges of co-ions}
   (c) Ionic mobility of the ions in aqueous state $\propto \frac{1}{\text{radius of ions in gaseous state}}$
   (d) Heat of formation of a compound depends on the number of steps involved in its formation reaction

10. Which of the following is/are amphoteric oxide?
    (a) BeO (b) BaO
    (c) Al_2O_3 (d) CaO

11. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because:
    (a) The hydration energy of Na_2SO_4 is more than its lattice energy
    (b) The lattice energy of $BaSO_4$ is more than its hydration energy
    (c) The lattice energy has no role to play in solubility
    (d) The lattice energy of Na_2SO_4 is more than its hydration energy

12. Select the correct statement(s) about barium:
    (a) It shows photoelectric effect
    (b) It is silvery white metal
    (c) It forms $Ba(NO_3)_2$ which is used in preparation of green fire
    (d) Its ionization energy is less than radium

13. Mg and Zn have following resemblance:
    (a) MgO and ZnO are amphoteric
    (b) $MgCO_3$ and $ZnCO_3$ both on heating give corresponding oxide
    (c) Both are *d*-block elements
    (d) Both are used to prevent corrosion

14. When dissolving moderate amount of sodium metal in liquid NH_3 at low temperature, which one of the following does occur?
    (a) Blue colored solution is obtained
    (b) Na^+ ions are formed in the solution
    (c) Liquid NH_3 becomes good conductor of electricity
    (d) Liquid NH_3 remains diamagnetic

15. Which of the following oxides is/are expected to react with sodium hydroxide?
    (a) CaO (b) SiO_2
    (c) BeO (d) B_2O_3

16. The compound(s) formed upon combustion of sodium metal in excess air is (are):
    (a) Na_2O_2 (b) Na_2O
    (c) NaO_2 (d) NaOH

17. Kieserite is not an ore of:
    (a) Cu (b) Fe
    (c) Mg (d) Al

18. Highly pure dilute solution of sodium in liquid ammonia:
    (a) Shows blue color
    (b) Exhibits electric conductivity
    (c) Produces sodium amide
    (d) Produces hydrogen gas

19. The addition of which metal into liquid NH_3 leads to the formation of blue solution:
    (a) Li (b) Sr
    (c) Cs (d) Ba

20. Which of the following element(s) is/are not react directly with nitrogen to form nitride?
(a) Na (b) Li
(c) K (d) Rb

21. Which of the following composition of minerals is/are correct:
(a) Soda ash – Na_2CO_3
(b) Carnallite – $KCl{\cdot}MgCl_2{\cdot}6H_2O$
(c) Borax – $Na_2B_4O_7{\cdot}7H_2O$
(d) Glauber's salt – $Na_2SO_4{\cdot}10H_2O$

22. The pairs of compounds which cannot exist together in aqueous solution are:
(a) NaH_2PO_4 and Na_2HPO_4
(b) Na_2CO_3 and $NaHCO_3$
(c) NaOH and NaH_2PO_4
(d) $NaHCO_3$ and NaOH

23. Which of the following is/are incorrect?
(a) Mg burns in air releasing dazzling light rich in UV-rays
(b) $CaCl_2 \cdot 6H_2O$ when mixed with ice gives freezing mixture
(c) Mg^{2+} cannot form complexes
(d) Be can form complexes due to its very small size

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

A soft silver white metal (*A*) burns with golden yellow flame to give a yellow power *B* which on treatment with water liberates oxygen giving a clear solution *C*. The solution placed on Al attacks this metal, liberating a gas *D* and forming a water soluble compound *E*. The metal (*A*) dissolves in liquid NH_3 to form deep blue solution which is a good conductor and an excellent reducing agent.

1. Identify *C*:
(a) KOH (b) $Al(OH)_3$
(c) NaOH (d) LiOH

2. Identify *D*:
(a) N_2 (b) Cl_2
(c) NH_3 (d) H_2

3. Identify *E*:
(a) NaOH (b) $NaAlO_2$
(c) $Ca(AlO_2)_2$ (d) None of these

Comprehension-2: (Q. 4 to Q. 6)

On the basis of E.N. difference of $|X_O - X_E|$ and $|X_O - X_H|$, acidic and basic characters of E — O — H can be decided, and acidic and basic strengths are compared.

4. Correct order of acidic strength is:
(a) Na — O — H > K — O — H > Rb — O — H
(b) Na — O — H < K — O — H < Li — O — H
(c) H — O — K > H — O — Rb > Na — O — H
(d) None of these

5. Correct order of basic strength is:
(a) H — O — I < H — O — Br < H — O — Cl
(b) H — O — Cl > H — O — I > H — O — Br
(c) H — O — I > H — O — Br > H — O — Cl
(d) None of these

6. Strongest acid among the following:
(a) HClO (b) $HClO_2$
(c) $HClO_4$ (d) $HClO_3$

Comprehension-3: (Q. 7 to Q. 11)

Alkali and alkaline earth metals along with hydrogen and helium constitute *s*-block elements. They have low ionization enthalpies and hence exhibit characteristic flame colorations. They have highly negative electrode potentials and hence are strong reducing agents. Their solutions in liquid ammonia are conducting and also act as strong reducing agents. Being stronger reducing agents than hydrogen, they are usually prepared by electrolysis of their fused chlorides. Their oxides are basic and the basic strength increases down the group. The solubility of carbonates and sulphates of alkali and alkaline earth metals shows opposite trends. The carbonates of alkaline earth metals and lithium carbonate decompose on heating while the carbonates of other alkali metals do not decompose on heating. The bicarbonates of both alkali and alkaline earth metals on heating give carbonates.

7. The compound insoluble in acetic acid is:
(a) Calcium oxide (b) Calcium carbonate
(c) Calcium oxalate (d) Calcium hydroxide

8. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order: K_2CO_3 (I), $MgCO_3$ (II), $CaCO_3$ (III), $BeCO_3$ (IV):
(a) I < II < III < IV (b) IV < II < III < I
(c) IV < II < I < III (d) II < IV < III < I

9. Property of alkaline earth metals that increases with their atomic number is:
(a) Ionization energy
(b) Solubility of their hydroxides
(c) Solubility of their sulphates
(d) Electronegativity

10. Which of the following process is used in the extractive metallurgy of magnesium?
(a) Fused salt electrolysis
(b) Self-reduction
(c) Aqueous solution electrolysis
(d) Thermite reduction

11. Identify the correct order of acidic strengths of CO_2, CuO, CaO, H_2O:
(a) $CaO < CuO < H_2O < CO_2$
(b) $H_2O < CuO < CaO < CO_2$
(c) $CaO < H_2O < CuO < CO_2$
(d) $H_2O < CO_2 < CaO < CuO$

Comprehension-4: (Q. 12 to Q. 14)

A colorless solid *A* liberates a brown gas *B* on acidification, a colorless alkaline gas *C* on treatment with NaOH solution, and colorless inactive gas *D* on heating.

12. What is the formula of colorless alkaline gas *C*?
(a) N_2 (b) NH_3
(c) NO (d) None of these

13. What is the formula of colorless inactive gas *D*?
(a) N_2 (b) H_2
(c) NH_3 (d) NO

14. What is the formula of gas *B*?
(a) Br_2 (b) N_2
(c) N_2O (d) NO_2

Comprehension-5: (Q. 15 to Q. 17)

Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas (*A*) and an alkaline solution. The solution on exposure to air produces a thin solid layer of (*B*) on the surface.

15. When CO_2 gas passed into the alkaline solution, then which of the following product will be formed?
(a) $BaCO_3$ (b) $CaCO_3$
(c) $SrCO_3$ (d) None of these

16. The gas *A* is:
(a) N_2 (b) NH_3
(c) N_2O (d) None of these

17. Find out *B*.
(a) CaO (b) $CaCO_3$
(c) Ca_3N_2 (d) None of these

Comprehension-6: (Q. 18 to Q. 21)

A colorless water soluble crystalline solid (*A*) on heating gives O_2 and gives a water soluble crystalline solid (*B*). Both *A* and *B* impart violet coloration to the Bunsen flame. When *B* is heated with NH_4Cl, inactive gas (*C*) is obtained but when *A* is heated with NH_4Cl, a gas (*D*) which supports combustion is formed. When gas (*D*) is heated with soda amide, solid substance *E* is obtained. The solid *E*, when heated with dil. H_2SO_4, forms a monobasic acid *F*; *F* and its salts are explosive.

18. Identify *A*:
(a) KNO_2 (b) KNO_3
(c) $AgNO_3$ (d) $NaNO_2$

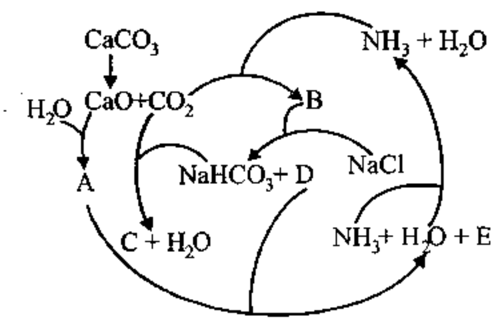
19. Identify *C*:
(a) N_2 (b) H_2
(c) O_2 (d) N_2O

20. Identify *E*:
(a) K_3N (b) NaN_3
(c) $NaHSO_4$ (d) None of these

21. Identify *F*:
(a) HF (b) NH_3
(c) HN_3 (d) None of these

Comprehension-7: (Q. 22 to Q. 25)

The Solvay process can be represented by the following scheme:



22. Find out *A*:
(a) CaO (b) $Ca(OH)_2$
(c) $CaCO_3$ (d) None of these

23. Find out *B*:
(a) $(NH_4)_2CO_4$ (b) NH_4HCO_3
(c) $(NH_4)_2C_2O_4$ (d) NH_4Cl

24. Find out *D*:
(a) NH_4Cl (b) $CaCl_2$
(c) $NH_4H\ CO_3$ (d) $Ca(OH)_2$

25. Find out *E*:
(a) NaCl (b) $NaCO_3$
(c) $CaCl_2$ (d) $Ca(OH)_2$

Assertion-Reasoning Type

1. **Statement-1:** The ionic mobility of $Na^+_{(aq)}$ is lower than that of $K^+_{(aq)}$

   Statement-2: $r_{Na^+(aq.)} > r_{K^+(aq.)}$

   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** Lithium chloride is predominately covalent compound.

   Statement-2: Electronegativity difference between Li and Cl is small.

   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Li	(p) Radioactive
(b) Na	(q) Atomic number 11
(c) K	(r) Cation of element which has higher degree of hydration among the elements
(d) Fr	(s) ns^1 configuration
	(t) First element of group-I

2. Match the column:

Column-I	Column-II
(a) Cs	(p) Nitride formed when metal react with N_2
(b) K	(q) Cation which is formed mainly superoxide
(c) Li	(r) Salts of cation are mostly hydrated
(d) Mg	(s) Violet color in to the flame

3. Match the column:

Column-I	Column-II
(a) Flame coloration	(p) $Be(OH)_2$
(b) Amphoteric character	(q) Li Cl
(c) Soluble in organic solvents	(r) $BeCl_2$
(d) Evolves CO_2 on heating	(s) $Al(OH)_3$
(e) Forms superoxide on heating with oxygen	(t) K
	(u) Li_2CO_3

4. Match the column:

Column-I	Column-II
(a) Ionic compound	(p) HCl (vap.)
(b) Non-polar covalent compound	(q) SiO_2
(c) Polar covalent compound having sigma bond only	(r) KNO_3
	(s) NO

5. Match the column:

Column-I	Column-II
(a) Li^+(aq)	(p) Metal(s) readily react vigorously with halogens to from ionic halides
(b) Na^+(aq)	(q) Highest ionic mobility among the ions
(c) K^+(aq)	(r) Highest hydrated size among the ions
(d) Rb^+(aq)	(s) Highest hydration energy among the cation
	(t) Lowest ionic mobility among the ion

6. Match the column:

Column-I	Column-II
(a) Be	(p) Show diagonal relationship with other elements
(b) Mg	(q) Highest hydration energy of cation among the element
(c) Ca	(r) Cation has lowest hydrated size in aqueous solution
(d) Sr	(s) Metal(s) which dissolve in liquid ammonia to give deep blue solution
	(t) s-block elements

7. Match the column:

Column-I	Column-II
(a) Li	(p) Metal(s) dissolve in liquid ammonia giving deep blue solution
(b) Na	(q) Very low solubility of fluoride salts in water
(c) K	(r) Diagonal relationship with Mg
(d) Cs	(s) Golden yellow color in flame
	(t) Superoxide ion is stable in the presence of larger cation(s)

8. Match the column:

Column-I	Column-II
(a) Alkali metal carbonate which does not decompose on heating	(p) $MgCO_3$
(b) Alkali metal carbonate which decomposes on heating	(q) Na_2CO_3
(c) K/liq. NH_3 is blue color solution which conducts electricity	(r) Li_2CO_3
	(s) Solvated electrons

Integer Answer Type

1. The number of covalent bonds formed by beryllium is ___________.

2. Find the number of amphoteric hydroxide(s) from the following:

   $Be(OH)_2$, $Mg(OH)_2$, $Al(OH)_3$, $LiOH$, $B(OH)_3$, $Zn(OH)_2$

3. Find the number of chloride(s) which do not impart color to the flame from the following:

   $BeCl_2$, $SrCl_2$, $MgCl_2$, $CaCl_2$, $BaCl_2$

4. Find the number of element(s) which is/are present in group-II:

   Ba, K, Ca, Cs, Rb, Na

5. What is the most common oxidation state of alkali metals?

6. How many $3C - 4e^-$ bonds are present in dimer of $BeCl_2$?

7. How many water moelcule(s) is/are present in gypsum?

8. Find the number of peroxide molecule(s) in the following:

   MgO, CaO, Li_2O, BaO_2

9. Find the number of element(s) which is/are present in group-I:

   Be, Li, Mg, Al, Na, Ca, Cs

10. What is the most common oxidation state of alkaline earth metals?

11. When Mg_3N_2 react with H_2O, then how many type of gaseous product(s) is/are formed?

12. How many water molecule(s) is/are present in dead burnt plaster?

13. When Mg_2C_3 undergoes hydrolysis, how many carbon atoms is/are present in product?

14. When $BeCl_2$ undergoes hydrolysis in alkaline medium, then what is the co-ordination number of Be in product?

15. When CaC_2 undergoes hydrolysis, then how many π bonds are present in gaseous product?

16. When alkaline earth metals react with phosphorous, then how many phosphorus atom(s) is/are present in product side?

17. How many *p*-orbital(s) is/are involved in hydridization of solid $BeCl_2$?

18. $Mg + N_2 \xrightarrow{\text{Heat}} X$

    $$\underset{\text{Colorless gas}}{X} \xrightarrow{H_2O} Z \xrightarrow{H_2O} \text{Solution} \xrightarrow{CuSO_4} \underset{\text{Blue colored}}{(A)}$$

    What is the coordination number of the central atom of compound having blue colored solution?

NCERT Exemplar Exercises

Single Correct Answer Type

1. The alkali metals are low melting. Which of the following alkali metal is expected to melt if the room temperature rises to 30°C?
   (a) Na (b) K
   (c) Rb (d) Cs

2. Alkali metals react with water vigorously to form hydroxides and dihydrogen. Which of the following alkali metals reacts with water least vigorously?
   (a) Li (b) Na
   (c) K (d) Cs

3. The reducing power of a metal depends on various factors. Suggest the factor which makes Li, the strongest reducing agent in aqueous solution.
   (a) Sublimation enthalpy
   (b) Ionization enthalpy
   (c) Hydration enthalpy
   (d) Electron-gain enthalpy

4. Metal carbonates decompose on heating to give metal oxide and carbon dioxide. Which of the metal carbonates is most stable thermally?
   (a) $MgCO_3$ (b) $CaCO_3$
   (c) $SrCO_3$ (d) $BaCO_3$

5. Which of the carbonates given below is unstable in air and is kept in CO_2 atmosphere to avoid decomposition.
   (a) $BeCO_3$ (b) $MgCO_3$
   (c) $CaCO_3$ (d) $BaCO_3$

6. Metals form basic hydroxides. Which of the following metal hydroxide is the least basic?
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Sr(OH)_2$ (d) $Ba(OH)_2$

7. Some of the Group 2 metal halides are covalent and soluble in organic solvents. Among the following metal halides, the one which is soluble in ethanol is:
(a) $BeCl_2$ (b) $MgCl_2$
(c) $CaCl_2$ (d) $SrCl_2$

8. The order of decreasing ionization enthalpy in alkali metals is:
(a) Na > Li > K > Rb (b) Rb < Na < K < Li
(c) Li > Na > K > Rb (d) K < Li < Na < Rb

9. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of LiF in water is due to:
(a) Ionic nature of lithium fluoride
(b) High lattice enthalpy
(c) High hydration enthalpy for lithium ion
(d) Low ionization enthalpy of lithium atom

10. Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?
(a) $Be(OH)_2$ (b) $Mg(OH)_2$
(c) $Ca(OH)_2$ (d) $Ba(OH)_2$

11. In the synthesis of sodium carbonate, the recovery of ammonia is done by treating NH_4Cl with $Ca(OH)_2$. The by-product obtained in this process is:
(a) $CaCl_2$ (b) NaCl
(c) NaOH (d) $NaHCO_3$

12. When sodium is dissolved in liquid ammonia, a solution of deep blue color is obtained. The colour of the solution is due to:
(a) Ammoniated electron
(b) Sodium ion
(c) Sodium amide
(d) Ammoniated sodium ion

13. By adding gypsum to cement:
(a) Setting time of cement becomes less
(b) Setting time of cement increases
(c) Color of cement becomes light
(d) Shining surface is obtained

14. Dead burnt plaster is:
(a) $CaSO_4$ (b) $CaSO_4 \cdot 4H_2O$
(c) $CaSO_4 \cdot H_2O$ (d) $CaSO_4 \cdot 2H_2O$

15. Suspension of slaked lime in water is known as:
(a) Lime water
(b) Quick lime
(c) Milk of lime
(d) Aqueous solution of slaked lime

16. Which of the following elements does not form hydride by direct heating with dihydrogen?
(a) Be (b) Mg
(c) Sr (d) Ba

17. The formula of soda ash is:
(a) $Na_2CO_3 \cdot 10H_2O$
(b) $Na_2CO_3 \cdot 2H_2O$
(c) $Na_2CO_3 \cdot H_2O$
(d) Na_2CO_3

18. A substance which gives brick red flame and breaks down on heating to give oxygen and a brown gas is
(a) Magnesium nitrate (b) Calcium nitrate
(c) Barium nitrate (d) Strontium nitrate

19. Which of the following statements is true about $Ca(OH)_2$?
(a) It is used in the preparation of bleaching powder
(b) It is a light blue solid
(c) It does not possess disinfectant property
(d) It is used in the manufacture of cement

20. A chemical **A** is used for the preparation of washing soda to recover ammonia. When CO_2 is bubbled through an aqueous solution of **A**, the solution turns milky. It is used in white washing due to disinfectant nature. What is the chemical formula of **A**?
(a) $Ca(HCO_3)_2$ (b) CaO
(c) $Ca(OH)_2$ (d) $CaCO_3$

21. Dehydration of hydrates of halides of calcium, barium and strontium i.e., $CaCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$, $SrCl_2 \cdot 2H_2O$, can be achieved by heating. These become wet on keeping in air. Which of the following statements is correct about these halides?
(a) Act as dehydrating agent
(b) Can absorb moisture from air
(c) Tendency to form hydrate decreases from calcium to barium
(d) All of the above

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Metallic elements are described by their standard electrode potential, fusion enthalpy, atomic size, etc. The alkali metals are characterized by which of the following properties?
   (a) High boiling point
   (b) High negative standard electrode potential
   (c) High density
   (d) Large atomic size
2. Several sodium compounds find use in industries. Which of the following compounds are used for textile industry?
   (a) Na_2CO_3 (b) $NaHCO_3$
   (c) $NaOH$ (d) $NaCl$
3. Which of the following compounds are readily soluble in water?
   (a) $BeSO_4$ (b) $MgSO_4$
   (c) $BaSO_4$ (d) $SrSO_4$
4. When Zeolite, which is hydrated sodium aluminium silicate is treated with hard water, the sodium ions are exchanged with which of the following ion(s)?
   (a) H^+ ions (b) Mg^{2+} ions
   (c) Ca^{2+} ions (d) SO_4^{2-} ions
5. Identify the correct formula of halides of alkaline earth metals from the following.
   (a) $BaCl_2 \cdot 2H_2O$ (b) $BaCl_2 \cdot 4H_2O$
   (c) $CaCl_2 \cdot 6H_2O$ (d) $SrCl_2 \cdot 4H_2O$
6. Choose the correct statements from the following.
   (a) Beryllium is not readily attacked by acids because of the presence of an oxide film on the surface of the metal
   (b) Beryllium sulphate is readily soluble in water as the greater hydration enthalpy of Be^{2+} overcomes the lattice enthalpy factor
   (c) Beryllium exhibits coordination number more than four
   (d) Beryllium oxide is purely acidic in nature
7. Which of the following are the correct reasons for anomalous behavior of lithium?
   (a) Exceptionally small size of its atom
   (b) Its high polarizing power
   (c) It has high degree of hydration
   (d) Exceptionally low ionization enthalpy

Short Answer Type

1. How do you account for the strong reducing power of lithium in aqueous solution?
2. When heated in air, the alkali metals form various oxides. Mention the oxides formed by Li, Na, and K.
3. Complete the following reactions
   (a) $O_2^{2-} + H_2O \rightarrow$ (b) $O_2^- + H_2O \rightarrow$
4. Lithium resembles magnesium in some of its properties. Mention two such properties and give reasons for this resemblance.
5. Name an element from Group 2 which forms an amphoteric oxide and a water soluble sulphate.
6. Discuss the trend of the following:
   (a) Thermal stability of carbonates of Group 2 elements.
   (b) The solubility and the nature of oxides of Group 2 elements.
7. Why are $BeSO_4$ and $MgSO_4$ readily soluble in water while $SrSO_4$ and $BaSO_4$ are insoluble?
8. All compounds of alkali metals are easily soluble in water but lithium compounds are more soluble in organic solvents. Explain.
9. In the Solvay process, can we obtain sodium carbonate directly by treating the solution containing $(NH_4)_2CO_3$ with sodium chloride? Explain.
10. Write Lewis strucure of O_2^- ion and find out oxidation state of each oxygen atom? What is the average oxidation state of oxygen in this ion?
11. Why do beryllium and magnesium not impart colour to the flame in the flame test?
12. What is the structure of $BeCl_2$ molecule in gaseous and solid state?

Matching Column Type

In the following questions more than one option of Column-I and Column-II may be correlated.

1. Match the elements given in Column-I with the properties mentioned in Column-II.

Column-I	Column-II
(a) Li	(p) Insoluble sulphate
(b) Na	(q) Strongest monoacidic base among these

(c) Ca — (r) Most negative E^0 value among alkali metals

(d) Ba — (s) Insoluble oxalate

(t) $6s^2$ outer electronic configuration

2. Match the compounds given in Column-I with their uses mentioned in Column-II.

Column-I	Column-II
(a) $CaCO_3$	(p) Dentistry, ornamental work
(b) $Ca(OH)_2$	(q) Manufacture of sodium carbonate from caustic soda
(c) CaO	(r) Manufacture of high quality paper
(d) $CaSO_4$	(s) Used in white washing

3. Match the elements given in Column-I with the colour they impart to the flame given in Column-II.

Column-I	Column-II
(a) Cs	(p) Apple green
(b) Na	(q) Violet
(c) K	(r) Brick red
(d) Ca	(s) Yellow
(e) Sr	(t) Crimson red
(f) Ba	(u) Blue

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

1. **Assertion (A):** The carbonate of lithium decomposes easily on heating to form lithium oxide and CO_2.

   Reason (R): Lithium being very small in size polarises large carbonate ion leading to the formation of more stable Li_2O and CO_2.

   (a) Both A and R are correct and R is the correct explanation of A.

   (b) Both A and R are correct but R is not the correct explanation of A.

   (c) Both A and R are not correct

   (d) A is not correct but R is correct.

2. **Assertion (A):** Beryllium carbonate is kept in the atmosphere of carbon dioxide.

   Reason (R): Beryllium carbonate is unstable and decomposes to give beryllium oxide and carbon dioxide.

   (a) Both A and R are correct and R is the correct explanation of A.

   (b) Both A and R are correct but R is not the correct explanation of A.

   (c) Both A and R are not correct.

   (d) A is not correct but R is correct.

Long Answer Type

1. The *s*-block elements are characterized by their larger atomic sizes, lower ionization enthalpies, invariable + 1 oxidation state and solubilities of their oxosalts.In the light of these features describe the nature of their oxides, halides, and oxosalts.

2. Present a comparative account of the alkali and alkaline earth metals with respect to the following characteristics:

   (a) Tendency to form ionic / covalent compounds

   (b) Nature of oxides and their solubility in water

   (c) Formation of oxosalts

   (d) Solubility of oxosalts

   (e) Thermal stability of oxosalts

3. When a metal of group 1 was dissolved in liquid ammonia, the following observations were obtained:

   (a) Blue solution was obtained initially.

   (b) On concentrating the solution, blue colour changed to bronze colour. How do you account for the blue color of the solution? Give the name of the product formed on keeping the solution for some time.

4. The stability of peroxide and superoxide of alkali metals increase as we go down the group. Explain giving reason.

5. When water is added to compound (A) of calcium, solution of compound (B) is formed. When carbon dioxide is passed into the solution, it turns milky due to the formation of compound (C). If excess of carbon dioxide is passed into the solution milkiness disappears due to the formation of compound (D). Identify the compounds A, B, C and D. Explain why the milkiness disappears in the last step.

6. Lithium hydride can be used to prepare other useful hydrides. Beryllium hydride is one of them. Suggest a route for the preparation of beryllium hydride starting from lithium hydride. Write chemical equations involved in the process.

7. An element of group 2 forms covalent oxide which is amphoteric in nature and dissolves in water to give an amphoteric hydroxide. Identify the element and write chemical reactions of the hydroxide of the element with an alkali and an acid.

8. Ions of an element of group 1 participate in the transmission of nerve signals and transport of sugars and aminoacids into cells. This element imparts yellow colour to the flame in flame test and forms an oxide and a peroxide with oxygen. Identify the element and write chemical reaction to show the formation of its peroxide. Why does the element impart colour to the flame?

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it:
   (a) Absorbs CO_2 and increases O_2 content
   (b) Eliminates moisture
   (c) Absorbs CO_2
   (d) Produces ozone
   (AIEEE, 2002)

2. The metallic sodium dissolves in liquid ammonia to form a deep blue-colored solution. The deep blue colour is due to formation of:
   (a) Solvated electron, $e(NH_3)_x^-$
   (b) Solvated atomic sodium, $Na(NH_3)_y$
   (c) $(Na^+ + Na^-)$
   (d) $NaNH_2 + H_2$
   (AIEEE, 2002)

3. A metal M readily forms its sulphate MSO_4, which is water soluble. It forms its oxide MO that becomes inert on heating. It forms an insoluble hydroxide $M(OH_2)$ that is soluble in NaOH solution. The M is:
   (a) Mg (b) Ba
   (c) Ca (d) Be
   (AIEEE, 2002)

4. In curing cement plasters, water is sprinkled from time to time. This helps in:
   (a) Developing interlocking needle-like crystals of hydrated silicates
   (b) Hydrating sand and gravel mixed with cement
   (c) Converting sand into silicic acid
   (d) Keeping it cool
   (AIEEE, 2003)

5. The substance that not likely to contain $CaCO_3$ is:
   (a) Calcined gypsum
   (b) Sea shells
   (c) Dolomite
   (d) A marble statue
   (AIEEE, 2003)

6. The solubilities of carbonates decrease down the magnesium group due to decrease in:
   (a) Hydration energies of cations
   (b) Interionic attraction
   (c) Entropy of solution formation
   (d) Lattice energy of solids
   (AIEEE, 2003)

7. Which one of the following processes will produce hard water?
   (a) Saturation of water with $MgCO_3$
   (b) Saturation of water with $CaSO_4$
   (c) Addition of Na_2SO_4 to water
   (d) Saturation of water with $CaCO_3$
   (AIEEE, 2003)

8. One mole of magnesium nitride on the reaction with an excess of water gives:
   (a) Two moles of ammonia
   (b) One mole of nitric acid
   (c) One mole of ammonia
   (d) Two moles of nitric acid
   (AIEEE, 2004)

9. Which of the following species is diamagnetic in nature?
   (a) H_2^- (b) H_2^+
   (c) H_2 (d) He_2^+
   (AIEEE, 2005)

10. Based on lattice energy and other considerations, which one of the following alkali metal chlorides is expected to have the highest melting point?
    (a) RbCl (b) KCl
    (c) NaCl (d) LiCl
    (AIEEE, 2005)

11. Which of the following statements in relation to the hydrogen atom is correct:
    (a) 3s-, 3p-, and 3d-orbitals all have the same energy
    (b) 3s- and 3p-orbitals are of lower energy than 3d-orbital
    (c) 3p-orbital is lower in energy than 3d-orbital
    (d) 3d-orbital is lower in energy than 3p-orbital
    (AIEEE, 2005)

12. The ionic mobility of alkali metal ions in aqueous solution is maximum for:
   (a) Li^+ (b) Na^+
   (c) K^+ (d) Rb^+
   (AIEEE, 2006)

13. In context with the industrial preparation of hydrogen from water gas ($CO + H_2$), which of the following is the correct statement?
   (a) CO and H_2 are fractionally separated using differences in their densities
   (b) CO is removed by absorption in aqueous Cu_2Cl_2 solution
   (c) H_2 is removed through occlusion with Pd
   (d) CO is oxidized to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali
   (AIEEE, 2008)

14. The products obtained on heating $LiNO_2$ will be:
   (a) $Li_2O + NO_2 + O_2$ (b) $Li_3N + O_2$
   (c) $Li_2O + NO + O_2$ (d) $LiNO_3 + O_2$
   (AIEEE, 2011)

15. What is the best description of the change that occurs when $Na_2O(s)$ is dissolved in water?
   (a) Oxide ion accepts sharing in a pair of electrons
   (b) Oxide ion donates a pair of electrons
   (c) Oxidation number of oxygen increases
   (d) Oxidation number of sodium decreases
   (AIEEE, 2011)

16. Which of the following on thermal decomposition yields a basic as well as an acidic oxide?
   (a) $NaNO_3$ (b) $KClO_3$
   (c) $CaCO_3$ (d) NH_4NO_3
   (AIEEE, 2012)

17. Very pure hydrogen (99.9) can be made by which of the following processes?
   (a) Reaction of methane with steam
   (b) Mixing natural hydrocarbons of high molecular weight
   (c) Electrolysis of water
   (d) Reaction of salts like hydrides with water
   (AIEEE, 2012)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with __________.
   (IIT-JEE, 1980)

2. The increase in the solubility of iodine in an aqueous solution of potassium iodide is due to the formation of __________.
   (IIT-JEE, 1982)

3. The adsorption of hydrogen by palladium is commonly known as __________.
   (IIT-JEE, 1983)

4. Sodium gets dissolved in liquid ammonia because of __________. **(IIT-JEE, 1985)**

5. Hydrogen gas is liberated by the action of aluminium with concentrated solution of __________. **(IIT-JEE, 1987)**

True/False Type

1. $MgCl_2 \cdot 6H_2O$ on heating gives anhydrous $MgCl_2$.
   (IIT-JEE, 1982)

2. Sodium when burnt in excess of oxygen gives sodium oxide.
   (IIT-JEE, 1987)

Single Correct Answer Type

1. The temporary hardness of water due to calcium bicarbonate can be removed by adding:
   (a) $CaCO_3$ (b) $Ca(OH)_2$
   (c) $CaCl_2$ (d) HCl
   (IIT-JEE, 1979)

2. Calcium is obtained by:
   (a) Electrolysis of molten $CaCl_2$
   (b) Electrolysis of a solution of $CaCl_2$ in water
   (c) Reduction of $CaCl_2$ with carbon
   (d) Roasting of limestone
   (IIT-JEE, 1980)

3. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:
   (a) Sodium atoms (b) Sodium hydride
   (c) Sodium amide (d) Solvated electrons
   (IIT-JEE, 1981)

4. Heavy water is:
   (a) H_2O^{18}
   (b) Water obtained by repeated distillation
   (c) D_2O
   (d) Water at 4°C
   (IIT-JEE, 1983)

5. The molecular formula of Glauber's salt is:
   (a) $MgSO_4 \cdot 7H_2O$ (b) $CuSO_4 \cdot 5H_2O$
   (c) $FeSO_4 \cdot 7H_2O$ (d) $Na_2SO_4 \cdot 10H_2O$
   (IIT-JEE, 1985)

6. Nitrogen dioxide cannot be obtained by heating:
   (a) KNO_3 (b) $Pb(NO_3)_2$
   (c) $Cu(NO_3)_2$ (d) $AgNO_3$
   (IIT-JEE, 1985)

7. A solution of sodium sulphate in water is electrolyzed using inert electrodes. The products at the cathode and anode are, respectively:
   (a) H_2, O_2 (b) O_2, H_2
   (c) O_2, Na (d) O_2, SO_2
   (IIT-JEE, 1987)

8. The metallic luster exhibited by sodium is explained by:
   (a) Diffusion of sodium ions
   (b) Oscillation of loose electron
   (c) Excitation of free protons
   (d) Existence of body-centered cubic lattice
   (IIT-JEE, 1987)

9. The following compounds have been arranged in the order of their increasing thermal stabilities. Identify the correct order.

   K_2CO_3 (I), $MgCO_3$ (II), $CaCO_3$ (III), $BeCO_3$ (IV)

   (a) I < II < III < IV (b) IV < II < III < I
   (c) IV < II < I < III (d) II < IV < III < I
   (IIT-JEE, 1996)

10. Sodium thiosulphate is prepared by:
   (a) Reducing Na_2SO_4 solution with H_2S
   (b) Boiling Na_2SO_3 solution with S in alkaline medium
   (c) Neutralizing $H_2S_2O_3$ solution with NaOH
   (d) Boiling Na_2SO_3 solution with S in acidic medium
   (IIT-JEE, 1996)

11. One mole of calcium phosphide on reaction with excess water gives:
   (a) 1 mol of phosphine
   (b) 2 mol of phosphoric acid
   (c) 2 mol of phosphine
   (d) 1 mol of phosphorus pentoxide
   (IIT-JEE, 1999)

12. Polyphosphates are used as water softening agents because they:
   (a) Form soluble complexes with anionic species
   (b) Precipitate anionic species
   (c) Form soluble complexes with cationic species
   (d) Precipitate cationic species
   (IIT-JEE, 2002)

13. An aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives:
   (a) $Na_2S_4O_6$ (b) $NaHSO_4$
   (c) NaCl (d) NaOH
   (IIT-JEE, 2008)

14. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?
   (a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
   (c) $MgCl_2{\cdot}MgSO_4$ (d) $MgSO_4$
   (IIT-JEE, 2006)

15. The reagent used for softening the temporary hardness of water is/are:
   (a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$
   (c) Na_2CO_3 (d) NaOCl
   (IIT-JEE, 2010)

Multiple Correct Answers Type

1. Sodium sulphate is soluble in water, whereas barium sulphate is sparingly soluble because:
   (a) The hydration energy of sodium sulphate is more than its lattice energy
   (b) The lattice energy of barium sulphate is more than its hydration energy
   (c) The lattice energy has no role to play in solubility
   (d) The hydration energy of sodium sulphate is less than its lattice energy
   (IIT-JEE, 1989)

2. When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with:
   (a) H^+ ions (b) Ca^{2+} ions
   (c) SO_4^{2-} ions (d) Mg^{2+} ions
   (e) OH^- ions
   (IIT-JEE, 1990)

3. The material used in solar cells contains:
   (a) Cs (b) Si
   (c) Sn (d) Ti
   (IIT-JEE, 1993)

4. Highly pure dilute solution of sodium in liquid ammonia:
   (a) Shows blue color
   (b) Exhibits electrical conductivity
   (c) Produces sodium amide
   (d) Produces hydrogen gas
   (IIT-JEE, 1998)

5. Sodium nitrate decomposes above ≈ 800°C to give:
   (a) N_2 (b) O_2
   (c) NO_2 (d) Na_2O
   (IIT-JEE, 1998)

6. The compound(s) formed upon combustion of sodium metal in excess air is/are:
   (a) Na_2O_2 (b) Na_2O
   (c) NaO_2 (d) NaOH
   (IIT-JEE, 2009)

7. The pair(s) of reagents that yield paramagnetic species is/are:
   (a) Na and excess of NH_3
   (b) K and excess of O_2
   (c) Cu and dilute HNO_3
   (d) O_2 and 2-ethylanthraquinol

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is true; Statement-II is the correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** The alkali metals can form ionic hydrides which contain the hydride ion, H^-.
   Statement-II: The alkali metals have low electronegativity, their hydrides conduct electricity when fused and liberate hydrogen at the anode.
   (IIT-JEE, 1994)

2. **Statement-I:** LiCl is predominantly a covalent compound.
   Statement-II: Electronegativity difference between Li and Cl is too small.
   (IIT-JEE, 1998)

3. **Statement-I:** Alkali metals dissolve in liquid ammonia to give blue solutions.
   Statement-II: Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$ (M = alkali metals).
   (IIT-JEE, 2007)

Subjective Type

1. Give reasons for the following:
   "Sodium carbonate is prepared by Solvay process but the same process is not extended to the manufacture of potassium carbonate".
   (IIT-JEE, 1981)

2. Write down the balanced equations for the reaction when calcium phosphate is heated with a mixture of sand and carbon.
   (IIT-JEE, 1985)

3. Give reasons in one or two sentences for the following
   "H_2O_2 is a better oxidising agent than water".
   (IIT-JEE, 1986)

4. Explain the following in one or two sentences only.
   (i) Magnesium oxide is used for the lining of steel making furnace.
   (ii) The mixture of hydrazine and hydrogen peroxide with a copper(II) catalyst is used as a rocket propellant.
   (iii) The molecule of magnesium chloride is linear, whereas that of stannous chloride is angular.
   (IIT-JEE, 1987)

5. Give balanced equations for the following:
   "Carbon dioxide is passed through a concentrated aqueous solution of sodium chloride saturated with ammonia".
   (IIT-JEE, 1988)

6. Write the balanced chemical equations for the following reactions.
   (i) An aqueous solution of sodium nitrate is heated with zinc dust and caustic soda solution.
   (ii) Sodium iodate is added to a solution of sodium bisulphite.
   (IIT-JEE, 1990)

7. Arrange the following as stated.
   Increasing order of basic character: MgO, SrO, K_2O, NiO, Cs_2O
   (IIT-JEE, 1991)

8. Complete and balance the following chemical reactions:
   Anhydrous potassium nitrate is heated with excess of metallic potassium.
   $KNO_3(s) + K(s) \rightarrow$
   (IIT-JEE, 1992)

9. Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas A and an alkaline solution. The solution on exposure to air produces a thin solid layer of B on the surface. Identify the compounds A and B.
   (IIT-JEE, 1996)

10. Element A burns in nitrogen to give an ionic compound B. Compound B reacts with water to give C and D. A solution of C becomes 'milky' on bubbling carbon dioxide. Identify A, B, C, and D. **(IIT-JEE, 1997)**

11. The crystalline salts of alkaline earth metals contain more water of crystallization than the corresponding alkali metal salts. Why? **(IIT-JEE, 1997)**

12. Arrange the following sulphates of alkaline earth metals in order of decreasing thermal stability: $BeSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$ **(IIT-JEE, 1997)**

13. Work out the following using chemical equations: "Chlorination of calcium hydroxide produces bleaching powder". **(IIT-JEE, 1998)**

14. Hydrogen peroxide acts both as an oxidizing and as a reducing agent in alkaline solution towards certain first-row transition metal ions. Illustrate both these properties of H_2O_2 using chemical equations. **(IIT-JEE, 1998)**

15. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid.
    (i) Identify the substance and explain with balanced equations.
    (ii) Explain what would happen to the red litmus if the white solid was the other compound. **(IIT-JEE, 1999)**

16. Give reasons for the following in one or two sentences only:
"$BeCl_2$ can be easily hydrolyzed". **(IIT-JEE, 1999)**

17. Write the balanced chemical equation for developing photographic films. **(IIT-JEE, 2000)**

18. Hydrogen peroxide solution (20 mL) reacts quantitatively with a solution of $KMnO_4$ (20 mL) acidified with dilute H_2SO_4. The same volume of the $KMnO_4$ solution is just decolorized by 10 mL of $MnSO_4$ in neutral medium simultaneously forming a dark brown precipitate of hydrated MnO_2. The brown pecipitate is dissolved in 10 mL of 0.2 M sodium oxalate under boiling condition in the presence of dilute H_2SO_4. Write the balanced equations involved in the reactions and calculate the molarity of H_2O_2. **(IIT-JEE, 2001)**

19. Identify X in the following synthetic scheme and write their structures.

$$Ba\overset{*}{C}O_3 + H_2SO_4 \rightarrow X(\text{gas})(C^* \text{ denotes } C^{14})$$

(IIT-JEE, 2001)

20. Identify the following:

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow[\Delta]{\text{Elemental S}} C \xrightarrow{I_2} D$$

Also mention the oxidation state of S in all the compounds. **(IIT-JEE, 2003)**

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

13. (b) $NaH + H_2O \longrightarrow NaOH + H_2$

43. (a) For third period, "s" block will form ionic oxide, 13th group forms amphoteric oxide, and 14th group element will form giant oxide (SiO_2).
$(X) < (Y) < (Z)$

JEE (Advanced) Exercises

Single Correct Answer Type

10. (d) (a) $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + HC \equiv CH \uparrow$
(b) $Be_2C + 2H_2O \longrightarrow 2\,BeO + CH_4 \uparrow$
(c) $Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4 \uparrow$
(d) $Mg_2C_3 + 4H_2O \longrightarrow 2Mg(OH)_2 + H_3C{-}C \equiv CH \uparrow$

34. (a) Both Mg^{2+} and Be^{2+} ions do not impart any color to the flame.

Multiple Correct Answers Type

9. (a), (c), (d)

(a) Lattice energy $\propto \frac{1}{r}$. Hence (a) is wrong

(b) Correct

(c) Ionic mobility in aqueous state

$\propto \frac{1}{\text{radius of ion in aqueous state}}$
(Hydration Radii)

Hence (c) is wrong

(d) Violating Hess law. Hence wrong.

10. (a), (c)

Because both react with acid and base.

16. (a), (b)

$$4Na + O_2 \longrightarrow 2Na_2O,$$
$$4Na + 2O_2 \longrightarrow 2Na_2O_2$$

19. (a), (b), (c), (d)

$$m + X \cdot NH_3 \rightarrow M^+ + \overline{e} \cdot xNH_3$$

Ammoniated electron responsible for blue color

Comprehension Type

4. (a) In hydroxide, down the group basic nature increases. Therefore, acidic nature decreases; thus,

$Na-O-H > K-O-H > Rb-O-H$

5. (c) In hydroxide, down the group basic nature increases

$H-O-I > H-O-Br > H-O-Cl$

6. (c) The more the electronegativity of an atom, the more is its oxidation atom. Hence, Cl is a better acid and will liberate H^+ more easily.

15–17. Ca burns in air to form CaO and Ca_3N_2.

$$2Ca + O_2 \longrightarrow 2CaO$$
$$3Ca + N_2 \longrightarrow Ca_3N_2$$

Calcium nitride on hydrolysis with H_2O gives ammonia (*A*)

$$Ca_3N_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + \underset{(A)}{2NH_3}$$

The alkaline solution of $Ca(OH)_2$ thus formed reacts with CO_2 present in the air to form $CaCO_3(B)$.

$$Ca(OH)_2 + CO_2 \longrightarrow \underset{(B)}{CaCO_3} + H_2O$$

Thus, $A = NH_3$ and $B = CaCO_3$ (white powder)

18–21.

$$\underset{(A)}{KNO_3} \xrightarrow{\Delta} \underset{(B)}{KNO_2} + \frac{1}{2}O_2$$

$$KNO_2 + NH_4Cl \longrightarrow NH_4NO_2 + KCl$$

$$NH_4NO_2 \xrightarrow{\Delta} \underset{(C)}{N_2} + 2H_2O$$

$$KNO_3 + NH_4Cl \longrightarrow NH_4NO_3 + KCl$$

$$NH_4NO_3 \xrightarrow{\Delta} \underset{(D)}{N_2O} + 2H_2O$$

$$N_2O + NaNH_2 \longrightarrow \underset{(E)}{NaN_3} + H_2O$$

$$2NaN_3 + H_2SO_4 \xrightarrow{\Delta} \underset{(F)}{2HN_3} + NaSO_4$$

22–25.

(i) $CaO + H_2O \longrightarrow \underset{(A)}{Ca(OH)_2}$

(ii) $NH_3 + H_2O + CO_2 \longrightarrow \underset{(B)}{NH_4HCO_3}$

(iii) $2NaHCO_3 \longrightarrow \underset{(C)}{Na_2CO_3} + CO_2 + H_2O$

(iv) $NH_4HCO_3 + NaCl \longrightarrow \underset{(D)}{NaHCO_3} + NH_4Cl$

(v) $2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + 2H_2O + \underset{(E)}{CaCl_2}$

Thus, $A = Ca(OH)_2$, $B = NH_4HCO_3$, $C = Na_2CO_3$, $D = NH_4Cl$, and $E = CaCl_2$

Assertion-Reasoning Type

1. (a) If hydrated size is more, then ionic mobility is less:

$\therefore$ $Na^+_{(aq)} < K^+_{(aq)}$ (order of ionic mobility)

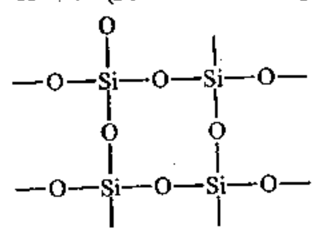
and $r_{Na^+(aq.)} > r_{K^+(aq.)}$ is true a statement

Matching Column Type

4. (a) r; (b) q; (c) p

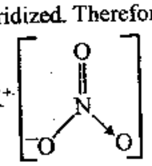
(p) $\overset{\delta+}{H}-\overset{\delta-}{Cl}$ (Polar covalent compound)

(q)



3-D network like structure; each Si is sp^3-hybridized. Therefore, non-polar compound.

(r) K^+



ionic compound with σ and π bonds.

(s) $:\dot{N}=\ddot{O}$

Integer Answer Type

11. (1) $Mg_3N_2 + H-OH \longrightarrow Mg(OH)_2 + NH_3$

12. (0) $CaSO_4$ (dead burnt plaster)

13. (3) $Mg_2C_3 + 4H - OH \longrightarrow 2Mg(OH)_2 + C_3H_4$
14. (4) $BeCl_2 + NaOH \longrightarrow [Be(OH)_4]^{2-}$
15. (2) $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + H - C \equiv C - H$
16. (2) $3M + 2P \longrightarrow M_3P_2$

NCERT Exemplar Exercises

Short Answer Type

3. (a) $O_2^{2+} + 2H_2O \rightarrow 2OH^- + H_2O_2$
(b) $2O_2^- + 2H_2O \rightarrow 2OH^- + H_2O_2 + O_2$

Long Answer Type

5. Compound: A: CaO; B: Ca $(OH)_2$; C: $CaCO_3$; D: $Ca(HCO_3)_2$
$Ca(HCO_3)_2$ is soluble in water. Hence, milkiness of solution disappears on passing excess carbon dioxide into the solution of compound B.
6. $8\ LiH + Al_2Cl_6 \rightarrow 2LiAlH_4 + 6LiCl$
$LiAlH_4 + 2BeCl_2 \rightarrow 2BeH_2 + LiCl + AlCl_3$
7. The element is beryllium
8. The element is sodium.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) $2KO_3 \xrightarrow{H_2O} 2KOH + \frac{3}{2}O_2$
$KOH + CO_2 \rightarrow K_2CO_3 + H_2O$
2. (a) Deep blue color is due to solvoted e^-, which absorbs energy in the visible region of light, and thus, imparts blue color to the solution.
$$M + (x+y)\,NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$$
3. (d) Sulphate of metal M is soluble but its hydroxide is insoluble. In alkaline earth metals, solubility of sulphates decreases down the group, whereas solubility of hydroxides increases down the group.
As the hydroxide is soluble in NaOH, thus, it must be amphoteric in nature. Be is the only element in II group which is amphoteric due to diagonal relationship with Al.
4. (a) When mixed with water, the setting of cement takes place to give a hard mass. This is due to hydration of the molecules of the constituents and their rearrangement to develop interlocked needle-like crystals of hydrated silicates.
5. (a) Calcined gypsum is $CaSO_4$ and gypsum is $CaSO_4 \cdot 2H_2O$
6. (a) As we move down in magnesium group, both hydration energies of cations and lattice energies of solids decrease but the decrease in hydration energies dominates, and as a result, solubility of carbonates decreases down the group.
7. (b) Sulphates of 2nd group causes hardness of water.
8. (a) Magnesium nitride is Mg_3N_2.
$$Mg_2N_2 + H_2O \rightarrow 3Mg(OH)_2 + 2NH_3 \uparrow$$
9. (c) According to MOT, that is, molecular orbital theory, H_2 has all electrons paired, so it is diamagnetic
10. (c) LiCl has covalent character in it. For other three salt, anion is same and for cations higher the charge density on cations, higher will be lattice energy, which increases the melting point of the solid.
12. (d) Due to less charge density on Rb ion, its hydration is low. So the size of hydrated $Rb^{\oplus}$ is the smallest of all. Hence, it has maximum mobility.
13. (d) Mixture of $(CO + H_2)$ is called water gas. The production of dihydrogen can be done by reacting CO of this mixture with steam in the presence of iron chromates as catalyst.
$$CO_{(g)} + H_{2(g)}O \xrightarrow[\text{Catalyst}]{673\text{ K}} CO_{2(g)} + H_{2(g)}$$
CO_2 is removed by scrubbing with sodium arsenite solution that is absorption of CO_2 in alkali
14. (a) $LiNO_2 \xrightarrow{\Delta} Li_2O + NO_2 + O_2$
15. (b) $Na_2O_{(s)} + H_2O \rightarrow NaOH$
Oxide ion donates e^- to $H^{\oplus}$. So, the answer is option (b).
16. (c) $CaCO_3 \xrightarrow{\Delta} \underset{\text{basic oxide}}{CaO} + \underset{\text{acidic oxide}}{CO_2}$
17. (d) Reaction of ionic hydrides like NaH with water
$$NaH + H_2O \rightarrow NaOH + H_2$$

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with **dry HCl**.
$$MgCl_2 \cdot 6H_2O \xrightarrow{\text{Dry HCl}} MgCl_2 + 6H_2O$$
2. The increase in the solubility of iodine in an aqueous solution of potassium iodide is due to the formation of **KI_3**.
$$KI + I_2 \rightarrow KI_3$$
3. The adsorption of hydrogen by palladium is commonly known as **occlusion**.

4. Sodium gets dissolved in liquid ammonia because of **ammoniated electrons.**
The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.
$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$
On heating, its blue color changes to bronze.
It is the ammoniated electron that is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.
5. Hydrogen gas is liberated by the action of aluminium with concentrated solution of **sodium hydroxide**.
$$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$$

True/False Type

1. **False.**
On heating, $MgCl_2 \cdot 6H_2O$ undergoes partial hydrolysis.
$$MgCl_2 \cdot 6H_2O \rightleftharpoons Mg(OH)Cl + HCl + 5H_2O$$
Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with dry HCl.
$$MgCl_2 \cdot 6H_2O \xrightarrow{\text{Dry HCl}} MgCl_2 + 6H_2O$$
2. **False.**
Sodium when burnt in excess of oxygen gives sodium peroxide (Na_2O_2).
Lithium gives oxide, sodium gives peroxide, and other alkali metals form superoxides in this reaction.

Single Correct Answer Type

1. (b) Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.
$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$$
The temporary hardness of water can be removed by the addition of calculated quantity of milk of lime which converts soluble bicarbonates into insoluble carbonates which can be removed.
2. (a) Calcium is obtained by the electrolysis of a fused mass consisting of six parts calcium chloride and one part calcium fluoride at about 700°C in an electrolytic cell made of graphite which acts as anode and a water-cooled cathode of iron which is suspended from the top in the fused mass. On passing current, calcium is discharged at the cathode.
$$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$$
At cathode: $Ca^{2+} + 2e^- \rightarrow Ca$
At anode: $2Cl^- \rightarrow 2Cl + 2e^-$
3. (d) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.
$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$
On heating, its blue color changes to bronze.
It is the ammoniated electron that is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.
4. (c) Heavy water is an oxide of heavy hydrogen, which is called deuterium. It is D_2O.
5. (d) Glauber's salt is $Na_2SO_4 \cdot 10H_2O$.
6. (a) Alkali metal nitrates, except lithium, decompose upon strong heating to give oxygen gas and a metal nitrite.
7. (a) At cathode, hydrogen is evolved. At anode, oxygen gas is evolved.
8. (d) The metallic luster of sodium and other metals is due to the oscillation of loosely bound electrons. When light falls upon the electrons, they absorb energy and are set into oscillations, and they emit radiations which are responsible for the metallic luster.
9. (b) $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$
Alkali metal carbonates are more stable than carbonates of alkaline earth metals, and they do not decompose on heating; therefore potassium carbonate is thermally most stable.
10. (b) One of the methods to prepare sodium thiosulphate is to heat sodium sulphate with sulphur in alkaline medium.
$$Na_2SO_3 + S \xrightarrow{OH^-, \Delta} Na_2S_2O_3$$
11. (c) Phosphine gas is obtained.
$$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$$
12. (c) Polyphosphates are used as water softening agents because they form soluble complexes with cations responsible for the hardness of water.
$$2CaSO_4 + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Ca_2(PO_3)_6] + 2Na_2SO_4$$
$$2MgSO_4 + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Mg_2(PO_3)_6] + 2Na_2SO_4$$

13. (b) $Na_2S_2O_3 + 4Cl_2 + 5H_2O \rightarrow 2NaHSO_4 + 8HCl$

14. (a) A white precipitate of magnesium ammonium phosphate is formed.

$$MgSO_4 + Na_2HPO_4 + NH_4OH \rightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4\downarrow} + Na_2SO_4 + H_2O$$

15. (b) Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$$

The temporary hardness of water can be removed by the addition of calculated quantity of milk of lime which converts soluble bicarbonates into insoluble carbonates, which can be removed.

Multiple Correct Answers Type

1. (a), (b) When the hydration energy is more than the lattice energy, the salt is soluble in water and vice versa.

2. (b), (d) When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with both Ca^{2+} and Mg^{2+} ions.

3. (b) Silicon is used in solar cells.

4. (a), (b) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solution is blue.

$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$

On heating, its blue color changes to bronze.
It is an ammoniated electron which is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.

5. (a), (b), (d)

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$$

$$2NaNO_3 \xrightarrow{800°C} Na_2O + N_2 + \frac{5}{2}O_2$$

6. (a), (b) Sodium when heated in dry air, first forms sodium oxide, then sodium peroxide.

7. (a, b, c) If ammonia considered as a gas then reaction will be:

(a) $Na + \underset{(\text{excess})}{NH_3} \rightarrow NaNH2 + \frac{1}{2}H_2$

($NaNH_2 + \frac{1}{2}H_2$ are diamagnetic)

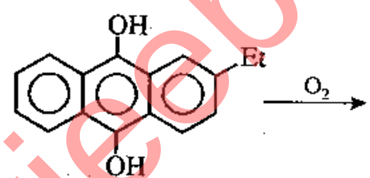
If ammonia considered as a liquid then reaction will be

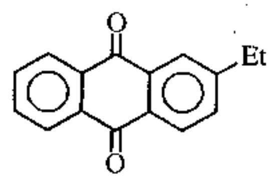
$$M + (x+y)NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)y]^-$$

ammoniated e–
blue colour
paramagnetic
S.R.A

(b) $K + \underset{\text{excess}}{O_2} \rightarrow KO_2\ (K^+, O_2^-)$

(c) $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

(d) 

 $+ H_2O_2$

In (a) product's are diamagnetic
(b) KO_2 is paramagnetic
(c) $Cu(NO_3)_2$, NO are paramagnetic
(d) produts are diamagnetic

Assertion-Reasoning Type

1. (a) Statement-I and Statement-II are correct and Statement-II gives the correct explanation.

2. (c) According to Fajan rule, the smaller the cation, the more is the polarizing power and, therefore, more is the polarization which leads to more covalent character. Due to the smaller size of lithium, it forms covalent chloride. There is a high difference between the electronegativities of Li and Cl.

3. (b) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.

$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$

On heating, its blue color changes to bronze.
It is an ammoniated electron which is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.

Subjective Type

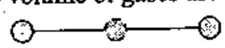
1. The Solvay process is used for the manufacture of sodium carbonate. It cannot be used for the manufacture of potassium carbonate as potassium bicarbonate is very soluble and does not crystallize like sodium bicarbonate. Therefore, potassium bicarbonate cannot be filtered out.

2. Calcium silicate and phosphorus are formed.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

3. H_2O_2 is a better oxidizing agent than water because it can provide nascent oxygen easily.
$H_2O_2 \rightarrow H_2O + [O]$

4. (i) MgO is used for the lining of steel making furnace because it is stable at very high temperatures and it forms slag with impurities. In this manner, it helps in removing the impurities.
(ii) $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$
The mixture of N_2H_4 and H_2O_2 (in the presence of Cu(II) catalyst) is used as a rocket propellant because of two reasons:
   (a) The reaction is highly exothermic.
   (b) Large volume of gases are evolved.

(iii) $MgCl_2$ 
sp-Hybridization
Linear shape
$SnCl_2$ 
sp^2-Hybridization
Two bond pairs, one lone pair
V-shaped
In the molecule of magnesium chloride, the valence orbital of magnesium is *sp*-hybridized (i.e., the molecule is linear). In the molecule of stannous chloride, valence orbital of tin is sp^2-hybridized (i.e., the molecule is angular).

5. $NaCl + NH_4OH + CO_2 \rightarrow NH_4Cl + NaHCO_3$
Sodium bicarbonate is formed. This reaction is used in the Solvay process for the manufacture of sodium carbonate.

6. (i) Ammonia is produced.

$$Zn + NaNO_2 + NaOH \rightarrow Na_2ZnO_2 + NH_3 + H_2O$$

(ii) Iodine is formed.

$$2NaIO_3 + 5NaHSO_3 \rightarrow 3NaHSO_4 + 2Na_2SO_4 + I_2 + H_2O$$

7. In the periodic table, the basic character of oxides decreases from left to right. Also the basic character of oxides increases down the group. Therefore, following is the increasing order of basic character of the given oxides:

$$NiO < MgO < SrO < K_2O < Cs_2O$$

8. $2KNO_3(s) + 10K(s) \rightarrow 6H_2O + N_2$

9. Gas *A* is ammonia and Solid *B* is calcium carbonate.
$3Ca + N_2 \rightarrow Ca_3N_2$
$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

10. The given data suggest the following reactions.
$3Ca + N_2 \rightarrow Ca_3N_2$
$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
It is given that a solution of *C* becomes "milky" on bubbling carbon dioxide. Therefore, it must be calcium or barium hydroxide which is more soluble than magnesium hydroxide.

11. The size of alkaline earth metal ions is lower than the size of alkali metal ions. The lower the size of the cation, the higher is the hydration energy.
So the salts of alkaline earth metals have more water molecules of crystallization than those of alkali metals.

12. Sulphates decompose on heating to give the corresponding oxide.

$$MgSO_4 \xrightarrow{\Delta} MgO + SO_2 + \frac{1}{2}O_2$$

The stability increases as the basic nature of the metal increases. This is clear from the increasing decomposition temperatures down the group.

$$SrSO_4 > CaSO_4 > MgSO_4 > BeSO_4$$

13. $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$
When chlorine is passed over dry slaked lime, bleaching powder is produced.

14. As oxidizing agent:
$H_2O_2 + 2e^- \rightarrow 2OH^-$
$2Cr(OH)_3 + 4NaOH + 3H_2O_2 \rightarrow 2Na_2CrO_4 + 8H_2O$
The oxidation number of chromium increases from +3 to +6.
As reducing agent:
$H_2O_2 + 2OH^- \rightarrow O_2 + 2H_2O + 2e^-$
$2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \rightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$

The oxidation number of iron decreases from +3 to +2.

15. (i) $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

$H_2O_2 \rightarrow H_2O + [O]$

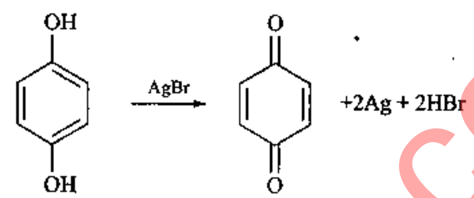
H_2O_2 turns the color of red litmus paper to white due to its bleaching action by oxidation. Therefore, the given substance is Na_2O_2.

(ii) $Na_2O + H_2O \rightarrow 2NaOH$

If the given substance was Na_2O, it would form only NaOH, which turns the color of red litmus paper to blue.

16. Beryllium ion is very small in size, and so it has a very high polarizing power (Fajan rules). Also, vacant *p*-orbitals are available. So beryllium chloride is readily hydrolyzed.

17. The light sensitized photographic film is treated with hydroquinone which is a very mild reducing agent. It does not affect the unexposed silver bromide.



Unexposed AgBr is dissolved in $Na_2S_2O_3$ (hypo) to give sodium argentothiosulphate.

$AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$

18. $2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O$

$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2 + 2H_2SO_4 + K_2SO_4$

$MnO_2 + Na_2C_2O_4 + 2H_2SO_4 \rightarrow MnSO_4 + Na_2SO_4 + 2H_2O + 2CO_2$

Millimoles of $Na_2C_2O_4 = 10 \times 0.2 = 2$

mEq of $Na_2C_2O_4 = 4$

mEq of $MnO_2 = 4$

mEq of $KMnO_2 = 4$

mEq of $H_2O_2 = 4$

Millimoles of $H_2O_2 = 2$

Millimoles of H_2O_2 = Molarity $\times V_{mL}$

$\therefore$ 2 = Molarity $\times$ 20

or Molarity = 0.1

19. $BaC^*O_3 + H_2SO_4 \rightarrow BaSO_4 + C^*O_2 + H_2O$

Carbon dioxide has a linear structure as follows:

$O{=}C{=}O$

20. $Na_2CO_3 + 2SO_2 + H_2O \rightarrow 2NaHSO_3 + CO_2$

$2NaHSO_3 + Na_2CO_3 \rightarrow 2Na_2SO_3 + H_2O + CO_2$

$Na_2SO_3 + S \rightarrow Na_2S_2O_3$

$2Na_2S_2O_3 + I_2 \xrightarrow{\Delta} Na_2S_4O_6 + 2NaI$

Oxidation states of sulphur:

$NaHSO_3$ (+6)

Na_2SO_3 (+6)

$Na_2S_2O_3$ (+2) or (+5 and −1)

$Na_2S_4O_6$ (+2) or (+5 and 0)

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (b)	4. (d)	5. (d)	6. (a)	7. (a)	8. (a)	9. (a)	10. (d)
11. (d)	12. (d)	13. (b)	14. (c)	15. (c)	16. (b)	17. (d)	18. (a)	19. (c)	20. (b)
21. (d)	22. (d)	23. (d)	24. (d)	25. (c)	26. (b)	27. (d)	28. (d)	29. (c)	30. (a)
31. (d)	32. (b)	33. (b)	34. (c)	35. (c)	36. (b)	37. (c)	38. (d)	39. (a)	40. (a)
41. (d)	42. (c)	43. (a)	44. (b)	45. (c)	46. (a)	47. (c)	48. (c)	49. (d)	50. (c)
51. (b)	52. (c)	53. (a)	54. (a)	55. (d)	56. (c)	57. (b)	58. (a)	59. (b)	60. (a)
61. (b)	62. (d)	63. (a)							

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (d)	3. (d)	4. (c)	5. (d)	6. (a)	7. (d)	8. (d)	9. (b)	10. (d)
11. (c)	12. (c)	13. (a)	14. (b)	15. (b)	16. (b)	17. (b)	18. (a)	19. (a)	20. (b)
21. (d)	22. (a)	23. (a)	24. (b)	25. (b)	26. (c)	27. (a)	28. (d)	29. (b)	30. (c)
31. (a)	32. (d)	33. (d)	34. (a)	35. (b)	36. (d)	37. (b)	38. (b)	39. (d)	40. (d)
41. (a)	42. (c)	43. (a)	44. (d)	45. (b)	46. (d)	47. (d)	48. (a)	49. (b)	50. (b)
51. (a)	52. (a)	53. (d)	54. (c)	55. (a)	56. (d)	57. (b)	58. (b)	59. (b)	60. (c)
61. (c)	62. (a)	63. (d)							

Multiple Correct Answers Type

1. (a), (b)	2. (a), (b), (c), (d)	3. (a), (b), (c)	4. (a), (b), (c)	5. (b), (c), (d)
6. (a), (b)	7. (b), (c), (d)	8. (a), (b), (d)	9. (a), (c), (d)	10. (a), (c)
11. (a), (b)	12. (b), (c), (d)	13. (b), (d)	14. (a), (b), (c)	15. (b), (c), (d)
16. (a), (b)	17. (a), (b), (d)	18. (a), (b)	19. (a), (b), (c), (d)	20. (a), (c), (d)
21. (a), (b), (d)	22. (c), (d)	23. (a), (b), (d)		

Comprehension Type

Comprehension-1	1. (c)	2. (d)	3. (b)		
Comprehension-2	4. (a)	5. (c)	6. (c)		
Comprehension-3	7. (c)	8. (b)	9. (b)	10. (a)	11. (a)
Comprehension-4	12. (b)	13. (a)	14. (d)		
Comprehension-5	15. (b)	16. (b)	17. (b)		
Comprehension-6	18. (b)	19. (a)	20. (b)	21. (c)	
Comprehension-7	22. (b)	23. (b)	24. (a)	25. (c)	

Assertion-Reasoning Type

1. (a) 2. (c)

Matching Column Type

1. (a) r, s, t; (b) q, s; (c) s; (d) p, s
2. (a) q; (b) q, s; (c) p, r; (d) p, r
3. (a) q, t, u; (b) p, s; (c) q, r; (d) u; (e) t
4. (a) r; (b) q; (c) p
5. (a) p, r, s, t; (b) p; (c) p; (d) p, q
6. (a) p, q, t; (b) p, t; (c) s, t; (d) r, s, t
7. (a) p, q, r; (b) p, s; (c) p, t; (d) p, t
8. (a) q; (b) p, r; (c) s

Integer Answer Type

1. (2)	2. (3)	3. (2)	4. (2)	5. (1)	6. (2)	7. (2)	8. (1)	9. (3)	10. (2)
11. (1)	12. (0)	13. (3)	14. (4)	15. (2)	16. (2)	17. (3)	18. (4)		

NCERT Exemplar Exercises

Single Correct Answer Type

1. (d) 2. (a) 3. (c) 4. (d) 5. (a) 6. (a) 7. (a) 8. (c) 9. (b) 10. (a)
11. (a) 12. (a) 13. (b) 14. (a) 15. (c) 16. (a) 17. (d) 18. (b) 19. (a) 20. (c)
21. (d)

Multiple Correct Answers Type

1. (b), (d) 2. (a), (c) 3. (a), (b) 4. (b), (c) 5. (a), (c) 6. (a), (b) 7. (a), (b)

Matching Column Type

1. (a) $\rightarrow$ (r); (b) $\rightarrow$ (q); (c) $\rightarrow$ (p), (s), (t); (d) $\rightarrow$ (p), (s), (t)
2. (a) $\rightarrow$ (r); (b) $\rightarrow$ (s); (c) $\rightarrow$ (q); (d) $\rightarrow$ (p)
3. (a) $\rightarrow$ (u); (b) $\rightarrow$ (s); (c) $\rightarrow$ (q); (d) $\rightarrow$ (r); (e) $\rightarrow$ (t); (f) $\rightarrow$ (p)

Assertion-Reasoning Type

1. (a) 2. (a)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) 2. (a) 3. (d) 4. (a) 5. (a) 6. (a) 7. (b) 8. (a) 9. (c) 10. (c)
11. (a) 12. (d) 13. (d) 14. (a) 15. (b) 16. (c) 17. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

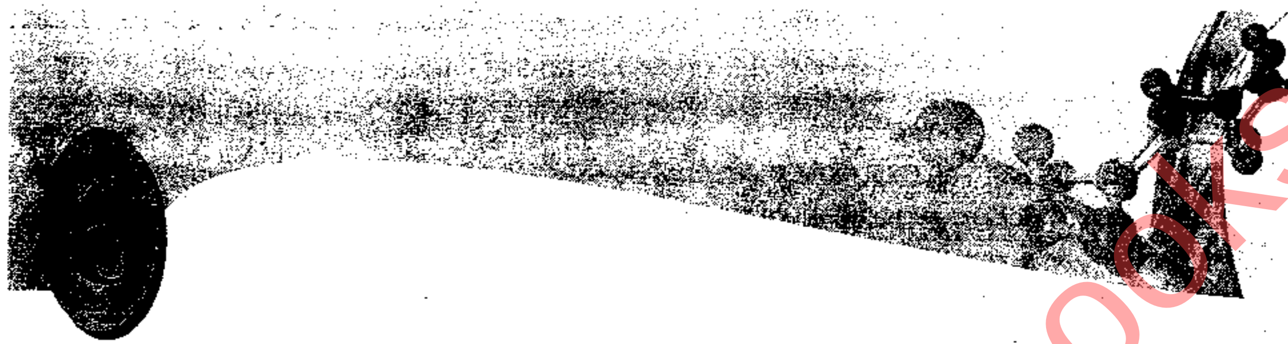
1. (b) 2. (a) 3. (d) 4. (c) 5. (d) 6. (a) 7. (a) 8. (d) 9. (b) 10. (b)
11. (c) 12. (c) 13. (b) 14. (a) 15. (b)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (d) 3. (b) 4. (a), (b) 5. (a), (b), (d)
6. (a), (b) 7. (a), (b), (c)

Assertion-Reasoning Type

1. (a) 2. (c) 3. (b)



p-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Which is true for an element present in group 13 of the periodic table?
   (a) It is gas at room temperature
   (b) It has oxidation state of 4+
   (c) It forms R_2O_3 (d) It forms RX_2
2. Borax is prepared by treating colemanite with:
   (a) $NaNO_3$ (b) $NaCl$
   (c) $NaHCO_3$ (d) Na_2CO_3
3. On the addition of mineral acid to an aqueous solution of borax, the following compound is formed:
   (a) Boron hydride (b) Ortho-boric acid
   (c) Meta-boric acid (d) Pyro-boric acid
4. Three centered bond is present in:
   (a) NH_3 (b) B_2H_6
   (c) BCl_3 (d) $AlCl_3$
5. Boron compounds behave as Lewis acids because of their:
   (a) Acidic nature (b) Covalent nature
   (c) Ionic nature (d) Vacant orbital
6. Which of the following is not a Lewis acid?
   (a) SiF_4 (b) $FeCl_3$
   (c) BF_3 (d) C_2H_4
7. $AlCl_3$ on hydrolysis gives:
   (a) $Al_2O_3 \cdot H_2O$ (b) $Al(OH)_3$
   (c) Al_2O_3 (d) $AlCl_3 \cdot 6H_2O$
8. Thallium shows different oxidation states because:
   (a) Of its high reactivity
   (b) Of inert pair of electrons
   (c) Of its amphoteric nature
   (d) It is a transition metal
9. H_3BO_3 is:
   (a) Monobasic and weak Lewis acid
   (b) Monobasic and weak Bronsted acid
   (c) Monobasic acid and strong Lewis acid
   (d) Tribasic acid and weak Bronsted acid
10. Which of the following compound is known as inorganic benzene?
    (a) B_6H_6 (b) C_5H_5B
    (c) $C_3N_3H_3$ (d) $B_3N_3H_6$
11. The structure and hybridization of $Si(CH_3)_4$ are:
    (a) Bent, sp (b) Trigonal, sp^2
    (c) Octahedral, sp^3d^2 (d) Tetrahedral, sp^3
12. Which of the following is not hydrolyzed?
    (a) CCl_4 (b) $SiCl_4$
    (c) $SnCl_4$ (d) $PbCl_4$
13. Which of the following halides is least stable and has doubtful existence?
    (a) CI_4 (b) SnI_4
    (c) GeI_4 (d) PbI_4
14. The number and type of bonds between two carbon atoms in CaC_2 are:
    (a) One sigma and one pi bond
    (b) One sigma and two pi bonds

(c) One sigma and one and a half pi bond
(d) One sigma bond

15. The material used in solar cells contains:
(a) Si (b) Sn
(c) Ti (d) Cs

16. Which of the following is correct composition of water gas?
(a) $CO + Cl_2$ (b) $CO + N_2$
(c) $CO + H_2$ (d) $CO + H_2 + N_2$

17. What is the formula for carbon suboxide?
(a) CO (b) CO_2
(c) C_2O_4 (d) C_3O_2

18. Percentage of lead in lead pencil is:
(a) Zero (b) 20
(c) 80 (d) 70

19. CCl_4 is used as fire extinguisher because:
(a) Its m.pt. is high (b) It forms covalent bond
(c) Its b.pt. is low
(d) It gives incombustible vapors

20. Marsh gas contains:
(a) CH_4 (b) CO_2
(c) C_2H_6 (d) N_2

21. Which of the following is most stable?
(a) Sn^{2+} (b) Ge^{2+}
(c) Si^{2+} (d) Pb^{2+}

22. Carborundum is:
(a) Al_2O_3 (b) SiC
(c) BF_3 (d) B_4C

23. The acid which contains a peroxo linkage is:
(a) Sulphurous acid (b) Pyrosulphuric acid
(c) Dithionic acid (d) Caro's acid

24. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behavior is that graphite:
(a) Has molecules of variable molecular masses like polymers
(b) Has carbon atoms arranged in large plated of rings of strongly bonded carbon atoms with weak interplate bonds
(c) Is a non-crystalline substance
(d) Is an allotropic form of diamond

25. In SiF_6^{2-} and $SiCl_6^{2-}$, which one is known and why?
(a) SiF_6^{2-} because of small size of F
(b) SiF_6^{2-} because of large size of F
(c) SiF_6^{2-} because of small size of Cl
(d) SiF_6^{2-} because of large size of Cl

26. Which is likely to show inert pair effect?
(a) K (b) Mg
(c) Al (d) Pb

27. The stability of dihalides of Si, Ge, Sn, and Pb increases steadily in the sequence:
(a) $PbX_2 < SnX_2 < GeX_2 < SiX_2$
(b) $GeX_2 < SiX_2 < SnX_2 < PbX_2$
(c) $SiX_2 < GeX_2 < PbX_2 < SnX_2$
(d) $SiX_2 < GeX_2 < SnX_2 < PbX_2$

28. Diamond is hard because:
(a) All the four valence electrons are bonded to each carbon atoms by covalent bonds
(b) It is a small molecule
(c) It is made up of carbon atoms
(d) It cannot be burnt

29. Products formed when $Pb(NO_3)_2$ is heated are:
(a) PbO, N_2, O_2 (b) $Pb(NO_2)_2, O_2$
(c) PbO, NO_2, O_2 (d) Pb, N_2, O_2

30. Which one of the following pairs is obtained on heating ammonium dichromate?
(a) N_2 and H_2O (b) H_2O and H_2O
(c) NO_2 and H_2O (d) NO and NO_2

31. Silver chloride dissolves in excess of NH_4OH. The cation present in solution is:
(a) Ag^+ (b) $[Ag(NH_3)_4]^+$
(c) $[Ag(NH_3)_2]^+$ (d) $[Ag(NH_3)_6]^+$

32. The catalyst used in the manufacture of ammonia by Haber's process is:
(a) Pt (b) Fe
(c) Mo (d) V_2O_5

33. Industrial preparation of nitric acid by Ostwald's process involves:
(a) Oxidation of NH_3
(b) Reduction of NH_3
(c) Hydrogenation of NH_3
(d) hydrolysis of NH_3

34. White phosphorus reacts with caustic soda. The products are PH_3 and NaH_2PO_2. This reaction is an example of:
(a) Oxidation (b) Reduction
(c) Neutralization (d) Disproportionation

35. Which one of the following is the strongest base?
(a) AsH_3 (b) SbH_3
(c) PH_3 (d) NH_3

36. When zinc reacts with very dilute nitric acid it produces:
(a) NH_4NO_3 (b) NO
(c) NO_2 (d) H_2

37. Nitrogen molecule is chemically less active because of its:
(a) small atomic energy
(b) high dissociation energy
(c) high electronegativity
(d) stable electronic configuration

38. Which of the following oxides of nitrogen is the anhydride of nitrous acid?
(a) NO (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

39. Which of the following fluorides does not exist?
(a) NF_5 (b) PF_5
(c) AsF_5 (d) SbF_5

40. When ammonia is passed over heated CuO, it is oxidized to:
(a) HNO_2 (b) N_2O
(c) N_2 (d) NO_2

41. The CN^- ion and N_2 are isoelectronic. But in contrast to CN^-, N_2 is chemically inert because of:
(a) Low bond energy
(b) Absence of bond polarity
(c) Unsymmetrical electron distribution
(d) Presence of more number of electrons in bonding orbitals

42. Which oxide does not act as a reducing agent?
(a) NO (b) NO_2
(c) N_2O (d) N_2O_5

43. When $AgNO_3$ is heated strongly, the products formed are:
(a) NO and NO_2 (b) NO_2 and N_2O
(c) NO_2 and O_2 (d) NO and O_2

44. Aqueous solution of ammonia consists of:
(a) H^+ only (b) OH^- only
(c) NH_4^+ only (d) NH_4^+ and OH^-

45. Which of the following species is paramagnetic?
(a) O_2^{2-} (b) NO
(c) CO (d) CN

46. The BCl_3 is a planar molecule, whereas NCl_3 is pyramidal because:
(a) N—Cl bond is more covalent than B—Cl bond
(b) B—Cl bond is more polar than N—Cl bond
(c) Nitrogen atom is smaller than boron
(d) BCl_3 has no lone pair but NCl_3 has a lone pair of electron

47. The hybridization of atomic orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ are:
(a) sp, sp^3 and sp^2 respectively
(b) sp, sp^2 and sp^3 respectively
(c) sp^2, sp and sp^3 respectively
(d) sp^2, sp^3 and sp respectively

48. In which of the following the bond angle is maximum?
(a) NH_3 (b) NH_4^+
(c) PCl_3 (d) SCl_2

49. The hybridization state of the central atom in PCl_5 is:
(a) sp^3d (b) sp^3d^2
(c) sp^3 (d) d^2sp^3

50. Cl—P—Cl bond angles in PCl_5 molecule are:
(a) 120° and 90° (b) 60° and 90°
(c) 60° and 120° (d) 120° and 30°

51. Phosphine acetylene and ammonia can be formed by treating water with:
(a) Mg_3P_2, Al_4C_3, Li_3N
(b) Ca_3P_2, CaC_2, Mg_3N_2
(c) Ca_3P_2, CaC_2, $CaCN_2$
(d) Ca_3P_2, Mg_2C, NH_4NO_3

52. The shape of PCl_3 molecule is:
(a) Trigonal bipyramidal (b) Tetrahedral
(c) Pyramidal (d) Square planar

53. Atoms in P_4 molecule of white phosphorus are arranged regularly in the following way:
(a) At the corners of a cube
(b) At the corners of an octahedron
(c) At the corners of a tetrahedron
(d) At the center and corners of a tetrahedron

54. Correct order of bond angles for the following is:
(a) $NH_3 > PCl_3 > BCl_3$ (b) $BCl_3 > CH_4 > PCl_3$
(c) $BCl_3 > PCl_3 > NH_3$ (d) $PCl_3 > BCl_3 > NH_3$

55. The reaction of elemental P_4 in aqueous NaOH gives:
(a) PH_3, NaH_2PO_2 (b) PH_3, Na_3PO_4
(c) NaH_2PO_4, Na_3PO_4 (d) Na_3P, Na_3PO_4

56. Which of the following oxides is amphoteric in character?
(a) CaO (b) CO_2
(c) SiO_2 (d) SnO_2

57. The geometry of H_2S and its dipole moment are:
(a) Angular and non-zero (b) Angular and zero
(c) Linear and zero (d) Linear and non-zero

58. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively, are:
(a) 0, +1 and –2 (b) +2, +1 and –2
(c) 0, +1 and +2 (d) –2, +1 and –2

59. Which of the following has $p_\pi - d_\pi$ bonding?
(a) NO_3^- (b) SO_3^{2-}
(c) BO_3^{3-} (d) CO_3^{2-}

60. In the species O_2, O_2^+, O_2^- and O_2^{2-}, the correct decreasing order of bond strength is:
(a) $O_2 > O_2^+ > O_2^- > O_2^{2-}$
(b) $O_2^+ > O_2 > O_2^- > O_2^{2-}$
(c) $O_2^{2-} > O_2^- > O_2^+ > O_2$
(d) $O_2^- > O_2^{2-} > O_2 > O_2^+$

61. The correct order of O—O bond length in O_2, H_2O_2 and O_3 is:
(a) $O_3 > H_2O_2 > O_2$ (b) $O_2 > H_2O_2 > O_3$
(c) $O_2 > O_3 > H_2O_2$ (d) $H_2O_2 > O_3 > O_2$

62. Oxidizing action increases in the following order:
(a) Cl < Br < I < F (b) Cl < I < Br < F
(c) I < F < Cl < Br (d) I < Br < Cl < F

63. Which of the following statements is correct for $CsBr_3$?
(a) It is a covalent compound
(b) It contains Cs^{3+} and Br^- ions
(c) It contains Cs^+ and Br_3^- ions
(d) It contains Cs^+, Br^- and lattice Br_2 molecule

64. When iodine is dissolved in CCl_4, the color that results is:
(a) Brown (b) Bluish green
(c) Violet (d) Colorless

65. Hydrogen bonding does not play any role in the boiling point of:
(a) NH_3 (b) H_2O
(c) HI (d) HF

66. The following acids have been arranged in order of decreasing acid strength. Identify the correct order:
ClOH(I) BrOH(II) IOH(III)
(a) I > II > III (b) II > I > III
(c) III > II > I (d) I > III > II

67. Hydrogen fluoride is a liquid unlike other hydrogen halides because:
(a) H—F bond is strong
(b) F-atom is small in size
(c) Hydrogen bonding is present
(d) HF is a weak acid

68. Which of the following possesses the highest bond energy?
(a) F_2 (b) Cl_2
(c) Br_2 (d) I_2

69. Order of boiling point is:
(a) HF > HI > HBr > HCl
(b) HF > HBr > HI > HCl
(c) HCl > HBr > HI > HF
(d) HCl > HI > HBr > HF

70. Which of the following is a pseudohalogen?
(a) IF_7 (b) CN^-
(c) ICl_2 (d) I_3^-

71. Which of the following is the strongest acid?
(a) HBr (b) HF
(c) H_2S (d) PH_3

72. Which is formed when $K_2Cr_2O_7$, $CaCl_2$, and conc. H_2SO_4 are heated?
(a) $Cr_2(SO_4)_3$ (b) $CrCl_3$
(c) CrO_2Cl_2 (d) K_2CrO_4

73. On heating $KClO_3$ we get:
(a) $KClO_2 + O_2$ (b) $KCl + O_2$
(c) $KCl + O_3$ (d) $KCl + O_2 + O_3$

74. The correct order of thermal stability of hydrogen halides (H—X) is:
(a) HI > HBr > HCl > HF
(b) HF > HCl > HBr > HI
(c) HCl > HF > HBr > HI
(d) HI > HCl > HF > HBr

75. The set with correct order of acidity is:
(a) $HClO < HClO_2 < HClO_3 < HClO_4$
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$
(c) $HClO < HClO_4 < HClO_3 < HClO_2$
(d) $HClO_4 < HClO_2 < HClO_3 < HClO$

76. The reaction,
$$3ClO^-_{(aq.)} \longrightarrow ClO^-_{3(aq.)} + 2Cl^-_{(aq.)}$$
is an example of:
(a) Oxidation reaction (b) Reduction reaction
(c) Disproportionation (d) Decomposition reaction

77. Hydrogen bond is strongest in:
(a) F—H—O (b) F—H—N
(c) F—H—F (d) All are equally strong

78. Which of the following has highest bond strength?
(a) HI (b) HCl
(c) HF (d) HBr

79. Shape and hybridization of IF_5 respectively are:
(a) Trigonal bipyramidal, sp^3d
(b) See-saw, sp^3d
(c) Square pyramidal, sp^3d^2
(d) Pentagonal pyramidal, sp^3d^3

80. The oxidation states of iodine in HIO_4, H_3IO_5, and H_5IO_6 are respectively:
(a) +1, + 3, +7 (b) +7, +7, +3
(c) +7, +7, +7 (d) +7, +5, +3

81. The electron affinity values (in kJ mol^{-1}) of three halogens X, Y, and Z are respectively −349, −333 and −325. X, Y, and Z respectively are:
(a) F_2, Cl_2, Br_2 (b) Cl_2, F_2 and Br_2
(c) Cl_2, Br_2, F_2 (d) Br_2, Cl_2 and F_2

82. Which one of the following reactions does not occur?
(a) $F_2 + 2Cl^- \longrightarrow 2F^- + Cl_2$
(b) $Cl_2 + 2F^- \longrightarrow 2Cl^- + F_2$
(c) $Br_2 + 2I^- \longrightarrow 2Br^- + I_2$
(d) $Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

83. Select the correct order from the following:
(a) $N_2O < N_2O_3 < NO$; Acidic character
(b) $MgO > Al_2O_3 > SiO_2$; Basic character
(c) $Fe^{2+} < Fe^{3+} < Mn^{2+}$; Ionic radius order
(d) Sc > La > Y; Ionisation energy order

84. Which of the following is the correct order of strength of H-bonding in the given compound?
(a) $HF < NH_3$ (b) $H_2O > H_2O_2$
(c) $H_2O_2 > H_2O$ (d) $NH_3 > H_2O$

85. In which of the following molecules central atom involve expansion of octet?
(a) PCl_3 (b) NCl_3
(c) ClF_3 (d) None of these

86. If pure "p" orbitals are involved in molecule formation, then the shape of H_3O^+ will be:
(a) Pyramidal (b) Tetrahedral
(c) Angular (d) Planar

87. Select the correct statement:
(a) NH_3 has higher bond dipole than NF_3
(b) CCl_4 is polar molecule
(c) SF_4 is polar molecule
(d) IF_7 is polar molecule

88. Arrange the following species according to their bond angle order:
(I) O_3 (II) NO_2^- (III) FNO
(a) I > II > III (b) II > I > III
(c) III > II > I (d) II > III > I

89. The species which is not tetrahedral in shape is:
(a) ICl_4^- (b) BI_4^-
(c) AlH_4^- (d) $\overset{+}{N}F_4$

90. Which of the following statements is/are correct regarding IF_5 molecule?
(I) There is only one lone pair present in equatorial
(II) All ∠FIF angles are identical
(III) There are eight faces in this molecule
(IV) The number ∠FIF angles less than 90° is 8
(a) I, II, and III (b) II, III, and IV
(c) III and IV (d) III only

91. When a solution of sodium hydroxide is added in excess to the solution of potash alum, we obtain:
(a) A white precipitate (b) Bluish white precipitate
(c) A clear solution (d) A crystalline mass

92. B—H—B bridge in B_2H_6 is formed by the sharing of:
(a) 2 electrons (b) 4 electrons
(c) 1 electron (d) 3 electrons

93. The bonds present in borazole are:
(a) 12σ, 3π (b) 9σ, 6π
(c) 6σ, 6π (d) 9σ, 9π

94. BCl_3 does not exist as dimer but BH_3 exists as dimer (B_2H_6) because:
(a) Chlorine is more electronegative than hydrogen
(b) There is $p_\pi - p_\pi$ back bonding in BCl_3, but BH_3 does not contain such multiple bonding
(c) Large-sized chlorine atoms do not fit in between the small boron atoms, whereas small-sized hydrogen atoms fit between boron atoms
(d) None of these

95. Lead chromate is:
(a) Red (b) Yellow
(c) White (d) Black

96. Which of the following is methanide:
(a) Be_2C (b) CaC_2
(c) Mn_3C (d) Mg_3C_2

97. Red lead is:
(a) PbO (b) Pb_3O_4
(c) PbO_2 (d) HgS

98. Laborer's working with phosphorus suffer from a disease in which bones decay. It is known as:

(a) Arthritis (b) Phossy jaw
(c) Rickets (d) Cancer

99. Pure phosphine is not combustible while impure phosphine is combustible; this combustibility is due to the presence of:
(a) P_2H_4 (b) N_2
(c) PH_5 (d) P_2O_5

100. Bond energies in NO, NO^+, and NO^- are such that:
(a) $NO > NO^+ > NO^-$ (b) $NO^- > NO > NO^+$
(c) $NO^+ > NO^- > NO$ (d) $NO^+ > NO > NO^-$

101. Which of the following are not known?
(a) PH_5 (b) PI_5
(c) NCl_5 (d) All of these

102. The most stable and basic hydride of 15th group is:
(a) NH_3 (b) PH_3
(c) AsH_3 (d) BiH_3

103. The gas which is supposed to be acidic anhydride:
(a) NO_2 (b) CO
(c) N_2O (d) NO

104. Bones glow in the dark because:
(a) They contain shining material
(b) They contain red phosphorus
(c) White phosphorus undergoes slow combustion in contact with air
(d) White phosphorus changes into red form

105. P_4O_{10} on reacting with water does not form:
(a) Tetra metaphosphoric acid
(b) Phosphorous acid
(c) Orthophosphoric acid
(d) Pyrophosphoric acid

106. The number of P—O—P bonds in cyclic metaphosphoric acid is:
(a) Zero (b) Two
(c) Three (d) Four

107. The correct order for acid strength is:
(a) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$
(b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
(c) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
(d) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$

108. The number of S—S bonds in sulphur trioxide trimer (S_3O_9) is:
(a) 3 (b) 2
(c) 1 (d) 0

109. NH_3 cannot be obtained by:
(a) Heating of NH_4NO_3 or NH_4NO_2
(b) Heating of NH_4Cl or $(NH_4)_2CO_3$
(c) Heating of NH_4NO_3 with NaOH
(d) Reaction of AlN or Mg_3N_2 or $CaCN_2$ with H_2O

110. An aqueous solution of BCl_3 is:
(a) Weak acid (b) Weak base
(c) Neutral (d) Strong base

111. In diborane:
(a) 4 bridged hydrogens and two terminal hydrogens are present
(b) 2 bridged hydrogens and four terminal hydrogens are present
(c) 3 bridged hydrogens and three terminal hydrogens are present
(d) None of the above

112. Which of the following metals burns in air at high temperature with the evolution of much heat?
(a) Cu (b) Hg
(c) Pb (d) Al

113. Aluminium (III) chloride forms a dimer because aluminium:
(a) Cannot form a trimer
(b) Has high ionization energy
(c) Belongs to third group
(d) Can have higher coordination number

114. Alum helps in purifying water by:
(a) Forming Si complex with clay particles
(b) Sulphate part which combines with the dirt and removes it
(c) Aluminium which coagulates the mud particles
(d) Making the mud, water soluble

115. The ion(s) that act/s as oxidizing agent in solution is/are:
(a) Tl^+ and Al^{3+} (b) B^{3+} and Al^{3+}
(c) Tl^{3+} only (d) B^{3+} only

116. The stability of +1 oxidation state increases in the sequence:
(a) Tl < In < Ga < Al (b) In < Tl < Ga < Al
(c) Ga < In < Al < Tl (d) Al < Ga < In < Tl

117. An example of major air pollutant is:
(a) O_2 (b) CO_2
(c) CO (d) He

118. The color imparted by Co(II) compounds to glass is:
(a) Deep blue (b) Green
(c) Yellow (d) Red

119. When PbO_2 reacts with conc. HNO_3, the gas evolved is:

(a) NO_2 (b) O_2
(c) N_2 (d) N_2O

120. Graphite is soft and lubricant, extremely difficult to melt. The reason for this anomalous behavior is that graphite:
(a) Has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interpellate bonds
(b) Is a non-crystalline substance
(c) Is an allotrope form of carbon
(d) Has molecules of variable molecular masses like polymers

121. Which one of the following is present in the chain structure of silicates?
(a) $(Si_2O_5^{2-})_n$ (b) $(SiO_3^{2-})_n$
(c) $(SiO_4)^{4-}$ (d) $Si_2O_7^{6-}$

122. Which of the following has the highest calorific value?
(a) Coal gas (b) Water gas
(c) Producer gas (d) Carbon dioxide gas

123. Among the following substituted silanes the one which will give rise to cross-linked silicone polymer on hydrolysis is:
(a) R_3SiCl (b) R_4Si
(c) $RSiCl_3$ (d) R_2SiCl_2

124. C—C bond length is maximum in:
(a) Diamond (b) Graphite
(c) Naphthalene (d) Fullerene

125. NH_3 has much higher boiling point than PH_3 because:
(a) NH_3 has much higher molecular mass
(b) NH_3 forms hydrogen bonds
(c) NH_3 contains ionic bonds while PH_3 contains covalent bonds
(d) NH_3 undergoes umbrella inversion

126. By the action of conc. H_2SO_4, phosphorus changes to:
(a) Phosphorus acid (b) Metaphosphoric acid
(c) Orthophosphoric acid (d) Pyrophosphoric acid

127. Among the following oxides, the lowest acidic is:
(a) P_4O_6 (b) P_4O_{10}
(c) As_4O_6 (d) As_4O_{10}

128. The basic character of the hydrides of Vth group elements decreases in the order:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $SbH_3 > AsH_3 > PH_3 > NH_3$
(c) $NH_3 > SbH_3 > PH_3 > AsH_3$
(d) $SbH_3 > PH_3 > AsH_3 > NH_3$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Nitrogen forms N_2 but phosphorus is converted into P_4 from P_2. The reason for this is:
(a) Triple bond is present between phosphorus atoms
(b) $p\pi$–$p\pi$ bonding is weak
(c) $p\pi$–$p\pi$ bonding is strong
(d) Multiple bond is formed easily

2. The element which forms oxides in all the oxidation states from +1 to +5 is:
(a) N (b) P
(c) As (d) Sb

3. N_2 forms NCl_3, whereas P can form both PCl_3 and PCl_5. Why?
(a) P has *d*-orbitals which can be used for bonding but N_2 does not have
(b) N atom is larger in size than P
(c) P is more reactive towards Cl than N
(d) None of the above

4. Which of the following compound is responsible for catching fire spontaneously in Holme's singal?
(a) P_2H_4 (b) PH_3
(c) C_2H_4 (d) All of these

5. Which is in the decreasing order of boiling points of Vth group hydrides?
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $SbH_3 > AsH_3 > PH_3 > NH_3$
(c) $PH_3 > NH_3 > AsH_3 > SbH_3$
(d) $SbH_3 > NH_3 > AsH_3 > PH_3$

6. Which compound acts as an oxidizing as well as a reducing agent?
(a) SO_2 (b) Mn_2O_7
(c) Al_2O_3 (d) CrO_3

7. Hydrolysis of one mole of peroxydisulphuric acid produces:
(a) Two moles of sulphuric acid
(b) Two moles of peroxymonosulphuric acid
(c) One mole of sulphuric acid and one mole of peroxymonosulphuric acid
(d) One mole of sulphuric acid, one mole of peroxymonosulphuric acid, and one mole of hydrogen peroxide

8. Which of the following is the most powerful oxidizing agent?

(a) H_2SO_4 (b) H_3BO_3
(c) HPO_3 (d) H_3PO_4

9. The most powerful oxidizing agent is:
(a) Fluorine (b) Chlorine
(c) Bromine (d) Iodine

10. Which one of the hydracids does not form any precipitate with $AgNO_3$?
(a) HF (b) HCl
(c) HBr (d) HI

11. The strongest reducing agent is:
(a) F^- (b) Cl^-
(c) Br^- (d) I^-

12. HBr and HI can reduce H_2SO_4, HCl can reduce $KMnO_4$, and HF can reduce:
(a) $K_2Cr_2O_7$ (b) $KMnO_4$
(c) H_2SO_4 (d) None of these

13. $Na_2S_2O_3$ is oxidized by I_2 to:
(a) Na_2S (b) Na_2SO_4
(c) $NaHSO_3$ (d) $Na_2S_4O_6$

14. Which of the possible molecule/species is having maximum values for dipole moment (where "A" is the central atom)?
(a) AX_3 (having one lone pair on central atom)
(b) AX_4 (Tetrahedral)
(c) AX_4Y (having no lone pair on central atom)
(d) Cannot be predicted

15. Which of the following is incorrect match?
(a) SiF_4 : Can act as lewis acid
(b) Benzyne : All C-atoms are sp^2 hybridized
(c) PBr_3 : Non polar
(d) CHF == C == CHF: Nodal planes of π-bonds are not lying in same plane

16. Which of the following molecule/species is having minimum number of lone pair on its central atom?
(a) BrF_3 (b) BrF_4^-
(c) XeF_5^+ (d) I_3^-

17. Select the correct statement:
(a) Basicity of phosphorous acid is three
(b) Perbromic acid is having only one peroxy linkage
(c) β–SO_3 is having cyclic structure
(d) Borazine is having zero dipole moment

18. Which of the following statement is not correct regarding SF_2Cl_2 molecule?
(a) Two axial bond lengths are longer compared to two equatorial bond lengths
(b) Two S–F bond lengths are identical
(c) Two S–Cl bond lengths are identical
(d) Lone pair is not changing its position

19. Select the correct statement regarding oxides:
(a) As the electronegativity of element increases, acidic character of oxide increases
(b) Down the group the acidic nature of oxide increases
(c) Both B_2O_3 and Al_2O_3 are acidic oxides
(d) Nitrogen forms all the three types of oxides (neutral, basic, and acidic)

20. Which of the following structure is non-planar?
(a) $Na_3B_3O_6$
(b) I_2Cl_6
(c) Sheet silicates
(d) Inorganic graphite layer

21. Alumina on heating with carbon in nitrogen atmosphere gives:
(a) Al + CO (b) Al + CO_2
(c) AlN + CO (d) Al + CO + N_2

22. Which of the following has the minimum heat of dissociation?
(a) $[(CH_3)_3N \longrightarrow BF_3]$
(b) $[(CH_3)_3N \longrightarrow B(CH_3)F_2]$
(c) $[(CH_3)_3N \longrightarrow B(CH_3)_2F]$
(d) $[(CH_3)_3N \longrightarrow B(CH_3)_3]$

23. Anhydrous $AlCl_3$ is obtained from:
(a) Hydrochloric acid and aluminium metal
(b) Dry hydrogen chloride gas and aluminium metal
(c) Alumina and chlorine gas
(d) None of these

24. Aluminium vessel should not be washed with materials containing washing soda because:
(a) Washing soda is expensive
(b) Washing soda is easily decomposed
(c) Washing soda reacts with aluminium to form soluble aluminate
(d) Washing soda reacts with aluminium to form insoluble aluminium oxide

25. In the reaction LiH + $AlH_3 \longrightarrow LiAlH_4$, AlH_3 and LiH act as:
(a) Lewis acid and Lewis base
(b) Lewis base and Lewis acid
(c) Bronsted base and Bronsted acid
(d) None of these

26. The solution of borax in water is:

(a) Neutral (b) Acidic

(c) Alkaline (d) Amphoteric

27. Al_2O_3 can be converted into anhydrous $AlCl_3$ by heating:

(a) A mixture of Al_2O_3 and carbon in dry Cl_2 gas

(b) Al_2O_3 with Cl_2 gas

(c) Al_2O_3 with HCl gas

(d) Al_2O_3 with NaCl solid state

28. The reaction,

$B(OH)_3 + NaOH \longrightarrow Na[B(OH)_4]$ can be made to proceed in forward direction by:

(a) Adding *cis*-1, 2-diol (b) Adding borax

(c) Adding *trans*-1, 2-diol

(d) Adding Na_2HPO_4

29. Aluminium chloride exists as dimer, Al_2Cl_6, in solid state as well as in solution of non-polar solvents such as C_6H_6. When dissolved in water it gives:

(a) $Al_2O_3 + 6HCl$ (b) $[Al(H_2O)_6] + 3Cl^-$

(c) $[Al(OH)_6]^{3-} + 3HCl$ (d) $Al^{3+} + 3Cl^-$

30. Carbon burns in air and forms two oxides CO and CO_2. This shows that carbon has:

(a) Two allotropic forms (b) Two oxidation states

(c) Two isotopes

(d) Four electrons in valence shell

31. By addition of excess of sodium hydroxide solution to stannous chloride solution, we obtain:

(a) $Sn(OH)_2$ (b) $SnO_2 \cdot H_2O$

(c) Na_2SnO_3 (d) Na_2SnO_2

32. Man dies in an atmosphere of carbon monoxide because it:

(a) Combines with the O_2 present in the body to form CO_2.

(b) Reduces the organic matter of tissues.

(c) Combines with hemoglobin of blood, making it incapable of absorbing O_2.

(d) Dries up the blood.

33. Which statement is correct with respect to the property of the elements with increase in atomic number in the carbon family?

(a) Their metallic character decreases.

(b) The stability of 2+ oxidation state increases.

(c) Their ionization energy increases.

(d) Their atomic size decreases.

34. Which gas is essential constituent of almost all fuel gases?

(a) CO_2 (b) N_2

(c) CO (d) H_2O

35. Regular use of which of the following fertilizer increases the acidity of soil:

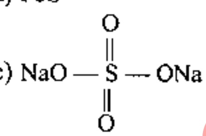
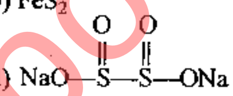
(a) Potassium nitrate (b) Urea

(c) Superphosphate of lime

(d) Ammonium sulphate

36. The oxidation state (O.S.) of S–atom is –1 in:

(a) FeS (b) FeS_2

(c)  (d) 

37. In silicon dioxide:

(a) Each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms

(b) Each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bonded to two silicon atoms

(c) Silicon atom is bonded to two oxygen atoms

(d) There are double bonds between silicon and oxygen atoms

38. Name the structure of silicate in which three oxygen atoms of $[SiO_4]^{4-}$ are shared:

(a) Pyrosilicate (b) Sheet silicate

(c) Linear chain silicate

(d) Three dimensional silicate

39. Which one is not an acid salt?

(a) NaH_2PO_2 (b) NaH_2PO_3

(c) NaH_2PO_4 (d) None of these

40. Sodium nitrate on heating with zinc dust and caustic soda gives:

(a) $NaNO_2$ (b) NH_3

(c) NO_2 (d) N_2O

41. The most thermodynamically stable allotropic form of phosphorus is:

(a) Red (b) White

(c) Black (d) Yellow

42. Which of the following statement regarding sulphur is incorrect?

(a) At 600°C, the gas mainly consists of S_2 molceules

(b) The oxidation state of sulphur is never less than +4 in its compounds

(c) S_2 molecule is paramagnetic

(d) The vapor at 200°C consists mostly of S_8 rings

43. Which is an ozonide?
(a) KO_3 (b) NH_4O_3
(c) Cr_2O_3 (d) Both (a) and (b)

44. Identify the incorrect statement among the following:
(a) Ozone reacts with SO_2 to give SO_3.
(b) Silicon reacts with NaOH(aq.) in the presence of air to give Na_2SiO_3 and H_2O.
(c) Cl_2 reacts with excess of NH_3 to give N_2 and HCl.
(d) Br_2 reacts with hot and strong NaOH solution to give NaBr, $NaBrO_4$, and H_2O.

45. When Na_2S is added to sodium nitroprusside solution:
(a) Beautiful violet color is produced
(b) A complex $[Fe(CN)_5NOS]^{4-}$
(c) The complex $Na_4[Fe(CN)_5NOS]$ is formed
(d) All of these

46. One gas bleaches the color of the flowers by reduction while the other by oxidation. The gases are:
(a) CO and CO_2 (b) H_2S and Br_2
(c) SO_2 and Cl_2 (d) NH_3 and SO_3

47. $[X] + H_2SO_4 \longrightarrow [Y]$ a colorless gas with irritating smell,
$[Y] + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ Green solution, $[X]$ and $[Y]$ is:
(a) SO_3^{2-}, SO_2 (b) Cl^-, HCl
(c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2

48. Which of the following is not oxidized by O_3?
(a) KI (b) $FeSO_4$
(c) $KMnO_4$ (d) K_2MnO_4

49. The halide which does not give a precipitate with $AgNO_3$ is:
(a) F^- (b) Cl^-
(c) Br^- (d) I^-

50. Which ion can bring about the highest oxidation state of a transition metal?
(a) F^- (b) Cl^-
(c) Br^- (d) I^-

51. Which halogen can be purified by sublimation?
(a) F_2 (b) Cl_2
(c) Br_2 (d) I_2

52. The ion that cannot undergo disproportionation is:
(a) ClO_4^- (b) ClO_3^-
(c) ClO_2^- (d) ClO^-

53. In the reaction between Cl_2 and hot conc. NaOH, which is correct:
(a) The oxidation number of Cl_2 changes from 0 to +5 and 0 to –1
(b) Cl_2 undergoes disproportionation
(c) Cl_2 undergoes self or auto redox change
(d) All of these

54. The correct order of acidic nature is:
(a) $Cl_2O_7 > SO_3 > P_4O_{10}$ (b) $CO_2 > N_2O_5 > SO_3$
(c) $Na_2O > MgO > Al_2O_3$ (d) $K_2O > CaO > MgO$

55. The product of oxidation of I^- with MnO_4^- in alkaline medium is:
(a) IO_3^- (b) I_2
(c) IO^- (d) IO_4^-

56. The numer of hydrogen atoms attached to phosphorus atom in hypophosphorous acid is:
(a) Zero (b) Two
(c) One (d) Three

57. Which of the following is only acidic in nature?
(a) $Be(OH)_2$ (b) $Mg(OH)_2$
(c) $B(OH)_3$ (d) $Al(OH)_3$

58. Which one of the following statements regarding helium is incorrect?
(a) It is used to produce and sustain powerful superconducting magnets
(b) It is used as a cryogenic agent for carrying out experiments at low temperatures
(c) It is used to fill gas balloons instead of hydrogen because it is lighter than hydrogen and is non-inflammable
(d) It is used in gas-cooled nuclear reactors

59. Which products are expected from the disproportionation of hypochlorous acid?
(a) $HClO_3$ and Cl_2O (b) $HClO_2$ and $HClO$
(c) HCl and Cl_2O (d) HCl and $HClO_3$

60. In view of the signs of $\Delta_rG°$ for the following reactions
$PbO_2 + Pb \rightarrow 2\,PbO$, $\Delta_rG° < 0$
$SnO_2 + Sn \rightarrow 2\,SnO$, $\Delta_rG° > 0$
Which oxidation states are more characteristic for lead and tin?
(a) For lead + 4, for tin + 2
(b) For lead + 2, for tin + 2
(c) For lead + 4, for tin + 4
(d) For lead + 2, for tin + 4

61. Select the correct statement about elements of group 15:

(a) The order of stability of oxidation state for +3 is $Bi^{3+} > Sb^{3+}$ and for +5 is $Bi^{5+} < Sb^{5+} < As^{5+}$

(b) In the case of nitrogen, all oxidation states from +1 to +4 tend to disproportionate in acid solution.

(c) There is a considerable increase in covalent radius from N to P but from As to Bi only a small increase in covalent radius is observed.

(d) All of these

62. Aluminium chloride exists as dimer, Al_2Cl_6, in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives

(a) $Al^{3+} + 3Cl^-$ (b) $[Al(H_2O)_6]^{3+} + 3Cl^-$

(c) $[Al(OH)_6]^{3-} + 3HCl$ (d) $Al_2O_3 + 6HCl$

63. By the action of conc H_2SO_4, phosphorus changes to:

(a) Phosphorus acid (b) Orthophosphoric acid

(c) Metaphosphoric acid (d) Pyrophosphoric acid

64. The liquefied metal expanding on solidification is:

(a) Al (b) Ga

(c) Zn (d) Cu

65. A layer of coke is spread over bauxite during extraction of aluminium. This acts as a/an:

(a) Flux

(b) Slag to remove impurities

(c) Reducing agent

(d) Insulation and does not allow heat to escape

66. BF_3 is used as catalyst in several industrial processes due to its:

(a) Strong reducing nature (b) Weak reducing action

(c) Strong Lewis acid nature

(d) Weak Lewis acid character

67. The chemical formula of feldspar is:

(a) $KAlSi_3O_8$ (b) Na_3AlF_6

(c) $NaAlO_2$

(d) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 4Al(OH)_3$

68. A mixture of boron trichloride and hydrogen is subjected to silent electric discharge to form '*A*' and HCl. '*A*' is mixed with NH_3 and heated to 200°C to form '*B*'. The formula of '*B*' is:

(a) H_3BO_3 (b) B_2O_3

(c) B_2H_6 (d) $B_3N_3H_6$

69. In aluminium extraction by the Baeyer's process, alumina is extracted from bauxite by sodium hydroxide at high temperature and pressure.

$$Al_2O_{3(s)} + 2OH^-_{(aq)} \longrightarrow 2AlO_2^-{}_{(aq)} + H_2O_{(l)}$$

Solid impurities such as Fe_2O_3 and SiO_2 are removed and then $Al(OH)_3$ is reprecipitated.

$$2Al(OH)_4^- \longrightarrow Al_2O_3 \cdot 3H_2O_{(s)} + 2OH^-_{(aq)}$$

In the industrial world:

(a) Carbon dioxide is added to precipitate the alumina

(b) Temperature and pressure are dropped and the super saturated solution seeded

(c) Both (a) and (b) are practised

(d) The water is evaporated

70. Solder is an alloy of:

(a) 70 % Pb, 30 % Sn (b) 33 % Pb, 67 % Sn

(c) 80 % Pb, 20 % Sn (d) 90 % Cu, 10 % Sn

71. Which of the following halide of carbon is used as refrigerant?

(a) CCl_4 (b) CF_4

(c) CH_2Cl_2 (d) CF_2Cl_2

72. Butter of tin is:

(a) $SnCl_2 \cdot 5H_2O$ (b) $SnCl_2 \cdot 2H_2O$

(c) $SnCl_4 \cdot 4H_2O$ (d) $SnCl_4 \cdot 5H_2O$

73. Me_2SiCl_2 on hydrolysis followed by polymerization will produce:

(a) $Me_2Si(OH)_2$ (b) $Me_2Si{=}O$

(c) $-[-O-(Me)_2Si-O-]_n$

(d) $Me_2SiClOH$

74. Litharge is chemically:

(a) PbO (b) PbO_2

(c) Pb_3O_4 (d) $Pb(CH_3COO)_2$

75. The straight chain polymer is formed by:

(a) Hydrolysis of CH_3SiCl_3 followed by condensation polymerization

(b) Hydrolysis of $(CH_3)_4Si$ followed by addition polymerization

(c) Hydrolysis of $(CH_3)_2SiCl_2$ followed by condensation polymerization

(d) Hydrolysis of $(CH_3)_3SiCl$ followed by condensation polymerization

76. On heating $K_4Fe(CN)_6$ with conc. H_2SO_4 gives the gas:

(a) SO_2 (b) CO_2

(c) CO (d) NO_2

77. Blasting of TNT is done by mixing:

(a) NH_4Cl (b) NH_4NO_3

(c) NH_4NO_2 (d) $(NH_4)_2SO_4$

78. Which of the following is the incorrect statement for PH_3?

(a) It is less basic than NH_3

(b) It has rotten fish smell

(c) It has pyramidal structure

(d) It does not show reducing properties

79. A pale blue liquid which is obtained by reacting equimolar mixture of two gases at –30°C is:

(a) N_2O_3 (b) N_2O
(c) N_2O_4 (d) N_2O_5

80. $(NH_4)_2Cr_2O_7$ on heating liberates a gas. The same gas will be obtained by:

(a) Heating NH_4NO_2 (b) Heating NH_4NO_3
(c) Treating Mg_3N_2 with H_2O
(d) Heating H_2O_2 on $NaNO_2$

81. Which one of the following oxides of nitrogen is solid?

(a) NO_2 (b) N_2O
(c) N_2O_3 (d) N_2O_5

82. Which is used to produce smoke screens?

(a) Zinc sulphide (b) Calcium phosphide
(c) Zinc phosphide (d) Sodium carbonate

83. The percentage of *p*-character in the orbitals forming P—P bonds in P_4 is:

(a) 25 (b) 33
(c) 50 (d) 75

84. Which of the following is the correct order of increasing enthalpy of vaporization?

(a) $NH_3 < PH_3 < AsH_3$ (b) $AsH_3 < PH_3 < NH_3$
(c) $PH_3 < AsH_3 < NH_3$ (d) $NH_3 < AsH_3 < PH_3$

85. Chlorine reacts with excess of ammonia to form:

(a) NH_4Cl (b) $N_2 + HCl$
(c) $N_2 + NH_4Cl$ (d) $N_2 + NCl_3$

86. The reaction of P_4 with *X* leads selectively to P_4O_6. The *X* is:

(a) A dry O_2 (b) A mixture of O_2 and N_2
(c) Moist O_2
(d) O_2 in presence of aqueous NaOH

87. Which shows maximum catenation property?

(a) Te (b) Se
(c) S (d) O

88. There is no S—S bond in:

(a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$
(c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

89. Which of the following bonds has the highest energy?

(a) Se—Se (b) Te—Te
(c) S—S (d) O—O

90. Which of the following does not have S—S linkage?

(a) $S_2O_8^{2-}$ (b) $S_2O_6^{2-}$
(c) $S_2O_5^{2-}$ (d) $S_2O_3^{2-}$

91. The element evolving two different gases on reaction with conc. H_2SO_4 is:

(a) P (b) C
(c) Hg (d) S

92. The function of $Fe(OH)_3$ in the contact process is:

(a) To detect colloidal impurity
(b) To remove moisture
(c) To remove dust particles
(d) To remove arsenic impurity

93. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives:

(a) $Na_2S_4O_6$ (b) $NaHSO_4$
(c) NaCl (d) NaOH

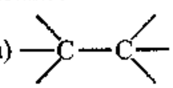
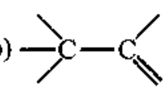
94. In which of the following molecule, the number of possible $\angle XAX$ angles is maximum in the anionic part of their solid state? [*A*: Central atom; *X*: surrounding atom]

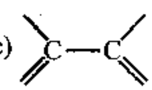
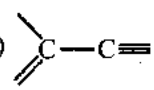
(a) PBr_5 (b) N_2O_5
(c) PCl_5 (d) Cl_2O_6

95. Which of the following compound have *X*—O—*X* linkage where '*X*' is the so called central atom like P, S etc?

(a) $P_2O_8^{4-}$ (b) $S_2O_3^{2-}$
(c) γ-SO_3 (d) $S_2O_5^{2-}$

96. In which of the following type of bond, C—C bond distance will be minimum?

(a)  (b) 

(c)  (d) 

97. Which of the following is pseudo alum?

(a) $(NH_4)_2SO_4{\cdot}Fe_2(SO_4)_3{\cdot}24H_2O$
(b) $K_2SO_4{\cdot}Al_2(SO_4)_3{\cdot}24H_2O$
(c) $MnSO_4{\cdot}Al_2(SO_4)_3{\cdot}24H_2O$
(d) None of these

98. Among the halides.

1. BCl_3 2. $AlCl_3$
3. $GaCl_3$ 4. $InCl_3$

The order of decreasing Lewis acid character is:

(a) 1, 2, 3, 4 (b) 4, 3, 2, 1
(c) 3, 4, 2, 1 (d) 2, 3, 4, 1

99. Which of the following has smell resembling to bleaching powder?

(a) NO_2 (b) HNO_4
(c) HNO_3 (d) None of these

100. Which of the following statement about boron carbide is wrong?

(a) Its molecular formula is B_4C.

(b) It is also called Norbia.

(c) It is the hardest substance.

(d) It is used for cutting glasses.

101. Which one of the following methyl diboranes does not exist?

(a) $B_2H_4(CH_3)_2$ (b) $B_2H_3(CH_3)_3$

(c) $B_2H_2(CH_3)_4$ (d) $B_2H(CH_3)_5$

102. Borax on heating strongly above its melting point melts to a liquid, then solidifies to a transparent mass commonly known as Borax Bead. The transparent glassy mass consists of:

(a) Sodium pyroborate (b) Boric anhydride

(c) Sodium metaborate

(d) Mixture of sodium metaborate and boric anhydride

103. For H_3PO_3 and H_3PO_4, the correct choice is:

(a) H_3PO_3 is dibasic and reducing agent

(b) H_3PO_3 is dibasic and non-reducing agent

(c) H_3PO_4 is tribasic and reducing agent

(d) H_3PO_3 is tribasic and non-reducing agent

104. A certain compound when burnt gave three oxides. The first turned lime water milky, the second turned cobalt chloride paper pink and the third formed an aqueous solution of pH 3 nearly. The elements present in the compound are:

(a) C, S, O (b) C, H, Na

(c) C, H, S (d) C, H, Ca

105. The number of S—S bonds in polythionic acid ($H_2S_nO_6$):

(a) n (b) $n - 1$

(c) $n - 2$ (d) None of these

106. Which of the following halogen oxides is ionic?

(a) I_4O_9 (b) I_2O_5

(c) BrO_2 (d) ClO_3

107. When Cl_2 water is added to an aqueous solution of potassium halide in the presence of chloroform, a violet color is obtained. On adding more of Cl_2 water, the violet color disappears and a colorless solution is obtained. This test confirms the presence of the following in aqueous solution:

(a) Iodide (b) Bromide

(c) Chloride (d) Iodide and bromide

108. Antichlor is a compound:

(a) which absorbs chlorine

(b) Which removes excess of Cl_2 from a material

(c) Which liberates Cl_2 from bleaching powder

(d) Which acts as a catalyst in the manufacture of Cl_2

109. Superhalogen is:

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

110. Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. This is due to:

(a) Strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution which appears like a cloudy smoke

(b) Strong affinity for water, conc. HCl pulls moisture of air towards itself. The moisture forms droplets of water and hence the cloud

(c) Conc. HCl emits strongly smelling HCl gas all the time

(d) Oxygen in air reacts with emitted HCl gas to form a cloud of Cl_2 gas

111. Which products are expected from the disproportionation of hypochlorous acid?

(a) $HClO_3$ and Cl_2O (b) $HClO_2$ and $HClO_4$

(c) HCl and Cl_2O (d) HCl and $HClO_3$

112. $B(OH)_3 + NaOH \longrightarrow Na[B(OH)_4]_{(aq)}$

Then addition of which of the following proceeds the reaction in the forward direction:

(a) *cis*-1, 2 diol (b) *trans* 1, 2 diol

(c) Borax (d) Na_2HPO_4

113. Which of the following statements about anhydrous aluminium chloride is correct?

(a) It fumes in moist air

(b) It exists as dimer both in the vapor state below 350°C and in non-polar solvents

(c) It is prepared by heating Al_2O_3 in a stream of sulphur chloride (S_2Cl_2) vapor and chlorine

(d) All of these

114. Aqueous solution of ortho-boric acid can be titrated against sodium hydroxide using phenolphthalein indicator only in presence of:

(a) *trans*-glycerol (b) Catechol

(c) *cis*-glycerol (d) Both (b) and (c)

115. $Mg_3B_2 \xrightarrow{HCl_{(aq)}} [X] + MgCl_2$ for [X] and [Y] the incorrect choice is:

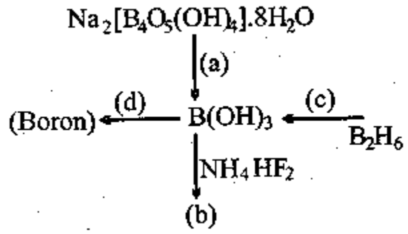
(a) $[X] + H_2O \xrightarrow{HCl_{(aq)}} [Y] + H_2$

(b) [X] is BCl_3 and [Y] is H_3BO_3

(c) [X] with air and [Y] on strong heating (red heat) give same compound

(d) In [Y], boron completes its octet by removing H^+ from water molecule

116. For the following flow diagram:



Which of the following options correctly describes the reagents, products, and the reaction conditions given in parentheses as small alphabets?

Option	(a)	(b)	(c)	(d)
(1)	Acidic hydrolysis	NH_3 and NH_4BF_4	Hydrolysis	Heating only
(2)	Acidic hydrolysis	NH_4BF_4	Hydrolysis	Heating in presence of Mg or Fe
(3)	Alkaline hydrolysis	NH_4BF_4	Hydrolysis	Heating only
(4)	Alkaline hydrolysis	$N_2 + BF_3$	Hydrolysis	Heating in presence of Mg or Fe

(a) 1 (b) 2

(c) 3 (d) 4

117. Which of the following statements regarding orthoboric acid (H_3BO_3) is false?

(a) It acts as a weak monobasic acid

(b) It is soluble in hot water

(c) It has a planar structure

(d) It acts as a tribasic acid

118. Peroxoborate in aqueous solution provides:

(a) $[B(OH)_4]^- + H_2O_2$ (b) $Na_2B_4O_7{\cdot}10H_2O$

(c) HBO_2 (d) $Na[B_3O_3(OH)_4]$

119. Which of the following statement about anhydrous aluminium chloride is correct?

(a) Its anhydrous form is deliquescent and fumes in air

(b) It is not easily hydrolyzed

(c) It sublimes at 20°C under vacuum

(d) It is a strong Lewis base

120. Al dissolves in molten NaOH with the formation of:

(a) Sodium aluminate (Na_3AlO_3)

(b) Sodium metaluminate ($NaAlO_2$)

(c) Aluminium hydroxide

(d) Alumina

121. Which reaction cannot give anhydrous $AlCl_3$?

(a) Heating of $AlCl_3{\cdot}6H_2O$

(b) Passing dry HCl over heated aluminium powder

(c) Passing dry Cl_2 over heated aluminium powder

(d) Heating a mixture of alumina and coke in a current of dry Cl_2

122. A brown colored mixture of two gases is obtained by the reduction of 6N nitric acid with metallic copper. This mixture on cooling condense to a blue liquid which on freezing (–30°) gives a blue solid. The correct choice for blue liquid or solid is:

(a) It is referred to as the anhydride of nitrous acid

(b) It is an acidic oxide and hence dissolves in alkalies producing nitrites

(c) It can also be prepared by the action of 50% HNO_3 on arsenious oxide and then cooling to 250 K

(d) All of these

123. Select the incorrect statement:

(a) Nitrous oxide supports combustion more vigorously than air

(b) Phosphorus pentaoxide dehydrates nitric acid forming nitrogen pentaoxide

(c) Reactivity order of various allotropic forms of phosphorus is white > red > black

(d) Red phosphorus changes to white phosphorus on heating in the atmosphere of CO_2 or coal gas at 573 K

124. The soldiers of Napolean army while at Alps during freezing winter suffered a serious problem as regards to the tin buttons of their uniforms. White Metallic tin buttons get converted to grey powder. This transformation is related to:

(a) An interaction with water vapor contained in humid air

(b) A change in crystalline structure of tin

(c) A change in the partial pressure of O_2 in air

(d) An interaction with N_2 of air at low temperature

125. $NH_4ClO_4 + HNO_{3(dil.)} \longrightarrow HClO_4 + [X]$

$[X] \xrightarrow{\Delta} Y_{(g)}$

[X] and [Y] are respectively:

(a) NH_4NO_3 and N_2O (b) NH_4NO_2 and N_2

(c) HNO_4 and O_2 (d) None

126. S_1: AgCl with liquid ammonia forms a complex $[Ag(NH_3)_2]^+$.

S_2: Ammonium dichromate on heating decomposes to give nitrogen and a green colored compound.

S_3: CaNCN on hydrolysis produces a white precipitate and a gas which turns filter paper moistened with copper sulphate solution deep blue.

(a) T T T (b) T F T

(c) F F T (d) T T F

127. The equivalent weight of H_3PO_4 in the reaction:

$NaOH + H_3PO_4 \rightarrow NaH_2PO_4 + H_2O$ is:

(a) 25 (b) 49

(c) 59 (d) 98

128. Hydrolysis of one mole of peroxodisulphuric produces:

(a) Two moles of sulphuric acid

(b) Two moles of peroxomonosulphuric acid

(c) One mole of sulphuric acid and one mole of peroxomonosulphuric acid

(d) One mole each of sulphuric acid, peroxomonosulphuric acid and hydrogen peroxide

Multiple Correct Answers Type

1. The incorrect statement/s among the following is/are:

(a) NCl_5 does not exist while PCl_5 does

(b) Lead prefers to form tetravalent compounds

(c) The three C—O bonds are not equal in the carbonate ion

(d) Both O_2^+ and NO are paramagnetic

2. Which of the following statements is/are correct?

(a) Silicon is used extensively as a semiconductor

(b) Carborundum is SiC

(c) Silicon occurs in free state in nature

(d) Mica contains the element silicon

3. CO is isostructural with:

(a) $SnCl_2$ (b) $HgCl_2$

(c) SCl_2 (d) ZnI_2

4. Which of the following carbides on treatment with water give methane?

(a) Al_4C_3 (b) Be_2C

(c) Mg_2C_3 (d) CaC_2

5. Which of the following are the ores of lead?

(a) Galena (b) Anglesite

(c) Cerussite (d) Carnallite

6. White phosphorus has:

(a) Six P—P single bonds

(b) Four P—P single bonds

(c) Four lone pairs of electrons

(d) P—P—P angle of 60°

7. Which of the following pairs is/are correctly matched?

(a) A halogen which is liquid at room temperature—Bromine

(b) The most electronegative element—Fluorine

(c) The most reactive halogen—Fluorine

(d) The strongest oxidizing agent—Iodine

8. Which one of the following arrangements does not give the correct picture of the trends indicated against it?

(a) $F_2 > Cl_2 > Br_2 > I_2$: Bond dissociation energy

(b) $F_2 > Cl_2 > Br_2 > I_2$: Electronegativity

(c) $F_2 > Cl_2 > Br_2 > I_2$: Oxidizing nature

(d) $F_2 > Cl_2 > Br_2 > I_2$: Electron gain enthalpy

9. Which one of the following is/are incorrect statement(s)?

(a) The hydroxide of aluminium is more acidic than that of boron

(b) The hydroxide of boron is basic while that of aluminium is amphoteric

(c) The hydroxide of boron is acidic while that of aluminium is amphoteric

(d) The hydroxides of both boron and aluminium are amphoteric

10. Which one of the following statement(s) about H_3BO_3 is/are correct?

(a) It is a strong tribasic acid

(b) It is prepared by acidifying an aqueous solution of borax

(c) It has a layer structure in which planar BO_3 units are joined by hydrogen bonds

(d) It does not act as proton donor as it acts as a Lewis acid by accepting lone pair of hydroxyl ions

11. Which of the following oxides are not neutral?

(a) CO (b) SnO_2

(c) ZnO (d) SiO_2

12. Identify the incorrect statement(s) with respect to CO:

(a) It combines with water to give carbonic acid

(b) It combines with haemoglobin of the blood

(c) It is a powerful oxidizing agent

(d) CO is weak field ligand

13. Which of the following oxides is/are not amphoteric in character?

(a) CaO (b) CO_2

(c) SiO_2 (d) SnO_2

14. Which of the following options are correct for isoelectronic pairs?

(a) H_2, HD (b) CO, N_2

(c) HCl, H_2S (d) D_2O, Ne

15. Which of the following pair(s) represent(s) the isoelectronic species?

(a) S^{-2} and Sc^{+3} (b) SO_2 and NO_3^-

(c) N_2 and CN^- (d) NH_3 and H_3O^+

16. Which one of the following is not hypovalent molecules / species?

(a) AlF_3 (b) $AlCl_3$

(c) HCO_2^- (d) $BeCl_2$

17. Which of the following compound(s) have same hybridization of the central atom?

(a) SeF_2Cl_2 (b) I_3^-

(c) $BeCl_2$ (d) XeF_3^+

18. Which of following species / compounds are planar?

(a) H_2O (b) ICl_2^-

(c) ICl_3 (d) BrF_4^-

19. Which of the molecule / species are not having perfect shape?

(a) CH_2Cl_2 (b) NF_4^+

(c) $SiCl_4$ (d) $BFCl_2$

20. Which of the following statements are correct for HCN molecule?

(a) Two π-bonds are perpendicular to each other

(b) Lone pair lying in the orbital which is perpendicular to both π-bonds

(c) The dipole moment value is non zero

(d) The direction of dipole moment is from N to H-atom

21. The bent-shape of the molecule may develop from which of the following hybridization(s)?

(a) sp^3d (b) sp^3

(c) sp (d) sp^2

22. Which of the following statement is correct?

(a) xz plane is the nodal plane for p_y orbital

(b) xy and xz planes are nodal planes for d_{xz} orbital

(c) Nodal planes for $d_{x^2-y^2}$ are at 45° inclined with the X-axis and perpendicular to xz-plane

(d) Nodal planes of π-bonds of $B_3N_3H_6$ are at molecular plane

23. Which of the following species are formed by Lewis acid–base interaction?

(a) CH_4 (b) $NaBF_4$

(c) PCl_4^+ (d) $Al(OH)_4^-$

24. Which of the following molecules are polar as well as planar?

(a) BFClBr (b) $B_3N_3H_6$

(c) ClF_3 (d) $CH_2=C=C=CF_2$

25. Which of the following product(s) may be formed by the reaction of diborane with ammonia?

(a) $(BN)_x$ (b) $B_2H_6.2NH_3$

(c) $B_3N_3H_6$ (d) $B_2H_6.NH_3$

26. Which of the following statements are true regarding $(ICl_3)_2$?

(a) All I—Cl bonds are identical in $(ICl_3)_2$

(b) In liquid state it conducts electricity

(c) Its monomer is also planar

(d) It has a planar structure

27. Be and Al show diagonal relationship and thus:

(a) Their oxides are soluble in alkali solution forming $[Be(OH)_4]^{2-}$

(b) They form complex anion BeF_4^{2-} and AlF_6^{3-}

(c) $BeCl_2$ and $AlCl_3$ are Lewis acids

(d) Oxides are basic

28. In the following statements, select the correct statement:

(a) $N(CH_3)_3$ has pyramidal structure

(b) $N(SiH_3)_3$ shows planar arrangement

(c) SiC is highly volatile (d) SiO_2 is called silane

29. Which of the following specie(s) is/are exists?

(a) $[BF_6]^{3-}$ (b) $[AlF_6]^{3-}$

(c) $[GaF_6]^{3-}$ (d) $[InF_6]^{3-}$

30. Which of the following is/are correct?

(a) Hydrolysis of NCl_3 gives NH_3 and HClO

(b) NH_3 is less stable than PH_3

(c) NH_3 is a weak reducing agent compared to PH_3

(d) Nitric oxide is paramagnetic

31. Ammonia on reaction with hypochlorite anion can form:

(a) NO (b) NH_4Cl

(c) N_2H_2 (d) HNO_2

32. The nitrogen oxide(s) that contain(s) N—N bond(s) is(are):

(a) N_2O (b) N_2O_3

(c) N_2O_4 (d) N_2O_5

33. Which statement is/are not correct about halogen?

(a) They are all diatomic and form univalent ions

(b) They are all capable of exhibiting several oxidation states

(c) They are all diatomic and form diatomic ions

(d) They are all reducing agents

34. The shape of O_2F_2 is/are not similar to:

(a) H_2O_2 (b) C_2F_2
(c) H_2F_2 (d) C_2H_2

35. Identify the statement(s) that is/are correct as far as structure of diborane is concerned:
(a) There are two bridging hydrogen atoms in diborane
(b) Each boron atom forms four bonds in diborane
(c) The hydrogen atoms are not in the same plane in diborane
(d) All B—H bonds in diborane are similar

36. Boric acid is a very weak acid but in the presence of certain organic compounds, it acts as a strong acid. Which one of the following organic compound(s) cannot affect such change?
(a) Glycerol (b) Acetic acid
(c) Ethyl alcohol (d) Ethylene

37. Which of the following species are having peroxy linkages?
(a) BrO_4^- (b) $S_2O_8^{2-}$
(c) $P_2O_8^{4-}$ (d) PO_5^{3-}

38. Which of the following statements is/are true?
(a) The strength of H-bond depends upon the polarity of the bond
(b) The extent of H-bond depends upon the number of sites available for H-bond
(c) The extent of H-bond in H_2O_2 is greater than that in H_2O
(d) The strength of H-bond in H_2O_2 is greater than that in H_2O

39. In which of the following option(s) all species contains X—O—X bond(s) in structure (X = central atom)?
(a) $H_2S_2O_5$, S_3O_9, $S_2O_6^{2-}$
(b) P_4O_{10}, P_4O_6, $H_5P_3O_{10}$
(c) N_2O_5, N_2O, N_2O_4
(d) S_3O_9, P_4O_6, $Si_2O_7^{6-}$

40. Which is/are true in case of BF_3?
(a) It is volatile liquid even at room temperature
(b) It is a Lewis acid
(c) It has planar geometry
(d) It forms adduct with NH_3

41. Which of the following order(s) is/are incorrect?
(a) $H_3PO_4 > H_3PO_3 > H_3PO_2$ (reducing character)
(b) $N_2O < NO < N_2O_5$ (oxidation state on nitrogen atom)
(c) $NH_3 > PH_3 > AsH_3 > SbH_3$ (basicity)
(d) $SbH_3 > NH_3 > AsH_3 > PH_3$ (reducing character)

42. The hybridization of Xe-atom in XeO_6^{4-} is same with:
(a) Xe in XeF_6 (b) Te in TeO_6^{6-}
(c) P in PF_6^- (d) Si in SiF_6^{2-}

43. The shape of H_2S_2 is identical to that of:
(a) S_2Cl_2 (b) O_2F_2
(c) C_2F_2 (d) H_2O_2

44. Which pair of compounds is not isostructural but possesses same number of lone pairs on the central atom?
(a) SF_4 and SO_3^{2-} (b) CO_2 and SO_2
(c) XeF_2 and BeH_2 (d) ClF_3 and XeF_4

45. In the reaction
$$2X + B_2H_6 \longrightarrow [BH_2X_2]^+ [BH_4]^-$$
the amine(s) X is (are):
(a) NH_3 (b) CH_3NH_2
(c) $(CH_3)_2NH$ (d) $(CH_3)_3N$

46. A solution of colorless salt H on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime upon addition of Zn dust to the same solution, the gas evolution restarts. The colorless salt(s) H is(are):
(a) NH_4NO_3 (b) NH_4NO_2
(c) NH_4Cl (d) $(NH_4)_2SO_4$

47. Select the correct statement(s) about the following:
(a) O_3 is used as germicide for purification of air
(b) In O_3, O—O bond length is identical with that of molecular oxygen
(c) O_3 molecule is angular in shape
(d) O_3 is an oxidizing agent

48. Which of the following statements is/are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?
(a) A deep red vapor is evolved
(b) The vapor when passed into NaOH solution gives yellow solution of Na_2CrO_4
(c) Chlorine gas is evolved
(d) Chromyl chloride is formed

49. Which of the following is correct about the reaction?
$$3NaClO \xrightarrow{\text{Heat}} NaClO_3 + 2NaCl$$
(a) It is a disproportionation reaction
(b) Oxidation number of chlorine decreases as well as increases in this reaction
(c) This reaction is used for the manufacture of halates
(d) It is a non-redox reaction

50. Which one of the following is/are the incorrect statement(s)?

(a) $B_2H_6 . 2NH_3$ is known as "inorganic benzene"

(b) Boric acid is a proton donor acid

(c) Beryllium exhibits coordination number of six

(d) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase or gas phase

51. Select the correct statement(s) for biogas and producer gas are made up of:

(a) Biogas contains CO_2 but producer gas does not

(b) Producer gas contains CO but not CO_2

(c) Both biogas and producer gas have N_2

(d) Both biogas and producer gas have CO_2

52. Which of the following statements is/are correct regarding graphite and inorganic graphite?

(a) Both are slippery in nature

(b) Both are conducting electricity but graphite is less conducting in nature compared to inorganic graphite

(c) Graphite is not having any charge separation like inorganic graphite

(d) All atoms in graphite as well as inorganic graphite are sp^2 hybridized

53. Which of the following statements is not correct for SiF_6^{2-} and ClF_6^{+}?

(a) They are isoelectronic

(b) They are isostructural

(c) All possible $\angle$FSiF and $\angle$FClF angles are identical

(d) d_{Si-F} and d_{Cl-F} (bond lengths) are identical

54. Select the correct statement:

(a) H_2O_2 is used as mild bleaching agent for bleaching delicate articles such as hair, silk, wool, etc.

(b) It restores the color of the old paints blackened by the action of H_2S. The lead sulphide (black) gets oxidized to lead sulphate (white)

$$\underset{\text{Black}}{PbS} + 4\,H_2O_2 \longrightarrow \underset{\text{White}}{PbSO_4} + 4H_2O$$

(c) When $CH_2 = CH_2$ is oxidized by H_2O_2 then ethane-1, 2-diol forms $\begin{array}{l} CH_2-OH \\ | \\ CH_2-OH \end{array}$

(d) H_2O_2 is a polar and non-planar

55. Select the correct reaction for H_2O_2:

(a) $Ag_2O + H_2O_2 \longrightarrow 2Ag + H_2O + O_2$

(b) $Cl_2 + H_2O_2 \longrightarrow 2HCl + O_2$

(c) $O_3 + H_2O_2 \longrightarrow H_2O + 2O_2$

(d) $H_2O_2 + 2KI \longrightarrow 2KOH + I_2$

56. Which of the following statements is / are correct?

(a) Nitrogen (IV) oxide in basic aqueous solution disproportionates

(b) Copper(II) nitrate and lead(II) nitrate each on thermal decomposition liberate both NO_2 and O_2 gases

(c) Some metals (Cr, Al and Fe) do not dissolve in conc. HNO_3 due to the formation of a passive film of oxide on the surface

(d) Hydrogen peroxide is oxidizing agent as well as reducing agent

57. Borax bead test is given by:

(a) An aluminium salt (b) A cobalt salt

(c) A copper salt (d) A nickelate salt

58. $Ca_2B_6O_{11} + Na_2CO_3 \xrightarrow{\Delta} [X] + CaCO_3 + NaBO_2$ (unbalanced equation) Correct choice(s) for [*X*] is/are:

(a) Structure of anion of crystalline [*X*] has one boron atom sp^3 hybridized and other three boron atoms sp^2 hybridized

(b) *X* with $NaOH_{(aq)}$ gives a compound which on reaction with hydrogen peroxide in alkaline medium yields a compound used as brightener in soaps

(c) Hydrolysis of [*X*] with HCl or H_2SO_4 yields a compound which on reaction with HF gives fluoroboric acid

(d) [*X*] on heating with chromium slats in oxidizing flame gives green colored bead

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

I_2 has less solubility in water and its solubility increases on adding KI solution. When KI and I_2 reacts then a species '*X*' is formed by which solubility of I_2 increases.

1. Hybridization of anionic part of '*X*' is:

(a) sp^2 (b) sp^3

(c) sp^3d (d) sp^3d^2

2. Geometry of anionic part of '*X*' is:

(a) Linear (b) T shape

(c) Pyramidal (d) See-saw

3. Which of the following is/are the correct characteristics of anionic part of '*X*'?

[Polar and non-polar nature to be considered on the basis of dipole moment]

(I) Planar (II) Non-planar

(III) Polar (IV) Non-polar

(a) I and III (b) I and IV
(c) II and III (d) II and IV

Comprehension-2: (Q. 4 and Q. 5)

Hybridization is the chemists attempt to explain the observed molecular shape by constructing hybridized atomic orbitals with the appropriate inter orbital angles. The molecule for which deviation from normal bond angle is observed, VSEPR theory suggests electron pair repulsive interaction ($lp-lp > lp-bp > bp-bp$). While from hybridization point of view that is departure from normal hybridization because the angle between any equivalent hybrid orbitals determine the fraction of s and p characters of the hybrid and *vice-versa*.

4. An element 'A' has outer shell configuration of $5s^2 5p^6$. If A forms covalent compound AF_2 with fluorine. The orbitals used by 'A' for bonding are:
(a) d-orbitals (b) p-orbitals
(c) sp-hybridized orbital (d) sp^3d hybrid orbital

5. In which species number of lone pair on iodine and number of d-orbitals used in hybridization by iodine are same?
(a) ICl_2^+ (b) ICl_2^-
(c) IF_7 (d) ICl_4^-

Comprehension-3: (Q. 6 to Q. 8)

Silicon, Germanium, Tin, and Lead along with carbon constitute the carbon family. The property called catenation facilitates the formation of a very large number of carbon compounds. Carbon also shows CF_3Cl are utilized in refrigeration, they have been blamed for ozone layer depletion.

6. C_{60} (fullerene) has the shape of a soccer ball. Consider the following statements and choose the correct one:
(i) Fullerene is an allotrope of carbon.
(ii) Fullerene has 5 and 6 member rings.
(iii) All carbon in fullerene are sp^2 hybridized.
(a) (i), (ii), and (iii) (b) (i) only
(c) (iii) only (d) (i) and (ii)

7. The carbide Mg_2C_3 upon hydrolysis gives:
(a) C_3H_6 (b) C_3H_4
(c) C_2H_2 (d) None of these

8. Which of the oxides of carbon can act as a reducing agent?
(a) CO_2 (b) CO
(c) CO_3^{2-} (d) None of these

Comprehension-4: (Q. 9 and Q. 10)

In a solution the Tl^+ ion is much more stable than Tl(III). The ionic radius of Tl^+ (1.50Å) is between that of K^+ (1.38Å) and Rb^+ (1.52Å). For this reason Tl^+ resembles group IA ion in number of ways. TlOH and Tl_2O are both soluble in water and are strongly basic. They absorb CO_2 from the air, forming Tl_2CO_3. The solubility of most of the salt is slightly lower than for potassium salts. Tl^+ can replace K^+ in some enzymes. There are some differences. TlOH is yellow and on heating to 100°C it turns into black; Tl_2O TlF is soluble in water, but LiF is insoluble.

9. +1 oxidation state of Tl is most stable due to:
(a) Inert pair effect (b) Small size
(c) Its basic nature (d) None of these

10. Which of the following has lowest melting point?
(a) Boron (b) Al
(c) In (d) Ga

Comprehension-5: (Q. 11 to Q. 14)

Hydrogen peroxide is an important compound of hydrogen and oxygen. It shows various types of properties and chemical reactions.

11. Hydrogen peroxide is not:
(a) A reducing agent (b) An oxidizing agent
(c) A dehydrating agent (d) A bleaching agent

12. The reaction $H_2S + H_2O_2 \longrightarrow S + 2H_2O$ manifests:
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidizing action of H_2O_2
(d) Reducing nature of H_2O_2

13. The species that do not contain peroxide ion (s) is/are:
(a) PbO_2 (b) SrO_2
(c) Na_2O_2 (d) BaO_2

14. The oxidation state of oxygen in H_2O_2 is:
(a) +1 (b) −1
(c) +2 (d) −2

Comprehension-6: (Q. 15 to Q. 18)

PCl_5 has trigonal pyramidal geometry with sp^3d hybridization in gases and liquid state but in solid state it exist as ionic compound.

15. The hybridization of P and shape of $POCl_3$ are:
(a) sp^3, tetrahedral
(b) sp^3, pyramidal
(c) sp^3d, square planar
(d) sp^3d, distorted tetrahedral

16. In presence of small amount of water, PCl_5 hydrolyzes to form:

(a) PCl_3 (b) $POCl$
(c) $POCl_3$ (d) H_3PO_3

17. In crystalline state PCl_5 exists as:

(a) $[PCl_4]^+Cl^-$ (b) $[PCl_4]^+[PCl_6]^-$
(c) $[PCl_3]^{2+} + 2Cl^-$ (d) $[PCl_6]^+ [PCl_4]^-$

18. What is the hybridization state of cation part of solid PCl_5?

(a) sp^3d^2 (b) sp^2
(c) sp^3 (d) sp^3d

Comprehension-7: (Q. 19 to Q. 21)

H_2SO_4 is the most important acid used in the chemical industry. Concentrated H_2SO_4 has quite strong oxidizing properties.

19. H_2SO_3 acts as:

(a) Reducing agent (b) Oxidizing agent
(c) Only monobasic acid (d) None of these

20. The shape of H_2SO_3 is:

(a) Tetrahedral (b) Pyramidal
(c) Planar (d) t-shaped

21. Oxidation state of S in H_2SO_3 is:

(a) +6 (b) +4
(c) +2 (d) +3

Comprehension-8: (Q. 22 to Q. 24)

NH_3 has got pyramidal structure. By replacement of H atoms it forms $(CH_3)_3N$ and $(SiH_3)_3N$ molecules which are found to have different geometries.

22. Which is the correct relation of bond angles?

(a) $NH_3 > (CH_3)_3N > (SiH_3)_3N$
(b) $(SiH_3)_3N > (CH_3)_3N > NH_3$
(c) $NH_3 > (SiH_3)_3N > (CH_3)_3N$
(d) $(CH_3)_3N > (SiH_3)_3N > NH_3$

23. Shape of $(SiH_3)_3N$ with respect to N is:

(a) Pyramidal (b) Tetrahedral
(c) Trigonal planar (d) T-shaped

24. Which of the following has highest basic character?

(a) NH_3 (b) $(CH_3)_2NH$
(c) $(CH_3)_3N$ (d) $(SiH_3)_3N$

Comprehension-9: (Q. 25 to Q. 27)

Solid N_2O_5 exists as $NO_2^+ \ NO_3^-$ and hence is called nitronium nitrate .

25. The gas which is acidic in nature is:

(a) NO (b) N_2O
(c) NO_2 (d) Both (a) and (c)

26. Which of the following statement is correct for the oxides of nitrogen?

(a) Dinitrogen trioxide dissolves in potassium hydroxide forming potassium nitrate
(b) Aqueous solution of nitrogen dioxide behaves both as a reducing agent and as an oxidizing agent
(c) Nitrous oxide is fairly soluble in cold water and turns blue litmus red
(d) NO_2 is non-planar

27. Identify the incorrect statement:

(a) In N_2O_4 the N—N bond length is longer than the usual N—N single bond distance
(b) NO_2 molecule is angular with N—O distance equal to intermediate distance between a single and a double bond
(c) N_2O is a linear molecule and has a small dipole moment
(d) None of these

Comprehension-10: (Q. 28 to Q. 30)

A number of molecules and polyatomic ions cannot be described accurately by a single Lewis structure and a number of descriptions based on the same skeletal structure are written and these taken together represent the molecule or ion. These structures have almost similar energies, same arrangement of atoms, and have same number of bonding and non-bonding pair of electrons. These contributing structures or canonical forms taken together constitute the resonance hybrid which represents the molecule or ion.

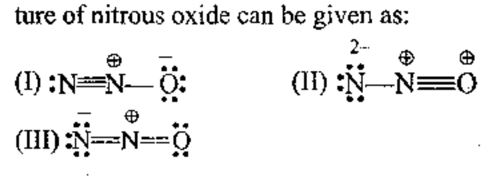
28. Which of the following is not correct about resonance?

(a) It averages the bond features as a whole
(b) It stabilizes the molecule since energy of the resonance hybrid is lower than that of any of the single canonical structure
(c) There is no equilibrium between these canonical structures
(d) These canonical structures have real existence also

29. The value of bond order of C — O bond for CO_3^{2-} ion is:

(a) 1.25 (b) 1.33
(c) 1.5 (d) 1.0

30. The correct order of stability for the resonating structure of nitrous oxide can be given as:



(a) III > II > I (b) I > II > III

(c) I > III > II (d) I > II >> III

Comprehension-11: (Q. 31 to Q. 33)

An inorganic salt '*A*' behaves like a Lewis acid and fumes in moist air. The intensity of fumes increases when NaOH is added dropwise but the precipitate dissolves on adding excess of NaOH. However, on adding NH_4Cl and NH_4OH (in excess) to the salt solution of '*A*', a white precipitate is obtained. '*A*' is $AlCl_3$.

31. Which of the following bond is present in $AlCl_3$?

(a) $3C - 4e^-$ (b) $2C - 2e^-$

(c) Both (a) and (b) (d) None of these

32. The reaction of $AlCl_3$ with NH_4OH (excess) is:

(a) $AlCl_{3(aq)} + 3NH_4OH \longrightarrow Al(OH)_3 + 3NH_4Cl$

(b) $AlCl_{3(aq)} + 6NH_4OH \longrightarrow [Al(NH_3)_6]^{3+} + 3Cl^- + 6H_2O$

(c) $AlCl_{3(aq)} + NH_4OH \longrightarrow [Al(OH)_4Cl_2]^{3-} + 3NH_4^+$

(d) $AlCl_3 + NH_4OH \longrightarrow [Al(OH_3)_4Cl_3] + OH^-$

33. $AlCl_3$ absorbs moisture readily because:

(a) The hydration energy is high

(b) The lattice energy is low

(c) Hydration energy overcomes lattice energy

(d) Lattice energy overcomes hydration energy

Comprehension-12: (Q. 34 to Q. 36)

Orthoboric acid contains triangular BO_3^{3-} units. In solid the $B(OH)_3$ units are hydrogen bonded together into two-dimensional sheets with almost hexagonal symmetry. The layers are quite a large distance apart (3.18 Å) and thus the crystal breaks quite easily into very fine partical. At one time ortho boric acid was used as mildly antiseptic talcum powder for babies, because it forms a fine powder. It is no longer used since it sometimes caused a rash.

34. In which of the following solvent Boric acid acts as strong acid?

(a) Acidic solvent (b) Water

(c) Solvent in which polyhydroxo compounds are present

(d) Boric acid never acts as a strong acid because it is weak acid

35. In solid state, Boric acid has which type of interaction between layers?

(a) Hydrogen bonding (b) van der Walls' force

(c) Covalent bond (d) None of these

36. Aqueous solution of Borax will be:

(a) Acidic (b) Basic

(c) Neutral (d) None of these

Comprehension-13: (Q. 37 to Q. 39)

The term carbide is generally applied to compounds in which carbon is bonded to the elements of lower or approximately same electronegativity. This definition excludes the compounds in which oxygen, sulphur, phosphorus, nitrogen, and halogens are united with carbon. Reactive metals (i.e., of groups 1 and 2) form ionic carbides. They hydrolyze to liberate hydrocarbons. Most of them resembles with NaCl in crystal structure. Transition metals forms interstitial carbides.

37. Consider the following carbides:

CaC_2	Be_2C	MgC_2	SrC_2
I	II	III	IV

Select the carbide which gives different product on hydrolysis than other carbides:

(a) I (b) II (c) III (d) IV

38. Select the methanides from compounds given below:

Al_4C_3	Be_2C	MgC_2	BaC_2
I	II	III	IV

(a) I only (b) I and IV

(c) I and II (d) I, II, III, and IV

39. The conductance of transition metal is not much affected when it forms interstitial carbide because:

(a) The carbide anion helps in conduction

(b) The carbon atoms occupy octahedral holes and so does not affect electrical conductivity

(c) The carbon atoms react with metal and liberate electrons

(d) The conduction is due to holes

Comprehension-14: (Q. 40 to Q. 43)

Oxygen is more electronegative than chlorine. In the series of oxyacids HOCl, $HClO_2$, $HClO_3$, $HClO_4$ an increasing number of oxygen atom are bonded to the chlorine atom.

Chlorine forms a number of oxyacids which differ in their strengths. The conjugate base of these acids also differ in their stability order.

40. The order of acidic strength of HOCl, $HClO_2$, $HClO_3$, and $HClO_4$ are:

(a) $HClO_4 > HClO_3 > HClO_2 > HClO$

(b) $HClO > HClO_2 > HClO_3 > HClO_4$

(c) $HClO_3 > HClO_4 > HClO_2 > HClO$

(d) $HClO_3 > HClO_2 > HClO > HClO_4$

41. Which of the following is strongest conjugate base?
(a) ClO^- (b) ClO_2^-
(c) ClO_3^- (d) ClO_4^-

42. The hybridization of Cl in ClO_2^- and its shape are:
(a) sp^3, pyramidal (b) sp^2, angular
(c) sp^3, angular (d) sp^2, trigonal planar

43. The least stable oxo-anion among the following is:
(a) ClO^- (b) ClO_2^-
(c) ClO_3^- (d) ClO_4^-

Comprehension-15: (Q. 44 to Q. 46)

Among the halogens, fluorine differs considerably from the other members. The hydrides of halogens also differ in their properties.

44. Fluorine differs from the other halogens due to:
(a) Small size
(b) Very high electronegativity
(c) Non-availability of *d*-orbitals
(d) All of these

45. Which of the following bond has highest bond energy?
(a) F—F (b) Cl—Cl
(c) Br—Br (d) I—I

46. Which of the following halogens do not form polyhalide?
(a) F (b) Cl
(c) Br (d) I

Comprehension-16: (Q. 47 to Q. 49)

All the boron trihalides except BI_3 may be prepared by direct reaction between the elements. Boron trihalides consist of trigonal-planar BX_3 molecules. Unlike the halides of the other elements in the group, they are monomeric in the gas, liquid, and solid states. BF_3 and BCl_3 are gases, BBr_3 is volatile liquid, and BI_3 is a solid. Boron trihalides are Lewis acids because they form simple Lewis complexes with suitable bases, as in the reaction.

$$BF_{3(g)} + :NH_{3(g)} \longrightarrow F_3B \leftarrow NH_{3(s)}$$

However boron chlorides, bromides, and iodides are susceptible (sensitive) to protolysis by mild proton sources such as water, alcohol, and even amines. For example, BCl_3 undergoes rapid hydrolysis

$$BCl_{3(g)} + 3H_2O_{(l)} \longrightarrow B(OH)_{3(aq)} + 3HCl_{(aq)}$$

It is expected that the first step in the above reaction is the formation of the complex Cl_3B —3/4 OH_2 which then eliminates HCl and reacts further with water.

47. Which of the following is the best order of Lewis acid strength of BF_3, BCl_3, and BBr_3?
(a) $BF_3 > BCl_3 > BBr_3$ (b) $BF_3 = BCl_3 = BBr_3$
(c) $BF_3 < BCl_3 < BBr_3$ (d) $BBr_3 > BF_3 > BCl_3$

48. Which of the following is the correct prediction observed B—*X* bond length, in BX_3 molecules?
(a) B—F bond length in BF_3 is found to be less than theoretical value because the electronegativity values of B(2.04) and F(4.0) suggest the bond to be ionic, and hence the attraction between oppositely charged ions must decrease the bond length
(b) BF_3 and $[BF_4]^-$ have equal B—F bond length
(c) The decrease in the B—F bond length in BF_3 is due to delocalized p_π–p_π bonding between vacant '2*p*' orbital of B and filled '2*p*' orbital of F
(d) The correct B—*X* bond length order is B—F > B—Cl > B—Br > B—I

49. Which of the following is correct regarding the hydrolysis of BX_3?
(a) All BX_3 undergo hydrolysis to produce $B(OH)_{3(aq)}$ and $HX_{(aq)}$.
(b) BF_3 does not undergo complete hydrolysis due to formation of HBF_4
(c) BBr_3 does not undergo hydrolysis at all because it cannot form hydrogen bonds with water
(d) All the above are correct

Comprehension-17: (Q. 50 and Q. 51)

Thermodynamically, hydrogen peroxide is unstable as shown by the following equation:

$$H_2O_{2(l)} \longrightarrow H_2O_{(l)} + \frac{1}{2}O_{2(g)}$$

$\Delta_r G^o = -122.6$ kJ/mol

As the reaction from left to right is a accompanied by a decrease in free energy, it is a spontaneous process. However, its decomposition at 25°C in the absence of catalysts is slow. The catalysts which accelerate decomposition are Pt, Ag, cobalt, iron, copper, manganese dioxide and light. Concentrated H_2O_2 solution can result into uncontrolled decompositions leading to explosion. H_2O_2 thus stored in colored wax-lined bottles (as rough glass surfaces) also causes its decomposition. A few stabilizers such as acids acetanilide, pyrophosphates, and stannates are added to slow down the decomposition of H_2O_2.

50. H_2O_2 is a:
(a) Diamagnetic (b) Paramagnetic
(c) Non-polar (d) All are incorrect

51. H_2O_2 stored is in colored wax-lined bottles because:
(a) It is radioactive
(b) It produced uncontrolled decompositions leading to explosion
(c) It is non-polar molecule
(d) None of these

Comprehension-18: (Q. 52 to Q. 54)

Study the given flow-sheet involving reactions of a metal and answer the questions at the end.

A metal M and its compounds can given the following observable changes in a sequence of reactions

$$M \xrightarrow[HNO_3]{\text{dilute}} \underset{A}{\begin{bmatrix}\text{Colorless}\\ \text{solution}\end{bmatrix}} \xrightarrow[NaOH]{\text{aqueous}} \underset{B}{\begin{bmatrix}\text{White}\\ \text{precipitate}\end{bmatrix}}$$

$$\xrightarrow[NaOH_{(aq.)}]{\text{excess}} \underset{C}{\begin{bmatrix}\text{Colorless}\\ \text{solution}\end{bmatrix}} \xrightarrow[NaOH_{(aq.)}]{H_2S} \underset{D}{\begin{bmatrix}\text{White}\\ \text{precipitate}\end{bmatrix}}$$

52. Which of the following metals corresponds to M?

(a) Mg (b) Zn

(c) Al (d) Pb

53. Metal M on reaction with NaOH forms:

(a) H_2 gas (b) O_2 gas

(c) MH_2 (hydride) (d) MH_3 (hydride)

54. Colorless solution C of the metal M has the formula?

(a) $M(OH)_4^-$ (b) $M(OH)_2$

(c) $M(OH)_3$ (d) $M(OH)_4^{2-}$

Comprehension-19: (Q. 55 to Q. 57)

Questions are based on following medical report.

In the first biological application of buckyball, chemists at the University of California at San Francisco and Santa Barbara made a discovery in 1993 that could help in designing drugs to treat AIDS. The human immunodeficiency virus (HIV) that causes AIDS reproduces by synthesizing a long protein chain, which is cut into smaller segments by an enzyme called HIV-protease. One way to stop AIDS then might be to inactivate the enzyme. When the chemists reacted a water-soluble derivative of buckyball with HIV-protease, they found that it binds to the portion of the enzyme that would ordinarily cleave the reproductive protein, thereby preventing the HIV virus from reproducing. Consequently, the virus could no longer infect the human cells they had grown in the laboratory. The buckyball compound itself is not a suitable drug for use against AIDS because of potential side effects and delivery difficulties, but it does provide a model for the development of such drugs.

55. Buckyball is the allotrope of:

(a) Phosphorus (b) Sulphur

(c) Carbon (d) Titanium

56. What is the formula of the buckyball?

(a) P_4 (b) S_8

(c) Ti_3 (d) C_{60}

57. In buckyball, each atom is:

(a) sp^2 hybridized element with extensive delocalized molecular orbital

(b) sp^2 hybridized element with delocalized molecular orbital

(c) sp^3 hybridized element with delocalized molecular orbital

(d) sp^3 hybridized element with localized molecular orbital

Comprehension-20: (Q. 58 to Q. 62)

White crystalline solid (A) reacts with H_2 to form a highly associated liquid (B) and a monoatomic colorless gas (C). The liquid (B) is used for etching glass. Compound (A) undergoes hydrolysis slowly to form (C), (B), and a diatomic gas (D) whose IE is almost similar to that of (C). (B) forms an addition compound with KF to form (E) which is electrolyzed in the molten state to form a most reactive gas (F) which combines with (C) in 1 : 1 ratio to produce (A).

58. The molecular shape and hybridization state of central atom in the molecule (A) are:

(a) Linear, sp (b) Triangular, sp^2

(c) Linear, sp^3d (d) V-shape, sp^3

59. The molecule of compound E contains which of the following types of bonds?

(a) Ionic (b) Ionic and covalent both

(c) Ionic, covalent, and metallic

(d) Ionic, covalent, and H-bonds

60. According to molecular orbital theory, which of the following is correct about the molecule D_2?

(a) Its bond order is 2.0

(b) It has two unpaired electrons in π-bonding molecular orbital

(c) It is paramagnetic (d) All of these

61. The liquid B combines with which of the following to form a magic or superacid?

(a) SbF_5 (b) XeF_2

(c) H_2O (d) BF_3

62. The compound (A) reacts with sulphur to form a compound in which hybridization state of sulphur atom is:

(a) sp^3d (b) sp^3d^2

(c) sp^3 (d) sp^3d^3

Comprehension-21: (Q. 63 to Q. 65)

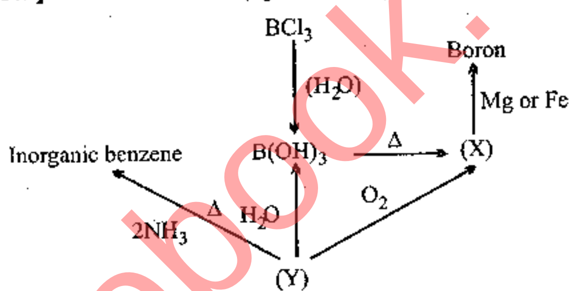
Compound (A) on reduction with $LiAlH_4$ gives a hydride (P) containing 21.72% hydrogen along with other products. The one mole of hydride (P) and 2 moles of ammonia at higher temperature gives a compound (Q) which is known as inorganic benzene. (A) hydrolysis incompletely and forms a compound (R) and H_3BO_3.

63. In hydride (P) (select correct statement):
   (a) The central atom has trigonal planar geometry
   (b) All H-atom lie in the same plane
   (c) All four terminal B—H bond length are equivalent but that of four bridging B—H bond lengths are not equivalent
   (d) A three-centre two-electron bond (3C—2e) is formed by overlap of an sp^3 hybrid orbital from each boron atom with the 1s-orbital of hydrogen atom

64. The hybridization of central atom of compound (R) is:
   (a) sp^2 (b) sp^3
   (c) sp (d) sp^3d

65. Which of the following statement is incorrect for the compound (A)?
   (a) It has trigonal planar geometry
   (b) The bond length between the central atom and the substituent atom is shorter than the sum of covalent radii
   (c) The coordination geometry around central atom of compound (A) and N atom in 1 : 1 complex of (A) and NH_3 is same
   (d) In compound (A), there is p_π–d_π bonding

Comprehension-22: (Q. 66 to Q. 68)



66. The compound Y is:
   (a) BF_3 (b) BCl_3
   (c) B_2H_6 (d) B_2O_3

67. The compound X is:
   (a) B_2H_6 (b) B_2O_3
   (c) $[B(OH)_4]^-$ (d) None of these

68. The formula of inorganic benzene:
   (a) $(BN)_x$ (b) C_6H_6
   (c) $B_3N_3H_6$ (d) $B_3N_3H_9Cl_3$

Assertion-Reasoning Type

1. **Statement-1:** Boron has unusually high melting point.
   Statement-2: Boron shows nonmetallic character.
   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** Aluminium forms $[AlF_6]^{3-}$ but B does not form $[BF_6]^{3-}$.
   Statement-2: BF_3 on hydrolysis gives HBF_4.
   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true.

3. **Statement-1:** Boron forms only covalent compounds.
   Statement-2: Due to small size of boron, the sum of its first three ionization enthalpies is very high.
   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true.

4. **Statement-1:** Amongst the trihalides of nitrogen, NF_3, NCl_3, NBr_3 and NI_3, NF_3 is least basic.
   Statement-2: In NF_3, the fluorine has the highest value of electronegativity and thus the lone pair of electrons on N-atom is strongly bound.
   (a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
   (b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
   (c) Statement-1 is true, statement-2 is false.
   (d) Statement-1 is false, statement-2 is true

5. **Statement-1:** Dimethyl dichloro silane on hydrolysis followed by condensation gives cross-linked silicones.

Statement-2: Silicones are macromolecules containing repeating —Si—O—Si— linkage.

(a) Statement-1 is true, statement-2 is true and statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT a correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

6. **Statement-1:** In water, orthoboric acid behaves as a weak monobasic acid.

Statement-2: In water, orthoboric acid acts as a proton donor.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

7. **Statement-1:** The order of densities of the various allotropes of phosphorus is as follows: black phosphorus > red phosphorus > white phosphorus because.

Statement-2: As tendency of polymerisation increases, the compactness of substance also increases.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

8. **Statement-1:** Size of atoms of inert gases are smaller than those of the preceding halogens.

Statement-2: Atomic (covalent or van der Waals' radii generally decreases with increase in atomic number along a period.)

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

9. **Statement-1:** Both SO_2 and Cl_2 are bleaching agent.

Statement-2: SO_2 bleaches by reduction, whereas Cl_2 bleaches by oxidation.

(a) Statement-1 is true, statement-2 is true and statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT a correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

10. **Statement-1:** Boiling solution containing Cl^-, Br^-, I^- with $K_2S_2O_8$, violet and brown vapor appears.

Statement-2: Br^- and I^- are oxidized to Br_2 and I_2 but Cl^- is not oxidized.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Dihydrogen hypophosphate ion	(p) All hydrogens are ionizable
(b) Hydrogen pyrophosphite ion	(q) Number of acidic hydrogen present is two
(c) Pyrosulphurous acid	(r) sp^3 hybridized central atom
(d) Hydrogen peroxymonosulphate ion	(s) Overall non-planar structure
	(t) Ion having peroxy linkage

2. Match the column:

Column-I	Column-II (Molecular consists of what type of bonds)
(a) σ bond	(p) CO
(b) π bond	(q) HCN
(c) Electrovalent bond (or ionic bond)	(r) NH_4Cl
(d) Coordinate	(s) SiH_4
	(t) $LiNO_3$

3. Match the column:

Column-I	Column-II
(a) $H_2C=C=CHF$	(p) Nonpolar and planar

(b) $B_3N_3H_6$ (q) Nodal planes of p-bonds are lying in the molecular plane

(c) XeO_3F_2 (r) Nonpolar and non-planar

(s) Polar and non-planar

4. Match the molecules/ions (in Column-I) with their shapes (in Column-II).

Column-I	Column-II
(a) ClF_3	(p) Square planar
(b) $[PCl_4]^+$	(q) T-shaped
(c) XeF_4	(r) Tetrahedral
(d) XeO_3	(s) Pyramidal

5. Match the following:

Column-I	Column-II
(a) XeF_5^+	(p) Central atom is having two lone pairs
(b) XeF_5^-	(q) Only five atoms are lying in the one plane
(c) XeF_4	(r) Species is not having any π-bond
(d) XeO_6^{4-}	(s) The central atom is having oxidation state of + 4
	(t) The species is sp^3d^2 hybridized having either zero or one lone pair on the central atom

6. Match the following:

Column-I (Number of electron pair around the central atom)	Column-II (Probable geometry)
(a) 2	(p) Bent
(b) 3	(q) Linear
(c) 4	(r) Sea-saw
(d) 5	(s) Trigonal pyramidal

7. Match the following:

Column-I	Column-II
(a) SiO_2	(p) Reacts with HF
(b) CN^-	(q) Pseudo halide
(c) I^-	(r) Gives compound with Cu^{2+} via redox reaction
(d) N_2	(s) Inert towards reaction

8. Match the following:

Column-I	Column-II
(a) $BBr_3 + H_2 \longrightarrow B$	(p) Borax bead test
(b) $Na_2B_4O_7.10H_2O + CuSO_4 \longrightarrow Cu(BO_2)_2$	(q) Reduction
(c) $AlCl_3 + H_2O \longrightarrow HCl$	(r) White fumes
(d) $Cr_2O_3 + Al \longrightarrow Cr$	(s) Hydrolysis

9. Match the following:

Column-I	Column-II
(a) BF_3	(p) Trigonal planar geometry
(b) $N(SiH_3)_3$ (with respect to N)	(q) $p\pi$–$p\pi$ back bonding
(c) SiF_4	(r) $p\pi$–$d\pi$ back bonding
	(s) Tetrahedral geometry

10. Match the column:

Column-I	Column-II
(a) BF_2Cl	(p) Molecules in the column-I is having maximum number of lying in the same plane
(b) $B_3N_3H_6$	(q) Molecules having maximum number of lone pair
(c) SF_4	(r) Molecule is non-polar
(d) XeO_4	(s) Molecule is planar
	(t) p_x, p_y and p_z orbitals are involved in the hybridization of the central atom

11. Match the following:

Column-I	Column-II
(a) Cl_2 + cold and dilute NaOH $\xrightarrow{0°C}$	(p) Disproportionation takes place
(b) Cl_2 + hot and conc. NaOH $\xrightarrow{> 50°C}$	(q) Chloride (Cl^-) is produced
(c) $KClO_3 \xrightarrow[\text{at low temp.} < 100°C]{\Delta}$	(r) Chlorate (ClO_3^-) is produced
(d) $ClO_2 + NaOH \longrightarrow$	(s) Hypochlorite (OCl^-) is produced
	(t) Chlorite (ClO_2^-) is produced

12. Match the reactions of metals with dilute HNO_3 (in column-I) with the nitrogen compounds (obtained by oxidation/reduction (in column-II).

Column-I	Column-II
(a) Mg + dil. HNO_3	(p) NO
(b) Zn + dil. HNO_3	(q) H_2
(c) Sn + dil. HNO_3	(r) N_2O
(d) Pb + dil. HNO_3	(s) NH_4NO_3

13. Match column-I with column-II and select the correct answer using the codes given below the lists.

Column-I (Allotropic form)	Column-II (Structure)
(a) Engel's sulphur	(p) Rings, Chair conformation, unstable
(b) Sulphur	(q) Fibrous or rubber like

(c) Rhombic sulphur (r) Crystalline form-yellow crystals

(d) Monoclinic sulphur (s) Puckered S_8 rings crown conformation

Integer Answer Type

1. Which of the following oxidation states are the most characteristic for lead and tin, respectively?
[If answer is 1 and 3, represent as 13]
2. In silica, SiO_2, each silicon atom is bonded to how many oxygen atom?
3. One mole of calcium phosphide on reaction with excess of water gives how many moles of phosphine?
4. PCl_3 reacts with water, then formed acid of phosphorous, what is the basicity of acid of phosphorous?
5. The electronic configuration of an element is $1s^2, 2s^2 2p^6, 3s^2 3p^3$. What is the atomic number of the element which is just below the above element in the periodic table?
6. Hydrolysis of NCl_3 gives NH_3 and X. What is the basicity of X?
7. The number of P—O bonds and lone pairs present in P_4O_6 molecule is/are:
[If answer is 11 and 22, represent as 1122]
8. Oxygen belongs to which group of the periodic table?
9. In OF_2 molecule, the total number of bond pairs and lone pairs of electrons present is/are:
[If answer is 3 and 6, represent as 36]
10. How many lone pair(s) is/are present in central atom I of I_3^- ion?
11. How many σ and π-bonds are present in cords?
[If answer is 2 and 4, represent as 24]
12. H_3PO_3 has .... non-ionizable P—H bonds.
13. Write the total number of $\angle$FIF angles in IF_7 having the bond angle value of 90°.
14. Calculate the minimum and maximum number of P—O linkages of identical length in P_4O_{10}.
(If answer is 3 and 18, represent as 318)
15. Find the number of S — S linkage in $\gamma - SO_3$ molecule.
16. Al_4C_3 on hydrolysis gives X gas. How many H atoms are present in X?
17. Find the number of P—O—P bonds in cyclic metaphosphoric acid.
18. In NO_3^- ion, find the number of bond pair and lone pair of electrons on nitrogen atoms.
[If answer is 2 and 4, represent as 24]
19. N_2O is isoelectronic with CO_2 and N_3^-, how many N—O—N linkages is/are present in N_2O?
20. The number of S—O—S bonds in sulphur trioxide trimer S_3O_9 is _________.
21. The number of sigma and pi bonds in peroxydisulphuric acid is/are:
[If answer is 13 and 6, represent as 136]
22. The angular shape of ozone molecule (O_3) consists of how many σ and π bonds?
[If answer is 3 and 2, represent as 32]
23. Find the number of compound which are having only acidic nature:
$Be(OH)_2$, $Mg(OH)_2$, $Al(OH)_3$, $B(OH)_3$
24. The numbers of $F\hat{I}F$ angles equal to 90° and less than 90° in IF_7 are ______ and ______ respectively.
[If answer is 15 and 9, represent as 159]
25. Find the number of P—O bonds of identical length in hypophosphate ion.
26. $SiCl_4 \xrightarrow{H_2O} X \xrightarrow{1000} Y$
In the above reaction, how many oxygen atom(s) is/are present in X and Y?
[If answer is 6 and 4, represent as 64]
27. Find the number of nitrate which gives NO_2 gas on heating from the following:
Nitrogen dioxide is released on heating:
NH_4NO_3, KNO_3, $NaNO_2$, $Pb(NO_3)_2$, $AgNO_3$
28. The atomicity of phosphorus is X and the P—P—P bond angle is Y. What are X and Y?
[If answer is 2 and 90°, represent as 290]
29. $SO_2 + H_2S \longrightarrow X + H_2O$, X belongs to which group of the periodic table?
30. Find the number of ions having S—S bond from following:
$S_2O_4^{2-}, S_2O_6^{2-}, S_2O_2^{2-}, S_2O_3^{2-}, S_2O_7^{2-}$
31. When thiosulphate ion is oxidized by iodine, the new product formed is how many S—S linkage is/are present in X?
32. Find the sum of the number of P=O, P—O—P linkages in $P_5O_{16}^{-7}$ ion.

NCERT Exemplar Exercises

Single Correct Answer Type

1. The element which exists in liquid state for a wide range of temperature and can be used for measuring high temperature is:
   (a) B (b) Al
   (c) Ga (d) In

2. Which of the following is a Lewis acid?
   (a) $AlCl_3$ (b) $MgCl_2$
   (c) $CaCl_2$ (d) $BaCl_2$

3. The geometry of a complex species can be understood from the knowledge of type of hybridization of orbitals of central atom. The hybridization of orbitals of central atom in $[Be(OH)_4]^{-2}$ and the geometry of the complex are respectively:
   (a) sp^3, tetrahedral (b) sp^3, square planar
   (c) $sp\,3d^2$, octahedral (d) dsp^2, square planar

4. Which of the following oxide is acidic in nature?
   (a) B_2O_3 (b) Al_2O_3
   (c) Ga_2O_3 (d) In_2O_3

5. The exhibition of highest coordination number depends on the availability of vacant orbitals in the central atom. Which of the following elements is **not** likely to act as central atom in MF_6^{3-}?
   (a) B (b) Al
   (c) Ga (d) In

6. Boric acid is an acid because its molecule:
   (a) Contains replaceable H^+ ion
   (b) Gives up a proton
   (c) Accepts OH^- from water releasing proton
   (d) Combines with proton from water molecule

7. Catenation i.e., linking of similar atoms depends on size and electronic configuration of atoms. The tendency of catenation in Group 14 elements follows the order:
   (a) C > Si > Ge > Sn (b) C >> Si > Ge > Sn
   (c) Si > C > Sn > Ge (d) Ge > Sn > Si > C

8. Silicon has a strong tendency to form polymers like silicones. The chain length of silicone polymer can be controlled by adding:
   (a) $MeSiCl_3$ (b) Me_2SiCl
   (c) Me_3SiCl (d) Me_4Si

9. Ionization enthalpy (Δ_iH_1 kJ mol^{-1}) for the elements of Group 13 follows the order.
   (a) B > Al > Ga > In > Tl
   (b) B < Al < Ga < In < Tl
   (c) B < Al > Ga < In > Tl
   (d) B > Al < Ga > In < Tl

10. In the structure of diborane:
    (a) All hydrogen atoms lie in one plane and boron atoms lie in a plane perpendicular to this plane
    (b) 2 boron atoms and 4 terminal hydrogen atoms lie in the same plane and 2 bridging hydrogen atoms lie in the perpendicular plane
    (c) 4 bridging hydrogen atoms and boron atoms lie in one plane and two terminal hydrogen atoms lie in a plane perpendicular to this plane
    (d) All the atoms are in the same plane

11. A compound X of boron reacts with NH_3 on heating to give another compound Y which is called inorganic benzene. The compound X can be prepared by treating BF_3 with lithium aluminium hydride. The compounds X and Y are represented by the formulas.
    (a) B_2H_6, $B_3N_3H_6$ (b) B_2O_3, $B_3N_3H_6$
    (c) BF_3, $B_3N_3H_6$ (d) $B_3N_3H_6$, B_2H_6

12. Quartz is extensively used as a piezoelectric material, it contains ______.
    (a) Pb (b) Si
    (c) Ti (d) Sn

13. The most commonly used reducing agent is:
    (a) $AlCl_3$ (b) $PbCl_2$
    (c) $SnCl_4$ (d) $SnCl_2$

14. Dry ice is:
    (a) Solid NH_3 (b) Solid SO_2
    (c) Solid CO_2 (d) Solid N_2

15. Cement, the important building material is a mixture of oxides of several elements. Besides calcium, iron and sulphur, oxides of elements of which of the group (s) are present in the mixture?
    (a) Group 2
    (b) Groups 2, 13 and 14
    (c) Groups 2 and 13
    (d) Groups 2 and 14

16. On addition of conc. H_2SO_4 to a chloride salt, colorless fumes are evolved but in case of iodide salt, violet fumes come out. This is because:
    (a) H_2SO_4 reduces HI to I_2
    (b) HI is of violet color
    (c) HI gets oxidised to I_2
    (d) HI changes to HIO_3

17. In qualitative analysis when H_2S is passed through an aqueous solution of salt acidified with dil. HCl, a black precipitate is obtained. On boiling the precipitate with dil. HNO_3, it forms a solution of blue color. Addition of excess of aqueous solution of ammonia to this solution gives ______.
    (a) Deep blue precipitate of $Cu(OH)_2$
    (b) Deep blue solution of $[Cu(NH_3)_4]^{2+}$
    (c) Deep blue solution of $Cu(NO_3)_2$
    (d) Deep blue solution of $Cu(OH)_2 \cdot Cu(NO_3)_2$

18. In a cyclotrimetaphosphoric acid molecule, how many single and double bonds are present?
    (a) 3 double bonds; 9 single bonds
    (b) 6 double bonds; 6 single bonds
    (c) 3 double bonds; 12 single bonds
    (d) Zero double bonds; 12 single bonds

19. Which of the following elements can be involved in $p\pi-d\pi$ bonding?
    (a) Carbon (b) Nitrogen
    (c) Phosphorus (d) Boron

20. Which of the following pairs of ions are isoelectronic and isostructural?
    (a) CO_3^{2-}, NO_3^- (b) ClO_3^-, CO_3^{2-}
    (c) SO_3^{2-}, NO_3^- (d) ClO_3^-, SO_3^{2-}

21. Affinity for hydrogen decreases in the group from fluorine to iodine. Which of the halogen acids should have highest bond dissociation enthalpy?
    (a) HF (b) HCl
    (c) HBr (d) HI

22. Bond dissociation enthalpy of E–H (E = element) bonds is given below. Which of the compounds will act as strongest reducing agent?

Compound	NH_3	PH_3	AsH_3	SbH_3
Δ_{diss} (E–H)/kJ mol^{-1}	389	322	297	255

    (a) NH_3 (b) PH_3
    (c) AsH_3 (d) SbH_3

23. On heating with concentrated NaOH solution in an inert atmosphere of CO_2, white phosphorus gives a gas. Which of the following statement is incorrect about the gas?
    (a) It is highly poisonous and has smell like rotten fish
    (b) Its solution in water decomposes in the presence of light
    (c) It is more basic than NH_3
    (d) It is less basic than NH_3

24. Which of the following acids forms three series of salts?
    (a) H_3PO_2 (b) H_3BO_3
    (c) H_3PO_4 (d) H_3PO_3

25. Strong reducing behavior of H_3PO_2 is due to
    (a) Low oxidation state of phosphorus
    (b) Presence of two –OH groups and one P–H bond
    (c) Presence of one –OH group and two P–H bonds
    (d) High electron gain enthalpy of phosphorus

26. On heating lead nitrate forms oxides of nitrogen and lead. The oxides formed are ______.
    (a) N_2O, PbO (b) NO_2, PbO
    (c) NO, PbO (d) NO, PbO_2

27. Which of the following elements does not show allotropy?
    (a) Nitrogen (b) Bismuth
    (c) Antimony (d) Arsenic

28. Maximum covalency of nitrogen is ______.
    (a) 3 (b) 5
    (c) 4 (d) 6

29. Which of the following statements is wrong?
    (a) Single N–N bond is stronger than the single P–P bond
    (b) PH_3 can act as a ligand in the formation of coordination compound with transition elements
    (c) NO_2 is paramagnetic in nature
    (d) Covalency of nitrogen in N_2O_5 is four

30. A brown ring is formed in the ring test for NO_3^- ion. It is due to the formation of:
    (a) $[Fe(H_2O)_5(NO)]^{2+}$ (b) $FeSO_4 \cdot NO_2$
    (c) $[Fe(H_2O)_4(NO)_2]^{2}$ (d) $FeSO_4 \cdot HNO_3$

31. Elements of group-15 form compounds in +5 oxidation state. However, bismuth forms only one well characterized compound in +5 oxidation state.

    The compound is:
    (a) Bi_2O_5 (b) BiF_5
    (c) $BiCl_5$ (d) Bi_2S_5

32. On heating ammonium dichromate and barium azide separately we get:

(a) N_2 in both cases

(b) N_2 with ammonium dichromate and NO with barium azide

(c) N_2O with ammonium dichromate and N_2 with barium azide

(d) N_2O with ammonium dichromate and NO_2 with barium azide

33. In the preparation of HNO_3, we get NO gas by catalytic oxidation of ammonia.

The moles of NO produced by the oxidation of two moles of NH_3 will be ______.

(a) 2 (b) 3

(c) 4 (d) 6

34. The oxidation state of central atom in the anion of compound NaH_2PO_2 will be ______.

(a) +3 (b) +5

(c) +1 (d) –3

35. Which of the following is not tetrahedral in shape?

(a) NH_4^+ (b) $SiCl_4$

(c) SF_4 (d) SO_4^{2-}

36. Which of the following are peroxoacids of sulphur?

(a) H_2SO_5 and $H_2S_2O_8$

(b) H_2SO_5 and $H_2S_2O_7$

(c) $H_2S_2O_7$ and $H_2S_2O_8$

(d) $H_2S_2O_6$ and $H_2S_2O_7$

37. Hot conc. H_2SO_4 acts as moderately strong oxidizing agent. It oxidises both metals and nonmetals. Which of the following element is oxidised by conc. H_2SO_4 into two gaseous products?

(a) Cu (b) S

(c) C (d) Zn

38. A black compound of manganese reacts with a halogen acid to give greenish yellow gas. When excess of this gas reacts with NH_3 an unstable trihalide is formed. In this process the oxidation state of nitrogen changes from ______.

(a) – 3 to +3 (b) – 3 to 0

(c) – 3 to +5 (d) 0 to – 3

39. In the preparation of compounds of Xe, Bartlett had taken $O_2^+ Pt F_6^-$ as a base compound. This is because:

(a) Both O_2 and Xe have same size.

(b) Both O_2 and Xe have same electron gain enthalpy.

(c) Both O_2 and Xe have almost same ionisation enthalpy.

(d) Both Xe and O_2 are gases.

40. In solid state PCl_5 is a ______.

(a) Covalent solid

(b) Octahedral structure

(c) Ionic solid with $[PCl_6]^+$ octahedral and $[PCl_4]^-$ tetrahedral

(d) Ionic solid with $[PCl_4]^+$ tetrahedral and $[PCl_6]^-$ octahedra

41. Reduction potentials of some ions are given below. Arrange them in decreasing order of oxidizing power.

Ion	ClO_4^-	IO_4^-	BrO_4^-
Reduction potential $E^\ominus$/V	$E^\ominus$=1.19V	$E^\ominus$=1.65V	$E^\ominus$=1.74V

(a) $ClO_4^- > IO_4^- > BrO_4^-$

(b) $IO_4^- > BrO_4^- > ClO_4^-$

(c) $BrO_4^- > IO_4^- > ClO_4^-$

(d) $BrO_4^- > ClO_4^- > IO_4^-$

42. Which of the following is isoelectronic pair?

(a) ICl_2, ClO_2 (b) BrO_2^-, BrF_2^+

(c) ClO_2, BrF (d) CN^-, O_3

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. The reason for small radius of Ga compared to Al is ______.

(a) Poor screening effect of d orbitals

(b) Increase in effective nuclear charge

(c) Presence of higher orbitals

(d) Higher atomic number

2. The linear shape of CO_2 is due to ______.

(a) sp^3 hybridisation of carbon

(b) sp hybridisation of carbon

(c) $p\pi$–$p\pi$ bonding between carbon and oxygen

(d) sp^2 hybridisation of carbon

3. Me_3SiCl is used during polymerisation of organo silicones because:

(a) The chain length of organo silicone polymers can be controlled by adding Me_3SiCl

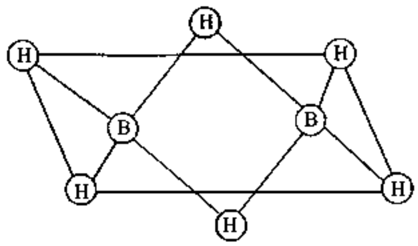
(b) Me_3SiCl blocks the end terminal of silicone polymer

(c) Me_3SiCl improves the quality and yield of the polymer

(d) Me_3SiCl acts as a catalyst during polymerisation

4. Which of the following statements are correct?
   (a) Fullerenes have dangling bonds
   (b) Fullerenes are cage-like molecules
   (c) Graphite is thermodynamically most stable allotrope of carbon
   (d) Graphite is slippery and hard and therefore used as a dry lubricant in machines

5. Which of the following statements are correct. Answer on the basis of the given figure.



   (a) The two bridged hydrogen atoms and the two boron atoms lie in one plane
   (b) Out of six B–H bonds, two bonds can be described in terms of 3 center 2-electron bonds
   (c) Out of six B–H bonds four B–H bonds can be described in terms of 3 center 2 electron bonds
   (d) The four terminal B–H bonds are two center two electron regular bonds

6. Identify the correct resonance structures of carbon dioxide from the ones given below:
   (a) $O-C=O$ (b) $O=C=O$
   (c) $^{-}O=C-O^{+}$ (d) $^{-}O-C\equiv O^{+}$

7. If chlorine gas is passed through hot NaOH solution, two changes are observed in the oxidation number of chlorine during the reaction. These are ______ and ______.
   (a) 0 to +5 (b) 0 to +3
   (c) 0 to –1 (d) 0 to +1

8. Which of the following options are not in accordance with the property mentioned against them?
   (a) $F_2 > Cl_2 > Br_2 > I_2$ Oxidizing power
   (b) MI > MBr > MCl > MF Ionic character of metal halide
   (c) $F_2 > Cl_2 > Br_2 > I_2$ Bond dissociation enthalpy
   (d) HI < HBr < HCl < HF Hydrogen–halogen bond strength

9. Which of the following is correct for P_4 molecule of white phosphorus?
   (a) It has 6 lone pairs of electrons
   (b) It has six P–P single bonds
   (c) It has three P–P single bonds
   (d) It has four lone pairs of electrons

10. Which of the following statements are correct?
   (a) Among halogens, radius ratio between iodine and fluorine is maximum
   (b) Leaving F—F bond, all halogens have weaker X—X bond than X—X′ bond in interhalogens
   (c) Among interhalogen compounds maximum number of atoms are present in iodine fluoride
   (d) Interhalogen compounds are more reactive than halogen compounds

11. Which of the following statements are correct for SO_2 gas?
   (a) It acts as bleaching agent in moist conditions
   (b) Its molecule has linear geometry
   (c) Its dilute solution is used as disinfectant
   (d) It can be prepared by the reaction of dilute H_2SO_4 with metal sulphide

12. Which of the following statements are correct?
   (a) All the three N—O bond lengths in HNO_3 are equal
   (b) All P—Cl bond lengths in PCl_5 molecule in gaseous state are equal
   (c) P_4 molecule in white phohsphorus have angular strain therefore white phosphorus is very reactive
   (d) PCl is ionic in solid state in which cation is tetrahedral and anion is octahedral

13. Which of the following orders are correct as per the properties mentioned against each?
   (a) $As_2O_3 < SiO_2 < P_2O_3 < SO_2$ Acid strength
   (b) $AsH_3 < PH_3 < NH_3$ Enthalpy of vaporization
   (c) S < O < Cl < F More negative electron gain enthalpy
   (d) $H_2O > H_2S > H_2Se > H_2Te$ Thermal stability

14. Which of the following statements are correct?
   (a) S–S bond is present in $H_2S_2O_6$
   (b) In peroxosulphuric acid (H_2SO_5) sulphur is in +6 oxidation state
   (c) Iron powder along with Al_2O_3 and K_2O is used as a catalyst in the preparation of NH_3 by Haber' s process
   (d) Change in enthalpy is positive for the preparation of SO_3 by catalytic oxidation of SO_2

15. In which of the following reactions conc. H_2SO_4 is used as an oxidizing reagent?

(a) $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$

(b) $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$

(c) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

(d) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

16. Which of the following statements are true?

(a) Only type of interactions between particles of noble gases are due to weak dispersion forces

(b) Ionization enthalpy of molecular oxygen is very close to that of xenon

(c) Hydrolysis of XeF_6 is a redox reaction

(d) Xenon fluorides are not reactive

Short Answer Type

1. Draw the structures of $BCl_3 \cdot NH_3$ and $AlCl_3$ (dimer).

2. Explain the nature of boric acid as a Lewis acid in water.

3. Draw the structure of boric acid showing hydrogen bonding. Which species is present in water? What is the hybridization of boron in this species?

4. Explain why the following compounds behave as Lewis acids?

(a) BCl_3 (b) $AlCl_3$

5. Give reasons for the following:

(a) CCl_4 is immiscible in water, whereas $SiCl_4$ is easily hydrolyzed.

(b) Carbon has a strong tendency for catenation compared to silicon.

6. Explain the following:

(a) CO_2 is a gas whereas SiO_2 is a solid.

(b) Silicon forms SiF_6^{2-} ion whereas corresponding fluoro compound of carbon is not known.

7. The +1 oxidation state in group 13 and +2 oxidation state in group 14 becomes more and more stable with increasing atomic number. Explain.

8. Carbon and silicon both belong to the group 14, but inspite of the stoichiometric similarity, the dioxides, (i.e., carbon dioxide and silicon dioxide), differ in their structures. Comment.

9. If a trivalent atom replaces a few silicon atoms in three dimensional network of silicon dioxide, what would be the type of charge on overall structure?

10. When BCl_3 is treated with water, it hydrolyzes and forms $[B(OH)_4]^-$ only, whereas $AlCl_3$ in acidified aqueous solution forms $[Al(H_2O)_6]^{3+}$ ion. Explain what is the hybridization of boron and aluminium in these species?

11. Aluminium dissolves in mineral acids and aqueous alkalies and thus shows amphoteric character. A piece of aluminium foil is treated with dilute hydrochloric acid or dilute sodium hydroxide solution in a test tube and on bringing a burning matchstick near the mouth of the test tube, a pop sound indicates the evolution of hydrogen gas. The same activity when performed with concentrated nitric acid, reaction does not proceed. Explain the reason.

12. Explain the following:

(a) Gallium has higher ionization enthalpy than aluminium.

(b) Boron does not exist as B^{3+} ion.

(c) Aluminium forms $[AlF_6]^{3-}$ ion but boron does not form $[BF_6]^{3-}$ ion.

(d) PbX_2 is more stable than PbX_4.

(e) Pb^{4+} acts as an oxidizing agent but Sn^{2+} acts as a reducing agent.

(f) Electron gain enthalpy of chlorine is more negative as compared to fluorine.

(g) $T\ell(NO_3)_3$ acts as an oxidizing agent.

(h) Carbon shows catenation property but lead does not.

(i) Why does the element silicon, not form a graphite like structure whereas carbon does.

13. Identify the compounds A, X, and Z in the following reactions:

(a) $A + 2HCl + 5H_2O \rightarrow 2NaCl + X$

$$X \xrightarrow[370K]{\Delta} HBO_2 \xrightarrow[>370K]{\Delta} Z$$

14. Complete the following chemical equations:

$Z + 3\,LiAlH_4 \rightarrow X + 3\,LiF + 3AlF_3$

$X + 6H_2O \rightarrow Y + 6H_2$

$3X + 3O_2 \xrightarrow{\Delta} B_2O_3 + 3H_2O$

15. In the preparation of H_2SO_4 by Contact process, why is SO_3 not absorbed directly in water to form H_2SO_4?

16. Write a balanced chemical equation for the reaction showing catalytic oxidation of NH_3 by atmospheric oxygen.

17. Write the structure of pyrophosphoric acid.

18. PH_3 forms bubbles when passed slowly in water but NH_3 dissolves. Explain why?

19. In PCl_5, phosphorus is in sp^3d hybridized state but all its five bonds are not equivalent. Justify your answer with reason.

20. Why is nitric oxide paramagnetic in gaseous state but the solid obtained on cooling it is diamagnetic?

21. Give reason to explain why ClF_3 exists but FCl_3 does not exist.

22. Out of H_2O and H_2S, which one has higher bond angle and why?

23. SF_6 is known but SCl_6 is not. Why?

24. On reaction with Cl_2, phosphorus forms two types of halides 'A' and 'B'. Halide A is yellowish-white powder but halide 'B' is colorless oily liquid. Identify A and B and write the formulas of their hydrolysis products.

25. In the ring test of NO_3^- ion, Fe^{2+} ion reduces nitrate ion to nitric oxide, which combines with Fe^{2+} (aq) ion to form brown complex. Write the reactions involved in the formation of brown ring.

26. Explain why the stability of oxoacids of chlorine increases in the order given below: $HClO < HClO_2 < HClO_3 < HClO_4$

27. Explain why ozone is thermodynamically less stable than oxygen.

28. P_4O_6 reacts with water according to equation $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$.

Calculate the volume of 0.1 M NaOH solution required to neutralize the acid formed by dissolving 1.1 g of P_4O_6 in H_2O.

29. White phosphorus reacts with chlorine and the product hydrolyzes in the presence of water. Calculate the mass of HCl obtained by the hydrolysis of the product formed by the reaction of 62 g of white phosphorus with chlorine in the presence of water.

30. Name three oxoacids of nitrogen. Write the disproportionation reaction of that oxoacid of nitrogen in which nitrogen is in +3 oxidation state.

31. Nitric acid forms an oxide of nitrogen on reaction with P_4O_{10}. Write the reaction involved. Also write the resonating structures of the oxide of nitrogen formed.

32. Phosphorus has three allotropic forms — (A) white phosphorus, (B) red phosphorus, and (C) black phosphorus. Write the difference between white and red phosphorus on the basis of their structure and reactivity.

33. Give an example to show the effect of concentration of nitric acid on the formation of oxidation product.

34. PCl_5 reacts with finely divided silver on heating and a white silver salt is obtained, which dissolves on adding excess aqueous NH_3 solution. Write the reactions involved to explain what happens.

35. Phosphorus forms a number of oxoacids. Out of these oxoacids phosphinic acid has strong reducing property. Write its structure and also write a reaction showing its reducing behavior.

Matching Column Type

In the following questions more than one correlation is possible between options of Column-I and Column-II.

1. Match the species given in Column-I with the properties mentioned in Column-II.

Column-I	Column-II
(a) BF_4^-	(p) Oxidation state of central atom is +4
(b) $AlCl_3$	(q) Strong oxidizing agent
(c) SnO	(r) Lewis acid
(d) PbO_2	(s) Can be further oxidized
	(t) Tetrahedral shape

2. Match the species given in Column-I with properties given in Column-II.

Column-I	Column-II
(a) Diborane	(p) Used as a flux for soldering metals
(b) Gallium	(q) Crystalline form of silica
(c) Borax	(r) Banana bonds
(d) Aluminosilicate	(s) Low melting, high boiling, useful for measuring high temperatures
(e) Quartz	(s) Used as catalyst in petrochemical industries

3. Match the species given in Column-I with the hybridisation given in Column-II.

Column-I	Column-II
(a) Boron in $[B(OH)_4]^-$	(i) sp^2
(b) Aluminium in $[Al(H_2O)_6]^{3+}$	(ii) sp^3
(c) Boron in B_2H_6	(iii) sp^3d^2
(d) Carbon in Buckminsterfullerene	
(e) Silicon in SiO_4^{4-}	
(f) Germanium in $[GeCl_6]^{2-}$	

4. Match the compounds given in Column-I with the hybridization and shape given in Column-II and mark the correct option.

Column-I	Column-II
(a) XeF_6	(p) sp^3d^3-distorted octahedral
(b) XeO_3	(q) sp^3d^2-square planar
(c) $XeOF_4$	(r) sp^3-pyramidal
(d) XeF_4	(s) sp^3d^2-square pyramidal

Code:

(a) a → (p); b → (r); c → (s); d → (q)
(b) a → (p); b → (q); c → (s) d → (r)
(c) a → (s); b → (r) c → (p) d → (q)
(d) a → (s); b → (p) c; → (q) d → (r)

5. Match the formulas of oxides given in Column-I with the type of oxide given in Column-II and mark the correct option.

Column-I	Column-II
(a) Pb_3O_4	(p) Neutral oxide
(b) N_2O	(q) Acidic oxide
(c) Mn_2O_7	(r) Basic oxide
(d) Bi2O$_3$	(s) Mixed oxide

Code:

(a) a → (p); b →(q); c → (r); d → (s)
(b) a → (s); b → (p); c → (q); d → (r)
(c) a → (r); b → (q); c → (s); d → (p)
(d) a → (s); b → (r); c → (p) d → (q)

6. Match the items of Columns I and II and mark the correct option.

Column-I	Column-II
(a) H_2SO_4	(p) Highest electron gain enthalpy
(b) CCl_3NO_2	(q) Chalcogen
(c) Cl_2	(r) Tear gas
(d) Sulphur	(s) Storage batteries

Code:

(a) a → (s); b → (r); c → (p); d → (q)
(b) a → (r); b → (s); c → (p); d → (q)
(c) a → (s); b → (p); c → (q); d → (r)
(d) a → (q); b → (p); c → (r); d → (s)

7. Match the species given in Column-I with the shape given in Column-II and mark the correct option.

Column-I	Column-II
(a) SF_4	(p) Tetrahedral
(b) BrF_3	(q) Pyramidal
(c) BrO_3^-	(r) Sea-saw shaped
(d) NH_4^+	(s) Bent T-shaped

Code:

(a) a → (r); b → (q); c → (p); d → (s)
(b) a → (r); b → (s); c → (q); d → (p)
(c) a → (p); b (q); c → (r); d → (s)
(d) a → (p); b → (s); c → (r); d → (q)

8. Match the items of Columns I and II and mark the correct option.

Column-I	Column-II
(a) Its partial hydrolysis does not	(p) He change oxidation state of central atom
(b) It is used in modern diving apparatus	(q) XeF_6
(c) It is used to provide inert atmosphere	(r) XeF_4 for filling electrical bulbs
(d) Its central atom is in sp^3d^2 hybridisation	(s) Ar

Code:

(a) a → (p); b → (s); c → (q); d → (r)
(b) a → (p); b → (q); c → (r); d → (s)
(c) a → (q); b → (p); c → (s); d → (r)
(d) a → (p); b → (r); c → (q); d → (s)

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

1. **Assertion (A):** If aluminium atoms replace a few silicon atoms in three-dimensional network of silicon dioxide, the overall structure acquires a negative charge.

   Reason (R): Aluminium is trivalent while silicon is tetravalent.

   (a) Both A and R are correct and R is the correct explanation of A.
   (b) Both A and R are correct but R is not the correct explanation of A.
   (c) Both A and R are not correct
   (d) A is not correct but R is correct.

2. **Assertion (A):** Silicones are water repelling in nature.

   Reason (R): Silicones are organosilicon polymers, which have ($-R_2SiO-$) as repeating unit.

(a) A and R both are correct and R is the correct explanation of A.

(b) Both A and R are correct but R is not the correct explanation of A.

(c) A and R both are not true.

(d) A is not true but R is true.

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are correct statements, and reason is the correct explanation of the assertion.

(b) Both assertion and reason are correct statements, but reason is not the correct explanation of the assertion.

(c) Assertion is correct, but reason is wrong statement.

(d) Assertion is wrong but reason is correct statement.

(e) Both assertion and reason are wrong statements.

3. **Assertion:** N_2 is less reactive than P_4.

   Reason: Nitrogen has more electron gain enthalpy than phosphorus.

4. **Assertion:** HNO_3 makes iron passive.

   Reason: HNO_3 forms a protective layer of ferric nitrate on the surface of iron.

5. **Assertion:** HI cannot be prepared by the reaction of KI with concentrated H_2SO_4

   Reason: HI has lowest H–X bond strength among halogen acids.

6. **Assertion:** Both rhombic and monoclinic sulphur exist as S_8 but oxygen exists as O_2.

   Reason: Oxygen forms $p\pi$–$p\pi$ multiple bond due to small size and small bond length but $p\pi$–$p\pi$ bonding is not possible in sulphur.

7. **Assertion:** NaCl reacts with concentrated H_2SO_4 to give colorless fumes with pungent smell. But on adding MnO_2 the fumes become greenish yellow.

   Reason: MnO_2 oxidizes HCl to chlorine gas which is greenish yellow.

8. **Assertion:** SF_6 cannot be hydrolyzed but SF_4 can be.

   Reason: Six F atoms in SF_6 prevent the attack of H_2O on sulphur atom of SF_6.

Long Answer Type

1. Describe the general trends in the following properties of the elements in Groups 13 and 14.
   (a) Atomic size
   (b) Ionization enthalpy
   (c) Metallic character
   (d) Oxidation states
   (e) Nature of halides

2. Account for the following observations:
   (a) $AlCl_3$ is a Lewis acid
   (b) Though fluorine is more electronegative than chlorine yet BF_3 is a weaker Lewis acid than BCl_3
   (c) PbO_2 is a stronger oxidizing agent than SnO_2
   (d) The +1 oxidation state of thallium is more stable than its +3 state

3. When aqueous solution of borax is acidified with hydrochloric acid, a white crystalline solid is formed which is soapy to touch. Is this solid acidic or basic in nature? Explain.

4. Three pairs of compounds are given below. Identify that compound in each of the pairs which has group 13 element in more stable oxidation state. Give reason for your choice. State the nature of bonding also.
   (a) $TlCl_3$, TlCl
   (b) $AlCl_3$, AlCl
   (c) $InCl_3$, InCl

5. BCl_3 exists as monomer whereas $AlCl_3$ is dimerized through halogen bridging. Give reason. Explain the structure of the dimer of $AlCl_3$ also.

6. Boron fluoride exists as BF_3 but boron hydride does not exist as BH_3. Give reason. In which form does it exist? Explain its structure.

7. (a) What are silicones? State the uses of silicones.
   (b) What are boranes? Give chemical equation for the preparation of diborane.

8. A compound (A) of boron reacts with NMe_3 to give an adduct (B) which on hydrolysis gives a compound (C) and hydrogen gas. Compound (C) is an acid. Identify the compounds A, B, and C. Give the reactions involved.

9. A nonmetallic element of group 13, used in making bullet proof vests is extremely hard solid of black color. It can exist in many allotropic forms and has unusually high melting point. Its trifluoride acts as Lewis acid towards ammonia. The element

exhibits maximum covalency of four. Identify the element and write the reaction of its trifluoride with ammonia. Explain why does the trifluoride act as a Lewis acid.

10. A tetravalent element forms monoxide and dioxide with oxygen. When air is passed over heated element (1273 K), producer gas is obtained. Monoxide of the element is a powerful reducing agent and reduces ferric oxide to iron. Identify the element and write formulae of its monoxide and dioxide. Write chemical equations for the formation of producer gas and reduction of ferric oxide with the monoxide.

11. An amorphous solid "A" burns in air to form a gas "B" which turns lime water milky. The gas is also produced as a by-product during roasting of sulphide ore. This gas decolorizes acidified aqueous $KMnO_4$ solution and reduces Fe^{3+} to Fe^{2+}. Identify the solid "A" and the gas "B" and write the reactions involved.

12. On heating lead(II) nitrate gives a brown gas "A". The gas "A" on cooling changes to colorless solid "B". Solid "B" on heating with NO changes to a blue solid 'C'. Identify 'A', 'B', and 'C' and also write reactions involved and draw the structures of 'B' and 'C'.

13. On heating compound (A) gives a gas (B) which is a constituent of air. This gas when treated with 3 mol of hydrogen (H_2) in the presence of a catalyst gives another gas (C) which is basic in nature. Gas C on further oxidation in moist condition gives a compound (D) which is a part of acid rain. Identify compounds (A) to (D) and also give necessary equations of all the steps involved.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Alum helps in purifying water by:
(a) Forming Si complex with clay particles
(b) Sulphate part which combines with the dirt and removes it
(c) Coagulating the mud particles
(d) Making mud water soluble **(AIEEE, 2002)**

2. In XeF_2, XeF_4, and XeF_6, the number of lone pairs on Xe are, respectively:
(a) 2, 3, and 1 (b) 1, 2, and 3
(c) 4, 1, and 2 (d) 3, 2, and 1
(AIEEE, 2002)

3. In case of nitrogen, NCl_3 is possible but not NCl_5, whereas in case of phosphorous, PCl_3 as well as PCl_5 are possible. It is due to: **(AIEEE, 2002)**
(a) Availability of vacant *d*-orbitals in P but not in N
(b) Lower electronegativity of P than N
(c) Lower tendency of H-bond formation in P than N
(d) Occurrence of P in solid whereas N is in gaseous state at room temperature

4. Which of the following statements is true?
(a) HF is less polar than HBr
(b) Absolutely pure water does not contain any ions
(c) Chemical bond formation takes place when forces of attraction overcome the forces of repulsion
(d) In covalency, transfer of electron takes place
(AIEEE, 2002)

5. Number of sigma bonds in P_4O_{10} is:
(a) 6 (b) 7
(c) 17 (d) 16
(AIEEE, 2002)

6. Oxidation number of Cl in $CaOCl_2$ (bleaching powder) is:
(a) Zero, since it contains Cl_2
(b) –1, since it contains Cl^-
(c) +1, since it contains ClO^-
(d) +1 and –1, since it contains ClO^- and Cl^-
(AIEEE, 2002)

7. What may be expected to happen when phosphine gas is mixed with chlorine gas?
(a) PCl_3 and HCl are formed and the mixture warms up
(b) PCl_3 and HCl are formed and the mixture cools down
(c) $PH_3 \cdot Cl_2$ is formed with warming up
(d) The mixture only cools down
(AIEEE, 2003)

8. Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. The explanation for it is that:
(a) Oxygen in air reacts with the emitted HCl gas to form a cloud of chlorine gas
(b) Strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution that appears like a cloudy smoke
(c) Due to strong affinity for water, concentrated hydrochloric acid pulls moisture of air towards itself. This moisture forms droplets of water and hence the cloud
(d) Concentrated hydrochloric acid emits strongly smelling HCl gas all the time
(AIEEE, 2003)

9. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behavior is that graphite:
   (a) Is an allotropic form of diamond
   (b) Has molecules of variable molecular masses like polymers
   (c) Has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interpolate bonds
   (d) Is a non-crystalline substance **(AIEEE, 2003)**

10. Glass is a
   (a) Super-cooled liquid
   (b) Gel
   (c) Polymeric mixture
   (d) Micro-crystalline solid **(AIEEE, 2003)**

11. Which one of the following substances has the highest proton affinity?
   (a) H_2S (b) NH_3
   (c) PH_3 (d) H_2O
   (AIEEE, 2003)

12. For making good quality mirrors, plates of float glass are used. These are obtained by floating molten glass over a liquid metal which does not solidify before glass. The metal used can be:
   (a) Tin (b) Sodium
   (c) Magnesium (d) Mercury
   (AIEEE, 2003)

13. Which among the following factors is the most important in making fluorine the strongest oxidizing halogen?
   (a) Hydration enthalpy
   (b) Ionization enthalpy
   (c) Electron affinity
   (d) Bond dissociation energy **(AIEEE, 2004)**

14. Which one of the following statement regarding helium is incorrect?
   (a) It is used to produce and sustain powerful superconducting magnets
   (b) It is used as a cryogenic agent for carrying out experiments at low temperatures
   (c) It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable
   (d) It is used in gas-cooled nuclear reactors
   (AIEEE, 2004)

15. Beryllium and aluminium exhibit many properties that are similar. But the two elements differ in:
   (a) Forming covalent halides
   (b) Forming polymeric hydrides
   (c) Exhibiting maximum covalency in compounds
   (d) Exhibiting amphoteric nature in their oxides
   (AIEEE, 2004)

16. Aluminium chloride, Al_2Cl_6, exists as dimer in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives:
   (a) $[Al(OH)_6]^{3-} + 3HCl$
   (b) $[Al(H_2O)_6]^{3+} + 3Cl^-$
   (c) $Al^{3+} + 3Cl^-$
   (d) $Al_2O_3 + 6HCl$ **(AIEEE, 2004)**

17. Excess of KI reacts with $CuSO_4$ solution and then $Na_2S_2O_3$ solution is added to it. Which of the statements is incorrect for this reaction?
   (a) $Na_2S_2O_3$ is oxidized
   (b) CuI_2 is formed
   (c) Cu_2I_2 is formed
   (d) Evolved I_2 is reduced
   (AIEEE, 2004)

18. The soldiers of napoleon army while at Alps, during freezing winter, suffered a serious problem as regards to the tin buttons of their uniforms. White metallic tin buttons got converted to grey powder. This transformation is related to:
   (a) A change in the partial pressure of oxygen in the air
   (b) A change in the crystalline structure of tin
   (c) An interaction with nitrogen of the air at very low temperature
   (d) An interaction with water vapor contained in the humid air **(AIEEE, 2004)**

19. The number of hydrogen atoms attached to phosphorus atom in hypophosphorous acid is:
   (a) Three (b) One
   (c) Two (d) Zero
   (AIEEE, 2005)

20. The correct order of the thermal stability of hydrogen halides (H – X) is:
   (a) HI > HCl < HF > HBr
   (b) HCl < HF > HBr < HI
   (c) HF > HCl > HBr > HI
   (d) HI < HBr > HCl < HF **(AIEEE, 2005)**

21. Heating an aqueous solution of aluminium chloride to dryness will give:
   (a) $Al(OH)Cl_2$ (b) Al_2O_3
   (c) $Al2Cl_6$ (d) $AlCl_3$
   (AIEEE, 2005)

22. In silicon dioxide:
 (a) There are double bonds between silicon and oxygen atoms
 (b) Silicon atom is bonded to two oxygen atoms
 (c) Each silicon atom is surrounded by two oxygen atoms, and each oxygen atom is bonded to two silicon atoms
 (d) Each silicon atom is surrounded by four oxygen atoms, and each oxygen atom is bonded to two silicon atoms

(AIEEE, 2005)

23. The structure of diborane (B_2H_6) contains
 (a) Four 2c–2e bonds and four 3c-2e bonds
 (b) Two 2c–2e bonds and two 3c–3c bonds
 (c) Two 2c–2e bonds and four 2c–2e bonds
 (d) Four 2c–2e bonds and two 3c–2e bonds

(AIEEE, 2005)

24. Which of the following statements is true?
 (a) $HClO_4$ is a weaker acid than $HClO_3$
 (b) HNO_3 is a stronger acid than HNO_2
 (c) H_3PO_3 is a stronger acid than H_2SO_3
 (d) In aqueous medium, HF is a stronger acid than HCl **(AIEEE, 2006)**

25. The increasing order of the first ionization enthalpies of the elements B, P, S, and F (lowest first) is:
 (a) $B < P < S < F$ (b) $B < S < P < F$
 (c) $F < S < P < B$ (d) $P < S < B < F$

(AIEEE, 2006)

26. What products are expected from the disproportionation reaction of hypochlorous acid?
 (a) HCl and Cl_2O (b) HCl and $HClO_3$
 (c) $HClO_3$ and Cl_2O (d) $HClO_2$ and $HClO_4$

(AIEEE, 2006)

27. Identify the incorrect statement among the following: **(AIEEE, 2007)**
 (a) Br_2 reacts with hot and strong NaOH solution to give NaBr and H_2O
 (b) Ozone reacts with SO_2 to give SO_3
 (c) Silicon reacts with NaOH(aq) in the presence of air to give Na_2SiO_3 and H_2O
 (d) Cl_2 reacts with excess of NH_3 to give N_2 and HCl

28. Regular use of the following fertilizers increases the acidity of soil?
 (a) Ammonium sulphate
 (b) Potassium nitrate
 (c) Urea
 (d) Superphosphate of lime **(AIEEE, 2007)**

29. The stability of dihalides of Si, Ge, Sn, and Pb increases steadily in the sequence **(AIEEE, 2007)**
 (a) $PbX_2 << SnX_2 << GeX_2 << SiX_2$
 (b) $GeX_2 << SiX_2 << SnX_2 << PbX_2$
 (c) $SiX_2 << GeX_2 << PbX_2 << SnX_2$
 (d) $SiX_2 << GeX_2 << SnX_2 << PbX_2$

30. Which one of the following is the correct statement?
 (a) Boric acid is a protonic acid
 (b) Beryllium exhibits coordination number of six
 (c) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase
 (d) $B_2H_6 \cdot 2NH_3$ is known as 'inorganic benzene'

(AIEEE, 2008)

31. Which one of the following reactions of xenon compounds is not feasible?
 (a) $3XeF_4 + 6H_2O \rightarrow 2Xe + XeO_3 + 12HF + 1.5O_2$
 (b) $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$
 (c) $XeF_6 + RbF \rightarrow Rb[XeF_7]$
 (d) $XeO_3 + 6HF \rightarrow XeF_6 + 3H_2O$

(AIEEE, 2009)

32. Which of the following statement is wrong?
 (a) The stability of hydride increases from NH_3 to BiH_3 in group 15 of the periodic table
 (b) Nitrogen cannot form dp–pp bond
 (c) Single N–N bond is weaker than the single P–P bond
 (d) N_2O_4 has two resonance structures

(AIEEE, 2011)

33. Which of the following statements regarding sulphur is incorrect?
 (a) S_2 molecule is paramagnetic
 (b) The vapor at 200°C consists mostly of S_8 rings
 (c) At 600°C, the gas mainly consists of S_2 molecules
 (d) The oxidation state of sulphur is never less than +4 in its compounds **(AIEEE, 2011)**

34. Boron cannot form which one of the following anions?
 (a) BF_6^{3-} (b) BH_4^-
 (c) $B(OH)_4^-$ (d) BO_2^-

(AIEEE, 2011)

35. Identify the incorrect statement from the following:
    (a) Ozone absorbs the intense ultraviolet radiation of the sun
    (b) Depletion of ozone layer is because of its chemical reactions with chlorofluoroalkanes
    (c) Ozone absorbs infrared radiation
    (d) Oxides of nitrogen in the atmosphere can cause the depletion of ozone layer

(AIEEE, 2011)

36. The correct order of electron gain enthalpy with negative sign of F, Cl, Br, and I having atomic number 9, 17, 35, and 53 respectively, is:
    (a) F > Cl > Br > I (b) Cl > F > Br > I
    (c) Br > Cl > I > F (d) I > Br > Cl > F

(AIEEE, 2011)

37. In view of the signs of $\Delta_r G^\circ$ for the following reactions:

$PbO_2 + Pb \rightarrow 2PbO$, $\Delta_r G^\circ < 0$

$SnO_2 + Sn \rightarrow 2SnO$, $\Delta_r G^\circ > 0$

which oxidation states are more characteristics for lead and tin?
    (a) For lead +2, for tin +2
    (b) For lead +4, for tin +4
    (c) For lead +2, for tin +4
    (d) For lead +4, for tin +2 **(AIEEE, 2011)**

38. Which of the following has maximum number of lone pairs associated with Xe?
    (a) XeF_4 (b) XeF_6
    (c) XeF_2 (d) XeO_3

(AIEEE, 2011)

39. The molecule having the smallest bond angle is:
    (a) NCl_3 (b) $AsCl_3$
    (c) $SbCl_3$ (d) PCl_3

(AIEEE, 2012)

40. In the following sets of reactants which two sets best exhibit the amphoteric character of $Al_2O_3.xH_2O$? **(JEE Main, 2014)**

Set-1: $Al_2O_3.xH_2O(s)$ and OH^- (aq)

Set-2: $Al_2O_3.xH_2O(s)$ and H_2O (l)

Set-3: $Al_2O_3.xH_2O(s)$ and H^+ (aq)

Set-4: $Al_2O_3.xH_2O(s)$ and NH_3 (aq)
    (a) 1 and 2 (b) 2 and 4
    (c) 1 and 3 (d) 3 and 4

41. The gas evolved on heating CaF_2 and SiO_2 with concentrated H_2SO_4, on hydrolysis gives a white gelatinous precipitate. The precipitate is:
    (a) Silica gel
    (b) Silicic acid
    (c) Hydrofluosilicic acid
    (d) Calciumfluorosilicate

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Iodine reacts with hot NaOH solution. The products are NaI and ________.

(IIT-JEE, 1980)

2. ________ phosphorus is reactive because of its highly strained tetrahedral structure.

(IIT-JEE, 1987)

3. The basicity of phosphorus acid (H_3PO_3) is ________.

(IIT-JEE, 1990)

4. The hydrolysis of alkyl-substituted chlorosilanes gives ________.

(IIT-JEE, 1991)

5. In P_4O_{10}, the number of oxygen atoms bonded to each phosphorus atom is ________.

(IIT-JEE, 1992)

6. The lead chamber process involves oxidation of SO_2 by atomic oxygen under the influence of ________ as catalyst.

(IIT-JEE, 1992)

7. The hydrolysis of trialkylchlorosilane, R_3SiCl, yields ________.

(IIT-JEE, 1994)

8. The two types of bonds present in B_2H_6 are covalent and ________. **(IIT-JEE, 1994)**

9. One recently discovered allotrope of carbon (e.g., C_{60}) is commonly known as ________.

(IIT-JEE, 1994)

10. A liquid which is permanently supercooled is frequently called a ________.

(IIT-JEE, 1998)

True/False Type

1. When PbO_2 reacts with a dilute acid, it gives hydrogen peroxide. **(IIT-JEE, 1982)**

2. Carbon tetrachloride burns in air when lighted to give phosgene.

(IIT-JEE, 1983)

3. Dilute HCl oxidizes metallic Fe to Fe^{2+}.
(IIT-JEE, 1983)

4. In aqueous solution, chlorine is a stronger oxidizing agent than fluorine.
(IIT-JEE, 1984)

5. The H—N—H bond angle in NH_3 is greater than the H—As—H bond angle in AsH_3.
(IIT-JEE, 1984)

6. Graphite is a better lubricant on the moon than on the earth.
(IIT-JEE, 1987)

7. All the Al—Cl bonds in Al_2Cl_6 are equivalent.
(IIT-JEE, 1989)

8. Nitric oxide, though an odd electron molecule, is diamagnetic in liquid state.
(IIT-JEE, 1991)

9. Diamond is harder than graphite.
(IIT-JEE, 1993)

10. The basic nature of the hydroxides of group 13 [Gr III (b)] decreases progressively down the group.
(IIT-JEE, 1993)

11. The tendency for catenation is much higher for C than for Si.
(IIT-JEE, 1993)

12. HBr is a stronger acid than HI because of hydrogen bonding.
(IIT-JEE, 1993)

Single Correct Answer Type

1. Which of the following statement is incorrect?
   (a) NO is heavier than O_2
   (b) The formula of heavy water is D_2O
   (c) Nitrogen diffuses faster than oxygen through an orifice
   (d) NH_3 can be used as a refrigerant
(IIT-JEE, 1978)

2. Ammonia gas can be dried by:
   (a) Conc. H_2SO_4 (b) P_2O_5
   (c) $CaCl_2$ (d) Quick lime
(IIT-JEE, 1978)

3. HBr and HI reduce sulphuric acid, HCl can reduce $KMnO_4$, and HF can reduce:
   (a) H_2SO_4 (b) $KMnO_4$
   (c) $K_2Cr_2O_7$ (d) None of these
(IIT-JEE, 1981)

4. Moderate electrical conductivity is shown by:
   (a) Silica (b) Graphite
   (c) Diamond (d) Carborundum
(IIT-JEE, 1982)

5. Chlorine acts as a bleaching agent only in the presence of:
   (a) Dry air (b) Moisture
   (c) Sunlight (d) Pure oxygen

6. The oxide that gives H_2O_2 on treatment with a dilute acid is:
   (a) PbO_2 (b) Na_2O_2
   (c) MnO_2 (d) TiO_2
(IIT-JEE, 1985)

7. A gas that cannot be collected over water is:
   (a) N_2 (b) O_2
   (c) SO_2 (d) PH_3
(IIT-JEE, 1985)

8. The bonds present in N_2O_5 are:
   (a) Only ionic
   (b) Covalent and coordinate
   (c) Only covalent
   (d) Covalent and ionic **(IIT-JEE, 1986)**

9. Which of the following oxides of nitrogen is a colored gas?
   (a) N_2O (b) NO
   (c) N_2O_4 (d) NO_2
(IIT-JEE, 1987)

10. Among the trihalides of nitrogen, which is the least basic?
   (a) NF_3 (b) NCl_3
   (c) NBr_3 (d) NI_3
(IIT-JEE, 1987)

11. Bromine can be liberated from potassium bromide solution by the action of:
   (a) Iodine solution (b) Chlorine water
   (c) Sodium chloride (d) Potassium iodide
(IIT-JEE, 1987)

12. Which of the following is the strongest base?
   (a) AsH_3 (b) NH_3
   (c) PH_3 (d) SbH_3
(IIT-JEE, 1989)

13. There is no S—S bond in:
   (a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$
   (c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$
(IIT-JEE, 1991)

14. The oxidation states of the most electronegative element in the products of the reaction, BaO_2 with dil. H_2SO_4, are:
(a) 0 and -1 (b) -1 and -2
(c) -2 and 0 (d) -2 and -1
(IIT-JEE, 1991)

15. The species that do not contain peroxide ions is:
(a) PbO_2 (b) H_2O_2
(c) SrO_2 (d) BaO_2
(IIT-JEE, 1992)

16. Hydrolysis of 1 mol of peroxodisulphuric acid produces:
(a) 2 mol of sulphuric acid
(b) 2 mol of peroxomono sulphuric acid
(c) 1 mol of sulphuric acid and 1 mol of peroxomono sulphuric acid
(d) 1 mol of sulphuric acid, 1 mol of peroxomono sulphuric acid, and 1 mol of hydrogen peroxide
(IIT-JEE, 1996)

17. Which of the following halides is least stable and has a doubtful existence?
(a) CCl_4 (b) GeI_4
(c) SnI_4 (d) PbI_4
(IIT-JEE, 1996)

18. Which of the following oxides is neutral?
(a) CO (b) SNO_2
(c) ZnO (d) SiO_2
(IIT-JEE, 1996)

19. The following acids have been arranged in the order of decreasing acid strength. Identify the correct order:
ClOH (I), BROH (II), IOH (III)
(a) I > II > III (b) II > I > III
(c) III > II > I (d) I > III > II
(IIT-JEE, 1996)

20. Which of the following species is not a pseudo halide?
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^-
(IIT-JEE, 1997)

21. In compounds of the type ECl_3, where $E = B, P$, As, or Bi, the angles Cl—E—Cl for different E are in the order:
(a) $B > P = As = Bi$ (b) $B > P > As > Bi$
(c) $B < P = As = Bi$ (d) $B < P < As < Bi$
(IIT-JEE, 1999)

22. The number of P—O—P bonds in cyclic metaphosphoric acid is:
(a) Zero (b) Two
(c) Three (d) Four
(IIT-JEE, 2000)

23. The correct order of acidic strength is:
(a) $Cl_2O_7 > SO_2 > P_4O_{10}$
(b) $CO_2 > N_2O_5 > SO_3$
(c) $Na_2O > MgO > Al_2O_3$
(d) $K_2O > CaO > MgO$ **(IIT-JEE, 2000)**

24. Among H_2O, H_2S, H_2Se, and H_2Te, the one with the highest boiling point is:
(a) H_2O because of hydrogen bonding
(b) H_2Te because of higher molecular weight
(c) H_2S because of hydrogen bonding
(d) H_2Se because of lower molecular weight
(IIT-JEE, 2000)

25. Ammonia can be dried by:
(a) Conc. H_2SO_4 (b) P_4O_{10}
(c) CaO (d) Anhydrous $CaCl_2$

26. The set with the correct order of acidity is:
(a) $HClO < HClO_2 < HClO_3 < HClO_4$
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$
(c) $HClO < HClO_4 < HClO_3 < HClO_2$
(d) $HClO_4 < HClO_2 < HClO_3 < HClO$
(IIT-JEE, 2001)

27. The number of S—S bonds in sulphur trioxide trimer (S_3O_9) is:
(a) Three (b) Two
(c) One (d) Zero
(IIT-JEE, 2001)

28. Identify the correct order of acidic strength of CO_2, CuO, CaO, and H_2O:
(a) $CaO < CuO < H_2O < CO_2$
(b) $H_2O < CuO < CaO < CO_2$
(c) $CaO < H_2O < CuO < CO_2$
(d) $H_2O < CO_2 < CaO < CuO$ **(IIT-JEE, 2002)**

29. H_3BO_3 is:
(a) A monobasic acid and weak Lewis acid
(b) A monobasic and weak Bronsted acid
(c) A monobasic and strong Lewis acid
(d) A tribasic and weak Bronsted acid
(IIT-JEE, 2003)

30. $(Me)_2SiCl_2$ on hydrolysis will produce:
(a) $(Me)_2Si(OH)_2$ (b) $(Me)_2Si{=}O$
(c) $[-O-Si(Me)_2-O-]_n$ (d) $Me_2SiCl(OH)$
(IIT-JEE, 2003)

31. When I^- is oxidized by MnO_4^- in an alkaline medium, I^- converts into:

(a) IO_3^- (b) I_2
(c) IO_4^- (d) IO^-

(IIT-JEE, 2004)

32. Which is the most thermodynamically stable allotropic form of phosphorus?

(a) Red (b) White
(c) Black (d) Yellow

(IIT-JEE, 2005)

33. Which of the following is not oxidized by O_3?

(a) KI (b) $FeSO_4$
(c) $KMnO_4$ (d) K_2MnO_4

(IIT-JEE, 2005)

34. Which blue liquid is obtained on reacting equimolar amounts of two gases at –30°C?

(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

35. The name of the structure of silicates in which three oxygen atoms of $[SiO_4]^{4-}$ are shared is:

(a) Pyrosilicate
(b) Sheet silicate
(c) Linear-chain silicate
(d) Three-dimensional silicate

(IIT-JEE, 2005)

36. $B(OH)_3 + NaOH \rightleftharpoons NaBO_2 + Na[B(OH)_4] + H_2O$
How can this reaction be made to proceed in the forward direction?

(a) By the addition of *cis*-1,2-diol.
(b) By the addition of borax.
(c) By the addition of *trans*-1,2-diol.
(d) By the addition of Na_2HPO_4.

(IIT-JEE, 2006)

37. The reaction of P_4 with X leads selectively to P_4O_6. X is:

(a) Dry O_2
(b) A mixture of O_2 and N_2
(c) Moist O_2
(d) O_2 in the presence of aqueous NaOH

(IIT-JEE, 2009)

38. The species having pyramidal shape is:

(a) SO_3 (b) BrF_3
(c) SiO_3^{2-} (d) OSF_2

(IIT-JEE, 2010)

39. Extra pure N_2 can be obtained by heating:

(a) NH_3 with CuO (b) NH_4NO_3
(c) $(NH_4)_2Cr_2O_7$ (d) $Ba(N_3)_2$

(IIT-JEE, 2011)

40. Concentrated nitric acid, upon long standing, turns yellow-brown due to the formation of:

(a) NO (b) NO_2
(c) N_2O (d) N_2O_4

(JEE Advanced, 2013)

41. Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is:

$$XeF_6 \xrightarrow[\text{Hydrolysis}]{\text{Complete}} P + \text{other product}$$

$$P \xrightarrow{OH^-/H_2O} Q \xrightarrow{\text{slow disproportionation in } OH^-/H_2O} \text{products}$$

(a) 0 (b) 1
(c) 2 (d) 3

(JEE Advanced, 2014)

42. The product formed in the reaction of $SOCl_2$ with white phosphorous is

(a) PCl_3 (b) SO_2Cl_2
(c) SCl_2 (d) $POCl_3$

(JEE Advanced, 2014)

43. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a:

(a) Reducing agent, oxidizing agent
(b) Reducing agent, reducing agent
(c) Oxidizing agent, oxidizing agent
(d) Oxidizing agent, reducing agent

(JEE Advanced, 2014)

Multiple Correct Answers Type

1. Nitrogen(I) oxide is produced by:

(a) Thermal decomposition of ammonium nitrate
(b) Disproportionation of N_2O_4
(c) Thermal decomposition of ammonium nitrite
(d) Interaction of hydroxylamine and nitrous acid

(IIT-JEE, 1989)

2. White phosphorus (P_4) has:
   (a) Six P—P single bonds
   (b) Four P—P single bonds
   (c) Four lone pairs of electrons
   (d) PPP angle of 60°

(IIT-JEE, 1998)

3. Ammonia, on reaction with hypochlorite anion, can form:
   (a) NO (b) NH_4Cl
   (c) N_2H_4 (d) HNO_2

(IIT-JEE, 1999)

4. When PbO_2 reacts with concentrated HNO_3, the gas(es) evolved is/are:
   (a) NO_2 (b) O_2
   (c) N_2 (d) N_2O

(IIT-JEE, 2005)

5. In the following reaction,
   $2X + B_2H_6 \rightarrow [BH_2(X)_2]^+[BH_4]^-$
   The amine(s) X is/are:
   (a) NH_3 (b) CH_3NH_2
   (c) $(CH_3)_2NH$ (d) $(CH_3)N$

(IIT-JEE, 2009)

6. The nitrogen oxide(s) that contains N—N bond is/are:
   (a) N_2O (b) N_2O_3
   (c) N_2O_4 (d) N_2O_5

(IIT-JEE, 2010)

7. The correct statement(s) about O_3 is(are)
   (a) O–O bond lengths are equal
   (b) Thermal decomposition of O_3 is endothermic
   (c) O_3 is diamagnetic in nature
   (d) O_3 has a bent structure

(JEE Advanced, 2013)

8. The correct statements(s) for orthoboric acid is/are:
   (a) It behaves as a weak acid in water due to self-ionization
   (b) Acidity of its aqueous solution increases upon addition of ethylene glycol
   (c) It has a three-dimensional structure due to hydrogen bonding
   (d) It is a weak electrolyte in water

(JEE Advanced, 2014)

Comprehension Type

For Problems 1–3

The noble gases have closed-shell electronic configuration and are monatomic gases under normal conditions. The low boiling points of the lighter noble gases are due to the weak dispersion forces between the atoms and the absence of other interatomic interactions.

The direct reaction of xenon with fluorine leads to a series of compounds with oxidation numbers +2, +4, and +6. XeF_4 reacts violently with water to give XeO_3. The compounds of xenon exhibit rich stereochemistry and their geometries can be deduced considering the total number of electron pairs in the valence shell.

1. Argon is used in arc welding because of its:
   (a) Low reactivity with metals
   (b) Ability to lower the melting point of metals
   (c) Flammability
   (d) High calorific value

2. The structure of XeO_3 is:
   (a) Linear (b) Planar
   (c) Pyramidal (d) T-shaped

3. XeF_4 and XeF_6 are expected to be:
   (a) Oxidizing (b) Reducing
   (c) Unreactive (d) Strongly basic

(IIT-JEE, 2007)

For Problems 4–6

There are some deposits of nitrates and phosphates in the earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under laboratory conditions but microbes do it easily. Ammonia forms a large number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3 and PH_3. Phosphine is a flammable gas and is prepared from white phosphorus.

4. Which of the following statemets is correct?
   (a) Phosphates have no biological significance in humans
   (b) Between nitrates and phosphates, phosphates are less abundant in earth's crust
   (c) Between nitrates and phosphates, nitrates are less abundant in earth's crust
   (d) Oxidation of nitrates is possible in soil

5. Which of the following statements is correct?
   (a) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical s-orbital and is less directional

(b) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies sp^3-orbital and is more directional

(c) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies sp^3-orbital and is more directional

(d) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies spherical s-orbital and is less directional

6. White phosphorus on reaction with NaOH gives PH_3 as one of the products. This is a:

(a) Dimerization reaction

(b) Disproportionation reaction

(c) Condensation reaction

(d) Precipitation reaction **(IIT-JEE, 2008)**

Paragraph for Question 7 and 8

The reaction of Cl_2 gas with cold dilute and hot concentrated NaOH in water give sodium salt of two (different) oxoacids of chlorine P and Q respectively. The Cl_2 gas reacts with SO_2 gas , in presence of charcoal to give a product R. R reacts with white phosphorous to give a compound S. On hydrolysis, S gives as oxoacid of phosphorous T.

7. R, S, and T, respectively are:

(a) SO_2Cl_2, PCl_5, and H_3PO_4

(b) SO_2Cl_2, PCl_3, and H_3PO_3

(c) $SOCl_2$, PCl_3, and H_3PO_2

(d) SO_2Cl_2, PCl_5, and H_3PO_4

(JEE Advanced, 2013)

8. P and Q, respectively, are the sodium salts of:

(a) Hypochlorus and chloric acid

(b) Hypochlorus and chlorus acid

(c) Chloric and perchloric acids

(d) Chloric and hypochlorus acids

(JEE Advanced, 2013)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is true; Statement-II is the correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** Although PF_5, PCl_5, and PBr_5 are known, the pentahalides of nitrogen have not been observed.

Statement-II: Phosphorous has lower electronegativity than nitrogen.

(IIT-JEE, 1994)

2. **Statement-I:** $Al(OH)_3$ is amphoteric in nature.

Statement-II: Al—O and O—H bonds can be broken with equal ease in $Al(OH)_3$.

(IIT-JEE, 1998)

3. **Statement-I:** HNO_3 is a stronger acid than HNO_2.

Statement-II: In HNO_3, there are two nitrogen to oxygen bonds, whereas in HNO_2 there is only one.

(IIT-JEE, 1998)

4. **Statement-I:** Between $SiCl_4$ and CCl_4, only $SiCl_4$ reacts with water.

Statement-II: $SiCl_4$ is ionic and CCl_4 is covalent.

(IIT-JEE, 2001)

5. **Statement-I:** In water, orthoboric acid behaves as a weak monobasic acid.

Statement-II: In water, orthoboric acid acts as a proton donor.

(IIT-JEE, 2007)

6. **Statement-I:** Boron always forms covalent bonds.

Statement-II: The small size of B^{3+} favors formation of covalent bond.

(IIT-JEE, 2007)

7. **Statement-I:** Pb^{4+} compounds are stronger oxidizing agents than Sn^{4+} compounds.

Statement-II: The higher oxidation states for group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'. **(IIT-JEE, 2008)**

Matching Column Type

1. Match the following:

Column-I	Column-II
(a) $Bi^{3+} \to (BiO)^+$	(p) Heat
(b) $[AlO_2]^- \to Al(OH)_3$	(q) Hydrolysis
(c) $SiO_4^{4-} \to Si_2O_7^{6-}$	(r) Acidification
(d) $(B_4O_7^{2-}) \to [B(OH)_3]$	(s) Dilution by water

(IIT-JEE, 2006)

2. Match each of the reactions given in Column-I with the corresponding product(s) given in Column-II.

Column-I	Column-II
(a) Cu + dil. HNO_3	(p) NO
(b) Cu + conc. HNO_3	(q) NO_2

(c) Zn + dil. HNO_3	(r) N_2O
(d) Zn + conc. HNO_3	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

(IIT-JEE, 2009)

3. All the compounds listed in Column-I react with water. Match the result of the respective reactions with the appropriate options listed in Column-II.

Column-I	Column-II
(a) $(CH_3)_2SiCl_2$	(p) Hydrogen halide formation
(b) XeF_4	(q) Redox reaction
(c) Cl_2	(r) Reacts with glass
(d) VCl_5	(s) Polymerisation
	(t) O_2 formation

(IIT-JEE, 2010)

4. The unbalanced chemical reactions given in List-I show missing reagent or condition (?) which are provided in List-II. Match List-I with List-II and select the correct answer using the code given below the lists:

List-I	List-II
(P) $PbO_2 + H_2SO_4 \longrightarrow PbSO_4 + O_2$ + other product	(a) NO
(Q) $Na_2S_2O_3 + H_2O \xrightarrow{?} NaHSO_4$ + other product	(b) I_2
(R) $N_2H_4 \xrightarrow{?} N_2$ + other product	(c) Warm
(S) $XeF_2 \xrightarrow{?} Xe$ + other product	(d) Cl_2

Codes:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	2	1	4
(c)	1	4	2	3
(d)	3	4	2	1

(JEE Advanced, 2013)

Integer Answer Type

1. The coordination number of Al in the crystalline state of $AlCl_3$ is__________.

(IIT-JEE, 2009)

2. Among the following, how many elements show only one non-zero oxidation state?
O, Cl, F, N, P, Sn, Tl, Na, Ti

(IIT-JEE, 2010)

3. What is the total number of diprotic acids among the following?
H_3PO_4, H_2SO_4, H_3PO_3, H_2CO_3, $H_2S_2O_7$, H_3BO_3, H_3PO_2, H_2CrO_4, H_2SO_3

(IIT-JEE, 2010)

4. The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is __________.

(IIT-JEE, 2010)

Subjective Type

1. Water is a liquid, while H_2S is a gas at ordinary temperature. Explain.

(IIT-JEE, 1978)

2. Write the chemical equations involved in the extraction of lead from galena by self-reduction process.

(IIT-JEE, 1979)

3. State with balanced equations, what happens when:
   (a) Aluminium is reacted with hot concentrated caustic soda solution.
   (b) Ammonium dichromate is heated.
   (c) Silver is treated with hot concentrated sulphuric acid.
   (d) H_2S is passed through a solution of potassium permanganate acidified with dilute sulphuric acid.
   (e) Tin is treated with moderately concentrated nitric acid.

(IIT-JEE, 1979)

4. The precipitation of second group sulphides in qualitative analysis is carried out with hydrogen sulphide in the presence of hydrochloric acid but not in nitric acid. Explain.

(IIT-JEE, 1979)

5. Write the balanced equations involved in the preparation of:
   (a) Bleaching powder from slaked lime.
   (b) Nitric oxide from nitric acid.
   (c) Chlorine from sodium chloride.
   (d) Anhydrous aluminium chloride from alumina.
   (e) Tin metal from cassiterite.

(IIT-JEE, 1979)

6. Give reasons for the following within two sentences:
   (i) Hydrogen bromide cannot be prepared by the action of concentrated sulphuric acid on sodium bromide.

(ii) When a blue litmus paper is dipped in a solution of hypochlorous acid, it first turns red and then gets decolorized.

(IIT-JEE, 1979)

7. Explain the following in not more than two sentences:
   (i) Concentrated HNO_3 turns yellow in sunlight.
   (ii) Bleaching powder loses its bleaching property when it is kept in an open bottle for a long time.

(IIT-JEE, 1980)

8. Give reasons for the following:
   (i) Sulphur melts to a clear mobile liquid at 119°C, but on further heating above 160°C, it again becomes viscous.
   (ii) Sodium carbonate is prepared by the Solvay process but the same process is not extended for the manufacture of potassium carbonate.

(IIT-JEE, 1981)

9. Give the structural formula for the following:
   (i) Phosphorous acid, H_3PO_3
   (ii) Pyrophosphoric acid, $H_4P_2O_7$

(IIT-JEE, 1981)

10. Explain why 'orthophosphoric acid, H_3PO_4, is tribasic but phosphorus acid, H_3PO_3, is dibasic'.

(IIT-JEE, 1982)

11. State the conditions under which the preparation of alumina from aluminium is carried out. Give the necessary equations which need not be balanced.

(IIT-JEE, 1983)

12. Give reason for the following in one or two sentences: "Solid carbon dioxide is known as dry ice".

(IIT-JEE, 1983)

13. Complete and balance the following reactions:
   (i) $HNO_3 + HCl \rightarrow NO + Cl_2$
   (ii) $Ce^{3+} + S_2O_8^{2-} \rightarrow SO_4^{2-} + Ce^{4+}$
   (iii) $Cl_2 + OH^- \rightarrow Cl^- + ClO^-$

(IIT-JEE, 1983)

14. When 16.8 g of white solid of *X* was heated, 4.4 g of acid gas *A* that turned lime water milky was driven off together with 1.8 g of a gas *B* which condensed to a colorless liquid. The solid that remained, *Y*, dissolved in water to give an alkaline solution, which with excess barium chloride solution gave a white precipitate *Z*. The precipitate effervesced with acid giving carbon dioxide. Identify *A*, *B*, and *Y*, and write the equations for the thermal decomposition of *X*.

(IIT-JEE, 1984)

15. Show with balanced equations what happens when the following are mixed:
   Aqueous solution of ferric sulphate and potassium iodide.

(IIT-JEE, 1984)

16. Give reasons in one or two sentences for each of the following:
   (i) Graphite is used as a solid lubricant.
   (ii) Fluorine cannot be prepared from fluorides by chemical oxidation.

(IIT-JEE, 1985)

17. What happens when
   (i) Hydrogen sulphide is bubbled through an aqueous solution of sulphur dioxide.
   (ii) Aqueous ammonia is added dropwise to a solution of copper sulphate till it is in excess.
   (iii) Tin is treated with concentrated nitric acid.
   (iv) $CrCl_3$ solution is treated with sodium hydroxide and then with hydrogen peroxide.
   (v) Pb_3O_4 is treated with nitric acid.

(IIT-JEE, 1985)

18. Write the balanced equations for the reactions when a mixture of potassium chlorate, oxalic acid, and sulphuric acid, is heated.

(IIT-JEE, 1985)

19. Write the resonance structure of nitrous oxide.

(IIT-JEE, 1985)

20. Write the balanced equations for the reactions when ammonium sulphate is heated with a mixture of nitric oxide and nitrogen dioxide.

(IIT-JEE, 1985)

21. Arrange the following in the order of:
   (i) Increasing bond strength: HCl, HBr, HF, HI
   (ii) Increasing oxidation number of iodine:
   I_2, HI, HIO_4, ICl

(IIT-JEE, 1986)

22. Complete and balance the following reactions.
   (i) $S + OH^- \rightarrow S_2O_3^{2-} + \cdots$
   (ii) $ClO_3^- + I^- + H_2SO_4 \rightarrow Cl^- + HSO_4^- + \cdots$

(IIT-JEE, 1986)

23. Mention the products formed in the following:
"Chlorine gas is bubbled through a solution of ferrous bromide".

(IIT-JEE, 1986)

24. Write balanced chemical equations for the following:
"Gold is dissolved in aquaregia".

(IIT-JEE, 1987)

25. Write balanced equations for the following:

(i) Phosphorus is reacted with boiling aqueous solution of sodium hydroxide in an inert atmosphere.

(ii) Dilute nitric acid is slowly reacted with metallic tin.

(IIT-JEE, 1987)

26. Explain the following in one or two sentences only:

"Orthophosphrous acid is not a tribasic acid".

(IIT-JEE, 1987)

27. "The valency of oxygen is generally two, whereas sulphur shows valency of two, four, and six". Explain.

(IIT-JEE, 1988)

28. Give balanced equations for the following:

(i) Iodate ion reacts with bisulphite ion to liberate iodine.

(ii) Phosphrous reacts with nitric acid to give equimolar ratio of nitric oxide and nitrogen dioxide.

(IIT-JEE, 1988)

29. Arrange the following in each sub-question as indicated.

(i) HOCl, $HOClO_2$, and HOClO in increasing order of thermal stability

(ii) CO_2, N_2O_5, SiO_2, and SO_3 in the order of increasing acidic character

(IIT-JEE, 1988)

30. Write the balanced chemical equations for the following:

(i) Hypophosphorus acid is heated.

(ii) Sodium bromate reacts with fluorine in the presence of an alkali.

(iii) Sodium chlorate reacts with sulphur dioxide in dilute sulphuric acid medium.

(IIT-JEE, 1989)

31. Explain the following:

(i) H_3PO_3 is a dibasic acid.

(ii) Phosphine has lower boiling point than ammonia.

(IIT-JEE, 1989)

32. Each entry in column X is in some way related to the entries in columns Y and Z. Match the appropriate entries.

X	Y	Z
Yeast	Fermentation	Ethanol
Mica	Graphite	Abrasive
Superphosphate	Crystallite cubic	Insulator
Carbon fibers	Layer structure	Fertilizer
Rock salt	Diamond structure	Reinforced plastics
Carborundum	Bone ash	Preservative

(IIT-JEE, 1989)

33. Write balanced equations for:

(i) The preparation of crystalline silicon from $SiCl_4$.

(ii) The preparation of phosphine from CaO and white phosphorus.

(iii) The preparation of ammonium sulphate from gypsum, ammonia, and carbon dioxide.

(IIT-JEE, 1990)

34. Write two resonance structures of N_2O that satisfy the octet rule.

(IIT-JEE, 1990)

35. Write balanced chemical equations for the following:

(i) Sodium nitrite is produced by absorbing the oxides of nitrogen in aqueous solution of washing soda.

(ii) Nitrogen is obtained in the reaction of aqueous ammonia with potassium permanganate.

(iii) Elemental phosphorus reacts with conc. HNO_3 to give phosphoric acid.

(iv) Sulphur is precipitated in the reaction of hydrogen sulphide with sodium bisulphite solution.

(v) Carbon dioxide is passed through a suspension of limestone in water.

(IIT-JEE, 1991)

36. Arrange the following as stated:
Increasing order of the extent of hydrolysis: CCl_4, $MgCl_2$, $AlCl_3$, PCl_3, PCl_5, $SiCl_4$

(IIT-JEE, 1991)

37. Give reasons in one or two sentences.
"Ammonium chloride is acidic in liquid ammonia solvent".

(IIT-JEE, 1991)

38. Write two resonance structures of ozone which satisfy the octet rule.

(IIT-JEE, 1991)

39. Give reasons in only two or three sentences for the following:

(i) Bond dissociation energy of F_2 is less than that of Cl_2.

(ii) Sulphur dioxide is a more powerful reducing agent in the alkaline medium than in the acidic medium. **(IIT-JEE, 1992)**

40. Complete and balance the following chemical reactions:
Red phosphorus is reacted with iodine in the presence of water to form H_3PO_3 and HI.
$2P + 3I_2 + 6H_2O \rightarrow$

(IIT-JEE, 1992)

41. Identify the compounds *A* and *B*.
$PCl_5 + SO_2 \rightarrow A + B$

(IIT-JEE, 1994)

42. Complete and balance the following reactions.

(i) $Ca_5(PO_4)_3F + H_2SO_4 + H_2O \xrightarrow{\text{Heat}}$

(ii) $Sn + 2KOH + 4H_2O \rightarrow$ **(IIT-JEE, 1994)**

43. Account for the following:

(i) The experimentally determined N—F bond length in NF_3 is greater than the sum of the single bond covalent radii of N and F.

(ii) Mg_3N_2 when reacted with water gives NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature.

(iii) $(SiH_3)_3N$ is a weaker base than $(CH_3)_3N$.

(IIT-JEE, 1995)

44. Draw the structure of P_4O_{10} and identify the number of single and double P—O bonds.

(IIT-JEE, 1996)

45. Complete the following chemical equations:

$KI + Cl_2 \rightarrow$

$KClO_3 + I_2 \rightarrow$

(IIT-JEE, 1996)

46. A soluble compound of a poisonous element *M*, when heated with Zn/H_2SO_4, gives a colorless and extremely poisonous gaseous compound *N*, which on passing through a heated tube gives a silvery mirror of element *M*. Identify *M* and *N*.

(IIT-JEE, 1997)

47. Anhydrous $AlCl_3$ is covalent. From the data given below, predict whether it would remain covalent or become ionic in aqueous solution. (Ionization energy for Al is 5137 kJ mol^{-1}.)

$\Delta H_{\text{hydration}}$ for $Al^{3+} = -4665$ kJ mol^{-1}

$\Delta H_{\text{hydration}}$ for $Cl^- = -381$ kJ mol^{-1}

(IIT-JEE, 1997)

48. Aluminium sulphide gives a foul odor when it becomes damp. Write a balanced chemical equation for the reaction.

(IIT-JEE, 1997)

49. Draw the structure of a cyclic silicate $(Si_3O_9)^{6-}$ with proper labelling.

(IIT-JEE, 1998)

50. Reaction of phosphoric acid with $Ca_5(PO_4)_3F$ yields a fertilizer 'triple superphosphate'. Represent the same through balanced chemical equations.

(IIT-JEE, 1998)

51. Complete and balance the following chemical equations:

(i) $P_4O_{10} + PCl_5 \rightarrow$

(ii) $SnCl_4 + C_2H_5Cl + Na \rightarrow$ **(IIT-JEE, 1998)**

52. In the following equation

$A + 2B + H_2O \rightarrow C + 2D$

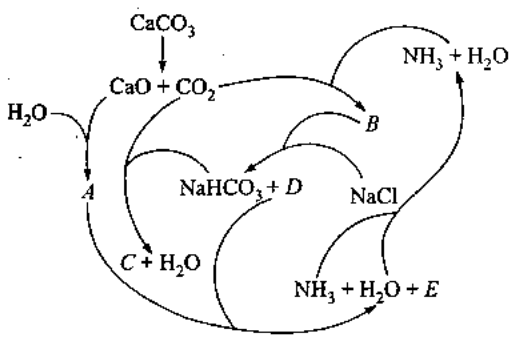
$A = HNO_2$, $B = H_2SO_3$, $C = NH_2OH$
Identify *D*. Draw the structures of *A*, *B*, *C*, and *D*.

(IIT-JEE, 1999)

53. In the contact process for industrial manufacture of sulphuric acid, some amount of sulphuric acid is used as a starting material. Explain briefly. What is the catalyst used in the oxidation of SO_2?

(IIT-JEE, 1999)

54. The Solvay process can be represented by the following scheme



Identify A, B, C, D, and E. **(IIT-JEE, 1999)**

55. Give an example of oxidation of one halide by another halogen. Explain the feasibility of the reaction.

(IIT-JEE, 2000)

56. Write the chemical reactions associated with the 'borax beat test' of cobalt(II) oxide.

(IIT-JEE, 2000)

57. Draw the molecular structure of XeF_2, XeF_4, and XeO_2F_2, indicating the location of lone pairs of electrons.

(IIT-JEE, 2000)

58. Give reason, why elemental nitrogen exists as a diatomic molecule, whereas elemental phosphorus is a tetra-atomic molecule.

(IIT-JEE, 2000)

59. Compound X on reduction with 21.72% gives a hydride Y containing 21.72% hydrogen along with other products. Compound Y reacts with air explosively resulting in boron trioxide. Identify X and Y. Give balanced reactions involved in the formation of Y and its reaction with air. Draw the structure of Y.

(IIT-JEE, 2001)

60. Starting from $SiCl_4$, prepare the following in steps not exceeding the number given in parenthesis (give reactions only).
   (i) Silicon (1)
   (ii) Linear silicone containing methyl group only (4)
   (iii) Na_2SiO_3(3)

(IIT-JEE, 2001)

61. How is boron obtained from borax? Give chemical equations with reaction conditions. Write the structure of B_2H_6 and its reaction with HCl.

(IIT-JEE, 2002)

62. Write the balanced equations for the reactions of the following compounds with water:
   (i) Al_4C_3
   (ii) CaNCN
   (iii) BF_3
   (iv) NCl_3
   (v) XeF_4

(IIT-JEE, 2002)

63. AlF_3 is insoluble in anhydrous HF but when little KF is added to the compound it becomes soluble. On addition of BF_3, AlF_3 is precipitated. Write the balanced chemical equations.

(IIT-JEE, 2004)

64. How many grams of CaO are required to neutralize 852 g of P_4O_{10}? Draw the structure of P_4O_{10}.

(IIT-JEE, 2005)

Hints & Solutions

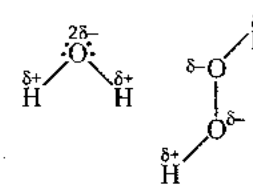
JEE (Main) Exercises

Single Correct Answer Type

83. (b) Acidic character increases with increase in electronegativity of central atom.

Ionic radius decreases with increase in positive charge on cation.

84. (b) The more is the partial charges generated, the more is the strength of H-bonding.



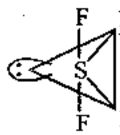
The strength of H-bonding is more in H_2O.

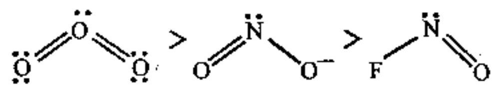
85. (c) Cl forms one bond in its ground state but three bonds in its first excited state.

Therefore, in ClF_3, Cl is having 10 electrons.

86. (a) H_3O^+ will have three bond pairs and one lone pair and shape same as $\ddot{N}H_3$, therefore is pyramidal.

87. (c) NH_3 has more dipole moment than NF_3 but bond moment (bond dipole) of NF_3, i.e. N—F, is more than N—H


polar molecule.

88. (a) 

(I) (II) (III)

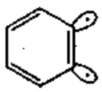
B.A. ∝ E.N. of central atom (F is more E.N., therefore bond pair towards F, bond angle decreases).

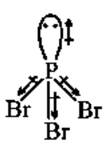
JEE (Advanced) Exercises

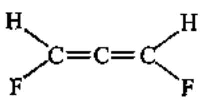
Single Correct Answer Type

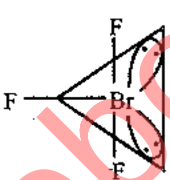
14. (d) Values of dipole moment cannot be predicted as we do not know about the electronegativities of the atoms.

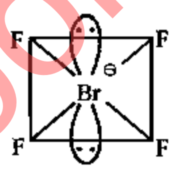
15. (c) $SiF_4 \rightarrow$ Si have vacant d-orbital so can act as Lewis acid.

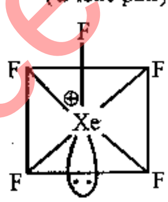
 → In benzyne all C-atoms are sp^2-hybridized.

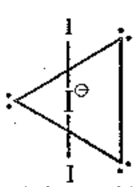
 → This is polar molecule.

 → The nodal planes of π–bonds are perpendicular to each other.

16. (c) 
(2 lone pair)


(2 lone pair)


(1 lone pair)

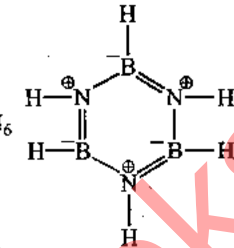

(3 lone pair)

17. (d) (a) Phosphorous acid is $H_3PO_3 \rightarrow$ Basicity: 2

(b) Perbromic acid is $HBrO_4 \rightarrow O = \overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{Br}} - OH$

No peroxy linkage

(c) γ-SO_3 is cyclic, β is helical chain.

(d) Borazine $\rightarrow B_3N_3H_6$ 

is having zero dipole moment.

19. (a) As we move from left to right in a period, electronegativity increases and acidic nature also increases (non-metals form acidic oxides)

64. (b) Ga is a soft silvery white metal and is liquid at room temperature. When it solidifies, it expands by 3.1 percent. Therefore, it should not be stored in glass or metal containers.

68. (d) $2BCl_3 + 3H_2 \xrightarrow[\text{discharge}]{\text{electric}} \underset{(A)}{B_2H_6} + 6HCl$

$B_2H_6 + 2NH_3 \longrightarrow B_2H_6 \cdot 2NH_3 \xrightarrow{200°C} B_3N_3H_6$

79. (a) $NO + NO_2 \xrightarrow{-30°C} N_2O_3$ (Pale blue)

86. (b) N_2 prevents the further reaction of P_4O_6 into P_4O_{10}.

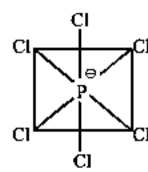
93. (b) $Na_2S_2O_3 + 4Cl_2 + 5H_2O \longrightarrow 2NaHSO_4 + 8HCl$

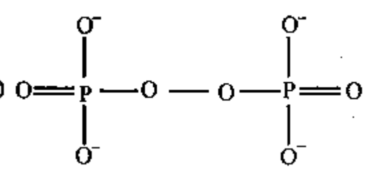
94. (c) $PBr_5(s) \rightarrow [PBr_4]^+ + Br^-$

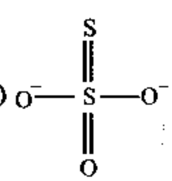
$N_2O_5(s) \rightarrow NO_2^+ + NO_3^-$ $(sp)^2$

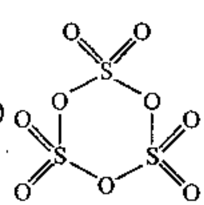
$PCl_5(s) \rightarrow PCl_4^+ + PCl_6^-$ (sp^3d^2)

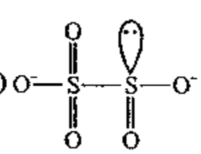
$Cl_2O_6(s) \rightarrow ClO_2^+ + ClO_4^-$ (sp^3)

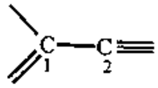


95. (c) (a)  $(P_2O_8^{4-})$

(b)  $(S_2O_3^{2-})$

(c)  (γ-SO_3 is cyclic)

(d)  $(S_2O_5^{2-})$

96. (d)  $\rightarrow sp^2$ hybridized

Therefore, more % *s*-character and least bond distance

$C_2 \rightarrow sp$ hybridized

115. (d) $Mg_3B_2 + HCl_{(aq)} \longrightarrow \underset{(X)}{B_2H_6} + MgCl_2$

$\underset{(X)}{B_2H_6} + 3H_2O \longrightarrow H_3BO_3 + 3H_2$

$B_2H_6 + O_2 \longrightarrow B_2O_3$

$H_3BO_3 \xrightarrow{\Delta} \underset{(Y)}{B_2O_3}$

In *Y*, B completes it octet by removing H^+ from water molecule.

116. (b) Solution

$B(OH)_3 + 2NH_4HF_2 \longrightarrow NH_4[BF_4] + NH_3\uparrow + 3H_2O$

126. (a) $AgCl + NH_3 \longrightarrow [Ag(NH_3)_2]^+ + Cl^-$

$(NH_4)Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$

$CaNCN + 3H_2O \longrightarrow \underset{\text{(white ppt.)}}{CaCO_3} + 2NH_3$

Multiple Correct Answers Type

1. (b), (d)

Hint: Lead prefers to form divalent compounds due to inert pair effect. In carbonate ion, all the three C—O bonds are equal due to resonance.

8. (a), (d)

$Cl_2 > Br_2 > F_2 > I_2$: Bond dissociation energy

$Cl_2 > F_2 > Br_2 > I_2$: Electron gain enthalpy

} correct trends

14. (a), (b), (c), (d)

(a) H_2, HD $\rightarrow$ 2 electron

(b) CO, $N_2 \rightarrow$ 14 electron

(c) HCl, $H_2S \rightarrow$ 18 electron

(d) D_2O, Ne $\rightarrow$ 10 electron

15. (a), (b), (c), (d)

S^{-2} and Sc^{+3} = 18 electrons

Species having same number of electrons are isoelectronic.

SO_2 and NO_3^- = 32 electrons

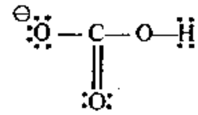
N_2 and CN = 14 electrons

NH_3 and H_3O^+ = 10 electrons

16. (a), (c)

$AlF_3 \rightarrow$ it is ionic. Therefore, Al^{3+} and $3F^-$ thus not hypovalent

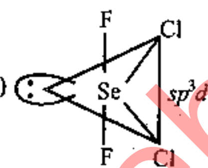
$AlCl_3 \rightarrow$ Covalent. Therefore, hypovalent

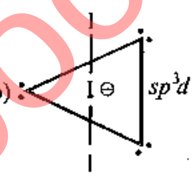
 $\rightarrow$ Complete octet

:C̤l̤ — Be — C̤l̤:

Hypovalent

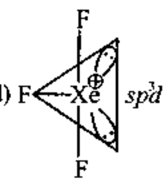
17. (a), (b), (d)

(a) 

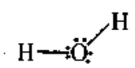
(b) 

(c) Cl—Be—Cl

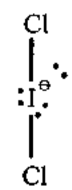
sp

(d) 

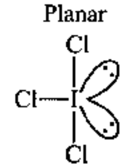
18. (a), (b), (c), (d)



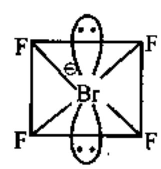
Bent
Planar



Linear planar



Bent
T-Shaped
Planar



Square Planar

19. (a), (d)

If surrounding atoms are not same and lone pairs are present then shape is not perfect.

20. (a), (b), (c)

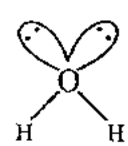
H—C≡N

$\downarrow$

sp

Dipole moment is directed from less electronegative to more electronegative and its dipole moment is non-zero.

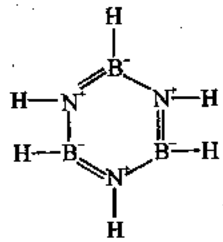
21. (b), (d)

(b) 

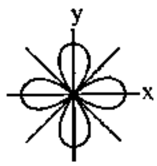
sp^3 bent shaped

(d) sp^2–hybridization with one lone pair is bent shaped.

22. (a), (d)



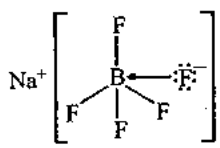
Molecularplane is nodal plane for π-bonds.



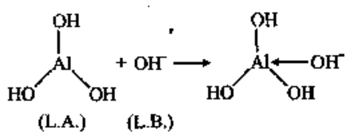
Nodal plane are at 45° with x and y-axis and perpendicular xy plane.

23. (b), (d)

(i) BF_3 (L.A.) + NaF (L.B.) $\longrightarrow$ $Na^+[BF_4]^-$

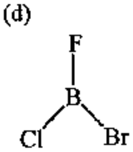


(ii)



24. (a), (c), (d)

(i)

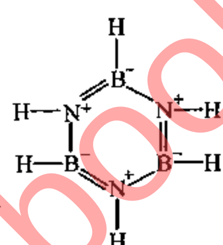


sp^2, Trigonal Planar

Polar

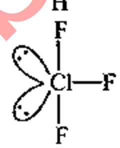
All atoms are sp^2 hybridized.

(ii)



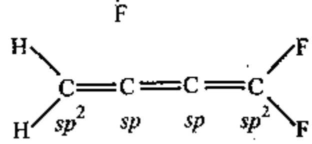
Overall molecule is planar. Non-polar.

(iii) ClF_3



Planar, Polar

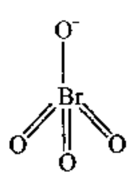
(iv)



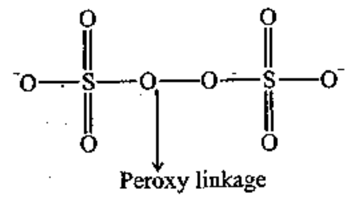
Planar, Polar

37. (b), (c), (d)

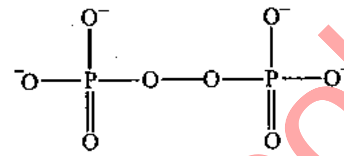
(a)



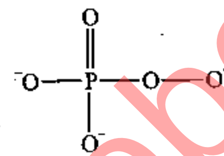
(b)



(c)



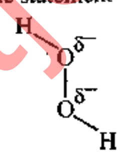
(d)

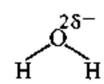


38. (a), (b), (c)

(a) The more polar a bond is, the more stronger is H-bonding H—F > H—O > H—N [Order of strength]

(b) True statement

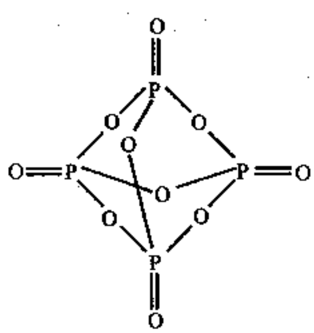




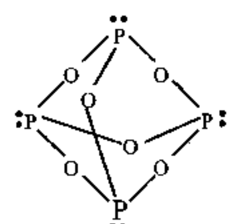
(c)

Strength is more in H_2O as it has $2\delta^-$ charge, but extent is more in H_2O_2 as it forms 6H bonds and H_2O forms 4 hydrogen bonds.

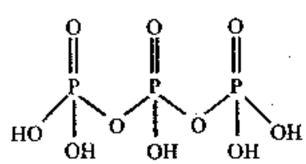
39. (b), (d)



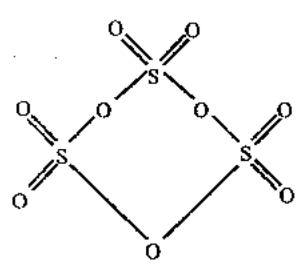
P_4O_{10}



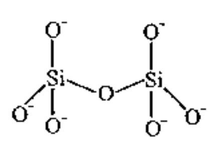
P_4O_{10}



$H_5P_3O_{10}$



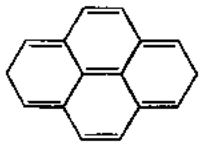
S_3O_9



45. (b), (c)

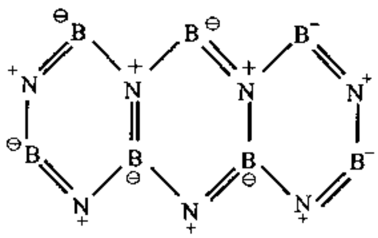
With $(CH_3)_3N$, B_2H_6 forms an adduct, $(CH_3)_3N \rightarrow BH_3$

52. (a), (c), (d)



Graphite have a layered structure and each C-atom is sp^2 hybridized

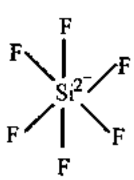
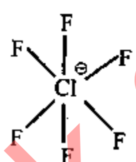
(No charge separation as all atoms are carbon.)



Inorganic graphite $(BN)_x$

Non-conducting, slippery in nature and 2-D layered structure. All atoms are sp^2-hybridized.

53. (c), (d)

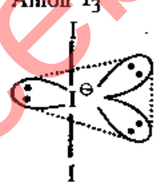
 

All the bond lengths are not equal as size of central atom is different.

Comprehension Type

1. (c) $I_2 + KI \rightarrow K^+[I_3^-]$

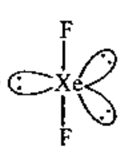
Anion I_3^-

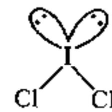


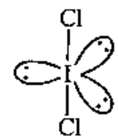
Hybridization $\rightarrow sp^3d$

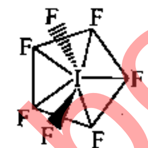
Geometry $\rightarrow$ Linear, and it is planar and non-polar.

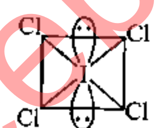
4. (d) A = Xe

Compound = XeF_2 Geometry $\Rightarrow$  sp^3d, Linear

5. (d) ICl_2^+  sp^3

ICl_2^-  sp^3d

IF_7  sp^3d^3

ICl_4^-  sp^3d^2

12. (c) $\overset{2-}{H_2S} + H_2\overset{1-}{O_2} \xrightarrow{} \overset{0}{S} + 2H_2\overset{2-}{O}$ (oxid, red)

65. (d) $4BF_4 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$

$3B_2H_6 + 6NH_3 \longrightarrow 3[B_2H_6 . 2NH_3] \xrightarrow{\text{heating}} 2B_3N_3H_6$

$BF_3 + 3H_2O \longrightarrow B(OH)_3 + 3HF$

$3BF_3 + 3HF \longrightarrow 3H[BF_4]$

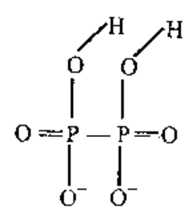
$4BF_3 + 3H_2O \longrightarrow 3H[BF_4] + B(OH)_3$

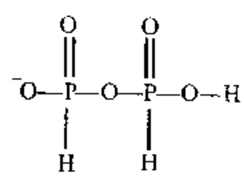
Assertion-Reasoning Type

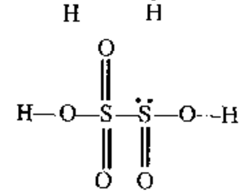
1. (d) Size of inert gases is larger than halogen because van der Waals' radius is considered for inert gas.

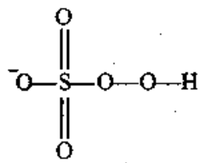
Matching Column Type

1. (a) p, q, r, s; (b) r, s; (c) p, q, r, s; (d) p, r, s, t

(a) $H_2P_2O_6^{2-}$ $\rightarrow$ 

(b) $H_3PO_5^-$ (Basicity = 2) $\rightarrow$ 

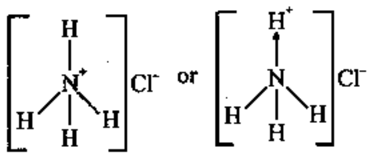
(c) $H_2S_2O_5$ $\rightarrow$ 

(d) HSO_5^- → 

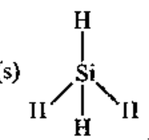
2. (a) p, q, r, s, t; (b) p, q, t; (c) r, t; (d) p, r, t

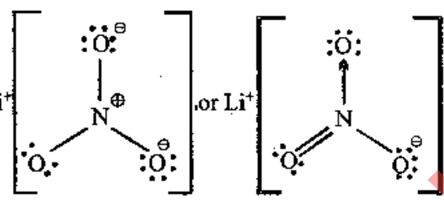
(p) :C≡O: or :C≡O: ⟶ A,B,D

(q) H–C≡N ⟶ A,B

(r) 

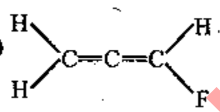
⟶ A,C,D

(s)  ⟶ A

(t) 

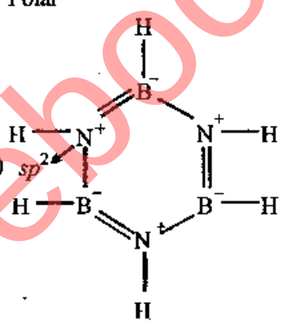
⟶ A,B,C,D

3. (a) s; (b) p, q; (c) r

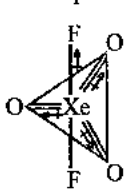
(a)  (s) Odd number of carbon atoms

Therefore, non-planar, surrounding atoms are not same.

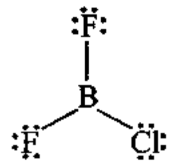
∴ Polar

(b)  (p,q) Non-polar and planar

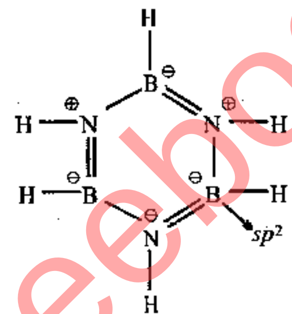
p_π-bond will be formed perpendicular to the σ-bond Therefore, nodal plane of the π-bond will be the molecular plane.

(c)  (r) Non-planar and non-polar

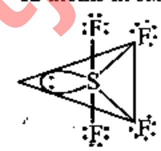
10. (a) s; (b) p, r, s; (c) q, t; (d) r, t

(a) 

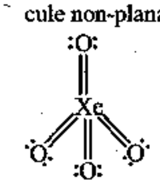
sp^2 hybridization, $\mu \neq 0$ (Polar). Total lone pairs = 9 and is planar; 4 atoms in same plane.

(b) 

sp^2 hybridized, Therefore planar, non-polar. 12 atoms in same plane.

(c) 

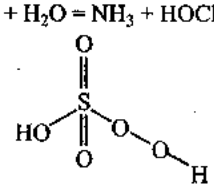
sp^3d hybridized. Total lone pairs = 13 molecule non-planar and polar.

(d) 

sp^3 Total *l.p.* = 8 non-planar and non-polar.

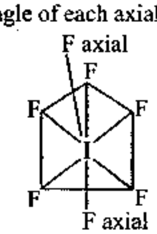
Integer Answer Type

6. (1) $NCl_3 + H_2O = NH_3 + HOCl$

11. (72) 

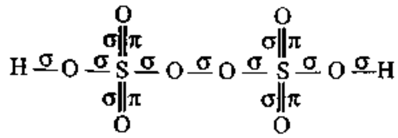
13. (10) $IF_7 \rightarrow sp^3d^3$ Pentagonal bipyronidal

Five 90° angle of each axial fluorine atom.



16. (4) CH_4

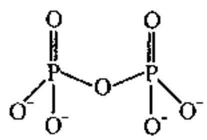
21. (114) Structure of peroxydisulphuric acid



23. (1) $Mg(OH)_2$ is a weak base and $Be(OH)_2$ and $Al(OH)_3$ are amphoteric in nature. $B(OH)_3$ can accept one hydroxyl ion from water and proton is released. Thus, it acts as a Lewis acid.

25. (6) Hypophosphate ion is →

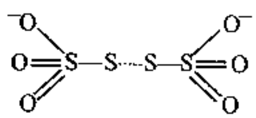
$$2H_3PO_4 \xrightarrow{-H_2O} H_4P_2O_7 \xrightarrow{-[O]} \underset{\text{Hypophosphoric acid}}{H_4P_2O_6}$$



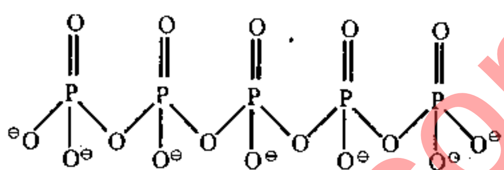
6 identical P—O bonds.

Hypophosphate ion

31. (3) $S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + I^-$



32. (9)



No. of P = O bonds 5

No. of P – O – P bonds = 4

Total = 5 + 4 = 9

NCERT Exemplar Exercises

Short Answer Type

2. Boric acid acts as Lewis acid in water by accepting a pair of electrons from water: $B(OH)_3 + 2HOH \rightarrow [B(OH)_4]^- + H_3O^+$

3. Species present in water is $[B(OH)_4]^-$. Boron is sp^3 hybridized.

4. BCl_3 and $AlCl_3$ being electron deficient due to incomplete octet of central metal atom behave as Lewis acids.

5. CCl_4 is a non polar covalent compound. Hence, insoluble in water whereas $SiCl_4$ is soluble because Si atom in $SiCl_4$ can accomodate the lone pair of electrons obtained from oxygen atom of water molecule in *d*-orbitals.

6. (a) Very high Si-O bond enthalpy and ionic character of Si-O bond.

(b) Vacant 3*d* orbitals are available on Si atom to accommodate electrons and expand its coordination number up to 6.

8. [**Hint:** In CO_2, carbon is *sp* hybridized and it is a linear molecule. In SiO_2, Si is tetrahedrally bonded to four oxygen atoms.]

9. Negative

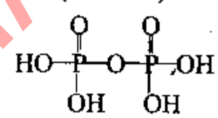
11. [**Hint:** Conc. HNO_3 renders aluminium passive by forming a protective oxide layer on the surface.]

13. A : $Na_2B_4O_7$ (Borax)
X : H_3BO_3
Z : B_2O_3

14. Z : BF_3
X : B_2H_6
Y : H_3BO_3

15. Acid fog is formed, which is difficult to condense.

16. $4NH_3 + \underset{\text{(From air)}}{5O_2} \xrightarrow[\text{500K, 9bar}]{\text{Pt/Rauge catalyst}} 4NO + 6H_2O$

17.  Pyrophosphoric acid

18. NH_3 forms hydrogen bonds with water therefore it is soluble in it but PH_3 cannot form hydrogen bond with water so it escapes as gas.

19. [**Hint:** It has trigonal bipyramidal geometry]

20. In gaseous state NO_2 exists as monomer which has one unpaired electron but in solid state it dimerizes to N_2O_4 so no unpaired electron is left hence solid form is diamagnetic.

21. Because fluorine is more electronegative as compared to chlorine.

22. Bond angle of H_2O is larger, because oxygen is more electronegative than sulphur therefore bond pair electron of O–H bond will be closer to oxygen and there will be more bond–pair bond–pair repulsion between bond pairs of two O–H bonds.

23. Due to small size of fluorine six F atom can be accomodated around sulphur whereas chloride ion is comparatively larger in size, therefore, there will be interatomic repulsion.

24. A is PCl_5 (It is yellowish white powder)

$P_4 + 10Cl_2 \rightarrow 4PCl_5$

B is PCl_3 (It is a colorless oily liquid)

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

Hydrolysis products are formed as follows:

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$

$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$

25. $NO_3^- + 3Fe^{2+} + 4H^+ \rightarrow NO + 3Fe^{3+} + 2H_2O$

$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5(NO)]^{2+} + H_2O$
(brown complex)

26. Oxygen is more electronegative than chlorine, therefore dispersal of negative charge present on chlorine increases from ClO^- to ClO_4^- ion because number of oxygen atoms attached to chlorine is increasing. Therefore, stability of ions will increase in the order given below:

$ClO^- < ClO_2^- < ClO_3^- < ClO_4^-$

Thus due to increase in stability of conjugate base, acidic strength of corresponding acid increases in the following order

$HClO < HClO_2 < HClO_3 < HClO_4$

28. $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$

$H_3PO_3 + 2NaOH \rightarrow Na_2HPO_3 + 2H_2O] \times 4$ (Neutralization reaction)

$P_4O_6 + 8NaOH \rightarrow 4Na_2HPO_4 + 2H_2O$

1 mol 8 mol

Product formed by 1 mol of P_4O_6 is neutralized by 8 mols of NaOH

$\therefore$ Product formed by $\frac{1.1}{220}$ mol of P_4O_6 will be neutralized by $\frac{1.1}{220} \times 8$ mols of NaOH.

Molarity of NaOH solution is 0.1M

$\Rightarrow$ 0.1 mol NaOH is present in 1 L solution

$\therefore \frac{1.1}{220} \times 8$ mols of NaOH is present in $\frac{1.1 \times 8}{220 \times 0.1}$ L

$= \frac{88}{220}$ L $= \frac{4}{10}$ L $= 0.4$ L

= 400 mL of NaOH solution

29. $P_4 + 6Cl_2 \rightarrow 4PCl_3$

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl] \times 4$

$P_4 + 6Cl_2 + 12H_2O \rightarrow 4H_3PO_3 + 12HCl$

1 mol of white phosphorus produces 12 mols of HCl

62 g of white phosphorus has been taken which is equivalent to $\frac{64}{124} = \frac{1}{2}$ mol.

Therefore 6 mols HCl will be formed.

Mass of 6 mols HCl $= 6 \times 36.5 = 219.0$ g HCl

30. Three oxoacids of nitrogen are

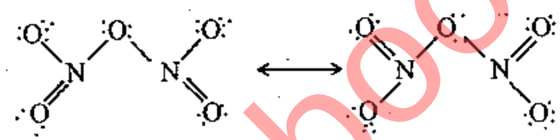
(a) HNO_2, Nitrous acid

(b) HNO_3, Nitric acid

(c) Hyponitrous acid, $H_2N_2O_2$

$3HNO_2 \xrightarrow{\text{Disproportionation}} HNO_3 + H_2O + 2NO$

31. $4HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + 2N_2O_5$



32. (a) Structures

White phosphorus is discrete tetrahedral molecule. Thus it has tetrahedral structure with six P–P bonds.

Red phosphorus has polymeric structure in which P_4 tetrahedra are linked together through P—P bonds to form chain.

(b) Reactivity

White phosphorus is much more reactive than red phosphorus. This is because in white phosphorus there is angular strain in P_4 molecules because the bond angles are only of 60°.

33. Dilute and concentrated nitric acid give different oxidation products on reaction with copper metal.

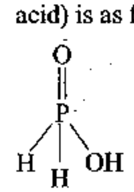
$3Cu + 8HNO_3 \text{ (dil.)} \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

$Cu + 4HNO_3 \text{ (Conc.)} \rightarrow 3Cu(NO_3)_2 + 2NO_2 + 2H_2O$

34. $PCl_5 + 2Ag \rightarrow 2AgCl + PCl_3$

$AgCl + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+ Cl^-$
(soluble compled)

35. Structure of phosphinic acid (Hypophosphorous acid) is as follows:



Reducing behavior of phosphinic acid is observable in the reaction with silver nitrate given below:

$4AgNO_3 + 2H_2O + H_3PO_2 \rightarrow 4Ag + 4HNO_3 + H_3PO_4$

Long Answer Type

5. [**Hint:** Absence of *d*-orbitals in boron.]

8. $A = B_2H_6$, $B = BH_3 \cdot NMe_3$, $C = B(OH)_3$ i.e. H_3BO_3.

11. 'A' is S_8 'B' is SO_2 gas

$$S_8 + 8O_2 \xrightarrow{\Delta} 8SO_2$$

$$\underset{\text{(violet)}}{2MnO_4^-} + 5SO_2 + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + \underset{\text{(colorless)}}{2Mn^{2+}}$$

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

12. $Pb(NO_3)_2 \xrightarrow[673\,K]{\Delta} PbO + 2NO_2$

(A)

(Brown color)

$$2NO_2 \underset{\text{Heating}}{\overset{\text{On cooling}}{\rightleftharpoons}} N_2O_4$$

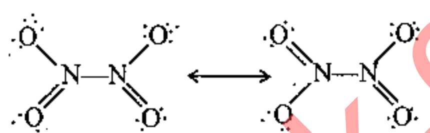
(B)

(Colorless solid)

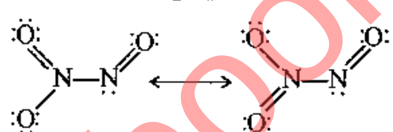
$$2NO + N_2O_4 \xrightarrow{\Delta 250\,K} 2\,N_2O_3$$

(C)

(Blue solid)



(Structure of N_2O_4)



(Structure of N_2O_3)

13. $A = NH_4NO_2$ $B = N_2$ $C = NH_3$ $D = HNO_3$

(a) $NH_4NO_2 \rightarrow N_2 + 2H_2O$

(b) $N_2 + 3H_2 \rightarrow 2NH_3$

(c) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$2NO + O_2 \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) The water obtained from natural sources often contains suspended impurities. Alum is added to such water to coagulate the suspended impurities and make water fit for drinking purposes.

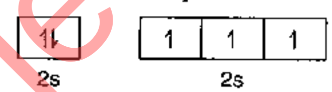
2. (d)

XeF_2	XeF_4	XeF_6
No. of σ bond = 2	No. of σ bond = 4	No. of σ bond = 6
No. of lp = 3	No. of lp = 2	No. of lp = 1

There are eight electrons in the outermost orbit of Xe and F is always monovalent.

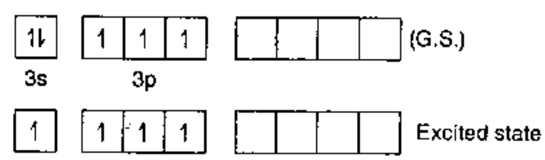
3. (a) No. of bonds = No. of unpaired electrons in the outermost orbit of central atom in ground or excited state

$N - 1s^2 2s^2 2p^3$



N can form 3 normal bonds in ground state, but it cannot form bond in excited state because there is no vacant orbitals in the outermost orbit, that is, 2nd orbit.

$P - 1s^2 2s^2 2p^6 3s^2 3p^3$ Ground state



Phosphorous can form 3 bonds in ground state and 5 bonds in excited state because it has vacant 3d-orbitals in the outermost orbit.

(b) N has more electronegativity than P but P has more negative electron gain enthalpy than N.

(c) Due to more electronegativity, N, O, and F can form hydrogen bond.

(d) P exist at P_4 molecule and N as N_2 molecule due to strong catanation property of P than N, it exist in solid state.

4. (c)

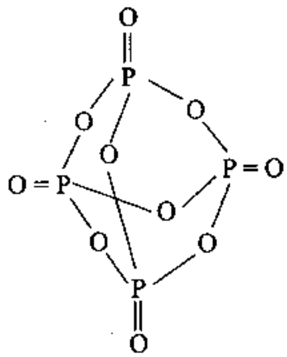
(a) HF is more polar than HBr. Dipole moment of HF is 1.78 D and of HBr is 079 D.

(b) N has more electronegativity than P, but P has more negative electron gain enthalpy than N.

(c) Due to more electronegativity, N, O, and F can form hydrogen bond.

(d) P exist as P_4 molecule and N as N_2 molecule due to strong catenation property of P than N it in solid state.

5. (d)



Number of σ bonds = 12

Number of π bonds = 4

6. (d) $CaOCl_2$ is actually $Ca(OH)_2 \cdot CaCl_2 \cdot Ca(OCl)_2 \cdot 2H_2O$

It contains Ca^{2+}, Cl^-, and OCl^-.

The oxidation number of Cl is –1 and +1.

7. (a) PH_3 is highly poisonous; it explodes with traces of oxidizing agent like HNO_3Cl_2 and Br_2 vapors.

$PH_3 + BCl_2 \rightarrow PCl_3 + 3HCl \ \Delta H = -ve$

8. (a) $2HCl(g) + \frac{1}{2}O_2(g) \rightarrow H_2O + Cl_2(g)$

Hydrogen has more affinity to oxygen than chlorine.

9. (c) Graphite is a covalent solid in which each carbon is attached with three other carbon atoms. In order to melt graphite, the strong covalent bond has to be broken; hence, the melting point of graphite is high.

10. (a) Glass is an example of amorphous solid. Glass shows the tendency to flow like liquid; hence, it is also known as supercooled liquid.

11. (b)

(a) H_2S is acidic in nature.

(b) NH_3 and PH_3 is basic but the basicity of NH_3 is more than PH_3 due to high charge density of *lp* in sp^3 hybridized orbital of NH_3, whereas in case of PH_3, *lp* is present in pure 3S orbital.

(c) H_2O is neutral.

12. (d) Among the given metals, mercury has lowest MP, which means lowest freezing point.

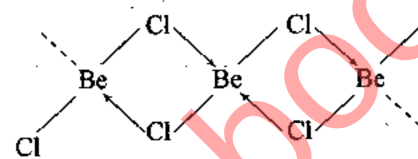
13. (d) The anomalous behavior of fluorine is due to small size, highest electronegativity, low F–F bond dissociation enthalpy and non-availability of *d*-orbitals in valence shell.

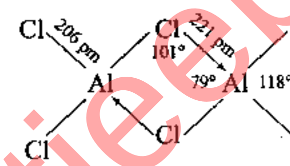
14. (c) He gas is heavier gas than H_2 gas. It is used instead of H_2 gas because H_2 is inflammable gas, whereas He is non-inflammable gas.

15. (c)

(a) $BeCl_2(s)$ and $AlCl_3(s)$ are dimers.

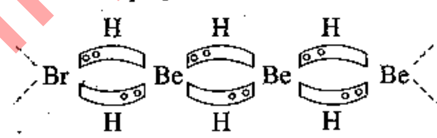
Anhydrous $BeCl_2$ is polymeric.

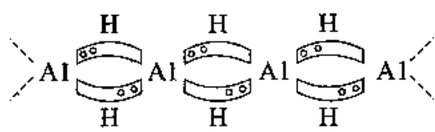




(b) $BeH_2(s)$ and $AlH_3(s)$ are polymers.

It exists in polymeric form.





(c) Be is second period element; Its maximum covalency is 4. Al is third period element; its maximum covalency is 6 due to vacant 3*d*-orbitals.

(d) $\left.\begin{array}{l} Be(OH)_2 \\ Al(OH)_3 \end{array}\right]$ both are amphotaric means they can react with acid as well as base.

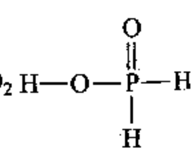
16. (b) When $AlCl_3(s)$ is dissolved in water, the high enthalpy of hydration is sufficient to break the covalent dimmer into $[Al(H_2O)_6]^{3+}$ and $3Cl^-$.

17. (b) $4KI(aq) + 2CuSO_4(aq) \rightarrow Cu_2I_2(s) + 2K_2SO_4(aq) + I_2$

$I_2 + 2Na_2S_2O_3(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$

18. (b) $\underset{\text{(diamond)}}{\underset{\text{grey}}{Sn(s)}} \xrightleftharpoons{13.2^\circ C} \underset{\text{(metalic)}}{\underset{\text{white}}{Sn(s)}}$

19. (c) Hypophosphorous acid H_3PO_2



Shortcut method to remember only applicable to H_3PO_4, H_3PO_3, and H_3PO_2. No. of replaceable H atom = No. of O atom in a molecule-1.

20. (c) The thermal stability of these halides decreases down the group due to decrease in bond (H–X) dissociation enthalpy, which 574 kJ/mol, 432 kJ/mol, 363 kJ/mol, and 295 kJ/mol for HF, HCl, HB and HI, respectively.

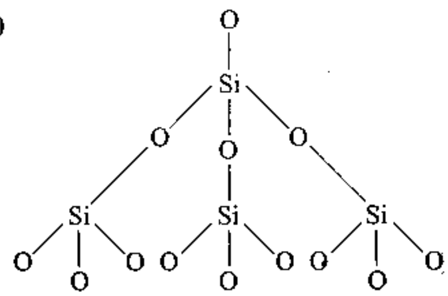
21. (b) $[Al(H_2O)_6]Cl_3 \xrightarrow{\Delta} Al(OH)_3 + 3HCl + 3H_2O$

$2[Al(H_2O)_6]Cl_3 \xrightarrow{\Delta} Al_2O_3 + 6HCl + 9H_2O$

$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

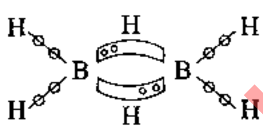
Note: We cannot obtain anhydrous $AlCl_3$ on heating hydrated $AlCl_3$.

22. (d)



SiO_2 is a 3D network solid in which each silicon atom is surrounded by 4 oxygen atoms, and each oxygen atom is surrounded by two silicon atoms.

23. (d)



B_2H_6: Four two-centered 2 electron bonds and two three-centered two electron bonds.

24. (b)

(a) $HClO_4$ is a stronger acid than $HClO_3$.

(b) HNO_3 is a stronger acid than HNO_2.

(c) H_2SO_3 is a stronger acid than H_3PO_3.

(d) HCl is stronger acid than HF.

25. (b) In general, the ionization energy increases from left to right in a period and decreases from top to bottom. The ionization energy of N is greater than O and P is greater than S due to half-filled P sub-orbit.

26. (b) $HClO \rightarrow HCl + HClO_3$

27. (d)

(a) $Br_2 + NaOH \rightarrow NaBr + NaBrO_3 + H_2O$

(b) $SO_2 + O_3 \rightarrow SO_3$

(c) $Si + 2NaOH(aq) + O_2 \rightarrow Na_2SiO_3 + H_2O$

(d) $Cl_2 + \underset{\text{excess}}{NH_3} \rightarrow NH_4Cl + N_2$

$\underset{\text{excess}}{Cl_2} + NH_3 \rightarrow \underset{\text{(explosive)}}{NCl_3} + HCl$

28. (a)

(a) Ammonium sulphate is a salt of weak base and strong acid. Its solution is acidic due to hydrolysis of atom.

(b) Potassium nitrate is a salt of strong base and strong acid. Its solution is neutral.

(c) Urea is basic in nature.

(d) Super phosphate of lime is $Ca(H_2PO_4)_2 + 7CaSO_4$.

29. (d) Stability of dihalides increases steadily down the group.

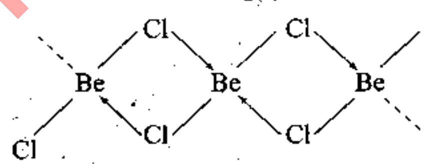
30. (c)

(a) Boric acid is Lewis acid. It accepts OH^- from base. It is not protonic acid.

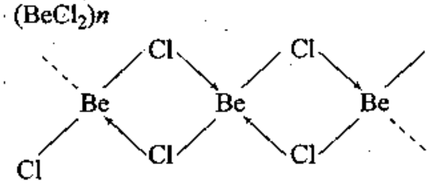
$$B(OH)_3 + NaOH \rightarrow Na[B(OH)_4]$$

(b) The maximum coordination number of beryllium is 4 because it is 2nd period element. It cannot form 6 bonds because it has no vacant *d*-orbitals in the outermost orbit.

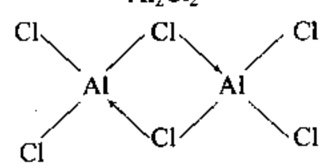
$BeCl_2(s)$



(c) $(BeCl_2)n$

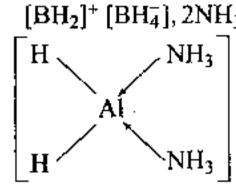


Al_2Cl_2



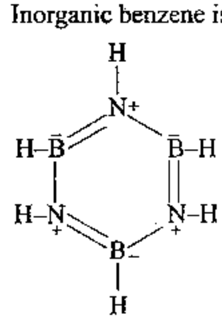
(d) $B_2H_6 \cdot 2NH_3$ is

$[BH_2]^+ [BH_4^-], 2NH_3$



$[BH_4^-]$

Inorganic benzene is $B_3N_3H_6$.



31. (d)

(a) XeF_4 is hydrolyzed to give Xe, XeO_3, HF, and O_2.

(b) XeF_2 is hydrolyzed to give Xe, HF, O_2.

(c) $XeF_6 + RbF \rightarrow Rb^+[XeF_7]^-$

(d) $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

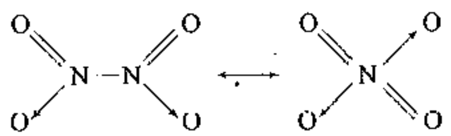
XeF_6 is hydrolyzed to give XeO_3 reaction, which is spontaneous in forward direction not in backward direction.

32. (a)

(a) Stability of NH_3 to BiH_3 decreases down the group due to increase in M–H bond length.

(a) Nitrogen has no vacant d-orbital in the outermost orbit, and hence, cannot form $d\pi-p\pi$ bond.

(c) N–N bond is weaker than P–P bond; hence, Nitrogen exist as N_2 and phosphorous as P_4.

(d) 

33. (d)

(a) S_2 molecule is paramagnetic like O_2 and both have two unpaired electrons. At elevated temperatures (~ 1000 K), S_2 is the dominant species and is paramagnetic lie O_2.

(b) The vapor at 200°C consists mostly of S_8 rings.

$$S_8(g) \xrightarrow{600°C} S_2(g)$$

(c) $\uparrow$ 200°C

$S_8(S)$

(d) Maximum oxidation state of 'S' is +6, e.g., SF_6.

34. (a) Maximum covalancy of B is 4; it cannot from 6 bonds because it has no vacant orbital in the outermost orbit.

35. (c)

(a) Chloro floro carbon (CFC) depletes ozone.

(b) Ozone absorbs ultraviolet radiation.

(c) Oxides of nitrogen in the atmosphere can cause the depletion of ozone layer like nitrogen oxides.

$$O_3 + NO \rightarrow NO_2 + O_2$$

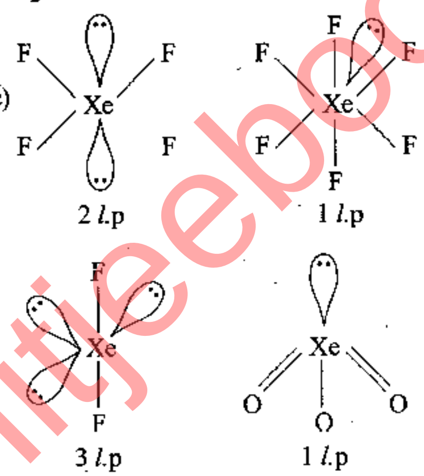
36. (b) The electron affinity of F is less than Cl due to small size of 2P orbital of F atom than 3P-orbital of Cl atom. The negative value of electron gain enthalpy is the highest.

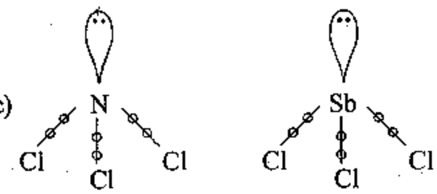
37. (c) $PbO_2 + Pb \rightarrow 2PBO, \quad \Delta_rG° < 0$

PbO is more stable than PbO_2.

$SnO_2 + Sn \rightarrow 2SnO, \Delta_rG° > 0$

SnO_2 is more stable SnO.

38. (c) 

39. (c) 

The electronegativity (EN) difference between Sb and Cl is more; hence, shared electrons are shifted more towards Cl atom. Therefore, b.p.–b.p. repulsion will be less.

40. (c) In set 1: $Al(OH)_4^-$ is formed

In set 2: Al^{+3} and H_2O is formed

41. (c) $CaF_2 + H2SO_4 \rightarrow H_2F_2 + Ca(HSO_4)_2$

$SiO_2 + 2H_2F_2 \rightarrow SiF_4 + 2H_2O$

$SiF_4 + H_2O \rightarrow H_2[SiF_6]$

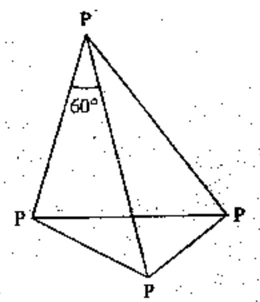
JEE (Advanced) Exercises

Fill in the Blanks Type

1. Iodine reacts with hot NaOH solution. The products are NaI and $\mathbf{NaIO_3}$.

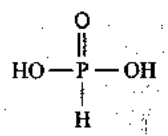
$$\underset{\text{(Hot concentrated)}}{6NaOH} + 3I_2 \rightarrow 5NaI + NaIO_3 + 3H_2O$$

2. **White/yellow** phosphorus is reactive because of its highly strained tetrahedral structure.



Yellow or white
Six P-P bonds

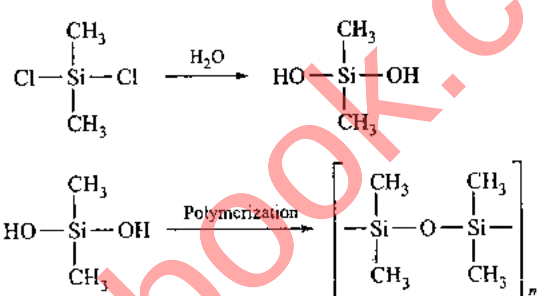
3. The basicity of phosphorus acid (H_3PO_3) is 2.



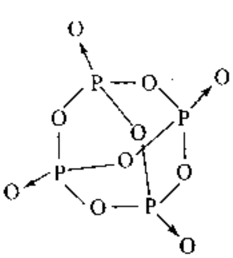
H_3PO_3

Only those hydrogens are replacable that are attached to oxygen and contribute to basicity. From the structure, it is clear that phosphorus acid (H_3PO_3) is dibasic.

4. The hydrolysis of alkyl substituted chlorosilanes gives **silicones**.



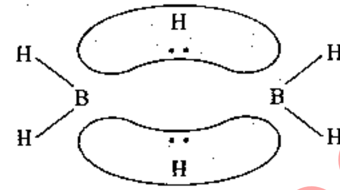
5. In P_4O_{10}, the number of oxygen atoms bonded to each phosphorus atom is **4**.



6. The lead chamber process involves oxidation of SO_2 by atomic oxygen under the influence of **nitrogen dioxide** as catalyst.

7. The hydrolysis of trialkylchlorosilane, R_3SiCl, yields $\mathbf{R_3Si(OH)}$ which may further form silicone.

8. The two types of bonds present in B_2H_6 are covalent and **banana bonds** (three-center two-electron bonds)

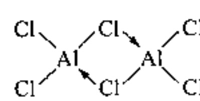


9. One recently discovered allotrope of carbon (e.g., C_{60}) is commonly known as **Buckeminsterfullerene**.

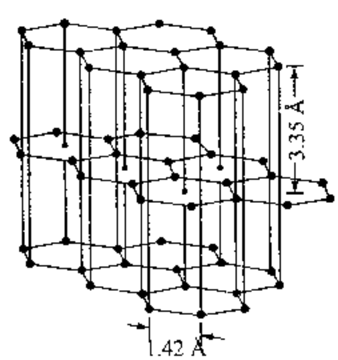
10. A liquid which is permanently supercooled is frequently called a **glass**.

True/False Type

1. **False.**
   PbO_2 with dilute acid does not give hydrogen peroxide, because it does not have a peroxide bond in it.
2. **False.**
   CCl_4 gives phosgene gas with superheated steam only.
   $CCl_4 + H_2O \rightarrow COCl_2 + 2HCl$
3. **True.**
   Dilute HCl oxidizes metallic Fe to Fe^{2+}.
   $Fe + 2HCl \rightarrow FeCl_2 + H_2$
4. **False.**
   The oxidizing power decreases from fluorine to iodine.
5. **True.**
   In hydrides of group 15, bond angle decreases down the group.
6. **True.**
   Graphite is a better lubricant on the moon than on earth because less gravitational attraction on moon as compared to earth.
7. **False.**



   Bridging chlorine bonds are different than terminal chlorine bonds.
8. **False.**
   Nitric oxide (NO) is paramagnetic.
9. **True.**



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to three other carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its p-orbital. This electron then overlaps with the other to form a π-bond. It is a soft structure and layers can slide past one another.

In diamond, each carbon atom is in sp^3-hybridized state and linked to four other carbon atoms tetrahedrally by covalent bonds. This gives a giant three-dimensional polymeric structure.

As the atoms are held firmly by strong covalent bonds, diamond is a very hard substance,

10. False.

The basic nature of the hydroxides of group 13 [Gr. III (b)] increases progressively down the group because the electropositive character of elements increases.

11. True.

The tendency for catenation is much higher for C than for Si. Due to smaller size of carbon, bonds are stronger.

12. False.

The strength of acidic character in halogen acids increases from HF to HI down the group.

Single Correct Answer Type

1. (a) Molecular weight of NO = 14 + 16 = 30

$$\text{Vapor density} = \frac{M}{2} = \frac{30}{2} = 15$$

Molecular weight of O_2 = 16 + 16 = 32

$$\text{Vapor density} = \frac{M}{2} = \frac{32}{2} = 16$$

Therefore, NO is lighter than O_2.

2. (d) $NH_3 \xrightarrow{H_2SO_4} (NH_4)_2SO_4$

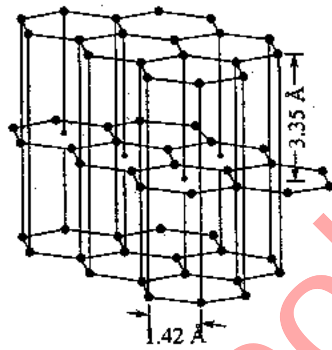
$NH_3 \xrightarrow{CaCl_2} CaCl_2 \cdot 8NH_3$

$NH_3 \xrightarrow{P_2O_5} (NH_4)_3PO_4$

Only CaO can be used for drying of ammonia as it does not react with ammonia.

3. (d) HF does not behave as a reducing agent. Therefore, it cannot be oxidized by any of these.

4. (b)



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to other three carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its p-orbital. This electron then overlaps with the other to form a π-bond. The π-electrons are free to move throughout the layers, so graphite is a good conductor of electricity.

5. (b) $Cl_2 + H_2O \rightarrow HCl + HClO$

$HOCl \rightarrow HCl + [O]$

Colored material + [O] $\rightarrow$ Colorless material

Therefore, chlorine acts as a bleaching agent only when moisture is present.

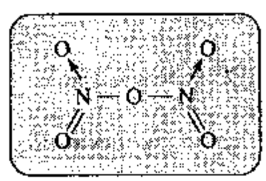
6. (b) Only true peroxides which have —O—O— bond give hydrogen peroxide with dilute acids.

$Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$

7. (c) SO_2 reacts with water to form sulphurous acid, so it cannot be collected over water.

$SO_2 + H_2O \rightarrow H_2SO_3$

8. (b) The bonds present in N_2O_5 are covalent as well as coordinate.



9. (d) NO_2 is a brown-colored gas.

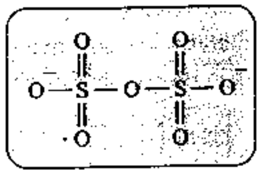
10. (a) Fluorine has the highest electronegativity, therefore in NF_3, the lone pair of electrons on nitrogen is the most difficult to donate. So it is least basic.

11. (b) Potassium bromide is oxidized by chlorine water and bromine is evolved.

12. (b) In the hydrides of group 15, the basic character decreases down the group. NH_3 is the strongest electron pair donor due to its small size as the electron density of the electron pair is concentrated over a small region. As the size increases, the

electron density gets diffused over a large region and hence the ability to donate the electron pair decreases. Therefore, the basic nature decreases.

13. (d)



14. (d) $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

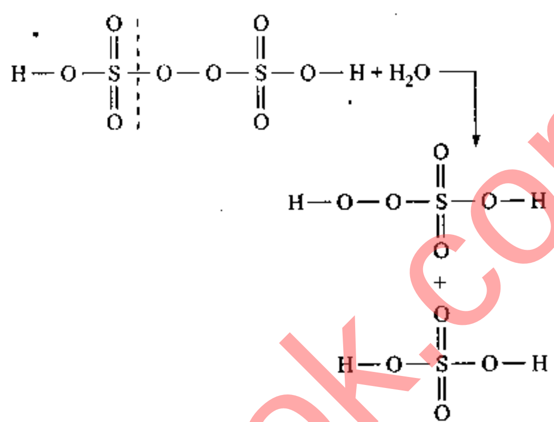
The oxidation state of O in $BaSO_4$ is –2.

The oxidation state of O in H_2O_2 is –1.

15. (a) Only true peroxides which have —O—O— bond give hydrogen peroxide with dilute acids.

PbO_2 does not give hydrogen peroxide with dilute acids. So it is not a true peroxide.

16. (c) Peroxodisulphuric acid ($H_2S_2O_8$) on partial hydrolysis gives 1 mol of peroxomonosulphuric acid and 1 mol of H_2SO_4.



17. (d) Due to strong inert pair effect, Pb^{2+} is more stable than Pb^{4+}. Non-existence of PbI_4 can be explained on the basis of strong oxidizing nature of Pb^{4+}. The iodide ions are reducing agents. In the presence of these ions, Pb^{4+} ions are reduced to Pb^{2+} ions.

$Pb^{4+} + 2I^- \rightarrow Pb^{2+} + I_2$

18. (a) CO, NO, N_2O, and H_2O are neutral oxides.

19. (a) For the same oxidation state, when the electronegativity of the halogen increases, the strength of the oxy acid increases.

HOCl > HOBr > HOI

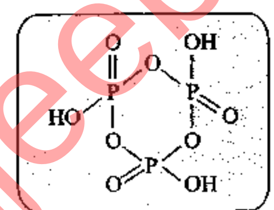
20. (b) There are some ions consisting of two or more electronegative atoms of which at least one is nitrogen that has properties similar to those of halide ions. These ions are called pseudohalide ions.

$RCOO^-$ is not a pseudohlide ion.

21. (b) BCl_3 is trigonal planar in structure and bond angles are 120° each. PCl_3, $AsCl_3$, and $BiCl_3$ are pyramidal in shape with sp^3-hybridization. In all of them, the bond angles are less than the normal tetrahedral angle of 109°28', and also these bond angles decrease down the group. Therefore, the correct order of bond angles is as follows:

$BCl_3 > PCl_3 > AsCl_3 > BiCl_3$

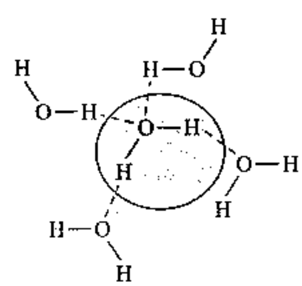
22. (c)



23. (a) $Cl_2O_7 > SO_2 > P_4O_{10}$

Going from left to right in the periodic table along a group, the acidic character of oxides goes on decreasing.

24. (a) In general, the boiling point of group 16 hydrides increases down the group because of increase in molecular mass, but in case of water, there is intramolecular hydrogen bonding, and so it has the highest boiling point.



25. (c) $NH_3 \xrightarrow{H_2SO_4} (NH_4)_2SO_4$

$NH_3 \xrightarrow{CaCl_2} CaCl_2 \cdot 8NH_3$

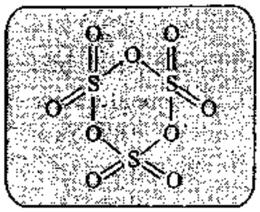
$NH_3 \xrightarrow{P_2O_5} (NH_4)_3PO_4$

Only CaO can be used for drying of ammonia as it does not react with ammonia.

26. (a) $HClO < HClO_2 < HClO_3 < HClO_4$

For the same halogen, the strength of the oxy-acids increases with increase in the oxidation state of the halogen.

27. (d)



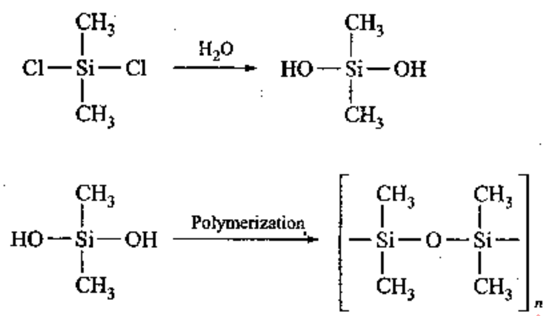
28. (a) $CaO < CuO < H_2O < CO_2$

Going from left to right in the periodic table along a group, the acidic character of oxides goes on decreasing.

29. (a) $B(OH)_3 + H_2O \rightarrow [B(OH)_4]^- + H^+$

H_3BO_3 is a monobasic weak Lewis acid.

30. (c)



31. (a) In alkaline medium, potassium permanganate oxidizes iodide salts to give iodate salts.

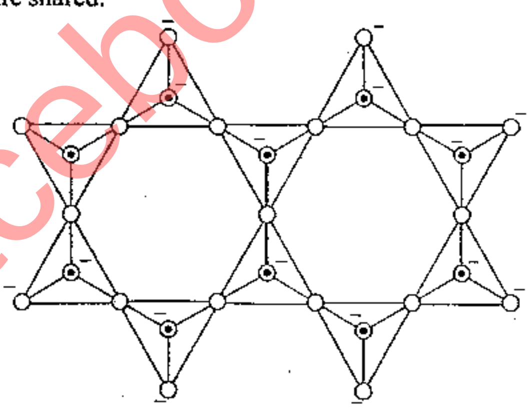
$2KMnO_4 + KI + H_2O \rightarrow 2KOH + 2MnO_2 + KIO_3$

32. (c) Black phosphorus is the most thermodynamically stable form of phosphorous.

33. (c) In $KMnO_4$, manganese is in its highest oxidation state of +7, and it cannot be oxidized any further.

34. (b) $NO_{(g)} + NO_{2(g)} \xrightarrow{-30°C} N_2O_3$ (Blue liquid)

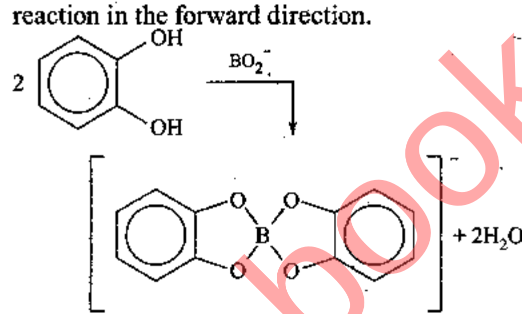
35. (b) In sheet silicates, three oxygen atoms of silicate are shared.



36. (a) $B(OH)_3 + NaOH \rightleftharpoons NaBO_2 + Na^+[B(OH)_4]^- + H_2O$

This reaction is reversible due to the hydrolysis of sodium metaborate, $NaBO_2$.

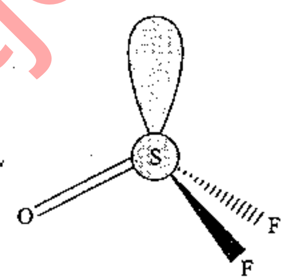
In the presence of complexing agents such as *cis*-1,2-diol, catechol, glycerol, etc., a complex is formed, and it prevents hydrolysis from taking the reaction in the forward direction.



37. (b) $P_4 + 3O_2 \xrightarrow{N_2} P_4O_6$

Nitrogen retards further oxidation of P_4O_6.

38. (d)



OSF_2

sp^3-Hybridization

Three bond pairs, one lone pair

Pyramidal shape

38. (d)

$NH_3 + CuO \xrightarrow{\Delta} N_{2(g)} + Cu_{(S)} + H_2O$

$NH_4NO_3 \xrightarrow{\Delta} N_2O_{(g)} + H_2O_{(g)}$

$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_{2(g)} + H_2O_{(g)} + Cr_2O_{3(s)}$

$Ba(N_3)_2 \xrightarrow{\Delta} Ba_3N_2 + N_{2(g)}$

Note: In the last reaction, we will get pure N_2 as no other gas is evolved.

40. (b) Conc. HNO_3 decomposes partly on long standing in light as follows:

$$2HNO_3 \rightarrow H_2O + 2NO_2 + \frac{1}{2}O_2$$

This NO_2 gets dissolved in remaining HNO_3 and turns its color yellow-brown which is due to the paramagnetic behavior of NO_2.

41. (c) $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

(P)

$XeO_3 + OH^-/H_2O \rightarrow HXeO_4^-$
(P) (Q)
$2HXeO_4^- \rightarrow Xe\uparrow + XeO_6^{4-} + O_2\uparrow + H_2O$
(Q)
Hence, there are two gaseous products Xe and O_2.

42. (a) $P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$

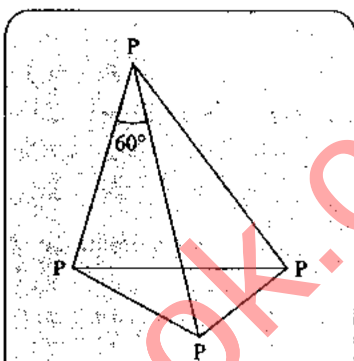
43. (a) $\underset{\text{Reducing agent}}{H_2O_2} + K\overset{+7}{I}O_4 \rightarrow O_2 + I$ (with oxidation state lower than 7)

$$40\,\overset{-1}{N}H_2OH + \underset{\substack{\text{Oxidizing}\\\text{agent}}}{10H_2O_2} \rightarrow 7H_2O + 20\,\overset{+3}{N_2}O_3$$

Multiple Correct Answers Type

1. (a), (d) Following two methods are used for the preparation of nitrous oxide:
$NH_4NO_3 \rightarrow N_2O + 2H_2O$
$NH_2OH{\cdot}HCl + NaNO_2 \rightarrow NaCl + 2N_2O + 2H_2O$

2. (a), (c), (d)



Yellow or white
Six P-P bonds

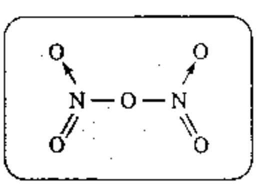
Every phosphorus atom has a lone pair of electrons.

3. (c) $2NH_3 + OCl^- \rightarrow H_2N{-}NH_2 + Cl^- + H_2O$

4. (b) When PbO_2 reacts with concentrated HNO_3, the gas evolved is oxygen.

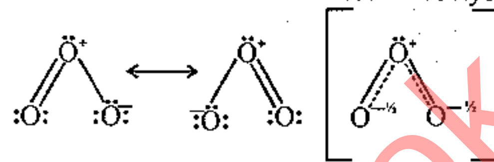
5. (a), (b), (c) Tertiary amines do not react in this reaction due to bulky methyl groups.

6. (a), (b), (c) N_2O_5 does not have an N—N bond.



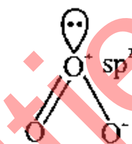
7. (a, c, d)
(a)

Resonance hybrid



Both bond length are identical

(b) $2O_3 \rightarrow 3O_2$ $\Delta H = -ve$
(c) All the e^- are paired in O_3 (diamagnetic)
(d) sp^2 hybridized "O" and bent shape molecule

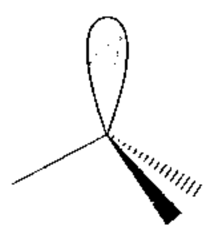


30. (b, d)
(a) It does not self-ionized in water and ionized in water as follows
$$H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$$
(b) Acidity of the aq.solution of boric acid not affected by ethylene glycol
(c) In boric acid due to hydrogen bonding two-dimensional sheet structure is formed.
(d) In water the pKa value of H_3BO_3 is 9.25
$$H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$$

Comprehension Type

1. (a) Argon is used in arc welding because of its low reactivity with metals. It causes an inert atmosphere without interaction with the metal.

2. (c)

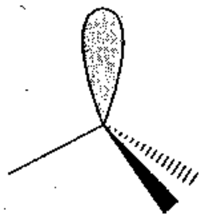


XeO_3
sp^3-Hybridization
Three bond pairs, one lone pair
Pyramidal shape

3. (a) XeF_4 and XeF_6 are expected to be oxidizing. In such reactions, the oxidation state of xenon is decreased.

4. (c) Between nitrates and phosphates, nitrates are less abundant in the earth's crust because most of them are soluble in water.

5. (c)



NH_3 is a better electron donor than phosphine because the lone pair of electrons occupies the sp^3-orbital and is more directional. It is easily donatable.

6. (b) Oxidation number increases as well as decreases, so this is called disproportionation reaction.

$P_4 + 3NaOH + 3H_2O \rightarrow 3NaH_2PO_2 + PH_3$

From $P_4 \rightarrow NaH_2PO_2$: 0 to +1

From $P_4 \rightarrow PH_3$: 0 to –3

7. (a) $\underset{}{Cl_2 + SO_2} \xrightarrow[\text{charcoal}]{\text{in presence of}} \underset{(R)}{SO_2Cl_2}$

$10\ \underset{(R)}{SO_2Cl_2} + P_4 \rightarrow \underset{(S)}{4PCl_5} + 10\ SO_2$

$\underset{(S)}{PCl_5} + 4H_2O \rightarrow \underset{(T)}{H_3PO_4} + 5\ HCl$

8. (a) $Cl_2 + 2NaOH\ (\text{dil. and cold}) \rightarrow NaCl + NaOCl + H_2O$

$5Cl_2 + 6NaOH\ (\text{conc. and hot}) \rightarrow 5NaCl + NaClO_3 + 3H_2O$

Assertion-Reasoning Type

1. (b) Statement-I and Statement-II are both correct but Statement-II is not the correct explanation for Statement-I. Nitrogen does not form pentahalides because it does not have *d*-orbitals. The electronegativity of N is greater than that of phosphorus.

2. (c) Statement-I is true; Statement-II is false. The O—H bond is stronger than the Al—O bond in aluminium hydroxide.

3. (a) Statement-I is true; Statement-II is true; Statement-II is the correct explanation for Statement-I. HNO_3 is a stronger acid than HNO_2.

4. (c) Statement-I is correct but Statement-II is incorrect. $SiCl_4$ also has covalent bonds. CCl_4 does not get hydrolyzed because carbon does not have vacant *d*-orbitals, so water cannot donate lone pair of electrons to start the reaction.

5. (c) Statement-I is true; Statement-II is false

$B(OH)_3 + H_2O \rightarrow [B(OH)_4]^- + H^+$

H_3BO_3 is a monobasic weak Lewis acid.

6. (a) Boron always forms covalent bond because boron requires very high energy to form a tripositive ion. Due to its very small size, B^{3+} has high polarizing power, so it forms covalent linkages according to Fajan rule.

7. (c) Statement-I is true; Statement-II is false. Down the group, the inert pair effect increases, therefore the higher oxidation state becomes less stable, and the lower oxidation state becomes more stable down the group. Pb^{4+} has a higher tendency to pass into Pb^{2+}, and is therefore a good oxidizing agent compared to Sn^{4+}.

Matching Column Type

1. (a) → (q, s); (b) → (s); (c) → (r); (d) → (q, r)

$Bi^{3+} + H_2O \rightarrow [BiO]^+ + 2H^+$

$NaAlO_2 + 2H_2O \rightarrow Al(OH)_3 + NaOH$

$2SiO_4^{4-} + 2H^+ \rightarrow Si_2O_7^{6-} + H_2O$

$Na_2B_4O_7 \xrightarrow{\text{Acid}} H_3BO_3$

$Na_2B_4O_7 \xrightarrow{H_2O} H_3BO_3$

2. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)

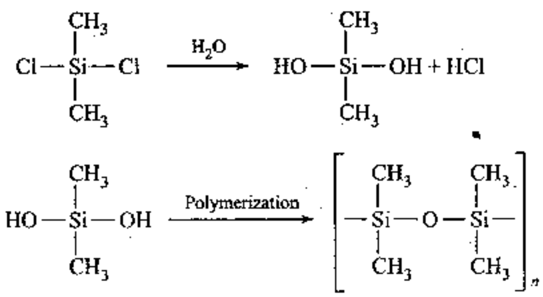
$3Cu + (\text{dil.})\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

$3Cu + (\text{conc.})\ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

$4Zn + (\text{dil.})\ 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

$Zn + (\text{conc.})\ 4HNO_3 \rightarrow Zn(NO_3)_2 + NO_2 + 2H_2O$

3. (a) → (p, s); (b) → (p, q, r, t); (c) → (p, q); (d) → (p)



$2XeF_4 + 3H_2O \rightarrow Xe + XeO_3 + 3H_2F_2 + F_2$

$Cl_2 + H_2O \rightarrow HCl + HClO$

$VCl_5 + H_2O \rightarrow VOCl + HCl$

4. (d)

(P) $PbO_2 + H_2SO_4 \xrightarrow{\Delta} PbSO_4 + O_2 + 2H_2O$

Other product = $2H_2O$

? = Δ

(Q) $Na_2S_2O_3 + 5H_2O \xrightarrow{4Cl_2} 2NaHSO_4 + 8HCl$

Other product = 8 HCl

? = Cl_2

(R) $N_2H_4 + 2I_2 \rightarrow N_2 + 4HI$

? = I_2

Other product = 4HI

(S) $XeF_2 + NO \rightarrow Xe + NOF$

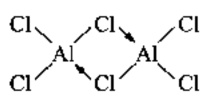
Other product = NOF

? = NO

Hence answer is (D)

Integer Answer Type

1. (6) The coordination number of Al in the crystalline state of $AlCl_3$ is 6.



2. (2) Among the following, the number of elements showing only one non-zero oxidation state is 2.
O, Cl, F, N, P, Sn, Tl, Na, Ti
Fluorine shows only –1 and sodium shows only +1.

3. (6) The total number of diprotic acids among the following is 6.

H_3PO_4, H_2SO_4, H_2CO_3, $H_2S_2O_7$, H_2CrO_4, H_2SO_3

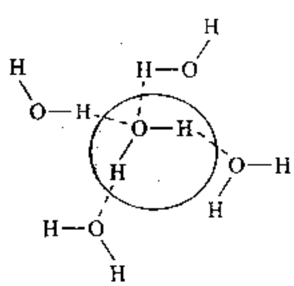
4. (3) The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is 3.

$2n + (2 \times 3) + (4 \times 6) + (18 \times -2) = 0$

or $n = 3$

Subjective Type

1. In water, there is intermolecular hydrogen bonding, and the molecules are associated. So it has a higher boiling point and occurs in liquid state.



Sulphur is less electronegative and cannot participate in hydrogen bonding, so in hydrogen sulphide there is no hydrogen bonding, and therefore it occurs in gaseous state with low boiling point.

2. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.
$2PbS + 3O_2 \rightarrow 2PbO + SO_2$
$PbS + 2O_2 \rightarrow PbSO_4$
$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$
$PbS + 2PbO \rightarrow 3Pb + SO_2$

3. (a) Hydrogen gas is evolved.

$$2Al + 2H_2O + 2NaOH \xrightarrow{\Delta} 2NaAlO_2 + 3H_2\uparrow$$

(b) Nitrogen gas is evolved.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + N_2\uparrow + 4H_2O$$

(c) Sulphur dioxide gas is evolved.

$$2Ag + 2H_2SO_4 \xrightarrow{\Delta} Ag_2SO_4 + SO_2\uparrow + 2H_2O$$

(d) Pink color of acidified potassium permanganate is discharged.

$$5H_2S + 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5S + 8H_2O$$

(e) Metastannic acid is formed.

$Sn + 4HNO_3 \rightarrow H_2SnO_3 + 4NO_2 + H_2O$

4. The precipitation of second group sulphides in the qualitative analysis is carried out with hydrogen sulphide in the presence of hydrochloric acid but not in nitric acid.
Nitric acid is a strong oxidizing agent and oxidizes H_2S into S. So, it cannot be used in the reactions involving hydrogen sulphide.

5. (a) $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

(b) $3Cu + (dil.)\, 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

(c) $2NaCl + 2H_2SO_4 + MnO_2 \rightarrow Na_2SO_4 + MnSO_4 + Cl_2\uparrow + 2H_2O$

(d) $Al_2O_3 + 3C + 3Cl_2 \xrightarrow{\Delta} 2AlCl_3 + 3CO$

(e) $SnO_2 + 2C \xrightarrow{\Delta} Sn + 2CO$

6. (i) $H_2SO_4 + 2HBr \rightarrow SO_2 + Br_2 + 2H_2O$

HBr is a stronger reducing agent, thus it reduces concentrated H_2SO_4 into SO_2 and itself gets oxidized to bromine.

(ii) Hypochlorous acid is acidic in nature, so it turns blue litmus red.

$HClO \rightarrow HCl + [O]$

It gives nascent oxygen, so it is also a bleaching agent, and the litmus gets decolorized.

7. (i) $2HNO_3 \rightarrow H_2O + 2NO_2 + \frac{1}{2}O_2$

In sunlight, slight decomposition of nitric acid produces nitrogen dioxide which is brown in color. It dissolves in nitric acid to give pale yellow color.

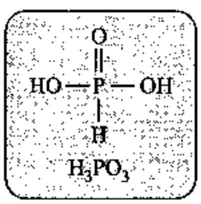
(ii) $CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$

In the presence of moisture, bleaching powder loses chlorine, so its bleaching action decreases.

8. (i) Sulphur consists of octa-atomic cyclic molecules. At its melting point, it becomes a clear liquid, and the rings slip over each other easily. On further heating to a higher temperature, the rings break and long chains are formed. Their network gives rise to a viscous substance.

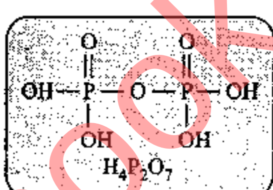
(ii) Potassium bicarbonate is more soluble than sodium bicarbonate. It cannot be filtered out and separated. Therefore, sodium carbonate is prepared by the Solvay process but the same process is not extended to the manufacture of potassium carbonate.

9. (i)



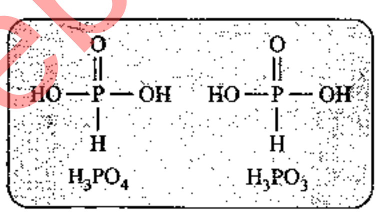
H_3PO_3

(ii)



$H_4P_2O_7$

10.



H_3PO_4 $\qquad$ H_3PO_3

Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structures it is clear that orthophosphoric acid, H_2PO_4, is tribasic but phosphorus acid, H_3PO_3, is dibasic.

11. $Al + NaOH \xrightarrow{\text{Aqueous}} NaAlO_2 + H_2O$

$NaAlO_2 \xrightarrow{CO_2} Al(OH)_3 + Na_2CO_3$

$Al(OH)_3 \xrightarrow{\Delta} \underset{\text{Alumina}}{Al_2O_3} + H_2O$

12. If CO_2 under pressure is allowed to escape through a nozzle, a white solid, dry ice is obtained. Solid CO_2 is a soft, white, snow-like substance. It sublimes and leaves no residue. So it is known as dry ice.

13. (i) $2HNO_3 + 6HCl \rightarrow 2NO + 3Cl_2 + 4H_2O$

(ii) $2Ce^{3+} + S_2O_8^{2-} \rightarrow 2SO_4^{2-} + 2Ce^{4+}$

(iii) $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$

14. *X*: $NaHCO_3$

Y: Na_2CO_3

A: CO_2

B: H_2O

$2MHCO_3 \xrightarrow{\Delta} M_2CO_3 + CO_2 + H_2O$

The gas *A* is carbon dioxide coming from a bicarbonate along with water *B*.

4.4 g CO_2 comes from 16.8 g of salt.

Then 44 g (1 mol) CO_2 must be coming from

$\frac{16.8}{4.4} \times 44 = 168 \text{ g of salt}$

So, the molecular mass of the salt is 168/2 = 84

Accordingly, M should be sodium.

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

$CO_2 + Ca(OH)_2 \rightarrow \underset{\text{Milkiness}}{CaCO_3\downarrow} + H_2O$

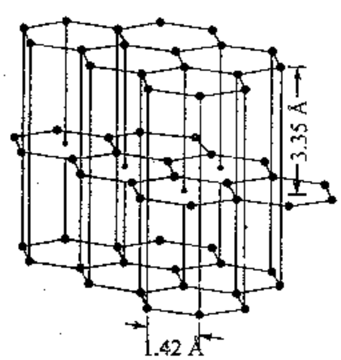
$Na_2CO_3 + BaCl_2 \rightarrow \underset{\text{White}}{BaCO_3\downarrow} + NaCl$

$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$

15. Ferric sulphate is reduced to give ferrous sulphate.

$Fe_2(SO_4)_3 + 2KI \rightarrow 2FeSO_4 + K_2SO_4 + I_2$

16. (i)



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to three other carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its *p*-orbital. This electron then overlaps with the other to form a π-bond. Hexagonal planes are held by weak van der Waals forces. These planes can slide over one another. Therefore, graphite is a good lubricant.

(ii) Fluorine has the maximum value of standard reduction potential, so it is the best oxidizing agent. That is why it cannot be produced by the oxidation of fluorides with other oxidizing agents.

17. (i) Sulphur is precipitated.

$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$

(ii) Ammonia gives deep-blue color with copper sulphate due to the formation of a complex.

$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2SO_4$

$Cu(OH)_2 + 2NH_4OH + (NH_4)_2SO_4$

$\rightarrow \underset{\text{Blue}}{[Cu(NH_3)_4]SO_4} + 4H_2O$

(iii) Metastannic acid is formed.

$Sn + 3HNO_3(conc) \rightarrow H_2SnO_3 + 4NO_2 + H_2O$

(iv) A yellow solution of sodium chromate is produced.

$H_2O_2 \rightarrow H_2O + O$

$2CrCl_3 + 10NaOH + 3[O]$

$\rightarrow 2Na_2CrO_4 + 6NaCl + 3H_2O$

(v) Lead dioxide is precipitated.

$Pb_3O_4 + 4HNO_3 \rightarrow 2Pb(NO_3)_2 + 2H_2O + PbO_2\downarrow$

18. $3KClO_3 + 3H_2SO_4$ (conc.)

$\xrightarrow{\Delta} 3KHSO_4 + HClO_4 + 2ClO_2 + H_2O$

$(COOH)_2 \xrightarrow{\text{Conc. } H_2SO_4} CO + CO_2 + H_2O$

19. $:N{\equiv}\overset{+}{N}{-}\ddot{\underset{..}{O}}: \longleftrightarrow :\overset{-}{\ddot{N}}{=}\overset{+}{N}{=}\ddot{O}:$

20.

$(NH_4)_2SO_4 + NO + NO_2 \xrightarrow{\Delta} 2N_2 + 3H_2O + H_2SO_4$

21. (i) HI < HBr < HCl < HF (Increasing bond strength)

(ii) HI < I_2 < ICl < HIO_4 (Increasing oxidation number of iodine)

22. (i) Thiosulphate is formed.

$4S + 6OH^- \rightarrow 2S^{2-} + S_2O_3^{2-} + 3H_2O$

(ii) Iodine is evolved.

$ClO_3^- + 6I^- + 6H_2SO_4 \rightarrow Cl^- + 6HSO_4^- + 3I_2 + 3H_2O$

23. Ferrous is oxidized to ferric with chlorine, and bromine is evolved.

$3Cl_2 + 2FeBr_2 \rightarrow 2FeCl_3 + 2Br_2$

24. Aquaregia is three parts concentrated HCl and one part concentrated HNO_3. Aquaregia forms nascent chlorine which attacks gold.

$HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl$

$Au + 3Cl \rightarrow AuCl_3$

$AuCl_3 + HCl \rightarrow HAuCl_4$

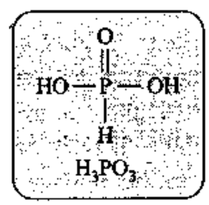
25. (i) Phosphine gas is formed.

$P_4 + 3NaOH + 3H_2O \xrightarrow[\text{atm.}]{\text{Inert}} 3NaH_2PO_2 + PH_3\uparrow$

(ii) Nitrous oxide is evolved.

$4Sn + (\text{dil.})\,10HNO_3 \rightarrow 4Sn(NO_3)_2 + N_2O\uparrow + 5H_2O$

26.



Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structure it is clear that phosphorus acid H_3PO_3 is dibasic.

27. Oxygen does not have vacant *d*-orbitals, so it cannot extend its valency beyond 2, but in case of sulphur, vacant *d*-orbitals participate in bonding, so it can also show valencies of 4 and 6.

28. (i) Iodine is formed.

$2IO_3^- + 5HSO_3^- \rightarrow I_2 + 3HSO_4^- + 2SO_4^{2-}$

(ii) Phosphoric acid is obtained.

$4P + 10HNO_3 + H_2O \rightarrow 5NO + 5NO_2 + 4H_3PO_4$

29. (i) HOCl < HOClO < $HOClO_2$ < $HOClO_3$

As the oxidation number of the central halogen increases, thermal stability of the oxy-acid increases.

(ii) $SiO_2 < CO_2 < N_2O_5 < SO_3$

Going from left to right in the periodic table along a group, the acidic character of oxides goes on decreasing. Also, down the group, acidic character decreases.

30. (i) Phosphine is formed.

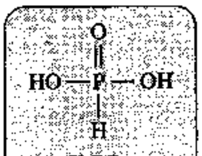
$$2H_3PO_2 \xrightarrow{\Delta} PH_3 + H_3PO_4$$

(ii) Oxygen difluoride is formed.

$$NaBrO_3 + 3F_2 \rightarrow NaBr + 3OF_2$$

(iii) Sulphur is precipitated.

31. (i)


H_3PO_3

Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structure it is clear that phosphorus acid, H_3PO_3, is dibasic.

(ii) In ammonia, there is intermolecular hydrogen bonding, and the molecules are associated. So, it has a higher boiling point. However, phosphorus is less electronegative and can not participate in hydrogen bonding, so in phosphine there is no hydrogen bonding, it has a low boiling point.

32.

X	Y	Z
Yeast	Fermentation	Ethanol
Mica	Layer structure	Insulator
Superphosphate	Bone ash	Fertilizer
Carbon fibers	Graphite	Reinforced plastics
Rock salt	Cubic	Preservative
Carborundum SiC	Diamond structure	Abrasive

33. (i) By passing vapors of $SiCl_4$ through molten aluminium.

$$3SiCl_4 + 4Al \xrightarrow{\Delta} 4AlCl_3 + 3Si$$

(ii) White phosphorus is heated with CaO to get calcium phosphide, which is then hydrolyzed to get phosphine gas.

$$15CaO + 4P_4 \xrightarrow{\Delta} 5Ca_3P_2 + 3P_2O_5\uparrow$$

$$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3\uparrow$$

(iii)

$$2NH_3 + CO_2 + H_2O \rightarrow (NH_4)_2CO_3$$

$$CaSO_4 + (NH_4)_2CO_3 \rightarrow CaCO_3\downarrow + (NH_4)_2SO_4$$

$$\overline{CaSO_4 + 2NH_3 + CO_2 + H_2O \rightarrow CaCO_3\downarrow + (NH_4)_2SO_4}$$

34. $:N\equiv\overset{+}{N}-\ddot{\underset{..}{O}}:^{-} \longleftrightarrow \,^{-}:\ddot{N}=\overset{+}{N}=\ddot{O}:$

35. (i) $NaCO_3 + NO + NO_2 \rightarrow 2NaNO_2 + CO_2$

(ii) $2KMnO_4 + 2NH_3 \rightarrow 2MnO_2 + 2KOH + N_2 + 2H_2O$

(iii) $P_4 + 20HNO_3 \rightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$

(iv) $2H_2S + NaHSO_3 + H^+ \rightarrow 3S + 3H_2O + Na^+$

(v) $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

36. $CCl_4 < MgCl_2 < AlCl_3 < PCl_5 < SiCl_4$

Increasing order of the extent of hydrolysis.

CCl_4 does not get hydrolyzed because carbon does not have vacant *d*-orbitals, so water cannot donate lone pair of electrons to start the reaction.

37. $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$

A substance which increases the concentration of ammonium ions in liquid ammonia is an ammono acid. When NH_4Cl is added, the concentration of ammonium increases.

38.


Resonating structures of ozone

39. (i) With the increase of size, the bond length increases from fluorine to iodine. Since the bond length of fluorine is minimum, its bond dissociation energy should be highest. But the bond dissociation energy of fluorine is less than Cl—Cl and Br—Br. The lower value of bond dissociation energy of fluorine is due to the high interelectronic repulsions between the non-bonding electrons in the 2*p*-orbitals of fluorine.

(ii) $SO_2 + 2OH^- \rightarrow SO_4^{2-} + 2H^+ + 2e^-$

In alkaline medium, the above reaction is shifted in forward reaction due to the removal of the hydrogen ions, therefore sulphur dioxide is a more powerful reducing agent in the alkaline medium than in acidic medium.

40. $2P + 3I_2 + 6H_2O \rightarrow 2H_3PO_3 + 6HI$

41. $PCl_5 + SO_2 \rightarrow POCl_3 + SOCl_2$

42. (i) $Ca_5(PO_4)_3F + 5H_2SO_4 + 10H_2O \xrightarrow{\Delta} 3H_3PO_4 + 5CaSO_4 \cdot 2H_2O + HF$

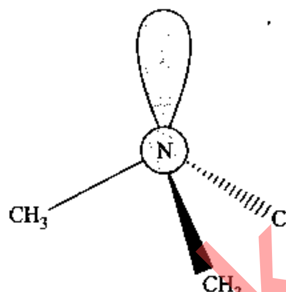
(ii) $Sn + 2KOH + H_2O \rightarrow K_2SnO_3 + 2H_2$

43. (i) Nitrogen and fluorine are small atoms, and electron density is high. When the bond is formed, the bond pairs suffer repulsions, therefore the bond length slightly increases. Therefore, the experimentally determined N–F bond length in NF_3 is greater than the sum of the single bond covalent radii of N and F.

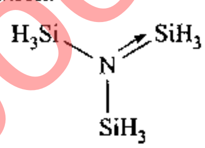
(ii) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

Magnesium chloride does not hydrolyze, being a stronger electrolyte. So, Mg_3N_2 when reacted with water gives NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature.

(iii)

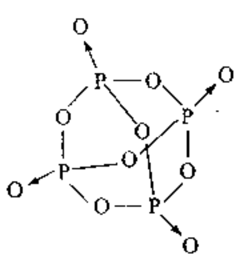


$N(Me)_3$ is pyramidal in shape due to sp^3-hybridization.



$N(SiMe_3)_3$ is trigonal planar. Nitrogen atom shows sp^2-hybridization. The structure is stabilized by the donation of a lone pair of electrons from nitrogen into vacant *d*-orbitals of silicon. Therefore, lone pair is not available for donation and hence it is less basic than $(CH_3)_3N$.

44.



There are 12 single P—O bonds, and there are four double or coordinate P—O bonds.

45. $2KI + Cl_2 \rightarrow 2KCl + I_2$

$2KClO_3 + I_2 \rightarrow 2KIO_3 + Cl_2$

46. The poisonous element must be arsenic.

$AsCl_3 + 6H \xrightarrow{Zn/HCl} AsH_3 + 3HCl$

$2AsH_3 \xrightarrow{\Delta} 2As + 3H_2\uparrow$

47. $(\Delta H_{hydration})$ for $AlCl_3 = -4665 + 3(-381)$
$= -5808$ kJ mol^{-1}

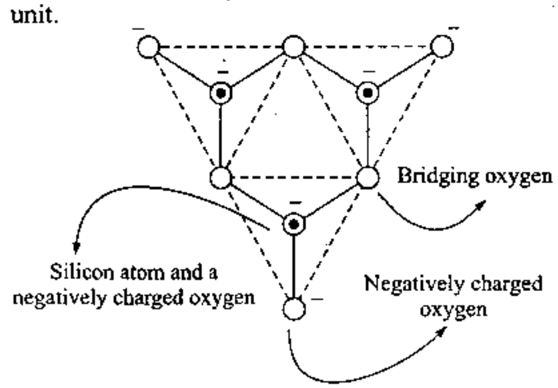
Hydration energy is more than ionization energy of aluminium; so in aqueous solution, it exists in ionic form.

$AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$

48. Aluminium sulphide gives a foul odor when it becomes damp because upon hydrolysis, hydrogen sulphide is produced which has a rotten egg-like smell.

$Al_2S_3 + 6H_2O \rightarrow 2Al(OH)_3\downarrow + 3H_2S$

49. There is sharing of two oxygen atoms per silicate unit.



$(Si_3O_9)^{6-}$

50. The reaction of phosphoric acid with $Ca_5(PO_4)_3$ yields a fertilizer "triple superphosphate."

$7H_3PO_4 + Ca_5(PO_4)_3F \rightarrow 5Ca(H_2PO_4)_2 + HF$

51. (i) $POCl_3$ is formed.

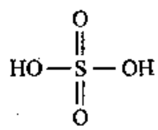
$P_4O_{10} + 6PCl_5 \rightarrow 10POCl_3$

(ii) Butane is formed.

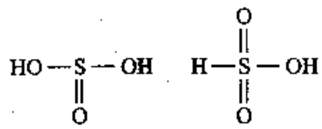
$SnCl_4 + 2C_2H_5Cl + 2Na \rightarrow Na_2SnCl_6 + C_4H_{10}$

52. $\underset{A}{HNO_2} + \underset{B}{2H_2SO_3} + H_2O \rightarrow \underset{C}{NH_2OH} + \underset{D}{2H_2SO_4}$

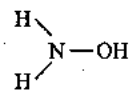
HNO_2: H—O—N=O



H_2SO_4



H_2SO_3



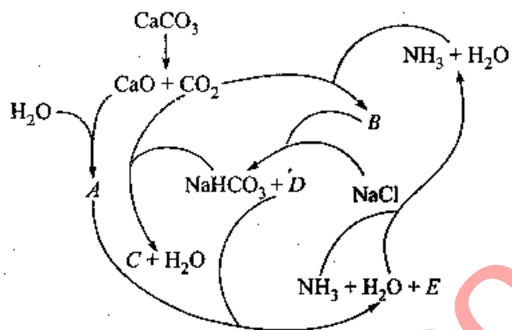
NH_2OH

53. If sulphur trioxide is directly added to water to get sulphuric acid, fumes are formed and it is highly exothermic. Therefore, first oleum is prepared by dissolving sulphur trioxide in sulphuric acid. Then oleum is treated with water to get sulphuric acid.

$H_2SO_4 + SO_3 \rightarrow H_2S_2O_7$ (Oleum)

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

54.



Reactions of the Solvay process:

$CaO + H_2O \rightarrow Ca(OH)_2 \{A\}$

$NH_3 + H_2O + CO_2 \rightarrow NH_4HCO_3 \{B\}$

$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl\{D\}$

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3\{C\} + CO_2 + H_2O$

$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2\{E\} + 2NH_3 + 2H_2O$

55. $2KI + Cl_2 \rightarrow I_2 + 2KCl$

Standard reduction potential of chlorine is more than that of iodine; therefore, in the reaction iodide gets oxidized to iodine, and chlorine gets reduced to chloride.

56. When borax is heated, a colorless glassy bead is formed of the following composition:

$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$

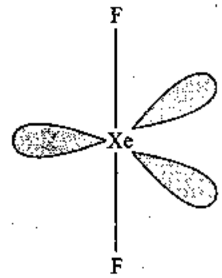
$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

Co(II) salt $\xrightarrow{\Delta}$ CoO + Some gas

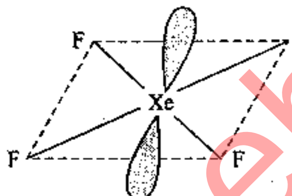
$CoO + B_2O_3 \xrightarrow{\Delta} Co(BO_2)_2$

Blue-colored bead of cobalt metaborate is formed.

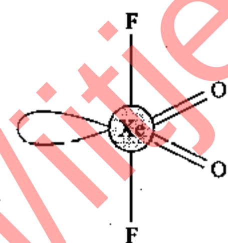
57.



sp^3d-Hybridization
Linear shape
Two bond pairs
Three lone pairs



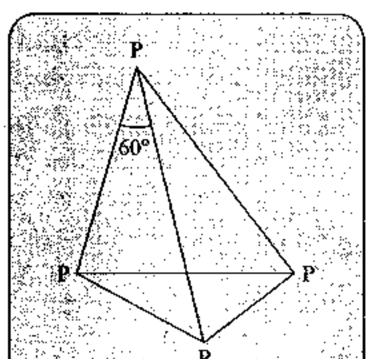
sp^3d^2-Hybridization
Square planar shape
Four bond pairs
Two lone pairs



XeO_2F_2:
sp^3d-Hybridization
Four bond pairs, one lone pair
See-saw shape

58. Nitrogen is a diatomic gaseous molecule at ordinary temperature. The existence of nitrogen as diatomic molecule (N≡N) is due to its ability to form multiple bonds.

The triple bond in nitrogen molecule is very stable as the dissociation energy is very high (225 kcal mol^{-1}). Phosphorus, arsenic, and antimony all exist as discrete tetratomic tetrahedral molecules, as these are not capable of forming multiple bonds due to the repulsion between the non-bonded electrons of the inner core.



Yellow or white
Six P-P bonds

59. Compound X on reduction with $LiAlH_4$ gives a hydride Y containing 21.72% hydrogen along with other products. Compound Y reacts with air explosively resulting in boron trioxide. Y seems to be a hydride of boron, may be B_2H_6.

$$\text{Percentage of H in } B_2H_6 = \frac{\text{Mass of H}}{\text{Mass of } B_2H_6} \times 100$$

$$= \frac{6}{27.6} \times 100$$

$$\approx 21.73\%$$

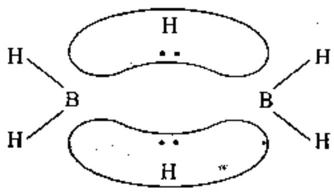
This matches the given data, so the hydride is B_2H_6.

X is some halide of boron which is reduced to B_2H_6 with lithium aluminium hydride.

$4BX_3 + 3LiAlH_4 \rightarrow 2B_2H_6 + 3AlX_3 + 3LiX$

$B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$

Structure of B_2H_6:



There are two types of hydrogen atoms. Four hydrogen atoms are terminal hydrogens. The other two hydrogen atoms are known as bridged hydrogens. The two boron atoms and the four terminal H atoms lie in the same plane, while the two bridging H atoms are in the plane perpendicular to the rest of the molecule. The four terminal hydrogens are bonded by normal covalent bonds. The bridged hydrogens are bonded by three-center electron pair bonds, which involve two electrons but bind three atoms. There are two such type of bonds in diborane. The boron atom undergoes sp^3-hybridization. Two hybrid orbitals of each B atom overlap with 1*s* orbitals of two H atoms. The hybrid orbital containing an unpaired electron of one B atom and the vacant hybrid orbital of the second B atom overlaps simultaneously with 1*s* orbital of an H atom to form B—H—B bridge bond, this B—H—B bond is called three-center electron pair bond. It is also called banana bond.

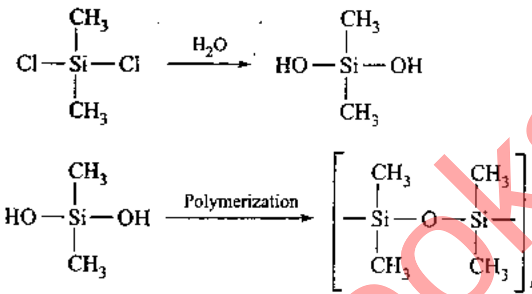
60. (i) With aluminium, it can be reduced to silicon.

$3SiCl_4 + 4Al \rightarrow 3Si + 4AlCl_3$

(ii) $3SiCl_4 + 4Al \rightarrow 3Si + 4AlCl_3$

$Si + Cu \xrightarrow{\Delta} Cu—Si$

$Cu — Si + 2CH_3Cl \rightarrow (CH_3)_2\,SiCl_2 + Cu$



(iii) $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + HCl$

$Si(OH)_4 \rightarrow SiO_2 + 2H_2O$

$SiO_2 + Na_2CO_3 \xrightarrow{1400°C} Na_2SiO_3 + CO_2$

61. The finely ground borax is heated with concentrated hydrochloric acid or concentrated sulphuric acid when sparingly soluble orthoboric acid separates out.

$Na_2B_4O_7 + 2HCl \rightarrow 2NaCl + H_2B_4O_7$

$Na_2B_4O_7 + H_2SO_4 \rightarrow Na_2SO_4 + H_2B_4O_7$

$H_2B_4O_7 + 5H_2O \rightarrow 4H_3BO_3$

Orthoboric acid is strongly heated to get B_2O_3.

$2H_3BO_3 \rightarrow B_2O_3 + 3H_2O$

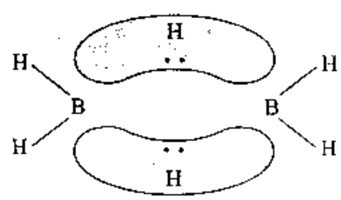
The reduction of boric anhydride (B_2O_3) can be done with sodium, potassium, or magnesium.

$B_2O_3 + 6K \rightarrow 2B + 3K_2O$

$B_2O_3 + 3Mg \rightarrow 2B + 3MgO$

Boron is obtained these days by the electrolysis of a fused mixture containing boric anhydride, magnesium oxide, and magnesium fluoride. The electrolysis is done in carbon crucible which acts as the anode and iron rod is used as the cathode. The magnesium discharged at the cathode reduces B_2O_3 to boron.

The structure of diborane is as follows:



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$$B_2H_6 + HCl \rightarrow \underset{\text{Chlorodiborane}}{B_2H_5Cl} + H_2$$

62. (i) With aluminium carbide, methane is formed.

$$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4\uparrow$$

(ii) With calcium cynamide, calcium carbonate is precipitated.

$$CaNCN + 5H_2O \rightarrow CaCO_3\downarrow + 2NH_4OH$$

(iii) With boron trifluoride, boric acid is formed.

$$4BF_3 + 3H_2O \rightarrow H_3BO_3 + 3HBF_4$$

(iv) With nitrogen trichloride, ammonia and hypochlorous acid are formed.

$$NCl_3 + 3H_2O \rightarrow NH_3 + 3HOCl$$

(v) With xenon tetrafluoride, xenon trioxide is formed.

$$2XeF_4 + 3H_2O \rightarrow Xe + XeO_3 + F_2 + 3H_2F_2$$

63. Anhydrous HF is stabilized due to intermolecular H bonding and is less dissociated. AlF_3 is soluble in HF in the presence of KF due to the formation of $[AlF_6]^{3-}$.

$3KF + AlF_3 \rightarrow K_3[AlF_6]$

BF_3 displaces F^- from $[AlF_6]^{3-}$ because it is more acidic than AlF_3.

$$K_3[AlF_6] + BF_3 \rightarrow AlF_3\downarrow + 3KBF_4$$

64. $P_4O_{10} + 6CaO \rightarrow 2Ca_3(PO_4)_2$

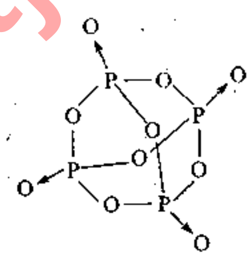
$6CaO \equiv P_4O_{10}$

$6 \times 56 \equiv 284$

$m \equiv 852$

$$\therefore \frac{6 \times 56}{m} = \frac{284}{852}$$

or $m = 336$ g of CaO



Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	2. (d)	3. (b)	4. (b)	5. (d)	6. (d)	7. (b)	8. (b)	9. (a)	10. (d)
11. (d)	12. (a)	13. (d)	14. (b)	15. (a)	16. (c)	17. (d)	18. (a)	19. (d)	20. (a)
21. (d)	22. (b)	23. (d)	24. (b)	25. (a)	26. (d)	27. (d)	28. (a)	29. (c)	30. (a)
31. (c)	32. (b)	33. (a)	34. (d)	35. (d)	36. (a)	37. (b)	38. (b)	39. (a)	40. (c)
41. (b)	42. (d)	43. (c)	44. (d)	45. (b)	46. (d)	47. (b)	48. (b)	49. (a)	50. (a)
51. (b)	52. (c)	53. (c)	54. (b)	55. (a)	56. (d)	57. (a)	58. (a)	59. (b)	60. (b)
61. (d)	62. (d)	63. (c)	64. (c)	65. (c)	66. (a)	67. (c)	68. (b)	69. (a)	70. (b)
71. (a)	72. (c)	73. (b)	74. (b)	75. (a)	76. (c)	77. (c)	78. (c)	79. (c)	80. (c)
81. (b)	82. (b)	83. (b)	84. (b)	85. (c)	86. (a)	87. (c)	88. (a)	89. (a)	90. (c)
91. (c)	92. (a)	93. (a)	94. (c)	95. (b)	96. (a)	97. (b)	98. (b)	99. (a)	100. (d)
101. (d)	102. (a)	103. (a)	104. (c)	105. (b)	106. (c)	107. (a)	108. (d)	109. (a)	110. (a)
111. (b)	112. (d)	113. (d)	114. (c)	115. (c)	116. (d)	117. (c)	118. (a)	119. (b)	120. (a)
121. (b)	122. (a)	123. (c)	124. (a)	125. (b)	126. (c)	127. (c)	128. (a)		

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (a)	4. (a)	5. (d)	6. (a)	7. (c)	8. (a)	9. (a)	10. (a)
11. (d)	12. (d)	13. (d)	14. (d)	15. (c)	16. (c)	17. (d)	18. (a)	19. (a)	20. (c)
21. (c)	22. (d)	23. (b)	24. (c)	25. (a)	26. (c)	27. (a)	28. (a)	29. (c)	30. (b)
31. (d)	32. (c)	33. (b)	34. (c)	35. (d)	36. (b)	37. (b)	38. (b)	39. (a)	40. (b)
41. (c)	42. (b)	43. (d)	44. (d)	45. (d)	46. (c)	47. (a)	48. (c)	49. (a)	50. (a)
51. (d)	52. (a)	53. (d)	54. (a)	55. (a)	56. (b)	57. (c)	58. (c)	59. (d)	60. (d)
61. (d)	62. (b)	63. (b)	64. (b)	65. (d)	66. (c)	67. (a)	68. (d)	69. (c)	70. (b)
71. (d)	72. (d)	73. (c)	74. (a)	75. (c)	76. (c)	77. (b)	78. (d)	79. (a)	80. (a)
81. (d)	82. (b)	83. (d)	84. (c)	85. (c)	86. (b)	87. (c)	88. (d)	89. (c)	90. (a)
91. (b)	92. (d)	93. (b)	94. (c)	95. (a)	96. (d)	97. (c)	98. (b)	99. (b)	100. (c)
101. (d)	102. (d)	103. (a)	104. (c)	105. (b)	106. (a)	107. (a)	108. (b)	109. (a)	110. (c)
111. (d)	112. (a)	113. (d)	114. (d)	115. (d)	116. (b)	117. (d)	118. (a)	119. (a)	120. (b)
121. (a)	122. (d)	123. (d)	124. (b)	125. (a)	126. (a)	127. (d)	128. (c)		

Multiple Correct Answers Type

1. (b), (c)	2. (a), (b), (d)	3. (b), (d)	4. (a), (b)	5. (a), (b), (c)
6. (a), (c), (d)	7. (a), (b), (c)	8. (a), (d)	9. (a), (b), (d)	10. (b), (c), (d)
11. (b), (c), (d)	12. (a), (c), (d)	13. (a), (b), (c)	14. (a), (b), (c), (d)	15. (a), (b), (c), (d)
16. (a), (c)	17. (a), (b), (d)	18. (a), (b), (c), (d)	19. (a), (d)	20. (a), (b), (c)
21. (b), (d)	22. (a), (d)	23. (b), (d)	24. (a), (c), (d)	25. (a), (b), (c)
26. (b), (c), (d)	27. (a), (b), (c)	28. (a), (b)	29. (b), (c), (d)	30. (a), (c), (d)
31. (b), (c)	32. (a), (b), (c)	33. (b), (c), (d)	34. (b), (c), (d)	35. (a), (b), (c)
36. (b), (c), (d)	37. (b), (c), (d)	38. (a), (b), (c)	39. (b), (d)	40. (b), (c), (d)
41. (a), (d)	42. (b), (c), (d)	43. (a), (b), (d)	44. (a), (d)	45. (b), (c)
46. (a), (b)	47. (a), (c), (d)	48. (a), (b), (d)	49. (a), (b), (c)	50. (a), (b), (c)
51. (a), (b), (c)	52. (a), (c), (d)	53. (c), (d)	54. (a), (b), (c), (d)	55. (a), (b), (c), (d)
56. (a), (b), (c), (d)	57. (b), (c), (d)	58. (b), (c), (d)		

Comprehension Type

Comprehension-1	1. (c)	2. (a)	3. (b)	
Comprehension-2	4. (d)	5. (d)		
Comprehension-3	6. (a)	7. (b)	8. (b)	
Comprehension-4	9. (a)	10. (d)		
Comprehension-5	11. (c)	12. (c)	13. (a)	14. (b)
Comprehension-6	15. (a)	16. (c)	17. (b)	18. (c)
Comprehension-7	19. (a)	20. (b)	21. (b)	
Comprehension-8	22. (b)	23. (c)	24. (b)	
Comprehension-9	25. (c)	26. (b)	27. (d)	
Comprehension-10	28. (d)	29. (b)	30. (c)	
Comprehension-11	31. (b)	32. (a)	33. (a)	
Comprehension-12	34. (c)	35. (b)	36. (b)	
Comprehension-13	37. (b)	38. (c)	39. (b)	
Comprehension-14	40. (a)	41. (a)	42. (c)	43. (a)
Comprehension-15	44. (d)	45. (b)	46. (a)	

Comprehension-16 **47.** (c) **48.** (c) **49.** (b)
Comprehension-17 **50.** (a) **51.** (b)
Comprehension-18 **52.** (b) **53.** (a) **54.** (d)
Comprehension-19 **55.** (c) **56.** (d) **57.** (a)
Comprehension-20 **58.** (c) **59.** (d) **60.** (d) **61.** (a) **62.** (b)
Comprehension-21 **63.** (d) **64.** (b) **65.** (d)
Comprehension-22 **66.** (c) **67.** (b) **68.** (c)

Assertion-Reasoning Type

1. (d) **2.** (b) **3.** (a) **4.** (a) **5.** (d) **6.** (c) **7.** (a) **8.** (d) **9.** (b) **10.** (a)

Matching Column Type

1. (a) p, q, r, s; (b) r, s; (c) p, q, r, s; (d) p, r, s, t
2. (a) p, q, r, s, t; (b) p, q, t; (c) r, t; (d) p, r, t
3. (a) s; (b) p, q; (c) r
4. (a) q; (b) r; (c) p; (d) s
5. (a) r, t; (b) p, r, s; (c) p, q, r, s; (d) q, t
6. (a) q; (b) p, q; (c) p, q, s; (d) p, q, r
7. (a) p; (b) q, r; (c) r; (d) s
8. (a) q; (b) p; (c) r, s; (d) q
9. (a) q, p; (b) r, p; (c) r, s
10. (a) s; (b) p, r, s; (c) q, t; (d) r, t
11. (a) p, q, s; (b) p, q, r; (c) p, q; (d) p, r, t
12. (a) s; (b) s; (c) p
13. (a) p; (b) s; (c) r; (d) q

Integer Answer Type

1. (24) **2.** (4) **3.** (2) **4.** (2) **5.** (33) **6.** (1) **7.** (1216) **8.** (6) **9.** (28) **10.** (3)
11. (72) **12.** (1) **13.** (10) **14.** (412) **15.** (0) **16.** (4) **17.** (3) **18.** (40) **19.** (0) **20.** (3)
21. (114) **22.** (21) **23.** (1) **24.** (105) **25.** (6) **26.** (42) **27.** (2) **28.** (460) **29.** (6) **30.** (4)
31. (3) **32.** (9)

NCERT Exemplar Exercises

Single Correct Answers Type

1. (c) **2.** (a) **3.** (a) **4.** (a) **5.** (a) **6.** (c) **7.** (b) **8.** (c) **9.** (d) **10.** (b)
11. (a) **12.** (b) **13.** (d) **14.** (c) **15.** (b) **16.** (c) **17.** (b) **18.** (c) **19.** (c) **20.** (a)
21. (a) **22.** (d) **23.** (c) **24.** (c) **25.** (c) **26.** (b) **27.** (a) **28.** (c) **29.** (a) **30.** (a)
31. (b) **32.** (a) **33.** (a) **34.** (c) **35.** (c) **36.** (a) **37.** (c) **38.** (a) **39.** (c) **40.** (d)
41. (c) **42.** (b)

Multiple Correct Answers Type

1. (a), (b) **2.** (b), (c) **3.** (a), (b) **4.** (b), (c) **5.** (a), (b), (d)
6. (b), (d) **7.** (a), (c) **8.** (b), (c) **9.** (b), (d) **10.** (a), (c), (d)
11. (a), (c) **12.** (c), (d) **13.** (a), (d) **14.** (a), (b) **15.** (b), (c)
16. (a), (b)

Matching Column Type

1. (a) → (t); (b) → (r); (c) → (s); (d) → (p), (q)
2. (a) → (r); (b) → (s); (c) → (p); (d) → (t); (e) → (q)
3. (a) → (q); (b) → (r); (c) → (q); (d) → (p); (e) → (q); (f) → (r)

4. (a) 5. (b) 6. (a) 7. (b) 8. (c)

Assertion-Reasoning Type

1. (a) 2. (b) 3. (c) 4. (c) 5. (b) 6. (a) 7. (a) 8. (a)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	2. (d)	3. (a)	4. (c)	5. (d)	6. (d)	7. (a)	8. (a)	9. (c)	10. (a)
11. (b)	12. (d)	13. (d)	14. (c)	15. (c)	16. (b)	17. (b)	18. (b)	19. (c)	20. (c)
21. (b)	22. (d)	23. (d)	24. (b)	25. (b)	26. (b)	27. (d)	28. (a)	29. (d)	30. (c)
31. (d)	32. (a)	33. (d)	34. (a)	35. (c)	36. (b)	37. (c)	38. (c)	39. (c)	40. (c)
41. (c)									

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (d)	3. (d)	4. (b)	5. (b)	6. (b)	7. (c)	8. (b)	9. (d)	10. (a)
11. (b)	12. (b)	13. (?)	14. (d)	15. (a)	16. (c)	17. (d)	18. (a)	19. (a)	20. (b)
21. (b)	22. (c)	23. (a)	24. (a)	25. (c)	26. (a)	27. (d)	28. (a)	29. (a)	30. (c)
31. (a)	32. (c)	33. (c)	34. (b)	35. (b)	36. (a)	37. (b)	38. (d)	39. (d)	40. (b)
41. (c)	42. (a)	43. (a)							

Multiple Correct Answers Type

1. (a), (d) 2. (a), (c), (d) 3. (c) 4. (b) 5. (a), (b), (c)
6. (a), (b), (c) 7. (a), (c), (d) 8. (b), (d)

Comprehension Type

1. (a) 2. (c) 3. (a) 4. (c) 5. (c) 6. (b) 7. (a) 8. (a)

Assertion-Reasoning Type

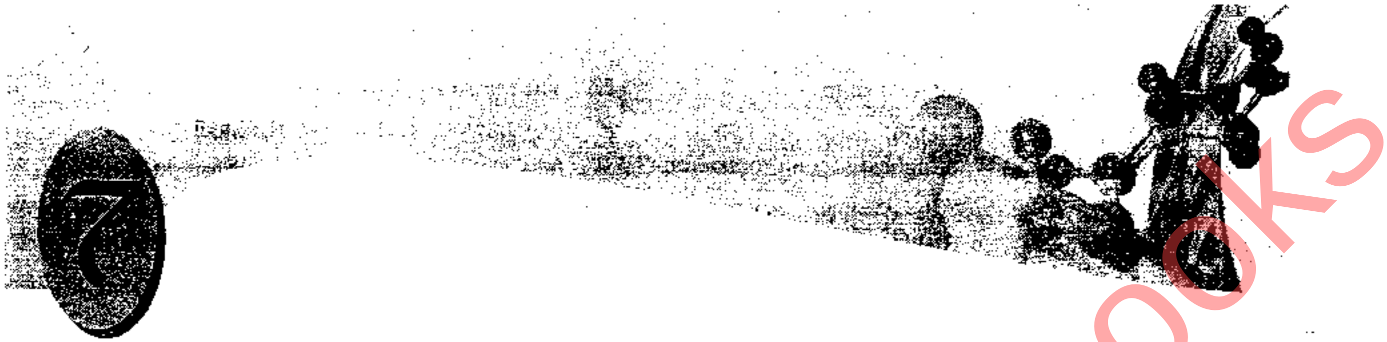
1. (b) 2. (c) 3. (a) 4. (c) 5. (c) 6. (a) 7. (c)

Matching Column Type

1. (a) → (q, s); (b) → (s); (c) → (r); (d) → (q, r)
2. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)
3. (a) → (p, s); (b) → (p, q, r, t); (c) → (p, q); (d) → (p)
4. (d)

Integer Answer Type

1. (6) 2. (2) 3. (6) 4. (3)



d-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. A transition element containing only one electron in 4*s*-orbital is:
   (a) $_{21}Sc$ (b) $_{23}Mn$
   (c) $_{26}Fe$ (d) $_{29}Cu$

2. The magnetic moment of a transition metal of 3*d*-series is 6.92 μ_B. Its electronic configuration will be:
   (a) $(3d)^4(4s)^2$ (b) $(3d)^5(4s)^1$
   (c) $(3d)^{10}$ (d) $(3d)^5(4s)^0$

3. Which of the following electronic configuration will be associated with the lowest magnetic moment?
   (a) d^2 (b) d^3
   (c) d^4 (d) d^9

4. Find the species/elemental atom has minimum number of unpaired electrons:
   (a) Kr^+ (b) Mn^{2+}
   (c) Fe^{3+} (d) O^+

5. In which of the following pairs do the two species resemble each other most closely in chemical properties?
   (a) ${}^1_1H$ and ${}^2_1H$ (b) ${}^{16}_{8}O$ and ${}^{16}_{8}O^{2-}$
   (c) ${}^{24}_{12}Mg$ and ${}^{24}_{12}Mg^{2+}$ (d) ${}^{14}_{7}N$ and ${}^{14}_{7}N^{3-}$

6. Which forms interstitial compounds?
   (a) Fe (b) Co
   (c) Ni (d) All

7. The highest magnetic moment is shown by the transition metal with the configuration:
   (a) $3d^2$ (b) $3d^5$
   (c) $3d^7$ (d) $3d^9$

8. Arrange the following ions in order of their magnetic moment:
   (i) V^{4+} (ii) Mn^{4+}
   (iii) Fe^{3+} (iv) Ni^{2+}
   (Atomic number of V = 23, Mn = 25, Fe = 26, Ni = 28)
   (a) (ii) > (iii) > (i) > (iv) (b) (iii) > (ii) > (iv) > (i)
   (c) (i) > (iv) > (iii) > (ii) (d) (iv) > (iii) > (i) > (ii)

9. Which of the ions will give colorless aqueous solution?
   (a) Ni^{2+} (b) Fe^{2+}
   (c) Cu^{2+} (d) Cu^+

10. Which of the following form an alloy?
    (a) Zn + Pb (b) Fe + Hg
    (c) Pt + Hg (d) Fe + C

11. In which of the following pairs are both the ion colored in aqueous solution?
    (a) Sc^{3+}, Co^{2+} (b) Ni^{2+}, Cu^+
    (c) Ni^{2+}, Ti^{3+} (d) Sc^{3+}, Ti^{3+}

12. The electronic configuration of four elements are:
    (i) [Xe] $6s^1$ (ii) [Xe] $4f^{14}$, $5d^1$ $6s^2$
    (iii) [Ar] $4s^2$ $4p^3$ (iv) [Ar] $3d^7$, $4s^2$
    Which one of the following statements about these elements is not correct?
    (a) (i) is a strong reducing agent

(b) (ii) is a d-block element

(c) (iii) has high electron affinity

(d) (iv) shows variable oxidation states

13. Among the following transition elements, pick out the element/elements with highest second ionization energy:

(i) V (At. no. = 23) (ii) Cr (At. no. = 24)

(iii) Mn (At. no. = 25) (iv) Cu (At. no. = 29)

(v) Zn (At. no. = 30)

(a) (i) and (iii) (b) (ii) and (v)

(c) Only (iii) (d) Only (iv)

14. Lanthanoids contraction is caused due to:

(a) The same effective nuclear charge from Ce to Lu

(b) The imperfect shielding on outer electrons by $4f$ electrons from the nuclear charge

(c) The appreciable shielding on outer electrons by $4f$-electrons from the nuclear charge

(d) The appreciable shielding on outer electrons by $5d$-electrons from the nuclear charge

15. Which of the following has the maximum number of unpaired electrons?

(a) Mg^{2+} (b) Ti^{3+}

(c) V^{3+} (d) Fe^{2+}

16. Which of the following halides is least stable and has doubtful existence?

(a) CI_4 (b) GeI_4

(c) SnI_4 (d) PbI_4

17. The lanthanoids contraction is responsible for the fact that:

(a) Zr and Y have about the same radius

(b) Zr and Nb have similar oxidation state

(c) Zr and Hf have about the same radius

(d) Zr and Zn have the same oxidation state

18. $K_2[HgI_4]$ detects the ion/group:

(a) NH_2^- (b) NO

(c) NH_4^+ (d) $AlCl_3$

19. Which of the following belongs to the actinoids series of elements?

(a) Y (b) Ta

(c) U (d) Y

20. Which oxides will not give metal on heating?

(a) HgO (b) ZnO

(c) Ag_2O (d) All of these

21. Most common oxidation state of lanthanoids is:

(a) +2 (b) +3

(c) +4 (d) +5

22. The purest form of Fe is:

(a) Stainless steel (b) Steel

(c) Cast iron (d) Wrought iron

23. For Ni and Pt different I.P. in kJ mol^{-1} are given below:

	$(IP)_1 + (IP)_2$	$(IP)_3 + (IP)_4$
Ni	2.49	8.80
Pt	2.60	6.70

Hence:

(a) Nickel(II) compounds tend to be thermodynamically more stable than platinum(II)

(b) Platinum(IV) compounds tend to be more stable than nickel(IV)

(c) Both are correct

(d) None is correct

24. An acidic solution contains Cu^{2+}, Pb^{2+}, and Zn^{2+}. If hydrogen sulphide gas is passed through this solution, the precipitate will contain:

(a) CuS and ZnS (b) PbS and ZnS

(c) CuS and PbS (d) CuS, PbS, and ZnS

25. Ti^{2+} is purple while Ti^{4+} is colorless, because:

(a) There is no crystal field effect in Ti^{4+}

(b) Ti^{4+} has $3d^2$ configuration

(c) Ti^{4+} has $3d^0$ configuration

(d) Ti^{4+} is a very small cation when compared to Ti^{2+}, and hence does not absorb any radiation

26. In dilute alkaline solution MnO_4^- changes to:

(a) MnO_4^{2-} (b) MnO_2

(c) Mn_2O_3 (d) MnO

27. Pyrolusite in MnO_2 is used to prepare $KMnO_4$. Steps are:

$$MnO_2 \xrightarrow{I} MnO_4^{2-} \xrightarrow{II} MnO_4^-$$

I and II are:

(a) Fused with KOH/air, electrolytic oxidation

(b) Fused with KOH/air, electrolytic reduction

(c) Fused with conc. HNO_3/air, electrolytic reduction

(d) All are correct

28. Maximum magnetic moment is shown by:

(a) d^5 (b) d^6

(c) d^7 (d) d^8

29. Magnetic moments of Cr ($Z = 24$), Mn^+ ($Z = 25$), and Fe^{2+} ($Z = 26$), are x, y, z. They are in order:

(a) $x < y < z$ (b) $x = y < z$

(c) $z < x = y$ (d) $x = y = z$

30. Maximum oxidation state is shown by:
(a) Os (b) Mn
(c) Cr (d) Co

31. Following elements do not show the properties characteristic of *d*-block elements:
(a) Cu, Ag, Au (b) Zn, Hg, Cd
(c) Sc, Ti, V (d) Fe, Co, Ni

32. AgCl and NaCl are colorless. NaBr and NaI are also colorless but AgBr and AgI are colored. This is due to:
(a) Ag^+ polarizes Br^- and I^-
(b) Ag^+ has unpaired *d*-orbital
(c) Ag^+ depolarizes Br^- and I^-
(d) None is correct

33. In 3*d* transition series, if nuclear charge increases, the screening effect:
(a) Increases (b) Decreases
(c) First decreases and then increases
(d) First increases and then decreases

34. Least paramagnetic property is shown by:
(a) Fe (b) Mn
(c) Ni (d) Cu

35. Which shows maximum magnetic moment among the bivalent ions of the first transition series?
(a) Fe^{2+} (b) Co^{2+}
(c) Ni^{2+} (d) Mn^{2+}

36. Which of the following compounds is amphoteric?
(a) $Cr(OH)_2$ (b) $Fe(OH)_2$
(c) $Cr(OH)_3$ (d) $Fe(OH)_3$

37. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by:
(a) Heating NH_4NO_2 (b) Heating NH_4NO_3
(c) $Mg_3N_2 + H_2O$ (d) $Na + H_2O_2$

38. The pair of compounds having metals in their highest oxidation state is:
(a) MnO_2, $FeCl_3$ (b) $[MnO_4]^-$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{3-}$, $[Co(CN)_3]$
(d) $[NiCl_4]^{2-}$, $[CoCl_4]^-$

39. The compound having tetrahedral geometry is:
(a) $[Ni(CN)_4]^{2}$ (b) $[Pd(CN)_4]^{2-}$
(c) $[PdCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

40. CrO_3 dissolves in aqueous NaOH to give:
(a) CrO_4^{2-} (b) $Cr(OH)_3$
(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

41. The electronic configuration of gadolinium (At. no.= 64) is:
(a) $[Xe]\,4f^8, 5d^0, 6s^2$ (b) $[Xe]\,4f^7, 5d^1, 6s^2$
(c) $[Xe]\,4f^3, 5d^5, 6s^2$ (d) $[Xe]\,4f^6, 5d^2, 6s^2$

42. Which of the following compounds is expected to be colored?
(a) Ag_2SO_4 (b) CuF_2
(c) MgF_2 (d) CuCl

43. Ammonium dichromate is used in fire works. The green colored powder blow in the air is:
(a) CrO_3 (b) Cr_2O_3
(c) Cr (d) $CrO(O_2)$

44. In acidic medium, one mole of MnO_4^- accepts how many moles of electrons in a redox process?
(a) 1 (b) 3
(c) 5 (d) 6

45. The correct formula for permanganic acid is:
(a) $HMnO_4$ (b) $HMnO_5$
(c) H_2MnO_4 (d) MnO_2

46. On heating ammonium dichromate, the gas evolved is:
(a) Oxygen (b) Ammonia
(c) Nitrous oxide (d) Nitrogen

47. Arrange the following in order of their increasing thermal conductivity.
(a) Al, Ag, Cu (b) Cu, Ag, Al
(c) Ag, Cu, Al (d) Al, Cu, Ag

48. Which one of the following forms a colorless solution in aqueous medium?
(a) Cr^{3+} (b) Ti^{3+}
(c) Sc^{3+} (d) V^{3+}

49. $KMnO_4$ acts as an oxidizing agent in:
(a) Acidic medium only
(b) Neutral and acidic media
(c) Neutral and alkaline media
(d) Neutral, acidic, and alkaline media

50. The transition metals are mostly:
(a) Diamagnetic (b) Paramagnetic
(c) Neither diamagnetic nor paramagnetic
(d) Both diamagnetic and paramagnetic

51. Titanium shows magnetic moment of 1.73 BM; then find out its oxidation state:
(a) + 1 (b) + 4
(c) + 3 (d) + 2

52. The colorless species is:
(a) VCl_3 (b) $VOSO_4$
(c) Na_3VO_4 (d) $[V(H_2O)_6SO_4].H_2O$

53. MnO_4^{2-} (1 mole) in neutral aqueous medium disproportionate to:
(a) 2/3 mole of MnO_4^- and 1/3 mole of MnO_2
(b) 1/3 mole of MnO_4^- and 2/3 mole of MnO_2
(c) 1/3 mole of Mn_2O_7 and 1/3 mole of MnO_2
(d) 2/3 mole of Mn_2O_7 and 1/3 mole of MnO_2

54. Lanthanoids contraction is observed in:
(a) Hf (b) At
(c) Xe (d) Ac

55. Lanthanoids are:
(a) 14 elements in the sixth period (atomic number 90 to 103) that are filling 4*f*-sublevel
(b) 14 elements in the seventh period (atomic number 90 to 103) that are filling 5*f*-subshell
(c) 14 elements in the sixth period (atomic number 58 to 71) that are filling the 4*f*-subshell
(d) 14 elements in the seventh period (atomic number 58 to 71) that are filling the 4*f*-subshell

56. For delocalization of 1 mole of $KMnO_4$, the moles of H_2O_2 required is:
(a) 1/2 (b) 3/2
(c) 5/2 (d) 7/2

57. Among the following pairs of ions, the lower oxidation state in aqueous solution is more stable than the other, in:
(a) Tl^+, Tl^{3+} (b) Fe^{+1}, Fe^{3+}
(c) Cr^{2+}, Cr^{3+} (d) V^{2+}, VO^{2+}

JEE (Advanced) Exercises

Single Correct Answer Type

1. The oxidation states of Mn in K_2MnO_4 and $KMnO_4$ respectively are:
(a) +6, +7 (b) +6, +6
(c) +7, +7 (d) +7, +6

2. The basic character of the transition metal monoxides follows the order:
(a) CrO > VO > FeO > TiO
(b) TiO > FeO > VO > CrO
(c) TiO > VO > CrO > FeO
(d) VO > CrO > TiO > FeO

3. Which is not a transition element?
(a) Cu (b) Ac
(c) Zn (d) Pd

4. One element (A) is having four valence shell electron. Which of following values will be maximum.
(a) EA of A (b) $IE_4 - IE_3$
(c) $IE_5 - IE_3$ (d) $IE_2 - IE_1$

5. The maximum oxidation state of osmium is:
(a) +6 (b) +7
(c) +8 (d) +5

6. Which of the following elements involves gradual filling of 5*f*-level?
(a) Lanthanoids (b) Actinoids
(c) Transition metals (d) Coinage metals

7. Which chromium compound in widely used in tanning of leather?
(a) Cr_2O_3 (b) CrO_2Cl_2
(c) $CrCl_3$
(d) $K_2SO_4 . Cr_2(SO_4)_3 . 24H_2O$
Chrome alum $K_2SO_4{\cdot}Cr_2(SO_4)_3{\cdot}24H_2O$ is widely used in tanning of leather.

8. $K_2Cr_2O_7$ reacts with NH_4Cl in the presence of H_2SO_4. The product formed is:
(a) Chromyl chlorate with green vapor
(b) Chromous chloride with white vapor
(c) Chromous chloride with blue vapor
(d) Chromyl chloride with deep red color

9. The "Spin-only" magnetic moment [in units of Bohr magneton, (μ_B)] of Ni^{2+} in aqueous solution would be (At. no. Ni = 28):
(a) 0 (b) 1.73
(c) 2.84 (d) 4.90

10. Which of the following compounds is not colored?
(a) Na_2CuCl_4 (b) Na_2CdCl_4
(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

11. When KI (excess) is added to:
(i) $CuSO_4$ (ii) $HgCl_2$ (iii) $Pb(NO_3)_2$
(a) A white ppt. of CuI in (i), an orange ppt. of HgI_2 in (ii), and a yellow ppt. of PbI_2 in (iii)
(b) A white ppt. of Cu_2I_2 in (i), a red ppt. dissolving to HgI_4^{2-} in (ii), and a yellow ppt. of PbI_2 in (iii)
(c) A white ppt. of CuI, HgI_2, and PbI_2 in each case
(d) None is correct

12. Due to lanthanoids contraction:
(a) Fe, Co, Ni have equal size
(b) Zr and Hf have equal size
(c) All *f*-block ions have equal size
(d) All isoelectronic ions have equal size

13. Silver ornaments turn black in atmosphere:

(a) O_2 (b) N_2

(c) Cl_2 (d) H_2S

14. What are the species A and B in the following:

$$CrO_3 + H_2O \longrightarrow A \xrightarrow{OH^-} B$$

(a) H_2CrO_4, $H_2Cr_2O_7$ (b) $H_2Cr_2O_7$, Cr_2O_3

(c) CrO_4^{2-}, $Cr_2O_7^{2-}$ (d) $H_2Cr_2O_7$, CrO_4^{2-}

15. In August 2003, IUPAC approved the name of the element of atomic number 110. Name of the elements is:

(a) Darmstadtium (b) Mountanium

(c) Rhenium (d) Bhorium

16. Which one of the following characteristics of the transition metals is associated with their catalytic activity?

(a) Color of hydrated ions

(b) Variable oxidation states

(c) Diamagnetic behavior

(d) Paramagnetic behavior

17. Which of the following factor may be regarded as the main cause of lanthanoids contraction?

(a) Poor shielding of one of the 4 f-electrons by another in the subshell.

(b) Effective shielding of one of the 4f-electrons by another in the subshell.

(c) Poorer shielding of 5d-electrons by 4f-electrons.

(d) Greater shielding of 5d-electrons by 4f-electrons.

18. An extremely hot copper wire reacts with steam to produce:

(a) Cu_2O (b) CuO_2

(c) Cu_2O_2 (d) CuO

19. Spin only magnetic moment of the compound $Hg[Co(SCN)_4]$ is:

(a) $\sqrt{3}$ (b) $\sqrt{15}$

(c) $\sqrt{24}$ (d) $\sqrt{8}$

20. Consider a titration of potassium dichromate solution with acidified Mohr's salt solution using diphenylamine as indicator. The number of moles of Mohr's salt required per mole of dichromate is:

(a) 3 (b) 4

(c) 5 (d) 6

21. $FeCr_2O_4 + Na_2CO_3 + O_2 \xrightarrow{\text{Fusion}} [X] \xrightarrow[H_2O]{H^+} [Y] \xrightarrow[H_2O_2]{H^+} [Z]$

Which of the following statements is true for the compounds [X], [Y], and [Z]?

(a) In all three compounds, the chromium is in +6 oxidation state

(b) [Z] is a deep blue-violet colored compound which decomposes rapidly in aqueous solution into Cr^{3+} and dioxygen

(c) Saturated solution of [Y] given bright orange compound, chromic anhydride, with concentrated H_2SO_4

(d) All of these

22. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite in an acidic solution is:

(a) 2/5 (b) 3/5

(c) 4/5 (d) 1

23. Which of the following metals will not form an amalgam?

(a) Gold (b) Silver

(c) Zinc (d) Iron

24. The equivalent weight of $K_2Cr_2O_7$ in acid medium is equal to:

(a) Molecular weight (b) 1/2 Molecular weight

(c) 1/6 Molecular weight (d) 1/5 Molecular weight

25. Number of electrons transfer in each case when $KMnO_4$ acts as an oxidizing agent to give MnO_2, Mn^{2+}, $Mn(OH)_3$, and MnO_4^{2-} are respectively:

(a) 3, 5, 4, and 1 (b) 4, 3, 1, and 5

(c) 1, 3, 4, and 5 (d) 5, 4, 3, and 1

26. The atomic numbers of V, Cr, Mn, and Fe are respectively 23, 24, 25, and 26. Which one of these may be expected to have the highest second ionization enthalpy?

(a) Cr (b) Mn

(c) Fe (d) V

27. In the reaction,

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + H_2O + Cr_2O_3$$

The coefficient of H_2O is:

(a) 1 (b) 2

(c) 3 (d) 4

28. Lanthanoids contraction is due to increase in:

(a) Shielding by 4f-electrons

(b) Atomic number

(c) Effective nuclear charge

(d) Size of 4f-orbital

29. A certain metal will liberate hydrogen from dilute acids. It will react with water to form hydrogen only

when the metal is heated and the water is in the form of steam. The metal is probably:

(a) Iron (b) Potassium

(c) Copper (d) Mercury

30. The product of oxidation of I^- with MnO_4^- in alkaline medium is:

(a) IO_3^- (b) I_2

(c) IO^- (d) IO_4^-

31. The non-metallic cation is present in:

(a) CrO_2Cl_2 (b) $VOCl$

(c) NH_4Cl (d) PCl_3

32. The compound of vanadium has magnetic moment of 1.73 BM. The vanadium chloride has the formula:

(a) VCl_2 (b) VCl_3

(c) VCl_4 (d) VCl_5

33. Which of the following species will be the strongest Lewis acid?

(a) Fe^0 (b) Fe^{3+}

(c) Fe^{2+} (d) Fe^{1+}

34. $Cr_2O_7^{2-} \xrightarrow{H^+} Cr^{3+}$. Eq.wt. of $Cr_2O_7^{2-}$ is:

(a) mol. wt./6 (b) mol. wt./3

(c) mol. wt./4 (d) mol. wt./1

35. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is:

(a) Greater metallic character of the lanthanoids than that of the corresponding actinoids.

(b) More active nature of the actinoids

(c) More energy difference between $5f$ and $6d$-orbitals than that between $4f$ and $5d$-orbitals

(d) Lesser energy difference between $5f$ and $6d$-orbitals than that between $4f$ and $5d$-orbitals

36. The reduction potential values of M, N and O are +2.46, −1.13 and −3.13 V respectively. Which of the following order is correct regarding their reducing property?

(a) $O > N > M$ (b) $O > M > N$

(c) $M > N > O$ (d) $M > O > N$

37. Which of the following compounds will not give positive chromyl chloride test?

(a) $CuCl_2$ (b) $HgCl_2$

(c) $ZnCl_2$ (d) $C_6H_5\overset{+}{N}H_3Cl^-$

38. The equivalent weight of $KMnO_4$ (formula weight: M) when it is used as an oxidant in neutral medium is:

(a) M (b) $M/2$

(c) $M/3$ (d) $M/5$

39. Hemoglobin and chlorophyll contain respectively:

(a) Fe, Co (b) Fe, Mn

(c) Mg, Fe (d) Fe, Mg

40. In $Cr_2O_7^{2-}$ every Cr is linked to:

(a) Two O-atoms (b) Three O-atoms

(c) Four O-atoms (d) Five O-atoms

41. Fe is made passive by:

(a) Dil. H_2SO_4 (b) Dil. HCl

(c) Aqua regia (d) Conc. H_2SO_4

42. $FeCr_2O_4$ (chromite) is converted to Cr by following steps:

$$\text{Chromite} \xrightarrow{\text{I}} Na_2CrO_4 \xrightarrow{\text{II}} Cr_2O_3 \xrightarrow{\text{III}} Cr$$

I, II, and III are:

	I	II	III
(a)	Na_2CO_3/air, Δ	C	C
(b)	Na_2CO_3/air, Δ	C, Δ	Al, Δ
(c)	NaOH/air, Δ	C, Δ	Mg, Δ
(d)	conc. H_2SO_4, Δ	NH_4Cl, Δ	C, Δ

43. When H_2O_2 is added to an acidified solution of $K_2Cr_2O_7$:

(a) Solution turns green due to formation of Cr_2O_3

(b) Solution turns yellow due to formation of K_2CrO_4

(c) A deep blue-violet colored compound $CrO(O_2)_2$ is formed

(d) Solution gives green ppt. of $Cr(OH)_3$

44. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them is expected to have the highest third ionization enthalpy?

(a) Vanadium ($Z = 23$) (b) Manganese ($Z = 25$)

(c) Chromium ($Z = 24$) (d) Iron ($Z = 26$)

45. Select incorrect statement(s):

(a) Ionization energies of $5d$-elements are greater than those of $3d$ and $4d$-elements

(b) Cu(I) is diamagnetic while Cu(II) is paramagnetic

(c) $[Ti(H_2O)_6]^{3+}$ is colored while $[Sc(H_2O_6)]^{3+}$ is colorless

(d) Transition elements cannot form complexes

46. Increasing basic properties of TiO_2, ZrO_2, and HfO_2 are in order:

(a) $TiO_2 < ZrO_2 < HfO_2$ (b) $HfO_2 < ZrO_2 < TiO_2$

(c) $HfO_2 < TiO_2 < ZrO_2$ (d) $ZrO_2 < TiO_2 < HfO_2$

47. Which is called chromic anhydrided?
(a) CrO (b) Cr_2O_3
(c) CrO_3 (d) CrO_2

48. Philosopher's wool on treatment with cobalt nitrate produces:
(a) $CoBaO_2$ (b) $CoZnO_2$
(c) $CoSrO_2$ (d) $CoMgO_2$

49. Fulminating gold is:
(a) $AuCl_3$ (b) Au_2S
(c) $Au(NH_2) = NH$ (d) $H[Au(Cl)_4]$

50. Anhydrous ferric chloride is prepared by:
(a) Heating hydrated ferric chloride at a high temperature in a stream of air
(b) Heating metallic iron in a stream of dry chlorine gas
(c) Reaction of ferric oxide with HCl
(d) Reaction of metallic iron with HCl

51. When MnO_2 is fused with KOH and $KClO_3$, a colored compound is formed, the product and its color is:
(a) K_2MnO_4, green (b) $KMnO_4$, purple
(c) Mn_2O_3, brown (d) Mn_3O_4, black

52. Which pair of compounds is expected to show similar color in aqueous medium?
(a) $FeCl_3$ and $CuCl_2$ (b) $VOCl_2$ and $CuCl_2$
(c) $VOCl_2$ and $FeCl_2$ (d) $FeCl_2$ and $MnCl_2$

53. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colorless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. The metal ion is:
(a) Pb^{2+} (b) Hg^{2+}
(c) Cu^{2+} (d) Co^{2+}

54. In the standardization of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is:
(a) (Molecular weight)/2 (b) (Molecular weight)/6
(c) (Molecular weight)/3
(d) Same as molecular weight

55. A red solid is insoluble in water. However, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets of a metal appear on the cooler parts of the test tube. The red solid is
(a) HgI_2 (b) HgO
(c) Pb_3O_4 (d) $(NH_4)_2 Cr_2O_7$

56. The value of 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is:
(a) d^4 (in strong ligand field)
(b) d^4 (in weak ligand field)
(c) d^3 (in weak as well as strong fields)
(d) d^5 (in strong ligand field)

57. When MnO_2 is fused with KOH, a colored compound is formed. The product and its color is:
(a) K_2MnO_4, purple green
(b) $KMnO_4$, purple
(c) Mn_2O_3, brown
(d) Mn_3O_4, black

Multiple Correct Answers Type

1. $d_{x^2-y^2}$ orbital is involved in which of the following hybridization:
(a) sp^3d (TBP) (b) sp^3d^2
(c) sp^3d^3 (d) None of these

2. Which of following is/are correctly matched?
(a) d-block element : electronic configuration is $ns^{0-2}(n-1)d^{1-10}$
(b) p-block element : electronic configuration is $ns^{1-2}np^{1-6}$
(c) s-block element : electronic configuration is ns^{1-2}
(d) Ce : f-block's first member

3. Which is true statement about $KMnO_4$?
(a) Its solution is unstable in acidic medium
(b) It has purple color
(c) MnO_4^- changes to Mn^{2+} in basic solution
(d) It is self-indicator in Fe^{2+} or $C_2O_4^{2-}$ titration

4. The ability of d-block elements to form complexes is due to:
(a) Small and highly charged ions
(b) Vacant low energy orbitals to accept lone pair of electrons from ligands
(c) Low polarizing power of cation
(d) None is correct

5. Out of $[Fe(CN)_6]^{4-}$, $[Ni(CN)_4]^{2-}$, and $[Ni(CO)_4]$: select the incorrect statement(s):
(a) All have identical geometry
(b) All are paramagnetic
(c) All are diamagnetic

(d) $[Fe(CN)_6]^{4-}$ is diamagnetic but $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ are paramagnetic

6. A transition element X has a configuration $[Ar]3d^4$ in its +3 oxidation state. Its atomic number is not
(a) 25 (b) 26
(c) 22 (d) 19

7. Which one of the following ionic species will not impart color to an aqueous solution?
(a) Ti^{4+} (b) Cu^+
(c) Zn^{2+} (d) Cr^{3+}

8. Which out of the following halogen to 3d-series?
(a) Copper (b) Cobalt
(c) Gold (d) Silver

9. Transition elements have greater tendency to form complexes because:
(a) They have vacant d-orbitals
(b) They have large size
(c) They show variable oxidation state
(d) They have two electrons in their outermost shells.

10. The color of the transition metal ions is due to:
(a) d-d transition (b) Charge transfer
(c) Change in the geometry
(d) None of these

11. The transition metals which do not form amalgams are:
(a) Zn (b) Fe
(c) Cd (d) Pt

12. The elements which exist in the liquid state at room temperature are:
(a) Na (b) Br
(c) Hg (d) Ga

13. Which of the following statements are correct with reference to the ferrous and ferric ions?
(a) Fe^{3+} gives brown color with potassium ferricyanide
(b) Fe^{2+} gives blue precipitate with potassium ferricyanide
(c) Fe^{3+} gives red color with potassium thiocyanate
(d) Fe^{2+} gives brown color with ammonium thiocyanate

14. Which of the following is false?
(a) Cr^{2+} (g) ion has greater magnetic moment compared to Co^{3+}(g)
(b) The magnitude of ionization potential of iron anion (monoanion) would be equal to electron gain enthalpy of iron
(c) Lanthanoids contraction is cause of lower I.P. of Pb than Sn
(d) If successive ionization energy are 332, 738, 849, 4080, 4958 (in kJ/mol). Then this element can be of 15th group

15. Which of the following represents the correct order of the properties indicated?
(a) $Ni^{2+} > Cr^{2+} > Fe^{2+} > Mn^{2+}$ (size)
(b) Sc > Ti > Cr > Mn (size)
(c) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$ (unpaired electron)
(d) $Cr^{3+} > Cr^{2+}$ (magnetic moment)

16. Which of the following represents the incorrect order of the properties indicated?
(a) $Ni^{2+} > Cr^{2+} > Fe^{2+} > Mn^{2+}$ (size)
(b) Sc > Ti > Cr > Mn (size)
(c) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$ (unpaired electron)
(d) $H_3AsO_4 > H_3PO_4$ (acidic strength order)

17. For CrO_3, following is/are true statement:
(a) It is called chromic anhydride
(b) It is colorless due to $3d^{10}$ configuration
(c) It is bright orange solid and color arises due to charge transfer
(d) It is toxic and corrosive

18. Coagulation of blood takes place by:
(a) Ferric alum (b) Potash alum
(c) Chrom alum (d) None of these

19. The correct statement for d-block element is:
(a) It shows magnetic property
(b) It has variable valency
(c) It has tendency of formation of colored ions
(d) It has complete d-orbitals

20. The aqueous solution of the salt will be colored in the case of:
(a) $Zn(NO_3)_2$ (b) $LiNO_3$
(c) $Co(NO_3)_2$ (d) $CrCl_3$

21. Complex forming tendency of an element depends upon:
(a) High charge (b) Small size of its cation
(c) Availability of vacant d-orbitals
(d) None of these

22. Potassium manganate (K_2MnO_4) is formed when:
(a) Chlorine is passed through aqueous $KMnO_4$ solution
(b) Manganese dioxide is fused with potassium hydroxide in air

(c) Formaldehyde reacts with potassium

(d) Potassium permanganate reacts with H_2SO_4

23. What will be the correct representation of quantum numbers for the last electron entered into Ce?

	n	l	m	s
(a)	4	3	–3	$-\frac{1}{2}$
(b)	4	3	0	$-\frac{1}{2}$
(c)	4	2	–3	$+\frac{1}{2}$
(d)	4	3	+2	$-\frac{1}{2}$

24. Cl_2 gas is obtained by various reactions select the reactions from the following(s):

(a) $KMnO_4 + \text{conc. } HCl \xrightarrow{\Delta}$

(b) $KCl + K_2Cr_2O_7 + \text{conc. } H_2SO_4 \xrightarrow{\Delta}$

(c) $MnO_2 + \text{conc. } HCl \xrightarrow{\Delta}$

(d) $KCl + F_2 \longrightarrow$

25. Which is/are true statement?

(a) Ions of *d*-block elements are colored due to *d-d* transition

(b) Ions of *f*-block elements are colored due to *f-f* transition

(c) $[Sc(H_2O)_6]^{3+}$, $[Ti(H_2O)_6]^{4+}$ are colored complexes

(d) Cu^+ is colorless ion

26. In $[Fe(CN)_5(NO)]^{2-}$, Fe has +2 state. It cannot be decided by:

(a) Magnetic measurement

(b) Colligative property

(c) Color (d) Hybridization

27. Which one of the following statements is/are correct?

(a) Zinc dissolves in sodium hydroxide solution

(b) Carbon monoxide reduces iron(III) oxide to iron

(c) Mercury(II) iodide dissolves in excess of potassium iodide solution

(d) Tin(IV) chloride is made by dissolving tin solution in concentrated hydrochloric acid

28. In $Na_2[Fe(CN)_5NO]$, sodium nitroprusside:

(a) Oxidation state of Fe is +2

(b) This has NO^+ as ligand

(c) d^2sp^3-hybridization

(d) None of the above is correct

29. In the iodometric estimation in the laboratory which process is involved?

(a) $Cr_2O_7^{2-} + H^+ + I^- \longrightarrow 2Cr^{3+} + I_2$

$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{4-} + I^-$

(b) $MnO_4^- + H^+ + I^- \longrightarrow Mn^{2+} + I_2$

$I_2 + S_2O_3^- \longrightarrow S_4O_6^{2-} + I^-$

(c) $MnO_4^- + OH^- + I^- \longrightarrow MnO_2 + I_2$

$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$

(d) $Cr_2O_7^{2-} + OH^- + I^- \longrightarrow 2Cr^{3+} + I_2$

$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$

30. $K_4[Fe(CN)_6]$ is used in detecting:

(a) Cu^{2+} ions (b) Fe^{2+} ions

(c) Fe^{3+} ions (d) Cu^{2+} ions

31. Which of the following statements are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?

(a) A deep red vapor is evolved

(b) The vapor when passed into NaOH solution gives yellow solution of Na_2CrO_4

(c) Chlorine gas is evolved

(d) Chromyl chloride is formed

32. Pyrolusite is MnO_2 used to prepare $KMnO_4$. Steps are:

$$MnO_2 \xrightarrow{\text{I}} MnO_4^{2-} \xrightarrow{\text{II}} MnO_4^-$$

Steps I and II are respectively:

(a) Fuse with KOH / air, electrolytic oxidation

(b) Fuse with KOH / KNO_3, electrolytic oxidation

(c) Fuse with concentrated HNO_3 / air, electrolytic reduction

(d) Dissolve in H_2O oxidation.

Comprehension Type

Comprehension-1: (Q.1 to Q.4)

The elements of the three transition series of the *d*-block are given below:

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Rd	Ag	Cd
La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg

In any transition series, as we move form left to right, the *d*-orbitals are progressively filled and their properties vary accordingly.

1. Which element do you expect to have the smallest atomic radius?

(a) Sc (b) Zn
(c) La (d) Hg

2. Which element do you expect to have the highest melting point?
(a) La (b) W
(c) Os (d) Pt

3. Which element out of the following do you expect to have the lowest melting point?
(a) Cr (b) Mn
(c) Fe (d) Co

4. Which of the following is the correct order of second ionization energy?
(a) V > Cr > Mn (b) V < Cr < Mn
(c) V < Cr > Mn (d) V > Cr < Mn

Comprehension-2: (Q. 5 to Q. 7)

Potassium permanganate is prepared from the mineral pyrolusite, MnO_2. Its crystals have deep purple color. It acts as an oxidizing agent in the neutral, alkaline as well as acidic medium. In acidic medium, it is used in volumetric analysis for the estimation of ferrous salts, oxalates, etc. The titrations are carried out in the presence of H_2SO_4. However, before using it as a titrant, it is first standardized with standard oxalic acid solution or Mohr salt solution. In one of the experiments on titration, 13.4 g of dry pure sodium oxalate (molar mass = 134 g mol^{-1}) was dissolved in 100 mL of distilled water and then 100 mL of distilled water and then 100 mL of 2M H_2SO_4 were added. The solution was cooled to 25.30°C. Now to this solution, 0.1M $KMnO_4$ solution was added till a very faint pink color persisted.

5. When pyrolusite is fused with KOH and $KClO_3$, we get:
(a) $KMnO_4$ (b) K_2MnO_4
(c) Both $KMnO_4$ and K_2MnO_4
(d) None of these

6. The purple color of $KMnO_4$ is due to:
(a) Incomplete d-subshell
(b) Ionic nature of $KMnO_4$
(c) Charge transfer
(d) Resonance in MnO_4^- ion

7. Mohr salt, $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$, is preferred over $FeSO_4 \cdot 7H_2O$ for standardization of $KMnO_4$ solution because:
(a) Mohr salt is a double salt while ferrous sulphate is a single salt
(b) Mohr salt is not hygroscopic but $FeSO_4 \cdot 7H_2O$ is hygroscopic
(c) Mohr salt contains only ferrous ions whereas ferrous sulphate contains some ferric ions
(d) Mohr salt solution can be titrated even in the absence of H_2SO_4

Assertion-Reasoning Type

1. **Statement-1:** 'La' should be the f-block element according to Aufbau principle.
Statement-2: 57th electron exceptionally enters into the 5d-orbital.
(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** The compounds of copper in +1 state are colorless.
Statement-2: Due to 3d^{10} electronic configuration of Cu^+ ion no d-d transition takes place.
(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

3. **Statement-1:** Mercurous compounds are diamagnetic.
Statement-2: Two Hg^+ species which have 6s^1 configuration are bonded together using s-electrons.
(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Ni	(p) Elements having same number of unpaired electron in their dipositive in column-I.
(b) K	(q) At least 13 electrons are having magnetic quantum number 'zero'.
(c) Mn	(r) Atom is paramagnetic.
(d) Pd	(s) Element is not transition element
	(t) Element having pseudo inert gas configuration in its dipositive cation.

2. Match the column:

Column-I	Column-II
(a) Cr^{3+}	(p) Zero B.M.
(b) Cu^{+}	(q) 5.92 B.M.
(c) Mn^{2+}	(r) 3.87 B.M.
(d) Fe^{2+}	(s) 4.90 B.M.

3. Match the column:

Column-I	Column-II
(a) Pt	(p) Used in X-ray tube
(b) Fe	(q) Do not form alloy with Hg
(c) Mo	(r) Element of VIII group
(d) Mn	(s) Native metal
	(t) highest unpaired e^- in *d*-orbital

4. Match coloum-I with coloum-II and select the correct answer using the codes given below the coloums.

Column-I (Metal ion)	Column-II (Magnetic moment (BM))
(a) Cr^{3+}	(p) $\sqrt{35}$
(b) Fe^{2+}	(q) $\sqrt{30}$
(c) Ni^{2+}	(r) $\sqrt{24}$
(d) Mn^{2+}	(s) $\sqrt{15}$
	(t) $\sqrt{8}$

5. Match the column:

Column-I (Property)	Column-II (Transition elements)
(a) Highest oxidation state	(p) Cr
(b) Highest density	(q) Os
(c) Element with maximum unpaired electrons	(r) Tc
(d) Radioactive transition element	(s) Ru

6. Match the following:

Column-I	Column-II
(a) K_2MnO_4	(p) Transition element in +6 oxidation state
(b) $KMnO_4$	(q) Paramagnetic
(c) $K_2Cr_2O_7$	(r) Manufactured from pyrolusite ore
(d) K_2CrO_4	(s) Manufactured from chromite ore

7. Match the column:

Column-I	Column-II
(a) CrO_2Cl_2	(p) d^3s-hybridization
(b) CrO_4^{2-}	(q) Diamagnetic
(c) VO_4^{3-}	(r) Colorless
(d) MnO_4^{-2}	(s) Paramagnetic
	(t) Colorful due to charge transfer

8. Match the alloys (in Column-I) with the constituents metal (in Column-II).

Column-I	Column-II
(a) Gun metal	(p) Pb, Sn
(b) German silver	(q) Cu, Sn, Zn
(c) Brass	(r) Cu, Zn
(d) Solder	(s) Cu, Zn, Ni

9. Match the column:

Column-I	Column-II
(a) Cu^{2+}	(p) Form amphoteric oxide
(b) Zn^{2+}	(q) Diamagnetic and colorless compounds
(c) Cr^{3+}	(r) Form complex with NH_3
(d) Ag^{+}	(s) White oxide but on heating become yellow,

10. Match coloum-I with coloum-II and select the correct answer using the codes give below the coloums:

Column-I (Alloys)	Column-II (Constituents)
(a) Gun metal	(p) Lead + tin
(b) German silver	(q) Copper + tin + zinc
(c) Brass	(r) Copper + zinc
(d) Solder	(s) Copper + zinc + nickel

11. Match the compounds in column-I with their properties in column-II:

Column-I	Column-II
(a) K_2MnO_4	(p) Transition element in +6 state
(b) $KMnO_4$	(q) Oxidizing agent in acid medium

(c) $K_2Cr_2O_7$ (r) Manufactured from pyrolusite ore

(d) K_2CrO_4 (s) Manufactured from chromite ore

12. Match the column:

Column-I	**Column-II**
(a) Baeyer's reagent	(p) $CuSO_4 + Ca(OH)_2$
	(q) 1% alkaline $KMnO_4$
(b) Bordeaux mixture	(r) Detection of unsaturation in organic compounds
(c) Nessler's reagent	(s) Complex of mercury

13. Match the compounds of column X with oxidation state of column-II.

Column-I	**Column-II**
(a) $[Cr(H_2O)_6]Cl_3$	(p) 5
(b) CrO_5	(q) 4
(c) K_3CrO_8	(r) 6
	(s) 3

14. Match the reactions in Column-I with nature of the reactions/type of the products in Column-II.

Column-I	**Column-II**
(a) $O_2^- \longrightarrow O_2 + O_2^{2-}$	(p) Redox reaction
(b) $CrO_4^{2-} + H^+ \longrightarrow$	(q) One of the products has trigonal planar structure
(c) $MnO_4^- + NO_2^- + H^+ \longrightarrow$	(r) Dimeric bridged tetrahedral metal ion
(d) $NO_3^- + H_2SO_4 + Fe^{2+} \longrightarrow$	(s) Disproportionation

Integer Answer Type

1. Calculate the Z_{eff} (approx.) for 4s-electron of Ni-atom according to Slater's rule.
2. Calculate the value of Z_{eff} on 3d-electron of Sc.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Electronic configuration of a transition element X in +3 oxidation state is $[Ar]3d^5$. What is its atomic number?

(a) 25 (b) 26
(c) 27 (d) 24

2. The electronic configuration of Cu(II) is $3d^9$ whereas that of Cu(I) is $3d^{10}$. Which of the following is correct?

(a) Cu(II) is more stable
(b) Cu(II) is less stable
(c) Cu(I) and Cu(II) are equally stable
(d) Stability of Cu(I) and Cu(II) depends on nature of copper salts

3. Metallic radii of some transition elements are given below. Which of these elements will have highest density?

Element	Fe	Co	Ni	Cu
Metallic radii/pm	126	125	125	128

(a) Fe (b) Ni
(c) Co (d) Cu

4. Generally transition elements form colored salts due to the presence of unpaired electrons. Which of the following compounds will be colored in solid state?

(a) Ag_2SO_4 (b) CuF_2
(c) ZnF_2 (d) Cu_2Cl_2

5. On addition of small amount of $KMnO_4$ to concentrated H_2SO_4, a green oily compound is obtained which is highly explosive in nature. Identify the compound from the following.

(a) Mn_2O_7 (b) MnO_2
(c) $MnSO_4$ (d) Mn_2O_3

6. The magnetic nature of elements depends on the presence of unpaired electrons. Identify the configuration of transition element, which shows highest magnetic moment.

(a) $3d^7$ (b) $3d^5$
(c) $3d^8$ (d) $3d^2$

7. Which of the following reactions are disproportionation reactions?

(a) $2Cu^+ \rightarrow Cu^{2+} + Cu$
(b) $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$
(c) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$
(d) $2MnO_4^- + 3Mn^{2+} + 2H_2O \rightarrow 5MnO_2 + 4H^+$

(a) a, b (b) a, b, c
(c) b, c, d (d) a, d

8. When $KMnO_4$ solution is added to oxalic acid solution, the decolorization is slow in the beginning but becomes instantaneous after some time because

(a) CO_2 is formed as the product
(b) Reaction is exothermic

(c) MnO_4^- catalyzes the reaction

(d) Mn^{2+} acts as autocatalyst

9. $KMnO_4$ acts as an oxidizing agent in acidic medium. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphide ions in acidic solution is

(a) $\frac{2}{5}$ (b) $\frac{3}{5}$

(c) $\frac{4}{5}$ (d) $\frac{1}{5}$

10. Which of the following is amphoteric oxide?
Mn_2O_7, CrO_3, Cr_2O_3, CrO, V_2O_5, V_2O_4

(a) V_2O_5, Cr_2O_3 (b) Mn_2O_7, CrO_3

(c) CrO, V_2O_5 (d) V_2O_5, V_2O_4

11. Interstitial compounds are formed when small atoms are trapped inside the crystal lattice of metals. Which of the following is not the characteristic property of interstitial compounds?

(a) They have high melting points in comparison to pure metals

(b) They are very hard

(c) They retain metallic conductivity

(d) They are chemically very reactive

12. The magnetic moment is associated with its spin angular momentum and orbital angular momentum. Spin only magnetic moment value of Cr^{3+} ion is ______.

(a) 2.87 B.M. (b) 3.87 B.M.

(c) 3.47 B.M. (d) 3.57 B.M.

13. $KMnO_4$ acts as an oxidizing agent in alkaline medium. When alkaline $KMnO_4$ is treated with KI, iodide ion is oxidized to ______.

(a) I_2 (b) IO^-

(c) IO_3^- (d) IO_4^-

14. Which of the following statements is not correct?

(a) Copper liberates hydrogen from acids

(b) In its higher oxidation states, manganese forms stable compounds with oxygen and fluorine

(c) Mn^{3+} and Co^{3+} are oxidizing agents in aqueous solution

(d) Ti^{2+} and Cr^{2+} are reducing agents in aqueous solution

15. When acidified $K_2Cr_2O_7$ solution is added to Sn^{2+} salts then Sn^{2+} changes to

(a) Sn (b) Sn^{3+}

(c) Sn^{4+} (d) Sn^+

16. Highest oxidation state of manganese in fluoride is +4 (MnF_4) but highest oxidation state in oxides is +7 (Mn_2O_7) because ______.

(a) Fluorine is more electronegative than oxygen

(b) Fluorine does not possess d-orbitals

(c) Fluorine stabilizes lower oxidation state

(d) In covalent compounds fluorine can form single bond only while oxygen forms double bond

17. Why is HCl not used to make the medium acidic in oxidation reactions of $KMnO_4$ in acidic medium?

(a) Both HCl and $KMnO_4$ act as oxidizing agents

(b) $KMnO_4$ oxidizes HCl into Cl_2 which is also an oxidizing agent

(c) $KMnO_4$ is a weaker oxidizing agent than HCl

(d) $KMnO_4$ acts as a reducing agent in the presence of HCl

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. Transition elements show magnetic moment due to spin and orbital motion of electrons. Which of the following metallic ions have almost same spin only magnetic moment?

(a) Co^{2+} (b) Cr^{2+}

(c) Mn^{2+} (d) Cr^{3+}

2. In the form of dichromate, Cr(VI) is a strong oxidizing agent in acidic medium but Mo(VI) in MoO_3 and W(VI) in WO_3 are not because ______.

(a) Cr(VI) is more stable than Mo(VI) and W(VI)

(b) Mo(VI) and W(VI) are more stable than Cr(VI)

(c) Higher oxidation states of heavier members of group-6 of transition series are more stable

(d) Lower oxidation states of heavier members of group-6 of transition series are more stable

3. Which of the following ions show higher spin only magnetic moment value?

(a) Ti^{3+} (b) Mn^{2+}

(c) Fe^{3+} (d) Co^{3+}

4. Transition elements form binary compounds with halogens. Which of the following elements will form MF_3 type compounds?

(a) Cr (b) Co

(c) Cu (d) Ni

5. Which of the following will not act as oxidizing agents?
   (a) CrO_3
   (b) MoO_3
   (c) WO_3
   (d) CrO_4^{2-}

Short Answer Type

1. Why does copper not replace hydrogen from acids?
2. Why E^0 values for Mn, Ni, and Zn are more negative than expected?
3. Why first ionization enthalpy of Cr is lower than that of Zn?
4. Transition elements show high melting points. Why?
5. When Cu^{2+} ion is treated with KI, a white precipitate is formed. Explain the reaction with the help of chemical equation.
6. Out of Cu_2Cl_2 and $CuCl_2$, which is more stable and why?
7. When a brown compound of manganese (A) is treated with HCl it gives a gas (B). The gas taken in excess, reacts with NH_3 to give an explosive compound (C). Identify compounds A, B, and C.
8. Although fluorine is more electronegative than oxygen, but the ability of oxygen to stabilize higher oxidation states exceeds that of fluorine. Why?
9. Although Cr^{3+} and Co^{2+} ions have same number of unpaired electrons but the magnetic moment of Cr^{3+} is 3.87 B.M. and that of Co^{2+} is 4.87 B.M. Why?
10. Explain why does color of $KMnO_4$ disappear when oxalic acid is added to its solution in acidic medium.
11. When orange solution containing $Cr_2O_7^{2-}$ ion is treated with an alkali, a yellow solution is formed and when H^+ ions are added to yellow solution, an orange solution is obtained. Explain why does this happen?
12. A solution of $KMnO_4$ on reduction yields either a colorless solution or a brown precipitate or a green solution depending on pH of the solution. What different stages of the reduction do these represent and how are they carried out?
13. E^0 of Cu is +0.34 V while that of Zn is –0.76 V. Explain.
14. The halides of transition elements become more covalent with increasing oxidation state of the metal. Why?
15. While filling up of electrons in the atomic orbitals, the 4s orbital is filled before the 3d orbital but reverse happens during the ionization of the atom. Explain why?
16. Reactivity of transition elements decreases almost regularly from Sc to Cu. Explain.

Matching Column Type

Note: Match the items of Column-I and Column-II in the following questions.

1. Match the catalysts given in Column-I with the processes given in Column-II.

Column-I (Catalyst)	Column-II (Process)
(a) Ni in the presence of hydrogen	(p) Zieglar Natta catalyst
(b) Cu_2Cl_2	(q) Contact process
(c) V_2O_5	(r) Vegetable oil to ghee
(d) Finely divided iron	(s) Sandmeyer reaction
(e) $TiCl_4 + Al(CH_3)_3$	(t) Haber's process
(f) Decomposition of $KClO_3$	

2. Match the properties given in Column-I with the metals given in Column-II.

Column-I (Property)	Column-II (Metal)
(a) An element which can show +8 oxidation state	(p) Mn
(b) 3*d* series element that can show up to +7 oxidation state	(q) Cr
(c) 3*d* series element with highest melting point	(r) Os
	(s) Fe

3. Match the solutions given in Column-I and the colors given in Column-II.

Column-I (Aqueous solution of salt)	Column-II (Color)
(a) $FeSO_4 \cdot 7H_2O$	(p) Green
(b) $NiCl_2 \cdot 4H_2O$	(q) Light pink
(c) $MnCl_2 \cdot 4H_2O$	(r) Blue
(d) $CoCl_2 \cdot 6H_2O$	(s) Pale green
(v) Cu_2Cl_2	(t) Pink
	(u) Colorless

4. Match the properties given in Column-I with the metals given in Column-II.

Column-I (Property)		Column-II (Metal)
(a) Element with highest second ionization enthalpy	(p)	Co
(b) Element with highest third ionization enthalpy	(q)	Cr
(c) M in M $(CO)_6$ is	(r)	Cu
(d) Element with highest heat of atomization	(s)	Zn
	(t)	Ni

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true, and reason is the correct explanation of the assertion.

(b) Both assertion and reason are true but reason is not the correct explanation of assertion.

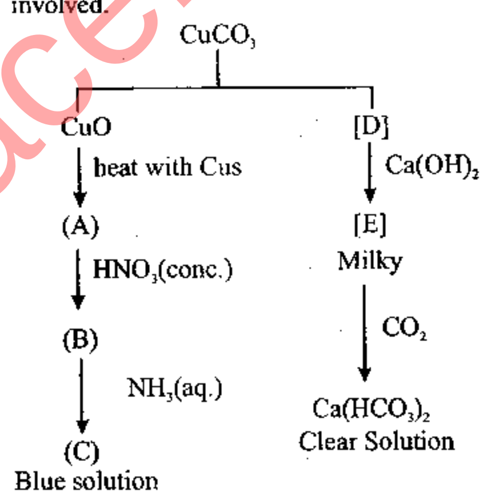
(c) Assertion is not true but reason is true.

(d) Both assertion and reason are false.

1. **Assertion:** Cu^{2+} iodide is not known.
   Reason: Cu^{2+} oxidizes I^- to iodine.
2. **Assertion:** Cu cannot liberate hydrogen from acids.
   Reason: Because it has positive electrode potential.
3. **Assertion:** The highest oxidation state of osmium is +8.
   Reason: Osmium is a 5d-block element.

Long Answer Type

1. Identify A to E and also explain the reactions involved.



2. When a chromite ore (A) is fused with sodium carbonate in free excess of air and the product is dissolved in water, a yellow solution of compound (B) is obtained. After treatment of this yellow solution with sulphuric acid, compound (C) can be crystallized from the solution. When compound (C) is treated with KCl, orange crystals of compound (D) crystallize out. Identify A to D and also explain the reactions.

3. When an oxide of manganese (A) is fused with KOH in the presence of an oxidizing agent and dissolved in water, it gives a dark green solution of compound (B). Compound (B) disproportionates in neutral or acidic solution to give purple compound (C). An alkaline solution of compound (C) oxidises potassium iodide solution to a compound (D) and compound (A) is also formed. Identify compounds A to D and also explain the reactions involved.

4. (I) Answer the following questions:
   (a) Which element of the first transition series has highest second ionization enthalpy?
   (b) Which element of the first transition series has highest third ionization enthalpy?
   (c) Which element of the first transition series has lowest enthalpy of atomization?

   (II) Identify the metal and justify your answer.
   (a) Carbonyl M $(CO)_5$
   (b) MO_3F

5. Mention the type of compounds formed when small atoms like H, C, and N get trapped inside the crystal lattice of transition metals. Also give physical and chemical characteristics of these compounds.

6. (a) Transition metals can act as catalysts because these can change their oxidation state. How does Fe(III) catalyze the reaction between iodide and persulphate ions?
   (b) Mention any three processes where transition metals act as catalysts.

7. A violet compound of manganese (A) decomposes on heating to liberate oxygen and compounds (B) and (C) of manganese are formed. Compound (C) reacts with KOH in the presence of potassium nitrate to give compound (B). On heating compound (C) with conc. H_2SO_4 and NaCl, chlorine gas is liberated and a compound (D) of manganese along with other products is formed. Identify compounds A to D and also explain the reactions involved.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Which of the following ions has the maximum magnetic moment?
   (a) Mn^{+2} (b) Fe^{+2}
   (c) Ti^{+2} (d) Cr^{+2}
   (AIEEE, 2002)

2. When $KMnO_4$ acts as an oxidizing agent and ultimately forms $[MnO_4]^{-2}$, MnO_2, Mn_2O_3, and Mn^{+2}, then the number of electrons transferred in each case, respectively, is:
   (a) 4, 3, 1, and 5 (b) 1, 5, 3, and 7
   (c) 1, 3, 4, and 5 (d) 3, 5, 7, and 1
   (AIEEE, 2002)

3. A red solid is insoluble in water. However, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets of a metal appear on the cooler parts of the test tube. The red solid is:
   (a) HgI_2 (b) HgO
   (c) Pb_3O_4 (d) $(NH_4)_2Cr_2O_7$
   (AIEEE, 2003)

4. What would happen when a solution of potassium chromate is treated with an excess of dilute nitric acid?
   (a) $Cr_2O_7^{2-}$ and H_2O are formed
   (b) CrO_4^{2-} is reduced to +3 state of Cr
   (c) CrO_4^{2-} is oxidized to +7 state of Cr
   (d) Cr^{3+} and $Cr_2O_7^{2-}$ are formed
   (AIEEE, 2003)

5. Which one of the following nitrates will leave behind a metal on strong heating?
   (a) Copper nitrate (b) Manganese nitrate
   (c) Silver nitrate (d) Ferric nitrate
   (AIEEE, 2003)

6. Of the following outer electronic configuration of atoms, the highest oxidation state is achieved by which one of them?
   (a) $(n-1)d^3\,ns^2$ (b) $(n-1)d^5\,ns^1$
   (c) $(n-1)d^8\,ns^2$ (d) $(n-1)d^5\,ns^2$
   (AIEEE, 2004)

7. Heating Cu_2O and Cu_2S will give:
   (a) Cu_2SO_3 (b) $CuO + CuS$
   (c) $Cu + SO_3$ (d) $Cu + SO_2$
   (AIEEE, 2005)

8. The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is:
   (a) +3 (b) +2
   (c) +6 (d) +4
   (AIEEE, 2005)

9. Calomel (Hg_2Cl_2) on reaction with ammonium hydroxide gives:
   (a) HgO (b) Hg_2O
   (c) $NH_2–Hg–Hg–Cl$ (d) $Hg\,NH_2Cl$
   (AIEEE, 2005)

10. Amount of oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4. The titration gives unsatisfactory result when carried out in the presence of HCl, because HCl:
    (a) Gets oxidized by oxalic acid to chlorine
    (b) Furnishes H^+ ions in addition to those from oxalic acid
    (c) Reduces permanganate to Mn^{2+}
    (d) Oxidizes oxalic acid to carbon dioxide and water
    (AIEEE, 2008)

11. In context with the transition elements, which of the following statements is incorrect?
    (a) In the highest oxidation states, the transition metals show basic character and form cationic complexes
    (b) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4s- and 3d-electrons are used for bonding
    (c) In addition to the normal oxidation state, the zero oxidation state is also shown by these elements in complexes
    (d) Once the d^5 configuration is exceeded, the tendency to involve all the 3d-electrons in bonding decreases
    (AIEEE, 2009)

12. Iron exhibits +2 and +3 oxidation states. Which of the following statements about iron is incorrect?
    (a) Ferrous oxide is more basic in nature than the ferric oxide
    (b) Ferrous compounds are relatively more ionic than the corresponding ferric compounds
    (c) Ferrous compounds are less volatile than the corresponding ferric compounds

(d) Ferrous compounds are more easily hydrolyzed than the corresponding ferric compounds

(AIEEE, 2012)

13. Which of the following arrangements does not represent the correct order of the property stated against it?
    (a) $V^{2+} < Cr^{2+} < Mn^{2} < Fe^{2+}$: paramagnetic behavior
    (b) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
    (c) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution
    (d) Sc < Ti < Cr < Mn: number of oxidation states

(JEE Main, 2013)

14. Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E^0_{M^{3+}/M^{2+}}$ value?
    (a) Cr(Z = 24) (b) Mn(Z = 25)
    (c) Fe (Z = 26) (d) Co(Z = 27)

(JEE Main, 2013)

15. Which series of reactions correctly represents chemical relations related to iron and its compound?
    (a) $Fe \xrightarrow{Cl_2,\ heat} Cl_2 \xrightarrow{heat,\ air} FeCl_2 \xrightarrow{Zn} Fe$
    (b) $Fe \xrightarrow{O_2,\ heat} Fe_3O_4 \xrightarrow{CO,\ 600°C} FeO \xrightarrow{CO,\ 700°C} Fe$
    (c) $Fe \xrightarrow{dil\ H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4,\ O_2} Fe_2(SO_4)_2 \xrightarrow{Heat} Fe$
    (d) $Fe \xrightarrow{O_2,\ heat} FeO \xrightarrow{dil\ H_2SO_4} FeSO_4 \xrightarrow{Heat} Fe$

(JEE Main, 2014)

16. Among the following oxoacids, the correct decreasing order of acid strength is:
    (a) $HClO_4 > HClO_3 > HClO_2 > HOCl$
    (b) $HClO_2 > HClO_4 > HClO_3 > HOCl$
    (c) $HOCl > HClO_2 > HClO_3 > HClO_4$
    (d) $HClO_4 > HOCl > HClO_2 > HClO_3$

(JEE Main, 2014)

17. Chloro compound of Vanadium has only spin magnetic moment of 1.73 BM. This Vanadium chloride has the formula: (at. no. of V = 23)
    (a) VCl_4 (b) VCl_3
    (c) VCl_2 (d) VCl_5

(JEE Main, 2014)

18. Which of the following is **not** formed when H_2S reacts with acidic $K_2Cr_2O_7$ solution?
    (a) K_2SO_4 (b) $Cr_2(SO_4)_3$
    (c) S (d) $CrSO_4$

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Mn^{2+} can be oxidized to MnO_4^- by ________ (SnO_2, PbO_2, BaO_2).

(IIT-JEE, 1981)

2. Galvanization of iron denotes coating with ________.

(IIT-JEE, 1983)

3. Silver chloride is sparingly soluble in water because its lattice energy is greater than ________ energy.

(IIT-JEE, 1987)

4. The salts ________ and ________ are isostructural. ($FeSO_4{\cdot}7H_2O$, $CuSO_4{\cdot}5H_2O$, $MnSO_4{\cdot}4H_2O$, $ZnSO_4{\cdot}7H_2O$)

(IIT-JEE, 1990)

5. Fehling solution A consists of an aqueous solution of copper sulphate, while Fehling solution B consists of an alkaline solution of ________.

(IIT-JEE, 1990)

6. The outermost electronic configuration of Cr is ________.

(IIT-JEE, 1994)

7. The compound $YBa_2Cu_3O_7$ which shows super conductivity has copper in oxidation state ________. Assume that the rare earth element yttrium is in its usual +3 oxidation state.

(IIT-JEE, 1994)

8. Silver jewellery items tarnish slowly in air due to their reaction with ________.

(IIT-JEE, 1997)

True/False Type

1. Copper metal reduces Fe^{2+} in an acid medium.

(IIT-JEE, 1982)

2. Silver fluoride is fairly soluble in water.

(IIT-JEE, 1982)

3. The electron density in the xy-plane in $3d_{x^2-y^2}$ orbital is zero.

(IIT-JEE, 1986)

4. Dipositive zinc exhibits paramagnetism due to loss of two electrons from 3*d*-orbitals of neutral atom. **(IIT-JEE, 1987)**

Single Correct Answer Type

1. One of the constituents of German silver is:
(a) Ag (b) Cu
(c) Mg (d) Al
(IIT-JEE, 1980)

2. Which of the following dissolves in hot concentrated NaOH solution?
(a) Fe (b) Zn
(c) Cu (d) Ag
(IIT-JEE, 1980)

3. How many unpaired electrons are present in Ni^{2+}?
(a) 0 (b) 2
(c) 4 (d) 4
(IIT-JEE, 1981)

4. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in:
(a) Slag (b) Gangue
(c) Metallic calcium (d) Calcium carbonate
(IIT-JEE, 1982)

5. Iron is rendered passive by treatment with concentrated:
(a) H_2SO_4 (b) H_3PO_4
(c) HCl (d) HNO_3
(IIT-JEE, 1982)

6. The types of bonds present in $CuSO_4 \cdot 5H_2O$ are only:
(a) Electrovalent and covalent
(b) Electrovalent and coordinate covalent
(c) Electrovalent, covalent, and coordinate covalent
(d) Covalent and coordinate covalent
(IIT-JEE, 1983)

7. Zinc–copper couple that can be used as a reducing agent is obtained by:
(a) Mixing zinc dust and copper gauze
(b) Zinc coated with copper
(c) Copper coated with zinc
(d) Zinc and copper wires welded together
(IIT-JEE, 1984)

8. The reaction which proceeds in the forward direction is:
(a) $Fe_2O_3 + 6HCl = 2FeCl_3 + 3H_2O$
(b) $NH_3 + H_2O + NaCl = NH_4Cl + NaOH$
(c) $SnCl_4 + Hg_2Cl_2 = SnCl_2 + 2HgCl_2$
(d) $2CuI + I_2 + 4H^+ = 2Cu^{2+} + 4KI$
(IIT-JEE, 1991)

9. Which of the following is formed when excess of KCN is added to an aqueous solution of copper sulphate?
(a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
(c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$
(IIT-JEE, 1996)

10. An aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:
(a) A colorless filtrate and a green residue
(b) A yellow filtrate and a green residue
(c) A yellow filtrate and a brown residue
(d) A green filtrate and a brown residue
(IIT-JEE, 1996)

11. Which compound does not dissolve in hot, diluted HNO_3?
(a) HgS (b) PbS
(c) CuS (d) CdS
(IIT-JEE, 1996)

12. Ammonium dichromate is used in some fireworks. The green-colored powder blown in the air is:
(a) CrO_3 (b) Cr_2O_3
(c) Cr (d) $CrO(O_2)$
(IIT-JEE, 1997)

13. Which of the following compounds is expected to be colored?
(a) Ag_2SO_4 (b) CuF_2
(c) MgF_2 (d) CuCl
(IIT-JEE, 1997)

14. Which of the following is an organometallic compound?
(a) Lithium methoxide
(b) Lithium acetate
(c) Lithium dimethylamide
(d) Methyl lithium
(IIT-JEE, 1997)

15. In the dichromate dianion:
(a) Four Cr — O bonds are equivalent
(b) Six Cr — O bonds are equivalent
(c) All Cr — O bonds are equivalent
(d) All Cr — O bonds are non-equivalent
(IIT-JEE, 1999)

16. On heating ammonium dichromate, the gas evolved is:
(a) Oxygen (b) Ammonia
(c) Nitrous oxide (d) Nitrogen
(IIT-JEE, 1999)

17. Among the following, identify the species with an atom in +6 oxidation state:
    (a) MnO_4^- (b) $Cr(CN)_6^{3-}$
    (c) NiF_6^{2-} (d) CrO_2Cl_2
    (IIT-JEE, 2000)

18. Anhydrous ferric chloride is prepared by:
    (a) Heating hydrated ferric chloride at a high temperature in a stream of air
    (b) Heating metallic iron in a stream of dry chlorine gas
    (c) Reaction of ferric oxide with HCl
    (d) Reaction of metallic iron with HCl
    (IIT-JEE, 2002)

19. When MnO_2 is fused with KOH, a colored compound is formed, the product and its color are:
    (a) K_2MnO_4, purple (b) $KMnO_4$, purple
    (c) Mn_2O_3, brown (d) Mn_3O_4, black
    (IIT-JEE, 2003)

20. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by:
    (a) Heating NH_4NO_2 (b) Heating NH_4NO_3
    (c) $Mg_3N_2 + H_2O$ (d) $Na(comp) + H_2O_2$
    (IIT-JEE, 2004)

21. Which pair of compounds is expected to show similar color in aqueous medium?
    (a) $FeCl_3$ and $CuCl_2$ (b) $VOCl_2$ and $CuCl_2$
    (c) $VOCl_2$ and $FeCl_2$ (d) $FeCl_2$ and $MnCl_2$
    (IIT-JEE, 2005)

22. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colorless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep-blue crystalline precipitate. The metal ion is:
    (a) Pb^{2+} (b) Hg^{2+}
    (c) Cu^{2+} (d) CO^2
    (IIT-JEE, 2007)

Multiple Correct Answers Type

1. Potassium manganate (K_2MnO_4) is formed when:
   (a) Chlorine is passed into aqueous $KMnO_4$ solution
   (b) Manganese dioxide is fused with potassium hydroxide in air
   (c) Formaldehyde reacts with potassium permanganate in the presence of a strong alkali
   (d) Potassium permanganate reacts with concentrated sulphuric acid
   (IIT-JEE, 1988)

2. The aqueous solutions of the following salts will be colored in the case of:
   (a) $Zn(NO_3)_2$ (b) $LiNO_3$
   (c) $Co(NO_3)_2$ (d) $CrCl_3$
   (e) Potash alum
   (IIT-JEE, 1990)

3. Which of the following alloys contain(s) Cu and Zn?
   (a) Bronze (b) Brass
   (c) Gun metal (d) Type metal
   (IIT-JEE, 1993)

4. Which of the following statements is/are correct, when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with concentrated H_2SO_4?
   (a) Deep red vapors are evolved
   (b) The vapors when passed into NaOH solution give a yellow solution of Na_2CrO_4
   (c) Chlorine gas is evolved
   (d) Chromyl chloride is formed
   (IIT-JEE, 1998)

5. The addition of high proportions of manganese makes steel useful in making rails or railroads because manganese:
   (a) Gives hardness to steel
   (b) Helps in the formation of oxides of iron
   (c) Can remove oxygen and sulphur
   (d) Can show the highest oxidation state of +7
   (IIT-JEE, 1998)

Comprehension Type

For Problems 1–3

p-Amino-*N,N*-dimethyl is added to a strongly acidic solution of *X*. The resulting solution is treated with a few drops of aqueous solution of *Y* to yield blue coloration due to the formation of methylene blue. Treatment of aqueous solution of *Y* with reagent potassium hexacyanoferrate(II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, the treatment of the solution of *Y* with the solution of potassium hexacyanoferrate(III) leads to a brown coloration due to the formation of *Z*.

1. Compound *X* is:
   (a) $NaNO_3$ (b) NaCl
   (c) Na_2SO_4 (d) Na_2S

2. Compound *Y* is:
   (a) $MgCl_2$ (b) $FeCl_2$
   (c) $FeCl_3$ (d) $ZnCl_2$

3. Compound Z is:
   (a) $Mg_2[Fe(CN)_6]$ (b) $Fe[Fe(CN)_6]$
   (c) $Fe_4[Fe(CN)_6]_3$ (d) $K_2Zn_3[Fe(CN)_6]_2$

(IIT-JEE, 2009)

For Problems 4–6

Copper is the most noble of the first row transition elements. It occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4 \cdot 5H_2O$), atacamite [$Cu_2Cl(OH)_3$], cuprite (Cu_2O), copper glance (Cu_2S), and malachite [$Cu_2(OH)_2CO_3$]. However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). Extraction of copper from chalcopyrite includes roasting, iron removal, and self-reduction.

4. Partial roasting of chalcopyrite produces:
   (a) Cu_2S and FeO (b) Cu_2O and FeO
   (c) CuS and Fe_2O_3 (d) Cu_2O and Fe_2O_3
5. Iron is removed from chalcopyrite as:
   (a) FeO (b) FeS
   (c) Fe_2O_3 (d) $FeSiO_3$
6. In self-reduction, the reducing species is:
   (a) S (b) O^{2-}
   (c) S^{2-} (d) SO_2

(IIT-JEE, 2010)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is also true; Statement-II is the correct explanation for Statement-I.
(b) Statement-I is true; Statement-II is true; Statement -II is not the correct explanation for Statement-I.
(c) Statement-I is true; Statement-II is false.
(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** To a solution of potassium chromate, if a strong acid is added, it changes its color from yellow to orange.
   Statement-II: The color change is due to the change in oxidation state of potassium chromate.

(IIT-JEE, 1998)

2. **Statement-I:** Zn^{2+} is diamagnetic.
   Statement-II: The electrons are lost from 4s-orbital to form Zn^{2+}.

(IIT-JEE, 1998)

3. **Statement-I:** $[Fe(H_2O)_5NO]SO_4$ is paramagnetic.
   Statement-II: The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons.

(IIT-JEE, 2008)

Matching Column Type

1. Match each of the reactions given in Column-I with the corresponding product(s) given in Column-II:

Column-I	Column-II
(a) Cu + dil. HNO_3	(p) NO
(b) Cu + conc. HNO_3	(q) NO_2
(c) Zn + dil. HNO_3	(r) N_2O
(d) Zn + conc. HNO_3	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

(IIT-JEE, 2009)

Integer Answer Type

1. The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is ________.

(IIT-JEE, 2009)

2. The number of water molecule(s) directly bonded to the metal center in $CuSO_4 \cdot 5H_2O$ is ________.

(IIT-JEE, 2009)

Subjective Type

1. What happens when sulphurdioxide gas is bubbled through an aqueous solution of copper sulphate in the presence of potassium thiocyanate?

(IIT-JEE, 1983)

2. Given reasons for the following in one or two sentences: "Silver bromide is used in photography".

(IIT-JEE, 1983)

3. Complete and balance the following reactions:
   (i) $Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$
   (ii) $Cr_2O_7^{2-} + C_2H_4O \rightarrow C_2H_4O_2 + Cr^{3+}$

(IIT-JEE, 1983)

4. State the conditions under which the following preparations are carried out. Give the necessary equations which need not be balanced.
   "Potassium permanganate from manganese dioxide".

(IIT-JEE, 1983)

5. Show with balanced equations what happens when the following are mixed:
   (i) Aqueous solution of potassium manganate and acid
   (ii) Aqueous solution of potassium chromate and acid

(IIT-JEE, 1984)

6. Write the balanced equations for the reactions when
   (i) Potassium permanganate interacts with manganese dioxide in the presence of potassium hydroxide.
   (ii) Potassium ferrocyanide is heated with concentrated sulphuric acid.

(IIT-JEE, 1985)

7. Mention the products formed in the following:
   (i) Zinc oxide is treated with excess of sodium hydroxide solution.
   (ii) Iodine is added to a solution of stannous chloride.

(IIT-JEE, 1986)

8. Write the balanced equations for the reaction occurring when gold is dissolved in aquaregia.

(IIT-JEE, 1987)

9. Write the balanced equation for the following: "Potassium permanganate is reacted with warm solution of oxalic acid in the presence of sulphuric acid". **(IIT-JEE, 1987)**

10. Complete and balance the following reactions:
   (i) $Mn^{2+} + PbO_2 \rightarrow MnO_4^- + H_2O$
   (ii) $Ag^+ + AsH_3 \rightarrow H_3AsO_3 + H^+$

(IIT-JEE, 1987)

11. Answer the following questions briefly:
   (i) What is the actual reducing agent of hematite in blast furnace?
   (ii) Zinc, not copper, is used for the recovery of metallic silver from the complex $[Ag(CN)_2]^-$, explain.
   (iii) Why is chalcocite roasted and not calcinated during the recovery of copper?

(IIT-JEE, 1987)

12. Write the balanced equations for extraction of silver from glance cyanide process.

(IIT-JEE, 1988)

13. Write the balanced chemical equations for the following:
   (i) Silver chloride is treated with aqueous sodium cyanide and the product thus formed is allowed to react with zinc in an alkaline medium.
   (ii) Cobalt(II) solution reacts with KNO_2 in acetic acid medium.

(IIT-JEE, 1989)

14. Write the balanced equation for 'the extraction of copper from copper pyrites by self-reduction'.

(IIT-JEE, 1990)

15. Write the balanced chemical equations for the following reactions:
   (i) A mixture of potassium dichromate and sodium chloride is heated with concentrated H_2SO_4.
   (ii) Potassium permanganate is added to a hot solution of manganous sulphate.

(IIT-JEE, 1990)

16. A light bluish-green crystalline compound responds to the following tests:
   (i) Its aqueous solution gives a brown precipitate on coloration with alkaline $K_2[HgI_4]$ solution.
   (ii) Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution.
   (iii) Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution.

   Identify the ions present and suggest the formula of the compound.

(IIT-JEE, 1992)

17. Complete and balance the following chemical reactions:
   (i) Na_2CO_3 is added to a solution of copper sulphate.
   $CuSO_4 + Na_2CO_3 + H_2O \rightarrow \cdots + Na_2SO_4 + \cdots$
   (ii) Potassium dichromate and concentrated HCl are heated together.
   $K_2Cr_2O_7 + HCl \rightarrow KCl + \cdots + \cdots + H_2O$
   (iii) Copper reacts with HNO_3 to give NO and NO_2 in molar ratio of 2 : 1.
   $Cu + HNO_3 \rightarrow \cdots + NO + NO_2 + \cdots$

(IIT-JEE, 1993)

18. Complete and balance the following:
   $(NH_4)_2 S_2O_8 + H_2O + MnSO_4 \rightarrow$

(IIT-JEE, 1993)

19. The composition of a sample of wustite is $Fe_{0.93}O_{100}$. What percentage of iron is present in the form of Fe(III)?

(IIT-JEE, 1994)

20. Complete and balance the following reactions:
   (i) $[MnO_4]^{2-} + H^+ \rightarrow \cdots + [MnO_4]^- + H_2O$
   (ii) $SO_2(aq.) + Cr_2O_7^{2-} + 2H^+ \rightarrow \cdots$

(IIT-JEE, 1994)

21. Write a balanced equation for the reaction of argentite with KCN and name the products in solution.

(IIT-JEE, 1996)

22. Write a balanced equation for the following: "Reaction of zinc with dilute nitric acid".

(IIT-JEE, 1997)

23. Thionyl chloride can be synthesized by chlorinating SO_2 using PCl_5. Thionyl chloride is used to prepare anhydrous ferric chloride starting from its hexahydrated salt. Alternatively, the anhydrous ferric chloride can also be prepared from its hexahydrated salt by treating with 2,2-dimethoxypropane. Discuss all this using balanced chemical equations.

(IIT-JEE, 1998)

24. When the ore hematite is burnt in air with coke around 2000 K along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations.

(IIT-JEE, 1998)

25. Work out the following using chemical equation: "In moist air, copper corrodes to produce a green layer on the surface".

(IIT-JEE, 1998)

26. Give reasons for following in one or two sentences: "CrO_3 is an acid anhydride".

(IIT-JEE, 1999)

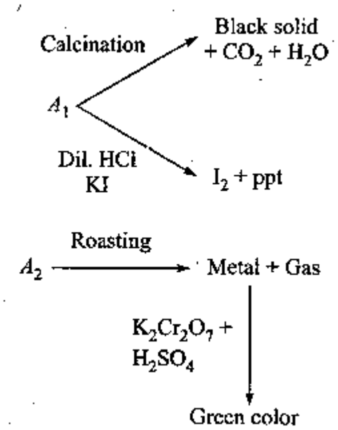
27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate A which is insoluble in warm aqueous solution of KOH. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate B. Identify the transition metal ion. Write the chemical reactions involved in the formation of A and B.

(IIT-JEE, 2000)

28. When a white crystalline compound X is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas A is evolved. On passing A into caustic soda solution, a yellow-colored solution B is obtained. Neutralizing the solution of B with acetic acid and on subsequent addition of lead acetate, a yellow precipitate C is obtained. When X is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate D is formed. Identify A, B, C, D, and X. Write the equations of the reactions involved.

(IIT-JEE, 2002)

29. A_1 and A_2 are two ores of metal M. A_1 on calcination gives black precipitate, CO_2, and water. Identify A_1 and A_2.



(IIT-JEE, 2004)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

4. (a) $Kr^+ \rightarrow 4s^2\,4p^5$ $\therefore$ 1 unpaired electron
$Mn^{2+} \rightarrow 3d^5\,4s^0$ $\therefore$ 5 unpaired electrons
$Fe^{3+} \rightarrow 3d^5\,4s^0$ $\therefore$ 5 unpaired electrons
$O^+ \rightarrow 2s^2\,2p^3$ $\therefore$ 3 unpaired electrons

5. (a) Both are having the same number of electrons on the basis of which chemical properties depend and both are neutral.

10. (d) Iron and carbon form alloy which is called cementite (Fe_3C).

JEE (Advanced) Exercises

Single Correct Answer Type

2. (c) The size of given metals decreases whereas ionization energy increases from Ti to V to Cr to Fe. Hence, the metallic character of the metals decreases so is their basicity of oxides from Ti to V to Cr to Fe.

3. (c) Zn ⟶ as both are in ground state and have most stable oxidation state $3d$ is completely filled.

4. (c) $A \to ns^2\, np^2$

⥮ $\boxed{\uparrow}\boxed{\uparrow}\boxed{\ }$

Maximum difference would be

$IE_5 - IE_3$

7. (d) Chrom alum $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$ is widely used in tanning of leather.

31. (c) $NH_4^+Cl^- \to$ Cation is non-metallic (PCl_3 is covalent)

32. (c) $\sqrt{n(n+2)} = 1.73$ $V \to [Ar]\, 3d^3\, 4s^2$

For $n = 1$, $\mu = 1.73$ and n is number of unpaired electron. Therefore, V^{4+} must be formed; thus VCl_4.

33. (b) Strongest Lewis Acid is one with maximum oxidation state.

Multiple Correct Answers Type

1. (b), (c)

$sp^3d^2 = d_{z^2}, d_{x^2-y^2}$ and sp^3d^3 uses $\to$ $d_{x^2-y^2}, d_{z^2}, d_{xy}$

2. (a), (c), (d)

For p-block, configuration is ns^2np^{1-6}

14. (a), (b), (d)

(a) $Cr^{2+} \to [Ar]\, 3d^4\, 4s^0$

$\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\ }$ 4 unpaired electrons

Magnetic moment $= \sqrt{n(n+2)} = \sqrt{4(4+2)} = \sqrt{24}$

$Co^{3+} \to [Ar]\, 3d^6\, 4s^0$

$\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ 4 unpaired electrons

$= \sqrt{4(4+2)} = \sqrt{24}$

(b) $Fe \xrightarrow{I.E.} Fe$, $Fe \xleftarrow{+\text{electron}} Fe$. So ionization energy of Fe^- is equal to ΔH_{eg} of Fe

(c) Pb has more ionization potential than Sn due to poor shielding of $4f$-orbitals.

(d) Number of valence electrons in given element is 3. Thus, from data of ionization potential thus element corresponds to 13 group.

16. (a), (d)

Sc Ti V Cr Mn ⟶ (size ↓) Fe Co Ni ⟷ (same) Cu Zn ⟶ (↑)

Same order for neutral atom and ion having same charge.

$H_3AsO_4 < H_3PO_4$ as P is more electronegative than As.

23. (a), (b), (d)

${}_{58}Ce \to f$-block element: Last electron enters in f-orbital and highest value of $n = 6$ but the last electron will enter in $4f$-orbitals filled would be $[Xe]\, 6s^2 4f^1 5d^1$.

Comprehension Type

Comprehension-1: (Q. 1 to Q. 4)

1. (b)

	Sc	Zn	La	Hg
Covalent radii (Å)	1.44	1.25	1.69	1.44

2. (b)
3. (b)
4. (c)

Assertion-Reasoning Type

1. (b) $La \to [Xe]\, 6s^2\, 5d^1$; $La \to$ Exception of Aufbau's rule.

Matching Column Type

1. (a) p, q, s; (b) r, s; (c) q, r; (d) p, q.

(a) $Ni_{(28)}$ — $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^8\, 4s^2$

$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$

Ni^{2+} — $3d^8\, 4s^0$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$

Number of unpaired electron in $Ni^{2+} = 2$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$ (min)

Atom is paramagnetic.

It is transition element.

(b) $K_{(19)}$ — $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^1$ $\boxed{\uparrow}$

K^{2+} — $3p^5$ $\boxed{\uparrow\downarrow}$

$m = 0$

Number of unpaired electron in $K^{2+} = 1$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 1 = 11$ (min)

Atom is paramagnetic.

It is not transition element.

(c) $Mn_{(25)}$ – $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^2\, 3d^5$

Mn^{2+} $3d^5$

$m = 2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$

(Transition element)

Number of unpaired electron in $Mn^{2+} = 5$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$ (min)

Atom is paramagnetic.

It is transition element.

(d) Pd – $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^2\, 3d^{10}$

Pd^{2+} $4d^6\, 5s^2\, 4d^8$

Number of unpaired electron in $Pd^{2+} = 2$

$m = 0$ present in all orbitals

$m = 2+2+2+2+2+2+2+2+2+1 = 19$

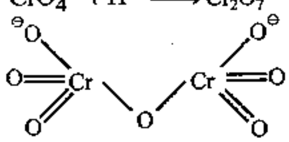
Atom is diamagnetic.

It is transition element.

14. (a) p, s; (b) r; (c) p, q; (d) p

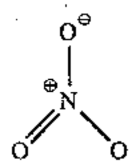
(a) $O_2^- \longrightarrow O_2 + O_2^{2-}$ (disproportionation reaction)

(b) $CrO_4^{2-} + H^+ \longrightarrow Cr_2O_7^{2-}$



dimeric bridged tetrahedral metal ion

(c) $MnO_4^- + NO_2^- + H^+ \longrightarrow Mn^{2+} + NO_3^-$



sp^2 Trigonal planar

(d) $NO_3^- + H_2SO_4 + Fe^{2+} \longrightarrow Fe_2(SO_3)_3 + NO]$

(redox reaction)

Integer Answer Type

1. (4) $Ni \rightarrow 1s^2\,2s^2 2p^6\,3s^2 3p^6\,3d^8 4s^2$

Grouping $\rightarrow \underbrace{(1s)^2}_{(n-3)}\ \underbrace{(2s2p)^8}_{(n-2)}\ \underbrace{(3s3p)^8(3d)^8}_{(n-1)}\ \underset{n}{(4s)^2}$

$\sigma = 10 \times 1 + 16 \times 0.85 + 1 \times 0.35 = 23.95$

$Z_{eff} = Z - \sigma$

$= 28 - 23.95 = 4.05 \simeq 4$

2. (3) $\underbrace{(1s)^2(2s\,2p)^8(3s\,3p)^8}_{0^{8\times 1} \times 0.35}\ \underbrace{(3d)^1}_{nd}\ \underbrace{(4s)^2}_{0.00}$

$S = 18 + 0.00 = 18.00$

$Z_{eff} = Z - S$

$= 21 - 18 \Rightarrow 3$

NCERT Exemplar Exercises

Short Answer Type

1. Cu shows positive $E^\ominus$ value.

2. **Hint:** Negative $E^\ominus$ values for Mn^{2+} and Zn^{2+} are related to stabilities of half filled and fully filled configuration respectively. But for Ni^{2+}, $E^\ominus$ value is related to the highest negative enthalpy of hydration.

3. Ionization enthalpy of Cr is lower due to stability of d 5 and the value for Zn is higher because its electron comes out from 4*s* orbital.

4. The high melting points of transition metals are attributed to the involvement of greater number of electrons in the interatomic metallic bonding from $(n-1)$ *d*-orbitals in addition to *ns* electrons

5. **Hint:** Cu^{2+} gets reduced to Cu^+

$2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$

(white precipitate)

6. **Hint:** $CuCl_2$ is more stable than Cu_2Cl_2. The stability of Cu^{2+} (aq.) rather than Cu^+(aq.) is due to the much more negative hyd$H^\ominus$ of Cu^{2+} (aq.) than Cu^+(aq.).

7. A = MnO_2 B = Cl_2 C = NCl_3

$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

(A) (B)

$NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$

(excess) (C)

8. **Hint:** It is due to the ability of oxygen to form multiple bonds to metals.

9. **Hint:** Due to symmetrical electronic configuration there is no orbital contribution in Cr^{3+} ion. However appreciable orbital contribution takes place in Co^{2+} ion.

10. $KMnO_4$ acts as oxidizing agent. It oxidizes oxalic acid to CO_2 and itself changes to Mn_{2+} ion which is colorless.

$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

(Colored) (Colorless)

11. $Cr_2O_7^{2-} \underset{H^+}{\overset{OH^-}{\rightleftharpoons}} CrO_4^{2-}$

Dichromate Chromate

(Orange) (Yellow)

12. Oxidizing behavior of $KMnO_4$ depends on pH of the solution. In acidic medium (pH < 7)

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

(Colorless)

In alkaline medium (pH > 7)

$MnO_4^- + e \rightarrow MnO_4^{2-}$

(Green)

In neutral medium (pH = 7)

$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH$

(Brown precipitate)

13. **Hint:** High ionization enthalpy to transform Cu(s) to Cu^{2+} (aq.) is not balanced by its hydration enthalpy. However, in case of Zn after removal of electrons from 4*s*-orbital, stable $3d^{10}$ configuration is acquired.

14. As the oxidation state increases, size of the ion of transition element decreases. As per Fajan's rule, as the size of metal ion decreases, covalent character of the bond formed increases.

15. $n + l$ rule: For $3d = n + l = 5$ $4s = n + l = 4$

So electron will enter in $4s$ orbital.

Ionization enthalpy is responsible for the ionization of atom. $4s$ electrons are loosely held by the nucleus. So electrons are removed from $4s$ orbital prior to $3d$.

16. **Hint:** It is due to regular increase in ionization enthalpy.

Long Answer Type

1. A = Cu B = $Cu(NO_3)_2$ C = $[Cu(NH_3)_4]$

D = CO_2

E = $CaCO_3$ F = $Cu_2[Fe(CN)_6]$ G = $Ca(HCO_3)_2$

$CuCO_3 \rightarrow CuO + CO_2$

$CuO + CuS \rightarrow Cu + SO_2$

(A)

$Cu + 4HNO_3 \text{ (Conc)} \rightarrow Cu(NO_3)_2 + 2NO + 2H_2O$

(B)

$Cu^{2+} + NH^3 \rightarrow [Cu(NH_3)_4]$

(B) (C)

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

(D) (E)

$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

2. A = $FeCr_2O_4$ B = Na_2CrO_4

C = $Na_2Cr_2O_7 \cdot 2H_2O$ D = $K_2Cr_2O_7$

$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

(A) (B)

$2NaCrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$

$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

(C) (D)

3. A = MnO_2 (B) K_2MnO_4 (C) $KMnO_4$ (D) KIO_3

$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

(A) (B)

$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(C)

$2MnO_4^- + H_2O + KI \rightarrow 2MnO_2 + 2OH^- + KIO_3$

(A) (D)

4. (a) (A) Cu, because the electronic configuration of Cu is $3d^{10}4s^1$. So second electron needs to be removed from completely filled d-orbital.

(b) Zn [**Hint:** As above]

(c) Zn [**Hint:** No unpaired electron for metallic bonding]

(b) (A) $Fe(CO)_5$ [**Hint: EAN rule**]

(b) MnO_3F [**Hint:** Mn shows +7 oxidation state; d-electrons are not involved in bonding.]

5. Interstitial compounds.

Characteristic properties:

(a) High melting points, higher than those of pure metals.

(b) Very hard.

(c) Retain metallic conductivity.

(d) Chemically inert.

6. (a) Reaction between iodide and persulphate ions is:

$2I^- + S_2O_8^{2-} \xrightarrow{Fe(III)} I_2 + 2SO_4^{2-}$

Role of Fe(III) ions:

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$

(b) (A) Vanadium (V) oxide in contact process for oxidation of SO_2 to SO_3.

(B) Finely divided iron in Haber's process in conversion of N_2 and H_2 to NH_3.

(C) MnO_2 in preparation of oxygen from $KClO_3$.

7. A = $KMnO_4$ B = K_2MnO_4

C = MnO_2 D = $MnCl_2$

$KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$

(A) (B) (C)

$MnO_2 + KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

$MnO_2 + 4NaCl + 4H_2SO_4 \rightarrow MnCl_2 + 2NaHSO_4 + 2H_2O + Cl_2$

(D)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Magnetic moment $\mu = \sqrt{n(n+2)}$

where n = no. of unpaired e^-.

Thus, more the no. of unpaired e^-, higher will be the value of magnetic moment. Mn^{2+} has 5 unpaired e^-s.

2. (c) $KMnO_4 \xrightarrow{+1e^-} MnO_4^{2-}$

$KMnO_4 \xrightarrow{+3e^-} MnO_2$

$KMnO_4 \xrightarrow{+4e^-} Mn_2O_3$

$KMnO_4 \xrightarrow{+5e^-} Mn^{2+}$

3. (a) HgI_2 is a red solid insoluble in water. On addition of some KI, it forms a soluble complex K_2HgI_4. On heating HgI_2 in the test tube, I_2 vapors, violet fumes are liberated and droplets of mercury appears on the cooler parts of the test tube.

4. (a) $2K_2CrO_4 + \text{dil. } 2HNO_3 \rightleftharpoons K_2Cr_2O_7 + H_2O + 2KNO_3$ CrO_4^{2-} and $Cr_2O_7^{2-}$ ions are in the state of dynamic equilibrium with each other. Under acidic pH, dichromate ions are formed, and under alkaline pH, chromate ions are formed mainly.

5. (c) Mercury and silver oxysalts on strong heating leaves behind metals.

$AgNO_3 \xrightarrow{\Delta} Ag\downarrow + NO_2\uparrow + \frac{1}{2}O_2\uparrow$

6. (d) The highest oxidation state in case of d-block elements is equal to the total number of s and unpaired *d*-electrons. Hence, the answer is (d) having the highest oxidation state of +7.

7. (d) $Cu_2O + Cu_2S \rightarrow Cu + SO_2\uparrow$

This reaction is an example of self-reduction reaction, which is a characteristic of Cu.

8. (a) $K_2Cr_2O_7 + 6KI + 7H_2SO_4$

$\downarrow$

$Cr_2(SO_4)_3 + 3I_2 + 4K_2SO_4 + 7H_2O$

Cr is in +3 oxidation state in $Cr_2(SO_4)_3$.

9. (d) $Hg_2Cl + 2NH_4OH \rightarrow \underset{\text{white}}{[Hg(NH_2)]Cl\downarrow} + \underset{\text{black}}{Hg\downarrow}$

It is disproportionation reaction.

10. (c) If titration is carried out in presence of HCl, then $KMnO_4$ will also be consumed by HCl as HCl will be oxidized to Cl_2.

$HCl + KMnO_4 \rightarrow Cl_2 + MnCl_2 + KCl$

11. (a) In the highest oxidation state, the transition metals show acidic character and form anionic complexes.

Example: Mn in +7 form MnO_4^{2-}.

Cr in +6 form $Cr_2O_7^{2-}$ and CrO_4^{2-}.

12. (d)

(a) With increase in oxidation state of the metal ion, its basic nature decreases.

(b) With increase in oxidation state of the metal ion, its covalent nature.

(c) Covalent compounds are more volatile than ionic compounds.

(d) With increase in oxidation state of the metal ion, hydration tendency of the compound increases.

13. (a) $V^{2+} = [Ar]$ 3d: ⇅ ⇅ ⇅ ↑ ↑

$Cr^{2+} = [Ar]$ 3d: ⇅ ⇅ ⇅ ↑ ↑

$Mn^{2+} = [Ar]$ 3d: ⇅ ⇅ ⇅ ↑ ↑

$Fe^{2+} = [Ar]$ 3d: ⇅ ⇅ ⇅ ↑ ↑

Correct order of Paramagnetic behaviour $Mn^{2+} > Fe^{+2} = Cr^{2+} > V^{2+}$

15. (b) Answer is (2) because all steps are correct as per information.

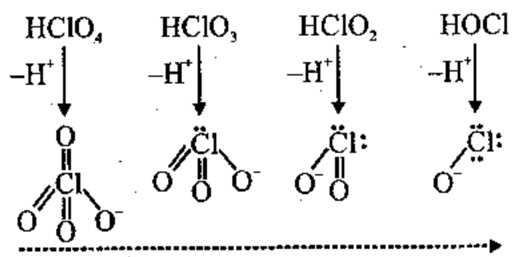
(a) is wrong because

$\overset{III}{FeCl_3} \xrightarrow[\text{1/2 } O_2 \text{ (in presence of air)}]{\Delta} \overset{III}{FeOCl} + Cl_2\uparrow$

(c) is wrong because $Fe_2(SO_4)_3 \xrightarrow{\Delta} Fe_2O_{3(s)} + 3SO_3\uparrow$

(d) is wrong because $2FeSO_4 \xrightarrow{\Delta} Fe_2O_{3(s)} + SO_2\uparrow + SO_3\uparrow$

16. (a)



Stability of conjugate base is decreasing due to decreasing no. of resonating structures.

$HClO_4 > HClO_3 > HClO_2 > HOCl$

17. (a) If the magnetic moment is 1.73 BM then the number of unpaired e^- V^{4+} having our unpaired electron

18. (d) $K_2Cr_2O_7 + H_2S \rightarrow Cr_2(SO_4)_3 + S + K_2SO_4 + H_2O$

JEE (Advanced) Exercises

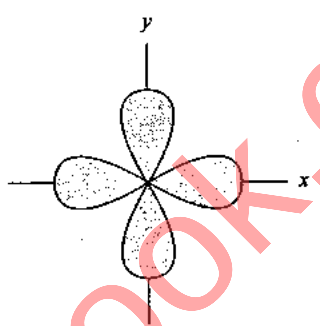
Fill in the Blanks Type

1. Mn^{2+} can be oxidized to MnO_4^- by **PbO_2**.
2. Galvanization of iron denotes coating with **zinc**.
3. Silver chloride is sparingly soluble in water because its lattice energy is greater than **its hydration** energy.

4. The salts $FeSO_4 \cdot 7H_2O$ and $ZnSO_4 \cdot 7H_2O$ are isostructural.
5. Fehling solution A consists of an aqueous solution of copper sulphate while Fehling solution B consists of an alkaline solution of **sodium potassium tartarate**.
6. The outermost electronic configuration of Cr is $3d^5\,4s^1$. It is a half-filled stable configuration.
7. The compound $YBa_2Cu_3O_7$, which shows super conductivity, has copper in the oxidation state $+\frac{7}{3}$.
8. Silver jewellery items tarnish slowly in air due to their reaction with H_2S. Black-colored silver sulphide is formed.

True/False Type

1. **False.**
   Fe^{2+} cannot be further reduced by copper metal.
2. **True.**
   Hydration energy of AgF is higher than its lattice energy. It is soluble in water, but chloride, bromide, and iodide of silver are not soluble in water.
3. **False.**



$d_{x^2-y^2}$

4. **False.**
   Zn^{2+}:
   The oxidation numner of Zn is +2.
   $z = 30$
   $Zn = [Ar]3d^{10}\,4s^2$
   $Zn^{2+} = [Ar]3d^{10}$

   3d

↑↓	↑↓	↑↓	↑↓	↑↓

   No unpaired electron present; hence diamagnetic.

Single Correct Answer Type

1. (b) German silver is an alloy which contains copper, zinc, and nickel.
2. (b) Only zinc dissolves due to the formation of sodium zincate.

$$Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2\uparrow$$

3. (b) Atomic number of Ni is 28.
   $Ni{:}[Ar]3d^8\,4s^2$
   $Ni^{2}{:}[Ar]3d^8$

   3d

↑↓	↑↓	↑↓	↑	↑

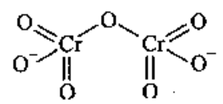
   There are two unpaired electrons.
4. (a) In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in slag.
   $CaCO_3 \rightarrow CaO + CO_2$
   $CaO + SiO_2 \rightarrow CaSiO_3$ (slag)
5. (d) The inertness exhibited by metals under conditions in which chemical activity is expected is known as passivity. The phenomenon of passivity is explained by assuming the formation of a thin film of oxide on the surface of the metal which prevents the action of the reagent. The concentrated nitric acid makes metals such as iron, cobalt, nickel, chromium, aluminium, etc., passive.
6. (c) $[Cu(H_2O)_4]SO_4 \cdot H_2O$
   There are electrovalent, covalent, and coordinate bonds.
7. (b) Zinc–copper couple, which can be used as a reducing agent, is obtained by coating zinc with copper. Zinc is dipped in a solution of copper salt. It displaces copper and copper gets deposited over the surface of zinc.
8. (a) $Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$
   Backward reaction will not take place due to the lack of hydrolysis of $FeCl_3$.
9. (d) When excess of KCN is added to an aqueous solution of copper sulphate, $K_3[Cu(CN)_4]$ is formed.
   $CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$
   $2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + (CN)_2$
   $Cu_2(CN)_2 + 6KCN \rightarrow 2K_3\,[Cu(CN)_4]$
10. (c) In the presence of peroxide, chromium ions are oxidized to chromate ions which give a yellow filtrate. Ferric ions form brown precipitate of $Fe(OH)_3$.
11. (a) HgS is not dissolved in hot dilute HNO_3. It dissolves only in aquaregia.
12. (b) Ammonium dichromate is used in some fireworks. The green-colored powder which blows in air is Cr_2O_3.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + N_2 + 4H_2O$$

13. (b) CuF_2 is blue colored.
In CuF_2, Cu^{2+} ions are present.
$Cu = [Ar]3d^{10}\,4s^1$
$Cu^{2+} = [Ar]3d^9$
Unpaired electron present.
Colored
$Cu+ = [Ar]3d^{10}$
No unpaired electron
Colorless

14. (d) Organometallic compounds are those compounds in which metal atom is directly bonded with C atom.
Methyl lithium is one such compound.

15. (b)



Due to resonance, six Cr—O bonds are equivalent in dichromate ion.

16. (d) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2\uparrow + Cr_2O_3 + 4H_2O$

17. (d) MnO_4^-: Mn (+ 7)
$Cr(CN)_6^{3-}$: Cr (+ 3)
NiF_6^{2-}: Ni (+ 4)
CrO_2Cl_2: Cr (+ 6)

18. (b) By heating metallic iron in a stream of dry chlorine gas.
$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

19. (a) Potassium manganate is formed which has purple color.
$2\,MnO_2 + 4KOH + O_2 \rightarrow 2K_2MNO_4 + 2H_2O$

20. (a) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + 4H_2O + N_2\uparrow$

$NH_4NO_2 \xrightarrow{\Delta} 2H_2O + N_2\uparrow$

21. (b) $VOCl_2$:
The oxidation number of V is +4.
$z = 23$
$V = [Ar]3d^3\,4s^2$
$V^{4+} = [Ar]3d^1$

↑				

One unpaired electron present
$CuCl_2$:
The oxidation number of Cu is +2.
$z = 29$
$Cu = [Ar]\,3d^{10}\,4s^1$
$Cu^+ = [Ar]3d^9$

↑↓	↑↓	↑↓	↑↓	↑

One unpaired electron present.
The metal ion salts having similar number of unpaired electrons in *d*-orbitals show similar color in aqueous medium.

22. (b) $Hg^{2+} + 2I^- \rightarrow HgI_2\downarrow$(Scarlet red precipitate)
$HgI_2 + 2I^- \rightarrow [HgI_4]^{2-}$
$Hg^{2+} + Co(SCN)_2 \rightarrow \underset{\text{Deep-blue crystalline}}{Hg(SCN)_2}\downarrow + Co^{2+}$

Multiple Correct Answers Type

1. (b), (c) Potassium manganate (K_2MnO_4) is formed when manganese dioxide is fused with potassium hydroxide in air or formaldehyde reacts with potassium permanganate in the presence of a strong alkali.
$4KOH + 2MnO_2 + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$
$HCHO + 2KMnO_4 + 2KOH$
$\rightarrow K_2MnO_4 + H_2O + HCOOH$

2. (c), (d) Co^{2+}:
$z = 27$
$Co = [Ar]3d^7\,4s^2$
$Co^{2+} = [Ar]3d^7$

↑↓	↑↓	↑	↑	↑

Two unpaired electrons present.
Cr^{3+}:
$z = 24$
$Cr = [Ar]3d^5 4s^1$
$Cr^{3+} = [Ar]3d^3$

↑	↑	↑		

$Co(NO_3)_2$ and $CrCl_3$ have unpaired electron; hence, they are colored.

3. (a), (b), (c) Brass (Cu, Zn)
Bronze (Cu, Sn)
Gun metal (Cu, Sn, Zn)
Type metal (Pb, Sn, and Sb).

4. (a), (b), (d)

$K_2Cr_2O_7 + 6H_2SO_4 + 4NaCl \rightarrow 2KHSO_4$
$+ 4NaHSO_4 + 2CrO_2Cl_2 + 3H_2O$

Orange-red vapors of CrO_2Cl_2 are produced.
When these vapors are passed through NaOH, a yellow solution of Na_2CrO_4 is produced.

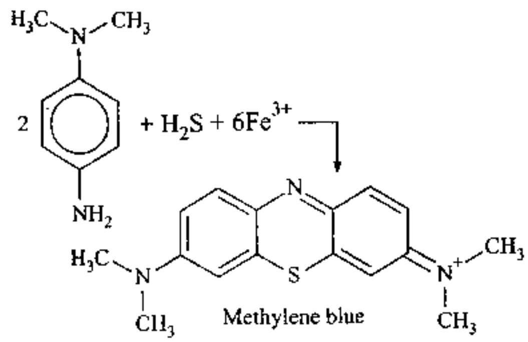
$CrO_2Cl_2 + 4NaOH \rightarrow \underset{\text{Yellow}}{Na_2CrO_4} + 2H_2O + 2NaCl$

5. (a), (c) Manganese gives hardness to steel.
It also removes oxygen and sulphur from steel by forming slag.

$Fe_2O_3 + 3Mn \rightarrow 3MnO + 2Fe$
$MnO + SiO_2 \rightarrow MnSiO_3$

Comprehension Type

1. (d) X is Na_2S.
   $Na_2S + 2H^+ \rightarrow H_2S + Na^+$
2. (b) Y is $FeCl_3$.

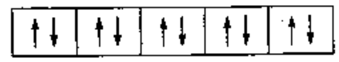


$+ 6Fe^{2+} + NH_4^+ + 4H^+$

3. (b) $4FeCl_3 + 3K_4[Fe(CN)_6] \rightarrow Fe_4[Fe(CN)_6]_3 + 2KCl$
   $FeCl_3 + K_3[Fe(CN)_6] \rightarrow Fe[Fe(CN)_6] + 3KCl$
   $Fe[Fe(CN)_6]$ is brown in color.
4. (a) Partial roasting:
   $2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$
   $2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$
5. (d) Removal of iron:
   $FeO + SiO_2 \rightarrow FeSiO_3$ (Slag)
6. (c) Self-reduction
   $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$
   The oxidation number of sulphur increases from –1 to +4. Therefore, S^{2-} is the reducing species.

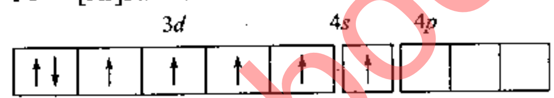
Assertion-Reasoning Type

1. (c) To a solution of potassium chromate if a strong acid is added, it changes its color from yellow to orange. The color change is due to the change in the oxidation state of potassium chromate, there is no change in the oxidation state of chromium which is +6 in both cases.
   $$\underset{\text{(Yellow)}}{2CrO_4^{2-}} + SO_4^{2-} + 2H^+ \rightarrow \underset{\text{(Orange)}}{Cr_2O_7^{2-}} + SO_4^{2-} + H_2O$$
2. (a) Both statements are correct and Statement-II is the correct explanation for Statement-I.
   Zn^{2+}:
   The oxidation number of Zn is + 2.
   $z = 30$
   $Zn = [Ar]3d^{10}\,4s^2$
   $Zn^{2+} = [Ar]3d^{10}$

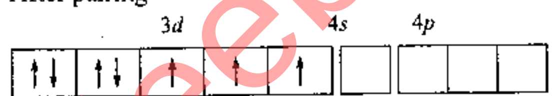


No unpaired electron present.

3. (a) $[Fe(H_2O)_5\,NO]\,SO_4$
   NO has charge equal to +1 in this complex. Therefore, the oxidation number of Fe in the complex becomes +1.
   $Fe = [Ar]3d^6\,4s^2$
   $Fe^+ = [Ar]3d^6\,4s^1$



After pairing



NO^+ causes pairing of 4s electron inside.
Thus, the configuration is $3d^7$ and the number of unpaired electrons is 3.

Matching Column Type

1. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)
   $3Cu + (\text{dil.})\,8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
   $3Cu + (\text{conc.})\,4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
   $4Zn + (\text{dil.})\,10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$
   $Zn + (\text{conc.})\,4HNO_3 \rightarrow Zn(NO_3)_2 + NO_2 + 2H_2O$

Integer Answer Type

1. (6) The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is 6.
   $2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$
   In K_2MnO_4, the oxidation state of Mn is +6.
2. (4) The number of water molecules directly bonded to the metal center in $CuSO_4{\cdot}5H_2O$ is 4.
   $[Cu(H_2O)_4]\,SO_4{\cdot}H_2O$

Subjective Type

1. $2CuSO_4 + SO_2 + 2KCNS + 2H_2O \rightarrow 2CuCNS\downarrow + K_2SO_4 + 2H_2SO_4$
2. Silver bromide is used in photography because silver bromide is photosensitive. It decomposes and is converted into metallic silver grains when light is incident on it.
3. (i) $4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$
   (ii) $Cr_2O_7^{2-} + 3C_2H_6O + 8H^+ \rightarrow 3C_2H_4O_2 + 2Cr^{3+} + 4H_2O$
4. Potassium permanganate can be prepared from manganese dioxide as follows:
   $2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

$$2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$$

The above reaction can also be carried out with ozone or carbon dioxide or electrolytically.

5. (i) Permanganate is formed.

$$2MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + MnO_4^- + 2H_2O$$

(ii) Yellow-colored chromate changes to orange-colored dichromate.

$$2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$$

6. (i) When potassium permanganate interacts with manganese dioxide in the presence of potassium hydroxide, potassium manganate is formed

$$2KMnO_4 + 4KOH + MnO_2 \rightarrow 3K_2MnO_4 + 2H_2O$$

(ii) When potassium ferrocyanide is heated with concentrated sulphuric acid, CO is evolved.

$$K_4Fe(CN)_6 + 6H_2SO_4 + 6H_2O$$
$$\rightarrow 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO\uparrow$$

When potassium ferrocyanide is heated with dilute sulphuric acid, HCN is evolved, which is a poisonous gas.

7. (i) Sodium zincate is formed.

$$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$$

(ii) Stannous chloride is a good reducing agent. It reduces iodine to iodide.

$$SnCl_2 + 2HCl + I_2 \rightarrow SnCl_4 + 2HI$$

8. Gold dissolves in aquaregia due to the reaction with nascent chlorine.

$$[HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl] \times 3$$
$$[Au + 3Cl \rightarrow AuCl_3] \times 2$$
$$[AuCl_3 + HCl \rightarrow HAuCl_4] \times 2$$
$$\overline{2Au + 3HNO_3 + 11HCl \rightarrow 2HAuCl_4 + 3NOCl + 6H_2O}$$

9.

$$2KMnO_4 + 3H_2SO_4$$
$$\rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$[(COOH)_2 + [O] \rightarrow 2CO_2 + H_2O] \times 5$$
$$\overline{2KMnO_4 + 3H_2SO_4 + 5(COOH)_2}$$
$$\rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO_2$$

10. (i) $2Mn^{2+} + 5PbO_2 + 4H^+ \rightarrow 2MnO_4^- + 5Pb^{2+} + 2H_2O$

(ii) $6Ag^+ + AsH_3 + 3H_2O \rightarrow 6Ag\downarrow + 6H^+ + H_3AsO_3$

11. (i) First by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then in blast furnace, smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

Carbon monoxide is the actual reducing agent of hematite in blast furnace.

(ii) Zinc is more reducing and cheaper than copper.

(iii) Chalcocite is a sulphide ore of copper; therefore, it must be roasted in the presence of air to get oxide.

12. In case of silver metal, sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{ppt.}}{2Ag\downarrow}$$

13. (i) Silver goes into the complex, and then it is displaced with zinc.

$$AgCl + 2NaCN \rightarrow NaCl + Na[Ag(CN)_2]$$
$$2Na[Ag(CN)]_2 + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$$

(ii) Yellow precipitate is formed.

$$KNO_2 + CH_3COOH \rightarrow CH_3COOK + HNO_2$$
$$CoCl_2 + 2KNO_2 \rightarrow Co(NO_2)_2 + 2KCl$$
$$Co(NO_2)_2 + 2HNO_2 \rightarrow Co(NO_2)_3 + NO + H_2O$$
$$Co(NO_2)_3 + 3KNO_2 + K_3[Co(NO_2)_6]$$

14. Roasting:

$$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$$
$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 3SO_2$$
$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$$

Smelting:

$FeO + SiO_2 \rightarrow FeSiO_3$ (Slag)

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Bessemerization:

Self-reduction

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

15. (i) Orange-red vapors of chromyl chloride are formed.

$$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \rightarrow 2CrO_2Cl_2$$
$$+ 4NaHSO_4 + 3H_2O + 2KHSO_4$$

(ii) Manganese dioxide is formed.

$$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2$$
$$+ K_2SO_4 + 2H_2SO_4$$

16. Its aqueous solution gives a brown precipitate or coloration with alkaline $K_2[HgI_4]$ solution. This suggests ammonium ions.

Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution. This suggests ferrous ions. Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution. This suggests sulphate ions. The formula of the compound can be $FeSO_4(NH_4)_2\ SO_4{\cdot}6H_2O$ (Mohr's salt).

17. (i) $CuSO_4 + Na_2CO_3 + H_2O$

$$\rightarrow \underset{\text{Blue}}{Cu(OH)_2}\downarrow + Na_2SO_4 + CO_2\uparrow$$

(ii) Chlorine is evolved.

$$K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2\uparrow$$

(iii) $Cu + (\text{conc.})\ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

$3Cu + (\text{dil.})\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

Multiplying the second equation by 2 and adding both the equations, we get

$7Cu + 20HNO_3 \rightarrow 7Cu(NO_3)_2 + 4NO + 2NO_2 + 10H_2O$

Molar ratio of NO and NO_2 is 2 : 1.

18. $(NH_4)_2S_2O_8 + 2H_2O + MnSO_4 \rightarrow MnO_2 + 2H_2SO_4 + (NH_4)_2SO_4$

19. $Fe_{0.93}O_{100}$

Let Fe occurring as +3 state be a.

Fe occurring as +2 state = $(0.93 - a)$

$\therefore 3a + 2(0.93 - a) = 2$

or $3a + 1.86 - 2a = 2$

or $a = 0.14$

Percentage of Fe(III) = $\dfrac{0.14}{0.93} \times 100 = 15$

20. (i) $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

(ii) $2SO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 3SO_4^{2-} + 2Cr^{3+} + H_2O$

21. Potassium argentocyanide is formed.

$Ag_2S + 4KCN \rightarrow 2K[Ag(CN)_2] + K_2S$

22. Zinc gives nitrous oxide with dilute nitric acid.

$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

23. Thionyl chloride is $SOCl_2$

$SO_2 + PCl_5 \rightarrow SOCl_2 + POCl_3$

$FeCl_3{\cdot}6H_2O + 6SOCl_2 \rightarrow FeCl_3 + 12HCl + 6SO_2$

$FeCl_3 \cdot 6H_2O + 6CH_3C(OCH_3)_2CH_3 \rightarrow FeCl_3 + 12CH_3OH + 6CH_3COCH_3$

24. First by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then in blast furnace, smelting is done, where it is reduced to get iron.

$4FeO + O_2 \rightarrow 2Fe_2O_3$

$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_2O_3 + CO \rightarrow FeO + CO_2$

$FeO + CO \rightarrow Fe + CO_2$

In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of lime. The slag formed consists of $Ca_3(PO_4)_2$. Phosphorous is oxidized to P_4O_{10} which reacts with lime to form slag.

$P_4 + 5O_2 \rightarrow P_4O_{10}$

$$6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$$

25. In moist air, copper corrodes to produce a green layer on the surface due to the following slow reaction. Basic copper carbonate is formed.

$Cu + H_2O + CO_2 + O_2 \rightarrow CuCO_3{\cdot}Cu(OH)_2$

26. CrO_3 is an acid anhydride. When it is added to water, it forms chromic acid. So it is the anhydride of chromic acid.

$CrO_3 + H_2O \rightarrow H_2CrO_4$

27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate A which is insoluble in warm aqueous solution of KOH. It must be the black precipitate of CuS because copper sulphate is also blue colored. The blue solution on treatment with KI in a weak acidic medium turns yellow and produces a white precipitate B. In this reaction, cupric iodide is first formed which decomposes to give white cuprous iodide and iodine.

$$CuSO_4 + H_2S \xrightarrow{\text{Acidic medium}} \underset{\text{Black}}{CuS}\downarrow + H_2SO_4$$

$CuSO_4 + 2KI \rightarrow CuI_2 + K_2SO_4$

$2CuI_2 \rightarrow Cu_2I_2\downarrow + I_2$

28. X: NH_4Cl

A: CrO_2Cl_2

B: Na_2CrO_4

C: $PbCrO_4$

D: $H_2N{-}Hg{-}O{-}Hg{-}I$

When a white crystalline compound X is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas A is evolved. This must be chromyl chloride coming from a chloride salt. On passing A into caustic soda solution, a yellow-colored solution B is obtained. This is sodium chromate. Neutralizing the solution of B with acetic acid and on subsequent addition of lead acetate, a yellow precipitate C is obtained. This is lead chromate. When X is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate D is formed. The gas is ammonia, so A is ammonium chloride. D is iodide of Millon's base.

$$K_2Cr_2O_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$$
$$NH_4Cl + H_2SO_4 \rightarrow NH_4HSO_4 + HCl$$
$$CrO_3 + 2HCl \rightarrow \underset{\text{Orange-red vapors}}{CrO_2Cl_2} + H_2O$$
$$NaOH + CrO_2Cl_2 \rightarrow \underset{\text{Yellow solution}}{Na_2CrO_4} + NaCl + H_2O$$
$$Pb(CH_3COO)_2 + Na_2CrO_4 \rightarrow \underset{\text{Yellow ppt.}}{PbCrO_4 \downarrow} + CH_3COONa$$
$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$$
$$2K_2HgI_4 + NH_3 + 3KOH \rightarrow H_2N—Hg—O—Hg—I + 7KI + 2H_2O$$

$H_2N—Hg—O—Hg—I$ is a brown-colored iodide of Millon's base.

29. A_1 is malachite $CuCO_3{\cdot}Cu(OH)_2$.

$$CuCO_3{\cdot}Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2\uparrow + H_2O$$

CuO is the black solid.

$$CuCO_3{\cdot}Cu(OH)_2 \xrightarrow{\text{dil.HCl}} CuCl_2 + CO_2 + H_2O$$
$$CuCl_2 \xrightarrow{KI} Cu_2I_2 + KCl + I_2$$

A_2 is copper glance Cu_2S, a sulphide ore.

$$Cu_2S \xrightarrow[\Delta]{O_2} Cu_2O + SO_2$$
$$Cu_2S + Cu_2O \rightarrow Cu + SO_2$$

The gas SO_2 gives green color with acidified $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + 4H_2O$$

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (d)	2. (b)	3. (d)	4. (a)	5. (a)	6. (d)	7. (b)	8. (b)	9. (d)	10. (d)
11. (c)	12. (b)	13. (d)	14. (b)	15. (d)	16. (d)	17. (c)	18. (c)	19. (c)	20. (b)
21. (b)	22. (d)	23. (c)	24. (c)	25. (b)	26. (b)	27. (a)	28. (a)	29. (c)	30. (a)
31. (b)	32. (a)	33. (a)	34. (d)	35. (d)	36. (c)	37. (a)	38. (b)	39. (d)	40. (a)
41. (b)	42. (b)	43. (b)	44. (c)	45. (a)	46. (d)	47. (c)	48. (c)	49. (d)	50. (b)
51. (c)	52. (c)	53. (a)	54. (a)	55. (c)	56. (c)	57. (a)			

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (c)	4. (c)	5. (c)	6. (b)	7. (d)	8. (d)	9. (c)	10. (b)
11. (b)	12. (b)	13. (d)	14. (d)	15. (a)	16. (b)	17. (a)	18. (d)	19. (b)	20. (d)
21. (d)	22. (a)	23. (d)	24. (c)	25. (c)	26. (a)	27. (d)	28. (c)	29. (a)	30. (a)
31. (c)	32. (c)	33. (b)	34. (a)	35. (d)	36. (a)	37. (b)	38. (c)	39. (d)	40. (c)
41. (c)	42. (b)	43. (c)	44. (b)	45. (d)	46. (a)	47. (c)	48. (b)	49. (c)	50. (b)
51. (a)	52. (b)	53. (b)	54. (b)	55. (a)	56. (d)	57. (a)			

Multiple Correct Answers Type

1. (b), (c)	2. (a), (c), (d)	3. (a), (b), (d)	4. (a), (b)	5. (a), (b), (d)
6. (b), (c), (d)	7. (a), (b), (c)	8. (a), (b)	9. (a), (c)	10. (a), (b)
11. (b), (c)	12. (b), (c), (d)	13. (a), (b), (c)	14. (a), (b), (d)	15. (b), (c)
16. (a), (d)	17. (a), (c), (d)	18. (a), (b), (c)	19. (a), (b), (c)	20. (c), (d)

21. (a), (b), (c) 22. (b), (c) 23. (a), (b), (d) 24. (a), (c), (d) 25. (a), (b), (d)
26. (b), (c), (d) 27. (a), (b), (c) 28. (a), (b), (c) 29. (a), (b) 30. (c), (d)
31. (a), (b), (d) 32. (a), (b)

Comprehension Type

Comprehension-1 1. (b) 2. (b) 3. (b) 4. (c)
Comprehension-2 5. (b) 6. (c) 7. (c)

Assertion-Reasoning Type

1. (b) 3. (a) 4. (a)

Matching Column Type

1. (a) p, q, s; (b) r, s; (c) q, r; (d) p, q
2. (a) r; (b) p; (c) q; (d) s
3. (a) q, r, s; (b) q, r; (c) p; (d) t
4. (a) s; (b) r; (c) t; (d) p
5. (a) q, s; (b) q; (c) p; (d) r
6. (a) p, q, r; (b) r; (c) p, s; (d) p, s
7. (a) p, q, t; (b) p, q, t; (c) p, q, r; (d) p, s, t
8. (a) q; (b) s; (c) r; (d) p
9. (a) r; (b) p, q, r, s; (c) p, r; (d) q, r
10. (a) q; (b) s; (c) r; d) p
11. (a) p, r; (b) q, r; (c) p, q, s; (d) p, s
12. (a) q, r; (b) p; (c) s
13. (a) s; (b) r; (c) p
14. (a) p, s; (b) r; (c) p, q; (d) p

Integer Answer Type

1. (4) 2. (3)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (a) 3. (d) 4. (b) 5. (a) 6. (b) 7. (a) 8. (d) 9. (a) 10. (a)
11. (d) 12. (b) 13. (c) 14. (a) 15. (c) 16. (d) 17. (b)

Multiple Correct Answers Type

1. (a), (d) 2. (b), (c) 3. (b), (c) 4. (a), (b) 5. (b), (c)

Matching Column Type

1. (a) → (r); (b) → (s); (c) → (q); (d) → (t); (e) → (p)
2. (a) → (r); (b) → (p); (c) → (q)
3. (a) → (s); (b) → (p); (c) → (q); (d) → (t); (e) → (u)
4. (a) → (r); (b) → (s); (c) → (q); (d) → (p)

Assertion-Reasoning Type

1. (a) 2. (a) 3. (b)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (a) 4. (a) 5. (c) 6. (d) 7. (d) 8. (a) 9. (d) 10. (c)
11. (a) 12. (d) 13. (a) 14. (d) 15. (b) 16. (a) 17. (a) 18. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b) 2. (b) 3. (b) 4. (a) 5. (d) 6. (c) 7. (b) 8. (a) 9. (d) 10. (c)
11. (a) 12. (b) 13. (b) 14. (d) 15. (b) 16. (d) 17. (d) 18. (b) 19. (a) 20. (a)
21. (b) 22. (b)

Multiple Correct Answers Type

1. (b), (c) 2. (c), (d) 3. (a), (b), (c) 4. (a), (b), (d) 5. (a), (c)

Comprehension Type

1. (d) 2. (b) 3. (b) 4. (a) 5. (d) 6. (c)

Assertion-Reasoning Type

1. (c) 2. (a) 3. (a)

Matching Column Type

1. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)

Integer Answer Type

1. (6) 2. (4)

Periodic Table

JEE (Main) Exercises

Single Correct Answer Type

1. Which electronic configuration of neutral atom will have the highest first ionization potential?
   (a) $1s^2, 2s^2 2p^1$ (b) $1s^2, 2s^2 2p^3$
   (c) $1s^2, 2s^2 2p^2$ (d) $1s^2, 2s^2 2p^4$
2. K^+, Cl^-, Ca^{2+}, and S^{2-} ions are isoelectronics. The decreasing order of their size is:
   (a) $S^{2-} > Cl^- > K^+ > Ca^{2+}$
   (b) $Ca^{2+} > K^+ > Cl^- > S^{2-}$
   (c) $K^+ > Cl^- > Ca^{2+} > S^{2-}$
   (d) $Cl^- > S^{2-} > Ca^{2+} > K^+$
3. The ionization energy will be maximum for the process:
   (a) $Ba \longrightarrow Ba^{2+}$ (b) $Be \longrightarrow Be^{2+}$
   (c) $Cs \longrightarrow Cs^+$ (d) $Li \longrightarrow Li^+$
4. Which of the following ion has the largest radius?
   (a) Cl^- (b) S^{2-}
   (c) Na^+ (d) F^-
5. Which of the following is isoelectronic with carbon atom?
   (a) Na^+ (b) Al^{3+}
   (c) O^{2-} (d) N^+
6. Which of the following species has four lone pairs of electrons in its outer shell?
   (a) I (b) O^-
   (c) Cl^- (d) He
7. Which among the following element has the lowest value of ionization energy?
   (a) Mg (b) Ca
   (c) Ba (d) Sr
8. Which ion is not isoelectronic with O^{2-}?
   (a) N^{3-} (b) Na^+
   (c) F^- (d) Ti^+
9. Which of the following does not reflect the periodicity of elements?
   (a) Bonding behavior (b) Electronegativity
   (c) Ionization potential (d) Neutron/proton ratio
10. The element with strong electropositive nature is:
    (a) Cu (b) Cs
    (c) Cr (d) Ba
11. Which among the following has the highest ionic radius?
    (a) F^- (b) B^{3+}
    (c) O^{2-} (d) Li^+
12. Ionic radii of:
    (a) $Ti^{4+} < Mn^{7+}$ (b) $Cr^{6+} > Cr^{3+}$
    (c) $K^+ > Cl^-$ (d) $P^{3+} > P^{5+}$
13. The most electronegative element is:
    (a) Nitrogen (b) Fluorine
    (c) Oxygen (d) Chlorine
14. The set representing the correct order of first ionization enthalpy is:
    (a) K > Na > Li (b) Be > Mg > Ca

(c) B > C > N (d) Ge > Si > C

15. The correct order of atomic radii is:
(a) Na < Be < B (b) $F^- < O^{2-} < N^{3-}$
(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

16. The outermost electronic configuration of the most electronegative element is:
(a) $ns^2\ np^3$ (b) $ns^2\ np^4$
(c) $ns^2\ np^5$ (d) $ns^2\ np^6$

17. Amongst the following elements (whose electronic configurations are given below) the one having the highest ionization is:
(a) [Ne] $3s^2\ 3p^1$ (b) [Ne] $3s^2\ 3p^3$
(c) [Ne] $3s^2\ 3p^2$ (d) [Ar] $3d^{10}, 4s^2\ 4p^3$

18. Which of the following set of ions represents a collection of isoelectronic species?
(a) $Ba^{2+}, Sr^{2+}, K^+, Ca^{2+}$ (b) $K^+, Cl^-, Ca^{2+}, Sc^{3+}$
(c) $N^{3-}, O^{2-}, F^-, S^{2-}$ (d) $Li^+, Na^+, Mg^{2+}, Ca^{2+}$

19. Aluminium is diagonally related to:
(a) Li (b) Si
(c) Be (d) B

20. Which of the following pair of atomic numbers represents *s*-block elements?
(a) 7, 15 (b) 6, 12
(c) 9, 17 (d) 3, 12

21. An element of atomic number 29 belongs to:
(a) *s*-block (b) *d*-block
(c) *p*-block (d) *f*-block

22. Which of the following has the largest radius?
(a) O^{2-} (b) Mg^{2+}
(c) Na^+ (d) F^-

23. The electronic configuration of an element is $1s^2, 2s^2 2p^6, 3s^2, 3p^3$. What is the atomic number of the element which is just below the above element in the periodic table?
(a) 34 (b) 49
(c) 33 (d) 31

24. Which of the following has the largest atomic size?
(a) Al (b) Al^{2+}
(c) Al^{3+} (d) Al^+

25. Alkaline earth metals form ions of the formula:
(a) M^+ (b) M^-
(c) M^{2+} (d) M^{2-}

26. Atomic number 56 belongs to which block?
(a) *s* (b) *p*
(c) *d* (d) *f*

27. Eka-aluminium and eka-silicon are known as:
(a) Gallium and germanium
(b) Aluminium and silicon
(c) Iron and sulphur
(d) Proton and silicon

28. Increasing order of electron gain enthalpy is:
(a) N < O < Cl < Al (b) O < N < Al < Cl
(c) N < Al < O < Cl (d) Cl < N < O < Al

29. According to modern periodic law, variations in the properties of elements are related to their:
(a) Atomic weights (b) Nuclear weights
(c) Atomic numbers (d) Neutron–proton ratios

30. Which of the following has maximum ionization enthalpy?
(a) K (b) Na
(c) Mg (d) Be

31. The electronic configuration of transition elements is exhibited by:
(a) ns^1 (b) $ns^2\ np^5$
(c) $ns^2\ (n-1)d^{10}$ (d) $(n-1)\ d^{1\text{-}10}\ ns^{0\text{-}2}$

32. Which of the following has the lowest ionization energy?
(a) Oxygen (b) Nitrogen
(c) Fluorine (d) Sulphur

33. If *A*, *B*, and *C* are the three elements of Dobereiner's triad, and atomic weights of *A* and *B* are 7 and 15, respectively, then the atomic weight of *C* is:
(a) 1 (b) 11
(c) 23 (d) 25

34. The incorrect hydrated radius order is:
(a) $Li^+_{(aq)} < Be^{2+}_{(aq)}$ (b) $Na^+_{(aq)} < Al^{3+}_{(aq)}$
(c) $I^-_{(aq)} > Cl^-_{(aq)}$ (d) $Ba^{2+}_{(aq)} < Ca^{2+}_{(aq)}$

35. The correct hydration energy order is:
(a) $Fe^{2+} > Fe^{3+}$ (b) $Cu^{2+} < Cu^+$
(c) $K^+ > Cs^+$ (d) $F^- < Br^-$

36. Atomic radii of fluorine and neon in Angstrom units are, respectively, given by:
(a) 0.72, 1.60 (b) 1.60, 1.60
(c) 0.72, 0.72 (d) 1.60, 0.72

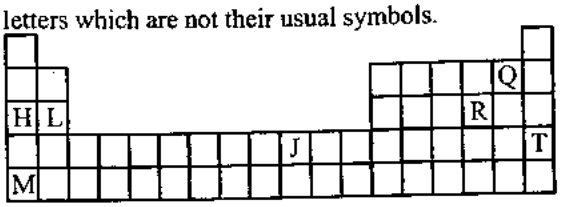
37. Select the correct ionic radius order:
(a) $P^{3-} < P^{2-}$ (b) $P^{3-} < S^{3-}$
(c) $Na^+ < Mg^{2+}$ (d) $S^{2-} < Ca^{2+}$

38. Which of the following element is not a "*p*-" block element?

(a) P (b) Al

(c) Pb (d) Hg

39. The diagram below shows a part of the skeleton of the periodic table in which elements are indicated by letters which are not their usual symbols.



Which one of the following statement is correct?

(a) The greatest ionic character of compounds formed by reaction of pairs of the listed elements would be exhibited by the compounds with the formula M_2

(b) The J^{2+} ion is colored and has an electronic configuration of $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^7$

(c) Element R is a gas at room temperature

(d) Element T is an inert gas with an electronic configuration $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^6$

40. What is the electronic configuration of the ground state of the magnesium cation, Mg^{2+}?

(a) $1s^2 2s^2 2p^6 3s^2$ (b) $1s^2 2s^2 2p^6 3s^1$

(c) $1s^2 2s^2 2p^6$ (d) $1s^2 2s^2 2p^4 3s^2$

41. The overall layout of the empty periodic table is shown below (up to element 54).

Answer the following question:

If X represents an element of atomic number 9 and Y an element of atomic number 20, the compound formed by these elements would be:

(a) Ionic with formula YX_2

(b) Covalent with formula YX_2

(c) Ionic with formula YX

(d) Covalent with formula YX

42. Which group III element is expected to have physical and chemical properties that are least similar to the other elements in that family?

(a) B (b) Al

(c) Ga (d) Tl

43. Which of the following moelcule has higher lattice energy?

(a) NaCl (b) Mg_3N_2

(c) Both (a) and (b) have equal lattice energy

(d) None of these

44. Which relationship between the radii of these species is correct?

(a) $Na < Na^+; F < F^-$ (b) $Na > Na^+; F > F^-$

(c) $Na < Na^+; F > F^-$ (d) $Na > Na^+; F < F^-$

45. Ionic radii are:

(a) Inversely proportional to effective nuclear charge

(b) Inversely proportional to the square of effective nuclear charge

(c) Directly proportional to effective nuclear charge

(d) Directly proportional to the square of effective nuclear charge

46. Which element has the smallest first-ionization energy?

(a) Mg (b) Al

(c) Si (d) P

47. Which property of an element is most dependent on the shielding effect?

(a) Atomic number (b) Atomic mass

(c) Atomic radius (d) Number of stable isotopes

48. Consider the ions Li^+, Na^+, Be^{2+}, and Mg^{2+}. Which two are closest to one another in size?

(a) Li^+ and Na^+ (b) Be^{2+} and Mg^{2+}

(c) Be^{2+} and Li^+ (d) Li^+ and Mg^{2+}

49. What is the electron configuration for a gas phase +3 ion of iron ($Z = 26$)?

(a) [Ar] $3d^5$ (b) [Ar] $4s^2\ 3d^3$

(c) [Ar] $4s^1\ 3d^4$ (d) [Ar] $4s^2\ 3d^6$

50. Which orbital fills completely immediately before the $4f$?

(a) $6s$ (b) $5p$

(c) $5d$ (d) $4d$

51. When the elements Li, Be, and B are arranged in order of increasing ionization energy, what is the correct order?

(a) Li, B, Be (b) B, Be, Li

(c) Be, Li, B (d) Li, Be, B

52. Of the elements given, which has the lowest ionization energy?

(a) N (b) P

(c) S (d) Cl

53. How many unpaired electrons are in a gaseous Fe^{2+} ion in its ground state?

(a) 0 (b) 2

(c) 4 (d) 6

54. Which of the following pair of symbols represents nuclei that have the same number of neutrons?
(a) ${}^{56}_{26}Fe$ and ${}^{58}_{28}Ni$ (b) ${}^{58}_{26}Fe$ and ${}^{56}_{26}Fe^{2+}$
(c) ${}^{57}_{27}Co$ and ${}_{26}Fe^{58}$ (d) ${}^{57}_{28}Ni$ and ${}^{58}_{28}Ni$

55. What is the electronic configuration for an Fe(III) ion in its ground state?
(a) $[Ar]3d^5$ (b) $[Ar]3d^6$
(c) $[Ar]4s^2\,3d^3$ (d) $[Ar]4s^2\,3d^6$

56. Select the correct order of ionic radii:
(a) $O^{2-} > S^{2-} > Se^{2-} > Te^{2-}$
(b) $Te^{2-} > S^{2-} > O^{2-} > Se^{2-}$
(c) $O^{2-} > Te^{2-} > S^{2-} > Se^{2-}$
(d) $Te^{2-} > Se^{2-} > S^{2-} > O^{2-}$

57. Select the correct order of ionic radii:
(a) $O^{2-} > F^- > Mg^{2+} > Na^+$
(b) $Na^+ > Mg^{2+} > O^{-2} > F^-$
(c) $O^{2-} > F^- > Na^+ > Mg^{2+}$
(d) $Mg^{2+} > Na^+ > F^- > O^{2-}$

58. Select the correct order of I.E.:
(a) $Cl^- > Cl > Cl^+$ (b) $Cl^+ > Cl > Cl^-$
(c) $Cl > Cl^+ > Cl^-$ (d) $Cl^- > Cl^+ > Cl$

59. Which configuration represents atom having the highest second ionization energy?
(a) $1s^2, 2s^2\,2p^4$ (b) $1s^2, 2s^2\,2p^6$
(c) $1s^2, 2s^2\,2p^6, 3s^1$ (d) $1s^2, 2s^2\,2p^6, 3s^2$

60. From the electronic configuration of the given element K, L, M, and N, which one has the highest ionization potential:
(a) $K = [Ne]3s^2, 3p^2$ (b) $L = [Ne]3s^2, 3p^3$
(c) $M = [Ne]3s^2, 3p^1$ (d) $N = [Ar]3d^{10}, 4s^2, 4p^3$

61. The increasing order of the first ionization enthalpies of the elements B, P, S, and F (lowest first) is:
(a) F < S < P < B (b) P < S < B < F
(c) B < P < S < F (d) B < S < P < F

62. The process requiring the absorption of energy is:
(a) $F \longrightarrow F^-$ (b) $H \longrightarrow H^-$
(c) $Cl \longrightarrow Cl^-$ (d) $O \longrightarrow O^{2-}$

63. Which of the following has the largest size?
(a) Al (b) Al^+
(c) Al^{2+} (d) Al^{3+}

64. Which of the following is isoelectronic with carbon atom?
(a) Na^+ (b) Al^{3+}
(c) O^{2-} (d) N^+

65. The correct ionic radii order is:
(a) $N^{3-} > O^{2-} > F^- > Na^+$
(b) $N^{3-} > Na^+ > O^{2-} > F^-$
(c) $Na^+ > O^{2-} > N^{3-} > F^-$
(d) $O^{2-} > F^- > Na^+ > N^{3-}$

66. The radii of F, F^-, O, and O^{2-} are in the order of:
(a) $O^{2-} > F^- > F > O$ (b) $F^- > O^{2-} > F > O$
(c) $O^{2-} > O > F^- > F$ (d) $O^{2-} > F^- > O > F$

67. Which of the following sets represents the collection of isoelectronic species?
(a) $Na^+, Mg^{2+}, Al^{3+}, Cl^-$ (b) $Na^+, Ca^{2+}, Sc^{3+}, F^-$
(c) $K^+, Cl^-, Mg^{2+}, Sc^{3+}$ (d) $K^+, Ca^{2+}, Sc^{3+}, Cl^-$

68. The calculated value of magnetic moment of ${}_{23}V^{3+}$ is:
(a) 1.73 μ_B (b) 2.83 μ_B
(c) 3.87 μ_B (d) 4.90 μ_B

69. The ionic radii of Fe^{2+} and Fe^{3+} are x and y, respectively. The correct relationship between x and y is:
(a) $x > y$ (b) $x < y$
(c) $x = y$ (d) Cannot be predicted

70. Ce (58) is a member of:
(a) s-block (b) p-block
(c) d-block (d) f-block

71. The element with the highest ionization potential from the following is:
(a) Oxygen (b) Nitrogen
(c) Carbon (d) Boron

72. The ions O^{2-}, F^-, Na^+, Mg^{2+}, and Al^{3+} are isoelectronic. Their ionic radii show:
(a) An increase from O^{2-} to F^- and then a decrease from Na^+ to Al^{3+}
(b) A decrease from O^{2-} to F^- and then an increase from Na^+ to Al^{3+}
(c) A significant increase from O^{2-} to Al^{3+}
(d) A significant decrease from O^{2-} to Al^{3+}

73. Which one of the following grouping represents a collection of isoelectronic species? (At. no., Cs = 55 and Br = 35)
(a) N^{3-}, F^-, Na^+ (b) Ca^{2+}, Cs^+, Br
(c) Be, Al^{3+}, Cl^- (d) Na^+, Ca^{2+}, Mg^{2+}

74. The first ionization enthalpies of four consecutive elements present in the second period of the periodic table are 8.3, 11.3, 14.5, and 13.6 eV, respectively. Which

one of the following is the first ionization enthalpy of nitrogen?

(a) 13.6 (b) 14.5

(c) 11.3 (d) 8.3

75. The electronic configuration of the element which is just above the element with atomic number 43 in the same periodic group is:

(a) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^5, 4s^2$

(b) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^5$

(c) $1s^2\ 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^6, 4s^1$

(d) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^1\ 4p^6$

76. If the atomic number of an element is 33, it will be placed in the periodic table in the:

(a) First group (b) Third group

(c) Fifth group (d) Seventh group

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which one of the following ions has the smallest radius?

(a) C^{4-} (b) S^{2-}

(c) K^+ (d) Ca^{2+}

2. The most electropositive element is:

(a) Cs (b) Ga

(c) Li (d) Pb

3. Which of the following has the lowest ionization enthalpy?

(a) $4s^1$ (b) $3d^2$

(c) $3p^6$ (d) $2p^6$

4. Of the following elements, which one has the highest electronegativity?

(a) I (b) Br

(c) Cl (d) F

5. Which one of the following is the smallest cation?

(a) Na^+ (b) Mg^{2+}

(c) Ca^{2+} (d) Al^{3+}

6. Which one of the following ions has the lowest magnetic moment?

(a) Cu^{2+} (b) Ni^{2+}

(c) Co^{3+} (d) Fe^{2+}

7. The lanthanide contraction is responsible for the fact that:

(a) Zr and Y have about the same radius

(b) Zr and Nb have similar oxidation state

(c) Zr and Hf have about the same radius

(d) Zr and Zn have the same oxidation state

8. Select the correct order of electronegativity (E.N.):

(a) F > Cl > Br > I (b) N > P > As

(c) Both (a) and (b) (d) S > O > Se

9. Identify the least stable ion amongst the following:

(a) Li^- (b) Be^-

(c) B^- (d) C^-

10. General electronic configuration of outermost and penultimate shell is $(n-1)\,s^2\,(n-1)p^6(n-1)\,d^x\,ns^2$. If $n = 4$ and $x = 5$, then the number of protons in the nucleus will be:

(a) > 25 (b) < 24

(c) 25 (d) 30

11. Select the correct order of hydrated size of ion:

(a) $Li^+_{(aq.)} > Na^+_{(aq.)} > K^+_{(aq.)}$

(b) $Be^{2+}_{(aq.)} < Mg^{2+} < Ca^{2+}_{(aq.)}$

(c) $Al^{3+}_{(aq.)} < Mg^{2+}_{(aq.)} < Si^{4+}_{(aq.)}$

(d) $Cs^+_{(aq.)} > Rb^+_{(aq.)} > K^+_{(aq.)}$

12. Outer electronic configurations of K, Cu, and Cr are, respectively,

(a) $4s^1, 3d^{10}, 3d^5$ (b) $4s^2, 3d^{10}, 3d^4$

(c) $4s^1, 3d^9, 3d^4$ (d) $4s^1, 3d^9, 3d^4$

13. In which one of the following pairs the radius of the second species is greater than that of the first?

(a) Na, Mg (b) O^{2-}, N^{3-}

(c) Li^+, Be^{2+} (d) Ba^{2+}, Sr^{2+}

14. The electronic configurations of four elements are given below. Arrange these elements in the correct order of magnitude (without sign) of their electron affinity:

(i) $2s^2\ 2p^5$ (ii) $3s^2\ 3p^5$

(iii) $2s^2\ 2p^4$ (iv) $3s^2 3p^4$

Select the correct answer using the codes given below:

(a) (i) < (ii) < (iii) < (iv) (b) (ii) > (i) > (iv) > (iii)

(c) (i) < (iii) < (iv) < (ii) (d) (iii) < (iv) < (ii) < (i)

15. The electronic configuration of the atom having maximum difference between first and second ionization energies is:

(a) $1s^2, 2s^2, 2p^6, 3s^1$ (b) $1s^2, 2s^2\ 2p^6, 3s^2$

(c) $1s^2, 2s^2\ 2p^1$ (d) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^3$

16. The electronic configuration of the element with maximum electron affinity is:

(a) $1s^2, 2s^2\ 2p^3$ (b) $1s^2, 2s^2\ 2p^5$

(c) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^5$ (d) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^3$

17. Which of the following magnetic moment values will correspond to the highest ionization energy for Mn species?

(a) $2\sqrt{2}$ (b) $\sqrt{15}$

(c) $\sqrt{35}$ (d) $\sqrt{24}$

18. Select the correct statement:

(a) Ionic mobility of Al^{3+} is greater than that of Mg^{2+} in water

(b) K^+ (aq) has lesser ionic mobility than Ca^{2+} (aq)

(c) Cl^-(aq) has the highest ionic mobility among halide (aq) ions

(d) Ionic mobility of Cs^+(aq) is the highest among the alkali metal ions

19. Nishit Bhandari went to meet his friend Rohit, where he saw that his friend was doing the study of a particular chemistry book. But he could not find the theoretical value of bond length in H—F but he found that r_H and r_F are 0.37 Å and 0.72 Å, respectively, and electronegativities of F and H are 4.0 and 2.1, respectively. What is the bond length of H—F bond?

(a) 1.09 (b) 1.784

(c) 0.92 (d) 0.46

20. Which element exhibits both +1 and +3 oxidation numbers in its compounds?

(a) B (b) Be

(c) Sn (d) Tl

21. What is the number of unpaired electrons in a manganese atom ($Z = 25$) in its lowest energy states?

(a) 1 (b) 3

(c) 5 (d) 7

22. In which pair do both species have the same electron configurations?

(a) Se^{2-}, Kr (b) Mn^{2+}, Cr^{3+}

(c) Na^+, Cl^- (d) Ni, Zn^{2+}

23. Which of the following species is paramagnetic?

1. Ti^{4+}, 2. Fe^{2+}, 3. Zn^0

(a) 2 only (b) 3 only

(c) 1 and only (d) 2 and 3 only

24. When the elements C, N, and Si are arranged in order of increasing first ionization energy, what is the correct order?

(a) C < N < Si (b) N < C < Si

(c) Si < C < N (d) Si < N < C

25. Which gaseous ion in its ground state has the greatest number of unpaired electrons?

(a) Mn^{3+} (b) Fe^{3+}

(c) Co^{3+} (d) Ni^{3+}

26. Which element can exhibit more than one oxidation state in compounds?

1. Cr, 2. Pb, 3. Sr

(a) 1 only (b) 1 and 2 only

(c) 2 and 3 only (d) 1, 2, and 3

27. Which set of orbitals is listed in the sequential order of filling in a many-electron atom?

(a) 3*s*, 3*p*, 3*d* (b) 3*d*, 4*s*, 4*p*

(c) 3*d*, 4*p*, 5*s* (d) 4*p*, 4*d*, 5*s*

28. When the atoms Li, Be, B, and Na are arranged in order of increasing atomic radius, what is the correct order?

(a) B, Be, Li, Na (b) Li, Be, B, Na

(c) Be, Li, B, Na (d) Be, B, Li, Na

29. What is the total number of valence electrons in the peroxydisulphate, $S_2O_8^{2-}$, ion?

(a) 58 (b) 60

(c) 62 (d) 64

30. What is the total number of *p* electrons in a single phosphorus atom in its ground state?

(a) 3 (b) 5

(c) 9 (d) 15

31. Which pair of symbols identifies two elements that are metalloids?

(a) B and Ge (b) Mg and Si

(c) P and As (d) Ti and V

32. Select the correct order of ionic radii:

(a) $Ti^{2+} > Ti^{3+} > Ti^{4+}$ (b) $Ti^{4+} > Ti^{2+} > Ti^{3+}$

(c) $Ti^{3+} > Ti^{2+} > Ti^{4+}$ (d) $Ti^{4+} > Ti^{3+} > Ti^{2+}$

33. The metalloid among the following group of elements is:

(a) P (b) As

(c) Al (d) N

34. The correct order of radii is:

(a) N < Be < B (b) $F^- < O^{2-} < N^{3-}$

(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

35. Which shows the highest lattice energy?

(a) RbF (b) CsF

(c) NaF (d) KF

36. Which of the following configurations is associated with biggest jump between 2nd and 3rd I.E.?
(a) $1s^2, 2s^2 2p^2$ (b) $1s^2, 2s^2 2p^6, 3s^1$
(c) $1s^2, 2s^2 2p^6, 3s^2$ (d) $1s^2, 2s^2 2p^1$

37. Alkali metals in each period have:
(a) Largest size (b) Lowest I.E.
(c) Highest I.E. (d) Highest electronegativity

38. The set representing the correct order of first ionization potential is:
(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

39. Lattice energy of an ionic compound depends upon:
(a) Charge on the ions only
(b) Size of the ions only
(c) Packing of the ions only
(d) Charge and size of the ions

40. Which of the following is the correct order for electron gain enthalpy?
(a) S < O < Cl < F (b) O < S < F < Cl
(c) Cl < F < S < O (d) F < Cl < O < S

41. The oxidation states of Cr in $K_2Cr_2O_7$ and K_2CrO_4, respectively, are:
(a) 6+, 7+ (b) 7+, 6+
(c) 6+, 6+ (d) 7+, 7+

42. Which of the following electronic configuration would be associated with the highest magnetic moment?
(a) d^2 (b) d^4
(c) d^5 (d) d^7

43. Select equations having exothermic step.
(I) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$
(II) $Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$
(III) $N_{(g)} \longrightarrow N^-_{(g)}$
(IV) $Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$
Choose the correct code:
(a) II (b) I, II
(c) III and IV (d) II and III

44. Which of the following is not an actinide?
(a) Curium (b) Californium
(c) Uranium (d) Terbium

45. Europium belongs to:
(a) *s*-block (b) *p*-block
(c) *d*-block (d) *f*-block

46. Which of the following pairs has both members from the same group of the periodic table?
(a) Na, Ca (b) Na, Cl
(c) Ca, Cl (d) Cl, Br

47. Which one of the following belongs to representative group of elements in the periodic table?
(a) Lanthanum (b) Argon
(c) Chromium (d) Aluminium

48. Of cobalt and zinc salts, which are attracted in magnetic field?
(a) Cobalt salts (b) Zinc salts
(c) Both (a) and (b) (d) None of these

49. Which is the largest stable atom?
(a) V (b) Na
(c) Al (d) Pb

50. Which of the following is the strongest base?
(a) $Be(OH)_2$ (b) $Mg(OH)_2$
(c) $Al(OH)_3$ (d) $Si(OH)_4$

51. Which one of these is amphoteric oxide?
(a) CO_2 (b) SnO_2
(c) NO_2 (d) SO_2

52. Calculate the lattice energy of a salt $MX_{(s)}$ from the data given below:
Heat of formation of $MX(\Delta H) = -550$ kJ/mol
Heat of sublimation of $M(S) = 80$ kJ/mol
Heat of dissociation of $X_2(D) = 155$ kJ/mol
Ionization energy of $M(I) = 347$ kJ/mol
Electron affinity of $X(E) = -343$ kJ/mol
(a) –838.5 kJ/mol (b) –938.5 kJ/mol
(c) –711.5 kJ/mol (d) –638.5 kJ/mol

53. Which of the following species has the highest electron gain enthalpy?
(a) F^- (b) S
(c) O^- (d) O

54. Two elements have electronegativities 1.2 and 3.0, respectively; the bond formed between them would be:
(a) Ionic (b) Covalent
(c) Coordinate (d) Metallic

55. Which of the following sets is of coinage metals?
(a) Cu, Ag, Au (b) Zn, Cd, Hg
(c) Au, Ag, Zn (d) Li, Na, K

56. The correct order of increasing electron affinity of halogens is:
(a) F < Cl < Br < I (b) I < Br < F < Cl
(c) I < Br < Cl < F (d) Br < I < F < Cl

57. If atomic number of inert gas is Z, then ionic bond is formed between:
(a) $(Z-1)$ and $(Z+1)$ (b) $(Z-2)$ and $(Z+2)$
(c) Both (a) and (b) (d) None of these

58. Comment on the E.N. of Sb in SbF_3 and SbF_5:
(a) E.N. of Sb (SbF_3) > E.N. of Sb (SbF_5)
(b) E.N. of Sb (SbF_3) < E.N. of Sb (SbF_5)
(c) E.N. of Sb is identical in both cases
(d) No comment can be predicted

59. In which of the following compounds is the size of cation to anion ratio minimum?
(a) CsF (b) LiI
(c) LiF (d) CsI

60. Which of the following has 2nd I.P. < 1st I.P.?
(a) Mg (b) Ne
(c) C (d) None of these

61. In which of the following processes is the maximum amount of energy involved?
(a) $Cl \rightarrow Cl^-$ (b) $Br^{2-} \rightarrow Br$
(c) $F^- \rightarrow F$ (d) $I^- \rightarrow I$

62. Which of the following has the highest electron affinity?
(a) F (b) Br
(c) Cl (d) I

63. Which one of the following series is arranged in order of increasing ionic radius?
(a) $Mg^{2+} < S^{2-} < Cl^- < K^+ < Ca^{2+}$
(b) $Mg^{2+} < Ca^{2+} < K^+ < Cl^- < S^{2-}$
(c) $S^{2-} < Cl^- < K^+ < Mg^{2+} < Ca^{2+}$
(d) $S^{2-} < Mg^{2+} < Ca^{2+} < Cl^- < K^+$

64. What is the formula for the basic anhydride of $Ba(OH)_2$?
(a) Ba_2O (b) BaO
(c) BaO_2 (d) Ba

65. An element with the electron configuration $[Xe]4f^{14}5d^7 6s^2$ is:
(a) An alkaline earth element
(b) A transition element
(c) An inert gas (d) A rare earth

66. The formula of sodium tungstate is Na_2WO_4 and that of lead phosphate is $Pb_3(PO_4)_2$. What is the formula of lead tungstate?
(a) $PbWO_4$ (b) $Pb_2(WO_4)_3$
(c) $Pb_3(WO_4)_2$ (d) $Pb_3(WO_4)_4$

67. Which metal requires the least energy to exhibit the photoelectric effect?
(a) Cs (b) Ca
(c) Cu (d) Hg

68. Which set is expected to show the smallest difference in first ionization energy?
(a) He, Ne, Ar (b) B, N, O
(c) Mg, Mg^+, Mg^{2+} (d) Fe, Co, Ni

69. In which list are the elements arranged in order of increasing first ionization energy?
(a) Li, Na, K (b) S, O, F
(c) Na, Mg, Al (d) F, Ne, Na

70. All of the following possess complete d-shells except:
(a) Ag^+ (b) Cu^{2+}
(c) Ga^{3+} (d) Zn^{2+}

71. Which element exhibits the greatest number of oxidation states in its compounds?
(a) Ca (b) V
(c) Cu (d) Na

72. Which terms are exothermic for the formation of NaF(s)?
I. $Na_{(g)} \rightarrow Na^+_{(g)} + e^-$
II. $F_{(g)} + e^- \rightarrow F^-_{(g)}$
III. $Na^+_{(g)} + F^-_{(g)} \rightarrow NaF_{(s)}$
(a) I only (b) II only
(c) I and III only (d) II and III only

73. The set(s) representing the correct order of ionic radius is/are:
(a) $Li^+ > Be^{2+} > Na^+ > Mg^{2+}$
(b) $Na^+ > Li^+ > Mg^{2+} > Be^{2+}$
(c) $Li^+ > Na^+ > Mg^{2+} > Be^{2+}$
(d) $Mg^{2+} > Be^{2+} > Li^+ > Na^+$

74. The formation of the oxide ion $O^{2-}(g)$ requires first an exothermic and then an endothermic step as shown below:

$O_{(g)} + e \longrightarrow O^-_{(g)}$; $\Delta H = -142$ kJ/mol

$O^-_{(g)} + e \longrightarrow O^{2-}_{(g)}$; $\Delta H = 844$ kJ/mol

This is because:
(a) O^- ion has comparatively larger size than oxygen atom
(b) Oxygen has high electron affinity

(c) O^- ion will lead to resisting of the addition of another electron

(d) Oxygen is more electronegative

75. Select the correct order of 2nd ionization energy of C, N, O, and F:

(a) C > N > O > F (b) N > C > O > F
(c) C < N < O < F (d) O > F > N > C

Multiple Correct Answers Type

1. Select the correct statement(s):
(a) Size of H^- is larger than F^-
(b) Rb is more electropositive compared to Ca
(c) Na^+ is more electronegative than Na
(d) Cl^- is more electronegative than F

2. Select the incorrect ionization energy order:
(a) Li < B < Be < C < N < O < F
(b) Na < Mg < Al < Si < S < P < Cl
(c) K < Ga < Ca < Ge < As < Se < Br
(d) Rb < Sr < In < Sn < Sb < Te < I

3. The statement(s) that is/are correct for the periodic classification of elements is/are:
(a) The properties of elements are periodic function of their atomic numbers
(b) Non-metallic elements are lesser in number than metallic elements
(c) The first ionization energies of the elements along the periods do not vary in a regular manner with the increase in atomic number
(d) For transition elements, the *d*-subshells are filled with electrons monotonically with increase in atomic number

4. Which of the following order(s) is/are correct?
(a) $NH_3 < PH_3 < AsH_3$ (Acidic)
(b) Li < Be < B < C ($I.E._1$)
(c) $Al_2O_3 < MgO < Na_2O < K_2O$ (Basic)
(d) $Li^+ < Na^+ < K^+ < Cs^+$ (Ionic radius)

5. Which is/are false about electronegativity order of the following elements?
(a) P > Si (b) C > N
(c) C > Br (d) Sr > Ca

6. Which of the following species has same number of unpaired electrons?
(a) Cr^{3+} (b) Mn^{2+}
(c) Fe^{3+} (d) Cu^{2+}

7. Select the correct statement(s):
(a) In general, more the ionization energy, more will be the electronegativity
(b) Electronegativity increases means metallic character increases
(c) In general, lower the ionization energy, higher will be the reducing property
(d) Cl has higher electron affinity than F

8. Which of the following statement is/are false?
(a) Lanthanum is the first element of lanthanides
(b) Actinium violates the Aufbau's principle
(c) Chromium violates the Pauli's exclusion principle
(d) Total 10 exchanges are possible for *d*-electrons in Zn

9. Which prediction(s) is/are incorrect according to the Lother Meyer's curve?
(a) Each peak of the curve is occupied by the alkali metals
(b) Alkaline earth metals occupy ascending positions of curve
(c) Atomic volume increases first and then decreases in a period (which is defined later) in Lother Meyer's curve
(d) Identically placed elements in the atomic volume *vs* atomic mass curve occur in the same period in the periodic table

10. Find the correct 2nd ionization energy order from the following option(s):
(a) Al > Mg (b) Te > Sb
(c) Fe > Fe^+ (d) In > Sr

11. Ionization energies of element *A* are given below in kJ/mol:

$I.E._1$	$I.E._2$	$I.E._3$
120	430	13000

If *A* reacts with different elements, which compounds are not possible:
(a) AF (b) A_2O
(c) A_3N (d) A_3N_2

12. The first ionization energy of oxygen is less than that of nitrogen. Which of the following is/are the incorrect reason(s) for this observation?
(a) Lesser effective nuclear charge of oxygen than nitrogen

(b) Lesser atomic size of oxygen than nitrogen

(c) Greater inter-electron repulsion between two electrons in the same p-orbital counter balances the increase in effective nuclear charge on moving from nitrogen to oxygen

(d) Greater effective nuclear charge of oxygen than nitrogen

13. Which of the following ionization energy order(s) is/are correct?

(a) $F > Cl^-$ (b) $F > Cl$

(c) $Cl > F^-$ (d) $Cl^- < F^-$

14. Select the correct I.E. order for the following species:

(a) $Cl > Br$ (b) $Br^- > Cl^-$

(c) $Cl > Cl^-$ (d) $Br > Br^-$

15. In which of the following arrangements, is/are the sequence strictly according to the property written against them?

(a) $CO_2 < SiO_2 < SnO_2 < PbO_2$: increasing oxidizing power

(b) $HF < HCl < HBr < HI$: increasing acidic strength

(c) $NH_3 < PH_3 < AsH_3 < SbH_3$: increasing basic strength

(d) $B < C < O < N$: increasing first ionization energy

16. The elements which exist in liquid state at room temperature are:

(a) Na (b) Fr

(c) Hg (d) Ga

17. Which of the following element belongs to the halogen group?

(a) $1s^2, 2s^2\,2p^6, 3s^2\,3p^5$ (b) $1s^2, 2s^2\,2p^6, 3s^2\,3p^6, 4s^2$

(c) $[Ar]\,3d^{10}, 4s^2\,4p^5$ (d) $[Kr]\,4d^{10}, 5s^2\,5p^5$

18. According to Lother Meyer's curve, which of the following statement is/are correct:

(a) The elements having same properties will occupy the same position in the curve

(b) Alkaline earth metals are at the peaks of the curve

(c) Halogens are at the ascending part of the curve

(d) The atomic volume of the elements in a period initially decreases and then increases

19. For $_{24}Cr$, which of the following statements is/are correct:

(a) Number of electrons with principle quantum number 3 is 13

(b) Number of electrons with azimuthal quantum number 1 is 12

(c) Number of electrons with magnetic quantum number 0 is 12

(d) Number of minimum or maximum electrons with spin quantum number +1/2 is 9 or 15

20. Select the correct option(s):

(a) Pauli's exclusion principle states that no two electrons in an atom can have the same spin

(b) Quantum numbers n, l, and m for $5p_x$ orbital must be 5, 1, and −1, respectively

(c) Zn^{2+} is a diamagnetic species

(d) In the ground state of chromium atom, five electrons have magnetic quantum number −1

21. For which sets of elements, "diagonal relationship" exists?

(a) B, Si (b) Li, Mg

(c) B, Mg (d) Be, Al

22. The correct statements among the following are:

(a) Helium has the highest first I.P. in the periodic table

(b) The process $O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)}$ is exothermic

(c) The electron affinities of S and P are less than that of O and N, respectively

(d) In any period, the first ionization potential of noble gas is the highest

23. In which of the following arrangements is/are the order correct according to the property indicated against it?

(a) Increasing size: $Al^{3+} < Mg^{2+} < Na^+ < F^-$

(b) Increasing I.E.$_1$: $B < C < O < N$

(c) Increasing E.A.$_1$: $I < Br < F < Cl$

(d) Increasing metallic radius: $Li < Na < K < Rb$

24. Select the incorrect statement(s):

(a) p-orbital can accommodate $6e^-$

(b) $Na \xrightarrow{I.E._1} Na^+ \xrightarrow{I.E._2} Na^{2+} \xrightarrow{I.E._3}$; the correct order of ionization energy is I.E.$_2$ > I.E.$_3$ > I.E.$_1$.

(c) Xe is a noble gas

(d) B is a non-metal

25. The correct statement(s) among the following is/are:

(a) The first ionization potential of Al is less than the first ionization potential of Mg

(b) The second ionization potential of Mg is greater than the second ionization potential of Na

(c) The first ionization potential of Na is less than the first ionization potential of Mg

(d) The third ionization potential of Mg is greater than the third ionization potential of Al

26. Stability of ions of Ge, Sn, and Pb will be in the order:

(a) $Ge^{2+} < Sn^{2+} < Pb^{2+}$

(b) $Ge^{4+} > Sn^{4+} > Pb^{4+}$

(c) $Sn^{4+} > Sn^{2+}$

(d) $Pb^{2+} > Pb^{4+}$

27. On moving down the group from F to I, which of the properties decrease?

(a) Ionic radius (b) Ionization energy

(c) Oxidizing agent (d) Electronegativity

28. Ionic radius of:

(a) $Fe^{2+} < Fe^{3+}$ (b) $Ne > Na^+$

(c) $Rb^+ < K^+$ (d) $As^{3+} > As^{5+}$

29. An element X belongs to fourth period and fifteenth group of the periodic table. Which one of the following is/are false regarding the outer electronic configuration of X? It has:

(a) Partially filled d-orbital and completely filled s-orbital

(b) Completely filled s-orbital and completely filled p-orbital

(c) Completely filled s-orbital and half filled p-orbital

(d) Half filled d-orbital and completely filled s-orbital

30. If X^{2-} is isoelectronic with "O_2^+" and has $Z + 1$ neutrons (Z is atomic number of X^{2-}), then:

(a) The mass number of X^{2-} is 27

(b) The mass number of X^{2-} is 57

(c) The atomic number of X^{2-} is 28

(d) The number of protons in X^{2-} is 13

31. Which of the following properties are the properties of metals?

(a) They are sonorous

(b) They are in general poor conductor of heat and electricity

(c) They are malleable and ductile

(d) They are hard

32. Ionization energy depends upon:

(a) Principal quantum number

(b) Azimuthal quantum number

(c) Magnetic quantum number

(d) Spin quantum number

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

If one electron has been removed from an atom, it becomes increasingly difficult to remove the second and subsequent electrons from the resulting positively charged ions on account of electrostatic attraction.

1. Suppose a gas mixture of F, Cl, Br, and I is irradiated with photons of frequency appropriate to ionize Cl. What ion(s) will be present in the mixture?

(a) F^+ only (b) Cl^+ only

(c) F^+, Cl^+, Br^+ only (d) Cl^+, Br^+, I^+ only

2. If the ionization values of elements are plotted against atomic number, then peaks are occupied by:

(a) Alkali metals (b) Alkaline earth metals

(c) Noble gas elements (d) Halogens

3. The numerical value of energy involved in the given process $K \longrightarrow K^-$ is less than that of which of the following processes?

(a) $K^- \longrightarrow K$ (b) $K \longrightarrow K^+$

(c) Both (a) and (b) (d) None of these

Comprehension-2: (Q. 4 to Q. 6)

On moving across a period, the atomic size decreases and nuclear charge increases and therefore the force of attraction exerted by the nucleus on the electron in the outermost shell increases.

4. The first ionization potentials (in eV) of As and Se atoms, respectively, are:

(a) 14.6, 13.6 (b) 13.6, 14.6

(c) 13.6, 13.6 (d) 14.6, 14.6

5. For the process

$A_{(g)} + e^- \longrightarrow A^-_{(g)}$; $\Delta H = x$

and $A^-_{(g)} \longrightarrow A_{(g)} + e^-$; $\Delta H = y$

select correct alternate:

(a) Ionization energy of $A^-_{(g)}$ is y

(b) Electron affinity of $A_{(g)}$ is x

(c) Electron affinity of $A_{(g)}$ is $-y$

(d) All are correct statements

6. Potassium forms K^+ ion but it does not form K^{2+} because of:

(a) Very low value of $(I.E.)_1$ and $(I.E.)_2$

(b) Very high value of $(I.E.)_1$ and $(I.E.)_2$

(c) Low value of $(I.E.)_1$ and low value of $(I.E.)_2$

(d) Low value of $(I.E.)_1$ and high value of $(I.E.)_2$

Assertion-Reasoning Type

1. **Statement-I:** Cl^- and Ca^{2+} are isoelectronic species.

Statement-II: Isoelectronic species should have same charges.

(a) Statement-I is true; Statement-II is true; Statement-II is correct explanation for statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is NOT the correct explanation for statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

2. **Statement-I:** Cd is a transition element.

Statement-II: Cd and Cd^{2+} both have completely filled *d*-orbitals in their ground state.

(a) Statement-I is true; Statement-II is true; statement-II is correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is NOT the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

3. **Statement-I:** 1st ionization energy of "P" is greater than "S".

Statement-II: Z_{eff} value of "S" is greater than "P".

(a) Statement-I is true; Statement-II is true; Statement-II is correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is NOT the correct explanation for statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; statement-II is true.

4. **Statement-I:** Mg^{2+} and Al^{3+} are isoelectronic but ionic radius of Al^{3+} is less than that of Mg^{2+}.

Statement-II: The effective nuclear charge on the outershell electrons in Al^{3+} is more than that in Mg^{2+}.

(a) Statement-I is true; Statement-II is true; Statement-II is correct explanation for Statement-I.

(b) Statement-I is true; Statement-II is true; Statement-II is NOT the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) He	(p) High electron gain enthalpy
(b) Cl	(q) Most electropositive element
(c) Cs	(r) Strongest reducing agent
(d) Li	(s) Highest ionization energy

2. Match the column:

Column-I	Column-II
(a) Noble gas	(p) Sodium
(b) Transition element	(q) Argon
(c) Lanthanide	(r) Cerium
	(s) Chromium

3. Match the column:

Column-I	Column-II
(a) Zinc	(p) Solid at room temperature
(b) Hg	(q) Transition element
(c) Cr	(r) *d*-block element
	(s) Liquid at room temperature

4. Match the column:

Column-I	Column-II
(a) Electron affinity	(p) Depends upon effective nuclear charge
(b) Ionization potential	(q) Depends upon shielding constant
(c) Electronegativity	(r) Depends upon half filled and fully filled electronic configuration
	(s) Can be estimated from bond-energy data

5. Match the column:

Column-I	Column-II
(a) 89	(p) *d*-block or *p*-block
(b) 35	(q) 5th period element
(c) 37	(r) Violates Aufbau's principle
(d) 24	(s) Not lanthanides

6. Match the column:

Column-I (Characteristic involved in the given process of Column-II)	Column-II (Process described)
(a) Energy released	(p) $S \longrightarrow S^-$
(b) Energy absorbed	(q) $O^- \longrightarrow O^{2-}$
(c) Inert gas configuration is achieved	(r) $Sr \longrightarrow Sr^{2+}$
(d) Half filled configuration is achieved	(s) $N^- \longrightarrow N$
	(t) $Ge \longrightarrow Ge^-$

7. Match the column:

Column-I	Column-II
(a) 17	(p) Two unpaired p-electrons
(b) 32	(q) p-block element
(c) 82	(r) More negative ΔH_{eg} then elements on either side of it in the same period
	(s) Have higher ionization energy than that of previous elements of the respective group

Integer Answer Type

1. The minimum number of electrons having magnetic quantum number of zero for Ni is ________.
2. How many elements from the following are not transition elements?
   Zr, Co, Cd, Hg, Au, Cu
3. Find the number of metals from the following: As, Fe, Xe, Li, B, Cl, Ba, P, I, Si.
4. Calculate the effective nuclear charge for the outermost electron of oxygen atom.
5. If there were 8 periods in the periodic table and each orbital could have maximum 5 electrons, then how many maximum number of elements would be present in period 8?
6. The first four ionization energy values of an element are 120, 240, 520, and 6420 kcal. The number of valence electrons in the element is ________.
7. How many unpaired electron(s) is/are present in tri-positive titanium ion?
8. Calculate the effective nuclear charge for a $3d$-electron of nickel atom.
9. Calculate the experimental bond moment (approximate, in debye) of the X— Y bond, if electronegativity of elements X and Y is 1 and 2.5, respectively, and bond length is 3.92 Å.
10. Calculate the difference in the number of protons of the largest element of the fourth period and the smallest element of the third period.
11. From the data given, calculate the energy deficit in the formation of $BeCl_2$ (it is a stable molecule).
    I.E.$_1$ for Be = 899 kJ/mol
    I.E.$_2$ for Be = 1757 kJ/mol
    I.A. for Cl = –348 kJ/mol

NCERT Exemplar Exercises

Single Correct Answer Type

1. Consider the isoelectronic species, Na^+, Mg^{2+}, F^-, and O^{2-}. The correct order of increasing length of their radii is ______.
   (a) $F^- < O^{2-} < Mg^{2+} < Na^+$
   (b) $Mg^{2+} < Na^+ < F^- < O^{2-}$
   (c) $O^{2-} < F^- < Na^+ < Mg^{2+}$
   (d) $O^{2-} < F^- < Mg^{2+} < Na^+$
2. The order of screening effect of electrons of s, p, d and f orbitals of a given shell of an atom on its outer shell electrons is:
   (a) $s > p > d > f$ (b) $f > d > p > s$
   (c) $p < d < s > f$ (d) $f > p > s > d$
3. The statement that is not correct for periodic classification of elements is:
   (a) The properties of elements are periodic function of their atomic numbers
   (b) Non-metallic elements are less in number than metallic elements
   (c) For transition elements, the $3d$-orbitals are filled with electrons after $3p$-orbitals and before $4s$-orbitals
   (d) The first ionization enthalpies of elements generally increase with increase in atomic number as we go along a period
4. Among halogens, the correct order of amount of energy released in electron gain (electron gain enthalpy) is:
   (a) F > Cl > Br > I (b) F < Cl < Br < I
   (c) F < Cl > Br > I (d) F < Cl < Br < I
5. The period number in the long form of the periodic table is equal to

(a) Magnetic quantum number of any element of the period
(b) Atomic number of any element of the period
(c) Maximum Principal quantum number of any element of the period
(d) Maximum Azimuthal quantum number of any element of the period

6. The elements in which electrons are progressively filled in 4*f*-orbital are called
(a) Actinoids (b) Transition elements
(c) Lanthanoids (d) Halogens

7. Which of the following is the correct order of size of the given species:
(a) $I > I^- > I^+$ (b) $I^+ > I^- > I$
(c) $I > I^+ > I^-$ (d) $I^- > I > I^+$

8. The formation of the oxide ion, $O^{2-}(g)$, from oxygen atom requires first an exothermic and then an endothermic step as shown below:

$O\,(g) + e^- \rightarrow O^-\,(g);\ \Delta H^\ominus = -141\ kJ\ mol^{-1}$

$O^-\,(g) + e^- \rightarrow O^{2-}\,(g);\ \Delta H^\ominus = +780\ kJ\ mol^{-1}$

Thus process of formation of O^{2-} in gas phase is unfavorable even though O^{2-} is isoelectronic with neon. It is due to the fact that:
(a) Oxygen is more electronegative
(b) Addition of electron in oxygen results in larger size of the ion
(c) Electron repulsion outweighs the stability gained by achieving noble gas configuration
(d) O^- ion has comparatively smaller size than oxygen atom

Paragraph

9. Comprehension given below is followed by some multiple choice questions. Each question has one correct option. Choose the correct option. In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration. Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, viz, *s*, *p*, *d*, and *f*. The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Aufbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32, and 32 elements respectively. The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

(i) The element with atomic number 57 belongs to:
(a) *s*-block (b) *p*-block
(c) *d*-block (d) *f*-block

(ii) The last element of the *p*-block in 6th period is represented by the outermost electronic configuration.
(a) $7s^2\,7p^6$ (b) $5f^{14}\,6d^{10}\,7s^2\,7p^0$
(c) $4f^{14}\,5d^{10}\,6s^2\,6p^6$ (d) $4f^{14}\,5d^{10}\,6s^2\,6p^4$

(iii) Which of the elements whose atomic numbers are given below, cannot be accommodated in the present set up of the long form of the periodic table?
(a) 107 (b) 118
(c) 126 (d) 102

(iv) The electronic configuration of the element which is just above the element with atomic number 43 in the same group is ______.
(a) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^2$
(b) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^3\,4p^6$
(c) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$
(d) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^7\,4s^2$

(v) The elements with atomic numbers 35, 53, and 85 are all ______.
(a) Noble gases (b) Halogens
(c) Heavy metals (d) Light metals

10. Electronic configurations of four elements A, B, C, and D are given below:
(a) $1s^2\,2s^2\,2p^6$ (b) $1s^2\,2s^2\,2p^4$
(c) $1s^2\,2s^2\,2p^6\,3s^1$ (d) $1s^2\,2s^2\,2p^5$

Which of the following is the correct order of increasing tendency to gain electron:
(a) a < c < b < d (b) a < b < c < d
(c) d < b < c < a (d) d < a < b < c

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following sequences contain atomic numbers of only representative elements?
(a) 3, 33, 53, 87 (b) 2, 10, 22, 36
(c) 7, 17, 25, 37, 48 (d) 9, 35, 51, 88

2. Which of the following elements will gain one electron more readily in comparison to other elements of their group?
(a) S(g) (b) Na(g)
(c) O(g) (d) Cl(g)

3. Which of the following statements are correct?
   (a) Helium has the highest first ionization enthalpy in the periodic table
   (b) Chlorine has less negative electron gain enthalpy than fluorine
   (c) Mercury and bromine are liquids at room temperature
   (d) In any period, atomic radius of alkali metal is the highest

4. Which of the following sets contain only isoelectronic ions?
   (a) Zn^{2+}, Ca^{2+}, Ga^{3+}, Al^{3+}
   (b) K^{+}, Ca^{2+}, Sc^{3+}, Cl^{-}
   (c) P^{3-}, S^{2-}, Cl^{-}, K^{+}
   (d) Ti^{4+}, Ar, Cr^{3+}, V^{5+}

5. In which of the following options order of arrangement does **not** agree with the variation of property indicated against it?
   (a) $Al^{3+} < Mg^{2+} < Na^{+} < F^{-}$ (increasing ionic size)
   (b) B < C < N < O (increasing first ionization enthalpy)
   (c) I < Br < Cl < F (increasing electron gain enthalpy)
   (d) Li < Na < K < Rb (increasing metallic radius)

6. Which of the following have no unit?
   (a) Electronegativity
   (b) Electron gain enthalpy
   (c) Ionization enthalpy
   (d) Metallic character

7. Ionic radii vary in:
   (a) Inverse proportion to the effective nuclear charge
   (b) Inverse proportion to the square of effective nuclear charge
   (c) Direct proportion to the screening effect
   (d) Direct proportion to the square of screening effect

8. An element belongs to 3rd period and group-13 of the periodic table. Which of the following properties will be shown by the element?
   (a) Good conductor of electricity
   (b) Liquid, metallic
   (c) Solid, metallic
   (d) Solid, non-metallic

Short Answer Type

1. Explain why the electron gain enthalpy of fluorine is less negative than that of chlorine.

2. Identify the group and valency of the element having atomic number 119. Also predict the outermost electronic configuration and write the general formula of its oxide.

3. Among the elements B, Al, C, and Si, (i) which element has the highest first ionization enthalpy? (ii) Which element has the most metallic character? Justify your answer in each case.

4. Choose the correct order of atomic radii of fluorine and neon (in pm) out of the options given below and justify your answer.
   (a) 72, 160 (b) 160, 160
   (c) 72, 72 (d) 160, 72

5. Nitrogen has positive electron gain enthalpy whereas oxygen has negative. However, oxygen has lower ionization enthalpy than nitrogen. Explain.

6. How would you explain the fact that first ionization enthalpy of sodium is lower than that of magnesium but its second ionization enthalpy is higher than that of magnesium?

7. Arrange the elements N, P, O, and S in the order of:
   (i) Increasing first ionization enthalpy
   (ii) Increasing non-metallic character

   Give reason for the arrangement assigned.

8. Explain the following:
   (a) Electronegativity of elements increase on moving from left to right in the periodic table.
   (b) Ionization enthalpy decrease in a group from top to bottom?

9. How does the metallic and non-metallic character vary on moving from left to right in a period?

10. The radius of Na^{+} cation is less than that of Na atom. Give reason.

11. Among alkali metals which element do you expect to be least electronegative and why?

Matching Column Type

1. Match the correct atomic radius with the element.

Element	Atomic radius (pm)
Be	74
C	88

O	111
B	77
N	66

2. Match the correct ionization enthalpies and electron gain enthalpies of the following elements.

Elements		ΔH_1	ΔH_2	$\Delta_{eg} H$
(a) Most reactive non metal	(p)	419	3051	–48
(b) Most reactive metal	(q)	1681	3374	–328
(c) Least reactive element	(r)	738	1451	–40
(d) Metal forming binary halide	(s)	2372	5251	+48

3. Electronic configuration of some elements is given in Column-I and their electron gain enthalpies are given in Column-II. Match the electronic configuration with electron gain enthalpy.

Column-I (Electronic configuration)	Column-II (Electron gain enthalpy/kJ mol^{-1})
(a) $1s^2\ 2s^2\ sp^6$	(p) –53
(b) $1s^2\ 2s^2\ 2p^6\ 3s^1$	(q) –328
(c) $1s^2\ 2s^2\ 2p^5$	(r) –141
(d) $1s^2\ 2s^2\ 2p^4$	(s) +48

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of reason (R) is given. Choose the correct option out of the choices given below each question.

1. **Assertion (A):** Generally, ionization enthalpy increases from left to right in a period.

   Reason (R): When successive electrons are added to the orbitals in the same principal quantum level, the shielding effect of inner core of electrons does not increase very much to compensate for the increased attraction of the electron to the nucleus.

   (a) Assertion is correct statement and reason is wrong statement.

   (b) Assertion and reason both are correct statements and reason is correct explanation of assertion.

   (c) Assertion and reason both are wrong statements.

   (d) Assertion is wrong statement and reason is correct statement.

2. **Assertion (A):** Boron has a smaller first ionization enthalpy than beryllium.

   Reason (R): The penetration of a $2s$ electron to the nucleus is more than the $2p$ electron hence $2p$ electron is more shielded by the inner core of electrons than the $2s$ electrons.

   (a) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

   (b) Assertion is correct statement but reason is wrong statement.

   (c) Assertion and reason both are correct statements and reason is correct explanation for assertion.

   (d) Assertion and reason both are wrong statements.

Long Answer Type

1. Discuss the factors affecting electron gain enthalpy and the trend in its variation in the periodic table.
2. Define ionization enthalpy. Discuss the factors affecting ionization enthalpy of the elements and its trends in the periodic table.
3. Write down the outermost electronic configuration of alkali metals. How will you justify their placement in group 1 of the periodic table?
4. Discuss and compare the trend in ionization enthalpy of the elements of group 1 with those of group 17 elements.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. According to the periodic law of elements, the variation in properties of elements is related to their

   (a) Nuclear masses

   (b) Atomic numbers

   (c) Nuclear neutron–proton number ratios

   (d) Atomic masses

   (AIEEE, 2003)

2. Which one of the following is an amphoteric oxide?

   (a) Na_2O (b) SO_2

   (c) B_2O_3 (d) ZnO

   (AIEEE, 2003)

3. Which one of the following ions has the highest value of ionic radius?
   (a) O^{2-} (b) B^{3+}
   (c) Li^+ (d) F^-

(AIEEE, 2004)

4. Among Al_2O_3, SiO_2, P_2O_3, and SO_2, the correct order of acid strength is:
   (a) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
   (b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
   (c) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$
   (d) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$

(AIEEE, 2004)

5. The formation of the oxide ion $O^{2-}_{(g)}$ requires first an exothermic and then an endothermic step as shown below.
   $O_{(g)} + e^- = O^-_{(g)}, \Delta H^\circ = -142 \text{ kJ mol}^{-1}$
   $O^-_{(g)} + e^- = O^{2-}_{(g)}, \Delta H^\circ = +844 \text{ kJ mol}^{-1}$
   This is because
   (a) O^- ion will tend to resist the addition of another electron
   (b) Oxygen has high electron affinity
   (c) Oxygen is more electronegative
   (d) O^- ion has comparatively larger size than oxygen atom

(AIEEE, 2004)

6. Which of the following oxides is amphoteric in character?
   (a) SnO_2 (b) SiO_2
   (c) CO_2 (d) CaO

(AIEEE, 2005)

7. In which of the following arrangements, the order is NOT according to the property indicated against it?
   (a) Li < Na < K < Rb: increasing metallic radius
   (b) I < Br < F < Cl: increasing electron gain enthalpy
   (c) B < C < N < O: increasing first ionization enthalpy
   (d) $Al^{3+} < Mg^{2+} < Na^+ < F^-$: increasing ionic size

(AIEEE, 2005)

8. In the following statements regarding the periodic trends of chemical reactivity of alkali metals and halogens, which of these statements gives the correct picture?
   (a) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens
   (b) In alkali metals, the reactivity increases, whereas in the halogens, it decreases with increase in atomic number down the group
   (c) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group
   (d) In both the alkali metals and the halogens, the chemical reactivity decreases with increase in atomic number down the group

(AIEEE, 2006)

9. In which of the following arrangements, the sequence is not strictly according to the property written against it?
   (a) HF < HCl < HBr < HI: increasing acid strength
   (b) $NH_3 < PH_3 < AsH_3 < SbH_3$: increasing basic strength
   (c) B < C < O < N: increasing first ionization enthalpy
   (d) $CO_2 < SiO_2 < SnO_2 < PbO_2$: increasing oxidizing power

(AIEEE, 2008)

10. The correct sequence that shows the decreasing order of the ionic radii of the elements is:
   (a) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$
   (b) $Na^+ > Mg^{2+} > Al^{3+} > O^{2-} > F^-$
   (c) $Na^+ > F^- > Mg^{2+} > O^{2-} > Al^{3+}$
   (d) $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$

(AIEEE, 2010)

11. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?
   (a) $Al_2O_3 < MgO < Na_2O < K_2O$
   (b) $MgO < K_2O < Al_2O_3 < Na_2O$
   (c) $Na_2O < K_2O < MgO < Al_2O_3$
   (d) $K_2O < Na_2O < Al_2O_3 < MgO$

(AIEEE, 2011)

12. The increasing order of the ionic radii of the given isoelectronic species is:
   (a) Cl^-, Ca^{2+}, K^+, and S^{2-}
   (b) S^{2-}, Cl^-, Ca^{2+}, and K^+
   (c) Ca^{2+}, K^+, Cl^-, and S^{2-}
   (d) K^+, S^{2-}, Ca^{2+}, and Cl^-

(AIEEE, 2012)

13. Which of the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, S, Se, and Ar?

(a) Ca < S < Ba < Se < Ar
(b) S < Se < Ca < Ba < Ar
(c) Ba < Ca < Se < S < Ar
(4) Ca < Ba < S < Se < Ar

(JEE Main, 2013)

14. The first ionization potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be:
(a) –2.55 eV (b) –5.1 eV
(c) –10.2 eV (d) +2.55 eV

(JEE Main, 2013)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The energy released when an electron is added to a neutral gaseous atom is called __________ of the atom. **(IIT-JEE, 1982)**
2. On Mulliken scale, the average of ionization potential and electron affinity is known as __________. **(IIT-JEE, 1985)**
3. Ca^{2+} has a smaller ionic radius than K^+ because it has __________. **(IIT-JEE, 1993)**
4. Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of the lower oxidation state is due to __________. **(IIT-JEE, 1997)**

True/False Type

1. The softness of group IA metals increases down the group with increasing atomic number. **(IIT-JEE, 1986)**
2. In group IA of alkali metals, the ionization potential decreases down the group. Therefore, lithium is a poor reducing agent. **(IIT-JEE, 1987)**
3. The decreasing order of electron affinity of F, Cl, and Br is F > Cl > Br. **(IIT-JEE, 1993)**
4. The basic nature of the hydroxides of group 13 (III A) decreases progressively down the group. **(IIT-JEE, 1993)**

Single Correct Answer Type

1. The correct order of second ionization potential of carbon, nitrogen, oxygen, and fluorine is:
(a) C > N > O > F (b) O > N > F > C
(c) O > F > N > C (d) F > O > N > C
(IIT-JEE, 1981)

2. The element with the highest first ionization potential is:
(a) Boron (b) Carbon
(c) Nitrogen (d) Oxygen
(IIT-JEE, 1982)

3. The first ionization potentials (in electron volts) of nitrogen and oxygen atoms are, respectively, given by:
(a) 14.5, 13.6 (b) 13.6, 14.6
(c) 13.6, 13.6 (d) 14.6, 14.6
(IIT-JEE, 1987)

4. Atomic radii of fluorine and neon (in Angstrom units) are, respectively, given by:
(a) 0.72, 1.60 (b) 1.60, 1.60
(c) 0.72, 0.72 (d) None of these
(IIT-JEE, 1987)

5. The electronegativity of the following elements increases in the order:
(a) C, N, Si, P (b) N, Si, C, P
(c) Si, P, C, N (d) P, Si, N, C
(IIT-JEE, 1987)

6. The first ionization potentials of Na, Mg, Al, and Si are in the order:
(a) Na < Mg > Al < Si (b) Na > Mg > Al > Si
(c) Na < Mg < Al > Si (d) Na > Mg > Al < Si
(IIT-JEE, 1988)

7. Which of the following is smallest in size?
(a) N^{3-} (b) O^{2-}
(c) F^- (d) Na^+
(IIT-JEE, 1989)

8. Among the following elements (whose electronic configurations are given below), the one having the highest ionization energy is:
(a) $[Ne]3s^23p^1$ (b) $[Ne]3s^23p^3$
(c) $[Ne]3s^23p^2$ (d) $[Ne]3d^{10}4s^24p^3$
(IIT-JEE, 1990)

9. Which of the following statements is not correct for the periodic classification of elements?
(a) The properties of elements are the periodic functions of their atomic numbers
(b) Non-metallic elements are lesser in number than metallic elements
(c) The first ionization energies of elements along a period do not vary in a regular manner with increase in atomic number
(d) For transition elements, the *d*-subshells are filled with electrons monotonically with increase in atomic number
(IIT-JEE, 1992)

10. Which of the following has the most stable +2 oxidation state?
    (a) Sn (b) Pb
    (c) Fe (d) Ag
    (IIT-JEE, 1995)

11. Which of the following has the maximum number of unpaired electrons?
    (a) Mg^{2+} (b) Ti^{3+}
    (c) V^{3+} (d) Fe^{2+}
    (IIT-JEE, 1996)

12. Which of the following statement is wrong?
    (a) The first ionization potential of Al is less than the first ionization potential of Mg
    (b) The second ionization potential of Mg is greater than the second ionization potential of Na
    (c) The first ionization potential of Na is less than the first ionization potential of Mg
    (d) The third ionization potential of Mg is greater than the third ionization potential of Al
    (IIT-JEE, 1997)

13. The correct order of acidic strength is:
    (a) $Cl_2O_7 > SO_2 > P_4O_{10}$
    (b) $CO_2 > N_2O_5 > SO_3$
    (c) $Na_2O > MgO > Al_2O_3$
    (d) $K_2O > CaO > MgO$
    (IIT-JEE, 2000)

14. The correct order of radii is:
    (a) $N < Be < B$ (b) $F^- < O^{2-} < N^{3-}$
    (c) $Na < Li < K$ (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$
    (IIT-JEE, 2000)

15. Which of the following has the highest boiling point?
    H_2O, H_2S, H_2Se, and H_2Te
    (a) H_2O because of hydrogen bonding
    (b) H_2Te because of higher molecular weight
    (c) H_2S because of hydrogen bonding
    (d) H_2Se because of lower molecular weight
    (IIT-JEE, 2000)

16. The set representing the correct order of first ionization potential is:
    (a) $K > Na > Li$ (b) $Be > Mg > Ca$
    (c) $B > C > N$ (d) $Ge > Si > C$
    (IIT-JEE, 2001)

Multiple Correct Answers Type

1. Which of the following statements is/are true for the long form of the periodic table?
   (a) It reflects the sequence of filling the electrons in the order of sub-energy levels *s*, *p*, *d*, and *f*
   (b) It helps to predict the stable valency states of the elements
   (c) It reflects trends in physical and chemical properties of the elements
   (d) It helps to predict the relative ionicity of the bond between any two elements
   (IIT-JEE, 1981)

2. Sodium sulphate is soluble in water whereas barium sulphate is sparingly soluble because:
   (a) The hydration energy of sodium sulphate is more than its lattice energy
   (b) The lattice energy of barium sulphate is more than its hydration energy
   (c) The lattice energy has no role to play in solubility
   (d) The hydration energy of sodium sulphate is less than its lattice energy
   (IIT-JEE, 1989)

3. Ionic radii of:
   (a) $Ti^{4+} < Mn^{7+}$ (b) $^{35}Cl^- < {}^{37}Cl^-$
   (c) $K^+ > Cl^-$ (d) $P^{3+} > P^{5+}$
   (IIT-JEE, 1999)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is true; Statement-II is the correct explanation for Statement-I.
(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.
(c) Statement-I is true; Statement-II is false.
(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** F atom has a less negative electron affinity than Cl atom.
   Statement-II: Additional electrons are repelled more effectively by 3*p* electrons in Cl atom than by 2*p* electron in F atom.
   (IIT-JEE, 1998)

2. **Statement-I:** The first ionization energy of Be is greater than that of B.
   Statement-II: 2*p*-orbital is lower in energy than 2*s*.
   (IIT-JEE, 2000)

Integer Answer Type

1. In an atom, the total number of electrons having quantum numbers $n = 4$, $|m_l| = 1$ and $m_s = -\frac{1}{2}$ is

(JEE Advanced, 2014)

Subjective Type

1. Arrange the following in the given order.
   (a) Decreasing ionic size: $Mg^{2+}, O^{2-}, Na^+, F^-$
   (IIT-JEE, 1985)
   (b) Increasing first ionization energy: Mg, Al, Si, Na **(IIT-JEE, 1985)**
   (c) Increasing bond length: F_2, N_2, Cl_2, O_2
   (IIT-JEE, 1985)
   (d) The order of their increasing size:
   $Cl^-, S^{2-}, Ca^{2+}, Al^{3+}$
   (IIT-JEE, 1986)

2. Explain the following statement:
   "The first ionization energy of carbon atom is greater than that of boron atom, whereas the reverse is true for the second ionization energy".
   (IIT-JEE, 1989)

3. Arrange the following as stated:
   Increasing order of ionic size
   $N^{3-}, Na^+, F^-, O^{2-}, Mg^{2+}$
   (IIT-JEE, 1991)

4. Arrange the following ions in order of their increasing radii:
   $Li^+, Mg^{2+}, K^+, Al^{3+}$
   (IIT-JEE, 1997)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (b) Removal of electron from $2p$ half filled is more difficult.
2. (a) The size of isoelectronic species decreases with increase in atomic number.
3. (b) Ionization energy increases along the period.
4. (b) Anions are always larger than their parent atom. Also atomic radius increases down the group and decreases along the period.
5. (d) Each has six electrons.
6. (c) Cl^- has $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6$ configuration.
7. (c) Ionization energy decreases down the group.
8. (d) Ti^+ has 21 electrons in it. Rest all have 10 electrons.
9. (d) Rest all are periodic properties of elements.
10. (b) Alkali metals are most electropositive elements.
11. (c) In O^{2-}, effective nuclear charge is minimum due to more number of electrons and thus the size of O^{2-} is maximum.

33. (c) $M_B = \dfrac{M_A + M_C}{2}$

$$15 = \frac{7 + M_C}{2}; \qquad M_C = 23$$

34. (c) Hydrated radius ∝ charge per unit on ion.
$I^-(aq) > Cl^-(aq)$

35. (c) Hydration energy $\propto \dfrac{1}{\text{Size of gaseous ion}}$
$K^+ > Cs^+$

36. (a) Ne > F order of size. Therefore, answer is "a" 0.72, 1.60.
37. (b) The more the negative charge, the more would be the size of the ion, and down the group size increases.
38. (d) Hg is a d-block element.
59. (c) Due to a jump in second ionization energy.
60. (b) From the electronic configuration of the given element $K, L, M,$ and N; $L = [Ne]3s^2, 3p^3$ has the highest ionization potential than others.
61. (d) Ionization enthalpy increases along the period and decreases down the group.
62. (d) $E.A._1$ for elements is exothermic and $E.A._2$ is endothermic. Also $E.A._2$ for O > $E.A._1$ for O.
63. (a) Cations are always smaller than their parent atoms: $Al^{3+} < Al^{2+} < Al^+ < Al$.
64. (d) Both C and N^+ have six electrons.
65. (a) Addition of electrons to an atom results in an increase in its size.
66. (d) Size of anions is larger than their parent atom. Also, the more the ENC, the lesser the size.
67. (d) Each has 18 electrons.
69. (a) Due to higher Z_{eff} value of Fe^{3+} in comparison to Fe^{2+}, there is more contraction in size of Fe^{3+} than in Fe^{2+}.

JEE (Advanced) Exercises

Single Correct Answer Type

17. (a)

Magnetic moment $\mu = \sqrt{n(n+2)}$	Unpaired electrons n	Species of Mn
(a) $2\sqrt{2}$	2	Mn^{5+}
(b) $\sqrt{15}$	3	Mn^{4+}
(c) $\sqrt{35}$	5	Mn^{2+}
(d) $\sqrt{24}$	4	Mn^{3+}

Species with greater positive charge have higher I.E.

18. (b) Ionic mobility in water $\propto \dfrac{1}{\text{Size of hydrated ion}}$

(a) Size of aqueous ions $Al^{3+} > Mg^{2+}$

(b) Size of $K^+(aq) > Ca^{2+}$ (aq)

(c) I^- (aq) has the highest ionic mobility among halide (aq) ions.

(d) Cs^+ (aq) has the highest ionic mobility because of lesser hydrated radius than any of alkali metal ions (aq).

19. (c) $$d_{H-F} = 0.37 + 0.72 - 0.09\,|4 - 2.1|$$
$$= 1.09 - 0.17 = 0.92\ \text{Å}$$

34. (b) The size of isoelectronic decreases with increase in atomic number.

35. (c) The smaller the size of cation, the more is the ionic character, and the more is the attraction among ions.

36. (c) The jump in ionization energy occurs when valence shell changes during removal of electron.

37. (b) Ionization energy increases along the period.

38. (b) The ionization potential decreases down the group.

39. (d) Lattice energy $\propto \dfrac{q_1 q_2}{d^2}$, where q_1, q_2 are the charge on ions and d is the distance of separation.

40. (b)

43. (a) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$ Electron affinity of an anion (endothermic)

$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$ Lattice energy (endothermic)

$N_{(g)} \longrightarrow N^-_{(g)}$ (exothermic)

More stable — Less stable

(Half filled p-subshell)

$Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$ (endothermic) (ionization is endothermic)

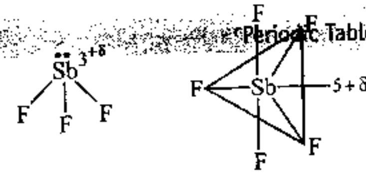
57. (c) If Z is the atomic number of the inert gas, then

$(Z-1) \Rightarrow$ halogens; $(Z+1) =$ alkali metals

$(Z-2) \Rightarrow$ oxygen family; $(Z+2) =$ alkaline earth metals

} forms ionic compound

58. (b)



Therefore, more electronegativity of Sb, as it has more $+\delta$ charge.

59. (b) $\dfrac{\text{Cation}}{\text{Anion}}$ ratio should be minimum.

Therefore, the largest anion and the smallest cation must be there; thus answer is LiI.

60. (d) $(I.P.)_2 > (I.P.)_1$ always as in case of $I.P._2$. Electron is removed from cation in which Z_{eff} has increased for the last electron.

61. (a) $Cl \rightarrow Cl^-$ [E.A.$_1$ of Cl]

and

$F^- \rightarrow F$ [$-$E.A.$_1$ of F]

As E.A. of Cl > E.A. of F, therefore, $Cl \rightarrow Cl^-$ will involve maximum energy.

74. (c) Anion (O^-) repels the test electron because of same charge.

Multiple Correct Answers Type

1. (a), (b), (c)

$H^- > F^-$ [true]

[larger]

(a), (b), (c) are all correct statements.

2. (a), (b), (c)

(i) I.E. order: $s > p > d > f$ for a particular principal quantum number.

(ii) I.E. depends upon half filled and fully filled configuration.

Factors (i) and (ii) disappear in the 5th and 6th periods because Z_{eff} dominates over all others.

7. (a), (c), (d)

(a) and (c) are correct

(b): EN↑, i.e., metallic character↓

(d): EA of Cl > EA of F

8. (a), (c), (d);

(a) False; lanthanum belongs to d-block.

(b) True; actinium violates Aufbau's principle; its configuration is [Rn] $7s^2\ 6d^1$.

(c) False.

(d) False; configuration of Zn is [Ar] $3d^{10}\ 4s^2$.

∴ Total exchanges are 20 not 10.

10. (a), (b), (d)

(a) $Al^+ \rightarrow 3s^2$ ∴ $Al^+ > Mg^+$

$Mg^+ \rightarrow 2s^2 2p^6, 3s^1$

(b) $Te^+ \rightarrow 5s^2\,5p^3$ ∴ $Te^+ > Sb^+$

$Sb^+ \rightarrow 5s^2 5p^2$

(c) Successive I.E. of element increases.

∴ $Fe^{2+} > Fe^+$; the more is the charge, the more will be the I.E.

(d) $In^+ \rightarrow 5s^2\,5p^0$ ∴ $In^+ > Sr^+$

$Sr^+ \rightarrow 5s^1$

11. (a), (b), (c)

($I.E._1 - I.E._2$) is very high. Therefore, A will be ionized only once and thus will form compounds with valency one like AF, A_2O, and A_3N.

13. (a), (b), (c)

The ionization energy order is $F > Cl > Cl^- > F^-$.

14. (a), (c), (d)

(a) Size of Cl is smaller than Br. ∴ I.E. Cl > Br.

(c) I.E. of neutral atom is more than anion.

∴ $Cl > Cl^-$ and $Br > Br^-$.

18. (a), (c), (d)

Alkaline earth metals are at descending positions in the curve.

19. (a), (b), (c), (d)

Cr (24): $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^1$

(a) Number of electrons with principle quantum number 3 is $3s^2\,3p^6\,3d^5 = 2 + 6 + 5 = 13$

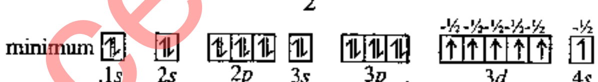
(b) Number of electrons with azimuthal quantum number 1 is $2p^6$, $3p^6 = 6 + 6 = 12$

(c) Number of electrons with magnetic quantum number 0 is $3p^6$

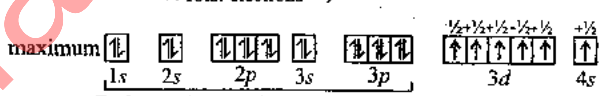
electrons in $m = 0$: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^5$ $4s^1$ → 2 2 2 2 2 1 1

Total = 12 electrons

(d) Number of minimum electrons with spin quantum number $s = +\frac{1}{2}$:



Each contains one electron with s = + ½
∴ Total electrons = 9



Each contains one electron with s = + ½
∴ Total electrons = 15

20. (c), (d)

(c) $Zn \longrightarrow [Ar]\,3d^{10}, 4s^2$

$Zn^{2+} \longrightarrow [Ar]\,3d^{10}, 4s^0$ ⇒ diamagnetic

(d) $Cr \longrightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$

↓ $2e^-$ (2p), ↓ $2e^-$ (3p), ↓ $1e^-$ (3d)

$5e^-$ having $m = -1$

21. (a), (b), (d)

B and Mg do not show diagonal relationship.

22. (a), (d)

"He" is the smallest inert gas.

∴ It has the highest I.P., and the $(I.P.)_1$ is highest for the noble gases in any period.

23. (a), (c), (d)

IE_1 of N > IE_1 of 0, due to half filled nature in N.

24. (a), (b)

(a) → p-orbital can accommodate a maximum of 2 electrons.

(b) → Na: $1s^2\,2s^2\,2p^6\,3s^1$ Na^{3+}: $1s^2\,2s^2\,2p^4$

Na^+: $1s^2\,2s^2\,2p^6$

Na^{2+}: $1s^2\,2s^2\,2p^5$ $I.E._3 > I.E._2 > I.E._1$

$I.E._3$ is greater than $I.E._2$ because to convert $Na^{2+} \rightarrow Na^{3+}$, electron is removed from a cation having more positive charge.

30. (a), (d)

X^{2-} is isoelectronic with "O_2^+" which has 7 + 8 = 15 electrons.

X has 13 electrons and 13 protons.

Number of neutrons (n) = (Z + 1) = 13 + 1 = 14.

Mass number (a) = (p + n) = 13 + 14 = 27.

32. (a), (b)

"n" and "l" decide the distance from the nucleus.

∴ Ionization energy depends on these two.

Comprehension Type

Comprehension-1 (Q. 1 to Q. 3)

1. (d) If the frequency is enough to ionize Cl, then I.E. of Br and I would be lesser than Cl; thus it can ionize them also.

2. (c) Noble gases have the highest I.E. in their respective periods.

3. (b) $K \longrightarrow K^-$ is on exothermic process, i.e., the energy involved has –ve value.

$K^- \longrightarrow K$ is opposite of $K \longrightarrow K^-$.

∴ Numerical value would be the same but sign will be opposite. But $K \rightarrow K^+$ is I.E. of K.

∴ It is higher than the above process as it is a having a positive value.

Comprehension-2 (Q. 4 to Q. 6)

4. (a) $I.E._1$ As > Se because of half filled configuration.

5. (a) $\Delta H_{eg} = -E.A.$

6. (d) $K \xrightarrow{I.E._1} K^+ \xrightarrow{I.E._2} K^{2+}$

$I.E._2 >> I.E._1$ $\therefore$ Potassium gets ionized only once after which it attains inert gas configuration.

$K^+ = 1s^2, 2s^2\,2p^6, 3s^2\,3p^6$

Assertion-Reasoning Type

1. (c) **Statement-I:** True, as both have 18 electrons.

Statement-II: False, for isoelectronic species number of electrons are same, not the charge.

2. (d) Cd is a *d*-block element, not a transition element as its *d*-orbital is filled completely in Cd and Cd^{2+} both.

$Cd \rightarrow 3d^{10}\,4s^2$, $\quad Cd^{2+} \rightarrow 3d^{10}\,4s^0$

Matching Column Type

3. (a) p, r; (b) r, s; (c) p, q, r

Zn and Hg are not transition elements because in their ground state and in the most stable oxidation state configuration, "*nd*" is completely filled.

4. (a) p, q, r; (b) p, q, r; (c) p, q, s;

Electronegativity is independent of configuration and it can be calculated by bond energy data by Pauling scale.

5. (a) p, r, s; (b) p, q, s; (c) s; (d) p, q, r, s.

(a) $89 \longrightarrow$ Ac $\quad$ (b) $35 \longrightarrow$ Br

(c) $37 \longrightarrow$ Rb $\quad$ (d) $24 \longrightarrow$ Cr

6. (a) p, s, t; (b) q, r; (c) q, r; (d) s, t

(a) Energy released

$S \longrightarrow S^-$ $\qquad \Delta H_{eg1}$

$N^- \longrightarrow N$ as $N \longrightarrow N^-$ is $\Delta H_{eg1} = +ve$

(b) Energy absorbed

$Ge \longrightarrow Ge^-$ $\qquad \Delta H_{eg1}$

$O^- \longrightarrow O^{2-}$ $\qquad \Delta H_{eg2}$

$Sr \longrightarrow Sr^{2+}$ $\qquad I.E._1 + I.E._2$

(c) Inert gas configuration is achieved

$O^- \longrightarrow O^{2-}$, $Sr \longrightarrow Sr^{2+}$

(d) Half-filled configuration is achieved

$Ge \longrightarrow Ge^-$

$N^- \longrightarrow N$

7. (a) q, r; (b) p, q, r; (c) p, q, s

$Z = 17 \rightarrow$ $3s^2$ [↑↓] $3p^5$ [↑↓|↑↓|↑]

→ One unpaired electron

→ *p*-block element

→ ΔH_{eg} is more negative than sulphur and argon

$Z = 32$ [Ar] → $4s^2$ [↑↓] $4p^4$ [↑↓|↑|↑]

→ Two unpaired electrons; *p*-block element

→ Less negative ΔH_{eg} than the element to its right side in the same period

$Z = 81$ element is Tl [Xe] $6s^2$ [↑↓] $6p^1$ [↑| |]

→ One unpaired electron; *p*-block element I.E. is more than above element (exception.)

Integer Answer Type

1. (13) Ni: $1s^2\,2s^2 2p^6\,3s^2\,3p^6\,3d^8\,4s^2$

Except 3*d*-subshell, remaining each subshell has two electrons; for them magnetic quantum number is zero, and 3*d*-subshell has one electron. Hence total number of electrons = 13.

2. (2) Cd and Hg are *d*-block elements but not transitional.

5. (125) Possible subshells are present in the 8th period: 8*s* 7*d* 6*f* 5*g* 8*p*

Total electrons = 5 + 25 + 35 + 45 + 15 = 125

6. (3) As there is very high difference between $I.E._3$ and $I.E._4$, thus it has three electrons in its valence shell.

9. (6) $\Delta X = E.N._y - E.N._x = 2.5 - 1.0 = 1.5$

% Ionic character = $16\Delta X + 3.5\,(\Delta X)^2$

% Ionic character = $\dfrac{\mu_{exp}}{\mu_{theo}} \times 100$

$$16(1.5) + 3.5\,(1.5)^2 = \frac{\mu_{exp} \times \frac{1}{3} \times 10^{-29}}{1.6 \times 10^{-19} \times 3.92 \times 10^{-10}} \times 100$$

$\mu_{exp} = 5.99 \approx 6$

10. (19) 3rd $\longrightarrow$ Na Mg Al Si P S Cl (smallest) $_{18}$Ar

4th $\longrightarrow$ K Ca Ga Ge As Se Br $_{36}$Kr (largest)

Total protons = 36 – 17 = 19.

11. (1960) $Be \longrightarrow Be^+$ energy required = 899

$Be^+ \longrightarrow Be^{2+}$ energy required = 1757

$Be \longrightarrow Be^{2+}$ energy required = 2656

$Cl \longrightarrow Cl^-$ energy released = – 348

For $2Cl^-$, energy released = – 696

Therefore, the energy deficit for the process

$Be + 2Cl \longrightarrow BeCl_2$ is

2656 – 696 = 1960 kJ/mol

NCERT Exemplar Exercises

Short Answer Type

1. The added electron in fluorine goes to second quantum level. Due to small size of fluorine it experiences repulsion from other electrons much more in comparison to that in chlorine because in chlorine, the electron is added to 3rd quantum level in which larger space is available for movement.
2. Group: 1, Valency: 1; Outermost electronic configuration = $8s^1$; Formula of Oxide = M_2O
3. (i) Carbon, (ii) Aluminium
4. (a)
5. The outermost electronic configuration of nitrogen ($2s^2 2p_x^1 2p_y^1 2p_z^1$) is very stable because p-orbital is half filled. Addition of extra electron to any of the 2p orbital requires energy. Oxygen has 4 electrons in 2p orbitals and acquires stable configuration i.e., $2p^3$ configuration after removing one electron.
6. After removing 1 electron from the sodium atom the ion formed acquires the configuration of inert gas, neon. The second electron is removed from one of the 2p-orbitals which are completely filled i.e., have a total of 6 electrons and are closer to the nucleus.
7. (i) S < P < N < O, (ii) P < S < N < O
8. (a) Decrease in size of atom and increase in nuclear charge.

   (b) Increase in atomic size.
9. Metallic character decreases and non metallic character increases in moving from left to right in a period. It is due to increase in ionization enthalpy and electron gain enthalpy.
10. Decrease of one shell.
11. Electronegativity decreases in a group from top to bottom. Thus, caesium is the least electronegative element.

Matching Column Type

1. Be = 111, O = 66, C = 77, B = 88, N = 74.
2. Most reactive non metal = (q), Most reactive metal = (p), Least reactive element = (s), Metal forming binary halide = (r)
3. (i) → (s); (ii) → (p); (iii) → (q); (iv) → (r)

Archives

JEE (Main) Exercises

Single Correct Answer Type

2. (d) Na_2O Basic Oxide

   SO_2 Acidic oxide

   B_2O_3 Acidic oxide

   ZnO Amphotoric oxide

   It can react with acid and base both.

   $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

   $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$
3. (a) These are all elements of second period. Anions have large size than anion. F^- and O^{2-} are isoelectronic and Z_{eff} of F^- is more than O^{2-}.
4. (d) As we move left to right along period in L.F.P.T. acidic strength increases.
6. (a) SnO_2 Amphotaric, amphotaric oxides react with acid as well as base.

   $SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$

   $SnO_2 + 4HCl \rightarrow SnCl_4 + 2H_2O$

   SiO_2 is acidic oxide

   CO_2 is acidic oxide

   CaO is basic oxide
7. (c) Ionization energy of N is greater than O due to its half filled 2p-subshell.
8. (b)
9. (b) Due to small size of N, the charge density of l.p. is more.

10. (d) For isoelectronic species σ is same for all

$$\text{size} \propto \frac{1}{Z_{\text{eff}}}$$

Z is atomic number

$Z_{\text{eff}} = (Z - \sigma)$

11. (a) Basic strength of oxides increases down the group and decreases across a period from left to right.

12. (c) For isoelectronic species σ is same for all

$$\text{size} \propto \frac{1}{Z_{\text{eff}}}$$

Z is atomic number

$Z_{\text{eff}} = (Z - \sigma)$

13. (c)

(i) In a group the I.E. decreases.

Hence Ca > Ba

and S > Se

(ii) In a period, I.E. increases from left to right in general.

Hence Ar > S and Se > Ca

Hence the order is Ar > S > Se > Ca > Ba and the answer is (c).

14. (b) $Na \underset{-\Delta H_{e.g.}}{\overset{+I.E.}{\rightleftharpoons}} Na^+ + e^-$

$|I.E.| = |\Delta H_{e.g.}|$ Hence

$\Delta H_{e.g.}$ of $Na^+ = -5.1$ eV

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The energy released when an electron is added to a neutral gaseous atom is called **electron gain enthalpy** of the atom.

2. On Mulliken scale, the average of ionization potential and electron affinity is known as **electronegativity**.

3. Ca^{2+} has a smaller ionic radius than K^+ because it has **higher** z/e **ratio**.

In isoelectronic species, as the number of protons (atomic number) goes on increasing, the size goes on decreasing due to stronger attraction on the electrons.

4. Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of the lower oxidation state is due to **inert pair effect**.

In the periodic table, inert pair effect increases down the group. So in group 14, the stability of smaller oxidation state of +2 goes on increasing down the group. Pb^{4+} has an oxidizing nature and Br^- and I^- have reducing nature, so Pb^{4+} is reduced to Pb^{2+}.

$$Pb^{4+} + 2Br^- \rightarrow Pb^{2+} + Br_2$$

$$Pb^{4+} + 2I^- \rightarrow Pb^{2+} + I_2$$

True/False Type

1. True.

The softness of group IA metals increases down the group with increasing atomic number. This is a true statement.

2. False.

In group IA of alkali metals, the ionization potential decreases down the group. But lithium is a very strong reducing agent because of its very high hydration energy.

3. False.

The decreasing order of electron affinity of F, Cl, and Br is Cl > F > Br.

In general, the electron affinity decreases down the group but the electron affinity for chlorine is more than that for fluorine, and similarly the electron affinity for sulphur is more than that for oxygen because in F and S, due to small size of the atom, the electrons are already crowded. Entry of one more electron results in more repulsions which leads to the absorption of some energy, so the energy released is less than what would be expected.

4. False.

The basic nature of the hydroxides increases progressively down the group.

Single Correct Answer Type

1. (c) The correct order is O > F > N > C.

From left to right, the ionization potential increases.

$O^+: 1s^2 2s^2 2p^3$

After losing one electron, oxygen atom acquires half-filled stable configuration, so its second ionization potential becomes larger than that for fluorine.

2. (c) $N: 1s^2 2s^2 2p^3$

From left to right in a period, the first ionization potential increases. But in nitrogen, half-filled stable configuration is present, therefore its ionization potential is greater than that of oxygen.

3. (a) $N:1s^2 2s^2 2p^3$

From left to right in a period, the first ionization potential increases. But in nitrogen, half-filled stable configuration is present, therefore its ionization potential is greater than that of oxygen.

4. (a) In case of fluorine, it is covalent radius. In case of neon, it is van der Waals radius because it is a noble gas which is monatomic. van der Waals radius is always more than the covalent radius.

5. (c) Si < P < C < N
Electronegativity increases from left to right in a period.
Electronegativity decreases down the group in the periodic table.

6. (a) Na < Mg > Al < Si

From left to right, the ionization potential increases. But in magnesium, stable configuration is present, therefore its ionization potential is greater than that of aluminium.

$Mg:1s^2 2s^2 2p^6 3s^2$

7. (d) All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

8. (b) $[Ne]3s^2 3p^3$

From left to right in a period, the first ionization potential increases. Down the group, ionization potential decreases. In option (c), half-filled stable configuration is also present.

9. (d) Option (d) is incorrect because for transition elements, the *d*-subshells are filled with electrons regularly with increase in atomic number.

10. (b) In the periodic table, inert pair effect increases down the group. So in group 14, the stability of smaller oxidation state of +2 goes on increasing down the group. This makes Pb^{2+} a stable oxidation state.
In $Fe^{2+}(3d^6)$, the *d*-orbital is not completely filled. $Ag^+(4d^{10})$ is the most stable oxidation state of silver because due to fully filled *d*-subshell, removal of the second electron is very difficult.

11. (d) $Mg^{2+}:1s^2 2s^2 2p^6$

No unpaired electron

$Ti^{3+}:1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$

One unpaired electron

$V^{3+}:1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

Two unpaired electrons

$Fe^{2+}:1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

Four unpaired electrons

12. (b) $Na(z=11):1s^2 2s^2 2p^6 3s^1$

$Na^+:1s^2 2s^2 2p^6$

After losing the first electron, sodium acquires a very stable noble gas configuration. Therefore, its second ionization potential is very high. So, it is incorrect to say that the second ionization potential of Mg is greater than the second ionization potential of Na.

13. (a) The correct order of acidic strength is

$Cl_2O_7 > SO_2 > P_4O_{10}$.

In the periodic table, the acidic nature of oxides increases from left to right. Acidic nature of oxides decreases down the group.

14. (b) $F^- < O^{2-} < N^{3-}$
All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, the size goes on decreasing due to stronger attraction on the electrons.

15. (a) In hydrides of group 16, boiling point increases down the group because of increasing molecular mass. But water has an exceptionally high boiling point because it shows intermolecular hydrogen bonding.

16. (b) From left to right in a period, the first ionization potential increases. Down the group, ionization potential decreases.

Multiple Correct Answers Type

1. (a), (c), (d) Only (b) seems to be incorrect because in many cases, stable valency states are difficult to predict on the basis of the periodic table.

2. (a), (b) When the hydration energy is more than the lattice energy, the salt is soluble in water and vice versa.

3. (d) $Ti^{4+} < Mn^{7+}$
Higher the value of positive charge on the cation, the smaller the ionic size.

Assertion-Reasoning Type

1. (c) Statement-II is incorrect. In general, the electron affinity decreases down the group but the electron affinity for chlorine is more than that for fluorine, and similarly the electron affinity

for sulphur is more than that for oxygen because in F and S, due to small size of the atom, the electrons are already crowded. Entry of one more electron results in more repulsions, which leads to absorption of some energy, so the energy released is less than what is expected.

2. (c) Statement-II is incorrect. The first ionization energy of Be is greater than that of B because of its relatively stable electronic configuration. $2p$-orbital is rather higher in energy than $2s$.

Integer Answer Type

1. (6) For $n = 4$, orbitals are

0

−1	0	+1

−2	−1	0	+1	+2

−3	−2	−1	0	+1	+2	+3

Total number of orbitals having $\{|m_l| = 1\} = 6$

Total number of electrons having $\left\{|m_l| = 1 \text{ and } m_s = -\frac{1}{2}\right\} = 6$

Subjective Type

1. (a) The decreasing order of ionic size is $O^{2-} > F^- > Na^+ > Mg^{2+}$.
All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

(b) The increasing order of first ionization energy is

$Na < Al < Mg < Si$

From left to right, the ionization energy increases. But in magnesium, stable configuration is present. Therefore, its ionization energy is greater than that of aluminium.

$Mg: 1s^2 2s^2 2p^6 3s^2$

(c) The increasing order of bond length is $N_2 < O_2 < F_2 < Cl_2$.
In nitrogen, triple bond is present which has the smallest bond length. In oxygen, double bond is present, which has smaller bond length than single bonds. In chlorine, bond length is larger than in fluorine due to larger size of the atom.

(d) The increasing order of size is

$Al^{+3} < Ca^{+2} < Cl^{\ominus} < S^{-2}$

All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

2. From left to right in the periodic table, the ionization energy increases; therefore, the first ionization energy of carbon atom is greater than that of boron.
The second ionization energy of boron is greater than that of carbon because after losing one electron, boron acquires a stable electronic configuration.

$B(z = 5): 1s^2 2s^2 2p^1$,

$B^+: 1s^2 2s^2$

3. The increasing order of ionic sizes is

$Mg^{2+} < Na < F^- < O^{2-} < N^{3-}$

All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

4. $Al^{3+} < Mg^{2+} < Li^+ < K^+$

Al^{3+} and Mg^{2+} are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons. K^+ is larger than Li^+ because on moving down the group, size decreases.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (b)	4. (b)	5. (d)	6. (c)	7. (c)	8. (d)	9. (d)	10. (b)
11. (c)	12. (d)	13. (b)	14. (b)	15. (b)	16. (c)	17. (b)	18. (b)	19. (c)	20. (d)

21. (b)	**22.** (a)	**23.** (c)	**24.** (a)	**25.** (c)	**26.** (a)	**27.** (a)	**28.** (c)	**29.** (c)	**30.** (d)
31. (d)	**32.** (d)	**33.** (c)	**34.** (c)	**35.** (c)	**36.** (a)	**37.** (b)	**38.** (d)	**39.** (d)	**40.** (c)
41. (a)	**42.** (a)	**43.** (b)	**44.** (d)	**45.** (a)	**46.** (b)	**47.** (c)	**48.** (d)	**49.** (a)	**50.** (a)
51. (a)	**52.** (c)	**53.** (c)	**54.** (a)	**55.** (a)	**56.** (d)	**57.** (c)	**58.** (b)	**59.** (c)	**60.** (b)
61. (d)	**62.** (d)	**63.** (a)	**64.** (d)	**65.** (a)	**66.** (d)	**67.** (d)	**68.** (b)	**69.** (a)	**70.** (d)
71. (b)	**72.** (d)	**73.** (a)	**74.** (b)	**75.** (a)	**76.** (c)				

JEE (Advanced) Exercises

Single Correct Answer Type

1. (d)	**2.** (a)	**3.** (a)	**4.** (d)	**5.** (d)	**6.** (a)	**7.** (c)	**8.** (c)	**9.** (b)	**10.** (c)
11. (a)	**12.** (a)	**13.** (b)	**14.** (b)	**15.** (a)	**16.** (c)	**17.** (a)	**18.** (d)	**19.** (c)	**20.** (d)
21. (c)	**22.** (a)	**23.** (a)	**24.** (c)	**25.** (b)	**26.** (b)	**27.** (c)	**28.** (a)	**29.** (c)	**30.** (c)
31. (a)	**32.** (a)	**33.** (b)	**34.** (b)	**35.** (c)	**36.** (c)	**37.** (b)	**38.** (b)	**39.** (d)	**40.** (b)
41. (c)	**42.** (c)	**43.** (a)	**44.** (d)	**45.** (d)	**46.** (d)	**47.** (d)	**48.** (a)	**49.** (d)	**50.** (b)
51. (b)	**52.** (c)	**53.** (b)	**54.** (b)	**55.** (a)	**56.** (b)	**57.** (c)	**58.** (b)	**59.** (b)	**60.** (d)
61. (a)	**62.** (c)	**63.** (b)	**64.** (b)	**65.** (b)	**66.** (a)	**67.** (a)	**68.** (d)	**69.** (b)	**70.** (b)
71. (b)	**72.** (d)	**73.** (b)	**74.** (c)	**75.** (d)					

Multiple Correct Answers Type

1. (a), (b), (c)	**2.** (a), (b), (c)	**3.** (a), (b), (c)	**4.** (a), (c), (d)	**5.** (b), (c), (d)
6. (b), (c)	**7.** (a), (c), (d)	**8.** (a), (c), (d)	**9.** (b), (c), (d)	**10.** (a), (b), (d)
11. (a), (b), (c)	**12.** (a), (b), (d)	**13.** (a), (b), (c)	**14.** (a), (c), (d)	**15.** (a), (b), (d)
16. (b), (c), (d)	**17.** (a), (c), (d)	**18.** (a), (c), (d)	**19.** (a), (b), (c), (d)	**20.** (c), (d)
21. (a), (b), (d)	**22.** (a), (d)	**23.** (a), (c), (d)	**24.** (a), (b)	**25.** (a), (c), (d)
26. (a), (b), (c), (d)	**27.** (b), (c), (d)	**28.** (b), (c), (d)	**29.** (a), (b), (d)	**30.** (a), (d)
31. (a), (c), (d)	**32.** (a), (b)			

Comprehension Type

1. (d) **2.** (c) **3.** (b) **4.** (a) **5.** (a) **6.** (d)

Assertion-Reasoning Type

1. (c) **2.** (d) **3.** (b) **4.** (a)

Matching Column Type

1. (a) s; (b) p; (c) q; (d) r
2. (a) q; (b) s; (c) r
3. (a) p, r; (b) r, s; (c) p, q, r
4. (a) p, q, r; (b) p, q, r; (c) p, q, s
5. (a) p, r, s; (b) p, q, s; (c) s; (d) p, q, r, s
6. (a) p, s, t; (b) q, r; (c) q, r; (d) s, t
7. (a) q, r; (b) p, q, r; (c) p, q, s

Integer Answer Type

1. (13) **2.** (2) **3.** (3) **4.** (4.55) **5.** (125) **6.** (3) **7.** (1) **8.** (7.55) **9.** (6) **10.** (19)
11. (1960)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (a) 3. (c) 4. (c) 5. (c) 6. (c) 7. (d) 8. (c)
9. (i) (c), (ii) (c), (iii) (c), (iv) (a), (v) (b) 10. (a)

Multiple Correct Answers Type

1. (a), (d) 2. (a), (d) 3. (a), (c), (d) 4. (b), (c)
5. (b), (c) 6. (a), (d) 7. (a), (c) 8. (a), (c)

Assertion-Reasoning Type

1. (b) 2. (c)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) 2. (d) 3. (a) 4. (d) 5. (a) 6. (a) 7. (c) 8. (b) 9. (b) 10. (d)
11. (a) 12. (c) 13. (c) 14. (b)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) 2. (c) 3. (a) 4. (a) 5. (c) 6. (a) 7. (d) 8. (b) 9. (d) 10. (b)
11. (d) 12. (b) 13. (a) 14. (b) 15. (a) 16. (b)

Multiple Correct Answers Type

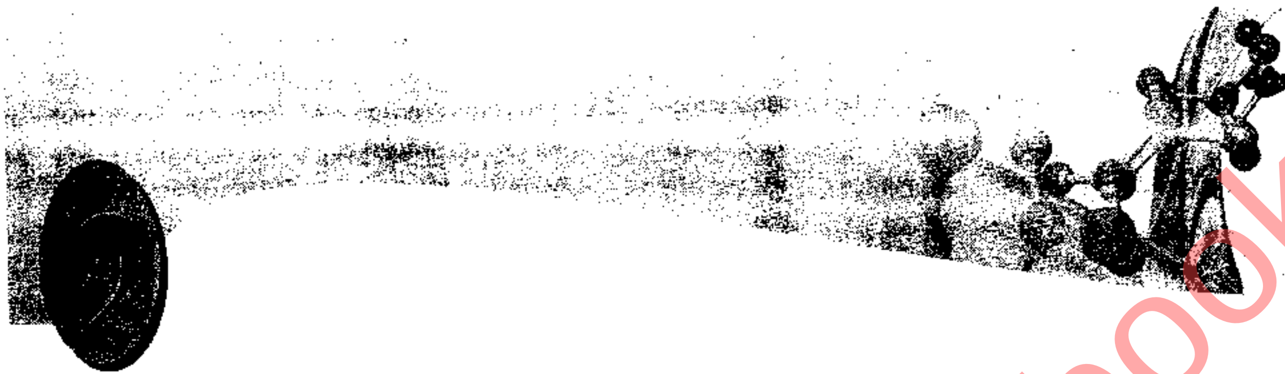
1. (a), (c), (d) 2. (a), (b) 3. (d)

Assertion-Reasoning Type

1. (c) 2. (c)

Integer Answer Type

1. (6)



Chemical Bonding (Part-B)

JEE (Main) Exercises

Single Correct Answer Type

1. In which of the following is the O—N—O bond angle highest?
   (a) NO_2 (b) NO_2^+
   (c) NO_2^- (d) NO_3^-
2. Which of the following has higher bond dipole moment?
   (a) H—C (b) N—O
   (c) P—H (d) None of these
3. Which of the following orbital is more directional?
   (a) *s*-orbital (b) *p*-orbital
   (c) *sp*-orbital (d) None of these
4. Select the incorrect geometry for hybridization:
   (a) sp = linear (b) sp^3d = T.B.P.
   (c) sp^3d^2 = P.B.P (d) All are correct
5. In benzene, what is the hybridization on each carbon atom?
   (a) sp^2 (b) sp^3
   (c) sp^3d (d) sp
6. What hybridization is expected on the central atom of each of the following molecules?
   (i) BeH_2 (ii) CH_2Br_2
   (iii) PF_6^- (iv) BF_3
   (a) sp^2, sp, sp^3, sp^2 (b) sp, sp^3, sp^3d, sp^2
   (c) sp, sp^3, sp^3d^2, sp^2 (d) sp^2, sp, sp^2, sp^3
7. Predict the geometry of the following species and describe the hybridization on the central atom:
   (i) $PbCl_4$ (ii) SbF_6^-
   (iii) BH_4^- (iv) PCl_3
   (a) Tetrahedral sp^2, octahedral sp^3d^3, tetrahedral sp^3, tetrahedral sp^3, respectively
   (b) Tetrahedral sp^3, octahedral sp^3d^2, tetrahedral sp^3, tetrahedral sp^3, respectively
   (c) Tetrahedral sp^3, octahedral sp^3d^2, tetrahedral sp^3, pyramidal sp^3, respectively
   (d) Trigonal planar sp^2, octahedral sp^3d^2, tetrahedral sp, tetrahedral sp^2, respectively
8. What is the value of 1D in SI units?
   (a) 3.336×10^{-30} cm (b) 33.36×10^{-30} cm
   (c) 333.6×10^{-30} cm (d) None of these
9. Arrange the following types of interactions in order of increasing stability (covalent, van der Waals' force, hydrogen bonding):
   (a) Hydrogen bonding < covalent < van der Waals' force
   (b) Covalent < hydrogen bonding < van der Waals' force
   (c) Hydrogen < van der Waals' force < covalent bonding
   (d) van der Waals' force < hydrogen bonding < covalent
10. Which of the following is the correct order of strength of H-bonding in the given compound?

(a) $HF < NH_3$ (b) $H_2O > H_2O_2$
(c) $H_2O_2 > H_2O$ (d) $NH_3 > H_2O$

11. Which of the following molecule has a planar structure?
(a) O_2SF_2 (b) OSF_2
(c) XeF_4 (d) ClO_4^-

12. What is the shape of ClF_2^- ion?
(a) Bent (b) Linear
(c) Pyramidal (d) None of these

13. Which of the following molecule is not hypovalent but completes its octet?
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlF_3
(d) All are hypovalent and complete their octet

14. Which of the following species are planar?
(a) I_3^-, XeF_2, ClF_3 (b) H_2O, $\bar{O}Cl$, ICl_2^+
(c) XeF_5^-, XeF_4, BF_3 (d) All are correct

15. In which of the following molecules are all the bonds not of equal length?
(a) BCl_3 (b) PF_5
(c) CF_4 (d) SF_6

16. The pair having similar geometry is:
(a) BH_3, NH_3 (b) BeH_2, H_2O
(c) CH_4, CCl_4 (d) IF_5, PF_5

17. Which of the following molecules is not tetrahedral?
(a) CF_4 (b) SF_4
(c) CH_4 (d) SiF_4

18. Which of the following pair does not have similar geometries?
(a) CH_4, CCl_4 (b) BF_3, NH_3
(c) H_2O, H_2S (d) PCl_5, $SbCl_5$

19. Which type of shape is found in SF_2 molecule?
(a) V-shaped (b) Bipyramidal
(c) Linear (d) Irregular tetrahedron

20. Which of the following molecule/ion has a triangular pyramidal shape?
(a) BF_3 (b) H_3O^+
(c) NO_3^- (d) CO_3^{2-}

21. Graphite has a two-dimensional layer structure and the nearest layers are joined together by:
(a) Electrovalent bonds (b) Covalent bonds
(c) van der Waals' forces (d) Metallic bonds

22. In XeF_2, XeF_4, and XeF_6, the number of lone pairs on Xe, respectively, is:
(a) 2, 3, 1 (b) 1, 2, 3
(c) 4, 1, 2 (d) 3, 2, 1

23. The correct sequence of decrease in bond angles of following hydrides is:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $NH_3 > AsH_3 > PH_3 > SbH_3$
(c) $SbH_3 > AsH_3 > PH_3 > NH_3$
(d) $PH_3 > NH_3 > AsH_3 > SbH_3$

24. A lone pair of electrons in an atom implies:
(a) A pair of valence electrons
(b) A pair of electrons
(c) A pair of electrons involved in bonding
(d) A pair of electrons not involved in bonding

25. Which of the following is soluble in water?
(a) CS_2 (b) C_2H_5OH
(c) CCl_4 (d) $CHCl_3$

26. Which one of the following groupings represents a collection of isoelectronic species?
[At. No.: Cs = 55, Br = 35]
(a) Be, Al^{3+}, Cl^- (b) Ca^{2+}, Cs^+, Br
(c) Na^+, Ca^{2+}, Mg^{2+} (d) N^{3-}, F^-, Na^+

27. The pair of species having identical shapes for molecules of both species is:
(a) BF_3, PCl_3 (b) PF_5, IF_5
(c) CF_4, SF_4 (d) XeF_2, CO_2

28. Which of the following ion is not tetrahedral in shape?
(a) BF_4^- (b) NH_4^+
(c) SF_4 (d) CF_4

29. Which of the following are arranged in the decreasing order of dipole moment?
(a) CH_3Cl, CH_3Br, CH_3F (b) CH_3Cl, CH_3F, CH_3Br
(c) CH_3Br, CH_3Cl, CH_3F (d) CH_3Br, CH_3F, CH_3Cl

30. Paramagnetism of oxygen is explained on the basis of which of the following electronic configuration?
(a) $1s^22s^22p^6$ (b) $1s^22s^22p^4$
(c) $1s^22s^2$ (d) None of these

31. An example of a polar covalent compound is:
(a) KCl (b) NaCl
(c) CCl_4 (d) HCl

32. Among the following, the molecule with the highest dipole moment is:
(a) CH_3Cl (b) CH_2Cl_2
(c) $CHCl_3$ (d) CCl_4

33. Shape of O_2F_2 is similar to that of:
(a) C_2F_2 (b) H_2O_2
(c) H_2F_2 (d) C_2H_2

34. The states of hybridization of boron and oxygen atoms in boric acid (H_3BO_3), respectively, are:
(a) sp^2 and sp^2 (b) sp^2 and sp^3
(c) sp^3 and sp^2 (d) sp^3 and sp^3

35. Decreasing order of C—C length in I. C_2H_4, II. C_2H_2, III. C_6H_6, IV. C_2H_6 is:
(a) IV > III > I > II (b) I > II > IV > III
(c) II > I > IV > III (d) IV > I > III > II

36. Which carbon is more electronegative?
(a) sp^3-hybridized carbon
(b) sp-hybridized carbon
(c) sp^2-hybridized carbon
(d) Always same irrespective of its hybrid state

37. Which of the following is least volatile?
(a) HF (b) HCl
(c) HBr (d) HI

38. Which of the following is not electron deficient?
(a) NH_3 (b) BF_3
(c) $AlCl_3$ (d) BH_3

39. Lattice energy of ionic compounds depends upon:
(a) Packing of ions only
(b) Charge and size of ions
(c) Charge on ion only
(d) Size of ions only

40. Which of the following gives the correct arrangement of compounds based on their bond strength?
(a) HF > HCl > HBr > HI (b) HI > HBr > HCl > HF
(c) HF > HBr > HCl > HI (d) HCl > HF > HBr > HI

41. Ionic compounds are formed most easily with:
(a) Low E.A., high I.E. (b) High E.A., low I.E.
(c) Low E.A., low I.E. (d) High E.A., high I.E.

42. Which of the following gas is linear?
(a) CO_2 (b) SO_2
(c) NO_2 (d) SO_3

43. Correct order of boiling point is:
(a) HF > HI > HBr > HCl
(b) HF > HBr > HI > HCl
(c) HCl > HBr > HI > HF
(d) HCl > HI > HBr > HF

44. Correct order of bond length is:
(a) $CO_3^{2-} > CO_2 > CO$ (b) $CO_2 > CO > CO_3^{2-}$
(c) $CO > CO_2 > CO_3^{2-}$ (d) None of these

45. Which molecule is only electron donor?
(a) NH_3 (b) BF_3
(c) PF_5 (d) AsF_5

46. Which of the following is sp^3-hybridized?
(a) NH_3 (b) BeH_2
(c) PCl_5 (d) $AlCl_3$

47. Among the following bonds, which has the most polar character?
(a) C — O (b) C — Br
(c) C — F (d) C — S

48. Octet rule is not valid for which of the following molecule?
(a) CO_2 (b) H_2O
(c) O_2 (d) CO

49. Which of the following has a giant covalent structure?
(a) PbO_2 (b) SiO_2
(c) NaCl (d) $AlCl_3$

50. In which of the following is the angle between the two covalent bonds greatest?
(a) CO_2 (b) CH_4
(c) NH_3 (d) H_2O

51. The correct order regarding the electronegativity of hybrid orbitals of carbon is:
(a) $sp < sp^2 > sp^3$ (b) $sp < sp^2 < sp^3$
(c) $sp > sp^2 < sp^3$ (d) $sp > sp^2 > sp^3$

52. The lattice energy order for lithium halide is:
(a) LiF > LiCl > LiBr > LiI
(b) LiCl > LiF > LiBr > LiI
(c) LiBr > LiCl > LiF > LiI
(d) LiI > LiBr > LiCl > LiF

53. π-Bonding occurs in each of the following except:
(a) CO_2 (b) C_2H_4
(c) CN^- (d) CH_4

54. The structure of XeF_4 is:
(a) Planar (b) Tetrahedral
(c) Square planar (d) Pyramidal

55. Compound formed by sp^3d-hybridization will have which of the following structure?
(a) Trigonal bipyramidal (b) T-shaped
(c) Linear
(d) Either of these depending on the number of lone pair of electrons on central atom

56. Which bond is more polar?
(a) Cl — Cl (b) N — F
(c) C — F (d) O — F

57. Which of the following has the highest bond angle?
(a) H_2O (b) H_2S
(c) NH_3 (d) PH_3

58. Which of the following has the lowest bond angle?
(a) NH_3 (b) BeF_2
(c) H_3O^+ (d) CH_4

59. Coordiante compounds are formed by:
(a) Transfer of electrons (b) Sharing of electrons
(c) Donation of electron pair
(d) None of these

60. Compounds formed by sp^3d^2-hybridization will have which of the following geometry?
(a) Square planar (b) Octahedral
(c) Trigonal bipyramidal (d) Pentagonal bipyramidal

61. As compared to covalent compounds, electrovalent compounds generally have:
(a) High m.pt. and low b.pt.
(b) Low m.pt. and high b.pt.
(c) High m.pt. and high b.pt.
(d) Low m.pt. and low b.pt.

62. Which of the following statement is not correct?
(a) Pi-bond always exists with sigma-bond according to V.B.T.
(b) Pi-bond can exist independently according to V.B.T.
(c) Pi-bond is weaker than sigma-bond
(d) Sigma-bond is less reactive than pi-bond

63. Which hybridization results in nonplanar orbitals?
(a) sp (b) sp^2
(c) sp^3 (d) dsp^2

64. For which of the following hybridization is the bond angle maximum?
(a) sp^2 (b) sp
(c) sp^3 (d) dsp^2

65. Among liq HF, liq NH_3, CH_4, CH_3OH, and N_2O_4, intermolecular hydrogen bond is expected in:
(a) All (b) All leaving one
(c) Three (d) None of these

66. CO_2 is isostructural with:
(a) $SnCl_2$ (b) $HgCl_2$
(c) H_2O (d) SCl_2

67. Which of the following has the shortest carbon–carbon bond length?
(a) C_6H_6 (b) C_2H_6
(c) C_2H_4 (d) C_2H_2

68. Which group of atoms have nearly the same atomic radius?
(a) Na, K, Rb, Cs (b) Li, Be, B, C
(c) Fe, Co, Ni (d) F, Cl, Br, I

69. Which set have the strongest tendency to form anions?
(a) Ga, In, Te (b) Na, Mg, Al
(c) N, O, F (d) V, Cr, Mn

70. A molecule in which sp^2-hybrid orbitals are used by the central atom in forming covalent bond is:
(a) He_2 (b) SO_2
(c) PCl_5 (d) N_2

71. Which has a zero dipole moment?
(a) ClF (b) PCl_3
(c) SiF_4 (d) $CFCl_3$

72. The hybridization of carbon atoms in C—C single bond of $CH \equiv C - CH = CH_2$ is:
(a) sp^3–sp^3 (b) sp^2–sp^3
(c) sp–sp^2 (d) sp^3–sp

73. Which has the lowest anion to cation size ratio?
(a) LiF (b) NaF
(c) CsI (d) CsF

74. In allene structure, three carbon atoms are joined by:
(a) Three σ- and three π-bonds
(b) Two σ- and one π-bond
(c) Two σ- and two π-bonds
(d) Three π- bonds only

75. H-bonding is not present in:
(a) Glycerine (b) Water
(c) H_2S (d) HF

76. Which species has the maximum number of lone pair of electrons on the central atom?
(a) ClO_3^- (b) XeF_4
(c) SF_4 (d) I_3^-

77. Which of the following has a regular tetrahedral geometry?
(a) SF_4 (b) BF_4^-
(c) XeF_4 (d) ClF_3

78. Which of the following has the least bond energy?
(a) H_2 (b) Mg_2
(c) F_2 (d) O_2^{2-}

79. Which is the best description of a covalent bond?
(a) Electrons are simultaneously attracted by more than one nucleus
(b) Filled orbitals of two or more atoms overlap one another

(c) Unoccupied orbitals of two or more atoms overlap one another

(d) Oppositely charged ions attract one another

80. Deduce the geometry of each of the following molecules:

(i) NH_3 (ii) C_2H_4 (iii) ClO_3^-

(a) Pyramidal, pyramidal, tetrahedral

(b) Pyramidal, tetrahedral, pyramidal

(c) Pyramidal, planar, tetrahedral

(d) Pyramidal, planar, pyramidal

81. What are the hybridization states of each carbon atom-(s) in the following molecules?

(i) $CH_3\overset{*}{C}H_2CH_2CH_3$

(ii) $CH_2 = CH—CH = CH_2$

(iii) $CH_3\overset{*}{C}H = CH—CH_3$

(iv) $H—\overset{*}{C} \equiv C—H$

(a) sp^3, sp^2, sp, sp^3 (b) sp^3, sp^2, sp^2, sp

(c) sp^2, sp^3, sp, sp^2 (d) sp^3, sp, sp^2, sp^2

82. Determine the geometry of each of the following molecules and hybridization about the central atom:

(i) $BeF_2(g)$ (ii) AlH_3 (iii) $CH \equiv CH$

(a) sp linear, sp^2 trigonal planar, sp^2 planar, respectively

(b) sp^2 planar, sp linear, sp^2 planar, respectively

(c) sp trigonal planar, sp^2 linear, sp^2 planar, respectively

(d) sp linear, sp^2 trigonal planar, sp linear, respectively

83. What is the hybridization of CH_2^{2+} ion?

(a) sp^2 (b) sp^3

(c) sp (d) sp^3d

84. What is the hybridization and shape of XeO_3 and ClO_4^-, respectively?

(a) sp^3 tetrahedral, sp^3 tetrahedral

(b) sp^3 tetrahedral, sp^3 pyramidal

(c) sp^3 pyramidal, sp^3 tetrahedral

(d) None of these

85. Which of the following molecule has a see-saw geometry?

(a) I_3^- (b) ICl_2^-

(c) ClF_3^- (d) $IO_2F_2^-$

86. The dipole moment of HBr is 2.60×10^{-30} cm and the interatomic spacing is 1.41 Å. What is the per cent ionic character of HBr?

(a) 10.11% (b) 9.11%

(c) 11.5% (d) 15%

87. A diatomic molecule has a dipole moment of 1.2 D, if its bond distance is 1.0 Å. What fraction of an electronic charge *e* exists on each atom?

(a) 20% of *e* (b) 21% of *e*

(c) 19% of *e* (d) 25% of *e*

88. Which of the possible molecule/species is having maximum values for dipole moment (where "A" is the central atom)?

(a) AX_3 (having one lone pair on central atom)

(b) AX_4 (tetrahedral)

(c) AX_4Y (having no lone pair on central atom)

(d) Cannot be predicted

89. Which of the following is an incorrect match?

(a) SiF_4 : Can act as Lewis acid

(b) Benzyne : All C-atoms are sp^2-hybridized

(c) PBr_3 : Nonpolar

(d) $CHF = C = CHF$: Nodal planes of π-bonds are not lying in the same plane

90. Which of the following two species have the same shape?

(I) NI_3 (II) I_3^- (III) SO_3^{2-} (IV) NO_3^-

(a) I and II (b) II and III

(c) III and I (d) I and IV

91. SbF_5 reacts with XeF_4 and XeF_6 to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of XeF_3^+ ion and XeF_5^+ ion, respectively, is:

(a) Square pyramidal, T-shaped

(b) Bent T-shaped, square pyramidal

(c) See-saw, square pyramidal

(d) Square pyramidal, see-saw

92. Which of the following is a neutral oxide?

(a) NO (b) NO_2

(c) N_2O_3 (d) N_2O_5

93. Which of the following is isoelectronic and isostructural with CO_2?

(a) NO_2 (b) NO_3^-

(c) NO_2^- (d) N_2O

94. Which out of SO_4^{2-}, SF_4, and SF_2 does not undergo sp^3-hybridization?

(a) SO_4^{2-} (b) SF_2 and SO_4^{2-}

(c) SF_2 (d) SF_4

95. In a system, the formation of chemical bond always decreases its:

(a) Kinetic energy (b) Potential energy

(c) Repulsive forces (d) Coordinate bond

96. Which one of the following arrangements of molecules is correct on the basis of the dipole moment?

(a) $BF_3 > NF_3 > NH_3$ (b) $NF_3 > BF_3 > NH_3$

(c) $NH_3 > BF_3 > NF_3$ (d) $NH_3 > NF_3 > BF_3$

97. Fluorine molecule is formed by:

(a) The axial *p–p* orbital overlap

(b) The side ways *p–p* orbital overlap

(c) The *s–s* orbital overlap

(d) The *s–p* orbital overlap

98. Which of the following has sp^2-hybridization?

(a) SO_2 (b) H_2O

(c) NH_3 (d) SO_3^{2-}

99. Chemical bond implies:

(a) Repulsion

(b) Attraction

(c) Attraction and repulsion

(d) None of these

100. In OF_2, the number of bond pairs and lone pairs of electrons is, respectively:

(a) 2, 6 (b) 2, 8

(c) 2, 10 (d) 2, 9

101. Which of the following does not contain a coordinate bond?

(a) BH_4^- (b) NH_4^+

(c) CO_3^{2-} (d) H_3O^+

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which of the following are isoelectronic and isostructural: NO_3^-, CO_3^{2-}, ClO_3^-, SO_3?

(a) NO_3^- and CO_3^{2-} (b) SO_3 and NO_3^-

(c) ClO_3^- and CO_3^{2-} (d) CO_3^{2-} and SO_3

2. Which one of the following is a planar molecule?

(a) NH_3 (b) H_3O^+

(c) BCl_3 (d) PCl_3

3. If the molecule of HCl were totally polar, the expected value of dipole moment is 6.12 D but the experimental value is 1.03 D. Calculate the percentage ionic character:

(a) 17 (b) 83

(c) 50 (d) 0

4. Element *X* is strongly electropositive and element *Y* is strongly electronegative. Both are univalent. The compound formed would be:

(a) $X^+ Y^-$ (b) $X^- Y^+$

(c) $X^- Y$ (d) $X \rightarrow Y$

5. Two ice cubes are pressed over each other and united to form one cube. Which force is responsible for holding them together?

(a) van der Waals' forces (b) Covalent attraction

(c) Hydrogen bond formation

(d) Dipole–dipole attraction

6. Multiple covalent bonds exist in the molecule of:

(a) F_2 (b) H_2

(c) N_2 (d) C_2H_6

7. The type of bonds present in $CuSO_4 \cdot 5H_2O$ are .... only:

(a) Electrovalent and covalent

(b) Electrovalent and coordinate

(c) Electrovalent, covalent, coordinate, and H-bond

(d) Covalent and coordinate

8. Carbon atoms in $C_2(CN)_4$ are:

(a) *sp*-hybridized (b) sp^2-hybridized

(c) *sp*-and sp^2-hybridized

(d) *sp*, sp^2, and sp^3-hybridized

9. A triple bond is made of:

(a) One σ- and two π-bonds

(b) Two σ- and one π-bond

(c) Three σ- and three π-bonds

(d) One σ- and four π-bonds

10. The bonds present in N_2O_5 are:

(a) Ionic (b) Covalent and coordinate

(c) Covalent (d) Ionic and covalent

11. In which of the following molecules are all bonds not equal?

(a) AlF_3 (b) NF_3

(c) ClF_3 (d) BF_3

12. The hybridizations of atomic orbitals of nitrogen in NO_2^+, NO_3^- and, NH_4^+ are:

(a) *sp*, sp^3, and sp^2, respectively

(b) *sp*, sp^2, and sp^3, respectively

(c) sp^2, *sp*, and sp^3, respectively

(d) sp^2, sp^3, and *sp*, respectively

13. The shape of ClO_4^- ion is:

(a) Square planar (b) Square pyramidal

(c) Tetrahedral (d) Trigonal bipyramidal

14. Which of the following species has a linear shape?
(a) NO_2^+ (b) O_3
(c) NO_2^- (d) SO_2

15. Which of the following is not isostructural with $SiCl_4$?
(a) PO_4^{3-} (b) NH_4^+
(c) SCl_4 (d) SO_4^{2-}

16. Which of the following has sp^2-hybridization?
(a) CO_2 (b) SO_2
(c) N_2O (d) CO

17. Intramolecular hydrogen bonding is found in:
(a) Salicyldehyde (b) Water
(c) Acetaldehyde (d) Phenol

18. Which combination is best explained by the coordinate covalent bond?
(a) $H_2 + I_2$ (b) $Mg + \frac{1}{2}O_2$
(c) $Cl + Cl$ (d) $H^+ + H_2O$

19. Two elements X and Y have following electronic configurations:
$X = 1s^2, 2s^2\,2p^6, 3s^2\,3p^6, 4s^2$ and
$Y = 1s^2, 2s^2\,2p^6, 3s^2\,3p^5$
The compound formed by the combination of X and Y is:
(a) XY_2 (b) X_5Y_2
(c) X_2Y_5 (d) XY_5

20. The hybridization of carbon in diamond, graphite, and acetylene is:
(a) sp^3, sp^2, sp (b) sp^3, sp, sp^2
(c) sp^2, sp^3, sp (d) sp, sp^3, sp^2

21. The angle between two covalent bonds is maximum in:
(a) CH_4 (b) H_2O
(c) CO_2 (d) SO_3

22. CO_2 has the same geometry as:
(i) $HgCl_2$ (ii) NO_2 (iii) $SnCl_4$ (iv) C_2H_2
(a) (i) and (iii) (b) (ii) and (iv)
(c) (i) and (iv) (d) (iii) and (iv)

23. Which of the following is an electron-deficient compound?
(a) NH_3
(b) ICl
(c) BCl_3 (d) PCl_3

24. The bond between atoms of two elements of atomic number 37 and 53 is:
(a) Covalent (b) Ionic
(c) Coordinate (d) Metallic

25. The weakest among the following is:
(a) Ionic bond (b) Covalent bond
(c) Metallic bond (d) van der Waals' forces

26. An atom with atomic number 20 is most likely to combine chemically with the atom whose atomic number is:
(a) 11 (b) 16
(c) 18 (d) 10

27. Which of the following molecules will have a dipole moment?
(a) CO_2 (b) CCl_2
(c) XeF_2 (d) BeF_2

28. Which of the following molecules does not possess a permanent electric dipole moment?
(a) H_2S (b) SO_2
(c) SO_3 (d) CS_2

29. Among the following metals, interatomic forces are probably the weakest in:
(a) Cu (b) Ag
(c) Zn (d) Hg

30. The octet rule is not followed in:
(a) F_2 (b) NaF
(c) CaF_2 (d) BF_3

31. In which of the following is the bond angle maximum?
(a) NH_3 (b) NH_4^+
(c) PCl_3 (d) SCl_2

32. Which one of the following molecules will form a linear polymeric structure due to H-bonding:
(a) HCl (b) H_2O
(c) H_2S (d) NH_3

33. Which among the following has the largest dipole moment?
(a) NH_3 (b) H_2O
(c) HI (d) SO_3

34. In which of the following pairs is the bond angle 109° 28′?
(a) $[NH_4^+], [BF_4^-]$ (b) $[NH_4^+], [BF_3]$
(c) $NH_3, [BF_4^-]$ (d) $[NH_3], [BF_3]$

35. The pair of species having identical shape of both species is:
(a) BF_3, PCl_3 (b) PF_5, IF_5
(c) CF_4, SF_4 (d) XeF_2, CO_2

36. Which pair of molecules will have a permanent dipole moment for both members?

(a) NO_2 and O_3 (b) SiF_4 and CO_2
(c) SiF_4 and NO_2 (d) NO_2 and CO_2

37. The percentage *s*-character of the central atom in beryllium fluoride is:
(a) 25% (b) 33.3%
(c) 50% (d) 20%

38. In which of the following sets do we have sp^3d-hybridization?
(a) XeF_2, IBr_3, XeO_3 (b) IBr_3, SF_5^+, SF_5^-
(c) XeF_2, IBr_3, SF_5^+ (d) SF_5^+ and SF_5^-

39. Select the correct order for covalent radii:
(a) Octahedral radii > linear radii > tetrahedral radii
(b) Octahedral radii > tetrahedral radii > linear radii
(c) Linear radii > tetrahedral radii > octahedral radii
(d) Tetrahedral radii > octahedral radii > linear radii

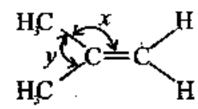
40. Which molecule among AX_3, AX_4, AX_5, and AX_6 is most likely to have a trigonal bipyramidal structure if A has no lone pair?
(a) AX_3 (b) AX_5
(c) Both (a) and (b) (d) AX_6

41. Which of the following structure is analogous of SO_3^{2-}?
(a) F_2SeO (b) F_2SeO_2
(c) SO_4^{2-} (d) SO_2

42. Select the correct statement:
(a) SF_4, CH_4, $SiCl_4$, and CCl_4 have tetrahedral structure
(b) BF_3, ClF_3, and ICl_3 have trigonal planar structure
(c) XeF_2, $BeCl_2$, and ICl_2^- have linear structure
(d) All are correct

43. Compare $F—\hat{I}—O$ and $F_{axial}—\hat{I}—F_{axial}$ bond angle in IOF_3 molecule:
(a) $F—\hat{I}—O > F_{axial}—\hat{I}—F_{axial}$
(b) $F_{axial}—\hat{I}—F_{axial} > F—\hat{I}—O$
(c) $F_{axial}—\hat{I}—F_{axial} = F—\hat{I}—O$
(d) None of these

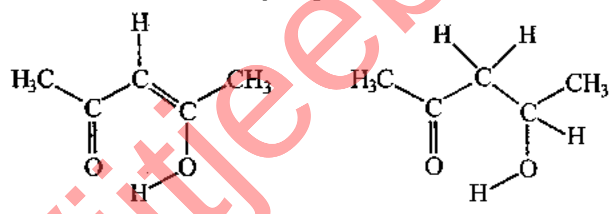
44. Compare bond angles x and y from the following molecule:



(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) $x = y = 120°$

45. The dipole moment of LiH is 1.964×10^{-29} cm and the interatomic distance between Li and H in this molecule is 1.596 Å. What is the per cent ionic character in LiH?
(a) 78.6% (b) 86.7%
(c) 8.67% (d) 76.8%

46. The two molecules indicated below are capable of intramolecular hydrogen bonding which is likely to form more stable hydrogen bonds.



(*A*) (*B*)

(a) *A* has higher H-bonding
(b) *B* has higher H-bonding
(c) Both *A* and *B* have equal H-bonding
(d) None of these

47. The HF_2^- ion exists in the solid state and also in liquid HF solution but not in dilute aqueous solution because:
(a) In aqueous solution, there is hydrogen bonding but each HF molecule hydrogen bond with the much more prevalent H_2O present instead of other HF molecules, and H_3O^+ and $F^\ominus$ are much more likely to be formed
(b) HF is weaker acid than H_2O
(c) HF has H-bonding
(d) None of these

48. SbF_5 reacts with XeF_4 and XeF_6 to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of XeF_3^+ ion and XeF_5^+ ion, respectively, is:
(a) Square pyramidal, T-shaped
(b) Bent T-shaped, square pyramidal
(c) See-saw, square pyramidal
(d) Square pyramidal, see-saw

49. Select the correct option for following statements:
(I) sp^3 hybrid orbitals are at 90° to one another
(II) sp^3d^2 adjacent hybrid orbitals are at 90° to one another
(III) sp^2 hybrid orbitals are at 120° to one another

(IV) Bond order of N—O bond in NO_3^- is $1\frac{1}{3}$

(a) T F T F (b) T T F F

(c) F T T T (d) F T F T

50. Which of the following is an example of a planar molecule having a net dipole moment?

(a) NF_3 (b) ClF_3

(c) XeO_3 (d) SO_3

51. Dipole moment is shown by:

(a) 1, 4-dichlorobenzene

(b) *cis*-1, 2-dichlorobutene

(c) *trans*-1, 2-dichlorobutene

(d) *trans*-2, 3-dichloro-2-butene

52. Which of the following has $p\pi$–$d\pi$ bonding?

(a) NO_3^- (b) SO_3^{2-}

(c) BO_3^{3-} (d) CO_3^{2-}

53. The electronegativities of F, Cl, Br, and I are 4.0, 3.0, 2.8, and 2.5, respectively. The hydrogen halide with a high percentage of ionic character is:

(a) HF (b) HCl

(c) HBr (d) HI

54. The nodal plane in the π-bond of ethene is located in:

(a) The molecular plane

(b) A plane parallel to the molecular plane

(c) A plane perpendicular to the molecular plane which bisects the carbon–carbon sigma bond at right angle

(d) A plane perpendicular to the molecular plane which contains the carbon–carbon σ-bond.

55. Which one of the following pairs of molecules will have a permanent dipole moments for both members?

(a) NO_2 and O_3 (b) SiF_4 and CO_2

(c) SiF_4 and NO_2 (d) NO_2 and CO_2

56. In the hypothetical molecule AX_2L_n (where A is central atom, X is surrounding atom, L is lone pair, n is the number of lone pair), for which possible value of "n" will the dipole moment of the molecule be minimum?

(a) Zero (b) 1

(c) 2 (d) 4

57. Which of the following is arranged in the increasing order of enthalpy of vaporization?

(a) NH_2, PH_3, AsH_3 (b) AsH_3, PH_3, NH_3

(c) NH_3, AsH_3, PH_3 (d) PH_3, AsH_3, NH_3

58. The number of π-bonds and σ-bonds in the Lewis structure of SO_3 is:

(a) 3 σ, 3 π (b) 3 σ, 2 π

(c) 3 σ, 1 π (d) None of these

59. In BrF_3 molecule, the lone pairs occupy equatorial position to minimize:

(a) Lone pair–bond pair repulsion only

(b) Bond pair–bond pair repulsion only

(c) Lone pair–lone pair repulsion and lone pair–bond pair repulsion

(d) Lone pair–lone pair repulsion only

60. The correct order of bond angles (smallest first) in H_2S, NH_3, BF_3, and SiH_4 is:

(a) $H_2S < SiH_4 < NH_3 < BF_3$

(b) $NH_3 < H_2S < SiH_4 < BF_3$

(c) $H_2S < NH_3 < SiH_4 < BF_3$

(d) $H_2S < NH_3 < BF_3 < SiH_4$

61. The molecular shapes of SF_4, CF_4, and XeF_4 are:

(a) Different with 0, 1, and 2 lone pairs of electrons on central atom, respectively

(b) Different with 1, 0, and 2 lone pairs of electrons on central atom

(c) Same with 2, 0, and 1 lone pairs

(d) Same with 1, 1 lone pair in each case

62. In silicon dioxide:

(a) One Si atom is bonded to two O atoms

(b) There are double bonds between Si and O atoms

(c) Each Si atom is surrounded by four O atoms and each oxygen atom is bonded to two Si atoms

(d) Each Si atom is surrounded by two O atoms and each O is bonded to two Si atoms

63. Which of the following statement is incorrect for the dipole moment measurement of the compound?

(a) It helps to predict the percentage ionic character in a bond

(b) It helps to predict the shape of the moelcule

(c) It helps to predict the particular *cis trans* isomers

(d) It helps to predict the bond energies of all bonds within the moelcule

64. Which of the following contains both polar and nonpolar covalent bonds?

(a) NH_4Cl (b) HCN

(c) H_2O_2 (d) CH_4

65. An sp^3 hybrid orbital contains:

(a) 1/4 *s*-character (b) 1/2 *s*-character

(c) 2/3 *s*-character (d) 3/4 *s*-character

66. Which contains a coordinate and a covalent bond?

(a) $BaCl_2$ (b) NH_4Cl

(c) HCl (d) H_2O

67. An atom of one element A has three electrons in its outermost shell, and that of B has six electrons in the outermost orbit. The formula of the compound formed by these two will be:

(a) A_3B_6 (b) A_2B
(c) A_2B_3 (d) A_3B_2

68. Dative bond is present in:

(a) SO_3 (b) NH_3
(c) $BaCl_2$ (d) N_2

69. Which of the following pair of species is not isostructural?

(a) KrF_2, ICl_2^- (b) SO_3, SO_3^{2-}
(c) CO_3^{2-}, BO_3^{3-} (d) SiO_4^{4-}, IO_4^-

70. If "n" number of H_3PO_4 molecules are polymerized to produce chain molecule and ring molecule separately, then the number of P–O–P linkages formed is, respectively:

(a) n and $(n-1)$ (b) $(n-1)$ and $(n-1)$
(c) $(n-1)$ and n (d) n and n

71. The molecule having zero dipole moment is:

(a) CH_3Cl (b) CH_2Cl_2
(c) $CHCl_3$ (d) CCl_4

72. The solubility of KCl is relatively more in (where D in dielectric constant):

(a) C_6H_6 (D = 0) (b) $(CH_3)_2CO$ (D = 2)
(c) CH_3OH (D = 32) (d) CCl_4 (D = 0)

73. If a molecule MX_3 has a zero dipole moment, the sigma bonding orbitals used by M (at. no. < 21) are:

(a) Pure p (b) sp-hybrid
(c) sp^2-hybrid (d) sp^3-hybrid

74. In which molecule are all atoms coplanar?

(a) CH_4 (b) BF_3
(c) PF_3 (d) NH_3

75. Two lone pairs of electrons and two bond pairs are present in:

(a) NH_3 (b) BF_3
(c) CO_3^{2-} (d) NH_2^-

76. When the hybridization state of carbon atom changes from sp^3 to sp^2 and finally to sp, the angle between the hybridized orbitals:

(a) Decreases gradually (b) Decreases considerably
(c) Is not affected (d) Increases progressively

77. Which of the following is expected to have a linear structure?

(a) SO_2 (b) CO_2
(c) CO_3^{2-} (d) SO_4^{2-}

78. Which of the following phenomenon will occur when two atoms of same spin will react?

(a) Bonding will not occur
(b) Orbital overlap will not occur
(c) Both (a) and (b)
(d) None of these

79. Which is not linear?

(a) CO_2 (b) HCN
(c) C_2H_2 (d) H_2O

80. Among NH_3, $BeCl_2$, CO_2, and H_2O, the nonlinear molecules are:

(a) $BeCl_2$ and H_2O (b) $BeCl_2$ and CO_2
(c) NH_3 and H_2O (d) NH_3 and CO_2

81. Dipole moment is highest for:

(a) $CHCl_3$ (b) CH_4
(c) CHF_3 (d) CCl_4

82. Consider the following iodides:

PI_3	AsI_3	SbI_3
102°	100.2°	99°

The bond angle is maximum in PI_3 which is:

(a) Due to small size of phosphorus
(b) Due to more bond pair–bond pair repulsion in PI_3
(c) Due to less electronegativity of P
(d) None of these

83. Which of the following is the largest ion?

(a) Na^+ (b) Mg^{2+}
(c) O^{2-} (d) F^-

84. The ionization potential order for which set is correct:

(a) Li > K < Cs (b) B > Li > K
(c) Cs > Li > B (d) Cs > Li < K

85. For the type of interactions: (I) covalent bond, (II) van der Waals' forces, and (III) hydrogen bonding, which represents the correct order of increasing stability?

(a) (I) < (III) < (II) (b) (II) < (III) < (I)
(c) (II) > (III) > (I) (d) (II) = (III) = (I)

86. Which of the moelcule/species has d^3s-hybridization?

(a) CrO_2Cl_2 (b) PCl_4^+
(c) NH_4^+ (d) ClO_3^-

87. Identify the least stable ion amongst the following:

(a) Li^- (b) Be^-
(c) B^- (d) C^-

88. Identity the pair in which the two species are isostructural:

(a) SiF_4 and SF_4 (b) IO_3^+ and XeO_3
(c) BH_4^- and NH_4^+ (d) PF_6^- and SF_6

89. The total right-angles $\angle ClPCl$ present in PCl_5, PCl_4^+, PCl_6^- are _ , _ , _, respectively.
(a) 0, 1, 4 (b) 6, 0, 4
(c) 2, 4, 0 (d) 6, 0, 12

90. Which molecule has a trigonal planar geometry?
(a) IF_3 (b) PCl_3
(c) NH_3 (d) BF_3

91. The molecule having permanent dipole moment is:
(a) SF_4 (b) XeF_4
(c) SiF_4 (d) BF_3

92. What is the formal charge on the chlorine atom in the oxyacid $HOClO_2$ if it contains single bonds?
(a) 2– (b) 1–
(c) 1+ (d) 2+

93. The hybridization of P in phosphate ion (PO_4^{3-}) is the same as in:
(a) I in ICl_4^- (b) S in SO_3
(c) N in NO_3^- (d) S in SO_3^{2-}

94. The electronegativity difference between N and F is greater than N and H, yet the dipole moment of NH_3 (1.5 D) is greater than that of NF_3 (0.2 D). This is because:
(a) In NH_3 as well as NF_3, the atomic dipole and bond dipole are in the opposite direction
(b) In NH_3, the atomic dipole and bond dipole are in the opposite direction, whereas in NF_3 these are in the same direction
(c) In NH_3 as well as in NF_3 the atomic dipole and bond dipole are in the same direction
(d) In NH_3, the atomic dipole and bond dipole are in the same direction, whereas in NF_3 these are in the opposite direction

95. Which of the following species have undistorted octahedral structures?
1. SF_6 2. PF_6^-
3. SiF_6^{2-} 4. XeF_6
Select the correct answer using the codes given below:
(a) 2, 3, and 4 (b) 1, 3, and 4
(c) 2 and 3 (d) 1, 2, and 3

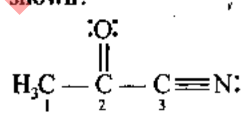
96. In the anion $HCOO^-$, the carbon–oxygen bonds are found to be of equal length. This is because:
(a) The anion $HCOO^-$ has two resonating structures
(b) The anion is obtained by the removal of a proton from the acid molecule
(c) Electronic orbitals of carbon are hybridized
(d) The C = O bond is weaker than the C — O bond

97. On analysis, a certain compound was found to contain 254 g of *X* and 80 g of *Y*. If the atomic weight of *X* is 127 and that of *Y* is 16, then the formula of the compound containing *X* and *Y* is:
(a) XY (b) X_2Y
(c) X_5Y_2 (d) X_2Y_5

98. How many bonding pairs and lone pairs surround the central atom in the I_3^- ion?

	Bonding pairs	Lone pairs
(a)	2	2
(b)	2	3
(c)	3	2
(d)	4	3

99. What hybrid orbitals are employed by carbon atoms 1, 2, and 3, respectively, as labeled in the compound shown?



(a) sp^3, sp, sp (b) sp^2, sp^2, sp
(c) sp^3, sp^2, sp (d) sp^3, sp^2, sp^2

100. Which reaction involves a change in the electron pair geometry for the underlined atom?
(a) $\underline{B}F_3 + F^- \rightarrow \underline{B}F_4^-$ (b) $\underline{N}H_3 + H^+ \rightarrow \underline{N}H_4^+$
(c) $2\underline{S}O_2 + O_2 \rightarrow 2\underline{S}O_3$ (d) $H_2\underline{O} + H^+ \rightarrow H_3\underline{O}^+$

Multiple Correct Answers Type

1. In V.B.T., the idea of hybridization was required to explain which of the following facts:
(a) The equivalence of the bonds in most of the compounds
(b) The stereochemistry of the molecules
(c) The better overlapping of the orbitals
(d) None of these

2. Which of the following molecule has/have structure similar to NH_3?
(a) PH_3 (b) H_3O^+
(c) SeF_3^+ (d) $\bar{C}H_3$

3. Which of the following properties of water is related to the hydrogen bonding?

(a) High boiling point (b) High heat of vaporization
(c) Low density of ice compared to water
(d) None of these

4. NH_3 is isoelectronic with:
(a) H_2O (b) CH_4
(c) HF (d) None of these

5. Which of the following molecule(s) is/are planar?
(a) ICl_2^- (b) IF_2^+
(c) SnI_2 (d) $CdBr_2$

6. Which of the following molecules are nonplanar and have a dipole moment?
(a) CH_2Cl_2 (b) $C_2H_2Cl_2$ (*cis*)
(c) ICl_2^- (d) NH_3

7. Which of the following molecules are planar and have an angular geometry?
(a) ClO_3^+ (b) Cl_2O^+
(c) H_3O^+ (d) BF_2^-

8. Which of the following molecule(s) have a bent shape?
(a) ClF_2^+ (b) ClF_2^-
(c) BF_2^- (d) None of these

9. Which of the following molecule(s) is/are having a square planar geometry?
(a) ICl_4^- (b) BrF_4^-
(c) XeF_4 (d) SF_4

10. Which of the following molecule(s) is/are having a linear geometry?
(a) XeF_2 (b) ICl_2^-
(c) I_3^- (d) CO_2

11. Which of the following molecule(s) is/are having a see-saw geometry?
(a) $TeBr_4$ (b) $TeCl_4$
(c) XeO_2F_2 (d) SF_4

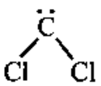
12. Which of the following sets of molecule(s) is/are having a V-shape but different hybridization?
(a) $SnCl_2$ and H_2O (b) SO_2 and NO_2^+
(c) BF_2^- and SCl_2 (d) OF_2 and SCl_2

13. sp^2-Hybridization is not shown by:
(a) $BeCl_2$ (b) BF_3
(c) NH_3 (d) XeF_2

14. Which statement(s) is/are correct?
(a) A double bond is shorter than a single bond
(b) A sigma bond is weaker than a π-bond
(c) A double bond is stronger than a sigma bond
(d) A covalent bond is stronger than a hydrogen bond

15. Which of the following molecule(s) is/are triangular pyramidal in shape?
(a) NH_3 (b) NCl_3
(c) PF_3 (d) BCl_3

16. Which oxide(s) of nitrogen is/are not isoelectronic with CO_2?
(a) NO_2 (b) N_2O
(c) NO (d) N_2O_2

17. Which of the following species are deficient?
(a) 

(b) Br^-
(c) BF_3 (d) NH_4^+

18. Which compound contains double bond or triple bond?
(a) C_2H_4 (b) H_2O
(c) N_2 (d) HCN

19. Which of the following molecule has/have structure similar to IF_5?
(a) PCl_5 (b) BrF_5
(c) SF_5^- (d) PF_5

20. Which of the following oxide(s) is/are amphoteric?
(a) CO_2 (b) SO_2
(c) SnO_2 (d) PbO_2

21. Which of the following acid(s) is/are monobasic?
(a) HPO_3 (b) H_3PO_3
(c) $H_4P_2O_7$ (d) H_3PO_2

22. Select the reaction in which coordinate bond is formed in product side:
(a) $BF_3 + F^- \longrightarrow BF_4^-$
(b) $CO + BF_3 \longrightarrow OCBF_3$
(c) $H_2O + H^+ \longrightarrow H_3O^+$
(d) $AlCl_3 + Cl^- \longrightarrow AlCl_4^-$

23. Which of the following molecules are planar and have a dipole moment?
(a) H_2S (b) I_3^-
(c) ClF_3 (d) H_2O

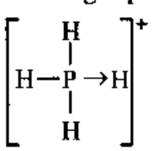
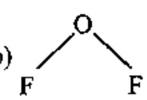
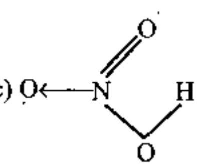
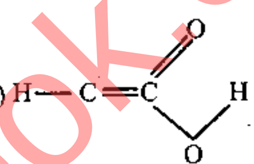
24. Which of the following molecule(s) is/are having two different types of bond lengths?
(a) PF_5 (b) PCl_5
(c) IF_7 (d) SF_6

25. Select the correct order of bond angle:
(a) $H_2O > H_2S$ (b) $NH_3 > PH_3$
(c) $OCl_2 > SCl_2$ (d) None of these

26. Which of the following molecule(s) is/are having a square pyramidal geometry?
(a) TeF_5^- (b) $XeOF_4$
(c) IF_5 (d) XeF_5^+

27. Which of the following moelcule(s) is/are having a V-shape?
(a) $SnCl_2$ (b) H_2O
(c) SO_2 (d) GeF_2

28. Which of the following statement(s) is/are correct?
(a) Every AB_5 molecule does in fact have a square pyramid structure
(b) Multiple bonds are always shorter than corresponding single bonds
(c) The electron-deficient molecules can act as Lewis acids

29. Which of the following formula correctly represent the bonding capacity of the atom involved?
(a) 
(b) 
(c) 
(d) 

30. The bond strength increases:
(a) With increasing bond order
(b) With increasing extent of overlapping of orbitals
(c) With decreasing difference between energies of overlapping orbitals
(d) With decreasing bond order

31. Which of the following order(s) is/are correct in accordance with the property stated against it?
(a) Electronegativity: $F_2 > Cl_2 > Br_2 > I_2$
(b) Bond dissociation energy: $F_2 > Cl_2 > Br_2 > I_2$
(c) Oxidizing power: $F_2 > Cl_2 > Br_2 > I_2$
(d) Acidic nature in water: $HI > HBr > HCl > HF$

32. Which of the following molecule(s) is/are nonplanar as well as nonpolar?
(a) SF_4 (b) XeF_4
(c) CCl_4 (d) NF_4^+

33. The dipole moments of AX_3, YX_3, and ZW_3 are 4.97×10^{-30}, 0.60×10^{-30}, and zero cm respectively. Select the correct statement(s) for AX_3, YX_3, and ZW_3:
(a) Both AX_3 and YX_3 are planar
(b) Both AX_3 and YX_3 are pyramidal
(c) ZW_3 is pyramidal
(d) ZW_3 is planar

34. Which of the following molecule(s) is/are having a square pyramidal shape?
(a) PCl_5 (b) BrF_5
(c) IF_5 (d) None of these

35. Which of the following molecule(s) is/are having a tetrahedral structure?
(a) O_2SF_2 (b) OSF_2
(c) ClO_4^- (d) I_3^-

36. Which of the following molecule(s) is/are having a see-saw geometry?
(a) SF_4 (b) ClF_3
(c) BrF_5 (d) $TeCl_4$

37. Select the correct order of bond angle:
(a) $PI_3 > PBr_3 > PCl_3 > PF_3$
(b) $H_2O > OF_2$
(c) $NH_3 > NF_3$
(d) $OCl_2 > OF_2$

38. Select the correct order of bond angle:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$
(b) $H_2O > H_2S > H_2Se > H_2Te$
(c) $BF_3 = BCl_3 = BBr_3 = BI_3$
(d) $BF_3 < BCl_3 < BBr_3 < BI_3$

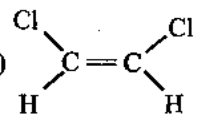
39. Which of the following molecule(s) is/are having a trigonal pyramidal geometry?
(a) ClO_3^- (b) $\overset{-}{C}H_3$
(c) SO_3^{2-} (d) XeO_3

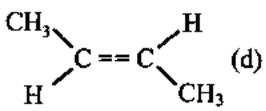
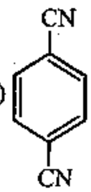
40. Which of the following sets of molecule(s) is/are having a linear shape but different hybridization?
(a) I_3^- and CO_2 (b) $HgCl_2$ and ICl_2^-
(c) XeF_2 and C_2H_2 (d) XeF_2 and $O\overset{-}{C}l$

41. Identify the correct statements:
(a) N_3^- is linear
(b) ClF_3 has a dipole moment
(c) SF_4 has see-saw shape
(d) XeF_4 is tetrahedral in shape

42. Which of the following has/have a least dipole

moment?

(a)  (b) $CH_3—C≡C—CH_3$

(c)  (d) 

43. Which pairs of atoms or ions will not have the same configuration?
(a) Li^+ and He^- (b) Cl^- and Ar
(c) Na and K (d) F^+ and Ne

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

NH_3 has one lone pair and three bond pairs and undergoes self-ionization

$$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$

1. The hybridization and shape of NH_2^- ion are:
(a) sp^2 and angular (b) sp^3 and angular
(c) sp^3 and linear (d) sp and linear
2. NH_2^- is isoelectronic and isostructural with:
(a) BH_3 (b) CH_4
(c) H_2O (d) H_3O^+
3. NH_4^+ ion is isoelectronic and isostructural with:
(a) H_3O^+ (b) CH_3^-
(c) CH_4 (d) CH_3^+

Comprehension-2: (Q. 4 to Q. 6)

When the central atom bears both the bond pair (b.p.) and the lone pair (l.p.), the structures are denoted by regular geometry.

4. Bond angles in NH_3 and H_2O are:
(a) 109° and 103° (b) 107 and 104.5°
(c) 102° and 104° (d) 109° and 90°
5. The shape of sp^3d^2-hybridized moelcule with 2 lone pairs will be:
(a) Octahedral (b) Square pyramidal
(c) Square planar (d) Tetrahedral
6. Which of the following pairs show maximum repulsion?
(a) Lone pair–lone pair (b) Lone pair–bond pair
(c) Bond pair–bond pair
(d) Bond pair–free radical pair

Comprehension-3: (Q. 7 to Q. 9)

Carbon exists in large number of oxidation of allotropic form. Covalency of carbon is four.

7. The nature of CO is:
(a) Acidic (b) Basic
(c) Amphoteric (d) Neutral
8. Hybridization of carbon in graphite is:
(a) sp (b) sp^2
(c) sp^3 (d) None of these
9. Oxidation state of carbon in $CHCl_3$ is:
(a) +1 (b) +2
(c) +4 (d) –2

Comprehension-4: (Q. 10 to Q. 13)

Different types of bonds are formed in the chemical compounds. These bonds have different strengths and bond energies associated with them. These bonds are formed in different environments associated with atoms and the compounds in which they are present.

10. Which of the following will form only σ-bond (generally)?
(a) s–s overlapping
(b) Hybrid orbital overlapping
(c) s–p overlapping
(d) All of these
11. Which of the following bonds has the highest bond energy?
(a) σ-bond (b) π-bond
(c) Hydrogen bond (d) Metallic bond
12. In C_3^{4-}, the number of σ-and π-bonds present between carbon atoms are:
(a) 1 σ and 1 π (b) 2 σ and 2 π
(c) 2 σ and 1 π (d) 2 σ bond only
13. Shape of the molecules is decided by:
(a) σ-bond (b) π-bond
(c) Both σ-and π-bonds (d) Neither σ- nor π-bond

Comprehension–5: (Q. 14 to Q. 16)

A polar bond is formed between two atoms of different electronegativity. A polar molecule results when there is only one polar bond, or more than one polar bond within it is not sufficiently symmetrically oriented to cancel the effects of the others.

14. Select the correct order of boiling point:
(a) $H_2O < HF$ (b) $H_2O > HF$
(c) $HF = H_2O$ (d) None of these

15. Select the correct order of dipole moment:
(a) $BF_3 < H_2O < H_2S$ (b) $H_2O > BF_3 > H_2S$
(c) $H_2S < H_2O < BF_3$ (d) $BF_3 < H_2S < H_2O$

16. Select the correct order of polarity of the bond in following molecule:
(a) $NH_3 < SbH_3 < AsH_3 < PH_3$
(b) $NH_3 > PH_3 > AsH_3 > SbH_3$
(c) $NH_3 < PH_3 < AsH_3 < SbH_3$
(d) $NH_3 > SbH_3 > AsH_3 > PH_3$

Comprehension-6: (Q. 17 to Q. 19)

Carbon exists in various allotropic forms of which diamond and graphite are crystalline and others are amorphous.

17. Which of the following is a good conductor of electricity?
(a) Diamond (b) Graphite
(c) Lamp black (d) Charcoal

18. Which of the following is used as lubricant?
(a) Graphite (b) Charcoal
(c) Diamond (d) Coke

19. Two layers of graphite are linked together with:
(a) Covalent bond
(b) van der Waals' forces
(c) Induced dipole interaction
(d) None of these

Comprehension-7: (Q. 20 to Q. 23)

The first ionization energy of Na, NO, Xe, and O_2 follows the order $Na < NO < Xe = O_2$. O_2 reacts with the powerful oxidizing agent PtF_6 to yield a compound $O_2[PtF_6]$.

20. When PtF_6 is allowed to react with other mentioned species, then the product(s) is/are:
(a) $Na[PtF_6]$
(b) $NO[PtF_6]$
(c) $Xe[PtF_6]$
(d) $Na[PtF_6]$, $NO[PtF_6]$, $Xe[PtF_6]$

21. Which of the following is first formed inert gas compound?
(a) $Xe[PtF_6]$ (b) $Kr[PtF_6]$
(c) XeF_2 (d) XeO_3

22. The oxidation state of Xe in $Xe[PtF_6]$ is:
(a) +1 (b) +2
(c) +4 (d) +6

23. Which of the following inert gas has the smallest ionization energy?
(a) He (b) Ne
(c) Ar (d) Xe

Comprehension-8: (Q. 24 to Q. 26)

Polarity of a bond depends on the difference in the electronegativity of the bonded atoms. The higher the difference in the electronegativity, the higher will be the polarity of bond.

24. The type of bond present in hydrogen chloride is:
(a) Ionic (b) Nonpolar covalent
(c) Coordinate covalent (d) Polar covalent

25. The boiling point of ICl is about 40°C higher than Br_2. This might be because:
(a) I — Cl bond is stronger than Br — Br bond
(b) I.E. of I < I.E. of Br
(c) I — Cl is polar, whereas Br_2 is nonpolar
(d) The size of I > the size of Br

26. Which of the following bond is nonpolar?
(a) N—H (b) H—F
(c) F—F (d) O—H

Comprehension-9: (Q. 27 to Q. 29)

Hydrogen bond is an important aspect of chemical bonding. It is formed in the molecules where hydrogen is attached with highly electronegative atom. There are a number of consequences of hydrogen bonding.

27. H_2O is liquid but H_2S is gas; this is because of:
(a) Larger size of S (b) Acidic nature of H_2S
(c) Hydrogen bonding (d) Small size of O

28. Intramolecular hydrogen bonding is found in:
(a) Salicylaldehyde (b) Water
(c) Acetaldehyde (d) Phenol

29. The stickiness of honey which mainly consists of water and sugar is due to:
(a) Presence of sugar
(b) Strong bonding in sugar
(c) Hydrogen bonding
(d) Presence of some organic compound

Comprehension-10: (Q. 30 to Q. 32)

One hydrogen bonding represented as X— H ..... D denotes the interaction between the donor species D and the acceptor species X — H through the hydrogen end. H atom should remain between the atoms (i.e., X and D) of more electronegative nonmetallic elements.

30. B—H—B bridges (in boro hydrides) and W — H — W links in $(OC)_6$ W H W $(CO)_6$ will be considered as:

(a) van der Waals' force (b) Hydrogen bond

(c) Ionic bond (d) None of these

(W—H—B covalent bridge bond not H—bond)

31. Which of the following compound does not have hydrogen bonding?

(a) K_2HPO_4 (b) K_2HPO_3

(c) Chloralhydrate (d) H_2O

32. The strength of H-bonding order is:

(a) $H_2O > H_2O_2 > H–F$ (b) $H_2O_2 > H_2O > HF$

(c) $HF > H_2O > H_2O_2$ (d) $HF = H_2O = H_2O_2$

Comprehension-11: (Q. 33 to Q. 35)

The elements (VI A group) all form covalent hydrides. These are water, hydrogen sulphide, hydrogen selenide, hydrogen telluride, etc.

33. Which of the following hydrides has the smallest H—X—H bond angle?

(a) H_2O (b) H_2S

(c) H_2Se (d) H_2Te

34. Which of the following hydrides is thermally most stable?

(a) H_2O (b) H_2S

(c) H_2Se (d) H_2Te

35. Maximum number of hydrogen bonds formed by a water molecule are:

(a) 1 (b) 2

(c) 3 (d) 4

Comprehension-12: (Q. 36 and Q. 37)

Dipole moment is a vector quantity, i.e., it has both magnitude as well as direction. The overall value of the dipole moment of a polar molecule depends on its geometry and shape, i.e., vectorial addition of dipole moment of the constituent bonds.

36. Dipole moments: HCl (1.03 D) and HI (0.38 D) compare the magnitude of the partial charge on hydrogen atom in HCl with that on the hydrogen atom of HI. If it is assumed that the partial positive and negative charges are central on the hydrogen and halogen atoms, respectively, the distance between charge centers are calculated to be 1.27 and 1.61 Å for HCl and HI, respectively:

(a) The charge on the hydrogen atom of HCl is over 3 times that on the hydrogen atom of HI

(b) The charge on the hydrogen atom of HCl is over 2 times that on the hydrogen atom of HI

(c) The charge on the hydrogen atom of HCl is over 4 times that on the hydrogen atom of HI

(d) The charge on the hydrogen atom of HCl is over 5 times that on the hydrogen atom of HI

37. In above question, compare the magnitude of the partial charge on the hydrogen atom in HCl with that of a single charge positive ion which is 4.80×10^{-10} esu:

(a) The charge on the hydrogen atom of HCl is about one third the charge on a monopositive ion

(b) The charge on the hydrogen atom of HCl is about one-fourth the charge on a monopositive ion

(c) The charge on the hydrogen atom of HCl is about one-sixth the charge on a monopositive ion

(d) The charge on the hydrogen atom of HCl is about one-fifth the charge on a monopositive ion

Comprehension-13: (Q. 38 and Q. 39)

The percentage ionic character of a single bond may be estimated from the ratio of the observed dipole moment to the calculated moments, assuming oppositely charged ions located at distance equal to the bond length.

38. The observed dipole moment of HBr is 0.79 D. Calculate the percentage ionic character of the bond in HBr if bond distance is 1.42 Å:

(a) 16.9% (b) 12.0%

(c) 5.0% (d) 20%

39. The observed dipole moment of HI is 0.38 D. Calculate the percentage ionic character of the bonding HI if bond distance is 1.61 Å:

(a) 16.4% (b) 12%

(c) 5.0% (d) 20%

Comprehension-14: (Q. 40 to Q. 42)

Covalent bond length gives the inter-nuclear distance between the atoms covalently bonded. These can be measured from the X-ray studies of the crystals, and for gases, these are done by diffraction and spectroscopic method.

40. Arrange C—C, C = C, and C ≡ C in order of decreasing bond energy:

(a) C — C > C=C > C≡C

(b) C≡C > C—C > C=C

(c) C≡C > C=C > C—C

(d) None of these

41. Arrange C—C, C=C, and C ≡ C in order of decreasing bond length:

(a) C—C > C=C > C≡C

(b) C≡C > C═C > C—C

(c) C—C > C≡C > C═C

(d) C═C > C—C > C≡C

42. The As—Cl bond distance in $AsCl_3$ is 2.20 Å. Estimate the single-bonded covalent radius of As, if radius of chlorine atom is 0.99 Å:

(a) 1.21 Å (b) 12.1 Å

(c) 1.12 Å (d) 11.2 Å

Assertion-Reasoning Type

1. **Statement-1:** The covalent radii reported for F, O, and N are remarkably different from the values obtained from F — F (= 144 Pm), HO — OH (= 148 Pm), and H_2N — NH_2 (= 147 Pm), respectively.

Statement-2: The elongated bond lengths in F — F, O — O, and N — N bonds arise probably due to the repulsion among the nonbonding electrons housed on adjacent atoms.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.

(b) Statement-1 is true; Statement-2 is true; Statement-2 is NOT the correct explanation for Statement-1

(c) Statement-1 is true; Statement-2 is false.

(d) Statement-1 is false; Statement-2 is true.

2. **Statement-1:** The unshared pairs residing in pure σ-or π-orbital do not contribute in dipole moment.

Statement-2: The σ-orbital is spherically symmetrical, hence it contributes nothing. Similarly, the two lobes of a pure π-orbital are projected in opposite directions to cause no effect.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.

(b) Statement-1 is true; Statement-2 is true; Statement-2 is NOT the correct explanation for Statement-1

(c) Statement-1 is true; Statement-2 is false.

(d) Statement-1 is false; Statement-2 is true.

3. **Statement-1:** The carbon–carbon double bond energy in C_2H_4 is more than the carbon–carbon single bond energy in C_2H_6.

Statement-2: A σ-orbital has greater electron overlap between the atoms because its component σ-orbitals are directed toward each other, whereas the component π-orbitals making-up the π-orbital are directed perpendicular to the inter-nuclear axis.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.

(b) Statement-1 is true; Statement-2 is true; Statement-2 is NOT the correct explanation for Statement-1

(c) Statement-1 is true; Statement-2 is false.

(d) Statement-1 is false; Statement-2 is true.

4. **Statement-1:** Both PCl_5 and BrF_5 have identical shapes.

Statement-2: PCl_5 has trigonal bipyramidal shape, whereas BrF_5 has square pyramidal.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.

(b) Statement-1 is true; Statement-2 is true; Statement-2 is NOT the correct explanation for Statement-1.

(c) Statement-1 is true; Statement-2 is false.

(d) Statement-1 is false,; Statement-2 is true.

Matching Column Type

1. Match the column:

Column-I		Column-II
(a) Tetrahedral	(p)	OSF_4
(b) Trigonal bipyramidal	(q)	CrO_2Cl_2
(c) Square pyramidal	(r)	SO_2Cl_2
(d) See-saw	(s)	$XeOF_4$
	(t)	$TeCl_4$

2. Match the column:

Column-I		Column-II
(a) H_3O^+	(p)	Pyramidal
(b) $\bar{C}H_3$	(q)	Planar
(c) XeF_5^-	(r)	Nonplanar
(d) $SnCl_2$	(s)	$\mu = 0$

3. Match the column:

Column-I		Column-II
(a) *sp*-hybridization	(p)	CO_2
(b) sp^2-hybridization	(q)	CS_2
(c) sp^3-hybridization	(r)	$SnCl_4$
(d) sp^3d-hybridization	(s)	NO_3^-
	(t)	AsF_5

4. Match the column:

Column-I		Column-II
(a) HCP molecule	(p)	Two σ-and 2π-bonds
(b) HCN molecule	(q)	*sp*-hybridization
(c) $S_2O_3^{2-}$ ion	(r)	Linear geometry
	(s)	$3p_\pi$ – $3d_\pi$ pi-bonding

5. Match the column:

Column-I	Column-II
(a) NH_2^-	(p) $\mu = 0$
(b) NH_4^+	(q) Planar
(c) I_3^-	(r) $d_{x^2-y^2}$ is involved in hybridization
(d) PCl_6^-	(s) d_{z^2} is involved in hybridization
(e) PCl_2^+	(t) Bent structure

6. Match the column:

Column-I	Column-II
(a) ClF_3	(p) Planar molecule
(b) XeO_2F_2	(q) Nonpolar molecule
(c) ClF_6^+	(r) dz^2 orbital is involved in bonding
(d) NF_4^+	(s) Equatorial bonds are stronger than axial bonds
	(t) nonplanar molecule

7. Match Column-I (molecule) with Column-II (shape):

Column-I	Column-II
(a) P_4	(p) Crown
(b) S_8	(q) Polymeric (dimeric)
(c) $AlCl_3$	(r) Tetrahedral
(d) PCl_5	(s) Trigonal bipyramidal

Integer Answer Type

1. How many molecules are planar from the following molecules?

   I_3^-, H_2O, ICl_2^-, C_2H_4, C_2H_2, H_3O^+

2. How many molecules have the same type of shape from the following molecules?

   H_3O^+, NH_3, ClO_3^-, PH_3, H_2O, $\bar{C}H_3$

3. The number of sigma bonds in P_4O_{10} is ________.

4. The total number of electrons that take part in forming bonds in N_2 is ________.

5. The number of σ-bonds and π-bonds in benzene are ________.

6. The number of unpaired electrons in a paramagnetic atom of an element with atomic number 16 is ________.

7. Find the number of proton donor acid(s) from the following:

   $B(OH)_3$, $Mg(OH)_2$, $Si(OH)_4$, $SO_2(OH)_2$, $Ba(OH)_2$

8. Find the number of acid(s) which are having hypo prefix in their name from the following:

   H_3PO_4, H_3PO_3, H_3PO_2, $HClO$, $H_4P_2O_6$, $H_2S_2O_6$

9. How many Cl — Cl bond(s) is/are present in Cl_2O_7?

10. How many S—O—S linkage(s) is/are present in $H_2S_3O_6$?

11. How many 3 member ring(s) is/are formed in CrO_5?

12. Find the sum of $P—\hat{P}—P$ angle and P — P side in P_4 molecule.

13. How many S — O — S linkages are there in dithionous acid?

14. Find the number of molecule(s) which is/are planar and having dipole moment:

    SF_4, PCl_3F_2, PCl_2F_3, I_3^-, BrF_3, ICl_2^-, XeF_4

15. Find the number of molecule(s) which is/are bent in shape but have different hybridization:

    XeF_2, BF_2^-, SF_2, H_2O, $SnCl_2$, I_3^+, I_3^-

16. Find the sum of atomicity of nitrogen and phosphorous.

17. In SF_6 molecule, find the maximum number of atoms that can lie on a single plane.

18. How many minimum atoms lie in same plane in $F_2C = C = CF_2$ molecule?

19. Find the number of molecule(s)/ion having Lewis acidic property from the following:

    H_2O, NH_3, H^+, BF_3, AlH_3, Cu^{+2}, $\bar{C}H_3$

20. Find the number of molecule(s)/ion having Lewis basic property from the following:

    H_2O, NH_3, CH_3NH_2, ROH, $FeCl_3$, SO_3

21. The nucleus of an element contains nine protons. Calculate its valency.

22. Find the maximum possible number of hydrogen bonds in which H_2O_2 molecule can participate.

23. Find the number of acid(s) which can form its meta derivative from the following:

    H_3BO_3, H_3PO_4, H_3PO_3, H_2SO_4, H_2SO_3

24. Find the number of acid(s) which are having pyro prefix in its name from the following:

    $H_4P_2O_7$, $H_4P_2O_5$, $H_2S_2O_7$, H_2SO_5

25. Find the number of acid(s) which are having per as well as peroxy prefix in its name from the following:

    C_6H_5COOOH, $HClO_4$, $H_2S_2O_8$, $H_4P_2O_8$, H_2SO_5, HNO_4

26. How many P—O—P linkage(s) is/are present in tetrapolyphosphoric acid?

27. How many S—S linkage(s) is/are present in $H_2S_4O_6$?

28. Find the number of sesquioxide(s) from the following:
Al_2O_3, C_3O_2, CO_2, Pb_2O_3, B_2O_3, $C_{12}O_9$

29. Find the number of $S^* — S$ linkage in $H_2S_2O_3$.

30. Find the number of molecule(s) which is/are nonplanar and have zero dipole moment in the above question.

31. How many $X - \hat{M} - X$ (90°) bond angle is/are present in pentagonal bipyramidal geometry?

32. Find the number of molecule(s) which do not exist:
NCl_3, PCl_3, PCl_5, NCl_5, OF_2, OF_4, OF_6

33. Find the number of reaction(s) in which coordinate bond is/are formed in product side:

$BF_3 + F^- \longrightarrow BF_4^-$

$HF + SbF_5 \longrightarrow HSbF_6$

$PCl_3 + Cl^- \longrightarrow PCl_4^-$

$NH_3 + H^+ \longrightarrow NH_4^+$

$H_3O + H^+ \longrightarrow H_4O^{2+}$

34. How many maximum atoms lie in same plane in $F_2B - C \equiv C - BF_2$ molecule?

35. In NO_3^- ion, find the sum of bond pairs and lone pairs of electrons on nitrogen atom.

36. Find the number of bonds between two carbon atoms in CaC_2.

37. Find the number of lone pairs of electrons on Xe in $XeOF_4$.

38. Find the number of ion(s) which are having ionizable hydrogen from the following:
$H_2PO_2^-$, HPO_3^{2-}, $H_2P_2O_5^{2-}$, $H_4P_2O_7^{2-}$

39. Find the number of acid(s) which are having peroxy linkage from the following:
H_3PO_5, H_2SO_5, $H_2S_2O_7$, $H_2S_2O_8$, $HClO_4$

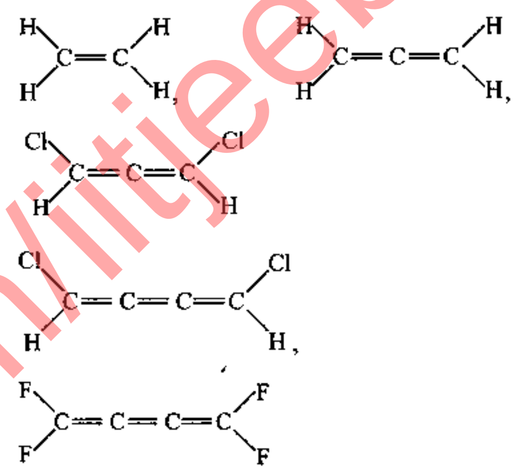
40. Find the ratio of number of σ-bonds and π-bonds in sodium hexa metaphosphate.

41. How many P—O—P bond(s) is/are present in $H_6P_6O_{18}$?

42. Find the sum of oxidation state of S-atom(s) in thio-sulphuric acid.

43. How many number of faces are there in P_4 molecule?

44. Find the number of molecule(s) which is/are planar as well as polar:



45. How many $X - \hat{M} - X$ (90°) bond angle is/are present in trigonal bipyramidal geometry?

46. How many maximum bond(s) is/are present in atoms of metals?

47. Potassium dichromate in alkaline solution with 30% H_2O_2 produces K_3CrO_8. How many peroxide linkages are found in the structure of K_3CrO_8?

Hints & Solutions

JEE (Main) Exercises

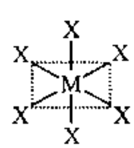
Single Correct Answer Type

2. (b)

	H — C	N — O
E.N.	= 2.1 2.5	3 3.5
E.N. difference	= 0.4	0.5
Bond dipole	= 0.39 D	1.51 D

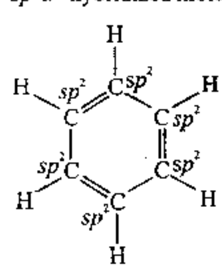
3. (c) p-orbital has equal-sized lobes. In sp-hybrid orbital most of the e^- probability is on one side, making the latter more directional in character.

4. (c)

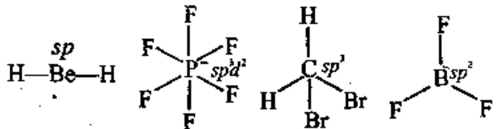


sp^3d^2-hybridized molecule has octahedral geometry.

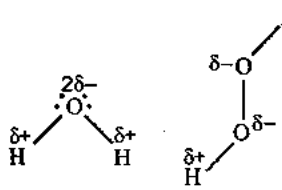
5. (a)



6. (c)

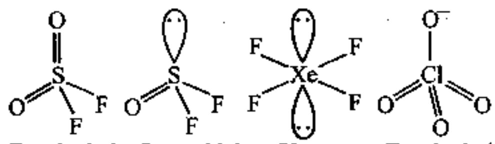


10. (b) The more are the partial charges generated, the more is the strength of H-bonding.



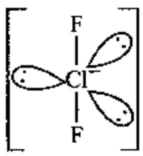
The strength of H-bonding is more in H_2O.

11. (c)



Tetrahedral Pyramidal Planar Tetrahedral

12. (b)



13. (c) AlF_3 is ionic and during the formation of ionic bond, octets of Al^{3+} and F^- have been completed. $AlCl_3$ and $AlBr_3$ are covalent and hypovalent.

47. (c) C—F bond has more electronegativity difference, F being the most electronegative.

48. (b) In H_2O, H-atom contains only two electrons.

49. (b) SiO_2 possesses giant molecular structure due to tetra valence and catenation nature of Si.

50. (a) CO_2 has 180° angle.

51. (d) As the *s* character increases in hybridized orbitals, its electronegativity increases.

	sp	sp^2	sp^3
s character	50%	33.3%	25%

52. (a) $\text{L.E.} = -\dfrac{Kq_1q_2}{r}$

53. (d) CH_4 is a saturated molecule having all the four sigma bonds.

54. (c) XeF_4 has sp^3d^2-hybridized Xe atom having two lone pair of electrons and thus, octahedral geometry changes to square planar due to lone pair effect.

55. (d) sp^3d-hybridization leads to trigonal bipyramidal geometry if no lone pair is present, e.g., PCl_5; in ClF_3, geometry is T shaped due to the presence of two lone pairs of electrons. In XeF_2, geometry is linear due to the presence of three lone pairs of electrons.

56. (c) Due to large electronegativity difference in C and F atoms.

57. (c) Bond angles decrease down the group.

$\therefore$ $H_2O > H_2S$. Also bond angle of $H_2O < NH_3$ due to lone pair effect.

58. (a) Due to the presence of lone pair on N atom.

59. (c) Coordiante bonding involves sharing of an electron pair provided by a donor atom to acceptor atom.

60. (b) sp^3d^2-hybridization leads to octahedral geometry.

61. (c) Due to stronger coulombic forces of attractions.

62. (b) H_2O is V-shaped.

63. (c) sp^3-hybridization leads to a tetrahedral geometry.

64. (b) *sp*-hybridization leads to bond angle of 180°.

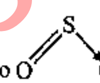
65. (c) Liq. NH_3, liq. HF, and CH_3OH show H-bonding.

66. (b) Both CO_2 and $HgCl_2$ are linear (*sp*-hybridization).

67. (d) Bond length decreases with increase in *s*-character.

68. (c) Due to shielding effect of $(n-1)$ *d*-subshell.

69. (c) All are nonmetals.

70. (b) SO_2 has sp^2-hybridization due to  geometry.

71. (c) SiF_4 has regular tetrahedral geometry.

72. (c) $\equiv C—$ has 2σ- and 2π- (thus, *sp*-hybridization); $—CH=$ has 3σ- and 1π- (thus, sp^2-hybridization). Remember hybridized orbitals do not form π-bonds.

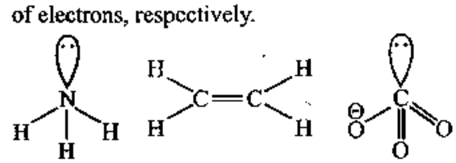
73. (d) Cs^+ is the biggest ion among these. F^- is the smallest.

74. (c) Allene is $CH_2=C=CH_2$.

75. (c) H-bonding is noticed in molecules having H atom attached on N, O, or F.

76. (d) I_3^-, XeF_4, SF_4, and ClO_3^- have 3, 2, 1, 1 lone pair of electrons, respectively.

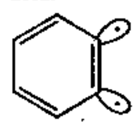
80. (d)



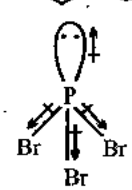
Pyramidal Planar Pyramidal

88. (d) Values of dipole moment cannot be predicted as we donot know about the electronegativities of the atoms.

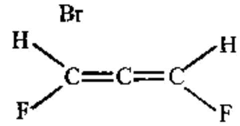
89. (c) $SiF_4 \rightarrow$ Si has vacant d-orbital and so can act as Lewis acid.



→ In benzyne all C-atoms are sp^2 hybridized.

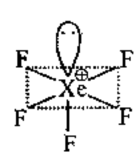


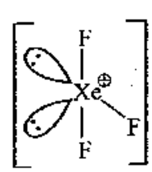
→ This is polar moelcule.



→ The nodal planes of π–bonds are perpendicular to each other.

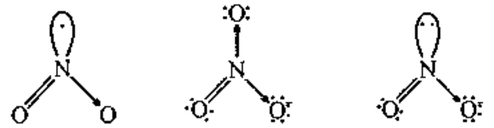
91. (b)





Bent T-shaped

92. (a) NO_2, N_2O_3, and N_2O_5 are acidic oxides
NO, N_2O, and CO are neutral oxides

93. (d) 

Total electrons = 23 Total electrons = 32 Total electrons = 24

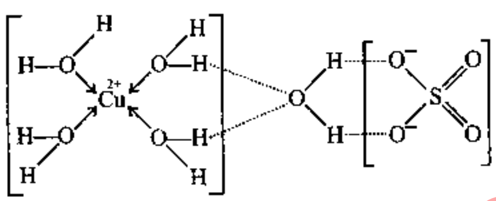
$N{\equiv}N\rightarrow\ddot{O}: \longleftrightarrow :\overset{=}{N}=\overset{+}{N}=\ddot{O}:$ Total electrons = 22

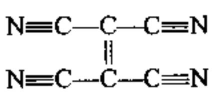
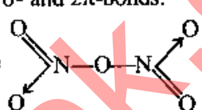
$\ddot{O}=C=\ddot{O}$ Total electrons = 22

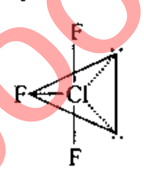
JEE (Advanced) Exercises

Single Correct Answer Type

4. (a) X loses electron, Y gains it.
5. (c) H_2O possesses the tendency for H-bonding.
6. (c) N_2 has triple (multiple) bond.
7. (c) Cu^{2+} and SO_4^{2-}

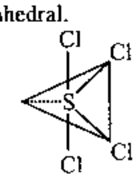


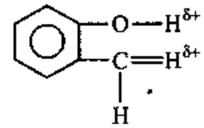
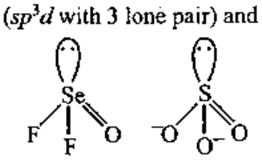
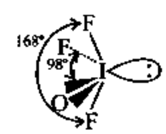
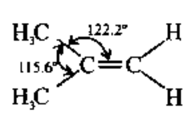
8. (c) $C_2(CN)_4$ is 
9. (a) Triple bond contains 1σ- and 2π-bonds.
10. (b) N_2O_5 has the structure 
11. (c) Cl in ClF_3 has sp^3d-hybridization



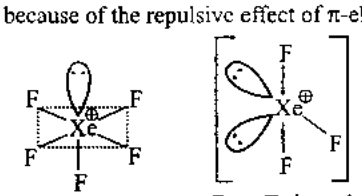
and possesses two axial Cl—F bonds and one equatorial bond.
Two lone pairs are at equatorial position and give rise to bent "T" shape to ClF_3.

12. (b) The hybridized states of N in NO_2^+, NO_3^- and NO_4^+ are sp, sp^2, and sp^3, respectively.
13. (c) ClO_4^- has sp^3-hybridization on Cl atom.
14. (a) $O=\overset{+}{N}=O$, N has no lone pair.
15. (c) S in SCl_4 is sp^3d-hybridized and possesses a see-saw structure.
SiCl$_4$ is tetrahedral.



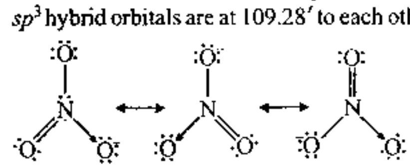
16. (b) SO_2 has sp^2-hybridization.
17. (a)  Intramolecular H-bonding.
18. (d) In H_2O, O atom will donate electron pair to H^+ forming H_3O^+.
19. (a) $[X]^{2+}[2Y]^-$ or XY_2
20. (a) Based on geometry of molecule.
21. (c) Carbon in CO_2 has sp-hybridization.
22. (c) Both $HgCl_2$ and C_2H_2 are linear like CO_2 because of sp-hybridization.
23. (c) BCl_3 has six electrons in outer shell of boron atom.
24. (b) 37 is atomic number of Rb (the electropositive element) and 53 is atomic number of iodine (the electronegative element).
25. (d) van der Waals' forces are the weakest; rest of all involves ionic or partially ionic (dipole) forces of attractions.
26. (b) Element with atomic number 20 is metal (Ca); it will combine with nonmetal.
28. (d) CS_2 is linear having zero dipole moment.
29. (d) Hg exists in liquid state.
30. (d) Boron in BF_3 has only six electrons.
31. (b) NH_4^+ has angle of 109° 28'.
32. (b) HF forms $(HF)_n$ linear polymeric structure due to H-bonding.
34. (a) Both NH_4^+ and BF_4^- have sp^3-hybridization.
35. (d) XeF_2 (sp^3d with 3 lone pair) and $CO_2(sp)$ are linear.
41. (a) 
43. (b) 
44. (a) 

The VSEPR model considers double and triple bonds to have slightly greater repulsive effects than single bonds because of the repulsive effect of π-electrons.

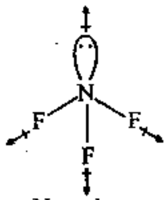
48. (b) 

Bent T-shaped

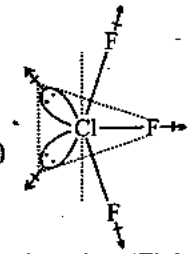
49. (c) (I) sp^3 hybrid orbitals are at 109.28' to each other

(IV) 

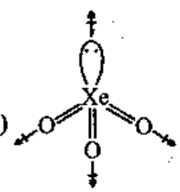
Bond order of N—O bond = $\frac{4}{3}$ = 1.33

50. (b) (a) 

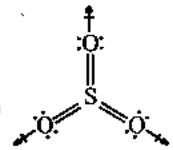
Non-planar (pyramidal) $\mu_D \neq 0$

(b) 

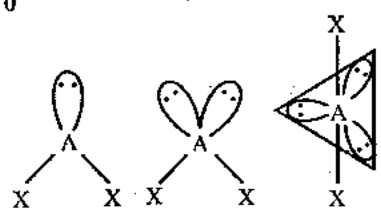
Planar, bent 'T' shape $\mu_D \neq 0$

(c) 

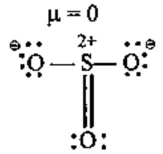
Pyramidal $\mu_D \neq 0$

(d) 

Trigonal planar $\mu = 0$

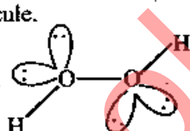
56. (a) $X—A—X$ 

$\mu = 0$ $\mu \neq 0$ $\mu \neq 0$ $\mu = 0$

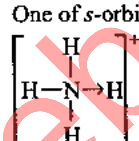
58. (c) 

Therefore, there are 3 σ and 1 π bond.

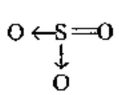
63. (d) With the knowledge of dipole moment, we cannot tell anything about the bond energies of all bonds within the molecule.

64. (c) H_2O_2 has  structure; O—O bond is nonpolar; O—H is polar.

65. (a) One of s-orbital + 3 of p-orbital = sp^3.

66. (b)  Cl^-, NH_4^+, and Cl^- form ionic bond.

67. (c) B completes its octet by sharing 2 electron pairs; A completes its octet by sharing of three electrons: A_2B_3, e.g., B_2O_3.

68. (a)  two O atoms are having coordinate (dative) linkage.

71. (d) Due to regular tetrahedral geometry.

72. (c) Polar solutes are more soluble in polar solvents.

73. (c) e.g., BF_3, a nonpolar molecule having sp^2-hybridization.

74. (b) Due to sp^2-hybridization.

75. (d) NH_2^- has sp^3-hybridization having two covalent bonds and two lone pairs on N-atom.

76. (d) The bond angles in sp^3, sp^2, and sp-hybridization are 109°, 120°, and 180°, respectively.

77. (b) CO_2 has sp-hybridization.

78. (c) Same spin electrons in two atoms do not take part in bonding.

79. (d) H_2O is V-shaped.

80. (c) Both NH_3 and H_2O have sp^3-hybridization. CO_2 and $BeCl_2$ are linear (sp-hybridization).

81. (c) C — F bond is more polar than C — Cl.

83. (c) Anions are larger in size than their parent atom.

84. (b) IP_1 of B > IP_1 of Li because E.N. of boron is more than Li. Also IP_1 of Li > IP_1 of K because removal of electron in K occurs from $4s$.

85. (b) It is the order of stability.

87. (b) Li^-: $1s^2, 2s^2$; Be^-: $1s^2, 2s^2, 2p^1$; in Li, addition of electron has taken place in $2s$ orbital; in Be^-, addition of electron has taken place in $2p$ orbital loosing its $2s$ completely filled configuration.

EA_1 for Be is more positive than EA_1 for Li. Thus, Be^- is least stable.

88. (c) Both NH_4^+ and $[BF_4]^-$ have tetrahedral shape due to sp^3-hybridization.

89. (d) PCl_5 = Trigonal bipyramidal

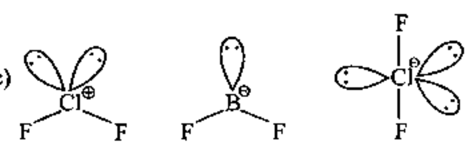
PCl_4^+ = Tetrahedral

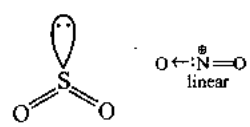
PCl_6^- = Square bipyramidal

90. (d) B in BF_3 has sp^2-hybridization.

91. (a) SF_4 has sp^3d^2-hybridization and see-saw geometry.

Multiple Correct Answers Type

8. (a), (c) 

12. (a), (c) 

13. (a), (c), (d)

$BeCl_2$–sp; BF_3–sp^2; NH_3–sp^3; XeF_2–sp^3d

14. (a), (c), (d)

Sigma bond formation involves more overlapping and thus is stronger.

15. (a), (b), (c)

BCl_3 has sp^2-hybridization. Rest all have sp^3-hybridization having one lone pair of electron, and thus are pyramidal in nature.

16. (a), (c), (d)

Both N_2O and CO_2 have 22 electrons.

18. (a), (c), (d)

H_2O has bent shape. No π-bond; H O H bonding.

28. (b), (c), (d)

IF_5 is square pyramidal (sp^3d^2-hybridization in I); PCl_5 is trigonal bipyramidal (sp^3d-hybridization in P).

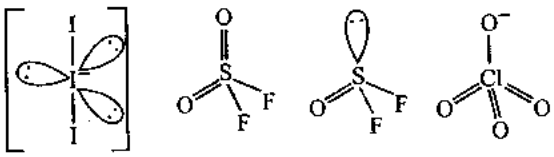
29. (a), (b), (c)

One carbon has three bonds and others five, whereas each should have four bonds.

30. (a), (b), (c)

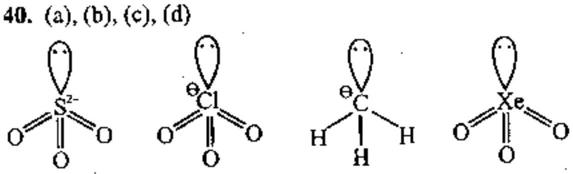
Characteristics of bond order concept.

35. (a), (c)



Linear Tetrahedral Pyramidal Tetrahedral

40. (a), (b), (c), (d)



43. (a), (c), (d)

Both Cl^- and Ar possess $1s^2, 2s^2\,2p^6, 3s^2\,3p^6$ configuration.

Comprehension Type

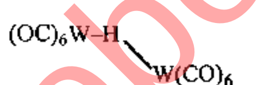
Comprehension-5: (Q. 14 and Q. 15)

14. (b) Both the molecules have the same number e^-, but ICl has dipole moment and should have the higher boiling point.

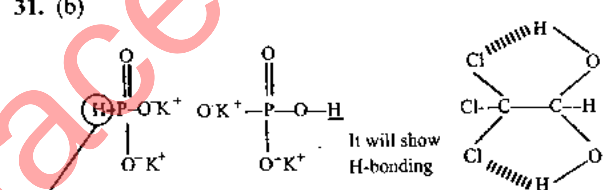
15. (d) BF_3 has zero dipole moment

Comprehension-10: (Q. 30 to Q. 31)

30. (d)



31. (b)



Chloralhydrate

Since it is not connected to electronegative atom and hence, it will not show H-bonding.

Comprehension-14: (Q. 42)

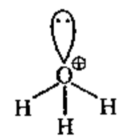
42. (a) Internuclear distance – radius of chlorine atom = radius of As-atom.

2.20 Å – 0.99 Å = 1.21 Å

Matching Column Type

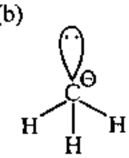
2. (a) p, r; (b) p, r; (c) q, s; (d) q

(a)



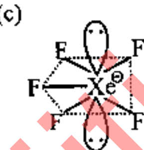
(i) Pyramidal
(ii) sp^3-hybridization
(iii) Nonplanar
(iv) $\mu \neq 0$, polar

(b)



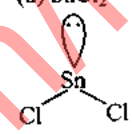
(i) Pyramidal
(ii) sp^3-hybridization
(iii) Nonplanar
(iv) $\mu \neq 0$, polar

(c)



(i) sp^3d^2-hybridization
(ii) Planar
(iii) $\mu = 0$
(iv) Nonpolar

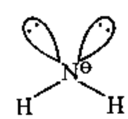
(d) $SnCl_2$



(i) sp^2-hybridization
(ii) Planar
(iii) $\mu \neq 0$
(iv) Polar

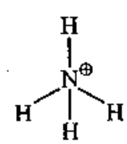
5. (a) q, t; (b) p; (c) p, q, s; (d) p, r, s (e) q, t

(a)



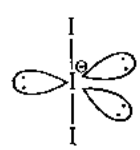
(i) Bent structure
(ii) sp^3-hybridization
(iii) Planar
(iv) $\mu \neq 0$, polar

(b)



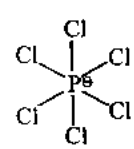
(i) Tetrahedral structure
(ii) Nonplanar
(iii) sp^3-hybridization
(iv) $\mu = 0$
(v) Nonpolar

(c)



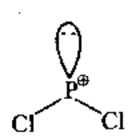
(i) sp^3d-hybridization
(ii) dz^2 is involved in hybridization
(iii) Linear, planar
(iv) $\mu = 0$, nonpolar

(d)



(i) sp^3d^2-hybridization
(ii) $d_{x^2-y^2}, d_{z^2}$ orbitals are involved in hybridization
(iii) Nonplanar
(iv) $\mu = 0$, nonpolar

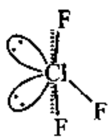
(e)



(i) sp^3-hybridization
(ii) Bent structure
(iii) Planar
(iv) $\mu \neq 0$, polar

6. (a) p, r, s; (b) r, s, t; (c) q, r, t; (d) q, t

(a)



(i) sp^3d-hybridization

(ii) dz^2 is involved in bonding

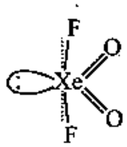
(iii) Axial bond lengths are longer than that of equatorial bonds, it means equatorial bonds are stronger than the axial bonds

(iv) Planar molecule

(v) Polar

(vi) $\mu \neq 0$

(b)



(i) sp^3d

(ii) dz^2 orbital is involved in bonding

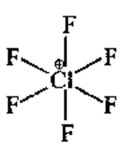
(iii) Nonplanar

(iv) Equatorial bonds are stronger than the axial bonds

(v) Polar

(vi) $\mu \neq 0$

(c)



(i) sp^3d^2

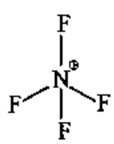
(ii) $d_{x^2-y^2}$ and d_{z^2} orbitals are involved in bonding

(iii) Nonplanar

(iv) Nonpolar

(v) $\mu = 0$

(d)



(i) sp^3d hybridization

(ii) Nonplanar

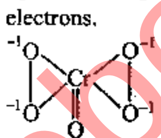
(iii) Nonpolar

(iv) $\mu = 0$

Integer Answer Type

6. (2) S_2 molecule is paramagnetic like O_2 having 2 unpaired electrons.

11. (2)



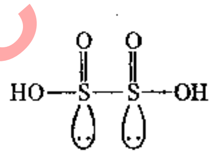
Two three member rings are present.

12. (18) $P-\hat{P}-P$ bond angle $= 12$

$P-P$ side $= 6$

Sum $= 12 + 6 = 18$

13. (0)

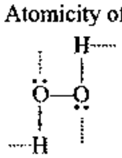


$S-O-S$ linkage $= 0$

16. (6) Atomicity of nitrogen $= 2$ (N_2)

Atomicity of phosphorous $= 4$ (P_4)

22. (4)

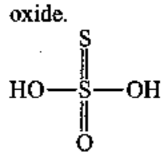


One site available for H-bonding at each H atom and two at O atom due to two lone pairs and partial –ve charge.

25. (3) $H_2S_2O_8$ = peroxydisulphuric acid is not a per acid; per acid of S is H_2SO_5.

$H_4P_2O_8$ = peroxy diphosphoric acid is not a per acid; per acid of P is H_3PO_5.

28. (3) If oxygen per atom is 1.5, then oxide is called sesquioxide.



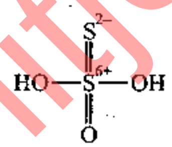
29. (1) $S-S$ linkage $= 1$

36. (3) C_2^{2-} has $[C\equiv C]^{2-}$ structure.

37. (1) Xe in $XeOF_4$ has sp^3d^2-hybridization having one lone pair on Xe-atom.

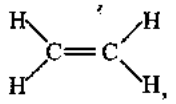
40. (4) $\dfrac{\text{Number of } \sigma \text{ bonds}}{\text{Number of } \pi \text{ bonds}} = \dfrac{24}{6} = 4$

42. (4)

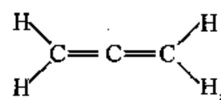


Sum of oxidation state $= 6 - 2 = 4$

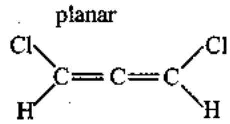
44. (1)



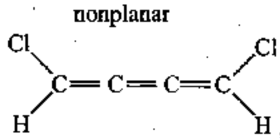
$\mu = 0$, nonpolar planar



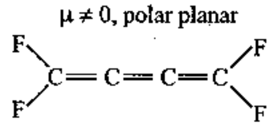
$\mu = 0$, nonpolar nonplanar



$\mu \neq 0$, nonpolar nonplanar

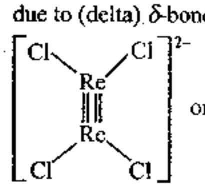


$\mu \neq 0$, polar planar



$\mu = 0$, nonpolar nonplanar

46. (4) Maximum three bonds are formed between two atoms of nonmetal, but in atoms of d-block elements, maximum four bonds are present in some moelcule due to (delta) δ-bond.



one $\sigma + 2\,\pi + 1\,\delta$ bond

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (b)	3. (c)	4. (c)	5. (a)	6. (c)	7. (c)	8. (a)	9. (d)	10. (b)
11. (c)	12. (b)	13. (c)	14. (d)	15. (b)	16. (c)	17. (b)	18. (b)	19. (a)	20. (b)
21. (c)	22. (d)	23. (a)	24. (d)	25. (b)	26. (d)	27. (d)	28. (c)	29. (b)	30. (b)
31. (d)	32. (a)	33. (b)	34. (a)	35. (a)	36. (b)	37. (a)	38. (a)	39. (b)	40. (a)
41. (b)	42. (a)	43. (a)	44. (a)	45. (a)	46. (a)	47. (c)	48. (b)	49. (b)	50. (a)
51. (d)	52. (a)	53. (d)	54. (c)	55. (d)	56. (c)	57. (c)	58. (a)	59. (c)	60. (b)
61. (c)	62. (b)	63. (c)	64. (b)	65. (c)	66. (b)	67. (d)	68. (c)	69. (c)	70. (b)
71. (c)	72. (c)	73. (d)	74. (c)	75. (c)	76. (d)	77. (b)	78. (b)	79. (a)	80. (d)
81. (b)	82. (d)	83. (c)	84. (d)	85. (d)	86. (c)	87. (d)	88. (d)	89. (c)	90. (c)
91. (b)	92. (a)	93. (d)	94. (d)	95. (b)	96. (d)	97. (a)	98. (a)	99. (b)	100. (b)
101. (c)									

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (a)	4. (a)	5. (c)	6. (c)	7. (c)	8. (c)	9. (a)	10. (b)
11. (c)	12. (b)	13. (c)	14. (a)	15. (c)	16. (b)	17. (a)	18. (d)	19. (a)	20. (a)
21. (c)	22. (c)	23. (c)	24. (b)	25. (d)	26. (b)	27. (b)	28. (d)	29. (d)	30. (d)
31. (b)	32. (b)	33. (b)	34. (a)	35. (d)	36. (a)	37. (c)	38. (c)	39. (b)	40. (b)
41. (a)	42. (c)	43. (b)	44. (a)	45. (d)	46. (a)	47. (a)	48. (b)	49. (c)	50. (b)
51. (b)	52. (b)	53. (a)	54. (a)	55. (a)	56. (a)	57. (d)	58. (c)	59. (d)	60. (c)
61. (b)	62. (c)	63. (d)	64. (c)	65. (a)	66. (b)	67. (c)	68. (a)	69. (b)	70. (c)
71. (d)	72. (c)	73. (c)	74. (b)	75. (d)	76. (d)	77. (b)	78. (c)	79. (d)	80. (c)
81. (c)	82. (b)	83. (c)	84. (b)	85. (b)	86. (a)	87. (b)	88. (c)	89. (d)	90. (d)
91. (a)	92. (d)	93. (d)	94. (d)	95. (d)	96. (a)	97. (d)	98. (b)	99. (c)	100. (a)

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (c), (d)	3. (a), (b), (c)	4. (a), (b), (c)	5. (a), (b), (c),(d)
6. (a), (d)	7. (b), (d)	8. (a), (c)	9. (a), (b), (c)	10. (a), (b), (c), (d)
11. (a), (b), (c), (d)	12. (a), (c)	13. (a), (c), (d)	14. (a), (c), (d)	15. (a), (b), (c)
16. (a), (c), (d)	17. (a), (c)	18. (a), (c), (d)	19. (b), (c)	20. (c), (d)
21. (a), (d)	22. (a), (b), (c), (d)	23. (a), (c), (d)	24. (a), (b), (c)	25. (a), (b), (c)
26. (a), (b), (c), (d)	27. (a), (b), (c), (d)	28. (b), (c)	29. (a), (b), (c)	30. (a), (b), (c)
31. (a), (c), (d)	32. (c), (d)	33. (b), (d)	34. (b), (c)	35. (a), (c)
36. (a), (d)	37. (a), (b), (c), (d)	38. (a), (b), (c)	39. (a), (b), (c), (d)	40. (a), (b), (c), (d)
41. (a), (b), (c)	42. (b), (c), (d)	43. (a), (c), (d)		

Comprehension Type

Comprehension-1	1. (b)	2. (c)	3. (c)	
Comprehension-2	4. (b)	5. (c)	6. (a)	
Comprehension-3	7. (d)	8. (b)	9. (b)	
Comprehension-4	10. (d)	11. (a)	12. (b)	13. (a)
Comprehension-5	14. (b)	15. (d)	16. (d)	

Comprehension-6	**17.** (b)	**18.** (a)	**19.** (b)	
Comprehension-7	**20.** (d)	**21.** (a)	**22.** (a)	**23.** (d)
Comprehension-8	**24.** (d)	**25.** (c)	**26.** (c)	
Comprehension-9	**27.** (c)	**28.** (a)	**29.** (c)	
Comprehension-10	**30.** (d)	**31.** (b)	**32.** (c)	
Comprehension-11	**33.** (d)	**34.** (a)	**35.** (d)	
Comprehension-12	**36.** (a)	**37.** (c)		
Comprehension-13	**38.** (b)	**39.** (c)		
Comprehension-14	**40.** (c)	**41.** (a)	**42.** (a)	

Assertion-Reasoning Type

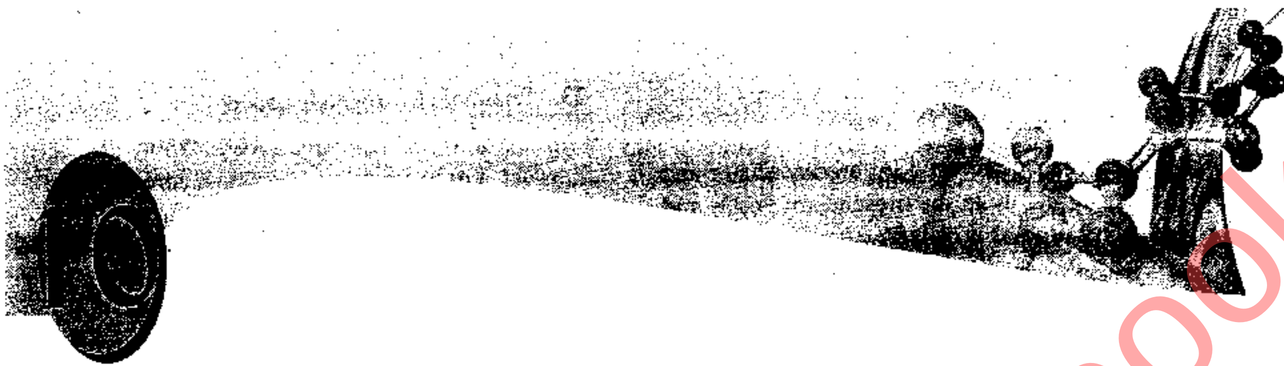
1. (a) **2.** (a) **3.** (b) **4.** (d)

Matching Column Type

1. (a) q, r; (b) p; (c) s; (d) t
2. (a) p, r; (b) p, r; (c) q, s; (d) q
3. (a) p, q; (b) s; (c) r; (d) t
4. (a) p, q, r; (b) p, q, r; (c) s
5. (a) q, t; (b) p; (c) p, q, s; (d) p, r, s; (e) q, t
6. (a) p, r, s; (b) r, s, t; (c) q, r, t; (d) q, t
7. (a) r; (b) p; (c) q; (d) s

Integer Answer Type

1. (5)	**2.** (4)	**3.** (16)	**4.** (6)	**5.** (12), (3)	**6.** (2)	**7.** (2)	**8.** (4)	**9.** (0)	**10.** (0)
11. (2)	**12.** (18)	**13.** (0)	**14.** (1)	**15.** (5)	**16.** (6)	**17.** (5)	**18.** (5)	**19.** (4)	**20.** (4)
21. (1)	**22.** (4)	**23.** (3)	**24.** (3)	**25.** (3)	**26.** (3)	**27.** (3)	**28.** (3)	**29.** (1)	**30.** (1)
31. (10)	**32.** (3)	**33.** (4)	**34.** (8)	**35.** (4)	**36.** (3)	**37.** (1)	**38.** (1)	**39.** (3)	**40.** (4)
41. (6)	**42.** (4)	**43.** (4)	**44.** (1)	**45.** (6)	**46.** (4)	**47.** (4)			



Hydrogen and Its Compounds

JEE (Main) Exercises

Single Correct Answer Type

1. Hydrogen burns in air with a:
   (a) Light bluish flame (b) Yellow flame
   (c) Green flame (d) None of these

2. Which pair does not show hydrogen isotopes?
   (a) Ortho hydrogen and para hydrogen
   (b) Protium and deuterium
   (c) Deuterium and tritium
   (d) Tritium and protium

3. Hydrogen from HCl can be prepared by:
   (a) Mg (b) Cu
   (c) P (d) Pt

4. The color of hydrogen is:
   (a) Black (b) Yellow
   (c) Orange (d) Colorless

5. Ordinary hydrogen at room temperature is a mixture of:
   (a) 75% of o-hydrogen + 25% of p-hydrogen
   (b) 25% of o-hydrogen + 75% of p-hydrogen
   (c) 50% of o-hydrogen + 50% of p-hydrogen
   (d) 1% of o-hydrogen + 99% of p-hydrogen

6. The adsorption of hydrogen by metals is called:
   (a) Dehydrogenation (b) Hydrogenation
   (c) Occlusion (d) Absorption

7. Which of the following produces hydrolith with dihydrogen?
   (a) Mg (b) Al
   (c) Cu (d) Ca

8. The metal which displaces hydrogen from a boiling caustic soda solution is:
   (a) As (b) Zn
   (c) Mg (d) Fe

9. In context with the industrial preparation of hydrogen from water gas ($CO + H_2$), which of the following is the correct statement?
   (a) CO is removed by absorption in aqueous Cu_2Cl_2 solution
   (b) H_2 is removed through occlusion with Pd
   (c) CO is oxidized to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali
   (d) CO and H_2 are fractionally separated using differences in their densities

10. Which is poorest reducing agent?
    (a) Nascent hydrogen
    (b) Atomic hydrogen
    (c) Dihydrogen
    (d) All have same reducing strength

11. An ionic compound is dissolved simultaneously in heavy water and simple water. Its solubility is:
    (a) Larger in heavy water
    (b) Smaller in heavy water
    (c) Same in both
    (d) Smaller in simple water

12. Ortho-hydrogen and para-hydrogen resemble in which of the following properties?

(a) Thermal conductivity
(b) Magnetic properties
(c) Chemical properties
(d) Heat capacity

13. Hydrogen can be prepared by mixing steam and water gas at 673 K in the presence of Fe_2O_3 and Cr_2O_3. This process is called:
(a) Nelson's process (b) Serpeck's process
(c) Bosch's process (d) Parke's process

14. An element reacts with hydrogen to form a compound 'A' which on treatment with water liberates hydrogen gas. The element can be:
(a) Nitrogen (b) Chlorine
(c) Selenium (d) Calcium

15. Which of the following halogen has maximum affinity for hydrogen?
(a) F_2 (b) Cl_2
(c) Br_2 (d) I_2

16. Hydrogen is not obtained when zinc reacts with:
(a) Cold water (b) Hot NaOH solution
(c) Conc. H_2SO_4 (d) Dil. HCl

17. The oxidation states shown by hydrogen are:
(a) –1 only (b) Zero only
(c) +1, –1, 0 (d) +1 only

18. Which element forms maximum compound in chemistry?
(a) O (b) H
(c) Si (d) C

19. When SO_3 is treated with heavy water the product is /are:
(a) Deuterium and sulphuric acid
(b) Deuterium and sulphurous acid
(c) Only deuterium
(d) Dideutero sulphuric acid

20. Which of the following gas is insoluble in water?
(a) SO_2 (b) NH_3
(c) H_2 (d) CO_2

21. The gas used in the hydrogenation of vegetable oils in the presence of nickel as catalyst is:
(a) Methane (b) Ethane
(c) Ozone (d) Hydrogen

22. The conversion of atomic hydrogen into ordinary hydrogen is:
(a) Exothermic change
(b) Endothermic change
(c) Nuclear change
(d) Photochemical change

23. Triatomic hydrogen is called:
(a) Deuterium (b) Hyzone
(c) Ortho form (d) Hydronium ion

24. $LiAlH_4$ is obtained by reacting an excess of .... with an ethereal solution of $AlCl_3$:
(a) LiCl (b) LiH
(c) Li (d) LiOH

25. Chemical A is used for water softening to remove temporary hardness. A reacts with sodium carbonate to generate caustic soda. When CO_2 is bubbled through a solution of A, it turns cloudy. What is the chemical formula of A?
(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

26. Which is the lightest gas?
(a) Nitrogen (b) Helium
(c) Oxygen (d) Hydrogen

27. The property of hydrogen which distinguish it from alkali metals is:
(a) Its electropositive character
(b) Its affinity for non-metal
(c) Its reducing character
(d) Its non-metallic character

28. Synthetic detergents are more effective in hard water than soaps because:
(a) They are highly soluble in water
(b) Their Ca^{++} and Mg^{++} salts are water soluble
(c) Their Ca^{++} and Mg^{++} salts are insoluble in water
(d) None of the above

29. Which of the following pairs of ions makes the water hard?
(a) Na^+, SO_4^{2-} (b) K^+, HCO_3^-
(c) Ca^{2+}, NO_3^- (d) NH4 +, Cl^-

30. H_2O is hard if it contains:
(a) $NaHCO_3$ (b) $MgSO_4$
(c) KCl (d) NaCl

31. Hardness of water is due to presence of salts of:
(a) Na^+ and K^+ (b) Ca^{2+} and Mg^{2+}
(c) Ca^{2+} and K^+ (d) Ca^{2+} and Na^{2+}

32. Temporary hardness of water is due to the presence of:
(a) Magnesium bicarbonate

(b) Calcium chloride
(c) Magnesium sulphate
(d) Calcium carbonate

33. Which of the following acid is formed when SiF_4 react with water?
(a) SiF_4 (b) H_2SiF_4
(c) H_2SO_4 (d) H_2SiF_6

34. The low density of ice compared to water is due to:
(a) Induced dipole–induced dipole interactions
(b) Dipole-induced–dipole interaction
(c) Hydrogen bonding interactions
(d) Dipole–dipole interactions

35. Lead pipes are not used for carrying drinking water because:
(a) They are covered with a coating of lead carbonate
(b) They are corroded by air and moisture
(c) Water containing dissolved air attacks lead forming soluble hydroxide
(d) None of the above

36. Which of the following will cause pure demineralised water:
(a) Passing water through cation exchange resin followed by anion exchanger resin succesively
(b) Passing water through anion exchange resin
(c) Passing water through sand
(d) Passing water through alumina

37. Permutit is the technical name given to:
(a) Aluminates of calcium and sodium
(b) Silicates of calcium and sodium
(c) Hydrated silicates of aluminium and sodium
(d) Silicates of calcium and magnesium

38. Which of the following is correct about heavy water?
(a) Water at 4°C having maximum density is known as heavy water
(b) It is heavier than water (H_2O)
(c) It is formed by the combination of heavier isotope of hydrogen and oxygen
(d) None of the above

39. The boiling point of water is exceptionally high because:
(a) There is covalent bond between H and O
(b) Water molecules are linear
(c) Water molecules associate due to hydrogen bonding
(d) Water molecules are not linear

40. Match List I with List II and select the correct answer using the codes given below the lists

List I	List II
(a) Heavy water	(p) Bicarbonates of Mg and Ca in water
(b) Temporary hard water	(q) No foreign ions in water
(c) Soft water	(r) D_2O
(d) Permanent hard water	(s) Sulphates and chlorides of Mg and Ca in water

Codes

	1	2	3	4
(a)	c	d	b	a
(b)	b	a	c	d
(c)	b	d	c	a
(d)	c	a	b	d

41. What is formed when calcium carbide reacts with heavy water?
(a) C_2D_2 (b) CaD_2
(c) Ca_2D_2O (d) CD_2

42. Metal which does not react with cold water but evolves H_2 with steam is:
(a) Na (b) K
(c) Pt (d) Fe

43. Why do calcium ions make water hard but sodium ions do not?
(a) Calcium forms insoluble compounds with stearate ions present in soap
(b) Sodium forms insoluble compounds with stearate ions present in soap
(c) Calcium forms soluble compounds with stearate ions present in soap
(d) Both calcium and sodium form insoluble compounds with stearate ions present in soap

44. Hydrogen has three isotopes protium, deuterium, and tritium, these isotopes differ from each other:
(a) These isotopes differ from one another in respect of the number of neutrons
(b) These isotopes differ from one another in respect of the number of proton
(c) These isotopes differ from one another in respect of the number of electrons
(d) None of these

45. Blackened oil painting can be restored into original form by the action of:

(a) Chlorine (b) BaO_2
(c) H_2O_2 (d) MnO_2

46. The reaction of $H_2S + H_2O_2 \rightarrow S + 2H_2O$ manifests
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidizing nature of H_2O_2
(d) Reducing action of H_2O_2

47. What is product of the reaction of H_2O_2 with Cl_2?
(a) $O_2 + HOCl$ (b) $HCl + O_2$
(c) $H_2O + HCl$ (d) $HCl + H_2$

48. H_2O_2 will oxidize:
(a) $KMnO_4$ (b) H_2S
(c) $K_2Cr_2O_7$ (d) $PbSO_4$

49. Fenton's reagent is
(a) $FeSO_4 + H_2O_2$ (b) Zn + HCl
(c) Sn + HCl (d) None of these

50. H_2O_2 is manufactured these days:
(a) By the action of H_2O_2 on BaO_2
(b) By the action of H_2SO_4 on Na_2O_2
(c) By electrolysis of 50% H_2SO_4
(d) By burning hydrogen in excess of oxygen

51. Which is false about H_2O_2?
(a) Act as both oxidizing and reducing agents
(b) Two OH bonds lies in the same plane
(c) Very pale blue liquid
(d) It can be oxidized by ozone

52. The structure of H_2O_2 is:
(a) Half open book like (b) Linear
(c) Closed book (d) Pyramidal

53. On shaking H_2O_2 with acidified potassium dichromate and ether, ethereal layer becomes:
(a) Green (b) Red
(c) Blue (d) Black

54. Which one of the following undergoes reduction with hydrogen peroxide in an alkaline medium?
(a) Mn^{2+} (b) HOCl
(c) PbS (d) Fe^{2+}

55. Polyphosphates are used as water softening agents because they:
(a) Form soluble complexes with anionic species
(b) Precipitate anionic species
(c) Forms soluble complexes with cationic species
(d) Precipitate cationic species

56. HCl is added to following oxides. Which one would give H_2O_2?
(a) MnO_2 (b) PbO_2
(c) BaO_2 (d) None of these

57. Out of the two allotropic forms of dihydrogen, the form with lesser molecular energy is:
(a) Ortho
(b) Meta
(c) Para
(d) All have same energy

58. Very pure hydrogen (99.9) can be made by which of the following processes?
(a) Reaction of methane with steam
(b) Mixing natural hydrocarbons of high molecular weight
(c) Electrolysis of water
(d) Reaction of salts like hydrides with water

59. Which of the following salts are responsible for hardness of water:
(a) Chloride of Ca and Mg
(b) Sulphates of Ca and Mg
(c) Bicarbonates of Ca and Mg
(d) All of these

60. Which of the following method(s) is/are used to removal of temporary hardness:
(a) By boiling (b) Clark's method
(c) Both (a) and (b) (d) None of these

61. Which of the following method(s) is/are used to removal of parmanent hardness:
(a) Calgon's method
(b) Ion-exchange method
(c) Synthetic resins method
(d) All of these

62. Metallic or non-stoichiometric (or interstitial) hydrides are formed by:
(a) Many *d*-block and *f*-block elements
(b) Many *s*-block elements
(c) Many *p*-block elements
(d) None of these

63. In which of the following hydrides, the law of constant composition does not hold good:
(a) Saline hydride (b) Metallic hydride
(c) Molecular hydride (d) All of these

64. Which of the following properties of water leads in comparison to H_2S and H_2Se due to H-bonding:

(a) Low freezing point
(b) Low boiling point
(c) Low heat of vaporization
(d) High heat of fuszion

65. Select the incorrect statements about ice:
(a) At atmospheric pressure ice crystallizes in the hexagonal form, but at very low temperature it condenses to cubic form
(b) Density of ice is less than that of water therefore, an ice cube floats on water
(c) In winter season ice formed on surface of a lake provides thermal insulation
(d) Volume of ice is less than that of water

66. Which of the following is the method for the manufacture of ammonia by the Haber process:
(a) $N_2 + O_2 \rightarrow NO$
(b) $N_2 + 3H_2 \xrightarrow[200\text{ atm., Fe}]{673} 2NH_3$
(c) $NH_3 + O_2 \rightarrow NO$
(d) None of these

67. Which of the following statement is correct for ionic hydrides:
(a) The ionic hydrides are crystalline
(b) The ionic hydrides are non-volatile
(c) The ionic hydrides are non-conducting in solid state
(d) All are correct

68. $LiH + \underline{B}_2H_6 \rightarrow 2Li\underline{B}H_4$,
find the change in hybridization of underlined atom.
(a) $sp^2 \rightarrow sp^3$ (b) $sp^3 \rightarrow sp^2$
(c) $sp \rightarrow sp^3$ (d) None

69. Which of the following isotope is called as heavy hydrogen:
(a) Protium (b) Deuterium
(c) Tritium (d) All of these

70. Which of the following isotope of hydrogen is radioactive and emits low energy $\beta^{\ominus}$ particles ($t_{1/2}$, 12.33 years)
(a) Protium (b) Deuterium
(c) Tritium (d) All of these

71. Isotopes of hydrogen have same electronic configuration and they have almost the same chemical properties but the only difference is in their rates of reactions.
(a) Mainly due to their different enthalpy of bond dissociation
(b) Mainly due to their different size
(c) Mainly due to their same number of e^-
(d) Mainly due to their same number of proton

72. In physical properties isotopes of hydrogen differ considerably due to their:
(a) Large size difference
(b) Significant mass difference
(c) Large atomic number difference
(d) None of these

73. H_2 gas is usually prepared by the reaction of
(a) Zn + dil. HCl (b) Zn + dil. H_2SO_4
(c) Zn + NaOH (d) All of these

74. High purity (> 99.95 %) dihydrogen is obtained by:
(a) Electrolysis of acidified water using platinum electrodes
(b) Electrolyzing warm aqueous barium hydroxide solution between nickel electrodes
(c) Electrolysis of brine solution
(d) Reaction of steam on hydrocarbons or coke at high temperature in the presence of catalyst

75. The mixture of CO and H_2 is called:
(a) Water gas (b) Producer gas
(c) Coal gas (d) All of these

76. (CO + H_2) mixture is called:
(a) Synthesis gas (b) Syn gas
(c) Both (a) and (b) (d) None of these

77. Nowadays syn gas is produced from:
(a) Sewage
(b) Saw–dust
(c) Scrap wood and newspaper
(d) All of these

78. The process of producing syn gas from coal is called coal gasification, which of the following reaction is correct for coal gasification.
(a) $CO_{(g)} + 2H_{2(g)} \xrightarrow{\text{Cobalt}} CH_3OH_{(l)}$
(b) $3H_{2(g)} + N_{2(g)} \xrightarrow[\text{Fe}]{} 2NH_{3(g)}$
(c) $C_{(s)} + H_2O_{(g)} \xrightarrow{1270\text{ K}} CO_{(g)} + H_{2(g)}$
(d) None of these

79. Which of the following reaction is called water gas shift / Bosch reaction
(a) $C_{(s)} + H_2O_{(g)} \xrightarrow{1270\text{ K}} CO_{(g)} + H_{2(g)}$
(b) $CO_{(g)} + H_2O_{(g)} \xrightarrow[Fe_2O_3-Cr_2O_3]{673\text{ K}} CO_{2(g)} + H_{2(g)}$
(c) $H_2 + CO + RCH{=}CH_2 \rightarrow RCH_2CH_2CHO$
(d) None of these

80. Select the correct statement about dihydrogen:
   (a) It is colorless, odorless, and tasteless
   (b) It is combustible gas
   (c) It is lighter than air and insoluble in water
   (d) All of these

81. When H_2 reacts with halogen X_2 then order of reactivity is:
   (a) $F_2 > Cl_2 > Br_2 > I_2$ (b) $Cl_2 > F_2 > Br_2 > I_2$
   (c) $Br_2 > I_2 > Cl_2 > F_2$ (d) $I_2 > Br_2 > Cl_2 > F_2$

NCERT Exemplar Exercises

Single Correct Answer Type

1. Hydrogen resembles halogens in many respects for which several factors are responsible. Of the following factors which one is most important in this respect?
   (a) Its tendency to lose an electron to form a cation
   (b) Its tendency to gain a single electron in its valence shell to attain stable electronic configuration
   (c) Its low negative electron gain enthalpy value.
   (d) Its small size

2. Why does H^+ ion always get associated with other atoms or molecules?
   (a) Ionization enthalpy of hydrogen resembles that of alkali metals
   (b) Its reactivity is similar to halogens
   (c) It resembles both alkali metals and halogens
   (d) Loss of an electron from hydrogen atom results in a nucleus of very small size as compared to other atoms or ions. Due to small size it cannot exist free

3. Metal hydrides are ionic, covalent or molecular in nature. Among LiH, NaH, KH, RbH, CsH, the correct order of increasing ionic character is:
   (a) LiH > NaH > CsH > KH > RbH
   (b) LiH < NaH < KH < RbH < CsH
   (c) RbH > CsH > NaH > KH > LiH
   (d) NaH > CsH > RbH > LiH > KH

4. Which of the following hydride is electron precise hydride?
   (a) B_2H_6 (b) NH_3
   (c) H_2O (d) CH_4

5. Radioactive elements emit α, β, and γ rays and are characterized by their halflives. The radioactive isotope of hydrogen is:
   (a) Protium (b) Deuterium
   (c) Tritium (d) Hydronium

6. Consider the reactions
   (i) $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$
   (ii) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$
   Which of the following statements is correct about H_2O_2 with reference to these reactions? Hydrogen perioxide is _______.
   (a) An oxidizing agent in both (i) and (ii)
   (b) An oxidizing agent in (i) and reducing agent in (ii)
   (c) A reducing agent in (i) and oxidizing agent in (ii)
   (d) A reducing agent in both (i) and (ii)

7. The compound that gives H_2O_2 on treatment with dilute H_2SO_4 is:
   (a) PbO_2 (b) $BaO_2.8H_2O + O_2$
   (c) MnO_2 (d) TiO_2

8. Which of the following equations depict the oxidizing nature of H_2O_2?
   (a) $2MnO_4^- + 6H+ 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$
   (b) $2Fe^{3+} + 2H^+ + H_2O_2 \rightarrow 2Fe^{2+} + 2H_2O + O_2$
   (c) $2I + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$
   (d) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

9. Which of the following equation depicts reducing nature of H_2O_2?
   (a) $2[Fe(CN)_6]^{4-} + 2H^+ + H_2O_2 \rightarrow 2[Fe(CN)_6]^{3-} + 2H_2O$
   (b) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$
   (c) $Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2OH^-$
   (d) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

10. Hydrogen peroxide is:
   (a) An oxidizing agent
   (b) A reducing agent
   (c) Both an oxidizing and a reducing agent
   (d) Neither oxidizing nor reducing agent

11. Which of the following reactions increases production of dihydrogen from synthesis gas?
   (a) $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270\ N} CO(g) + 3H_2(g)$
   (b) $C(s) + H_2O(g) \xrightarrow{1270\ K} CO(g) + H_2(g)$

(c) $CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673\text{ K}} CO_2(g) + H_2(g)$

(d) $C_2H_6 + 2H_2O \xrightarrow[\text{Ni}]{1270\text{ K}} 2CO + 5H_2$

12. When sodium peroxide is treated with dilute sulphuric acid, we get:
    (a) Sodium sulphate and water
    (b) Sodium sulphate and oxygen
    (c) Sodium sulphate, hydrogen, and oxygen
    (d) Sodium sulphate and hydrogen peroxide

13. Hydrogen peroxide is obtained by the electrolysis of:
    (a) Water
    (b) Sulphuric acid
    (c) Hydrochloric acid
    (d) Fused sodium peroxide

14. Which of the following reactions is an example of use of water gas in the synthesis of other compounds?
    (a) $CH_4(g) + H_2O(g) \xrightarrow[\text{Ni}]{1270\text{ N}} CO(g) + H_2(g)$
    (b) $CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673\text{ K}} CO_2(g) + H_2(g)$
    (c) $C_nH_{2n+2} + nH_2O(g) \xrightarrow[\text{Ni}]{1270\text{ K}} nCO + (2n+1)H_2$
    (d) $CO(g) + 2H_2(g) \xrightarrow[\text{Catalyst}]{\text{Cobalt}} CH_3OH(\ell)$

15. Which of the following ions will cause hardness in water sample?
    (a) Ca^{2+} (b) Na^+
    (c) Cl (f) K^+

16. Which of the following compounds is used for water softening?
    (a) $Ca_3(PO_4)_2$ (b) Na_3PO_4
    (c) $Na_6P_6O_{18}$ (d) Na_2HPO_4

17. Elements of which of the following group(s) of periodic table do not form hydrides.
    (a) Groups 7, 8, 9 (b) Group 13
    (c) Groups 15, 16, 17 (d) Group 14

18. Only one element of which group forms hydride.
    (a) Group 6 (b) Group 7
    (c) Group 8 (d) Group 9

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following statements are not true for hydrogen?
   (a) It exists as diatomic molecule
   (b) It has one electron in the outermost shell
   (c) It can lose an electron to form a cation which can freely exist
   (d) It forms a large number of ionic compounds by losing an electron

2. Dihydrogen can be prepared on commercial scale by different methods. In its preparation by the action of steam on hydrocarbons, a mixture of CO and H_2 gas is formed. It is known as:
   (a) Water gas (b) Syngas
   (c) Producer gas (d) Industrial gas

3. Which of the following statement(s) is/are correct in the case of heavy water?
   (a) Heavy water is used as a moderator in nuclear reactor
   (b) Heavy water is more effective as solvent than ordinary water
   (c) Heavy water is more associated than ordinary water
   (d) Heavy water has lower boiling point than ordinary water

4. Which of the following statements about hydrogen are correct?
   (a) Hydrogen has three isotopes of which protium is the most common
   (b) Hydrogen never acts as cation in ionic salts
   (c) Hydrogen ion H^+, exists freely in solution
   (d) Dihydrogen does not act as a reducing agent

5. Some of the properties of water are described below. Which of them is/are not correct?
   (a) Water is known to be a universal solvent
   (b) Hydrogen bonding is present to a large extent in liquid water
   (c) There is no hydrogen bonding in the frozen state of water
   (d) Frozen water is heavier than liquid water

6. Hardness of water may be temporary or permanent. Permanent hardness is due to the presence of:
   (a) Chlorides of Ca and Mg in water
   (b) Sulphates of Ca and Mg in water
   (c) Hydrogen carbonates of Ca and Mg in water
   (d) Carbonates of alkali metals in water

7. Which of the following statements is correct?
   (a) Elements of group 15 form electron deficient hydrides

(b) All elements of group 14 form electron precise hydrides

(c) Electron precise hydrides have tetrahedral geometries

(d) Electron-rich hydrides can act as Lewis acids

8. Which of the following statements is correct?

(a) Hydrides of group 13 act as Lewis acids

(b) Hydrides of group 14 are electron deficient hydrides

(c) Hydrides of group 14 act as Lewis acids

(d) Hydrides of group 15 act as Lewis bases

9. Which of the following statements is correct?

(a) Metallic hydrides are deficient of hydrogen

(b) Metallic hydrides conduct heat and electricity

(c) Ionic hydrides do not conduct electricity in solid state

(d) Ionic hydrides are very good conductors of electricity in solid state

Short Answer Type

1. How can production of hydrogen from water gas be increased by using water gas shift reaction?

2. What are metallic/interstitial hydrides? How do they differ from molecular hydrides?

3. Name the classes of hydrides to which H_2O, B_2H_6 and NaH belong.

4. If same mass of liquid water and a piece of ice is taken, then why is the density of ice less than that of liquid water?

5. Complete the following equations:

(a) $PbS(s) + H_2O_2(aq) \rightarrow$

(b) $CO(g) + 2H_2(g) \xrightarrow[\text{Catalyst}]{\text{Cobalt}}$

6. Give reasons:

(a) Lakes freeze from top towards bottom.

(b) Ice floats on water.

7. What do you understand by the term 'auto protolysis of water'? What is its significance?

8. Discuss briefly de-mineralization of water by ion exchange resin.

9. Molecular hydrides are classified as electron deficient, electron precise and electron-rich compounds. Explain each type with two examples.

10. How is heavy water prepared? Compare its physical properties with those of ordinary water.

11. Write one chemical reaction for the preparation of D_2O_2.

12. Calculate the strength of 5 volume H_2O_2 solution.

13. (a) Draw the gas phase and solid phase structure of H_2O_2.

(b) H_2O_2 is a better oxidizing agent than water. Explain.

14. Melting point, enthalpy of vaporization and viscosity data of H_2O and D_2O is given below:

	H_2O	D_2O
Melting point / K	373.0	374.4
Enthalpy of vaporization at (373 K)/ kJ mol^{-1}	40.66	41.61
Viscosity/centipoise	0.8903	1.107

On the basis of these data, explain in which of these liquids intermolecular forces are stronger?

15. Dihydrogen reacts with dioxygen (O_2) to form water. Write the name and formula of the product when the isotope of hydrogen which has one proton and one neutron in its nucleus is treated with oxygen. Will the reactivity of both the isotopes be the same towards oxygen? Justify your answer.

16. Explain why HCl is a gas and HF is a liquid.

17. When the first element of the periodic table is treated with dioxygen, it gives a compound whose solid state floats on its liquid state. This compound has an ability to act as an acid as well as a base. What products will be formed when this compound undergoes autoionization?

18. Rohan heard that instructions were given to the laboratory attendent to store a particular chemical i.e., keep it in the dark room, add some urea in it, and keep it away from dust. This chemical acts as an oxidizing as well as a reducing agent in both acidic and alkaline media. This chemical is important for use in the pollution control treatment of domestic and industrial effluents.

(a) Write the name of this compound.

(b) Explain why such precautions are taken for storing this chemical.

19. Give reasons why hydrogen resembles alkali metals?

20. Hydrogen generally forms covalent compounds. Give reason.

21. Why is the ionization enthalpy of hydrogen higher than that of sodium?

22. Basic principle of hydrogen economy is transportation and storage of energy in the form of liquid or gaseous hydrogen. Which property of hydrogen may be useful for this purpose? Support your answer with the chemical equation if required.

23. What is the importance of heavy water?

24. Write the Lewis structure of hydrogen peroxide.

25. An acidic solution of hydrogen peroxide behaves as an oxidizing as well as reducing agent. Illustrate it with the help of a chemical equation.

26. With the help of suitable examples, explain the property of H_2O_2 that is responsible for its bleaching action?

27. Why is water molecule polar?

28. Why does water show high boiling point as compared to hydrogen sulphide? Give reasons for your answer.

29. Why can dilute solutions of hydrogen peroxide not be concentrated by heating. How can a concentrated solution of hydrogen peroxide be obtained?

30. Why is hydrogen peroxide stored in wax lined bottles?

31. Why does hard water not form lather with soap?

32. Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides. Why?

33. How will you account for 104.5° bond angle in water?

34. Write redox reaction between fluorine and water.

35. Write two reactions to explain amphoteric nature of water.

Matching Column Type

1. Correlate the items listed in Column-I with those listed in Column-II. Find out as many correlations as you can.

Column-I	Column-II
(a) Synthesis gas	(p) $Na_2[Na_4(PO_3)_6]$
(b) Dihydrogen	(q) Oxidizing agent
(c) Heavy water	(r) Used in softening of water
(d) Calgon	(s) Reducing agent
(e) Hydrogen peroxide	(t) Stoichiometric compounds of s-block elements
(f) Salt-like hydrides	(u) Produced by prolonged electrolysis of water
	(v) Zn + NaOH
	(w) Zn + dil. H_2SO_4
	(x) Synthesis of methanol
	(y) Mixture of CO and H_2

2. Match Column-I with Column-II for the given properties/applications mentioned therein.

Column-I	Column-II
(a) H	(p) Used in the name of perhydrol
(b) H_2	(q) Can be reduced to dihydrogen by NaH
(c) H_2O	(r) Can be used in hydroformylation of olefin
(d) H_2O_2	(s) Can be used in cutting and welding

3. Match the terms in Column-I with the relevant item in Column-II.

Column-I	Column-II
(a) Electrolysis of water produces	(p) Atomic reactor
(b) Lithium aluminium hydride is used as	(q) Polar molecule
(c) Hydrogen chloride is a	(r) Combines on metal surface to generate high temperature
(d) Heavy water is used in	(s) Reducing agent
(e) Atomic hydrogen	(t) Hydrogen and oxygen

4. Match the items in Column-I with the relevant item in Column-II.

Column-I	Column-II
(a) Hydrogen peroxide is used as a	(p) Zeolite
(b) Used in Calgon method	(q) Perhydrol
(c) Permanent hardness of water is removed by	(r) Hexametaphosphate
	(s) Propellant

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the options given below each question.

1. **Assertion (A):** Permanent hardness of water is removed by treatment with washing soda.

   Reason (R): Washing soda reacts with soluble magnesium and calcium sulphate to form insoluble carbonates.

   (a) Statements A and R both are correct and R is the correct explanation of A.

   (b) A is correct but R is not correct.

   (c) A and R both are correct but R is not the correct explanation of A.

   (d) A and R both are false.

2. **Assertion (A):** Some metals like platinum and palladium, can be used as storage media for hydrogen.

   Reason (R): Platinum and palladium can absorb large volumes of hydrogen.

   (a) Statements A and R both are correct and R is the correct explanation of A.

   (b) A is correct but R is not correct.

   (r) A and R both are correct but R is not the correct explanation of A.

   (d) A and R both are false.

Long Answer Type

1. Atomic hydrogen combines with almost all elements but molecular hydrogen does not. Explain.
2. How can D_2O be prepared from water? Mention the physical properties in which D_2O differs from H_2O. Give at least three reactions of D_2O showing the exchange of hydrogen with deuterium.
3. How will you concentrate H_2O_2? Show differences between structures of H_2O_2 and H_2O by drawing their spatial structures. Also mention three important uses of H_2O_2.
4. (a) Give a method for the manufacture of hydrogen peroxide and explain the reactions involved therein.

   (b) Illustrate oxidizing, reducing and acidic properties of hydrogen peroxide with equations.
5. What mass of hydrogen peroxide will be present in 2 litres of a 5 molar solution? Calculate the mass of oxygen which will be liberated by the decomposition of 200 mL of this solution.
6. A colorless liquid 'A' contains H and O elements only. It decomposes slowly on exposure to light. It is stabilized by mixing urea to store in the presence of light.

   (a) Suggest possible structure of A.

   (b) Write chemical equations for its decomposition reaction in light.
7. An ionic hydride of an alkali metal has significant covalent character and is almost unreactive towards oxygen and chlorine. This is used in the synthesis of other useful hydrides. Write the formula of this hydride. Write its reaction with Al_2Cl_6.
8. Sodium forms a crystalline ionic solid with dihydrogen. The solid is nonvolatile and non-conducting in nature. It reacts violently with water to produce dihydrogen gas. Write the formula of this compound and its reaction with water. What will happen on electrolysis of the melt of this solid.

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Hydrogen burns in air with light bluish flame.
2. (a) Ortho-hydrogen and para-hydrogen are nuclear isomers based on nuclear spin, isomers of hydrogen are protium, deuterium, and tritium.
3. (a) $Mg + HCl \rightarrow MgCl_2 + H_2$

   Cu, P, and Pt are weak reducing agent.
4. (d) Hydrogen is colorless.
5. (a) Ordinary hydrogen at room temperature is a mixture of 75% of ortho-hydrogen and 25% of para-hydrogen.
6. (c) Occlusion—The property of metal to absorb any gas is called occlusion.
7. (d) $Ca + H_2 \rightarrow CaH_2$ (Hydrolith)
8. (b) $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2\uparrow$

10. (c) Reactivity order

    Atomic hydrogen > Nascent hydrogen > Molecular hydrogen

11. (b) Solubility of ionic compound smallar in heavy water than simple water because value of die-electric constant $|c^2|N.m^2$ for water 78.39 and D_2O 78.06

13. (c) $CO_{(2)} + H_2O_{(d)} \xrightarrow[\substack{Fe_2O_3|Cr_2O_3 \\ (Catalyst)}]{673\text{ K}} CO_{2(2)} + H_{2(g)}$

This is called water-gas shift reaction/Bosch process.

14. (d) $Ca + H_2 \rightarrow \underset{\substack{(A) \\ (Hydrolith)}}{CaH_2} \xrightarrow{H—OH} Ca(OH)_2 + H_2$

16. (c) $Zn + \text{conc. } H_2SO_4 \rightarrow ZnSO_4 + SO_2 \uparrow$

19. (d) $SO_3 + D_2O \rightarrow D_2SO_4$ (Dideutero sulphuric acid)

25. (c) $\underset{(A)}{Ca(OH)_2} + Na_2CO_3 \rightarrow CaCO_3 + NaOH$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

$Ca(OH)_2$ is used to remove temporary hardness in Clark's method.

30. (b) Presence of calcium and magnesium salts in the form of hydrogen carbonate, chloride, and sulphate in water makes water hard water.

32. (a) Temporary hardness is due to the presence of magnesium and calcium hydrogen carbonate.

57. (c) In ortho-hydrogen spin of nucleus is same, so they will repeal each other and because of this repulsion internal energy of ortho-hydrogen increase, so, ortho-hydrogen has more internal energy.

66. (b) $N_2 + 3H_2 \xrightarrow[200\text{ atm, Fe}]{673\text{ K}} 2NH_3(g), OH^{\oplus} =$ 92.6 kJ/mol

69. (b) Deuterium is called heavy hydrogen.

70. (c) Tritium

75. (a) The mixture of CO and H_2 is called water gas.

76. (c) The mixture of CO and H_2 is called water gas. As this mixture of CO and H_2 is used for the synthesis of methonol and a number of hydrocarbons, it is also called synthesis gas or syngas.

81. (a) H_2 reacts with halogen, X_2 to give hydrogen halide

$H_{2(g)} + X_{2(g)} \rightarrow 2\,HX_{(g)}$ (X = F, Cl, Br, I)

order of reactivity

$F_2 > Cl_2 > Br_2 > I_2$

While the reaction with fluorine occurs even in dark, with iodine it requires a catalyst.

NCERT Exemplar Exercises

Short Answer Type

12. 5 volume H_2O_2 solution means that hydrogen peroxide contained in 1 volume of this solution will decompose to give 5 volumes of oxygen at STP i.e. if 1 L of this solution is taken, then 5 L of oxygen can be produced from this at STP. Chemical equation for the decomposition of H_2O_2 is $2H_2O_2(l) \rightarrow O_2(g) + H_2O(l)$.

It shows that 68 g H_2O_2 gives 22.7 L of O_2 at STP, so 5 L oxygen will be obtained from:

$$\frac{68\text{ g} \times 5\text{L}}{22.7\text{L}} = \frac{3400}{227}\text{ g } H_2O_2 = 14.9\text{ g} \approx 15\text{ g } H_2O_2$$

i.e., 15 g H_2O_2 dissolved in 1 L solution will give 5 L oxygen or 1.5 g H_2O_2/100 mL solution will give 500 mL oxygen. Thus 15 g/L or 1.5% solution is known as 5 volume solution of H_2O_2.

15. [**Hint:** Heavy water; Bond dissociation energy of dihydrogen is less than dideuterium]

17. [**Hint:** $H_2O + H_2O \rightarrow H_3O^+ + {}^-OH$]

18. (a) H_2O_2

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	**2.** (a)	**3.** (a)	**4.** (d)	**5.** (a)	**6.** (c)	**7.** (d)	**8.** (b)	**9.** (c)	**10.** (c)
11. (b)	**12.** (c)	**13.** (c)	**14.** (d)	**15.** (a)	**16.** (c)	**17.** (c)	**18.** (b)	**19.** (d)	**20.** (c)
21. (d)	**22.** (a)	**23.** (b)	**24.** (b)	**25.** (c)	**26.** (d)	**27.** (d)	**28.** (b)	**29.** (b)	**30.** (b)
31. (b)	**32.** (a)	**33.** (d)	**34.** (c)	**35.** (c)	**36.** (a)	**37.** (c)	**38.** (c)	**39.** (c)	**40.** (d)
41. (a)	**42.** (d)	**43.** (a)	**44.** (d)	**45.** (c)	**46.** (c)	**47.** (b)	**48.** (b)	**49.** (a)	**50.** (c)
51. (b)	**52.** (a)	**53.** (c)	**54.** (b)	**55.** (c)	**56.** (c)	**57.** (c)	**58.** (d)	**59.** (d)	**60.** (c)
61. (d)	**62.** (a)	**63.** (b)	**64.** (d)	**65.** (d)	**66.** (b)	**67.** (d)	**68.** (d)	**69.** (b)	**70.** (c)

71. (a) 72. (b) 73. (d) 74. (b) 75. (a) 76. (c) 77. (d) 78. (c) 79. (b) 80. (d)
81. (a)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (d) 3. (b) 4. (d) 5. (c) 6. (b) 7. (b) 8. (c) 9. (b) 10. (c)
11. (c) 12. (d) 13. (b) 14. (d) 15. (a) 16. (c) 17. (a) 18. (a)

Multiple Correct Answers Type

1. (c), (d) 2. (a), (b) 3. (a), (c) 4. (a), (b) 5. (c), (d) 6. (a), (b) 7. (b), (c) 8. (a), (d) 9. (a), (b), (c)

Matching Column Type

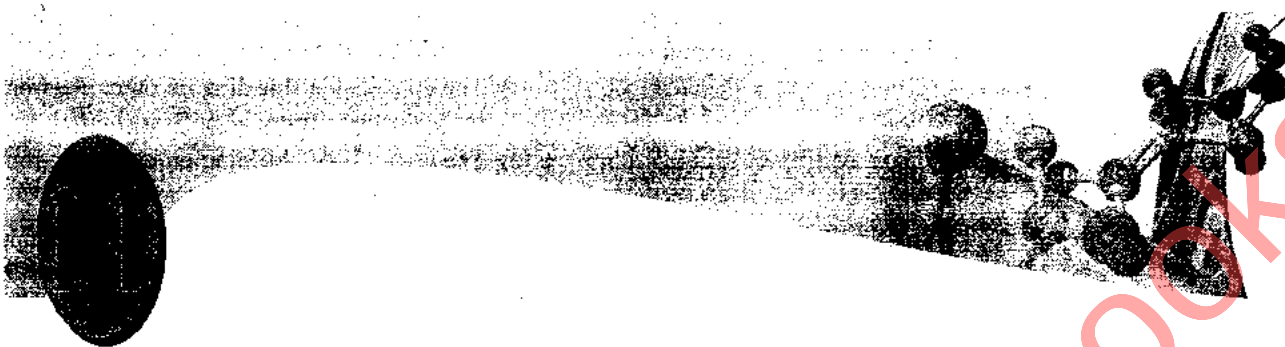
1. (a) → (x, y); (b) → (s, t, u, v, w); (c) → (t, u); (d) → (p, r); (e) → (q), (s) (f) → (t)
2. (a) → (s); (b) → (r); (c) → (q); (d) → (p)
3. (a) → (t); (b) → (s); (c) → (q); (d) → (p); (E) → (r)
4. (a) → (q, s); (b) → (r); (c) → (p, r)

Assertion-Reasoning Type

1. (a) 2. (b)

Long Answer Type

5. 68 g, 3.2 g



f-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Lanthanoids used in glass blower's goggles are:
   (a) Pr and Nd (b) Eu and Gd
   (c) Tb and Dy (d) Pm and Sm

2. Most common oxidation state of lanthanoid series is:
   (a) +2 (b) +3
   (c) +4 (d) +1

3. The electronic configuration of actinoids cannot be assigned with degree of certainty because of:
   (a) Overlapping of inner orbitals
   (b) Free movement of electrons over all the orbitals
   (c) Small energy difference between 5*f* and 6*d* levels
   (d) None of above

4. Consider the following statements in respect of lanthanoids:
   (i) The basic strength of hydroxides of lanthanoids increases from $La(OH)_3$ to $Lu(OH)_3$.
   (ii) The lanthanoid ions Lu^{3+}, Yb^{2+}, and Ce^{4+} are diamagnetic. Which of the statement(s) given above is/are correct?
   (a) (i) Only (b) (ii) Only
   (c) Both (i) and (ii) (d) Neither (i) nor (ii)

5. Lanthanoid contraction implies:
   (a) Decrease in density
   (b) Decrease in mass
   (c) Decrease in ionic radii
   (d) Decrease in radioactivity

6. If the lanthanoid element with *x f* electrons has a pink color, then the lanthanoid with **(14 – *x*)** *f* electrons will have the color as:
   (a) Blue (b) Red
   (c) Green (d) Pink

7. In aqueous solution, Eu^{2+} ion acts as:
   (a) An oxidizing agent (b) A reducing agent
   (c) Either (a) or (b) (d) None of these

8. The actinoids showing +7 oxidation state are:
   (a) U, Np (b) Pu, Am
   (c) Np, Pu (d) Am, Cm

9. Among the lanthanoids the one obtained by synthetic method is:
   (a) Lu (b) Pm
   (c) Pr (d) Gd

10. Across the lanthanoid series, the basicity of the lanthanoid hydroxides:
    (a) Increases
    (b) Decreases
    (c) First increases and then decreases
    (d) First decreases and then increases

11. The reason for the stability of Gd^{3+} ion is:
    (a) 4*f* subshell—half filled

(b) $4f$ subshell—completely filled
(c) Possesses the general electronic configuration of noble gases
(d) $4f$ subshell empty

12. Most common oxidation states shown by cerium are:
(a) +2, +4 (b) +3, +4
(c) +3, +5 (d) +2, +3

13. The +3 ion of which one of the following has half filled $4f$ subshell?
(a) La (b) Lu
(c) Gd (d) Ac

14. Arrange Ce^{3+}, La^{3+}, Pm^{3+}, and Yb^{3+} in *increasing order* of their ionic radii:
(a) $Yb^{3+} < Pm^{3+} < Ce^{3+} < La^{3+}$
(b) $Ce^{3+} < Yb^{3+} < Pm^{3+} < La^{3+}$
(c) $Yb^{3+} < Pm^{3+} < La^{3+} < Ce^{3+}$
(d) $Pm^{3+} < La^{3+} < Ce^{3+} < Yb^{3+}$

15. The radius of La^{3+} (At. No. of La = 57) is 1.06 Å. Which one of the following given values will be closest to the radius of Lu^{3+} (At. No. of Lu = 71)?
(a) 1.40 Å (b) 1.06 Å
(c) 0.85 Å (d) 1.60 Å

16. A reduction in atomic size with increase in atomic number is a characteristic of elements of:
(a) *d*-block (b) *f*-block
(c) Radioactive series (d) High atomic masses

17. Cerium (Z = 58) is an important member of the lanthanoids. Which of the following statement about cerium is incorrect?
(a) The common oxidation states of cerium are +3 and +4
(b) Cerium(IV) acts as an oxidizing agent
(c) The +4 oxidation state of cerium is more stable in solutions
(d) The +3 oxidation state of cerium is more stable than the +4 oxidation state

18. The lanthanoid contraction is responsible for the fact that:
(a) Zr and Nb have similar oxidation state
(b) Zr and Y have about the same radius
(c) Zr and Zn have the same oxidation state
(d) Zr and Hf have about the same radius

19. Lanthanoid contraction is caused due to
(a) The same effective nuclear charge from Ce to Lu
(b) The imperfect shielding on outer electrons by $4f$ electrons from the nuclear charge
(c) The appreciable shielding on outer electrons by $4f$ electrons from the nuclear charge
(d) The appreciable shielding on outer electrons by $5d$ electrons from the nuclear charge

20. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because:
(a) The $5f$ orbitals extend further from the nucleus than the $4f$ orbitals
(b) The $5f$ orbitals are more buried than the $4f$ orbitals
(c) There is a similarity between $4f$ and $5f$ orbitals in their angular part of the wave function
(d) The actinoids are more reactive than the lanthanoids

21. The group of elements in which the differentiating electron enters into the antepenultimate shell of atoms is called:
(a) *f*-block elements (b) *p*-block elements
(c) *s*-block elements (d) *d*-block elements

22. Knowing that the chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statement is incorrect?
(a) The ionic sizes of Ln(III) decrease in general with increasing atomic number
(b) Ln(III) compounds are generally colorless
(c) Ln(III) hydroxides are mainly basic in character
(d) Because of the large size of the Ln(III) ions, the bonding in its compounds is predominantly ionic in character

23. Which is *not correct* statement about the chemistry of $3d$ and $4f$ series elements?
(a) $3d$-elements show more oxidation states than $4f$-series elements
(b) The energy difference between $3d$ and $4s$ orbitals is very little
(c) Europium(II) is more stable than Ce(II)
(d) The paramagnetic character in $3d$-series elements increases from scandium to copper

24. The maximum oxidation state exhibited by actinoid elements is:
(a) +5 (b) +4
(c) +7 (d) +8

25. Which of the following lanthanoid ion is paramagnetic?

(a) Ce^{4+} (b) Yb^{2+}
(c) Lu^{3+} (d) Eu^{2+}

26. In context of the lanthanoids, which of the following statement is not correct?
    (a) There is a gradual decrease in the radii of the members with increasing atomic number in the series
    (b) All the members exhibit +3 oxidation state
    (c) Because of similar properties, the separation of lanthanoids is not easy
    (d) Availability of $4f$ electrons results in the formation of compounds in +4 state for all the members of the series

27. The outer electronic configuration of Gd (At. No. = 64) is:
    (a) $4f^3\ 5d^5\ 6s^2$ (b) $4f^8\ 5d^0\ 6s^2$
    (c) $4f^4\ 5d^4\ 6s^2$ (d) $4f^7\ 5d^1\ 6s^2$

28. Consider the following statements:
    (i) $La(OH)_3$ is the least basic among hydroxides of lanthanoid.
    (ii) Zr^{4+} and Hf^{4+} possess almost the same ionic radii.
    (iii) Ce^{4+} can act as an oxidizing agent.

    Which of the above is/are true?
    (a) (i) and (iii) (b) (ii) and (iii)
    (c) (ii) only (d) (i) and (ii)
    (e) (i) only

29. On which factors, the stability of oxidation states of lanthanoid elements depends?
    (a) Enthalpy
    (b) Internal energy
    (c) Combined effects of hydration enthanlpy and ionization enthalpy
    (d) Electronic configuration

NCERT Exemplar Exercises

Single Correct Answer Type

1. Which of the following oxidation state is common for all lanthanoids?
   (a) +2 (b) +3
   (c) +4 (d) +5

2. There are 14 elements in actinoid series. Which of the following elements does not belong to this series?
   (a) U (b) Np
   (c) Tm (d) Fm

3. Gadolinium belongs to $4f$ series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?
   (a) [Xe] $4f^7 5d^1 6s^2$ (b) [Xe] $4f^6 5d^2 6s^2$
   (c) [Xe] $4f^8 6d^2$ (d) [Xe] $4f^9 5s^1$

4. Although Zirconium belongs to $4d$ transition series and Hafnium to $5d$ transition series even then they show similar physical and chemical properties because ______.
   (a) Both belong to d-block
   (b) Both have same number of electrons
   (c) Both have similar atomic radius
   (d) Both belong to the same group of the periodic table

Multiple Correct Answers Type

1. Generally transition elements and their salts are colored due to the presence of unpaired electrons in metal ions. Which of the following compounds are colored?
   (a) $KMnO_4$ (b) $Ce(SO_4)_2$
   (c) $TiCl_4$ (d) Cu_2Cl_2

2. Which of the following actinoids show oxidation states up to +7?
   (a) Am (b) Pu
   (c) U (d) Np

3. General electronic configuration of actionoids is $(n-2)f^{1-14}\ (n-1)d^{0-2}ns^2$. Which of the following actinoids have one electron in $6d$ orbital?
   (a) U (Atomic no. 92) (b) Np (Atomic no. 93)
   (c) Pu (Atomic no. 94) (d) Am (Atomic no. 95)

4. Which of the following lanthanoids show +2 oxidation state besides the characteristic oxidation state +3 of lanthanoids?
   (a) Ce (b) Eu
   (c) Yb (d) Ho

5. Although +3 is the characteristic oxidation state for lanthanoids but cerium also shows +4 oxidation state because ______.
   (a) It has variable ionization enthalpy
   (b) It has a tendency to attain noble gas configuration
   (c) It has a tendency to attain f^0 configuration
   (d) It resembles Pb^{4+}

Short Answer Type

1. Ionization enthalpies of Ce, Pr, and Nd are higher than Th, Pa, and U. Why?
2. Although Zr belongs to $4d$ and Hf belongs to $5d$ transition series but it is quite difficult to separate them. Why?
3. Although +3 oxidation state is the characteristic oxidation state of lanthanoids but cerium shows +4 oxidation state also. Why?
4. The second and third rows of transition elements resemble each other much more than they resemble the first row. Explain why?

Matching Column Type

1. Match the compounds/elements given in Column-I with uses given in Column-II.

Column-I (Compound/element)	**Column-II (Use)**
(a) Lanthanoid oxide	(p) Production of iron alloy
(b) Lanthanoid	(q) Television screen
(c) Misch metal	(r) Petroleum cracking
(d) Magnesium-based alloy is	(s) Lanthanoid metal + iron constituent of
(e) Mixed oxides of	(t) Bullet lanthanoids are employed
	(u) In X-ray screen

2. Match the statements given in Column-I with the oxidation states given in Column-II.

Column-I	**Column-II**
(a) Oxidation state of Mn in MnO_2 is	(p) +2
(b) Most stable oxidation state of Mn is	(q) +3
(c) Most stable oxidation state of Mn in oxides is	(r) +4
(d) Characteristic oxidation state of lanthanoids is	(s) +5
	(t) +7

3. Match the property given in Column-I with the element given in Column-II.

Column-I (Property)	**Column-II (Element)**
(a) Lanthanoid which shows +4 oxidation state	(p) Pm
(b) Lanthanoid which can show +2 oxidation state	(q) Ce
(c) Radioactive lanthanoid	(r) Lu
(d) Lanthanoid which has $4f^7$ electronic configuration in +3 oxidation state	(s) Eu
(e) Lanthanoid which has $4f^{14}$ electronic configuration in +3 oxidation state	(t) Gd
	(u) Dy

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true, and reason is the correct explanation of the assertion.

(b) Both assertion and reason are true but reason is not the correct explanation of assertion.

(c) Assertion is not true but reason is true.

(d) Both assertion and reason are false.

1. **Assertion:** Separation of Zr and Hf is difficult.

   Reason: Because Zr and Hf lie in the same group of the periodic table.

2. **Assertion:** Actinoids form relatively less stable complexes as compared to lanthanoids.

   Reason: Actinoids can utilize their $5f$ orbitals along with $6d$ orbitals in bonding but lanthanoids do not use their $4f$ orbital for bonding.

3. On the basis of lanthanoid contraction, explain the following:
   (a) Nature of bonding in La_2O_3 and Lu_2O_3
   (b) Trends in the stability of oxo salts of lanthanoids from La to Lu
   (c) Stability of the complexes of lanthanoids
   (d) Radii of $4d$ and $5d$-block elements
   (e) Trends in acidic character of lanthanoid oxides

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Most common oxidation states of Ce (cerium) are:
   (a) +2, +3 (b) +2, +4
   (c) +3, +4 (d) +3, +5

   (AIEEE, 2002)

2. Arrange Ce^{+3}, La^{+3}, Pm^{+3}, and Yb^{+3} in increasing order of their ionic radii:
(a) $Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$
(b) $Yb^{+3} < Pm^{+3} < La^{+3} < Ce^{+3}$
(c) $La^{3+} < Ce^{3+} < Yb^{3+} < Pm^{3+}$
(d) $Pm^{+3} < La^{+3} < Ce^{+3} < Yb^{+3}$
(AIEEE, 2002)

3. The radius of La^{3+} (atomic number of La = 57) is 1.06 Å. Which one of the following given values will be closest to the radius of Lu^{3+} (Atomic number of Lu = 71)?
(a) 1.40 Å (b) 1.06 Å
(c) 0.85 Å (d) 1.60 Å
(AIEEE, 2002)

4. A reduction in atomic size with increase in atomic number is a characteristic of:
(a) *d*-block elements
(b) *f*-block elements
(c) Radioactive series elements
(d) High atomic mass elements
(AIEEE, 2003)

5. Cerium (Z = 58) is an important member of the lanthanides. Which of the following statements about cerium is incorrect?
(a) The +4 oxidation state of cerium is not known in solutions
(b) The +3 oxidation state of cerium is more stable than the +4 oxidation state
(c) The common oxidation states of cerium are +3 and +4
(d) Cerium (IV) acts as an oxidizing agent
(AIEEE, 2004)

6. The lanthanide contraction is responsible for the fact that:
(a) Zr and Zn have the same oxidation state
(b) Zr and Hf have about the same radius
(c) Zr and Nb have similar oxidation state
(d) Zr and Y have about the same radius
(AIEEE, 2005)

7. Which of the following factors may be regarded as the main cause of lanthanide contraction?
(a) Greater shielding of 5*d*-electrons by 4*f*-electrons
(b) Poorer shielding of 5*d*-electrons by 4*f*-electrons
(c) Effective shielding of one of 4*f*-electrons by another in the subshell
(d) Poor shielding of one of 4*f*-electrons by another in the subshell
(AIEEE, 2005)

8. Lanthanide contraction is caused due to:
(a) The same effective nuclear charge from Ce to Lu
(b) The imperfect shielding on outer electrons by 4*f*-electrons from the nuclear charge
(c) The appreciable shielding on outer electrons by 4*f*-electrons from the nuclear charge
(d) The appreciable shielding on outer electrons by 5*d*-electrons from the nuclear charge
(AIEEE, 2006)

9. Identify the incorrect statement among the following statements:
(a) 4*f*- and 5*f*-orbitals are equally shielded
(b) *d*-block elements show irregular and erratic chemical properties among themselves
(c) La and Lu have partially filled *d*-orbitals and no other partially filled orbitals
(d) The chemistry of various lanthanides is very similar
(AIEEE, 2007)

10. The actinides exhibit more number of oxidation states in general than the lanthanides. This is because:
(a) The 5*f*-orbitals extend further from the nucleus than the 4*f*-orbitals
(b) The 5*f*-orbitals are more buried than the 4*f*-orbitals
(c) There is a similarity between 4*f*- and 5*f*-orbitals in their angular part of the wave function
(d) The actinides are more reactive than the lanthanides
(AIEEE, 2007)

11. Larger number of oxidation states is exhibited by the actinides than those by the lanthnides because:
(a) 4*f*-orbitals are more diffused than the 5*f* orbitals
(b) Of lesser energy difference between 5*f*- and 6*d*-orbitals than between 4*f*- and 5*d*-orbitals
(c) Of more energy difference between 5*f*- and 6*d*-orbitals than between 4*f*- and 5*d*-orbitals
(d) Of more reactive nature of the actinides than the lanthanides
(AIEEE, 2008)

12. Knowing that the chemistry of lanthanides (Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect?
(a) The ionic size of Ln(III) decreases in general with increasing atomic number

(b) Ln(III) compounds are generally colorless
(c) Ln(III) hydroxide is mainly basic in character
(d) Because of the large size of the Ln(III) ions, the bonding in its compounds is predominantly ionic in character

(AIEEE, 2009)

13. In context of the lanthanides, which of the following statements is not correct?
(a) There is a gradual decrease in the radii of the members with increasing atomic number in the series
(b) All the members exhibit +3 oxidation state
(c) Because of similar properties, the separation of lanthanides is not easy
(d) Availability of 4*f*-electrons results in the formation of compounds in +4 oxidation state for all the members of the series

(AIEEE, 2011)

14. The outer electron configuration of Gd (Atomic No. = 64) is:
(a) $4f^3\,5d^5\,6s^2$ (b) $4f^8\,5d^{10}\,6s^2$
(c) $4f^4\,5d^4\,6s^2$ (d) $4f^7\,5d^1\,6s^2$

(AIEEE, 2011)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Pr and Nd: Lantharoids used in glass blower's goggles.
2. (b) +3 Most common oxidation state of larthanoid series.
3. (c) The electronic configuration of actinoids cannot be assigned with degree of certainty because of small energy difference between *sf* and *bd* levels.
4. (b) $La(OH)_3$ is most basic in nature while $Lu(OH)_3$ least basic.
5. (c) Lanthanoid contraction implies decrease in ionic radii.
6. (d) The ions often with $4f^n$ configuration have similar color to those ions having $4f^{14-n}$ configuration.
7. (b) In aqueous solution, E_4^{+2} ions acts as a reducing agent.
8. (c) Np and PU actinoids showing +7 oxidation state.
11. (a) $Gd = 4f^7\,5d^1\,6s^2$
$Gd^{+2} = 4f^7$
4*f* subshell half filled
12. (b) The formation of Ce^{+4} is favored by its noble gas configuration, but it is a strong oxidant reverting to the common +3 0.5. The value of E° for Ce^{+4}/Ce^{+3} is 1.74 V which suggests that it can oxidize water.
13. (c) $Gd = 4f^7\,5d^1\,6s^2$
$Gd^{+3} = 4f^7$
14. (a) The overall decrease in atomic and ionic radii from lanthanum to lutetium

$$Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$$

15. (c) The overall decreases in atomic and ionic radii from lanthanum to lutetium

$$La^{+3} = 1.06\ Å$$
$$Lu^{+3} = 0.85\ Å$$

17. (c) The E° value for Ce^{+4}/Ce^{+3} is 1.74 V which suggests that it can oxidize water.
20. (a) There is a greater range of oxidation states, which is in part attributed to the fact that the 5*f*, 6*d*, and 7*s* levels are of comparable energies.
22. (b) The lanthanide ions have unpaired electrons in their orbitals, thus these ions absorb visible region of light and undergo *f*-*f* transition and hence exhibit color.
29. (c) The stability of oxidation states of lanthanoid elements depends on combined effects of hydration enthalpy and ionization enthalpy.

NCERT Exemplar Exercises

Short Answer Type

1. **Hint:** It is because in the beginning, when 5*f* orbitals begin to be occupied, they will penetrate less into the inner core of electrons. The 5*f* electrons will therefore, be more effectively shielded from the nuclear charge than 4*f* electrons of the corresponding lanthanoids. Therefore outer electrons are less firmly held and they are available for bonding in the actinoids.

2. **Hint:** Due to lanthanoid contraction, they have almost same size (Zr, 160 pm) and (Hf, 159 pm).

3. It is because after losing one more electron, Ce acquires stable $4f^0$ electronic configuration.

4. Due to lanthanoid contraction, the atomic radii of the second and third row transition elements is almost same. So, they resemble each other much more as compared to first row elements.

Assertion-Reasoning Type

3. **Hint:**
   (a) As the size decreases, covalent character increases. Therefore, La_2O_3 is more ionic and Lu_2O_3 is more covalent.
   (a) As the size decreases from La to Lu, stability of oxosalts also decreases.
   (c) Stability of complexes increases as the size of lanthanoids decreases.
   (d) Radii of 4*d*- and 5*d*-block elements will be almost same.
   (e) Acidic character of oxides increases from La to Lu.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) +3, +4
2. (a) $La^{3+} > Ce^{3+} > Pm^{3+} > Yb^{3+}$

   In lanthanides, there is fairly regular decrease in the sizes with increasing atomic numbers.
3. (c) Refer Solution 2.
4. (b) Refer Solution 2.

   The overall decrease in atomic and ionic radii from lanthanum to lutetium (the lanthanide contraction) is a unique feature in the chemistry of the lanthanides.
5. (a) Formation of Ce^{+4} is favored due to its noble gas configuration. Thus, answer is (a). +3 is the common most oxidation state though for cerium.
6. (b) The filling of 4*f* before 5*d*-orbital results in a regular decrease in atomic radii called lanthanide contraction, which essentially compensates for the expected increase in atomic size with increasing atomic number. The net result of the lanthanide contractions is that the corresponding elements of second and the third *d*-series exhibit similar radii (e.g., Zr 160 pm, Hf 159 pm) and have very similar physical and chemical properties.
7. (d) Lanthanide contraction can be defined as the following:

   Due to high electrostatic attraction of protons on *ns* and *np* electrons, coupled with poor shielding of $(n-1)$ of electrons, there is continuous decrease in size from left to right in the series. As a result of lanthanide contraction, the radii of the members of the third transition series are very similar to those of the corresponding members of the second series.
8. (c) Refer Solution 7, $m = \sqrt{n(n+2)}$

   In Ni^{2+}, unpaired electrons is 2.

   $$\therefore m = \sqrt{2(2+2)} = \sqrt{8}$$
   $$= 2.828$$
   $$= 2.84$$
9. (a) Shielding of 5*f* is low as compared with 4*f*.
10. (a) Due to lesser energy differences between 5*f* and 6*d* than between 4*f*- and 5*d*-orbitals.
11. (b) Lesser energy difference between 5*f*- and 6*d*-orbitals as compared with 4*f*- and 5*d*-orbitals.
12. (b) Most of Ln^{3+} compounds are colored.
13. (d) Because +4 state, 0.5 for lanthanides is occasional.
14. (d) It is a fact.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	2. (b)	3. (c)	4. (b)	5. (c)	6. (d)	7. (b)	8. (c)	9. (b)	10. (b)
11. (a)	12. (b)	13. (c)	14. (a)	15. (c)	16. (b)	17. (c)	18. (d)	19. (b)	20. (a)
21. (a)	22. (b)	23. (d)	24. (c)	25. (d)	26. (d)	27. (d)	28. (b)	29. (c)	

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (c) 3. (a) 4. (c)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (d) 3. (a), (b) 4. (b), (c) 5. (b), (c)

Matching Column Type

1. (a) → (q); (b) → (p); (c) → (s); (d) → (t); (e) → (r)
2. (a) → (r); (b) → (p); (c) → (t); (d) → (q)
3. (a) → (q); (b) → (s); (c) → (p); (d) → (t); (e) → (r)

Assertion-Reasoning Type

1. (a) 2. (b)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) 2. (a) 3. (c) 4. (b) 5. (a) 6. (b) 7. (d) 8. (c) 9. (a) 10. (a)
11. (b) 12. (b) 13. (d) 14. (d)

Quantum Number

JEE (Advanced) Exercises

Single Correct Answer Type

1. Spin only magnetic moment of dipositive ion of Zn is:
   (a) 0 (b) $\sqrt{8}$ BM
   (c) $\sqrt{24}$ BM (d) $\sqrt{35}$ BM

2. In boron atom screening on the last electron is due to:
   (a) Electrons of 'K' shell only
   (b) All the electrons of K and L shell
   (c) 2-Electrons of 1s and 2s each
   (d) All the electrons of L shell only

3. The zero probability of finding the electron in p_x orbitals:
   (a) Two opposite sides of the nucleus along x-axis
   (b) In the nucleus
   (c) Same on all the sides around the nucleus
   (d) None of these

4. Which electronic configuration does not follow the Pauli's exclusion principle?
   (a) $1s^2, 2s^2, 2p^4$ (b) $1s^2, 2s^2, 2p^4, 3s^2$
   (c) $1s^2, 2p^4$ (d) $1s^2, 2s^2\ 2p^6, 3s^3$

5. In which of the following orbitals, there is zero probability of finding electron in XY plane:
   (a) p_x (b) p_y
   (c) d_{xy} (d) d_{xz}

6. Choose the correct set of quantum number of last electron of $_{29}$Cu:
   (a) $3, 1, 0, +\frac{1}{2}$ (b) $3, 2, -3, +\frac{1}{2}$
   (c) $3, 2, -2, -\frac{1}{2}$ (d) None of these

7. Which of the following statement is **Correct**?
   (a) Total number of electrons in a subshell is $2\ell + 1$
   (b) p_z, $d_{x^2-y^2}$ and d_{z^2} orbitals are non-axial
   (c) Only s-orbitals has directional orientation while p_z, d, and f-orbitals have non-directional properties
   (d) Spin multiplicity of N-atom is 4

8. Find the sum of maximum number of electrons having +1 and –1 value of 'm' in Ti:
   (a) 6 (b) 8
   (c) 10 (d) 12

9. Imagine a Universe in which four quantum numbers can have same possible value as in our universe except the magnetic quantum number (m) can have integral values from 0 to $\pm(\ell + 1)$. Find the electronic configuration of atomic number 20.
   (a) $1s^6\ 2s^6\ 2p^8$
   (b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
   (c) $1s^4\ 2s^4\ 2p^6\ 3s^4\ 3p^2$
   (d) $1s^2\ 1p^6\ 2s^2\ 1d^{10}$

10. Choose the correct set of quantum number of last electron entered of $_{29}$Cu:

(a) $3, 1, 0, +\frac{1}{2}$ (b) $3, 2, -3, +\frac{1}{2}$

(c) $3, 2, -2, -\frac{1}{2}$ (d) None of these

11. Find the correct set of quantum numbers for 30^{th} electron entered into Ga (At. No. 31):

	n	l	m	s
(a)	4	1	0	$-\frac{1}{2}$
(b)	4	1	1	$+\frac{1}{2}$
(c)	3	2	−1	$+\frac{1}{2}$
(d)	4	0	0	$-\frac{1}{2}$

12. The subshell which are filled just before and just after the filling of $5p$ subshell are respectively:

(a) $5sd$, $5d$ (b) $4d$, $6s$

(c) $4d$, $4f$ (d) $6s$, $4f$

13. The value of $(n \times l \times m)$ for the last electron entered in K is:

(a) 2 (b) 3

(c) 4 (d) 0

Multiple Correct Answers Type

1. Which of the following is/are correct:

(a) In single electron species subshells of same shell are degenerate in the absence of external electric and magnetic field

(b) In multielectron atoms, orbitals of same subshell are degenerate in the absence of external electric and magnetic field

(c) $3d$ subshell is filled completely before $4s$

(d) Energy order of subshell s in single electron species is decided by $(n + \ell)$ rule

2. Which of the following set of quantum numbers is/are valid for electrons of ground state electronic configuration of elements, having atomic no. up to 25.

	n	ℓ	m	s
(a)	3	2	0	$+\frac{1}{2}$
(b)	4	0	0	$+\frac{1}{2}$
(c)	4	1	0	$-\frac{1}{2}$
(d)	2	2	+1	$+\frac{1}{2}$

3. Which of the following may have same set of quantum no?

(a) Last electron of Ga and last electron of Zn

(b) Unpaired electron of S and entered electron in S^-

(c) Last electron of Sc and last e^- of Cr

(d) Unpaired electron in $2p$ orbital of N and unpaired electron in $2p$ orbital of F

4. Select the incorrect statement:

(a) In $d_{x^2-y^2}$ orbital 2 nodal planes are in xz and yz plane

(b) d_{xy} and $d_{x^2-y^2}$ have one common nodal plane

(c) One $4d$ orbital contains only 2 electrons of same spin

(d) One $3d$ orbital contains a total of 10 electrons

5. Choose the correct statement among the following:

(a) Number of orbitals in n^{th} shell are n^2

(b) Number of orbitals in a subshell are $(2\ell + 1)$

(c) Number of subshell in n^{th} shell are n

(d) Number of electrons in an orbital of subshell are $2(2\ell + 1)$

6. Select the incorrect statement(s) from the following options:

(a) The nodal plane of p_x identical with that of p_y orbital

(b) d_{yz} orbital has two nodal plane which are xz and yz planes

(c) p_x, p_y, and p_z orbitals have the same value of 'ℓ'

(d) d_{xy}, $d_{x^2-y^2}$, and d_{z^2} orbitals have the different orientation in space but have the same value of 'm'

7. Which of the following can be a stable ground state electronic configuration (only valence shell) of carbon atom?

(a) $2s^2$: [$\uparrow\downarrow$] $2p^2$: [$\downarrow$][$\downarrow$][ ]
(b) $2s^2$: [$\uparrow\downarrow$] $2p^2$: [$\downarrow$][ ][$\downarrow$]

(c) $2s^2$: [$\uparrow\downarrow$] $2p^2$: [ ][$\uparrow$][$\uparrow$]
(d) $2s^2$: [$\uparrow\downarrow$] $2p^2$: [ ][$\downarrow$][$\downarrow$]

8. Choose the correct statement among the following:

(a) Number of orbitals in n^{th} shell are n^2

(b) Number of orbitals in ℓ^{th} subshell are $(2\ell + 1)$

(c) Number of subshell in n^{th} shell are n

(d) Number of electrons in an orbital of ℓ^{th} subshell are $2(2\ell + 1)$

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

The plane and point at which zero electron density exists is known as nodal plane and nodal point. Nodal plane also refers as angular node. Number of angular nodes depends on shape of orbital only and size of orbital has no role in it.

Based on the comprehension above, answer the following questions:

1. Ratio of number of nodal plane in $6d_{xy}$ orbital to $3dxz$ is:
   (a) 0 (b) 1
   (c) 2 (d) 3

2. Which of the following pair of orbitals contains at least one common nodal plane:
   (a) p_x and p_y (b) d_{xz} and d_{z^2}
   (c) d_{xy} and p_z (d) d_{xz} and p_x

3. Select the correct statement:
   (a) In d_{z^2} orbital 2 nodal planes are in xz and yz plane
   (b) d_{z^2} and $d_{x^2-y^2}$ have one common nodal plane
   (c) One $4d$ orbital contains only 2 electrons of opposite spin
   (d) One $3d$ orbital contains a total of 10 electrons

Comprehension-2: (Q. 4 to Q. 6)

Imagine a universe in which the four quantum number can have the following values.

$$n = 1 \text{ to } \infty$$
$$\ell = 0 \text{ to } n$$
$$m = -(\ell + 1) \text{ to } +(\ell + 1) \text{ including zero}$$
$$s = +\frac{1}{2} \text{ and } -\frac{1}{2}$$

Answer the following questions based on the above values:

4. Total number of elements in the III period of periodic table is:
   (a) 8 (b) 20
   (c) 30 (d) 15

5. If Aufbau $(n + \ell)$ rule is valid then block of Zn is: [Atomic number of Zn = 30]
   (a) s-block (b) p-block
   (c) d-block (d) f-block

6. Spin only magnetic moment (μ) of the element sulphur (S) is: [Atomic number of S = 16]
   (a) 0 (b) $\sqrt{3}$ BM
   (c) $\sqrt{8}$ BM (d) $\sqrt{15}$ BM

Comprehension-3: (Q. 7 and Q. 8)

Imagine a universe in which the four quantum number varies as:

$$n = 1, 2, 3, \dots \infty$$
$$\ell = 0 \text{ to } n$$
$$m = -2\ell \text{ to } +2\ell$$
$$s = +\frac{1}{2} \text{ and } -\frac{1}{2}$$

By using above concept of atom, answer the following:

7. Maximum electrons which can be accommodated in 3rd shell are:
   (a) 32 (b) 18
   (c) 56 (d) 48

8. If ground state electronic configuration of $_{17}Cl$ is written by using above set of definition of quantum number, then last electron will enter in:
   (a) $3p$ (b) $1d$
   (c) $2s$ (d) $2p$

Comprehension-4: (Q. 9 and Q. 10)

Electronic configuration of penultimate shell of an element is $2s^2\ 2p^6$. In valence shell, 2 electrons are in s and 4 electrons are in p-subshell. If atomic mass is twice to that of atomic number, then answer the following questions: **(Take: $N_A = 6 \times 10^{23}$)**

9. Total number of protons present in 6.4 g of the element:
   (a) 1×10^{24} (b) 1.2×10^{23}
   (c) 2×10^{24} (d) 19.2×10^{23}

10. Maximum number of electrons in an atom of the given element having $\ell = 1$ and $s = -\frac{1}{2}$
   (a) 11 (b) 6
   (c) 4 (d) 1

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Fe^{+2}	(p) Set of quantum number for last e^- $n = 2, \ell = 1, m = 1, s = +\frac{1}{2}$
(b) Mn^{+4}	(q) Magnetic moment (μ) = zero
(c) Zn^{+2}	(r) Spin multiplicity (SM) = 4
(d) Na^+	(s) Total number of exchange pair in $3d$-subshell = 10
	(t) Paramagnetic

Integer Answer Type

1. Find maximum number of electrons in 'Al' in which $\frac{l \times m}{n} = 0$. [At. no. of Al = 13]
2. Find total number of orbitals in 'S' atom, for which $|m| \le 1$ and contains at least one electron. [At. no. of S = 16]
3. Ltal number of '5s' electrons in 'Pd' is ______. [At. no. of Pd = 46]
4. Total no. of exchange pair possible in $3d^8$ electronic configuration is ______.

   [If answer is in double digits, then add all the digits, till obtain the single digit]
5. Find the $(n + l)$ value for the last electron entered into Hf.
6. Find |total spin| of 3*d* electron Fe^{+x} ion, if its magnetic moment is $\sqrt{24}$ BM.
7. Find total number of orbitals in which electron density is observed along any of the axis (*x* or *y* or *z*). $s, p_x, p_y, p_z, d_{xy}, d_{xz}, d_{yz}, d_{z^2}, d_{x^2-y^2}$.
8. Find the $(n + l)$ value for the last electron entered into Ga. [Atomic no. 31]
9. What is the value of $(n + \ell)$ for the unpaired e^- in an atom of an element which is present in the third period and seventeenth group of the periodic table.
10. In multielectronic atom, maximum number of degenerated orbitals present in 3rd shell.
11. Calculate maximum number of electrons in $_{25}Mn$ which have $n = 3$, $m = 0$ and $s = +\frac{1}{2}$.
12. Find the total number of orbitals present in 'M' shell of an atom.
13. Find the $(n + \ell)$ value for 4*f* orbital.
14. Find the value of $n + \ell$ for the last electron of $_{19}K$.
15. Find the maximum number of electrons in Cr atom which have $m = -1$ and $s = +\frac{1}{2}$ but $n \ne 2$.
16. In case of *s* and *p*-orbital electrons, each of the $(n - 2)^{th}$ shell electrons shield the n^{th} shell (valence shell) electron by.
17. Find the maximum number of electrons having $(n + l + m)$ equal to zero in Cr, if it follows aufbau principle.
18. Find the number of electrons having $(n \times l + m) = 3$ for Kr-atom (At. number: $Z = 36$).
19. Find the maximum number of e^- having *m* value ≤ 1 in Cr.

Hints & Solutions

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) According to E.C. Zn^{2+} ion has no unpaired electron so spin only magnetic moment for Zn^{2+} ion is 0.

   $Zn^{2+} \Rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6\, 3d^{10}, 4s^0$
2. (c) E.C. of B is $1s^2, 2s^2, 2p^1$

   in which last electron of 2*p* is shielded by electron of 1*s*, 2*s*
9. (a) $m = 0$ to $\pm(\ell + 1)$

   $n = 1$ $\ell = 0$ $m = -1, 0, 1$

   $n = 2$ $\ell = 1$ $m = -2, -1, 0, 1, 2$

   $n = 3$ $\ell = 2$ $m = -3, -2, -1, 0, 1, 2, 3$

   Hence *s* subshell will have 3 orbitals

   and *p* subshell will have 5 orbitals

   d subshell will have 7 orbitals

   hence configuration is

   $1s^6\, 2s^6\, 2p^8$
13. (d) $K[Ar]\,4s^1$

   $n = 4$

   $\ell = 0$

   $m = 0$

   $n \times \ell \times m = 0$

Integer Answer Type

1. (9) $_{13}A\ell$

0	0	−1 0 +1	0	0
⇅	⇅	⇅ ⇅ ⇅	⇅	↑ □ □
1*s*	2*s*	2*p*	3*s*	3*p*
$n = 1$	$n = 2$	$n = 2$	$n = 3$	$n = 3$
$\ell = 0$	$\ell = 0$	$\ell = 1$	$\ell = 0$	$\ell = 1$

2. (9)

⇅	⇅	⇅ ⇅ ⇅	⇅	⇅ ↑ ↑
1*s*	2*s*	2*p*	3*s*	3*p*

3. (0) Electronic configuration of Pd

   $[Kr], 4d^{10}, 5s^0$
4. (4) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓

   Total no. of exchange pair $= \frac{5(5-1)}{2} + \frac{3(3-1)}{2}$

   $= 10 + 3 = 13$
10. (5) In 3rd shell 3*s*, 3*p*, 3*d* subshells are present and maximum 5 degenerated orbitals are present in *d*-subshell.

Answers

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (b) 4. (d) 5. (d) 6. (c) 7. (d) 8. (c) 9. (a) 10. (c)
11. (c) 12. (b) 13. (d)

Multiple Correct Answers Type

1. (a), (b) 2. (a), (b) 3. (c), (d) 4. (a), (b), (c), (d)
5. (a), (b), (c) 6. (a), (b), (d) 7. (a), (c), (d) 8. (a), (b), (c)

Comprehension Type

Comprehension-1 1. (b) 2. (d) 3. (c)
Comprehension-2 4. (c) 5. (b) 6. (a)
Comprehension-3 7. (c) 8. (d)
Comprehension-4 9. (d) 10. (b)

Matching Column Type

1. (a) $\rightarrow$ s, t; (b) $\rightarrow$ r, t; (c) $\rightarrow$ q; (d) $\rightarrow$ p, q

Integer Answer Type

1. (9) 2. (9) 3. (0) 4. (4) 5. (7) 6. (2) 7. (6) 8. (5) 9. (4) 10. (5)
11. (3) 12. (9) 13. (7) 14. (4) 15. (2) 16. (1) 17. (0) 18. (6) 19. (022)