SOME BASIC CONCEPTS AND MOLE CONCEPT (★ ★ ★)

SUBJECTIVE TYPE

Laws of Chemical Combination

1. 10 mL of hydrogen combines with 5 mL of oxygen to yield water. When 200 mL of hydrogen at STP is passed over heated CuO, the CuO loses 0.144 g of its weight. Do these results correspond to the law of constant composition?

2. Common salt obtained from Clifton beach contained 60.75% chlorine while 6.40 g of a sample of common salt from Khewra mine contained 3.888 g of chlorine. Show that these data are in accordance with the law of constant composition.

3. 3.2 g sulphur combines with 3.2 g of oxygen, to form a compound in one set of conditions. In another set of conditions 0.8 g of sulphur combines with 1.2 g of oxygen to form another compound. State the law illustrated by these chemical combinations.

4. 1 g of oxygen combines with 0.1260 g of hydrogen to form H_2O. 1 g of nitrogen combines with 0.2160 g of hydrogen to form NH_3. Predict the weight of oxygen required to combine with 1 g of nitrogen to form an oxide.

5. KCl contains 52% of potassium, KI contains 23.6% of potassium, and ICl contains 77.8% of iodine. Show that the above data is in agreement with the law of reciprocal proportions.

6. What weight of sodium chloride would be decomposed by 4.9 g of sulphuric acid, if 6 g of sodium bisulphate ($NaHSO_4$) and 1.825 g of hydrogen chloride were produced in the reaction and the law of conservation of mass is true ?

7. If the law of constant composition is true, what weights of calcium, carbon, and oxygen are present in 1.5 g of calcium carbonate, if a sample of calcium carbonate from another source contains the following percentage composition: Ca = 40.0%; C = 12.0%, and O = 48.0%?

8. An element forms two oxides containing, respectively, 50% and 40% by weight of the element. Show that these oxides illustrate the law of multiple proportions.

9. Elements A and B combine to form three different compounds :

   $0.3 \text{ g of A} + 0.4 \text{ g of B} \rightarrow 0.7 \text{ g of compound X}$

   $18.0 \text{ g of A} + 48.0 \text{ g of B} \rightarrow 66.0 \text{ g of compound Y}$

   $40.0 \text{ g of A} + 159.99 \text{ g of B} \rightarrow 199.99 \text{ g of compound Z}$

   Show that the law of multiple proportions is illustrated by the data given above.

Limiting Reagent

10. An impure sample of sodium chloride that weighed 0.50 g gave 0.90 g of silver chloride as precipitate on treatment with excess of silver nitrate solution. Calculate the percentage purity of the sample.

11. How much magnesium sulphide can be obtained from 2.00 g of Mg and 2.00 g of S by the reaction.

    $Mg + S \rightarrow MgS$. Which is the limiting reagent? Calculate the amount of one of the reactants which remains unreacted?

Empirical and Molecular Formulae

12. 1.00 g of a hydrated salt contains 0.2014 g of iron, 0.1153 g of sulphur, 0.2301 g of oxygen and 0.4532 g of water of crystallisation. Find its empirical formula. (Fe = 56; S = 32; O = 16)

13. A compound on analysis gave the following percentage composition by weight: hydrogen = 9.09, oxygen = 36.36, carbon = 54.55

    Its. VD is 44. Find the molecular formula of the compound.

14. An inorganic substance has the following composition: N = 35%; H = 5%; O = 60%

    On being heated, it yielded a gaseous compound containing N = 63.63% and O = 36.37%. Suggest a formula for each substance and equation for the chemical change.

15. A compound of carbon, hydrogen, and nitrogen contains the three elements in the respective ratio of 9:1:3.5. Calculate the empirical formula. If the molecular weight of the compound is 108, what is its molecular formula?

16. Carbohydrates are compounds containing only carbon, hydrogen and oxygen having the atomic ratio of H:O as

2:1. When heated in the absence of air, these compounds decompose to form carbon and water.

a. If 310 g of a carbohydrates leaves a residue of 124 g of carbon on heating in absence of air, what is the empirical formula of the carbohydrate?

b. If 0.0833 mole of the carbohydrate contain 1.0 g hydrogen, what is the molecular formula of the carbohydrate ?

17. 0.45 g of an organic compound containing only C, H, and N on combustion gave 1.1 g of CO_2 and 0.3 g of H_2O. What is the percentage of C, H, and N in the organic compound.

18. A pure sample of cobalt chloride weighing 1.30 g was found to contain 0.59 g cobalt and 0.71 g chloride on quantitative analysis. What is the percentage composition of cobalt chloride?

19. Glucose is a physiological sugar. What is the mass% C, mass% H, and mass% O in glucose ($C_6H_{12}O_6$)?

Avogadro's Hypothesis and Mole Concept

20. Find the weight of NaOH in its 50 milli equivalents.

21. Find the normality of H_2SO_4 having 50 milli equivalents in 2 litres.

22. Find the weight of H_2SO_4 in 1200 mL of a solution of 0.2 N strength.

23. What weight of Na_2CO_3 of 95% purity would be required to neutralise 45.6 mL of 0.235 N acid?

24. What is the strength in gram per litre of a solution of H_2SO_4, 12 mL of which neutralised by 15 mL of N/10 NaOH solution?

25. Two litres of NH_3 at 30°C and 0.20 atmosphere is neutralised by 134 mL of a solution of H_2SO_4. Calculate the normality of H_2SO_4.

26. 1 g of calcium was burnt in excess of O_2 and the oxide was dissolved in water to make up 1 L solution. Calculate the normality of alkaline solution.

27. Calculate the amount of KOH required to neutralise 15 mEq of the following:

a. HCl b. $KHSO_4$ c. N_2O_5 d. CO_2

28. What volume of a solution of hydrochloric acid containing 73 g acid per litre would suffice for the exact neutralisation of sodium hydroxide obtained by allowing 0.46 g of metallic sodium to act upon water.

29. Find out the equivalent weight of H_3PO_4 in the reaction:

$$Ca(OH)_2 + H_3PO_4 \rightarrow CaHPO_4 + 2H_2O$$

30. What weight of AgCl will be precipitated when a solution containing 4.77 g NaCl is added to a solution of 5.77 g of $AgNO_3$.

Mole Concept in Solution

31. A sample of an alloy weighing 0.50 g and containing 90% Ag was dissolved in concentrated HNO_3. Ag was analysed by Volhard method in which 25 mL of KCNS was required for complete neutralisation. Determine the normality of KCNS.

32. HNO_3 used as a reagent has specific gravity of 1.42 g mL^{-1} and contains 70% by strength HNO_3. Calculate:

a. Normality of acid

b. Volume of acid that contains 63 g pure acid

c. Volume of water required to make 1 N solution from 2 mL concentration HNO_3.

33. Find the molality of H_2SO_4 solution whose specific gravity is 1.98 g mL^{-1} and 95% by (weight/volume) H_2SO_4.

34. A piece of Al weighing 2.7 g is titrated with 75.0 mL of H_2SO_4 (specific gravity 1.18 g mL^{-1} and 24.7% H_2SO_4 by weight). After the metal is completely dissolved, the solution is diluted to 400 mL. Calculate the molarity of free H_2SO_4 solution.

35. A 10 mL sample of human urine was found to have 5 mg of urea on analysis. Calculate the molarity of the given sample w.r.t. urea. (molecular mass of urea = 60)

36. Calculate the molarity and molality of 20% aqueous ethanol (C_2H_5OH) solution by volume. (density of solution = 0.96 g mL^{-1})

37. If 4 g NaOH are dissolved in 100 mL of aqueous solution, what will be the difference in its normality and molarity?

38. An aqueous solutions of diabasic acid (molecular mass = 118) containing 35.4 g of acid per litre of the solution has density 1.0077 g mL^{-1}.

Express the concentration in as many ways as you can?

39. A solution contains 2.80 moles of acetone (CH_3COCH_3) and 8.20 mole of $CHCl_3$. Calculate the mole fraction of acetone.

40. The percentage composition (by weight) of a solution is 45% X, 15% Y, and 40% Z. Calculate the mole fraction of each component of the solution. (Molecular mass of X = 18, Y = 60, and Z = 60)

LIKED COMPREHENSION TYPE

This section contains 12 paragraphs. Based on each paragraph, 2–4 multiple choice questions have to be answered. Each question has four choices (a), (b), (c), and (d), out of which only one is correct.

Paragraph for Problems 1 and 2

A sample of urine containing 0.3 g of urea was treated with an excess of 0.2 M nitrous acid, according to the equation.

$$NH_2CONH_2 + 2HNO_2 \longrightarrow CO_2 + 2N_2 + 2H_2O$$

The gases produced passed through aqueous KOH solution and the final volume is measured.

(Given, $Mw_{urea} = 60$ g mol^{-1}, molar volume of gas at standard condition, i.e., at room temperature 25°C and 1 atm pressure. RTP (room temperature pressure) also is 24.4 L or 24400 mL mol^{-1})

1. What is the volume at RTP?

   a. 122 mL b. 244 mL c. 366 mL d. 488 mL

2. What is the volume of HNO_2 consumed by urea?

   a. 12.5 mL b. 25 mL c. 50 mL d. 75 mL

Paragraph for Problems 3 and 4

Fluoro carbon polymers can be made by fluorinating polyethene.

(i) $(CH_2)_n + 4nCoF_3 \longrightarrow (CF_2)_n + 2nHF + 4nCoF_2$

where n is a large integer. The CoF_3 can be regenearted by the above reaction.

(ii) $2CoF_2 + F_2 \longrightarrow 2CoF_3$

3. If the HF formed in reaction (i) cannot be reused, calculate the weight of F_2 consumed by 1.0 g of $(CF_2)_n$ produced.

   a. 2.0 g b. 2.52 g c. 1.52 g d. 3.0 g

4. If HF can be recovered and electrolyzed to H_2 and F_2 and if F_2 is used for regenerating CoF_3, what is the net consumption of F_2 for 1.0 g of $(CF_2)_n$.

   a. 1.0 g b. 1.26 g c. 0.76 g d. 1.5 g.

Paragraph for Problems 5 and 6

Consider the following series of reactions:

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$$

$$3NaClO \longrightarrow 2NaCl + NaClO_3.$$

$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

5. How much Cl_2 is needed to prepare 122.5 g $NaClO_4$ by above sequence?

   a. 284.0 g b. 213.0 g
   c. 142.0 g d. 71.0 g

6. How much Cl_2 is needed to prepare 106.5 g of $NaClO_3$ by the above sequence?

   a. 284.0 g b. 213.0 g
   c. 142.0 g d. 71.0 g

Paragraph for Problems 7 and 8

7. One of the reactions used in the petroleum industry for improving octane number of fuels is

$$C_7H_{14} \longrightarrow C_7H_8 + 3H_2$$

   The two hydrocarbons C_7H_{14} and C_7H_8 are liquids; H_2 formed is gas. What is the percentage reduction in liquid weight accompanying the completion of the above reaction?

   a. ≈1% b. ≈3% c. ≈5% d. ≈6%

8. In aviation gasoline of 100 octane number, 1.0 mL of tetraethyl lead (TEL), $(C_2H_5)_4Pb$, of density 1.615 g mL^{-1}, per litre is added to the product. TEL is prepared as follows:

   $4C_2H_5Cl + 4Na(Pb) \longrightarrow (C_2H_5)_4Pb + 4NaCl + 3Pb$

   Calculate the amount of C_2H_5Cl required to make enough TEL for 1.0 L of gasoline.

   a. 0.645 g b. 1.29 g
   c. 1.935 g d. 2.58 g

Paragraph for Problems 9–11

The percentage labelling of oleum (mixture of H_2SO_4 and SO_3) refers to the total mass of pure H_2SO_4. The total amount of H_2SO_4 found after adding calculated amount of water to 100 g oleum is the percentage labelling of oleum. The higher the percentage labeling of oleum higher is the amount of free SO_3 in the oleum sample.

9. What is the amount of free SO_3 in an oleum sample labelled as '118%'.

   a. 40% b. 50% c. 70% d. 80%

10. The percent free SO_3 is an oleum is 20%. Label the sample of oleum in terms of percent H_2SO_4.

    a. 113.5% b. 104.5% c. 106.75% d. 120%

11. 100 g sample of '147 %' oleum was taken and calculated amount of H_2O was added to make H_2SO_4. 500 mL solution of x M KOH solution is required to neutralize the solution. The value of x is.

    a. 1 M b. 2 M c. 4 M d. 6 M

Paragraph for Problems 12–14

Cisplation is used as an anticancer agent for the treatment of solid tumors, and its prepared as follows:

$$K_2[PtCl_4] + 2NH_3 \longrightarrow [Pt(NH_3)_2Cl_2] + 2KCl$$

Potassium tetra chloro platinate (II) Ciplatin

Given 83.0 g of $K_2[PtCl_4]$ is reacted with 83.0 g of NH_3. [Atomic weights: K = 39, Pt = 415, Cl = 35.5, N = 14]

12. Which reactant is the limiting reagent and which is in excess?

	Limiting	Excess
a.	$K_2[PtCl_4]$	NH_3
b.	NH_3	$K_2[PtCl_4]$
c.	None	None
d.	Both	Both

13. The number of mol of $K_2[PtCl_4]$ and NH_3 used, respectively, are

a. 0.1, 0.2 b. 0.2, 0.4 c. 0.3, 0.6 d. 0.03, 0.06

14. The number of mol of excess reactant is

a. 4.68 b. 4.78 c. 4.58 d. 4.48

Paragraph for Problems 15 and 16

Iodine can be prepared by the following reactions.

$$2NaIO_3 + 5NaHSO_3 \longrightarrow 2NaHSO_4 + 2Na_2SO_4 + H_2O + I_2$$

15. How much $NaIO_3$ is required to produce 127 g of I_2?

a. 1.98 kg b. 3.96 kg c. 5.94 kg d. 0.99 kg

16. How much $NaHSO_3$ is required to produce 381 g of I_2?

a. 156.0 g b. 390.0 g c. 520.0 g d. 780.0 g

Paragraph for Problems 17–19

When phosphours (P_4) is heated in limited amount of O_2, P_4O_6 (tetraphosphorus hexaoxide) is obtained, and in excess of O_2, P_4O_{10} (tetraphosphours decaoxide) is obtained.

i. $P + 3O_2 \longrightarrow P_4O_6$; ii. $P_4 + 5O_2 \longrightarrow P_4O_{10}$

17. What mass of P_4O_6 will be produced by the combustion of 2.0 g of P_4 with 2.0 g of O_2.

a. 0.0145 mol b. 0.072 mol
c. 0.029 d. 0.0048

18. What mass of P_4O_{10} will be produced by the combustion of 2.0 g fo P_4 with 2.0 g of O_2.

a. 1.04 g b. 0.52 g c. 2.04 g d. 3.04 g

19. How many moles of O_2 left unreacted initially in reaction (i)?

a. 0.0145 mol b. 0.072 mol
c. 0.029 mol d. 0.0048 mol

Paragraph for Problems 20 and 21

Copper (Cu) and (Zn) react differently with HNO_3 as follows:

$$Cu + 4H^{\oplus}(aq) + 2NO_3^{\ominus}(aq) \longrightarrow 2NO_2(g) + Cu^{2+} + 2H_2O$$

$$4Zn + 10H^{\oplus}(aq) + 2NO_3^{\ominus}(aq) \longrightarrow NH_4^{\oplus} + 4Zn^{2+} + 3H_2O$$

20. What volume of 2.0 M HNO_3 would react with 10.0 g of a brass (90.0% Cu, 10.0% Zn) according to the above equation?

a. ≈100 mL b. ≈150 mL c. ≈200 mL d. ≈300 mL

21. What volume of NO_2 gas at 27°C and 1.0 atm pressure would be produced?

a. 6.97 L b. 5.97 L c. 4.97 L d. 3.97 L

Paragraph for Problems 22–25

In coal, pyrites (FeS_2) is present as a pollution-causing impurity, which is removed by combustion.

$$2FeS_2 + 5O_2 \longrightarrow 4SO_2 + 2FeO.$$

22. Calculate the moles of SO_2 produced by burning 1.0 metric ton (10^3 kg) of coal containing 0.05% by mass of pyrites impurity?

a. 8.32 mol b. 4.16 mol c. 12.48 mol d. 2.08 mol

23. What volume of 3.0 M KOH would be required to react with the SO_2 produced in Q. 22?

a. 2.77 L b. 5.54 L c. 1.38 L d. 8.31 L

24. A process designed to remove organic sulphur from coal prior to combustion involves the reaction.

$$X\text{–}S\text{–}Y + 2NaOH \longrightarrow X\text{–}O\text{–}Y + Na_2S + H_2O$$

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$Na_2S + CO_2 + H_2O \longrightarrow Na_2CO_3 + H_2S$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 + 2NaOH$$

In the processing of 320 metric tons of a coal having 1.0% sulphur content, how much limestone ($CaCO_3$) must be edecomposed to provide enough $Ca(OH)_2$ to regenerate the NaOH used in the original leaching step?

a. 2.0 metric ton b. 4.0 metric ton
c. 8.0 metric ton d. 10.0 metric ton

25. What mass of H_2SO_4 can be prepared from 3.0 g of Cu_2S if each atom of S in Cu_2S is converted into 1 moleucle of H_2SO_4?

a. 1.85 g b. 68.62 g c. 3.85 g d. 4.85 g

Paragraph for Problems 26 and 27

Salt cake (Na_2SO_4) is prepared as follows:

$$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$$

26. How much salt cake could be produced from 100.0 g of 90% pure salt in the above reaction?

a. 109.8 g b. 54.9 g c. 36.6 g d. 209.8 g

27. How much 80% pure salt cake could be produced form 100.0 g of 90% pure salt in the above reaction?

a. 43.92 g b. 68.62 g c. 87.84 g d. 137.25 g

Paragraph for Problems 28–30

A mixture of a mol of C_3H_8 and b mol of C_2H_4 was kept is a container of V L exerts a pressure of 4.93 atm at temperaure T. Mixture was burnt in presence of O_2 to convert C_3H_8 and C_2H_4 into CO_2 in the container at the same temperature. The pressure of gases after the reaction and attaining the thermal equilibrium with atmosphere at temperature T was found to be 11.08 atm.

28. The mole fraction of C_3H_8 in the mixture is

a. 0.25 b. 0.75 c. 0.45 d. 0.55

29. The mole fraction of C_2H_4 in the mixture is

a. 0.25 b. 0.75 c. 0.45 d. 0.55

30. The moles of O_2 needed for combustion at temperature T is equal to.

a. 14 a b. 14 b c. 15 a d. 12 b

MATCHING COLUMN TYPE

1. Match the items given in column I with those in column II.

	Column I		Column II
a.	What mass of $(NH_4)_2CO_3$ ($Mw = 96$ g mol^{-1}) contains 0.4 mol $NH_4^{\oplus}$?	p.	1.92 g
b.	Mass of $(NH_4)_2CO_3$ which contains 6.02×10^{23} hydrogen atoms	q.	19.2 g
c.	Mass of $(NH_4)_2CO_3$ which will produce 3.0 mL of CO_2 when treated with sufficient acid.	r.	12.0 g
d.	Mass of $(NH_4)_2CO_3$ is required to prepare 100 mL of 0.2 M$(NH_4)_2CO_3$ solution.	s.	288.0 g

2. Match the solution mixtures given in column I with the concentrations given in column II.

	Column I		Column II
a.	11.1 g $CaCl_2$ and 29.25 g of NaCl are diluted with water to 100 mL	p.	$[Ca^{2+}] = 0.8$ M $[Na^{\oplus}] = 1.2$ M $[Cl^{\ominus}] = 2.8$ M
b.	3.0 L of 4.0 M NaCl and 4.0 L of 2.0 M $CaCl_2$ are combined and diluted to 10.0 L	q.	$[Ca^{2+}] = 0.001$ M $[Na^{\oplus}] = 0.005$ M $[Cl^{\ominus}] = 0.007$ M
c.	300 mL of 3.0 M NaCl is added to 200 mL of 4.0 M $CaCl_2$	r.	$[Ca^{2+}] = 1.6$ M $[Na^{\oplus}] = 1.8$ M $[Cl^{\ominus}] = 5.0$ M
d.	100 mL of 2.0 M HCL + 200 mL of 1.0 M NaOH + 150 mL of 4.0 M $CaCl_2$ + 50 mL of H_2O	s.	$[Ca^{2+}] = 1.2$ M $[Na^{\oplus}] = 0.4$ M $[Cl^{\ominus}] = 2.8$ M

3. Match the reactions given in column I with the volumes given in column II.

	Column I		Column II
a.	What volume of 98% H_2SO_4 by mass (density = 1.8 g mL^{-1}) is required to prepare 3.0 L of 3.0 M H_2SO_4.	p.	500 mL
b.	How many mL of 3.0 M HCl should be added to react completely with 21.0 g of $NaHCO_3$. (Mw of $NaHCO_3 = 84$ g) $HCl + NaHCO_3 \longrightarrow NaCl + CO_2 + H_2O$	q.	83.3 mL
c.	What volume of 3.0 M H_2SO_4 is required to react with 6.54 g of Zn (Atomic weight Zn = 65.4 g) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$	r.	33.3 mL
d.	How many mL of 0.5 M $KMnO_4$ solution will react completely with 92.0 g of $K_2C_2O_4 \cdot H_2O$ (Mw of $K_2C_2O_4 \cdot H_2O = 184$ g) $16H^{\oplus} + 2MnO_4^{\ominus} + 5C_2O_4^{2-} \longrightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$	s.	400 mL

4. Match the reactions given in column I with the volumes given in column II.

	Column I		Column II
a.	What volume of 0.5 M HBr is required to neutralise 250 mL 0.2 M $Ba(OH)_2$ solution. $2HBr + Ba(OH)_2 \longrightarrow BaBr_2 + 2H_2O$	p.	100 mL
b.	What volume of 2M H_2SO_4 is required to produce 3.4 g of H_2S by the reaction. $8KI + 5H_2SO_4 \longrightarrow K_2SO_4 + 4I_2 + H_2S + 4H_2O$	q.	750 mL
c.	What volume of 8.0 M H_2SO_4 is needed to react completely with 108 g of Al (Atomic weight Al = 27.0 g) $[2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + H_2]$	r.	250 mL
d.	How many mL of 1 M $BaCl_2$ is required to precipitate all the SO_4^{2-} ions from 100 mL of a solution containing 142 g Na_2SO_4 ($Mw = 142$ g) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 3NaCl$	s.	200 mL

5. Match the items given in column I with those in column II.

	Column I		Column II
a.	Molarity (M)	p.	Temperature
b.	Molality (m)	q.	Dilution
c.	Mole fraction (χ)	r.	volume
d.	Normality (N)		

6. Match the weight of reactants given in column I with weight of products marked (?) given in column II.

	Column I		Column II
a.	$\underset{1.0\,g}{2H_2} + \underset{1.0\,g}{O_2} \longrightarrow \underset{?}{2H_2O}$	p.	0.56 g
b.	$\underset{1.0\,g}{N_2} + \underset{1.0\,g}{3H_2} \longrightarrow \underset{?}{2NH_3}$	q.	1.333 g
c.	$\underset{1.0\,g}{CaCO_3} \xrightarrow{\Delta} CaO + \underset{?}{CO_2}$	r.	1.125 g
d.	$\underset{1.0\,g}{C} + \underset{1.0\,g}{2H_2} \longrightarrow \underset{?}{CH_4}$	s.	1.214 g

7. Match the reactions given in column I with neutralisation reactions given in column II.

	Column I		Column II
a.	0.1 mol Na_2CO_3 + 0.2 mol $NaHCO_3$ + 0.3 mol NaCl	p.	320 mL of 0.25 N KOH solution
b.	200 mL of 0.1 M HCl + 100 of 0.1 M H_2SO_4 + 200 ML of 0.1 M $H_2C_2O_4$.	q.	400 mL of 0.5M H_2SO_4
c.	1 g NaOH and 2.25 g of oxalic acid	r.	125 mL of N/5 $Mg(OH)_2$
d.	0.01 mol H_3PO_4 and 0.0025 mol of $Ca(OH)_2$	s.	125 mL of N/5 H_2SO_4

8. Match the amount of reactant given in column I with neutralisation reactions given in column II.

	Column I		Column II
a.	4.9 g H_2SO_4	p.	200 mL of 0.5 N NaOH is used for complete neutralisation
b.	4.9 g of H_3PO_4	q.	200 mmol oxygen atoms
c.	4.5 g of $H_2C_2O_4$	r.	Central atom has its highest oxidation state.
d.	5.3 g Na_2CO_3	s.	May react with an oxidising agent.
		t.	Shape and geometry around the central atom is same

9. Match the items given in column I with those in column II.

	Column I		Column II
a.	9.8% H_2SO_4 by weight (density = 1.8 g mL^{-1})	p.	3.6 N
b.	9.8% H_3PO_4 by weight (density = 1.2 g mL^{-1})	q.	1.2 M
c.	1.8 N_A molecules of HCl is 500 mL	r.	1.8 Equivalents
d.	250 mL of 4N NaOH + 250 mL of 1.6 M $Ca(OH)_2$	s.	1.10 m

10. Match the items given in column I with those in column II.

	Column I		Column II
a.	15.8 g $KMnO_4$	p.	6.023×10^{22} molecules
b.	9.0 g $H_2C_2O_4$	q.	24.092×10^{22} atoms of oxygen
c.	8.8 g CO_2	r.	0.1 mol
d.	5.6 g CO	s.	0.2 mol

MULTIPLE CORRECT ANSWER TYPE

Laws of Chemical Combination

1. Which of the statements are true?
   a. Law of constant composition is true for all types of compounds.
   b. Molar volume of a gas at standard conditions is 22.4 L.
   c. Vapour density of a gas is twice of its molecular mass.
   d. Atomic masses of most elements are fractional.
2. Which of the statements are true?
   a. Brass is an element.
   b. Dry ice is a mixture.
   c. Aerated drink, e.g., coca cola, is a mixture.
   d. Diesel is a mixture.
3. Two bulbs A and B contains 16 g O_2 and 16g O_3, respectively. Which of the statements are true?
   a. Both bulbs contain same number of atoms.
   b. Both bulbs contain different number of atoms.
   c. Both bulbs contain same number of moleucles.
   d. Bulb A contains $N_A/2$ molecules while bulb B contains $N_A/3$ molecnles. (N_A = Avogadro's number).

4. A bulb contains 1.6 g of O_2. It contains.
   a. 0.05 mol of O_2
   b. 3.011×10^{22} molecules of O_2
   c. 1.12 L of O_2 at STP
   d. 1.22 L of O_2 at SATP

5. **Which of the following have same significant figures?**
   a. 0.070 b. 0.70 c. 7.0 d. 70

6. **Which of the following statements are correct?**
   a. French chemist A. Lavoisier is called the father of chemistry and proposed the law of conservation of mass.
   b. French chemist Joseph Proust proposed the law of definite proportions.
   c. Dalton proposed the law of multiple proportions.
   d. Richter proposed the law of reciprocal proportions.

7. Which of the statements are true about the law of chemical combination?
   a. Potassium combines with two isotopes of chlorine (^{35}Cl and ^{37}Cl) to form two samples of KCl. Their formation follows the law of definite composition.
   b. Different proportions of oxygen in the varius oxidies of sulphur prove the law of multiple proportions.
   c. H_2O and H_2S contain 11.11% hydrogen and 5.88% hydrogen, respectively, whereas SO_2 contains 50% sulphur. The above data prove the law of reciprocal proportions.
   d. In the decomposition of NH_3, ($2NH_3 \xrightarrow{\Delta} N_2 + 3H_2$), the ratio of volumes of NH_3, N_2, and H_2 is 2:1:3. The above data proves the Gay Lussac law.

8. Which of the following statements are **wrong**?
   a. 1.6 g of a hydrocarbon on combustion in excess of oxygen produces 1.2 of CO_2 and 0.4 of H_2O. The data illustrates the law of conservation of mass.
   b. The product of atomic mass and specific heat of any elements is a constant and is approximately 6.4. This is known as Dulong Petit's law.
   c. The atomic masses of the elements are usually fractional because they are mixtures of allotropes.
   d. The best standard of atomic mass is hydrogen-1.008.

9. Which of the following pair of compounds illustrate the law of multiple proportions?
   a. SO_2 and SO_3
   b. NO_2 and N_2O
   c. MgO and $Mg(OH)_2$
   d. NO and N_2O_5

10. Which of the following statements are correct?
    a. A sample of $CaCO_3$ contains Ca = 40%, C = 12%, and O = 48%. If the law of constant compostion is true, then the mass of Ca in 10 g of $CaCO_3$ from another source is 4.0 g.
    b. 12 g of carbon is heated in vacuum and there is no change in the mass, is the best example of the law of conservation of mass.
    c. Air is heated at constant pressure and there is no change in mass but the volume increases, is the best example of the law of conservation of mass.
    d. SO_2 gas was prepared by (i) heating Cu with conc H_2SO_4, (ii) burning sulphur in oxygen, (iii) reacting sodium sulphite (Na_2SO_3) with dilute H_2SO_4. It was observed that is each case, S and O combine in the ratio of 1:1. This data illustrates the law of constant compositon.

Mole Concept

11. Which of the following statements is/are correct?
    a. Chloropicrin ($CCl_3 \cdot NO_2$) can be made cheaply for use as an insecticide by the following reaction:
    $CH_3NO_2 + Cl_2 \longrightarrow CCl_3 \cdot NO_2 + HCl$
    b. In a rocket motor fueled with butane (C_4H_{10}), 0.1 mol of butane requires 14.56 L of O_2 at STP for complete combustion.
    c. A portable hydrogen generator utilises the reaction: ($CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2$). 2.1 g of CaH_2 would produce 2.24 L of H_2 at STP.
    d. In the Mond process for purifying nickel, the volatile nickel carbonyl [$Ni(CO)_4$] is produced by the reaction. $Ni + CO \longrightarrow Ni(CO)_4$. 58.7 g of Ni utilises 89.6 L of CO at standard conditions.

12. Which of the following statements is/are correct?
    a. CaC_2 is made in an electric furnace by the reaction:
    $CaO + C \longrightarrow CaC_2 + CO$.
    16.0 g of CaC_2 is obtained from 9.0 g of C.
    b. Polyethene can be produced form CaC_2 as follows:
    $CaC_2 + H_2O \longrightarrow CaO + HC{\equiv}CH$
    $HC{\equiv}CH + H_2 \longrightarrow H_2C{=}CH_2$
    $n(CH_2{=}CH_2) \longrightarrow {-}\!(CH_2{-}CH_2)\!{-}_n$ (Polyethene)
    32.0 kg of CaC_2 produces 14.0 kg of polyethene.
    c. 1.435 g of AgCl is obtained from 17.75 g of $[Ag(NH_3)_2]Cl$ by the following reaction:
    $[Ag(NH_3)_2]Cl + 2HNO_3 \longrightarrow AgCl + 2NH_4NO_3$.
    d. Commercial sodium 'hydrosulfite' is 50% pure $Na_2S_2O_4$. It is prepard as follows:
    i. $Zn + 2SO_2 \longrightarrow ZnS_2O_4$
    ii. $ZnS_2O_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2S_2O_4$
    174.0 metric ton of commercial product ($Na_2S_2O_4$) can be made from 65.4 metric ton of Zn, with a sufficient supply of other reactants.

13. Which of the following statements is/are correct?

a. 21.2 g sample of impure Na_2CO_3 is dissolved and reacted with a solution of $CaCl_2$, the weight of precipitate of $CaCO_3$ is 10.0 g. The % purity of Na_2CO_3 is 50%.

b. The percentage purity of Na_2CO_3 is 60%.

c. The number of moles of $Na_2CO_3 = CaCO_3 = 0.1$ mol.

d. The number of moles of NaCl formed is 0.1 mol.

Limiting Reagent

14. Which of the following statements is/are correct?

For the reaction:

$4Fe + 3O_2 \longrightarrow 2FeO_3$

a. Fe is the limiting reagent.

b. The mass O_2 left over at the end of the reaction is 1.2 g.

c. The mass of Fe_2O_3 produced is 12.0 g.

d. O_2 is the limiting reagent.

15. Which of the following statements is/are correct?

A mixture containing 64.0 g H_2 and 64.0 g O_2 is ignited so that water is formed as follows:

$2H_2 + O_2 \longrightarrow 2H_2O$

a. H_2 is the limiting reagent

b. O_2 is the limiting reagent.

c. The reaction mixture contains 72.0 g of H_2O and 56.0 g of unreacted H_2.

d. The reaction mixture contains 56.0 g of H_2O and 72.0 g of unreacted H_2.

16. Which of the following statements is/are **wrong**?

The following reactions occur:

i. $P_4 + 5O_2 \longrightarrow P_4O_{10}$.

ii. $P_4 + 3O_2 \longrightarrow P_4O_6$.

1.24 g of P_4 reacts with 8.0 g of O_2.

a. P_4 is the limiting quantity.

b. O_2 is the limiting quantity.

c. Mass of P_4O_{10} obtained is 2.2 g.

d. Mass of P_4O_6 obtained is 2.84 g.

17. Which of the following is/are correct.

The following reaction occurs:

$CS_2 + 3Cl_2 \xrightarrow{\Delta} CCl_4 + S_2Cl_2$

1.0 g of CS_2 and 2.0 g of Cl_2 reacts.

a. 0.714 g CS_2 is used in the reaction.

b. 0.286 g CS_2 is in excess.

c. 1.45 g of CCl_4 is formed.

d. 0.8 g Cl_2 is in excess.

18. Which of the following statements is/are correct?

The following reaction occurs:

$2Al + 3MnO \xrightarrow{\Delta} Al_2O_3 + 3Mn.$

108.0 g of Al and 213.0 g of MnO was heated to initiate the reaction. (*Mw* of MnO = 71, atomic weight of Al = 13)

a. Al is present in excess.

b. MnO is present is excess.

c. 54.0 g of Al is required.

d. 159.0 g of MnO is in excess.

19. Which of the following statements is/are correct?

i. 21.0 of lithium reacts with 32.0 g of O_2.

$4Li + O_2 \longrightarrow 2Li_2O$

ii. 3.9 g of K reacts with 4.26 g of Cl_2.

$2K + Cl_2 \longrightarrow 2KCl$

[Atomic weight of Li = 7 and K = 39. *Mw* of Li_2O = 30 and KCl = 74.5 g mol^{-1})

a. In reaction (i), O_2 is in excess.

b. 45.0 g of Li_2O is formed is reaction (i).

c. In reaction (ii), Cl_2 is in excess.

d. 7.45 g of KCl is formed is reaction (ii).

20. Which of the following is/are correct?

The following reaction occurs:

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

106.0 g of Na_2CO_3 reacts with 109.5 g of HCl.

a. The HCl is in excess.

b. 117.0 g of NaCl is formed.

c. The volume of CO_2 produced at 1 bar and 273 K is 22.7 L.

d. The volume of CO_2 produced at 1 bar and 298 K is 24.7 L.

Mole Concept in Solution

21. Which of the following solution contains approximately equal hydrogen ion concentration?

a. 100 mL of 0.1 M HCl + 50 mL H_2O

b. 75 mL of 0.1 M HCl + 75 mL H_2O

c. 50 mL of 0.1 M H_2SO_4 + 100 mL H_2O

d. 100 mL of 0.1 N H_2SO_4 + 50 mL H_2O

22. Which of the following statement is/are correct?

Excess of $H_2S(g)$ is bubbled into 1.0 L of 0.1 M $CuCl_2$ solution.

$Cu^{2+} + H_2S(g) \longrightarrow CuS(s) + 2H^{\oplus}$

a. 9.55 of CuS is produced.

b. The concentratikon of $H^{\oplus}$ ions is 0.2 M

c. The concentration of $H^{\oplus}$ ions is 0.1 M.

d. 95.5 g CuS is produced

23. Which of the following statements is/are correct?
20.0 mL of 6.0 M HCl is mixed with 50.0 mL of 2.0 M $Ba(OH)_2$, and 30mL of water is added.

a. The concentration of OH remaining in solution is 0.8 M.
b. The concentration of $Cl^{\ominus}$ remaining in solution is 1.2 M.
c. The concentration of Ba^{2+} remaining in solution is 1.0 M
d. 80 mmoles of OH is in excess.

24. Which of the following is/are correct?
100 mL of 3.0 M $HClO_3$ reacts with excess of $Ba(OH)_2$ according to the equation:

$$Ba(OH)_2 + 2HClO_3 \longrightarrow Ba(ClO_3)_2 + 2H_2O$$

(Mw of $Ba(ClO_3)_2 = 304\ g\ mol^{-1}$)

a. 1.5 mol of $Ba(ClO_3)_2$ is formed.
b. 3 mol of $Ba(ClO_3)_2$ is formed.
c. 45.6 g of $Ba(ClO_3)_2$ is obtained.
d. 4.56 g of $Ba(ClO_3)_2$ is obtained.

25. Which of the following statements is/are correct?

a. Mass of $Al_2(SO_4)_3 \cdot 18H_2O$ needed to make up 100 mL of an aqueous solution of concentration 27.0 mg of Al^{3+} per mL is 33.3 g.
(Mw of $Al_2(SO_4)_3 \cdot 18H_2O = 666\ g\ mol^{-1}$, atomic weight of Al = 27 g).
b. Mass of $CrCl_3 \cdot 6H_2O$ (Mw = 266.5 g) needed to prepare 1.0 L solution containing 26.0 g Cr^{3+} per litre is 133.25 g. (Atomic weight of Cr = 52 g)
c. Mass of NH_4Cl needed to prepare 100 mL of a solution containing 80 mg NH_4Cl per mL is 8.0 g.
d. Mass of NH_3 per mL of solution needed for solution of NH_3 in water containing 20% NH_3 by weight (density = $0.8\ g\ mL^{-1}$) is $0.16\ g\ mL^{-1}$.

26. 100 mL of 0.06 M $Ca(NO_3)_2$ is added to 50 mL of 0.06 M $Na_2C_2O_4$. After the reaction is complete.

a. 0.003 moles of calcium oxalate will get precipitated.
b. 0.003 M of excess Ca^{2+} will remain in excess.
c. $Na_2C_2O_4$ is the limiting reagent.
d. $Ca(NO_3)_2$ is the excess reagent.

27. If 100 mL of 1 M H_2SO_4 solution is mixed with 100 mL of 98% (W/W) of H_2SO_4 solution ($d = 0.1\ g\ mL^{-1}$), then

a. Concentration of solution becomes half.
b. Volume of solution becomes 200 mL.
c. Mass of H_2SO_4 in the solution is 98 g.
d. Mass of H_2SO_4 in the solution is 19.6 g.

28. $KClO_4$ can be prepared by following reactions:

i. $Cl_2 + 2KOH \longrightarrow KCl + KClO + H_2O$
ii. $3KClO \longrightarrow 2KCl + KClO_3$
iii. $4KClO_3 \longrightarrow 3KClO_4 + KCl$

(Atomic wieght of K, Cl, and O are 39, 35.5, and 16)

a. The amount of Cl_2 required to prepare 277 g of $KClO_4$ by above series of reaction is 568 g.
b. The volume of KOH in litres used by Cl_2, if KOH is 1.5 M, is 1.067 L.
c. The amount of Cl_2 required to prepare 200 g of $KClO_4$ by above series of reaction is 284 g.
d. The volume of KOH in litres used by Cl_2, if KOH is 1.5 M, is 10.67 L.

29. When 100 mL of 0.1 M KNO_3 and 400 mL of 0.2 M HCl and 500 mL of 0.3 M H_2SO_4 are mixed, then in the resulting solution

a. The molarity of $K^{\oplus}$ = 0.01 M
b. The molarity of SO_4^{2-} = 0.15 M
c. The molarity of $H^{\oplus}$ = 0.38 M
d. The molarity of $NO_3^{\ominus}$ = 0.08 and $Cl^{\ominus}$ = 0.01 M

30. 100 g sample of clay (containing 19% H_2O, 40% silica, and inert impurities as rest) is partially dried so as to contain 10% H_2O.
Which of the following is/are correct statements(s)?

a. The percentage of silica in it is 44.4 %.
b. The mass of partially dried clay is 90.0 g.
c. The precentage of inert impurity in it is 45.6%.
d. The mass of water evaporated is 10.0 g.

31. In which of the following pairs, 10 g of each have an equal number of molecules?

a. N_2O and CO
b. N_2 and C_3O_2
c. N_2 and CO
d. N_2O and CO_2

32. Equal weights of X (atomic weight = 36) and Y (atomic weight = 24) are reacted to form the compound X_2Y_3, which of the following is/are correct?

a. X is the limiting reagent.
b. Y is the limiting reagent.
c. No reactant is left over.
d. Mass of X_2Y_3 formed is double the mass of X taken.

SINGLE CORRECT ANSWER TYPE

1. 10 g of $CaCO_3$ contains

a. 10 moles of $CaCO_3$
b. 0.1 g atom of Ca
c. 6×10^{23} atoms of Ca
d. 0.1 of equivalent of Ca

2. Two glucose solutions are mixed. One has a volume of 480 mL and a concentration of 1.50 M and the second has a volume of 520 mL and concentration 1.20 M. The molarity of final solution is

a. 1.20 M b. 1.50 M c. 1.344 M d. 2.70 M

3. 1.0 g of a monobasic acid when completely acted upon Mg gave 1.301 g of anhydrous Mg salt. Equivalent weight of acid is

a. 35.54 b. 36.54 c. 17.77 d. 18.27

4. 0.1 g of metal combines with 46.6 mL of oxygen at STP. The equivalent weight of metal is

a. 12 b. 24 c. 6 d. 36

5. The vapour density of a chloride of an element is 39.5. The *Ew* of the elements is 3.82. The atomic weight of the element is

a. 15.28 b. 7.64 c. 3.82 d. 11.46

6. The *Mw* of a oxide of an element is 44. The *Ew* of the element is 14. The atomic weight of the element is

a. 14 b. 28 c. 42 d. 56

7. Potassium selenate is isomorphous with potassium sulphate and contains 50.0% of Se. Find the atomic weight of Se.

a. 142 b. 71 c. 47.33 d. 284

8. The *Ew* of an element is 13. It forms an acidic oxide which with KOH forms a salt isomorphous with K_2SO_4. The atomic weight of element is

a. 13 b. 26 c. 52 d. 78

9. 0.05 g of a piece of metal in dilute acid gave 24.62 mL of H_2 at 27° C and 760 mm pressure. The *Ew* of metal is

a. 25 b. 12.5 c. 50 d. 37.5

10. An element A (atomic weight = 12) and B (atomic weight = 35.5) combines to form a compound X. If 4 mol of B combines with 1 mol of A to give 1 mol of X. The weight of 1 mol of X would be

a. 47.5 g b. 74.0 g c. 154.0 g d. 148.8 g

11. How many moles of ferric alum $(NH_4)_2SO_4Fe_2(SO_4)_3 \cdot 24H_2O$ can be made from the sample of Fe containing 0.0056 g of it?

a. 10^{-4} mol b. 0.5×10^{-4} mol

c. 0.33×10^{-4} mol d. 2×10^{-4} mol

12. Suppose elements X and Y combine to form two compounds XY_2 and X_3Y_2 when 0.1 mole of former weigh 10 g while 0.05 mole of the latter weigh 9 g. What are the atomic weights of X and Y.

a. 40, 30 b. 60, 40 c. 20, 30 d. 30, 20

13. In an experiment, 6.67 g of $AlCl_3$ was produced and 0.54 g Al remained unreacted. How many g atoms of Al and Cl_2 were taken originally (Al = 27, Cl = 35.5)?

a. 0.07, 0.15 b. 0.07, 0.05

c. 0.02, 0.05 d. 0.02, 0.15

14. 27 g of Al will react completely with .... g of O_2.

a. 8 g b. 10 g c. 24 g d. 49 g

15. 1 g of the carbonate of a metal was dissolved in 25 mL of N-HCl. The resulting liquid required 5 mL of N-NaOH for neutralisation. The *Ew* of the metal carbonate is

a. 50 b. 30 c. 20 d. None

16. 5 mL of N-HCl, 20 mL of N/2 H_2SO_4 and 30 mL of N/3 HNO_3 are mixed together and the volume is made to 1 L. The normality of the resulting solution is

a. N/5 b. N/10 c. N/20 d. N/40

17. The *Ew* of H_3PO_4 in the reaction is

$$Ca(OH)_2 + H_3PO_4 \longrightarrow CaHPO_4 + 2H_2O$$

(Ca = 40, P = 31, O = 16)

a. 49 b. 98 c. 32.66 d. 147

18. 10 g of a sample of a mixture of $CaCl_2$ and NaCl is treated to precipitate all the calcium as $CaCO_3$. This $CaCO_3$ is heated to convert all the Ca to CaO and the final mass of CaO is 1.62 g. The percent by mass of $CaCl_2$ in the original mixture is

a. 32.1% b. 16.2% c. 21.8% d. 11.0%

19. If 0.5 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ then can be formed is

a. 0.1 b. 0.2 c. 0.5 d. 0.7

20. What weight of a metal of equivalent weight 12 will give 0.475 g of its chloride?

a. 0.12 g b. 0.24 g c. 0.36 g d. 0.48 g

21. 4.2 g of a metallic carbonate MCO_3 was heated in a hard glass tube and CO_2 evolved was found to have 1120 mL of volume at STP. The *Ew* of the metal is

a. 12 b. 24 c. 18 d. 15

22. If 0.5 g of a mixture of two metals A and B with respective equivalent weights 12 and 9 displace 560 mL of H_2 at STP from an acid, the composition of the mixture is

a. 40% A, 60% B b. 60% A, 40% B

c. 30% A, 70% B d. 70% A, 30% B

23. What is the valency of an element of which the equivalent weight is 12 and the specific heat is 0.25?

a. 1 b. 2 c. 3 d. 4

24. The mineral rutile is an oxide of titanium containing 39.95% oxygen and is isomorphous with cassiterite (SnO_2). The atomic weight of titanium is

a. 68.10 b. 58.10 c. 48.10 d. 38.10

25. 13.4 g of a sample of unstable hydrated salt $Na_2SO_4 \cdot XH_2O$ was found to contain 6.3 g of H_2O. The number of molecules of water of crystalisation is

a. 5 b. 7 c. 2 d. 10

26. A mineral consists of an equimolar mixture of the carbonates of two bivalent metals. One metal is present to the extent of 15.0% by weight, 3.0 g of the mineral on heating lost 1.10 g of CO_2. The percent by weight of other metal is

a. 65 b. 25 c. 75 d. 35

27. One litre of 0.15 M HCl and one litre of 0.3 M HCl is given. What is the maximum volume of 0.2 M HCl which one can make from these two solutions. No water is added.

a. 1.2 L b. 1.5 L c. 1.3 L d. 1.4 L

28. Ammonia in 0.224 g of a compound $Zn(NH_3)_xCl_2$ is neutralised by 30.7 mL of 0.20 M HCl. The value of x in the formula is

a. 4 b. 5 c. 6 d. 8

29. The normality of a solution that results from mixing 4 g of NaOH, 500 mL of 1 M HCl, and 10.0 mL of H_2O_4 (specific gravity 1.1, 49% H_2SO_4 by weight) is

(The total volume of solution was made to 1 L with water)

a. 0.51 b. 0.71 c. 1.02 d. 0.45

30. A mixture of formic acid and oxalic acid is heated with conc H_2SO_4. The gas produced is collected and treated with KOH solution, whereby the volume decreases by 1/6th. The molar ratio of the two acids (formic acid/oxalic acid) is

a. 4:1 b. 1:4 c. 2:1 d. 1:2

31. A certain compound has the molecular formula X_4O_6. If 10 g of X_4O_6 has 5.72 g X, the atomic mass of X is

a. 32 amu b. 37 amu c. 42 amu d. 98 amu

32. 5.6 g of a metal forms 12.7 g of metal chloride. Hence equivalent weight of the metal is

a. 127 b. 254 c. 56 d. 28

33. The molarity of H_2SO_4 is 18 M. Its density is 1.8 g mL^{-1}. Hence, molality is:

a. 36 b. 200 c. 500 d. 18

34. 10 L of hard water required 0.56 g of lime (CaO) for removing hardness. Hence, temporary hardness in ppm (part per million 10^6) of $CaCO_3$ is:

a. 100 b. 200 c. 10 d. 20

35. How many grams of phosphoric acid would be needed to neutralise 100 g of magnesium hydroxide? (The molecular weights are: H_3PO_4 = 98 and $Mg(OH)_2$ = 58.3)

a. 66.7 g b. 252 g c. 112 g d. 168 g

36. When 10 mL of ethyl alcohol (density = 0.7893 g mL^{-1}) is mixed with 20 mL of water (density 0.9971 g mL^{-1}) at 25°C, the final solution has a density of 0.9571 g mL^{-1}. The percentage change in total volume on mixing is

a. 3.1% b. 2.4%

c. 1% d. None of these

37. The molality of 1 L solution with x% H_2SO_4 is equal to 9. The weight of the solvent present in the solution is 910 g. The value of x is:

a. 90 b. 80.3 c. 40.13 d. 9

38. The density of 1 M solution of NaCl is 1.0585 g mL^{-1}. The molality of the solution is

a. 1.0585 b. 1.00 c. 0.10 d. 0.0585

39. 100 mL of mixture of NaOH and Na_2SO_4 is neutralised by 10 mL of 0.5 M H_2SO_4. Hence, NaOH in 100 mL solution is

a. 0.2 g b. 0.4 g c. 0.6 g d. None

40. An organic compound contains 4% sulphur. Its minimum molecular weight is

a. 200 b. 400 c. 800 d. 1600

41. A gaseous mixture contains oxygen and nitrogen in the ratio 1:4 by weight. Therefore, the ratio of the number of moleucles is:

a. 1:4 b. 1:8 c. 7:32 d. 3:16

42. 0.116 g of $C_4H_4O_4$ (A) is neutralised by 0.074 g of $Ca(OH)_2$. Hence, protonic hydrogen ($H^{\oplus}$) in (A) will be

a. 1 b. 2 c. 3 d. 4

43. A hydrate of Na_2SO_3 has 50% water by mass. It is

a. $Na_2SO_3 \cdot 5H_2O$ b. $Na_2SO_3 \cdot 6H_2O$

c. $Na_2SO_3 \cdot 7H_2O$ d. $Na_2SO_3 \cdot 2H_2O$

44. 10 g mixture of $NaHCO_3$ and Na_2CO_3 has 1.68 g $NaHCO_3$. it is heated at 400 K. Weight of the residue will be

a. 9.38 g b. 8.32 g c. 10.0 g d. 1.68 g

45. Mole fraction of ethanol in ethanol water mixture is 0.25. Hence, the percentage concentration of ethanol by weight of mixture is

a. 25% b. 75% c. 46% d. 54%

46. How many moles of electrons weigh one kilogram?

a. 6.023×10^{23} b. $\frac{1}{9.108} \times 10^{31}$

c. $\frac{6.023}{9.108} \times 10^{54}$ d. $\frac{1}{9.108 \times 6.023} \times 10^{8}$

47. The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is

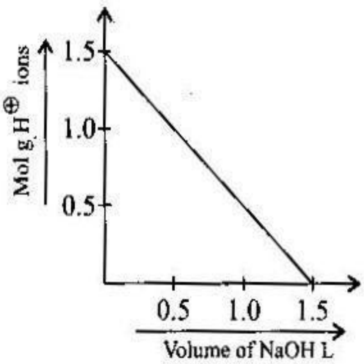
a. 4.14 g b. 5.14 g c. 6.14 g d. 7.14 g

48. How many moles of O_2 will be liberated by one mole of CrO_5 is the following reaction:

$$CrO_5 + H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + H_2O + O_2$$

a. 4.5 **b.** 2.5 **c.** 1.25 **d.** None

49. To 1 L of 1.0 M impure H_2SO_4 sample, 1.0 M NaOH solution was added and a plot was obtained as follows:



The % purity of H_2SO_4 and the slope of curve, respectively, are:

a. 75%, –1/2 **b.** 75%, –1
c. 50%, –1/3 **d.** 50%, –1/2

50. The expression relating mole fraction of solute (χ_2) and molarity (M) of the solution is: (where d is the density of the solution in g L^{-1} and Mw_1 and Mw_2 are the molar masses of solvent and solute, respectively

a. $x_2 = \dfrac{M \times Mw_1}{M(Mw_1 - Mw_2) + 1000d}$

b. $x_2 = \dfrac{M \times Mw_1}{M(Mw_1 - Mw_2) + d}$

c. $x_2 = \dfrac{M \times Mw_1}{M(Mw_1 - Mw_2) - 1000d}$

d. $x_2 = \dfrac{M \times Mw_1}{M(Mw_1 - Mw_2) - d}$

51. Consider the ionisation of H_2SO_4 as follow:

$$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^{\oplus} + SO_4^{2-}$$

The total number of ions furnised by 100 mL of 0.1 M H_2SO_4 will be

a. 1.2×10^{23} **b.** 0.12×10^{23} **c.** 0.18×10^{23} **d.** 1.8×10^{23}

52. Calculate the number of oxygen atoms required to combine with 7.0 g of N_2 to form N_2O_3 if 80% of N_2 is converted into products.

$$N_2 + \frac{3}{2}O_2 \longrightarrow N_2O_3$$

a. 3.24×10^{23} **b.** 3.6×10^{23}
c. 18×10^{23} **d.** 6.02×10^{23}

53. 36.5% HCl has density equal to 1.20 g mL^{-1}. The molarity (M) and molality (m), respectively, are

a. 15.7, 15.7 **b.** 12, 12
c. 15.7, 12 **d.** 12, 15.7

54. 10 mL of 1 M $BaCl_2$ solution and 5 mL 0.5 M K_2SO_4 are mixed together to precipitate out $BaSO_4$. The amount of $BaSO_4$ precipated will be

a. 0.005 mol **b.** 0.00025 mol
c. 0.025 mol **d.** 0.0025 mol

55. Mole fraction of a solute in an aqueous solution is 0.2. The molality of the solution will be

a. 13.88 **b.** 1.388
c. 0.138 **d.** 0.0138

56. An excess of NaOH was added to 100 mL of a $FeCl_3$ solution which gives 2.14 of $Fe(OH)_3$. Calculate the normality of $FeCl_3$ solution.

a. 0.2 N **b.** 0.3 N
c. 0.6 N **d.** 1.8 N

57. Two samples of HCl of 1.0 M and 0.25 M are mixed. Find volumes of these samples taken in order to prepare 0.75 M HCl solution. Assume no water is added

(I) 20 mL, 10 mL (II) 100 mL, 50 mL
(III) 40 mL, 20 mL (IV) 50 mL, 25 mL

a. I, II, IV **b.** I, II **c.** II, III, IV **d.** I, II, III, IV

58. If 100 mL of H_2SO_4 and 100 mL of H_2O are mixed, the mass percent of H_2SO_4 in the resulting solution is ($d_{H_2SO_4} = 0.09$ g mL^{-1}, $d_{H_2O} = 1.0$ g mL^{-1})

a. 90 **b.** 47.36 **c.** 50 **d.** 60

59. 12.5 mL of a solution containing 6.0 g of a dibasic acid in 1 L was found to be neutralized by 10 mL of a decinormal solution of NaOH. The molecular weight of the acid is

a. 150 **b.** 120 **c.** 110 **d.** 75

60. One litre of a sample of hard water contains 5.55 mg of $CaCl_2$ and 4.75 mg of $MgCl_2$. The total harness in terms of ppm of $CaCO_3$ is

a. 5 ppm **b.** 10 ppm
c. 20 ppm **d.** None of these

61. 10 mL of 0.2 N HCl and 30 mL of 0.1 N HCl together exactly neutralises 40 mL of solution of NaOH, which is also exactly neutralised by a solution in water of 0.61 g of an organic acid. What is the equivalent weight of the organic acid?

a. 61 **b.** 91.5 **c.** 122 **d.** 183

62. A metal oxide has the formula Z_2O_3. It can be reduced by hydrogen to give free metal and water. 0.2 g of the metal oxide requires 12 mg of hydrogen for complete reduction. The atomic weight of the metal is

a. 52 b. 104 c. 26 d. 78

63. The reaction between yttrium metal and dilute HCl produces H_2 (g) and Y^{3+} ions. The molar ratio of yttrium to that hydrogen produced is

a. 2:3 b. 3:2 c. 1:2 d. 2:1

64. What volume of H_2 at 273 K and 1 atm will be consumed in obtaining 21.6 g of elemental boron (atomic mass of B = 10.8) from the reduction of BCl_3 with H_2.

a. 89.6 L b. 67.2 L c. 44.8 L d. 22.4 L

ASSERTION - REASONING TYPE

In each of the following questions, an Assertion (A) is followed by a corresponding Reason (R). Use the following keys to choose the appropriate answer.

a. If both (A) and (R) are correct and (R) is the correct explantaion for (A).

b. If both (A) and (R) are correct but (R) is not the correct explanation for (A).

c. If (A) is correct but (R) is incorrect.

d. If (A) is incorrect and (R) is correct.

e. If both (A) and (R) are incorrect.

1. **Assertion (A)** : Atomic mass of potassium is 39.

   Reason (R) : An atom of potassium is 39 times heavier than 1/12th of the mass of carbon atom (C^{12}).

2. **Assertion (A)** : Both 138 g of K_2CO_3 and 12 g of carbon have same number of carbon atoms.

   Reason (R) : Both contains 1 g atom of carbon which contains 6.022×10^{23} carbon atoms.

3. **Assertion (A)** : 1 Avogram is equal to 1 amu.

   Reason (R) : Avogram is reciprocal of Avogadro's number.

4. **Assertion (A)** : 1 g of O_2 and 1 g atom of O_3 have equal number of molecules.

   Reason (R) : Mass of 1 mol atom is equal to its gram atomic mass.

   Reason (R) : 1 mol gas at SATP occupies 24.4 L volume.

5. **Assertion (A)** : The equivalent mass of an element is variable.

   Reason (R) : It depends on the valency of the element.

INTEGER TYPE

1. What volume of 90% alcohol by weight ($d = 0.8$ g mL^{-1}) must be used to prepare 80 mL of 10% alcohol by weight ($d = 0.9$ g mL^{-1})?

2. 50 mL of 1 M HCl, 100 mL of 0.5 M HNO_3, and x mL of 5 M H_2SO_4 are mixed together and the total volume is made upto 1.0 L with water. 100 mL of this solution exactly neutralises 10 mL of M/3 $Al_2(CO_3)_3$. Calculate the value of x.

3. How many mL of a solution of concentration 100 mg Co^{2+} per mL is needed to prepare 10 mL of a solution of concentration 20 mg Co^{2+} per mL.

4. HCl gas is passed into water, yielding a solution of density 1.095 g mL^{-1} and containing 30% HCl by weight. Calculate the molarity of the solution.

5. A solution contains 75 mg NaCl per mL. To what extent must it be diluted to give a solution of concentration 15 mg NaCl per mL of solution.

6. To prepare 100 g of a 92% by weight solution of NaOH, how many g of H_2O is needed?

7. To make a benzene soluble cement, 60 g rosin is melted in an iron pot and 68 g beeswax and 12 g shellac are added. How much of shellac should be taken to make 35 g cement?

8. In the reaction: $2Al + Cr_2O_3 \longrightarrow Al_2O_3 + 2Cr$,

   4.98 g of Al reacted with 20.0 g Cr_2O_3. How much grams of reactant remains at the completion of the reaction?

9. Silver is removed from the solutions of its salts with metallic zinc, according to the reaction:

   $$Zn + 2Ag^{\oplus} \longrightarrow Zn^{2+} + 2Ag.$$

   A 65.4 g piece of Zn is put into a 100 L vat containing 3.24 g $Ag^{\oplus}$ per litre. How many moles of reactant remained unreacted?

10. A sample contains a mixture of $NaHCO_3$ and Na_2CO_3.

    HCl is added to 15.0 g. of the sample, yielding 11.0 g of NaCl. What percent of the sample is Na_2CO_3?

    Reactions are:

    $$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

    $$NaHCO_3 + HCl \longrightarrow NaCL + CO_2 + H_2O$$

    Mw of NaCl = 58.5, *Mw* of $NaHCO_3$ = 84, *Mw* of Na_2CO_3 = 106 g mol^{-1}

11. A person takes 6.1 g of an anta-acid tablet comprising bicarbonate ion at 20.8%. The volume of CO_2 evolved at (1 atm and 25° C) in the stomach (on neutralisation) multiplied by a factor of '10' will be x L. Calculate the approximate (integer) value of x.

12. The specific gravity of a salt solution is 1.025. If V mL of water is added to 1.0 L of this solution to make its density 1.02 g mL^{-1}, what is value of V in mL approximately?

13. A 19.6 g of a given gaseous sample contains 2.8 g of moleules ($d = 0.75$ g L^{-1}), 11.2 g of molecules ($d = 3$ g L^{-1}) and 5.6 g of molecules ($d = 1.5$ g L^{-1}). All density measurements are made at STP. Calculate the total number of molecules (N) present in the given sample. Report your answer in '$10^{23} N$'.

Assume Avogardro's number as 6×10^{23}.

ARCHIVES

Single Correct Answer Type

1. The largest number of molecules is in **(IIT-JEE, 1979)**

a. 36 g of water

b. 28 g of carbon monoxide

c. 46 g of ethly alcohol

d. 54 g of nitrogen pentoxide

2. When the same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volume of hydrogen evolved is **(IIT-JEE, 1979)**

a. 1:1 **b.** 1:2 **c.** 2:1 **d.** 9:4

3. A gaseous mixture contains oxygen and nitrogen in the ratio of 1:4 by weight. Therefore, the ratio of their number of moleucles is **(IIT-JEE, 1979)**

a. 1:4 **b.** 1:8 **c.** 7:32 **d.** 3:16

4. The total number of electrons in one molecular of carbon dioxide is **(IIT-JEE, 1979)**

a. 22 **b.** 44 **c.** 66 **d.** 88

5. When 2.76 g of silver carbonate is strongly heated, it yields a residue weighing **(IIT-JEE, 1979)**

a. 2.16 g **b.** 2.48 g **c.** 2.32 g **d.** 2.64 g

6. Equal weights of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is **(IIT-JEE, 1981)**

a. $\frac{1}{3}$ **b.** $\frac{1}{2}$ **c.** $\frac{2}{3}$ **d.** $\frac{1}{3} \times \frac{273}{298}$

7. If 0.50 mol of $BaCl_2$ is mixed with 0.20 mol of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is **(IIT-JEE, 1981)**

a. 0.70 **b.** 0.50 **c.** 0.20 **d.** 0.10

8. An isotope of Ge^{76}_{32} is **(IIT-JEE, 1984)**

a. Ge^{77}_{32} **b.** As^{77}_{33} **c.** Se^{77}_{34} **d.** Se^{78}_{34}

9. A molal solution is one that contains 1 mol of a solute in **(IIT-JEE, 1986)**

a. 1000 g of solvent **b.** 1 L of solvent

c. 1 L of solution **d.** 22.4 L of solution.

10. In which mode of expression, the concentration of a solution remains independent of temperature? **(IIT-JEE, 1988)**

a. Molarity **b.** Normality **c.** Formality **d.** Molality

11. The normality of 0.3 M phosphorous acid (H_3PO_3) is **(IIT-JEE, 1999)**

a. 0.1 **b.** 0.9 **c.** 0.3 **d.** 0.6

12. At 100°C and 1 atm, if the density of the liquid water is 1.0 g cm^{-3} and that of water vapour is 0.0006 g cm^{-3}, then the volume occupied by water molecules in 1 L of steam at this temperature is **(IIT-JEE, 2000)**

a. 6 cm^3 **b.** 60 cm^3 **c.** 0.6 cm^3 **d.** 0.06 cm^3

13. An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is **(IIT-JEE, 2001)**

a. 40 mL **b.** 20 mL **c.** 10 mL **d.** 4 mL

14. How many moles of electron weigh 1 kg? **(IIT-JEE, 2002)**

a. 6.023×10^{23} **b.** $\frac{1}{9.108} \times 10^{31}$

c. $\frac{6.023}{9.108} \times 10^{54}$ **d.** $\frac{1}{9.108 \times 6.023} \times 10^{8}$

15. A, mixture x containing 0.02 mol of $[Co(NH_3)_5SO_4]Br$ and 0.02 mol of $[Co(NH_3)_5Br]SO_4$ was prepared in 2L of solution. **(IIT-JEE, 2003)**

1 L of mixture X + excess $AgNO_3 \rightarrow Y$

1 L of mixture X + excess $BaCl_2 \rightarrow Z$

The numbers of moles of Y and Z are

a. 0.01, 0.01 **b.** 0.02, 0.01

c. 0.01, 0.02 **d.** 0.02, 0.02

16. Which of the following has the maximum number of atoms? **(IIT-JEE, 2003)**

a. 24 g of C(12) **b.** 56 g of Fe(56)

c. 27 of Al(27) **d.** 108 g of Ag(108)

17. Given that the abundance of isotopes ^{54}Fe, ^{56}Fe, and ^{57}Fe is 5%, 90%, and 5%, respectively. The atomic mass of Fe is **(IIT-JEE, 2009)**

a. 55.85 **b.** 55.95 **c.** 55.75 **d.** 55.05

18. Dissolving 120 g of urea ($Mw = 60$) in 1000 g of water gave a solution of density 1.15 g mL^{-1}. The molarity of solution is: **(IIT-JEE, 2011)**

a. 1.78 M **b.** 2.00 M **c.** 2.05 M **d.** 2.22 M

Integer Type

1. The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is .... **(IIT-JEE, 2010)**

2. A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titre value is .... (IIT-JEE, 2010)

3. Silver (atomic weight 108 g mol^{-1}) has a density of 10.5 g cm^{-3}. The number of silver atoms on a surface of area 10^{-12} m^2 can be expressed in scientific notation as $Y \times 10^{x}$, The value of x is .... (IIT-JEE, 2010)

4. Among the following, what is the number of elements showing only one non-zero oxidation state?

O, Cl, F, N, P, Sn, Tl, Na, Ti (IIT-JEE, 2010)

Fill in the Blanks Type

1. The total number of electrons present in 18 mL of water is .... (IIT-JEE, 1980)
2. The modern atomic mass unit is based on the mass of .... (IIT-JEE, 1980)
3. Three grams of salt of molecular weight 30 is dissolved in 250 g of water. The molality of the solution is .... (IIT-JEE, 1983)
4. The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is .... (IIT-JEE, 1980)

Subjective Type

1. What is the molarity and molality of a 13% solution (by weight) of sulphuric acid with a density of 1.02 g mL^{-1}? To what volume should 100 mL of this acid be diluted in order to preapre a 1.5 N solution? (IIT-JEE, 1978)
2. Calculate the density of NH_3 at 30°C and 5 atm pressure. (IIT-JEE, 1979)
3. When 4.215 g of metalic carbonate was heated in a hard glass tube, the CO_2 evolved was found to be measured 1336 mL at 27°C and 700 mm pressure. What is the equivalent weight of the metal? (IIT-JEE, 1979)
4. The density of 3 M sodium thiosulphate solution ($Na_2S_2O_3$) is 1.25 g mL^{-1}. Calculate
   a. The percentage by weight of sodium thiosulphate.
   b. The mole fraction of sodium thiosulphate.
   c. The molalities of $Na^{\oplus}$ and $S_2O_3^{2-}$ ions.

   (IIT-JEE, 1983)
5. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}O_{11}$). Calculate
   a. the molal concentration.
   b. the mole fraction of the sugar in the syrup.

   (IIT-JEE, 1988)
6. Calculate the molality of 1 L solution of 93% H_2SO_4 (weight/volume). The density of the solution is 1.84 g. (IIT-JEE, 1990)
7. Calculate the volume occupied by 5.0 g of acetylene gas at 50° C and 740 mm pressure. (IIT-JEE, 1991)
8. On mixing 45.0 mL of 0.25 M lead nitrate solution with 25.0 mL of 0.10 M chromic sulphate solution, precipitation of lead sulphate takes place. How many moles of lead sulphate are formed? Also calculate the molar concentra-tions of the species left behind in the final solution. Assume that lead sulphate is completely insoluble. (IIT-JEE, 1993)
9. When 0.575×10^{-2} kg of Glauber's salt is dissolved in water, we get 1 dm^3 of a solution of density 1077.2 kg m^{-3}. Calculate the molarity, molality, and mole fraction of Na_2SO_4 in the solution.(IIT-JEE, 1994)
10. Calculate the molarity of water if its density is 1000 kg m^{-3}. (IIT-JEE, 2003)
11. Calculate the amount of calcuium oxide required when it reacts with 852 g of P_4O_{10}. (IIT-JEE, 2005)

HINTS AND SOLUTIONS

Subjective Type

1. **First method**

First case

Weight of 10 mL of H_2 at STP $= \dfrac{10 \times 2}{22400} = 0.0008$ g

Weight of 5 mL of O_2 at STP $= \dfrac{5 \times 32}{22400} = 0.0007$g

Second case

Weight of 200 mL of H_2 at STP $= \dfrac{200 \times 2}{22400} = 0.0178$ g

Weight of oxygen taken away from cupric oxide by 200 mL or 0.0178 g of H_2 at STP = 0.144 g

Weight of O_2 that combines with 0.0008 g of H_2 in first case

$$= \frac{0.144 \times 0.0008}{0.0178} = 0.0065 \approx 0.007 \text{ g}$$

Thus, the weights of O_2 that combine with same weight of H_2 is the same in two cases. Hence, the law of constant composition is proved.

Second method

First case

$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

1 mL $\quad \frac{1}{2}$ mL

10 mL $\quad$ 5 mL

200 mL $\quad$ 100 mL

Second case

Weight of oxygen taken away from cupric oxide by 200 mL of H_2 at STP = 0.144 g

$\therefore$ Volume of 0.144 g of $O_2 = \frac{22400 \times 0.144}{32}$

$= 100.8$ mL

So the volume of O_2 that combines with H_2 in both the cases is same. Hence, the law of constant composition is verified.

2. First case

Common salt from Clifton beach contains = 67.75% Cl_2

100 g of salt = 60.75 g of Cl_2

1 g of salt = $\frac{60.75}{100}$ = 0.6075 g of Cl_2

Second case

6.40 g of NaCl from Khewra mine = 3.888 g of Cl_2

1 g of NaCl from Khewra mine = $\frac{3.888}{6.40}$ = 0.6075 g of Cl_2

Thus, the weight of Cl_2 in 1 g of salt in both the cases is same. Hence, the law of constant composition is verified.

3. First case

3.2 g of S combines with 3.2 g of O_2

1 g of S combines with = 1 g of O_2

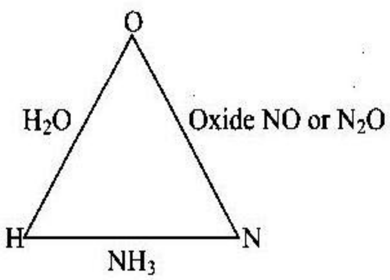
Second case

0.8 g of S combines with 1.2 g of O_2.

1 g of S combines with = $\frac{1.2}{0.8}$ = 1.5 g of O_2

Thus, the ratio of the O_2 in both cases which combines with a fixed mass (1 g) of S = 1:1.5 or 2:3, which is a simple whole number ratio, and hence the law of multiple proportion is verified.

4.



In H_2O: 0.126 g of H_2 combines with 1 g of oxygen.

$\therefore$ 1 g of H_2 combines with = $\frac{1}{0.126}$ = 7.936 g of O_2

In NH_3: 0.216 g of H_2 combines with 1 g of N_2.

$\therefore$ 1 g of H_2 combines with = $\frac{1}{0.216}$ = 4.629 g of N_2

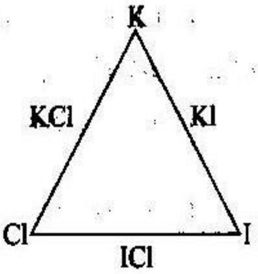
Ratio of O:N in H_2O and NH_3 which combines with a fixed weight of H_2 (1 g) = 7.936:4.629 = $\frac{7.936}{4.629} : \frac{4.629}{4.629}$ = 1.71:1

$\therefore$ Weight of oxygen which combines with 1 g of N should be 1.71 g or its simple multiple.

5. KCl = 52% K, 48% Cl

KI = 23.6% K, 76.4% I

ICl = 77.8% I, 22.2% Cl



In KCl: 48 g of Cl reacts with 52 g of K.

1 g of Cl reacts with = $\frac{52}{48}$ = 1.08 g of K

In ICl: 22.2 g of Cl reacts with 77.8 g of I

1 g of Cl reacts with = $\frac{77.8}{22.2}$ g of I = 3.5 g of I

Ratio of K and I in KCl and ICl which reacts with fixed mass of Cl (1 g) = 1.08:3.5 = $\frac{1.08}{1.08} = \frac{3.5}{1.08}$ = 1 : 3.2

Ratio of K and I in KI = 23.6:76.4 = $\frac{23.6}{23.6} : \frac{76.4}{23.6}$ = 1:3.2

These two ratios are = $\frac{1}{1} : \frac{3.2}{3.2}$ = 1:1

This prove the law of reciprocal proportions.

6. $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

According to the law of conservation of mass, the weight of reactants must be equal to the weight of the products. Thus,

$x + 4.9 = 6 + 1.825$

$x = 7.825 - 4.9 = 2.925$ g = 2.9 g

7. According to the law, the samples of calcium carbonate from the two sources must be identical, i.e., their percentage composition must be the same.

Thus, the weights, Ca, C, and O in 1.5 g $CaCO_3$ are:

Calcium (Ca) = $\frac{40 \times 1.5}{100}$ = 0.60g;

Carbon (C) = $\frac{12 \times 1.5}{100}$ = 0.18g;

Oxygen (O) = $\frac{48 \times 1.5}{100}$ = 0.72 g

8. In one oxide:

50 g of element combines with 50 g of oxygen.

Therefore, 1 g of element will combine with 1 g of oxygen

In the other oxide:

40 g of element will combine with 60 g of oxygen.

Therefore, 1g of element will combine with 64/40 or 1.5 g of oxygen.

Thus, the weights of oxygen that combine with 1 g of the element in the two oxides are in the ratio of 1:1.5 or 2:3; which is a simple ratio. This illustrates the law of multiple proportions.

9. Weights of B that combine with 1.0 g of A in the compounds X, Y, and Z, are, respectively,

0.4/0.3 = 1.33; 48.0/18.0 = 2.66; and 159.99/40.0 = 4.00

Ratio being 1.33:2.66:4.00 or 1:2:3 is simple and this illustrates the law of multiple proportions.

10. $NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

$23 + 35.5 = 58.5$ g $108 + 35.5 = 143.5$ g

143.5 g of AgCl is obtained from 58.5 g of pure NaCl.

0.9 g of AgCl is obtained from $= \dfrac{58.5 \times 0.9}{143.5}$

$= 0.36$ g of pure NaCl

$\% \text{ purity} = \dfrac{0.36 \times 100}{0.5} = 72\%$

11. $Mg + S \longrightarrow MgS$

24 g 32 g $32 + 24 = 56$ g

32 g of S in obtained from 24 g of Mg.

2 g of S in obtained from $= \dfrac{24}{32} \times 2 = 1.5$ g of Mg

So, S is completely consumed and Mg is left.

Hence, S is the limiting reagent.

Therefore, the amount of product, i.e., MgS, will be determined from S and not from Mg.

32 g of S = 56 g of MgS

2 g of S $= \dfrac{56}{32} \times 2 = 3.5$ g of MgS

Amount of Mg unreacted $= 2 - 1.5 = 0.5$ g

12.

Element	Moles	Least ratio
Fe	$\dfrac{0.2014}{56} = 0.0036$	$\dfrac{0.0036}{0.0036} = 1$
S	$\dfrac{0.1153}{32} = 0.0036$	$\dfrac{0.0036}{0.0036} = 1$
O	$\dfrac{0.2301}{16} = 0.0143$	$\dfrac{0.0143}{0.0036} = 3.97 \approx 4$
H_2O	$\dfrac{0.4532}{18} = 0.025$	$\dfrac{0.025}{0.0036} = 6.94 \approx 7$

Empirical formula is $FeSO_4 \cdot 7H_2O$.

13.

Element	Moles	Least ratio
C	$\dfrac{54.55}{12} = 4.54$	$\dfrac{4.54}{2.27} = 2$
H	$\dfrac{9.09}{1} = 9.09$	$\dfrac{9.09}{2.27} = 4$
O	$\dfrac{36.36}{16} = 2.27$	$\dfrac{2.27}{2.27} = 1$

Empirical formula $= C_2H_4O$.

Empirical formula weight $= 12 \times 2 + 1 \times 4 + 16 = 44$

VD = 44,

Molecular weight $= 2 \times VD = 2 \times 44 = 88$

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{88}{44} = 2$$

Molecular Formula $= 2 \times$ Empirical formula

$= 2 \times (C_2H_4O) = C_4H_8O_2$

14. a.

Element	Moles	Least ratio	Whole no. ratio
N	$\dfrac{15}{14} = 2.5$	$\dfrac{2.5}{2.5} = 1$	2
H	$\dfrac{5}{1} = 5$	$\dfrac{5}{2.5} = 2$	4
O	$\dfrac{60}{16} = 3.75$	$\dfrac{3.75}{2.5} = 1.5$	3

Empirical formula $N_2H_4O_3 = NH_4NO_3$

$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$

b. Empirical formula of the gaseous product:

Element	Moles	Least ratio
N	$\dfrac{63.63}{14} = 4.545$	$\dfrac{4.545}{2.273} = 1.99 \approx 2$
O	$\dfrac{36.37}{16} = 2.273$	$\dfrac{2.273}{2.273} = 1$

Empirical formula $= N_2O$

15. C : H : N = 9 : 1 : 3.5

Moles ratio C:H:N $= \dfrac{9}{12} : \dfrac{1}{1} : \dfrac{3.5}{14} = 0.75 : 1 : 10.25$

$= \dfrac{0.75}{0.25} : \dfrac{1}{0.25} : \dfrac{0.25}{0.25} = 3 : 4 : 1$

Empirical formula $= C_3H_4N$

Empirical formula weight $= C_3H_4N$

$= 12 \times 3 + 1 \times 4 + 14 = 54$

$Mw = 108$

$$n = \frac{Mw}{EFw} = \frac{108}{54} = 2$$

Molecular formula $= 2 \times C_3H_4N = C_6H_8N_2$

16. a. Empirical formula: Carbon present = 124 g
Water present = 310 − 124 = 186 g

$$\text{Moles of Carbon} = \frac{124}{12} = 10.03$$

$$\text{Moles of } H_2O = \frac{186}{18} = 10.03$$

Ratio of $C:H_2O = 1:1$

Hence, the empirical formula $= CH_2O$

b. Molecular formula: 0.0833 moles of the carbohydrate contain 1.00 g or one atom of hydrogen.

Therefore, one mole of the carbohydrate will contain hydrogen atoms = 1/0.0833 = 12

Number of hydrogen atoms in the molecule being 12, the molecular formula should be six times the empirical formula, i.e., $CH_2O \times 6$ or $C_6H_{12}O_6$.

Hence, the molecular formula of the carbohydrate is $C_6H_{12}O_6$.

17. $$\%\text{ of C} = \frac{12}{44} \times \frac{\text{Weight of } CO_2 \times 100}{\text{Weight of compound}}$$

$$= \frac{12 \times 1.1 \times 100}{44 \times 0.45} = 66.66\%$$

$$\%\text{ of H} = \frac{2}{18} \times \frac{\text{Weight of } H_2O \times 100}{\text{Weight of compound}}$$

$$= \frac{2 \times 0.3 \times 100}{18 \times 0.45} = 7.4\,\%$$

$\%$ of N $= [100 - (66.66 + 7.4)] = 25.93\%$

18. a. 1.30 g of the compound = 0.59 g of Co

$$100 \text{ g of the compound} = \frac{0.59 \times 100}{1.3} = 45.4\%$$

b. 1.30 g of the compound = 0.71 g of chloride

$$100 \text{ g of the compound} = \frac{0.71 \times 100}{1.3} = 54.6\%$$

19. Mw of glucose $= C_6H_{12}O_6 = 12 \times 6 + 1 \times 12 + 16 \times 6$
$= 180$ g

a. 180 g of glucose = 72 g of C

$$100 \text{ g of glucose} = \frac{72 \times 100}{180} = 40\%$$

b. $$\%\text{ of H} = \frac{12 \times 100}{180} = 6.67\%$$

c. $$\%\text{ of O} = \frac{96 \times 100}{180} = 53.33\%$$

20. Mw of NaOH = 23 + 16 + 1 = 40 g
1 g equivalent of NaOH = 1000 mEq = 40 g

$$50 \text{ mEq} = \frac{40 \times 50}{1000} = 2 \text{ g}$$

21. $$N = \frac{\text{g equivalent}}{V_{sol}\text{ (in L)}} = \frac{\text{mEq}}{V_{sol}\text{ (in mL)}} = \frac{50}{2000} = 0.025\text{ N}$$

22. Mw of $H_2SO_4 = 2 \times 1 + 32 + 16 \times 4 = 98$ g

$$Ew = \frac{98}{2} = 49$$

$$N = \frac{W_2 \times 1000}{Ew_2 \times V_{sol}\text{ (in mL)}}$$

$$0.2 = \frac{W_2 \times 1000}{49 \times 1200} \Rightarrow W_2 = 11.76 \text{ g}$$

23. mEq of Na_2CO_3 = mEq of acid

$$\frac{\text{Weight} \times 1000}{Ew} = V(\text{in mL}) \times N$$

$$\frac{W_2 \times 1000}{53} = 45.6 \times 0.235$$

$W_2 = 0.5679$ g

$$\left[\begin{array}{l} Mw \text{ of } Na_2CO_3 = 23 \times 2 + 12 + 16 \times 3 = 106 \text{ g} \\ Ew = \frac{Mw}{2} = \frac{106}{2} = 53 \text{ g} \end{array}\right]$$

$$\text{Weight of } Na_2CO_3 \text{ of 95\% purity} = \frac{0.5679 \times 100}{95} = 0.5978 \text{ g}$$

24. mEq of H_2SO_4 = mEq of NaOH

$N_1V_1 = N_2V_2$

$$N_1 \times 12 = \frac{1}{10} \times 15$$

$\therefore N_2 = 0.125$

Strength $= N \times Ew = 0.125 \times 49 = 6.125 \text{ g L}^{-1}$

$$\left[\begin{array}{l} Mw \text{ of } H_2SO_4 = 1 \times 2 + 32 + 16 \times 4 = 98 \text{ g} \\ Ew = \frac{Mw}{2} = \frac{98}{2} = 49 \text{ g} \end{array}\right]$$

25. $$PV = \frac{W}{Mw} RT$$

$$\text{Mole} = \frac{W}{Mw} = \frac{PV}{RT} = \frac{0.2 \times 2}{0.0821 \times 303} = 0.01608 \text{ mol}$$

= 16.08 mmol or mEq

$$\left(\begin{array}{l} 1 \text{ mole of } NH_3 = 1 \text{ g Eq. of } NH_3 \\ 1 \text{ mmole of } NH_3 = 1 \text{ mEq of } NH_3 \end{array}\right)$$

$N \times V = \text{mEq}$

$N \times 134 \text{ mL} = 16.08$

$\therefore N = 0.12$

26. $Ca + \frac{1}{2}O_2 \longrightarrow CaO$

40 g of Ca = 56 g of CaO

$1 \text{ g of Ca} = \frac{56}{40} = 1.4 \text{ g of CaO}$

$$N = \frac{W_2 \times 1000}{Ew \times V_{sol} \text{ (in mL)}} = \frac{1.4 \times 1000}{\frac{56}{2} \times 1000} = 0.05 \text{ N}$$

27. a. ($Mw = Ew$ of KOH = 39 + 16 + 1 = 56 g)

15 mEq HCl = 15 mEq of KOH

$\Rightarrow 15 \times 10^{-3} \times 56 = 0.84$ g of KOH

b. 15 mEq of $KHSO_4$ = 15 mEq of KOH

$\Rightarrow 15 \times 10^{-3} \times 56 = 0.84$ g of KOH

c. 15 mEq of N_2O_5 = 15 mEq of KOH = 0.84 g

d. 15 mEq of CO_2 = 15 mEq of KOH = 0.84 g

28. ($Mw = Ew$ of HCl = 1 + 35.5 = 36.5)

$$Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2$$

23 g   23 + 16 + 1 = 40 g

mEq of Na = mEq of NaOH = mEq of HCl

$$\frac{0.46}{23} \times 1000 = \frac{73}{36.5} \times V \left(N \text{ of HCl} = \frac{\text{Weight}}{Ew} \right)$$

$V = 10$ mL

29. $Ca(OH)_2 + H_3PO_4 \longrightarrow CaHPO_4 + 2H_2O$

In the above equation, 2H atom has reacted, so H_3PO_4 acts as a dibasic acid.

($\therefore Mw$ of $H_3PO_4 = 3 + 31 + 16 \times 4 = 98$ g)

$\therefore Ew$ of $H_3PO_4 = \frac{Mw}{n} = \frac{98}{2} = 49$ g

30. $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

	$AgNO_3$	$NaCl$	$AgCl$	$NaNO_3$
Initial	$\frac{5.77}{170} = 0.033$	$\frac{4.77}{58.5} = 0.08$	0	0
Left	0	0.08 − 0.033 = 0.048	0.033	0.033

[Mw of $AgNO_3 = 108 + 14 + 16 \times 3 = 170$ g]

[Mw of NaCl = 23 + 35.5 = 48.5 g]

0.033 moles of AgCl is formed.

Weight of AgCl = 0.033 × 143.5 = 4.7355 g

(Weight = Moles × Mw, Mw of AgCl = 108 + 35.5 = 143.5 g)

31. Weight of Ag $= \frac{90 \times 0.5}{100} = 0.45$ g

mEq of Ag = mEq of KCNS

$$\frac{\text{Weight of Ag}}{Ew \text{ of Ag}} \times 1000 = \text{Volume in mL} \times N$$

$$\frac{0.45 \times 1000}{108} = 25 \times N$$

$\therefore N = 0.167$

$$\left(Ag \xrightarrow{HNO_3} AgNO_3 \xrightarrow{KCNS} AgCNS \right)$$

(mEq of Ag = mEq of $AgNO_3$ = mEq of Ag CNS)

32. a. ($Mw = Ew$ of $HNO_3 = 1 + 14 + 16 \times 3 = 63$ g)

$$N = \frac{\% \text{ by weight} \times 10 \times d}{Ew} = \frac{70 \times 10 \times 1.42}{63} = 15.78$$

b. 70 × 1.42 g of pure acid is present in 100 mL.

63 g of pure acid is present in $= \frac{100 \times 63}{70 \times 1.42}$

= 63.38 mL

c. mEq of HNO_3 (before) = mEq of dil. HNO_3 (after dilution)

($\because$ mEq does not change on dilution)

$N_1V_1 = N_2V_2$

$15.78 \times 2 = 1 \times V_2$

$\therefore V_2 = 31.56$ mL

Volume of H_2O added = 31.56 − 2 = 29.56 mL

33. H_2SO_4 is 95% by volume,

Weight of H_2SO_4 = 95 g

Volume of solution = 100 mL

Weight of solution = 100 × 1.98 = 198 g

Weight of H_2O = 198 − 95 = 103 g

$$m = \frac{W_2 \times 1000}{Mw \times W_1} = \frac{95 \times 1000}{98 \times 103} = 9.412$$

34. mEq of Al = mEq of H_2SO_4 reacted

mEq of Al $= \frac{2.7}{9} \times 1000 = 300$

$\left(Ew \text{ of Al} = \frac{Mw}{3} = \frac{27}{3} = 9 \text{ g} \right)$

$(Al \longrightarrow Al^{3+} + 3e^-)$

$$N \text{ of } H_2SO_4 = \frac{\% \text{ by weight} \times 10 \times d}{Ew_2} = \frac{24.7 \times 10 \times 1.18}{98/2} = 5.95$$

mEq of H_2SO_4 = N × Volume in mL = 5.95 × 75 = 446.25

mEq of Al added = 300

mEq of H_2SO_4 left after reaction = 446.25 − 300 = 146.25

Solution is diluted to 400 mL.

$\therefore N_{H_2SO_4}$ left $= \frac{mEq}{mL} = \frac{146.25}{400} = 0.0367$

$M_{H_2SO_4}$ left $= \frac{N}{n} = \frac{0.0367}{2} = 0.183$

35. $M = \frac{W_2 \times 1000}{Mw_2 \times V_{sol} \text{ (in mL)}}$

$W_2 = 5 \text{ mg} = 5 \times 10^{-3} \text{ g}$

$\therefore M = \frac{5 \times 10^{-3} \times 10^3}{60 \times 10} = 0.008$

36. C_2H_5OH is 20% by volume, i.e., 20 mL of C_2H_5OH is dissolved in 100 mL of solution.

Volume of $H_2O = 100 - 20 = 80$ mL

Weight of $H_2O = 80 \times 1 = 80$ g $(d_{H_2O} = 1)$

Weight of solution $= 100 \times 0.96 = 96$ g

Weight of $C_2H_5OH = 96 - 80 = 16$ g

(Mw of $C_2H_5OH = 12 \times 2 + 5 + 16 + 1 = 46$)

$\therefore M = \frac{W_2 \times 1000}{Mw_2 \times V_{sol}} = \frac{16 \times 1000}{46 \times 100} = 3.48$

$m = \frac{W_2 \times 1000}{Mw_2 \times W_1} = \frac{16 \times 1000}{46 \times 80} = 4.35$

37. (Mw of NaOH $= 23 + 16 + 1 = 40$)

$M = \frac{W_2 \times 1000}{Mw_2 \times V_{sol}} = \frac{4 \times 1000}{40 \times 100} = 1$

(Since NaOH is monobasic acid its normality and molarity will be same)

38. $M = \frac{35.4 \times 1000}{118 \times 1000} = 0.3$

$m = \frac{W_2 \times 1000}{Mw_2 \times (V_{sol} \times d_{sol} - W_2)}$

$= \frac{35.4 \times 1000}{118\,(1000 \times 1.0077 - 35.4)}$

$= \frac{35.4 \times 1000}{118 \times 972.3} = 0.31$

$N = n \times M = 2 \times 0.3 = 0.6$

Weight of solvent (W_1)

$=$ Weight of solution – Weight of solute

$= V_{sol} \times d_{sol} - W_2$

$= 1000 \times 1.0077 - 35.4 = 972.3$

$\chi_2 = \frac{n_2}{n_1 + n_2} = \frac{W_2 / M_{w_2}}{\frac{W_1}{Mw_1} + \frac{W_2}{Mw_2}}$

$= \frac{35.4/118}{\frac{972.3}{18} + \frac{35.4}{118}}$

$= \frac{0.3}{54 + 0.3} = 0.0055$

$\chi_1 = 1 - \chi_2 = 1 - 0.0055 = 0.9945$

39. $\chi_2 = \frac{n_2}{n_1 + n_2} = \frac{2.80}{8.2 + 2.8} = \frac{2.8}{11} = 0.255$

40. $X = 45\%, n_1 = \frac{45}{18} = 2.5$

$Y = 15\%, n_2 = \frac{15}{60} = 0.25$

$Z = 40\%, n_3 = \frac{40}{60} = 0.666$

$\chi_1 = \frac{n_1}{n_1 + n_2 + n_3} = \frac{2.5}{2.5 + 0.25 + 0.666}$

$= \frac{2.5}{3.416} = 0.73$

$\chi_2 = \frac{n_2}{n_1 + n_2 + n_3} = \frac{0.25}{3.416} = 0.073$

$\chi_3 = [1 - (\chi_1 + \chi_2)] = (1 - 0.73 - 0.073) = 0.195$

Linked Comprehension Type

1. b $NH_2CONH_2 + 2HNO_2 \longrightarrow CO_2\uparrow + 2N_2\uparrow + 3H_2O(l)$

mmoles $= \frac{0.3 \times 10^3}{60}$

$= 5$

Initial	5	10 (0.2 M)	—	—	—
Final	—	—	5	10	15

V_{H_2O} at room temperature = 0 (since it is liquid).

V_{CO_2} is absorbed by KOH or NaOH.

$\therefore$ millimoles of gases (i.e., N_2) = 10

V at RTP $= 24400 \times 10 \times 10^{-3}$ mL $= 244$ mL

2. c. millimoles of $HNO_2 = 10 = 0.2\text{ M} \times V_{HNO_2}$ (mL)

$V_{HNO_2} = 50$ mL

3. c. $1.0 \text{ g } (CF_2)_n = \left(\frac{1 \text{ mol } (CF_2)_n}{50\, n \text{ g } (CF_2)_n}\right)\left(\frac{4n \text{ mol } CoF_3}{\text{mol } (CF_2)_n}\right)\left(\frac{1 \text{ mol } F_2}{2 \text{ mol } CoF_3}\right)\left(\frac{38\text{g } F_2}{\text{mol } F_2}\right)$

$\Rightarrow 1 \times \frac{1}{50} \times \frac{4}{1} \times \frac{1}{2} \times \frac{38}{1} \Rightarrow 1.52 \text{ g } F_2$

(note for n cancels)

4. c. If $4n CoF_3$ yields $4n CoF_2$, $4nF$ atoms are consumed. Saving $2nF$ atoms by recovery of the F from HF reduces the consumption by half.

Hence, $\frac{1.52}{2} = 0.76$ g of F_2 is required.

5. a Factor label method: (Mw of $NaClO_4 = 122.5$, *Mw* of $NaClO_3 = 106.5\ g\ mol^{-1}$)

$$x\text{ g of } Cl_2 = \left(\frac{122.5\text{ g } NaClO_4}{\begin{matrix}122.5\text{ g } NaClO_4\\ \text{per mol of } NaClO_3\end{matrix}}\right)\left(\frac{4\text{ mol } NaClO_3}{3\text{ mol } NaClO_4}\right)$$

$$\left(\frac{3\text{ mol } NaClO}{1\text{ mol } NaClO_3}\right)\left(\frac{1\text{ mol } Cl_2}{1\text{ mol } NaClO}\right)\left(\frac{71.0\text{ g } Cl_2}{1\text{ mol } Cl_2}\right)$$

$$= \frac{122.5}{122.5}\times\frac{4}{3}\times\frac{3}{1}\times\frac{1}{1}\times\frac{71.0}{1} = 284.0\text{ g}$$

Mole method:

$n(NaClO) = n(Cl_2)$,

$$n(NaClO_3) = \frac{1}{3}n(NaClO) = \frac{1}{3}n(Cl_2)$$

$$n(NaClO_4) = \frac{3}{4}n(NaClO_3) = \frac{3}{4}\times\frac{1}{3}n(Cl_2) = \frac{1}{4}n(Cl_2)$$

$$n(NaClO_4) = \frac{122.5\text{ g } NaClO_4}{122.5\text{ of } NaClO_4/\text{mol } NaClO_4}$$

$= 1.0\text{ mol}\cdot NaClO_4$

$n(Cl_2) = 4\times 1.0 = 4\text{ mol}\cdot Cl_2$

Mass of $(Cl_2) = 4\times 71.0\text{ g} = 284.0\text{ g } Cl_2$

6. b $$x\text{ g } Cl_2 = \left(\frac{106.5\text{ g } NaClO_3}{\begin{matrix}106.5\text{ g } NaClO_3\\ \text{per mol } NaClO_3\end{matrix}}\right)\left(\frac{3\text{ mol } NaClO}{1\text{ mol } NaClO_3}\right)$$

$$\left(\frac{1\text{ mol } Cl_2}{1\text{ mol } NaClO}\right)\left(\frac{71.0\text{ g } Cl_2}{1\text{ mol } Cl_2}\right)$$

$$= \frac{106.5}{106.5}\times\frac{3}{1}\times\frac{1}{1}\times\frac{17.0}{1} = 213.0\text{ g } Cl_2$$

7. d $$\text{Ratio} = \frac{1\text{ mol } C_7H_8\ (92.0\text{ g/mol})}{1\text{ mol.} C_7H_{14}\ (98.0\text{ g/mol})} = 0.939$$

$$\%\text{ reduction} = \left(\frac{1-0.939}{1}\right)\times 100 = 6.1\ \%$$

8. b The weight of 1.0 mL TEL = 1.0 mL × 1.615 = 1.615 g

The weight of TEL needed per litre of gasoline = 1.615g

[*Mw* of TEL $[C_2H_5)_4Pb] = 4\times 29 + 207 = 323\text{ g mol}^{-1}$)

$$\text{moles of TEL} = \frac{1.615}{323\text{g mol}^{-1}}\ 0.005\text{ mol}$$

1 mol of TEL requires = 4 mol. pf C_2H_5Cl.

0.005 mol of TEL requires = 4 × 0.005

= 0.02 mol of C_2H_5Cl

Weight of $C_2H_5Cl = 0.02\times(64.5\text{ g/mol}) = 1.29$ g

9. d 118% oleum means 100 g of oleum requires 18 g of H_2O to form 118 g of H_2SO_4.

$$\underset{\substack{1\text{ mol}\\(80g)}}{SO_3} + \underset{\substack{1\text{ mol}\\(18\text{ g})}}{H_2O} \longrightarrow H_2SO_4$$

$$\therefore \%\text{ of free } SO_3 = \frac{18}{18}\times 80 = 80\%$$

10. b % of free $SO_3 = 20\%$

i.e., 20 g SO_3 is present in 100 g oleum.

$\because$ 80 g SO_3 requires 18 g H_2O

$$20\text{ g } SO_3\text{ requires} = \frac{18}{80}\times 20 = 4.5\text{ g } H_2O$$

$\therefore$ % labelling of oleum = 100 + 4.5 = 104.5%

11. d 147% oleum sample implies 100 g oleum sample on addition of 47 g of H_2O will form 147 g H_2SO_4.

$$\text{Equivalent of } H_2SO_4 = \frac{147}{49} = 3 = 3\times 10^3\text{ mEq}$$

$\therefore$ mEq of H_2SO_4 = mEq of NaOH

$3\times 10^3 = 500\text{ mL}\times x\times 1$

$$x = \frac{3000}{500} = 6\text{ M}$$

12. a *Mw* of $K_2[PtCl_4] = 2\times 39 + 195 + 4\times 35.5 = 415$ g, *Mw* of $NH_3 = 17$ g

$$\text{Mol of } K_2[PtCl_4] = \frac{83.0}{415} = 0.2\text{ mol (limiting reagent)}$$

$$\text{Mol of } NH_3 = \frac{83}{17} = 4.88\text{ mol (excess)}$$

13. b Mol of $K_2[PtCl_4]$ consumed = 0.2 mol

= mol of cisplatin

NH_3 consumed = 2 × 0.2 = 0.4 mol.

14. d Excess of NH_3 unreacted = 4.88 – 0.4 = 4.48 mol

15. a (*Mw* of $I_2 = 245$ g, *Mw* of $NaIO_3 = 198$ g, *Mw* of $NaHSO_3 = 104$ g)

$$\text{Mol of } I_2 = \frac{127}{254} = 0.5\text{ mol } I_2$$

$$(0.5\text{ mol } I_2)\left(\frac{2\text{ mol } NaIO_3}{\text{mol } I_2}\right)\left(\frac{198\text{ g of } NaIO_3}{\text{mol of } NaIO_3}\right)$$

$\Rightarrow 0.5\times 2\times 198 = 1980\text{ g} = 1.98$ kg of $NaIO_3$

16. d $$\text{Mol of } I_2 = \frac{381}{254} = 1.5\text{ mol } I_2$$

$$(1.5\text{ mol } I_2)\left(\frac{5\text{ mol } NaHSO_3}{\text{mol } I_2}\right)\left(\frac{104\text{ g } NaHSO_3}{\text{mol } NaHSO_3}\right)$$

$\Rightarrow 1.5\times 5\times 104 = 780$ g of $NaHSO_3$

17. b Mol of $P_4 = \frac{2.0}{31\times4} = 0.016$ mol

Mol of $O_2 = \frac{2.0}{32} = 0.0625$ mol

This is not enough O_2 to produce P_4O_{10}, which would have required $5 \times 0.016 = 0.08$ mol O_2. Thus,

$$(0.016 \text{ mol } P_4)\left(\frac{3 \text{ mol } O_2}{\text{mol } P_4}\right)$$

$= 0.048$ mol O_2 used to make P_4O_6

Mol of O_2 unreacted $= (0.0625 - 0.048) = 0.0145$ mol O_2

This O_2 can react according to the equation

$P_4O_6 + 2O_2 \longrightarrow P_4O_{10}$

Then,

$$(0.0145 \text{ mol } O_2)\left(\frac{1 \text{ mol } P_4O_{10}}{2 \text{ mol } O_2}\right) = 0.00721 \text{ mol } P_4O_{10}$$

Of the 0.016 mol of P_4O_6 orginally formed, 0.00725 mol is converted to P_4O_{10}, leaving $(0.016 - 0.00721) = 0.009$ mol P_4O_6.

(Mw of $P_4O_6 = 220$)

Weight of $P_4O_6 = 0.009 \times 220 = 1.98$ g P_4O_6

18. c. (Mw of $P_4O_{16} = 284$)

Weight of $P_4O_{10} = 0.0072 \times 284 = 2.04$ g P_4O_{10}

19. a Moles of O_2 left unreacted initially in reaction (i) $= 0.0145$ mol O_2

20. d Weight of Cu $= \frac{10\times90}{100} = 9.0$ g

Weight of Zn $= \frac{10\times10}{100} = 1.0$ g

Mol of HNO_3 with Cu = (9.0 g Cu)

$$\left(\frac{1 \text{ mol. Cu}}{63.5 \text{ g}}\right)\left(\frac{4 \text{ mol } HNO_3}{1 \text{ mol Cu}}\right)$$

$= \frac{9.0\times1\times4}{63.5} = 0.56$ mol HNO_3

Mol of HNO_3 with Zn = (1.0 g)

$$\left(\frac{1 \text{ mol Zn}}{65.37}\right)\left(\frac{10 \text{ mol } HNO_3}{4 \text{ mol Zn}}\right)$$

$= \frac{1.0\times10}{65.37\times4}$

$= 0.038$ mol HNO_3

Total moles of $HNO_3 = 0.56 + 0.038 = 0.598 \approx 0.6$

$M \times V_L$ = moles

$2.0 \times V_L = 0.6$

$V_L = 0.3$ L = 300 mL

21. a NO_2 gas is produced only with Cu and HNO_3.

Mol of NO_2 with Cu and HNO_3

$$= (9.0 GCu)\left(\frac{1 mol Cu}{63.5 g}\right)\left(\frac{2 mol NO_2}{1 mol Cu}\right)$$

$= \frac{9\times1\times2}{63.5\times1} = 0.283$ mol NO_2

$V = \frac{nRT}{P}$

$$= \frac{(0.283 \text{ mol})(0.082 L \text{ atm mol}^{-1} K^{-1}) \times 300 K}{1.00 \text{ atm}}$$

$= 6.97$ L

22. a Mol of $SO_2 = (1.0 \times 10^6$ g coal$)$

$$\left(\frac{0.05 \text{ g } FeS_2}{100 \text{ g coal}}\right)\left(\frac{1 \text{ mol g } FeS_2}{120 \text{ g Coal}}\right)\left(\frac{4 \text{ mol } SO_2}{2 \text{ mol } FeS_2}\right)$$

$= \frac{10^6\times0.05\times1\times4}{100\times120\times2} = 8.32$ mol SO_2

23. b $2KOH + SO_2 \longrightarrow K_2SO_3 + H_2O$

Moles of KOH $= 2 \times$ moles of $SO_2 = 2 \times 8.32$

$M \times V_L$ = Moles of SO_2

$3 \times V_L = 2 \times 8.32$

$V_L = 5.54$ L

24. d Weight of $CaCO_3 = (320 \times 10^6$ g coal$)$

$$\left(\frac{1.0 \text{ g S}}{100 \text{ g coal}}\right)\left(\frac{1 \text{ mol S}}{32 \text{ g S}}\right)\left(\frac{1 \text{ mol } CaCO_3}{\text{mol S}}\right)\left(\frac{100 \text{ g } CaCO_3}{\text{mol } CaCO_3}\right)$$

$= \frac{320\times10^6\ 1\times1\times1\times100}{100\times32}$

$= 10 \times 10^6$ g $CaCO_3$

$= 10$ metric ton $CaCO_3$

25. a $Cu_2S \longrightarrow H_2SO_4$

Weight of $H_2SO_4 = (3.0 \text{ g } Cu_2S)$

$$\left(\frac{1 \text{ mol } Cu_2S}{159 \text{ g } Cu_2S}\right)\left(\frac{1 \text{ mol S}}{\text{mol S}}\right)\left(\frac{98 \text{ g } H_2SO_4}{\text{mol } H_2SO_4}\right)$$

$= \frac{3\times1\times1\times98}{159} = 1.85$ g H_2SO_4

26. a Weight of $Na_2SO_4 = (100$ g NaCl$)$

$$\left(\frac{90.0 \text{ g NaCl}}{100 \text{ g mixture}}\right)\left(\frac{1 \text{ mol NaCl}}{58.5 \text{ g NaCl}}\right)\left(\frac{1 \text{ mol } Na_2SO_4}{2 \text{ mol NaCl}}\right)\left(\frac{142 \text{ g } Na_2SO_4}{\text{mol } Na_2SO_4}\right)$$

$$= \frac{100 \times 90 \times 1 \times 1 \times 142}{100 \times 58.5 \times 2}$$

$$= 109.79 \approx 109.8 \text{ g}$$

27. d Weight of $Na_2SO_4 = (109.8 \text{ g } Na_2SO_4) \times \left(\frac{100 \text{ g new mixture}}{80.0 \text{ g } Na_2SO_4}\right)$

$$= \frac{109.8 \times 100}{80}$$

$= 137.25$ g minutes

28. a $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O(l)$

a mol $5a$ mol $3a$ mol —

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 4H_2O(l)$

b mol $3b$ mol $2b$ mol —

Initially,

$PV = nRT$

$4.93 \times V = (a+b)RT$ ...(i)

After combustion, pressure is due to the total moles of CO_2

$11.8 \times V = (3a + 2b)RT$ ...(ii)

Divide equation (ii) by equation (i), we get

$$\frac{11.08}{4.93} = 2.25 = \frac{3a+2b}{a+b}$$

$2.25a + 2.25b = 3a + 2b$

$0.25b = 0.75a$

$b = 3a$

$$\chi_{C_2H_8} \text{ or } \chi_a = \frac{a}{a+b} = \frac{a}{a+3a} = \frac{1}{4} = 0.25$$

29. b $\chi_{C_2H_4}$ or $\chi_b = 1 - 0.25 = 0.75$

30. a. moles of C_3H_8 + moles of $C_2H_4 = a + b$

$= a + 3a = 4a$

moles of $O_2 = 5a + 3b = 5a + 3 \times 3a = 14a$

MATCHING COLUMN TYPE

1. (a → q) 2 mol $NH_4^{\oplus} \equiv 1$ mol of $(NH_4)_2CO_3 = 96$ g

$$0.4 \text{ mol } NH_4^{\oplus} = \frac{96 \times 0.4}{2} = 19.2 \text{ g}$$

(b → r) 8 mol H atoms ≡ 1 mol $(NH_4)_2CO_3 = 96$ g

1 mol H atoms (6.02×10^{23} H atoms)

$$= \frac{96}{8} = 12.0 \text{ g}$$

(c → s) $\underset{1\text{mol}}{(NH_4)_2CO_3} + 2HCl \longrightarrow$

$2NH_4Cl + \underset{1\text{ mol}}{CO_2} + H_2O$

1 mol of $CO_2 \equiv 1$ mol of $(NH_4)_2CO_3 = 96$ g

3 mol of $CO_2 \equiv 96 \times 3 = 288.0$ g

(d → p) $100 \text{ mL} \times 0.2 \text{ M} = 20$ mmol $(NH_4)_2CO_3$

$= 20 \times 10^{-3} \times 93 = 1.92$ g

2. (a → q) i. Moles of $CaCl_2 = \frac{11.1}{111} = 0.1$ mol $CaCl_2$

$= 0.1$ mol Ca^{2+}

$+ 0.2$ mol $Cl^{\ominus}$

ii. Moles of NaCl $= \frac{29.25}{58.5} = 0.5$ mol NaCl

$= 0.5$ mol $Na^{\oplus}$

$+ 0.5$ mol $Cl^{\ominus}$

Adding (i) and (ii), we get

0.1 mol Ca^{2+} + 0.5 mol $Na^{\oplus}$ + 0.7 mol $Cl^{\ominus}$

$$\therefore [Ca^{2+}] = \frac{0.1}{100} = 0.001 \text{ M}$$

$$[Na^{\oplus}] = \frac{0.5}{100} = 0.005 \text{ M}$$

$$[Cl^{\ominus}] = \frac{0.7}{100} = 0.007 \text{ M}$$

(b → p) i. $NaCl \Rightarrow 3 \times 4 = 12 \Rightarrow Na^{\oplus} = 12$ mol, $Cl^{\ominus} = 12$ mol

ii. $CaCl_2 \Rightarrow 4 \times 2 = 8 \Rightarrow Ca^{2+} = 8$ mol, $Cl^{\ominus} = 16$ mol

Adding (i) and (ii), we get

12 mol $Na^{\oplus}$ + 8 mol Ca^{2+} + 28 mol $Cl^{\ominus}$

$$\therefore [Ca^{2+}] = \frac{8}{10} = 0.8 \text{ M}$$

$$[Na^{\oplus}] = \frac{12}{10} = 1.2 \text{ M}$$

$$[Cl^{\ominus}] = \frac{28}{10} = 2.8 \text{ M}$$

(c → r) i. $NaCl = 300 \times 3 = 900$ mmol $\Rightarrow 900$ mmol $Na^{\oplus}$ + 900 mmol $Cl^{\ominus}$

ii. $CaCl_2 = 200 \times 4 = 800$ mmol $\Rightarrow 800$ mmol Ca^{2+} = 1600 mmol $Cl^{\ominus}$

Adding (i) and (ii), we get

800 m mol Ca^{2+} + 900 mmol $Na^{\oplus}$

+ 2500 mmol $Cl^{\ominus}$

Total volume = 300 + 200 = 500 mL

$$\therefore [Ca^{2+}] = \frac{800 \text{ mmol}}{500 \text{ mL}} = 1.6 \text{ M}$$

$$[Na^{\oplus}] = \frac{900 \text{ mmol}}{500 \text{ mL}} = 1.8 \text{ M}$$

$$[Cl^{\ominus}] = \frac{2500 \text{ mmol}}{500 \text{ mL}} = 5 \text{ M}$$

(d → s) i. HCl = 100 × 2 = 200 mmol ⇒ 200 mmol $H^{\oplus}$ + 200 mmol $Cl^{\ominus}$

ii. $NaOH = 200 \times 1 = 200\ mmol \Rightarrow 200\ mmol\ Na^{\oplus}$
$+ 200\ mmol\ \overset{\ominus}{O}H$

Since $H^{\oplus}$ and $\overset{\ominus}{O}H$ react to give H_2O.

$$H^{\oplus} + \overset{\ominus}{O}H \longrightarrow H_2O$$
200 mmol 200 mmol 200 mmol

$Cl^{\ominus} = 200\ mmol, Na^{\oplus} \Rightarrow 200\ mmol$

iii. $CaCl_2 \Rightarrow 150 \times 4 = 600 = mmol \Rightarrow 600\ mmol$
$Ca^{2+} + 1200\ mmol\ Cl^{\ominus}$

iv. Total volume $= 200 + 100 + 150 + 50$
$= 500\ mL$

v. Total $Ca^{2+} = 600\ mmol$

$$\therefore [Ca^{2+}] = \frac{600}{500} = 1.2\ M$$

Total $Na^{\oplus} = 200\ mmol$

$$\therefore [Na^{\oplus}] = \frac{200}{500} = 0.4\ M$$

Total $Cl^{\ominus} = 200 + 1200 = 1400\ mmol$

$$\therefore [Cl^{\ominus}] = \frac{1400}{500} = 2.8\ M$$

3. $(a \rightarrow p)$ $M = \dfrac{\%\text{ by weight} \times 10 \times d}{Mw_2} = \dfrac{98 \times 10 \times 1.8}{98} = 18\ M$

$18\ M \times V_L = 3.0\ M \times 3\ L \Rightarrow V_L = 0.5\ L = 500\ mL$

$(b \rightarrow q)$ Moles of $NaHCO_3 = \dfrac{21.0}{84} = 0.25$ mol

Moles of HCl = Moles of $NaHCO_3$
$3\ M \times V_L = 0.25$ mol; $V_L = 0.083\ L = 83.3\ mL$

$(c \rightarrow r)$ Moles of Zn $= \dfrac{6.54}{65.4} = 0.1$ mol

Moles of H_2SO_4 = moles of Zn
$3\ M \times V_L = 0.1$, $V_L = 0.033\ L = 33.3\ mL$

$(d \rightarrow s)$ Moles of $K_2C_2O_4 \cdot H_2O = \dfrac{92}{184} = 0.5$ mol

5 mol of $C_2O_4^{2-} \equiv 2$ mol of $MnO_4^{\ominus}$
0.5 mol of $C_2O_4^{2-} \equiv 0.2$ mol of $MnO_4^{\ominus}$
$M \times V_L$ of $MnO_4^{\ominus} \equiv 0.2$ mol of $MnO_4^{\ominus}$
$0.5 \times V_L = 0.2 \Rightarrow V_L = 0.4\ L = 400\ mL$

4. $(a \rightarrow s)$ 1 mol $Ba(OH)_2 \equiv 2$ mol HBr
$250 \times 0.2 = 50$ mmol $Ba(OH)_2$ $\Rightarrow 2 \times 50$ mmol HBr

$M \times V_{mL}$ HBr = mmol HBr
$0.5 \times V_{mL} = 2 \times 50$
$V_{mL} = 200\ mL$

$(b \rightarrow r)$ Moles of $H_2S = \dfrac{3.4}{34} = 0.1$ mol

0.1 mol $H_2S \equiv 0.5$ mol H_2SO_4

$M \times V_L (H_2SO_4) = 0.5$ mol H_2SO_4
$2 \times V_L = 0.5$;
$V_L \Rightarrow 0.25\ L = 250\ mL$

$(c \rightarrow q)$ Moles of Al $= \dfrac{108}{27} = 4$ mol

Number of moles of H_2SO_4 required for 4 mol Al

$= \dfrac{3}{2} \times 4 = 6.0$ mol
$M \times V_L (H_2SO_4) = 6.0$
$8 \times V_L = 6.0$,
$V_L = 0.75\ L = 750\ mL$

$(d \rightarrow p)$ Moles of $Na_2SO_4 = \dfrac{142}{142} = 1$ mol of $BaCl_2$
$= 1 \times 100\ mL\ BaCl_2$
$= 100$ mmol $BaCl_2$

$M \times V_{mL} (BaCl_2) = 100$ mmol $BaCl_2$
$1 \times V_{mL} = 100$,
$V_{mL} = 100\ mL$

5.

$(a \rightarrow p, q, r)$ Molarity (M) depends on temperature, dilution, and volume.

$(b \rightarrow q)$ Molality (m) depends only on dilution.

$(c \rightarrow q)$ Mole fraction (χ) also depends only on dilution

$(d \rightarrow p, q, r)$ Normality like molarity depends on all.

6.

$(a \rightarrow r)$ $2H_2 + O_2 \longrightarrow 2H_2O$
1.0 g 1.0g

$\frac{1}{2}$ mol $\frac{1}{32}$ mol

O_2 is the limiting reagent : 1 mol $O_2 \equiv 2$ mol H_2O

$$\Rightarrow \frac{1}{32}\text{ mol } O_2 \equiv \frac{1}{16}\text{ mol } H_2O \equiv \frac{18}{16}\text{ g of } H_2O$$
$= 1.125$ g

$(b \rightarrow s)$ $N_2 + 3H_2 \longrightarrow 2NH_3$
1.0 g 1.0g

$\frac{1}{28}$ mol $\frac{1}{2}$ mol

N_2 is the limiting reagent.

$$\therefore \frac{1}{28}\text{ mol } N_2 \equiv \frac{1}{14}\text{ mol } NH_3 \equiv \frac{1}{14} \times 17\text{ g} = 1.214\text{g}$$

$(c \rightarrow p)$ $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
1.0 g

$\frac{1}{100}$ mol $\frac{1}{100}$ mol $\frac{1}{100}$ mol

$= \dfrac{1}{100} \times 56$ g CaO
$= 0.56$ g

(d → q) $C + 2H_2 \longrightarrow CH_4$

1.0 g 1.0 g

$\frac{1}{12}$ mol $\frac{1}{2}$ mol

C is the limiting reagent.

$\therefore \frac{1}{12}$ mol C $\equiv \frac{1}{12}$ mol $CH_4 \equiv \frac{16}{12}$ g $= 1.333$ g

7.

	Column I		Column II
a.	Equivalent of base $= 0.1 \times 2 + 0.2 \times 1$ $= 0.4 = 400$ mEq [NaCl is not taken, since it neither reacts with acid nor with base]	q	mEq of H_2SO_4 $= 400 \times 0.5 \times 2$ $= 400$ mEq [400 mEq if H_2SO_4 neutralises 400 mEq of base in (a)]
b.	mEq of acid $= 200 \times 0.1 + 100 \times 0.1 \times 2 + 200 \times 0.1 \times 2$ $= 20 + 20 + 40 = 80$	p	mEq of KOH $= 320 \times 0.25$ $= 80$ mEq [80 mEq of KOH neutralises with 80 mEq of acid in (b)]
c.	1 g NaOH $= \frac{1}{40}$ mol $\times 10^3 = 25$ mEq; 2.25 g oxalic acid $= \frac{2.25}{90/2} \times 100 = 50$ mEq; mEq of oxalic acid left $= 50 - 25 = 25$ mEq	r.	mEq of $Mg(OH)_2$ $= 125 \times \frac{1}{5} = 25$ mEq [25 mEq of acid in (c) and (d) neutralises with 25 mEq of $Mg(OH)_2$]
d	0.01 mol H_3PO_4 $= 0.01 \times 3 = 0.03$ eq; 0.0025 mol $Ca(OH)_2$ $= 0.0025 \times 2$ $= 0.005$ Eq; Eq of H_3PO_4 left $= 0.03 - 0.005$ $= 0.025$ Eq $= 0.025$ mEq	s.	mEq of $H_2SO_4 = 125 \times \frac{1}{5}$ $= 25$ mEq [H_2SO_4 is acid and H_3PO_4 in (d) is also acid. No reaction.]

8. **(a → p, q, r, t)**

p. mEq of NaOH $= 200 \times 0.5 = 100$ mEq $\equiv 100$ mEq of H_2SO_4

q. 4.9 g $H_2\overset{+6}{S}O_4 = \frac{4.9}{98} \times 10^3$

$= 50$ mmol $\equiv 100$ mEq (n factor $= 2$)

$\equiv 200$ mmol of O atoms. (1 mol $H_2SO_4 \equiv 4$ mol O atoms)

r. Highest oxidation state of S = +6

t. Hybridisation = sp^3; geometry and shape ⇒ Tetrahedral

(b → q, r, t)

4.9 g $H_3PO_4 \equiv \frac{4.9}{98} \times 1000 = 50$ mmol

$= 50 \times 3$ (n factor) $\equiv 150$ mEq

q. 50 mmol of $H_3PO_4 \equiv 50 \times 4 = 200$ mmol of O atoms). (1 mol $H_3PO_4 \equiv 4$ mol O atoms)

p. But 150 mEq $H_3PO_4 \neq$ mEq of NaOH

t. Hybridisation is sp^3, so geometry and shape is tetrahedral.

r. Maximum oxidation state of P = +5

(c → p, q, r, s)

p. 4.9 g $H_2C_2O_4 \equiv \frac{4.9}{90} \times 1000$

$= 50$ mmol $= 100$ mEq (n factor $= 2$)

q. 50 mmoles of $H_2C_2O_4 \equiv 50 \times 4 = 200$ mmoles O atoms (1 mol $H_2C_2O_4 = 4$ mol o atoms)

$\equiv 100$ mEq NaOH

r. Highest oxidation state of C = +4

s. Reacts with oxidising agents such as $MnO_4^{\ominus}$ and $Cr_2O_7^{2-}$.

(d → r, t)

i. 5.3 g of $Na_2CO_3 = \frac{5.3}{106} \times 1000$

$= 50$ m moles

ii. Na_2CO_3 does not react with NaOH.

r. Highest oxidation states of C = +4

t. CO_3^{2-}, hybridisation is sp^2, so geometry and shape is planar.

v. 1 mol $Na_2CO_3 \equiv 3$ mol O atoms

9. **(a → p, s)**

$$M = \frac{9.8 \times 10 \times 1.8}{98} = 1.8$$

$N = 1.8 \times 2 = 3.6$

$$d = M\left(\frac{Mw_2}{1000} + \frac{1}{m}\right),$$

$$1.8 = 1.8\left(\frac{98}{1000} + \frac{1}{m}\right) \Rightarrow m = 1.10$$

(b → p, q, s)

q. $M = \frac{9.8 \times 10 \times 1.2}{98} = 1.2$

p. $N = 1.2 \times 3 = 3.6$

s. $d = M\left(\frac{Mw_2}{1000} + \frac{1}{m}\right)$,

$1.8 = 1.8\left(\frac{98}{1000} + \frac{1}{m}\right) \Rightarrow m = 1.10$

(c → p, r)

$1.8N_A$ molecules = 1.8 mol of HCl 500 mL = 1.8 Eq.

$M = \frac{1.8 \times 1000}{500} = 3.6\text{ M} = 3.6\text{ N}$ (n factor = 1)

(d → r)

mEq of base = $250 \times 4 + 250 \times 1.6 \times 2$
= 1000 + 800
= 1800 mEq
= 1.8 Eq

10. (a → p, q, r)

p., r. mol of $KMnO_4 = \frac{15.8}{158} = 0.1$ mol
$= 6.023 \times 10^{22}$ molecules

q. 0.1 mol $KMnO_4$ = 0.4 mol O atoms
$= 0.4 \times 6.023 \times 10^{22}$ atoms
$= 24.092 \times 10^{22}$ atoms of oxygen

(b → p, q, r)

p., r. mol of $H_2C_2O_4 = \frac{9.0}{9.0} = 0.1$ mol
$= 6.023 \times 10^{22}$ molecules

q. 0.1 mol $H_2C_2O_4$ = 0.4 mol O atoms
$= 24.092 \times 10^{22}$ atoms of oxygen

(c → q, s)

mol of $CO_2 = \frac{8.8}{44} = 0.2$ mol

1 mol CO_2 = 2 mol of O atoms

0.2 Mol CO_2 = 0.4 of O atoms
$= 24.092 \times 10^{22}$ atoms of oxygen

(d → s) Mol of CO = $\frac{5.6}{28} = 0.2$ mol

MULTIPLE CORRECT ANSWER TYPE

1. (d)

a. Not applicable if the elements exists in different isotopes which may be involved in the formation of compound.

b. At 1 atm, 25°C molar volume = 22.7 L

c. $Mw = 2 \times VD$,

d. Due to existence of isotopes.

2. (c, d)

(a) and (b) are compound. (c) and (d) are mixture.

3. (a, d)

a. Number of of O_2 atoms $= \frac{16}{32} \times 2 \times N_A = 1 \times N_A$

b. Number of of O_3 atoms $= \frac{16}{48} \times 3 \times N_A = 1 \times N_A$

c. i. Number of of O_2 molecules $= \frac{16}{32} \times N_A = \frac{1}{2} N_A$

ii. Number of of O_2 molecules $= \frac{16}{48} \times N_A = \frac{1}{3} N_A$

(d) is correct.

4. (a, b, c, d)

a. Moles of $O_2 = \frac{1.6}{32} = 0.05$

b. Molecules of $O_2 = 0.05 \times 6.023 \times 10^{23} = 3.011 \times 10^{22}$

c. Volume of O_2 at STP = $0.05 \times 22.4 = 1.12$ L

d. V_{O_2} at SATP = $0.05 \times 24.4 = 1.22$ L

5. (a, b, c, d) Two

6. (a, b, c, d) All correct

7. (b, c, d) Self explanatory

8. (c, d) (c) ⇒ isotopes
(d) ⇒ C-12

9. (a, b, d) Self explanatory.

10. (a, d) Self explanatroy.

11. (a, b, c)

a. $CH_3NO_2 + 3Cl_2 \longrightarrow CCl_3 \cdot NO_2 + 3HCl$
3 mol   1 mol

Volume of Cl_2 at STP = $3 \times 0.54 \times 22.4 = 33.6$ L

b. $C_4H_{10} + \frac{13}{2} O_2 \longrightarrow 4CO_2 + 5H_2O$
1 mol   13/2 mol

Volume of O_2 at STP $= \frac{13}{2} \times 0.1 \times 22.4 = 14.56$ L

c. $CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + 2H_2$
(1 mol = 42 g)   2mol

Mol of $H_2 = \frac{2.1}{42} = \frac{1}{20}$

Volume of H_2 at STP $= 2 \times \frac{1}{20} \times 22.4 = 2.24$ L

d. $Ni + 4CO \longrightarrow Ni(CO_4)$
1 mol   4 mol
= 58.7 g

Volume of CO at standard conditions = 4×24.4
= 97.6 L

Hence, (d) is wrong.

12. (a, b)

a. $CaO + 3C \longrightarrow CaC_2 + CO$
1 mole   3 mol   (1 mol
= 64 g)

Moles of $CaC_2 = \frac{16}{64} = \frac{1}{4}$ mol

Weight of C = $3 \times \frac{1}{4} \times 12 = 9.0$ g

b. Weight of $C_2H_4 = (32.0\ \text{kg})\left(\frac{10^3\ \text{g}}{\text{kg}}\right)\left(\frac{1\ \text{mol}\ CaC_2}{64\ \text{g}}\right)$

$$\left(\frac{1\ \text{mol}\ C_2H_4}{\text{mol}\ CaC_2}\right)\left(\frac{28\ \text{g}\ C_2H_4}{\text{mol}\ C_2H_4}\right)$$

$$= \frac{32 \times 10^3 \times 1 \times 1 \times 28}{64}$$

$$= 14 \times 10^3\ \text{g} = 14.0\ \text{kg}$$

c. [Mw of $[Ag(NH_3)_2]Cl$ = 177.5, Mw of AgCl = 143.5 g mol^{-1}]

Weight of AgCl = [17.75 g $Ag(NH_3)_2Cl$]

$$\left(\frac{1\ \text{mol}\ Ag(NH_3)_2Cl}{177.5\ \text{g}\ Ag(NH_3)_2Cl}\right)$$

$$\left(\frac{1\ \text{mol AgCl}}{\text{mol}\ Ag(NH_3)_2Cl}\right)\left(\frac{143.5\ \text{g AgCl}}{\text{mol AgCl}}\right)$$

$$= \frac{17.75 \times 143.5}{177.5} = 14.35\ \text{g}$$

Hence, (c) is wrong.

d. (Atomic weight of Zn = 65.4 g, Mw of $Na_2S_2O_4 = 174$)

Weight of pure $Na_2S_2O_4 = (65.4 \times 10^6\ \text{g Zn})$

$$\left(\frac{1\ \text{mol Zn}}{65.4\ \text{g Zn}}\right)\left(\frac{1\ \text{mol}\ Na_2S_2O_4}{\text{mol Zn}}\right)$$

$$\left(\frac{174\ \text{g}\ Na_2S_2O_4}{\text{mol}\ Na_2S_2O_4}\right)$$

$$= \frac{65.4 \times 10^6 \times 1 \times 1 \times 74}{65.4}$$

$$= 174 \times 10^6\ \text{g}$$

= 174 metric ton

Weight of 50% pure $Na_2S_2O_4 = \frac{174 \times 100}{50}$

= 348 metric ton

Hence, (d) is wrong.

13. (a, c)

Mw of $CaCO_3 = 100$, Mw of $Na_2CO_3 = 106$

Mw of $HNO_3 = 63$ g mol^{-1}

$$Na_2CO_3 + CaCl_2 \longrightarrow CaCO_3 + 2NaCl$$

a. moles of $CaCO_3 = \frac{10}{100} = 0.1$ mol

moles of Na_2CO_3 = moles of $CaCO_3 \equiv 2 \times$ moles of NaCl

Weight of $Na_2CO_3 = 0.1 \times 106 = 10.6$ g

% purity $Na_2CO_3 = \frac{10.6}{21.2} \times 100 = 50\%$

b. Wrong.

c. Correct.

d. moles of NaCl = $2 \times 0.1 = 0.2$ mol

14. (a, b, c)

Moles of $O_2 = \frac{4.8}{32} = 0.15$ mol O_2

Moles of Fe required = $\frac{4\ \text{mol Fe}}{3\ \text{mol}\ O_2} \times 0.15 = 0.2$ mol

a. Given mol of Fe = 0.15. Hence Fe is the limiting reagent and no Fe will remain after the reaction.

b. Weight of O_2 required = (0.15 mol Fe)

$$\left(\frac{3\ \text{mol}\ O_2}{4\ \text{mol Fe}}\right)\left(\frac{32\ \text{g}\ O_2}{\text{mol}\ O_2}\right)$$

$$= \frac{0.15 \times 3 \times 32}{4}$$

= 3.6 g O_2 required

Weight of O_2 in excess = (4.8 g O_2 present) – (3.6 g O_2 required)

= 1.2 g O_2 in excess

c. Weight of Fe_2O_3 produced = (0.15 mol Fe)

$$\left(\frac{2\ \text{mol}\ Fe_2O_3}{4\ \text{mol Fe}}\right)\left(\frac{160\ \text{g}\ Fe_2O_3}{\text{mol}\ Fe_2O_3}\right)$$

$$= \frac{0.15 \times 2 \times 160}{4}$$

= 12.0 g Fe_2O_3 produced

d. O_2 is not the limiting reagent.

15. (b, c)

$n_{H_2} = \frac{64}{2} = 32$ mol

$n_{O_2} = \frac{64}{32} = 2$ mol

1 mol of O_2 requires = 2 mol of H_2

2 mol of O_2 requires = 4 mol g H_2

Since H_2 is present in excess, therefore, O_2 is the limitng reagent.

a. Wrong.

b. So, O_2 is the limiting reagent

c. 2 mol of O_2 = 4 moles of $H_2O = 4 \times 18 = 72$ g H_2O
moles of H_2 left $= 32 - 4 = 28$ mol $= 28 \times 2 = 56$ g H_2
Mixture contains = (72 g H_2O + 56 g H_2)

d. Wrong.

16. (b, c, d) $n_{P_4} = \frac{1.24}{31 \times 4} = 0.01$ mol, $n_{O_2} = \frac{8}{32} = 0.25$ moles

In reaction (i), moles of O_2 required

$$= (0.01 \text{ mol } P_4)\left(\frac{5 \text{ mol } O_2}{\text{mol } P_4}\right)$$
$$= 0.01 \times 5 = 0.05 \text{ mol}$$

Since there is more O_2 present than required

a. Therefore, P_4 is the limiting quantity.

b. Wrong.

c. [Mw $P_4O_{10} = 284$]
0.01 mol of P_4 produces = 0.01 mol of P_4O_{10}

$$= (0.01 \text{ mol } P_4)\left(\frac{1 \text{ mol } P_4O_{10}}{\text{mol } P_4O_{10}}\right)\left(\frac{284 \text{ g } P_4O_{10}}{\text{mol } P_4O_{10}}\right)$$
$$= 0.01 \times 284 = 2.84 \text{ g}$$

Hence, (c) is wrong.

d. [*Mw* of $P_4O_6 = 220$]
Weight of P_4O_6 produced

$$= (0.01 \text{ mol } P_4)\left(\frac{1 \text{ mol } P_4O_6}{\text{mol } P_4O_6}\right)\left(\frac{220 \text{ g } P_4O_6}{\text{mol } P_4O_6}\right)$$
$$= 0.01 \times 220 = 2.2 \text{ g}$$

Hence, (d) is wrong

17. (a, b, c)
(*Mw* of CS_2 = 76, *Mw* of Cl_2 = 71, *Mw* of CCl_4 = 154 g mol^{-1})
Weight of Cl_2 needed

$$= (1.0 \text{g } CS_2)\left(\frac{1 \text{ mol } CS_2}{76 \text{ g } CS_2}\right)\left(\frac{3 \text{ mol } CS_2}{\text{mol } CS_2}\right)\left(\frac{71 \text{ g } Cl_2}{\text{mol } Cl_2}\right)$$
$$= \frac{1 \times 3 \times 71}{76} = 2.8 \text{ g } Cl_2 \text{ needed}$$

Since there is 2.0 g Cl_2 present, Cl_2 is the limiting quantity

a. Weight of Cs_2 used

$$= (2.0 \text{g } Cl_2)\left(\frac{1 \text{ mol } Cl_2}{71 \text{ g } Cl_2}\right)\left(\frac{1 \text{ mol } CS_2}{3 \text{ mol } Cl_2}\right)\left(\frac{76 \text{ g } CS_2}{\text{mol } CS_2}\right)$$
$$= \frac{2 \times 1 \times 1 \times 76}{71 \times 3} = 0.714 \text{ g } CS_2 \text{ used.}$$

b. Weight of CS_2 excess or formed
= (1.0 g CS_2 present) – (0.714 g used)
= 0.286 g CS_2 formed

c. Weight of CCl_4 formed

$$= (2.0 \text{ g } Cl_2)\left(\frac{1 \text{ mol } Cl_2}{71 \text{ g } Cl_2}\right)\left(\frac{1 \text{ mol } CCl_4}{3 \text{ mol } Cl_2}\right)\left(\frac{154 \text{ g } CCl_4}{\text{mol } CCl_4}\right)$$
$$= \frac{2 \times 1 \times 154}{71 \times 3} = 1.45 \text{ g } CCl_4$$

d. Wrong.

18. (a, c)

moles of Al $= \frac{108}{27} = 4.0$ mol

moles of MnO $= \frac{213}{71} = 3.0$ mol

a. Since 2 mol of Al requires 3 mol of MnO, therefore Al is in excess.

b. Wrong

c. Weight of Al required

$$= (3.0 \text{ mol MnO})\left(\frac{2 \text{ mol Al}}{3 \text{ mol MnO}}\right)\left(\frac{27 \text{g Al}}{\text{mol Al}}\right)$$
$$= \frac{3 \times 2 \times 27}{3} = 54.0 \text{g of Al}$$

d. Weight of Al in excess = (108 – 54) = 54.0 g

19. (a, b, c, d)

Moles of Li $= \frac{21}{7} = 3.0$ mol

Moles of $O_2 = \frac{32}{32} = 3.0$ mol

a. Since $(3.0 \text{ mol Li})\left(\frac{1 \text{ mol } O_2}{4 \text{ mol Li}}\right) = \frac{3}{4} = 0.75$ mol of O_2 is required, therefore (1.0 – 0.75) = 0.25 mol of O_2 is in excess. Hence, Li is the limiting reagent

b. Weight of Li_2O formed

$$= (3.0 \text{ mol Li})\left(\frac{1 \text{ mol } Li_2O}{2 \text{ mol Li}}\right)\left(\frac{30 \text{g } Li_2O}{\text{mol } Li_2O}\right)$$
$$= \frac{3 \times 1 \times 30}{2} = 45.0 \text{ g } Li_2O$$

c. Moles of K $= \frac{3.9}{39} = 0.1$ mol

Moles of $Cl_2 = \frac{4.26}{71} = 0.06$ mol

Since $\left(\frac{0.1}{2}\right) = 0.05$ mol of Cl_2 is required. Therefore, (0.06 – 0.05) = 0.01 mol of Cl_2 is in excess.
Hence K is the limiting reagent.

d. Weight of KCl formed

$$=(0.1\text{ mol K})\left(\frac{1\text{ mol KCl}}{\text{mol K}}\right)\left(\frac{74.5\text{ g KCl}}{\text{mol KCl}}\right)$$

$=0.1\times1\times74.5=7.45$ g of KCl

20. (a, b, c, d)

(*Mw* of Na_2CO_3 = 106, *Mw* of HCl = 36.5, *Mw* of NaCl = 58.5)

Moles of $Na_2CO_3=\frac{106}{106}=1.0$ mol

Moles of HCl $=\frac{109.5}{36.5}=3.0$ mol

a. Since for 1 mol of Na_2CO_3, 2 mol of HCl is required. So, HCl is in excess $(3-2)=1.0$ mol

Therefore, Na_2CO_3 is the limiting quantity.

b. Weight of NaCl formed

$$=(1.0\text{ mol }Na_2CO_3)\left(\frac{2\text{ mol NaCl}}{\text{mol }Na_2CO_3}\right)\left(\frac{58.5\text{ g NaCl}}{\text{mol NaCl}}\right)$$

$=1\times2\times58.5=117.0$ g NaCl

c. 1 mol of Na_2CO_3 = 1 mol of CO_2 = 22.7 L at 1 bar, 273 K

d. 1 mol of Na_2CO_3 = 1 mol of CO_2 = 24.7 L at 1 bar, 298 K

21. (c, d)

a. $100\times0.1=10$ mmol $H^{\oplus}$/150 mL

b. $75\times0.1=7.5$ mmol $H^{\oplus}$/150 mL

c. $50\times0.1\times2$ (*n* factor) = 10 mmol/150 mL

d. $100\times0.1=10$ mmol/150 mL

22. (a, b)

Mol of $Cu^{2+}=1.0\text{ L}\times0.1\text{ M}=0.1$ mol $Cu^{2+}=0.1\times2$ mol $H^{\oplus}$

a. Weight of CuS $=0.1\times95.5=9.55$ g

b. Concentration of $H^{\oplus}=\frac{0.2\text{ mol}}{1.0\text{L}}=0.2$ M

(c) and (d) are wrong.

23. (a, b, c, d)

mmoles of HCl $\Rightarrow20\times6=120\Rightarrow120$ mmol $H^{\oplus}$ + 120 mmol $Cl^{\ominus}$

mmoles of $Ba(OH)_2\Rightarrow50\times2=100\Rightarrow100$ mmol Ba^{2+} + 200 mmol $\overset{\ominus}{O}H$

$$H^{\oplus}+\overset{\ominus}{O}H\longrightarrow H_2O$$

Total volume = 20 + 50 + 30 = 100 mL

a. $\therefore[\overset{\ominus}{O}H]=\frac{(200-120)\text{ mmol}}{100\text{ mL}}=0.8$ M

b. $[Cl^{\ominus}]=\frac{120\text{ mmol}}{100\text{ mL}}=1.2$ M

c. $[Ba^{2+}]=\frac{100\text{ mmol}}{100\text{ mL}}=1.0$ M

d. mmoles of OH left = 200 − 120 = 80 mmol

24. (a, c)

a. mmoles of $HClO_3=100\times3=300$ mmol

$=\frac{300}{2}$ mmol of $Ba(ClO_3)_2$

$=150$ mmol $=1.5$ mol

b. Wrong.

c. Weight of $Ba(ClO_3)_2=150\times10^{-3}\times304=45.6$ g

d. Wrong.

25. (a, b, c, d)

a. Weight g Al^{3+} in 100 mL of solution $=100\times27$

$=2700$ mg $=2.7$ g

2 mol Al^{3+} $(27\times2\text{ g})\equiv1$ mol of $Al_2(SO_4)_3\cdot18H_2O$

$\equiv666$ g

2.7 g of $Al^{3+}=\frac{666\times2.7}{54}=33.3$ g

b. Moles of $Cr^{3+}=\frac{26}{52}=0.5$ mol

Weight of $CrCl_3\cdot6H_2O=0.5$ mol $Cr^{3+}\times266.5$ g

$=133.25$ g

c. Weight of $NH_4Cl=(100\text{ mL})\left(\frac{80\text{ mg}}{\text{mL}}\right)\left(\frac{10^{-3}\text{ g}}{\text{mg}}\right)=8.0$ g

d. Weight of $NH_3=\left(\frac{0.8\text{ g}}{\text{mL solution}}\right)\left(\frac{20\text{ g }NH_3}{100\text{ g solution}}\right)$

$=0.16$ g mL^{-1}

26. (a, c, d)

$$\underset{\substack{100\times0.06\\=6\text{ mmol}}}{Ca(NO_3)_2}+\underset{\substack{50\times0.06\\=3\text{ mmol}}}{Na_2C_2O_4}\longrightarrow\underset{3\text{ mmol}=0.003\text{ mol}}{CaC_2O_4\downarrow}+2NaNO_3$$

$Na_2C_2O_4$ is the limiting reagent.

$\therefore$ 3 mmol $Na_2C_2O_4\equiv3$ mmol $Ca(NO_3)_2$

$\equiv3$ mmol $CaC_2O_4\equiv6$ mmol $NaNO_3$

mmol of $Ca(NO_3)_2$ left $=6-3=3$ mmol $=0.003$ mol

$M_{Ca^{2+}}$ (left) $=\frac{3\text{ mmol}}{(100+50)\text{ mL}}=\frac{3}{150}=0.02$ M

Hence, option (b) is wrong.

27. (b, d)

100 mL of 1 M H_2SO_4 + 100 mL (98%, $d=0.1$) H_2SO_4

$\Rightarrow100\times1\text{ M}+100\text{ mL}\times\left(\frac{98\times10\times0.1}{98}\right)$

$\Rightarrow 100 \times 1\,M + 100 \times 1\,M$

$\therefore [H_2SO_4] = \dfrac{100\times1+100\times1}{200\text{ mL}} = 1\text{ M} = 98\text{ g}/1000\text{ mL}$

Mass of $H_2SO_4 = \dfrac{98\text{ g}\times 200\text{ mL}}{1000\text{ mL}} = 19.6\text{ g}$

Concentration of each component becomes half of the initial value.

28. (a,d)

$1\text{ mol } Cl_2 \equiv 2\text{ mol KOH} \equiv 1\text{ mol KClO} \equiv \dfrac{1}{3}\text{ mol } KClO_3$

$\equiv \dfrac{1}{4}\text{ mol } KClO_4$

Moles of $KClO_4 = \dfrac{277}{138.5} = 2$

$\left[\begin{array}{l}\text{Moles of } Cl_2 = 2\times4 = 8\\ \text{mass of } Cl_2 = 8\times71 = 568\text{ g}\end{array}\right]$

Moles of KOH $= 2\times8 = 16$

$V_{KOH} = \dfrac{16}{1.5} = 10.67\text{ L}$

29. (a, b, c)

$$\underset{\left(\begin{array}{c}100\times0.1\\=10\text{ mmol}\end{array}\right)}{KNO_3} + \underset{\left(\begin{array}{c}400\times0.2\\=80\text{ mmol}\end{array}\right)}{HCl} + \underset{\left(\begin{array}{c}500\times0.3\\=150\text{ mmol}\end{array}\right)}{H_2SO_4}$$

Total volume $= 100+400+500 = 1000$ mL

$M_{K^\oplus} = \dfrac{10}{1000} = 0.01\text{ M}$

$M_{SO_4^{-2}} = \dfrac{150}{1000} = 0.15\text{ M}$

$M_{H^\oplus} = \dfrac{80+2\times150}{1000} = 0.38\text{ M}$

$M_{NO_3^\ominus} = \dfrac{10}{1000} = 0.01\text{ M}$

$M_{Cl^\ominus} = \dfrac{80}{1000} = 0.08\text{ M}$

30. (a, c)

	Silica	H_2O	Impurities
% in original clay] ⇒	40	19	100 − (40 + 19) = 41
% after partial drying] ⇒	a	10	100 − (a + 10) = 90 − a

On heating, only water evaporates from clay, whereas silica and impurities are left as it is. Therefore, % ratio of silica and impurities remains unchanged, i.e.,

$\dfrac{40}{a} = \dfrac{41}{90-a}$, $\therefore a = 44.4\%$

% of mipurities after partial drying $= (90-a) = (90-44.4)$
$= 45.6\%$

Mass of H_2O evaporated $= (19-10) = 9$ g

31. (c, d)

Equal number of molecules are present when moles are same. For the same mass the molecular weight has to be same.

Hence Mw of $N_2 = Mw$ of $CO = 28$ g

Mw of $N_2O = Mw$ of $CO_2 = 44$ g

32. (c, d)

(Let 'a' g of X and Y taken)

	$2X$	+ $3Y$	$\longrightarrow X_2Y_3$
Initial moles] ⇒	$\frac{a}{36}$	$\frac{a}{24}$	
Final moles] ⇒	—	—	$\frac{a}{72}$

Since both X and Y are completely consumed, there is no limiting reagent.

Moles of $X_2Y_3 = \dfrac{a}{72}$,

(Mw of $X_2Y_3 = 2\times36+24\times3 = 144$)

Weight of $X_2Y_3 = \dfrac{a}{72}\times144 = 2a = 2\times$ Weight of X

SINGLE CORRECT ANSWER TYPE

1. b. Mw_2 of $CaCO_3 = 40+12+48 = 100$

Moles of $CaCO_3$ in 10 g $= \dfrac{10}{100}$
$= 0.1\text{ mol} = 0.1$ g atom

2. c. $M_1V_1 + M_2V_2 = M_3V_3$

$(V_3 = V_1 + V_2)$

$1.5\times480 + 1.2\times520 = M_3\times1000$

$M_3 = 1.344$ M

3. b $\dfrac{Ew\text{ of acid}}{Ew\text{ of salt of Mg}} = \dfrac{\text{Weight of acid}}{\text{Weight of salt}}$

$Mg + 2HCl\text{ (monobasic acid)} \rightarrow MgCl_2 + H_2$

Let Ew of acid $= Ew$ of H $+ Ew$ of acid redical

$\therefore Ew$ of salt of Mg $= Ew$ of Mg $+ Ew$ of acid radical

$\therefore \dfrac{Ew\text{ of acid}}{Ew\text{ of Mg salt}} = \dfrac{\text{Weight of acid}}{\text{Weight of Mg salt}}$

$\Rightarrow \dfrac{Ew\text{ of H} + Ew\text{ of acid radical }(E)}{Ew\text{ of Mg} + Ew\text{ of acid radical }(E)} = \dfrac{1.0}{1.301}$

$\Rightarrow \dfrac{1+E}{12+E} = \dfrac{1.0}{1.301}$

$\therefore E = 35.54$

$\therefore Ew$ of acid $= Ew$ of H $+ Ew$ of acid radical
$= 1 + 35.54 = 36.54$

4. a 1 mol of O_2 = 4 eq. of O

22400 mL of O_2 = 4 eq. of O

46.6 mL of $O_2 = \frac{4}{22400} \times 46.6$

$= 0.00832$ eq.

Equivalent of metal = Equivalent of O

$\frac{Weight}{Ew} = 0.00832$

$\frac{0.1}{E} = 0.00832$

$\therefore E = \frac{0.1}{0.00832} = 12.0$

5. b Mw of metal chloride (MCl_x) $= M + x \times 35.5$

$= 2 \times VD = 2 \times 39.5$

$= 79.0$

$Mw = Ew \times x$

Valency of metal = x

Atomic weight of element = $Ew \times x$

$MCl_x = 3.82 \times x + x \times 35.5 = 79$

$x = \frac{79}{3.82 + 35.5} \approx 2$

Atomic weight = $Ew \times x = 3.82 \times 2 = 7.64$

6. a Let the formula of oxide = $M_2O_x = 44$

$2 \times M + x \times 16 = 44$

$2(E \times x) + x \times 16 = 44$

$2(14 \times x) + 16x = 44$

$\therefore x = 1$

Atomic weight = $14 \times 1 = 14$

7. a K_2SO_4 and K_2SeO_4 are isomorphous.

K_2SeO_4

$\Rightarrow 39 \times 2 + x + 64 = 142 + x$

$(142 + x)$ g of $K_2SeO_4 \Rightarrow x$ g of Se

100 g of $K_2SeO_4 \Rightarrow \frac{x}{142 + x} \times 100$

$\therefore \frac{x}{142 + x} \times 100 = 50$

$\therefore x = 142$

8. d K_2MSO_4 and K_2SO_4 are isomorphous.

Valency of S and M should be same = 6

Atomic weight = $Ew \times$ Valency = $13.00 \times 6 = 78$

9. a Volume of H_2 at STP $= 24.62 \times \frac{273}{300} = 22.40$ mL

22400 mL of H_2 at STP = 1 mole = 2 Eq of H_2

22.4 mL of $H_2 = \frac{2}{22400} \times 22.4$

$= 0.002$ Eq of H_2

$= 0.002$ Eq of metal

$\therefore \frac{Weight}{Ew} = 0.002$

$\frac{0.05}{0.002} = Ew = 25$

10. c
$$\underset{4\times 35}{4B} + \underset{12}{A} \longrightarrow X$$

Weight of X = $4 \times 35.5 + 12 = 154$

11. b Moles of Fe $= \frac{0.0056}{56} = 10^{-4}$ mol

1 mol of alum = 2 mol of Fe

2 mol of Fe = 1 mol of alum

10^{-4} mol of Fe $= \frac{1}{2} \times 10^{-4}$ mol

$= 0.5 \times 10^{-4}$ mol

12. a i. $X + 2Y \longrightarrow XY_2$

0.1 mol of XY_2 = 10 g

1 mol of XY_2 = 100 g

ii. $3X + 2Y \longrightarrow X_3Y_2$

0.05 mol of X_3Y_2 = 9g

1 mol of $X_3Y_2 = \frac{9}{0.05} = 180$ g

$\therefore X + 2Y = 100$] $MwXY_2 = 100$

$3X + 2Y = 180$] $MwX_2Y_3 = 180$

Solve for X and Y

$X = 40$ g

$Y = 30$ g

13. a

Moles of $AlCl_3$ produced $= \frac{6.67}{133.5} = 0.05$ mol

Excess of Al $= \frac{0.54}{27} = 0.02$ mole

g atom or moles of Al taken = 0.05 + 0.02 = 0.07

g atom or moles of Cl_2 taken = $3 \times 0.05 = 0.15$

14. c $4Al + 3O_2 \longrightarrow 2Al_2O_3$

4×27 g of Al $\Rightarrow 3 \times 32$ g of O_2

27 g of Al $\Rightarrow \frac{3 \times 32}{4 \times 27} \times 27 \Rightarrow 24$ g

15. a Total HCl $\Rightarrow 25 \times 1 = 25$ mEq

Excess HCl $\Rightarrow 5 \times 1 = 5$ mEq

HCl used $\Rightarrow 25 - 5 = 20$ mEq

$\therefore$ mEq of HCl = mEq of carbonate

$\frac{20}{1000}$ Eq = $\frac{\text{Weight}}{Ew}$ of carbonate = $\frac{1}{Ew}$

$\therefore Ew = \frac{1000}{20} = 50$

16. d $N_1V_1 + N_2V_2 + N_3V_3 = N_4V_4$

$(V_4 = V_1 + V_2 + V_3 + V_4)$ or

V_4 = Final volume = 1 L ≡ 1000 mL

$5 \times N + 20 \times \frac{N}{2} + 30 \times \frac{N}{3} = N_4 \times 1000$

$\therefore N_4 = \frac{N}{40}$

17. a Since two H-atoms are replaced

$\therefore Ew = \frac{Mw}{n} = \frac{98}{2} = 49$

18. a $CaCl_2 + NaCl = 10$ g

Let weight of $CaCl_2 = x$ g

$CaCl_2 \longrightarrow CaCO_3 \longrightarrow CaO$

1 mol 1 mol 1 mol

$\frac{x}{111}$ mol $\frac{x}{111}$ mol $\frac{x}{111}$ mol

Mole of CaO = $\frac{1.62}{56}$

$\therefore \frac{x}{111} = \frac{1.62}{56}$

$x = 3.21$ g

% of $CaCl_2 = \frac{3.21}{10} \times 100 = 32.1\%$

19. a $3\,BaCl_2 + 2Na_3PO_4 \longrightarrow 6NaCl + Ba_3(PO_4)_2$

[3 mol 2 mol 6 mol 1 mol]

Given ⇒ 0.5 mol of $BaCl_2$ and 0.2 mol of Na_3PO_4

To find the limiting reagent:

2 mol of Na_3PO_4 ⇒ 3 mol of $BaCl_2$

0.2 mol of Na_3PO_4 ⇒ 0.3 mol of $BaCl_2$

$\therefore$ Na_3PO_4 is the limiting reagent

$\therefore$ 2 mol of Na_3PO_4 ⇒ 1 mol of $Ba_3(PO_4)_2$

0.2 mol of Na_3PO_4 ⇒ 0.1 mol of $Ba_3(PO_4)_2$

20. a Ew of metal chloride = Ew of M + Ew of Cl

$= 12 + 35.5 = 47.5$

47.5 g of metal chloride ⇒ Weight of metal ⇒ 12 g

0.475 g of metal chloride ⇒ $\frac{12 \times 0.475}{47.5}$

⇒ 0.12 g

21. a 22400 mL = 1 mol of CO_2 = 2 Eq of CO_2

11200 mL = 1/2 mol of CO_2 = 1 Eq of CO_2

= 1 Eq of CO_3^{2-}

Weight of metallic carbonate that would produce 1 g equivalent or 22 g or 11.2 L of CO_2 at STP would be its Ew.

Ew of metallic carbonate = $\frac{4.2 \times 11200}{1120} = 42$ g

Ew of metal = Ew of MCO_3 – Ew of CO_3^{2-}

$= 42 - 30 = 12$

$\left[Ew \text{ of } CO_3^{2-} = \frac{60}{2} = 30\right]$

Alternatively:

22400 mL = 1 mol of CO_2 = 2 Eq CO_3^{2-}

11200 mL ⇒ 1 Eq of CO_3^{2-}

$\therefore$ 1120 mL ⇒ $\frac{1}{11200} \times 1120 = 0.1$ Eq of CO_3^{2-}

Eq of MCO_3 = Eq of CO_3^{2-}

p. $\frac{\text{Weight}}{Ew} = \frac{\text{Weight}}{Ew} = 0.1$ Eq

$\therefore 0.1 = \frac{4.2}{Ew \text{ of } MCO_3}$

s. $\therefore$ Eq of $MCO_3 = 42$

$\therefore$ Ew of M = Ew of MCO_3 – Ew of CO_3^{2-}

$= 42 - 30 = 12$

22. a 1 mol of H_2 = 22400 mL = 2 Eq of H_2

1 Eq of H_2 = 11200 mL

Eq of $H_2 = \frac{560}{11200} = \frac{1}{20}$ Eq

[Let the weight of A be x g; weight of B = $0.5 - x$]

Eq of A + Eq of B = Eq of H_2

$\frac{x}{12} + \frac{0.5 - x}{9} = \frac{1}{20}$

$\therefore \quad x = 0.2$

% of A = $\frac{0.2 \times 100}{0.5} = 40\%$

% of B = 60%

23. b Specific heat × Atomic weight = 6.4

(Dulong and Petit law)

Atomic weight = $\frac{6.4}{\text{specific heat}} = \frac{6.4}{0.25}$

Atomic weight = Ew × valency = 25.6

Valency = $\frac{\text{Atomic weight}}{Ew} = \frac{25.6}{12} = 2$

(Valency is always a whole number)

24. c. $\begin{bmatrix} \text{Rutile} = TiO_2 \\ \text{Cassiterite} = SnO_2 \end{bmatrix}$ Both are isomorphous

Mw of $TiO_2 = x + 32$

$(x+32)$ g of $TiO_2 \Rightarrow 32$ g of oxygen

$$100 \text{ g of } TiO_2 \Rightarrow \frac{32}{(32+x)} \times 100$$

$$\therefore \frac{32 \times 100}{(32+x)} = 39.95$$

$\therefore x = 48.10$

25. b Weight of salt = 13.4 g

Weight of $H_2O = 6.3$ g

Weight of anhydrous salt = 13.4 – 6.3 = 7.1 g

$$\text{Moles of anhydrous salt} = \frac{7.1}{842} = 0.05$$

$$\text{Moles of } H_2O = \frac{6.3}{18} = 0.35 \text{ mol}$$

0.05 mol of anhydrous salt $\Rightarrow$ 0.35 mol of H_2O

$$1 \text{ mole of anhydrous salt} \Rightarrow \frac{0.35}{0.05} = 7 \text{ mol}$$

26. d $MCO_3 \longrightarrow MO + CO_2\uparrow$

$M'CO_3 \longrightarrow M'O + CO_2\uparrow$

Eq of CO_2 = Eq of carbonates of metals

1 mol of CO_2 = 1 mol of CO_3^{2-}

44 g of CO_2 = 60 g of CO_3^{2-}

$$1.10 \text{ g of } CO_2 = \frac{60}{44} \times 1.10 = 1.5 \text{ g of } CO_3^{2-}$$

$$\% \text{ of } CO_3^{2-} = \frac{1.5 \times 100}{3} = 50\%$$

% of one metal = 15%

% of another metal = 100 – 50 – 15 = 35%

27. b Since no water added, so volume of solution cannot exceed 2 L. So, less concentrated solution should be taken in its total volume.

Only the small portion of more concentrated solution is to be mixed, so that the total concentrated is less than (0.3 M HCl).

Let x L of 0.3 M solution is mixed.

Total volume = $(x+1)$ L

$M_1V_1 + M_2V_2 = M_3V_3 \quad [V_3 = (1+x)$ L

$0.3 \times x \text{ L} + 0.15 \times 1 \text{ L} = M_3(1+x)$ L

Final molarity = 0.2 M

$0.3x + 0.15 = 0.2(1+x)$

$x = 0.5$ L

Maximum volume = 1 + 0.5 = 1.5 L

28. c. Mw of $Zn(NH_3)_xCl_2 = 65.30 + 17x + 35.5 \times 2$

$= 136.30 + 17x$

$(17x + 36.30)$ g of compound contains = x mole of NH_3

$$0.224 \text{ g compound} = \frac{x}{17x + 136.30} \times 0.224$$

x mol of NH_3 = x eq of NH_3

Eq of NH_3 = Eq of HCl

$$\frac{0.224x}{17x + 136.30} = \frac{30.7 \times 0.2}{1000} \text{ eq of HCl}$$

$x \approx 6.75 \approx 6$ (as the choice given)

29. a. 4 g of NaOH = 4/40 = 0.1 mole = 100 mmol ≡ 100 mEq

HCl = 500 × 1 = 500 mEq

$$N \text{ of } H_2SO_4 = \frac{W_2 \times 1000}{Ew_2 \times V_{sol} \text{ (in mL)}}$$

or

$$= \frac{\% \text{ by weight} \times 10 \times d}{Ew_2}$$

$$= \frac{49 \times 10 \times 1.1}{49} = 11 \text{ N}$$

mEq of H_2SO_4 = 11N × 10.00 mL = 110 mEq

Total acid = 110 + 500 = 610 mEq

NaOH = 100 mEq

Acid left = 610 – 100 = 510 mEq

Total volume = 1000 mL

$$\text{Normality of solution} = \frac{\text{mEq}}{\text{mL}} = \frac{510}{1000} = 0.51 \text{ N}$$

30. a. Let x mol of HCOOH and y mol of $(COOH)_2$.

$$\underset{x}{HCOOH} \xrightarrow{H_2SO_4} H_2O + \underset{x}{CO}$$

$$\underset{x}{(COOH)_2} \xrightarrow{H_2SO_4} H_2O + \underset{x}{CO} + \underset{y}{CO_2}$$

Total moles of $(CO + CO_2) = x + 2y$

Total moles of $CO_2 = y$

According to the question:

$$(x+2y) \times \frac{1}{6} = y$$

$$\therefore \frac{x}{y} = 4:1$$

Alternatively:

$$\text{Mole fraction of } CO_2 = \frac{y}{x+2y} = \frac{1}{6}$$

$$\therefore \frac{x}{y} = 4:1$$

31. a $\dfrac{\text{Molecular weight of } X_4O_6}{\text{Atomic weight of 4 X}} = \dfrac{\text{Weight of } X_4O_6}{\text{Weight of X}}$

$\dfrac{4x+96}{4x} = \dfrac{10}{5.72}$

$x = 32$

32. d Weight of Cl reacted = 12.7 − 5.6 − 7.1 g

7.1 g Cl ≡ 5.6 g of metal

35.5 g Cl = 28 g of metal

33. c. Use formula

$d = M\left(\dfrac{Mw_2}{1000} + \dfrac{1}{m}\right) \Rightarrow 1.8 = 18\left(\dfrac{98}{1000} + \dfrac{1}{m}\right)$

Solve for m:

$\therefore m = 500$

34. b Temporary hardness is due to $HCO_3^{\ominus}$ of Ca^{2+} and Mg^{2+}

$Ca(HCO_3)_2 + \underset{56\text{ g}}{CaO} \longrightarrow \underset{(2\times100)\text{ g}}{2CaCO_3} + H_2O$

0.56 g CaO ≡ 2 g $CaCO_3$ in 10 L H_2O

= 2 g $CaCO_3$ in 10^4 mL H_2O

= 200 g $CaCO_3$ in 10^6 mL H_2O

35. c. $3Mg(OH)_2 + 2H_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 3H_2O$

$\dfrac{3\times58.3}{2\times98} = \dfrac{100}{W}$, $\therefore W = 112$ g

36. a. Total weight of alcohol and water

$= 10\times0.7893 + 20\times0.9971$

Volume of mixture $= \dfrac{10\times0.7893+20\times0.9971}{0.9571}$

= 29.08 mL

Change in volume = (20 + 10) − 29.08

= 0.92 mL

% change in volume $= \dfrac{0.92\times100}{30} = 3.06\%$

$\approx 3.1\%$

37. b Molality $= \dfrac{1000\times\text{Weight of solute}}{Mw\times\text{Weight of solvent}}$

$9 = \dfrac{1000\times W}{98\times910}$

$W = 802.6\text{ g L}^{-1}$

= 80.26 g per 100 mL

38. b Use formula

$d = M\left(\dfrac{Mw_2}{1000} + \dfrac{1}{m}\right) \Rightarrow 1.0585 = 1\left(\dfrac{58.5}{1000} + \dfrac{1}{m}\right)$

Solve for m:

$\therefore m = 1$

39. b Na_2SO_4 does not react.

$N(NaOH) = 0.1 = 4$ g L

= 0.4 g per 100 mL

40. c. 4 g sulphur is in 100 g compound, hence 32 g sulphur is in $= \left(\dfrac{100}{4}\times32\right) = 800$ g compound

41. c. Mol. ratio $O_2:N_2$

$\dfrac{1}{32}:\dfrac{4}{28}$

Molecules $\dfrac{N_A}{32}:\dfrac{4N_A}{28} \Rightarrow 7:32$

42. b $\dfrac{0.116\text{ g of A}}{116\text{ g }(Mw\text{ A})} = \dfrac{0.074\text{ of }Ca(OH)_2}{W\,[Ca(OH)_2]}$

$W = 74\text{ g} \equiv 1\text{ mol }Ca(OH)_2 \cong 2\text{ mol }(\overset{\ominus}{O}H) \equiv 2\text{ mol }(H^{\oplus})$

43. c. $Na_2SO_3:H_2O \equiv 50:50$ (Mw of $Na_2SO_3 = 126$)

Mole: $\dfrac{50}{126}:\dfrac{50}{18}$

Ratio: 1:7

44. a Na_2CO_3 is not affected by heating.

$2NaHCO_3 \longrightarrow \underset{\text{Residue}}{Na_2CO_3} + H_2O + CO_2$

45. c. $\chi_2 = \dfrac{n_2}{n_1+n_2} = 0.25$ (ethanol) (solute) ($Mw_2 = 46$ g)

$\chi_1 = \dfrac{n_1}{n_1+n_2} = 0.75$ (water) (solvent) ($Mw_1 = 18$ g)

$\dfrac{\chi_1}{\chi_2} = \dfrac{n_1}{n_2} = \dfrac{3}{1} \Rightarrow \dfrac{W_1\times Mw_2}{Mw_1\times W_2} = \dfrac{3}{1}$

$\dfrac{W_1\times46}{18\times W_2} = 3$

$\dfrac{W_1}{W_2} = 1.17$

$\therefore \dfrac{W_2}{W_1+W_2} = 0.46$

46. d. $\because 9.108\times10^{-31}$ kg of electrons contain

$= \dfrac{1}{6.023\times10^{23}}$ mol

$\therefore$ 1 kg of electron will contain

$= \dfrac{1}{6.023\times10^{23}\times9.108\times10^{-31}}$

$= \dfrac{1}{6.023\times9.108}\times10^8$ mol

47. a Weight of 6.023×10^{23} (Avogadro's number) = Mw of $CuSO_4 \cdot 5H_2O = 249$ g

$= 1$ mol of $CuSO_4 \cdot 5H_2O$

Weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$

$$= \frac{249 \times 1 \times 10^{22}}{6.023 \times 10^{23}} = 4.14 \text{ g}$$

48. d Balance the equation:

$$2CrO_5 + 3H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 3H_2O + \frac{7}{2}O_2$$

$2 \text{ mol } CrO_5 \Rightarrow \frac{7}{2}$ mol of O_2

$1 \text{ mol } CrO_5 \Rightarrow \frac{7}{4}$ mol of O_2

49. b i. Moles of NaOH = 1.0 M × 1.5 L = 1.5 mol

Moles of H_2SO_4 = 1.0 M × 1L = 1.0 mol

$$\underset{2 \text{ mol}}{2NaOH} + \underset{1 \text{ mol}}{H_2SO_4} \longrightarrow Na_2SO_4 + 2H_2O$$

Moles of H_2SO_4 reacted with NaOH

$= \frac{1}{2}$ mol of NaOH

$= \frac{1}{2} \times 1.5 = 0.75$ mol H_2SO_4

$$\% \text{ purity of } H_2SO_4 = \frac{0.75 \text{ mol} \times 100}{1.0 \text{ mol}} = 75\%$$

ii. For slope: $\frac{x}{a} + \frac{y}{b} = 1$

$$\text{Slope}\left(\frac{y}{x}\right) = \frac{-b}{a} = -\frac{1.5}{1.5} = -1$$

50. b Let the volume of solution = 1 L

Weight of solution = 1 × d = d g

Number of moles of solute (n_2) in 1 L solution = M

$$\therefore \frac{W_2}{Mw_2} = M$$

W_2 (weight of solute) = $M \times Mw_2$

W_1 (weight of solvent) = Weight of solution – Weight of solute

$= (d - M \times Mw_2)$

Number of moles of solvent (n_1)

$$= \frac{W_1}{Mw_1} = \left(\frac{d - M \times Mw_2}{Mw_1}\right)$$

$$\therefore \chi_2 = \frac{n_2}{n_1 + n_2} = \frac{M}{\left(\frac{d - M \times Mw_2}{Mw_1}\right) + M}$$

$$= \frac{M \times Mw_1}{M(Mw_1 - Mw_2) + d}$$

51. c. 1 mol $H_2SO_4 \equiv 2$ mol $H_3O^{\oplus} \equiv 1$ mol SO_4^{2-}

$$\left(\frac{100}{1000} \times 0.1 = 0.01\right) \equiv 2 \times 0.01 + 0.01 = 0.03 \text{ mol}$$

Total number of g ions = $0.03 \times 6.02 \times 10^{23}$

$= 0.18069 \times 10^{23}$

52. b $2N_2 + 3O_2 \longrightarrow 2N_2O_3$, (% yield = 80%)

$$\text{Initial mol of } N_2 = \frac{7.0}{28} = 0.25 \text{ mol}$$

$$\text{Moles of } N_2 \text{ converted} = 0.25 \times \frac{80}{100} = 0.2$$

2 mol N_2 = 3 mol O_2

0.2 mol N_2 = 0.3 mol O_2 (1 mol O_2 = 2 oxygen atom)

= 2 × 0.3 mol O atom

$= 2 \times 0.3 \times 6.02 \times 10^{23} = 3.6 \times 10^{23}$

53. d $$M = \frac{\% \text{ by weight} \times 10 \times d}{Mw_2} = \frac{36.5 \times 10 \times 1.2}{36.5} = 12 \text{ M}$$

$$m = \frac{36.5 \times 1000}{36.5 \times (100 - 36.5)} = \frac{1000}{63.5} = 15.7\, m$$

54. d $BaCl_2 + K_2SO_4 \longrightarrow BaSO_4\downarrow + 2KCl$

10 × 1   5 × 0.5

= 10 mmol   = 2.5 mmol

Here, K_2SO_4 is the limiting reagent

1 mmol $K_2SO_4 \equiv 1$ mmol $BaSO_4$

2.5 mmol $K_2SO_4 \equiv 2.5$ mmol $BaSO_4$

$$\equiv \frac{2.5}{1000} = 0.0025 \text{ mol } BaSO_4$$

55. a $\chi_B = 0.2, \chi_A = 0.1$

$$m = \frac{\chi_B \times 1000}{\chi_A \times Mw_A} = \frac{0.2 \times 1000}{0.8 \times 18} = 13.88$$

56. c. $3NaOH + FeCl_3 \longrightarrow Fe(OH)_3 + 3NaCl$

(excess)   100 mL

1 mmol ≡ 1 mmol

$FeCl_3 \equiv Fe(OH)_3$

$$M \times 100 \equiv \frac{2.14}{107} \times 1000$$

$M_{FeCl_3} = 0.2$

$N_{FeCl_3} = 0.2 \times 3$ (valency factor = 3)

= 0.6 N

57. d $M_1 = 1.0$ M, $M_2 = 0.25$ M

Let V_1 and V_2 are volumes required.

$(1.0 \times V_1 + 0.25 \times V_2) = 0.75\,(V_1 + V_2)$

$\Rightarrow 0.25V_1 = 0.5V_2, \Rightarrow V_1 : V_2 = 2 : 1$

58. b $X_{H_2SO_4} = \dfrac{100 \times 0.9}{100 \times 0.9 + 100 \times 1} = \dfrac{90}{190} = 0.4736$

% mass of $H_2SO_4 = 43.36\%$

59. a Dibasic acid ≡ NaOH

12.5 mL $10\text{ mL} \times 0.1\text{ N} = 1\text{ mEq}$

Strength of dibasic acid = 6 g L^{-1}

mEq of acid = mEq of NaOH

$12.5 \times N = 1\text{ mEq}$

$$\dfrac{12.5 \times 6 \times 1000}{\dfrac{Mw}{2} \times 1000} = 1$$

$\therefore Mw\text{ (acid)} = 150$

60. b $55.5\text{ g } CaCl_2 \equiv 50\text{ g } CaCO_3$

$55.5\text{ mg } CaCl_2 \equiv 50 \times 10^{-3}\text{ g } CaCO_3$

$47.5\text{ g } MgCl_2 \equiv 50\text{ g } CaCO_3$

$47.5\text{ mg } MgCl_2 \equiv 50 \times 10^{-3}\text{ g } CaCO_3$

Total $CaCO_3 = (50 + 50) \times 10^{-3} = 10^{-2}\text{ g L}^{-1}$

$$\text{ppm} = \dfrac{10^{-2}}{1000\text{ mL}} \times 10^6\text{ mL} = 10$$

61. c. 10 mL of 0.2 N HCl + 30 mL of 0.1N HCl ≡ 40 mL of NaOH (≡ 0.61 g organic acid)

mEq of HCl ≡ mEq of NaOH ≡ mEq of organic acid

$$10 \times 0.2 + 30 \times 0.1 \equiv \dfrac{0.61}{E} \times 1000$$

$$5 = \dfrac{0.61 \times 1000}{E}$$

$$E = \dfrac{610}{5} = 122$$

62. c. $Z_2O_3 \quad + \quad 3H_2 \longrightarrow 2Z + 3H_2O$

[2 g = 200 mg] $\dfrac{12\text{ mg}}{2\text{ mg}} = 6\text{ mmol}$

Since H_2 used is 6 m mol, Z_2O_3 used should be 2 mmol.

$$\text{Mol of } Z_2O_3 = \dfrac{\text{Weight}}{Mw} = \dfrac{200\text{ mg} \times 10^{-3}\text{g}}{Mw} = 2 \times 10^{-3}\text{ moles}$$

$\therefore Mw(Z_2O_3) = 100$

$\therefore 2Z + 16 \times 3 = 100$

$$Z = \dfrac{100 - 48}{2} = 26$$

63. a. $2Y \longrightarrow 2Y^{3+} + 6e^- (Y \rightarrow Y^{3+} + 3e^-, (n\text{ factor} = 3)$

$6H^{\oplus} + 6e^- \longrightarrow 3H_2\ (2H^{\oplus} + 2e^- \rightarrow H_2, (n\text{ factor} = 2)$

1 eq of Y = 1 eq of H_2

$(n = 3)$ $(n = 2)$

$\dfrac{1}{3}$ mol Y = $\dfrac{1}{2}$ mol H_2

$\therefore Y : H_2 = 2 : 3$

64. b $2BCl_3 + 3H_2 \longrightarrow 2B + 6HCl$

$2 \times 10.8\text{ g B} \equiv 3 \times 22.4\text{ L of } H_2$

$$21.6\text{ g B} \equiv \dfrac{3 \times 22.4 \times 21.6}{2 \times 10.8} = 67.2\text{ L of } H_2$$

ASSERTION - REASONING TYPE

1. a Factual statement.

2. a $138\text{ g } K_2CO_3 = 1\text{ mol} \equiv 1$ g atom of C.

$12\text{ g C} = 1$ g atom of C

3. c. (A) is correct but (R) is wrong.

4. b 1 g atom = 1 mol of any compound = N_A molecules. Both (A) and (R) are correct, but (R) is not the correct explanation of (A).

5. a. Both are factual statements.

INTEGER TYPE

1. (10) Use $M = \dfrac{\%\text{ by weight} \times 10 \times d}{Mw_2}$

$M_1V_1 = M_2V_2$

$$\dfrac{90 \times 10 \times 0.8}{46} \times V = \dfrac{10 \times 10 \times 0.9}{46} \times 80$$

$$V = \dfrac{10 \times 0.9 \times 80}{90 \times 0.8} = 10\text{ mL}$$

2. (10) Total mEq of acid $= 50 \times 1 + 100 \times 0.5 + x \times 5 \times 2$ (n factor)

$= (100 + 10x)$ mEq

$= \dfrac{(100 + 10x)}{100\text{ mL}}$ N

$N_1V_1\text{ (Acid)} = N_1V_1\ [Al_2(CO_3^{2-})_3]$ (Total charge = 6) $(n = 6)$

$$\therefore \dfrac{(100 + 10x)}{100\text{ mL}}\text{ N} \times 100\text{ mL} = 10\text{ mL} \times \dfrac{1}{3} \times 6$$

$(100 + 10x) = 200$

$\therefore x = 10$ mL

3. (2) $M_1V_1 = N_2V_2$ (Atomic weight of Co = 58.93 g)

$$\dfrac{100\text{ mg}}{58.93\text{ mg}} \times V_1 = \dfrac{20\text{ mg}}{58.93\text{ mg}} \times 10\text{ mL}$$

$$V_1 = \dfrac{20 \times 10}{100} = 2\text{ mL}$$

4. (9) $M = \dfrac{\%\text{ by weight} \times 10 \times d}{Mw_2} = \dfrac{30 \times 10 \times 1.095}{36.5} = 9\text{ M}$

5. (5) The concentration is reduced to 1/5th, without any change in the number of g of solute, hence the volume must increase five fold. Dilute it to 5.0 times its former volume.

6. (8) Weight of NaOH = $\left(\frac{92\text{ g}}{100\text{ g solution}}\right)$ (100 g solution)

$= 92$ g NaOH

Weight of $H_2O = 100 - 92 = 8.0$ g H_2O

7. (3) 60 g rosin + 68 g beeswax + 12 g shellac = 140 g total.

Weight of shellac = (35 g total) $\left(\frac{12\text{ g shellac}}{140\text{ g total}}\right)$

= 3 g shellac

8. (6) (Atomic weight of Al and Cr = 27 and 52, Mw of $Cr_2O_3 = 152$)

Moles of Al = $\frac{4.98\text{ g}}{27\text{ g Al}} = 0.184$ mol

$= \frac{0.184}{2} = 0.92$ mol of Cr_2O_3

Moles of $Cr_2O_3 = \frac{20\text{ g}}{152\text{ g } Cr_2O_3} = 0.131$ mol

Since 2 mol Al is required for 1 mol of Cr_2O_3.

So, Al is the limiting reagent and Cr_2O_3 is in excess.

Moles of Cr_2O_3 in excess = (0.131 – 0.092) = 0.039 ≈ 0.04 mol

Weight of Cr_2O_3 is excess = 0.04 × 152 ≈ 6 g Cr_2O_3

9. (1) Total weight of $Ag^{\oplus} = \left(\frac{3.24\text{ g}}{1\text{ L}}\right)(100\text{ L}) = 324$ g

Mol of $Ag^{\oplus} = \frac{324\text{ g}}{108\text{ g Ag}} = 3$ mol

Mol of Zn = $\frac{65.4\text{ g}}{65.4\text{ g Zn}} = 1$ mol $= 2$ mol of $Ag^{\oplus}$

Since the mole ratio $Ag^{\oplus}$/Zn present (3/1) exceeds the mole ratio required (2/1) in the reaction, the $Ag^{\oplus}$ is in excss; the Zn is completely consumed.

Moles of $Ag^{\oplus}$ consumed = 2 mol

Moles of $Ag^{\oplus}$ left = 3 – 2 = 1 mol of $Ag^{\oplus}$ excess

10. (9) Let x of Na_2CO_3. Then, weight of $NaHCO_3 = (15 - x)$ g

Moles of NaCl produced = $\frac{11.0\text{ g}}{58.5\text{ g}} = 0.188$ mol

The NaCl is produced by the reaction of $\left(\frac{x}{106}\right)$ mol of Na_2CO_3 and $\frac{(15-x)}{84}$ mol of $NaHCO_3$. Each mol of Na_2CO_3 produces 2 mol of NaCl.

$\therefore \frac{2x}{106} + \frac{15-x}{84} = 0.188$

Solve x: = 13.5 g Na_2CO_3,

$NaHCO_3 = (15 - 1.35) = 13.6$ g

$\%Na_2CO_3 = \frac{1.35}{15} \times 100 = 9.0\%\ Na_2CO_3$

11. (7) $HCO_3^{\ominus} \longrightarrow CO_2$

Moles $HCO_3^{\ominus}$

$= \frac{6.1\text{ g}}{61} \times \frac{20.8}{100} = 0.0286$ moles of CO_2

1 mol CO_2 at 1 atm, and 25°C = 24.4 L

0.0308 mol $CO_2 = 24.4 \times 0.0286 = 0.697 \approx 0.7$ L

$V_{CO_2} = 0.7 \times 10 = 7$ L

12. (5) $V_{New} = (V + 1000)$ mL

Number of moles of salt remains same.

$\therefore (V + 1000) \times 1.02 = 1.025 \times 1000$

$V = 4.9$ mL ≈ 5 mL

13. (3) Total weight = 19.6 g

a. 2.8 g of molecules, $d = 0.765$ g L^{-1}

Volume = $\frac{\text{Mass}}{d} = \frac{2.8}{0.75}$ L at STP

1 mol ≡ 22.4 L at STP

moles = $\frac{2.8}{0.75} \times \frac{1}{22.4}$

Molecules = $\frac{2.8}{0.75} \times \frac{1}{22.4} \times 6 \times 10^{23} = 1 \times 10^{23}$

b. 11.2 g molecules, $d = 3$ g L^{-1}

Molecules = 1×10^{23}

c. 5.6 g molecules, $d = 1.5$ g L^{-1}

Molecules = 1×10^{23}

Total number of molecules = $3 \times 10^{23} = 3$

ARCHIVES

Single Correct Answer Type

1. a. The number of molecules in 36 g of water is

$\frac{36}{18} N = 2N$

The number of molecules in 28 g of CO is

$\frac{28}{28} N = N$

The number of molecules in 46 g of C_2H_5OH is

$\frac{46}{46} N = N$

The number of molecules in 54 g of N_2O_5 is

$\frac{54}{108} N = \frac{1}{2} N$

2. a In both cases, the same volume of hydrogen is evolved for the same amount of zinc reacted.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$
$$Zn + NaOH \longrightarrow Na_2ZnO_2 + H_2\uparrow$$

3. c.

	O_2	N_2
Weight ratio	1	4
Moles ratio	$\frac{1}{32}$	$\frac{4}{28} = \frac{1}{7}$
Molecules ratio	$\frac{1}{32}N$	$\frac{1}{7}N$
Molecules ratio	7	32

4. a In one molecule of CO_2, the number of electrons is $6 + 8 + 8 = 22$

5. a $Ag_2CO_3 \longrightarrow 2Ag + CO_2 + \frac{1}{2}O_2$

276 g Ag_2CO_3 gives $2 \times 108 = 216$ g residue

2.76 g Ag_2CO_3 gives 2.16 g residue (silver)

6. a Let 32 g of each be present.

$$\text{Moles of } O_2 = \frac{32}{32} = 1$$

$$\text{Moles of } CH_4 = \frac{32}{16} = 2$$

$$\text{Mole fraction of } O_2 = \frac{1}{1+2} = \frac{1}{3}$$

which is same as the fraction of pressure.

7. d

8. a Atoms of the same element having same atomic numbers but different mass numbers are called isotopes.

9. a A molal solution is one that contains 1 mol of a solute in 1000 g or kg of the solvent.

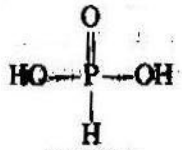
$$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

10. d Molarity, normality, and formality are calculated against the volume of the solution. The volume of the solution changes with change in temperature; therefore, these quanities do not remain constant with temperature.

$$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

The molality of a solution remains independent of temperature becuase it involves only mass, which is independent of temperature.

11. d



(H_3PO_3)

Only hydrogens attached to oxygen and contribute to basicity are replacable. From the structures it is clear that phosphours acid, H_3PO_3, is dibasic.

Normality = Molarity × Basicity (for an acid)

$N = 0.3 \times 2 = 0.6$

12. d For water vapours, $P = 0.0006$ g cc^{-1}

$$\therefore 0.0006 = \frac{\text{Mass}}{\text{Volume}} = \frac{\text{Mass}}{1000}$$

Mass $= 1000 \times 0.0006 = 0.6$ g

The density of liquid water is 1 g cc^{-1}

So, the volume occupied by water is

$$\frac{\text{Mass}}{\text{Density}} = \frac{0.6}{1} = 0.6 \text{ cc}$$

13. a The normality of oxalic acid dihydrate is

$$\frac{6.3}{63} \times \frac{1}{250} \times 1000 = 0.4$$

[Ew for $(COOH)_2 \cdot 2H_2O$ is 63]

$N_1V_1(\text{acid}) = N_2V_2(\text{base})$

or $0.4 \times 10 = 0.1 \times V_2$

or $V_2 = 40$ mL

14. d

15. a A mixture X containing 0.02 mol of $[Co(NH_3)_5SO_4]Br$ and 0.02 mol of $[CO(NH_3)_5Br]\,SO_4$ was prepared in 2 L of solution. This means 1 L of the mixture contains 0.01 mol of $[Co(NH_3)_5SO_4]Br$ 0.01 mol of $[Co(NH_3)_5Br]SO_4$.

1 L of mixture X + excess $AgNO_3 \longrightarrow 0.01$ mol AgBr

1 L of mixture X + excess $BaCl_2 \longrightarrow 0.01$ mol $BaSO_4$

This is according to the following reactions taking place:

$$[Co(NH_3)_5SO_4]Br + AgNO_3 \longrightarrow [Co(NH_3)_5SO_4]NO_3 + AgBr\downarrow$$

$$[Co(NH_3)_5Br]SO_4 + BaCl_2 \longrightarrow [Co(NH_3)_5Br]Cl_2 + BaSO_4\downarrow$$

16. a The number of atoms in 24 g C is

$$\frac{24}{12}N = 2N$$

The number of atoms in 56 g of Fe is

$$\frac{56}{56}N = N$$

The number of atoms in 27 g of Al is

$$\frac{27}{27}N = N$$

The number of atoms in 108 g of Ag is

$$\frac{108}{108}N = N$$

17. b The atomic mass of iron is

$$= \frac{(5\times 54)+(90\times 56)+(5\times 57)}{100} = 55.95$$

18. c. $V_{sol} = \frac{(120+1000)}{1.15}$ mL

$$M = \frac{W_2 \times 1000}{Mw_2 \times V_{sol}} = \frac{120\times 1000}{60\times 1120/1.15} = \frac{2\times 115}{112} = 2.05\text{ M}$$

Integer Type

1. (3) $Be_nAl_2Si_6O_{18}$

$(2n)+(3\times 2)+(4\times 6)+(-2\times 18)=0$

or $2n+30-36=0$

or $2n=6$

or $n=3$

2. (3) A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL and 25.0 mL. The number of significant figures in the average titre value is 3. This is according to the rules of significant figures.

If two or more numbers having different precision are to be added or subtracted, the answer should be taken as the number of decimal places in the number having less decimal places.

3. (7) Density = 10.5 g cc^{-1}

This means 10.5 g silver is present in 1 cm^3.

$\frac{10.5}{108}$ mol silver is present in 1 cm^3.

$\frac{10.5}{108}N$ silver atoms present in 1 cm^3.

$\sqrt[3]{\frac{10.5}{108}N}$ silver atoms present in 1 cm

$\left(\sqrt[3]{\frac{10.5}{108}N}\right)^{1/2}$ silver atoms present is 1 cm^2.

10^{-12} m^2 is equal to 10^{-8} cm^2.

$\left(\sqrt[3]{\frac{10.5}{108}N}\right)^{1/2} \times 10^{-8}$ silver atoms present in 10^{-12} m^2.

On solving, we get $1.5\times 10^{-7} = Y\times 10^{-x}$

$\therefore x = 7$

4. (2) O, Cl, F, N, P, Sn, Tl, Na, Ti

Na shows only +1.

F shows only −1.

Fill in the Blanks Type

1. The total number of electrons present in 18 mL of water is **6.023×10^{24}.**

Number of electron in one molecule of H_2O is 2 + 8 = 10

Density = 1

18 mL means 18 g

Moles = $\frac{18}{18} = 1$

Molecules = 6.023×10^{23}

Electrons = $6.023\times 10^{23}\times 10 = 6.023\times 10^{24}$

2. The modern atomic mass unit is based on the mass of **C-12.**

3. Three grams of a salt of molecular weight 30 is dissolved in 250 g of water. The molality of the solution is **0.4.**

$$\text{Molality } (m) = \frac{3}{30}\times\frac{1}{250}\times 1000 = 0.4$$

4. The weight of 1×10^{22} molecules of $CuSO_4\cdot 5H_2O$ is **4.14 g.**

Subjective Type

1. $\text{Molarity} = \frac{\%\text{ by weight}\times 10\times d}{Mw_2}$

$$= \frac{13\times 1.02\times 10}{98} = 1.35\text{ M}$$

13% solution by weight means 13 g of solute is dissolved in 87 g of solvent.

$$m = \frac{W_2\times 1000}{Mw_2\times W_1}$$

$$= \frac{13}{98}\times\frac{1}{87}\times 1000 = 1.52\text{ m}$$

Normality = Molarity × 2 ('n' factor for H_2SO_4)

Normality = 1.35 × 2 = 2.70

For dilution,

$N_1V_1 = N_2V_2$

or $100\times 2.70 = 1.5\times V_2$

or $V_2 = 180$ mL

2. $\text{Density of a gas} = \frac{PM}{RT} = \frac{5\times 17}{0.0821\times 303} = 3.417\text{ g L}^{-1}$

3. $PV = nRT = \frac{W}{Mw}RT$

$$\therefore \frac{700}{760}\times\frac{1336}{1000} = \frac{W}{44}\times 0.0821\times 300$$

or $W = 2.198$ g CO_2

The molecular mass of any metal carbonate is 2E + 60, where E is the equivalent mass of the metal. So

$$\frac{2E+60}{4.215}=\frac{44}{2.198}$$

or $E = 12.188$ g

5. a. Weight of solvent = 214.2 – 34.2 = 180 g

$$m=\frac{W_2\times 1000}{Mw_2\times W_1}=\frac{34.2\times 1000}{342\times 180}=0.555$$

b. $$\chi_2=\frac{n_1}{n_1+n_2}=\frac{34.2/342}{\frac{180}{18}+\frac{34.2}{342}}=0.0099$$

6. Density = 1.84 g L^{-1}

Mass of 100 mL solution = 100 × 1.84 = 184 g

Mass of H_2SO_4 in 100 mL solution = 93 g

Mass of water in 100 mL soltution = 184 – 93 = 91 g

$$\text{Molality}=\frac{93}{98}\times\frac{1}{91}\times 1000=10.428$$

7. $$PV=nRT=\frac{W}{Mw}RT$$

or $$V=\frac{1}{P}\frac{W}{Mw}RT$$

(Mw for C_2H_5 is 26 g)

$$V=\frac{760}{740}\times\frac{5}{26}\times 0.0821\times 323=5.237\text{ L}$$

9. Glauber's salt is $Na_2SO_4\cdot 10H_2O$.

Given mass = 8.0575×10^{-2} kg = 80.575 kg

Mw = 322 g mol^{-1}

Mw of Na_2SO_4 = 142 g mol^{-1}

$$\text{Mass of } Na_2SO_4 \text{ in 80.575 g sample}=\frac{142}{322}\times 80.575=35.53\text{ g}$$

$$\text{Molarity (M)}=\frac{35.53}{142}\times 1=0.2502$$

Density = 1077.2 kg m^{-3} = 1077.2 g L

$$\text{Density}=\frac{\text{Mass}}{\text{Volume}}$$

Mass of solution = density × volume
= 1077.2 × 1 = 1077.2 g

Mass of water = 1077.2 – 35.53 = 1041.67 g

$$\text{Molality (m)}=\frac{35.53}{142}\times\frac{1}{1041.67}\times 1000=0.2402$$

$$\text{Moles of } Na_2SO_4=\frac{35.53}{142}=0.2502$$

$$\text{Moles of } H_2O=\frac{1041.67}{18}=57.87$$

$$\text{Moles fraction } (Na_2SO_4)=\frac{\text{Moles of } Na_2SO_4}{\text{Total Moles}}=\frac{0.2502}{0.2502+57.87}=4.304\times 10^{-3}$$

10. Density of water = 1000 kg m^{-3}

1 kg = 1000 g

1 m^3 = 1000 L

Density of water = 1000 g L^{-1}

$$\text{Number of moles in 1 L}=\frac{1000}{18}$$

Molarity = 55.555

11. a. $6CaO+P_4O_{10}\longrightarrow 2Ca_3(PO_4)_2$

$6CaO\equiv P_4O_{10}$

$$\frac{6(40+16)}{W}=\frac{(31\times 4)+(16\times 10)}{852}$$

or $W = 1008$ g