Qualitative Analysis

Detection of elements

Lassaigne's test: Nitrogen, sulphur, and halogens in an organic compound are detected by Lassaigne's test through Lassaigne's extract. This extract is prepared using the following method:

Sodium reacts with elements of the organic compound to give the following reaction:

$$C + N + Na \rightarrow NaCN;\ S + 2Na \rightarrow Na_2S$$

$$X + Na \rightarrow NaX \text{ (where X = Cl, Br, or I)}$$

When nitrogen and sulphur both are present in the organic compound, then sodium thiocynate is formed.

$$Na + C + N + S \rightarrow NaSCN$$

All the sodium salts being soluble in water can be easily detected.

1. *Detection of nitrogen*

$$2NaCN + FeSO_4 \rightarrow Fe(CN)_2 + Na_2SO_4$$

$$Fe(CN)_2 + \underset{\text{(excess)}}{4NaCN} \longrightarrow Na_4[Fe(CN)_6]$$

$$FeSO_4 \xrightarrow[H_2SO_4]{\text{Oxidized by}} Fe_2(SO_4)_3$$

$$3Na_4[Fe(CN)_6] + 2Fe_2(SO_4)_3 \rightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 6Na_2SO_4$$

2. *Detection of sulphur:* If the organic compound contains sulphur, the sodium fusion extract will contain sodium sulphide. It is divided into two portions, and following tests are performed:

- Sodium nitroprusside test

$$Na_2S + Na_2[Fe(CN)_5NO] \rightarrow \underset{\text{Violet color}}{Na_4[Fe(CN)_5NOS]}$$

- Lead acetate test

$$Na_2S + \underset{\text{Lead acetate}}{(CH_3COO)_2Pb} \longrightarrow \underset{\text{black ppt.}}{PbS\downarrow} + 2CH_3COONa$$

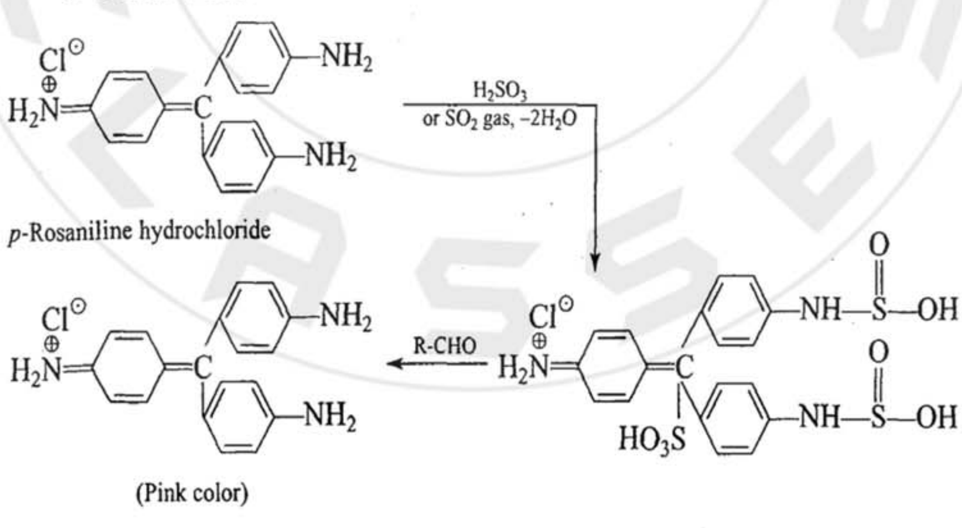
3. *Detection of halogens*: If the organic compound contains halogen, the sodium fusion extract will contain sodium halide. The sodium fusion extract is boiled with dilute nitric acid to decompose sodium cyanide or sodium sulphide (if present), otherwise a white precipitate of silver cyanide or silver sulphide will be formed even in the absence of halogen. The solution is then cooled and silver nitrate solution is added. The characteristic precipitate confirms the presence of a halide.

$$NaX + AgNO_3 \rightarrow AgX\downarrow + NaNO_3$$

- White precipitate soluble in aqueous ammonia indicates chlorine.
- Light yellow precipitate sparingly soluble in aqueous ammonia indicates bromine.
- Pale yellow precipitate insoluble in aqueous ammonia indicates iodine.

Detection of functional groups

1. *Tests for carboxylic acid group*
   - **Sodium bicarbonate test:** Add a small quantity of the organic compound to sodium bicarbonate solution taken in a test tube. Compound dissolves with brisk effervescences.
2. *Tests for aldehyde group*
   - **Schiff's test**



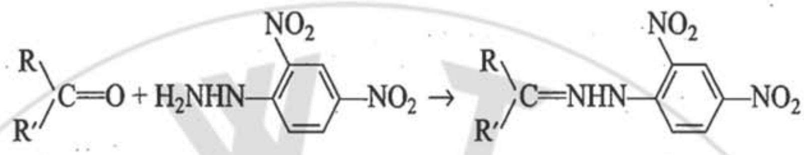
- **Fehling's test**

$$RCHO + 2CuO \longrightarrow RCOOH + \underset{\text{Red ppt.}}{Cu_2O\downarrow}$$

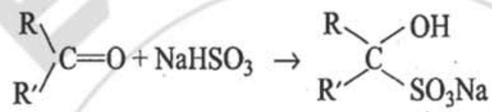
- **Tollen's test**

$$\underset{\text{Tollen's reagent}}{RCHO + 2[Ag(NH_3)_2]OH} + H_2O \rightarrow RCOONH_4 + NH_3 + 2NH_4OH + \underset{\text{Silver mirror}}{2Ag\downarrow}$$

3. *Tests for ketone group*: Ketones, unlike aldehydes, do not restore the pink color of Schiff's reagent nor do they reduce Fehling's solution or ammoniacal silver nitrate solution. Ketones yellow or red crystalline precipitate with 2,4-dinitrophenylhydrazine and also with sodium bisulphite reagent.



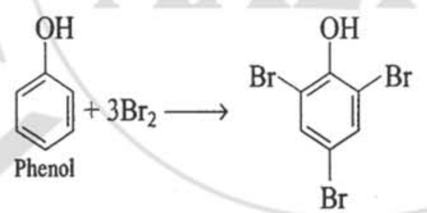
Ketones add on sodium hydrogen sulphite to form crystalline bisulphite compounds.



(Bisulphite addition compound)

4. *Tests for phenol group*

- **Neutral $FeCl_3$ test:** When phenols are treated with neutral ferric chloride solution, they form colored complexes. The color of the complex may be violet, red, blue, or green. This is a characteristic reaction of compounds having enolic group (=C–OH). All stable enols respond to this test.
- **Bromine water test**



2,4,6-Tribromophenol
(yellowish white)

- **Ceric ammonium nitrate test**

$$(NH_4)_2[Ce(NO_3)_6] + \underset{\text{Phenol}}{2C_6H_5OH} \rightarrow \underset{\text{Green or brown ppt.}}{[Ce(NO_3)_4(C_6H_5OH)_2]} + 2NH_4NO_3$$

- **Liebermann's test:** Take a small amount of the compound and fuse with a few crystals of $NaNO_2$ in a test tube. Cool the test tube and add some concentrated H_2SO_4. A deep green color is obtained and when poured into large excess of water, green color changes to red. When a little NaOH solution is added to the aqueous solution, the solution becomes deep blue colored.

5. *Tests for alcohol group*: Alcohols may be considered as neutral compounds. They are soluble in water or dioxane.

- **Sodium test**

  $$2ROH + 2Na \longrightarrow 2RO^-Na^+ + H_2\uparrow$$

- **Ceric ammonium nitrate test:** This test is useful only when the compound contains less than 10 carbon atoms per molecule.

  $$2ROH + (NH_4)_2[Ce(NO_3)_6] \rightarrow \underset{\text{Red color}}{[Ce(NO_3)_4(ROH)_2]} + 2NH_4NO_3$$

6. *Tests for primary amines ($-NH_2$)*

- **Carbylamines test**

  $$RNH_2 + CHCl_3 + 3KOH \rightarrow R-N\overset{=}{\rightarrow}C + 3KCl + 3H_2O$$

7. *Tests for secondary amines (–NH–)*

- **Liebermann's nitroso test:** Dissolve some organic compound in concentrated HCl, and then add a small amount of water. Cool the solution in ice-cold water bath and then add cold dilute $NaNO_2$ solution. A yellow oily emulsion is produced. Take this emulsion in a test tube and add phenol and concentrated H_2SO_4 to it. Green color appears. Addition of water changes green color to red, which changes to deep blue on adding NaOH solution.

8. *Tests for nitro group*

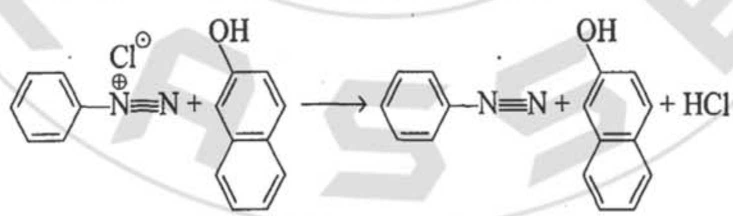
- **Reduction test**

  $$Zn + 2HCl \rightarrow ZnCl_2 + 2[H]$$

  $$C_6H_5NO_2 + 6[H] \rightarrow C_6H_5NH_2 + 2H_2O$$

  $$NaNO_2 + HCl \rightarrow HNO_2 + NaCl$$

  $$C_6H_5NH_2 + HNO_2 + HCl \rightarrow C_6H_5N_2^+Cl^- + 2H_2O$$



β-Napththol   Orange red dye

- **Mulliken's test**

  $$Zn + 2H_2O \longrightarrow Zn(OH)_2 + 2[H]$$

  $$C_6H_5NO_2 + 4[H] \longrightarrow C_6H_5NHOH + H_2O$$

  $$C_6H_5NHOH + Ag_2O \longrightarrow C_6H_5NO + H_2O + \underset{\text{Grey or black ppt.}}{2Ag\downarrow}$$

Quantitative Analysis

1. *Estimation of carbon and hydrogen*

- **Liebig's combustion method:** A known mass of an organic compound is heated in a current of dry oxygen (free from CO_2) in the presence of cupric oxide till all the carbon is oxidized to carbon dioxide and all the hydrogen is oxidized to water.

$$C_xH_y\left(x+\frac{y}{4}\right)O_2 \longrightarrow xCO_2+\frac{y}{2}H_2O$$

∴ Percentage of carbon in organic compound

$$=\frac{12}{44}\times\frac{\text{Mass of } CO_2 \text{ formed}}{\text{Mass of organic compound}}\times 100$$

∴ Percentage of hydrogen in organic compound

$$=\frac{2}{18}\times\frac{\text{Mass of } H_2O \text{ formed}}{\text{Mass of organic compound}}\times 100$$

2. *Estimation of nitrogen*

- **Duma's method:** Known mass of an organic compound is heated with cupric oxide in an atmosphere of carbon dioxide. The carbon and hydrogen get oxidized to carbon dioxide and water, while the nitrogen is set free.

$C + 2CuO \rightarrow CO_2 + 2Cu;\ 2H + CuO \rightarrow H_2O + Cu$

$2N + CuO \rightarrow N_2$ + Oxides of nitrogen

Oxides of nitrogen + $Cu \rightarrow CuO + N_2$

$$\text{Percentage of nitrogen} = \frac{\text{Mass of nitrogen}}{\text{Mass of organic compound}}\times 100 = \frac{28x\times 100}{22.4\times w}$$

where x is the volume of N_2 (in liter) at NTP and w is the mass of the organic compound.

- **Kjeldahl's method**
  - Organic compounds containing nitrogen in the ring such as pyridine and quinoline.
  - Orgainc compounds containing nitro ($-NO_2$) and diazo ($-N=N-$) groups.

Principle: A known weight of the organic compound is heated with concentrated H_2SO_4 so that nitrogen is quantitatively converted into ammonium sulphate. The solution is then heated with excess of sodium hydroxide. The ammonia gas evolved is passed into a known but excess volume of standard acid (HCl or H_2SO_4). The acid left unused is estimated by titrating the solution with standard alkali. From the amount of acid left unused, the amount of acid used for neutralization of ammonia can be calculated. From this, the percentage of nitrogen can be calculated. The chemical reactions involved are as follows:

$$\underset{\text{(known amount of organic compound)}}{C,H,S} \xrightarrow{\text{Conc. } H_2SO_4} CO_2 + H_2O + SO_2$$

$$\underset{\text{(known weight of organic compound)}}{N} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$$

$$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$$

$$\underset{(n=1)}{2NH_4} + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

$$\underset{\text{(excess)}}{H_2SO_4} + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

$$\text{Percentage of nitrogen} = \frac{\text{Mass of nitrogen}}{\text{Mass of organic compound}} \times 100$$

$$= \frac{(N_1V_1 - N_2V_2) \times 10^{-3} \times 14}{w} \times 100 = \frac{1.4(N_1V_1 - N_2V_2)}{w}$$

where N_1 and N_2 are the milliequivalents of standard acid and alkali, respectively.

3. *Estimation of halogens*

- **Carius method:** In this method, a known mass of the organic substance is heated with fuming nitric acid in the presence of silver nitrate in a special sealed tube known as Carius tube.

$$C + 2O \xrightarrow{HNO_3} CO_2$$

$$2H + O \xrightarrow{HNO_3} H_2O$$

$$S + H_2O + 3O \xrightarrow{HNO_3} H_2SO_4$$

$$\underset{\text{(halogen)}}{X} + AgNO_3 \longrightarrow AgX \downarrow$$

$$\text{Percentage of halogen} = \frac{\text{Atomic mass of halogen} \times \text{Weight of AgX}}{(108 + \text{Atomic mass of halogen}) \times \text{Weight of organic compound}} \times 100$$

4. *Estimation of sulphur*: The organic compound containing sulphur is heated with fuming nitric acid. The sulphur in the compound is oxidized to sulphuric acid, which is then precipitated as barium sulphate by adding excess of barium chloride solution.

Percentage of sulphur

$$=\frac{32\times \text{Weight of } BaSO_4}{\text{Molar mass of } BaSO_4 \times \text{Weight of organic compound}}\times 100$$

$$=\frac{62\times \text{Weight of } Mg_2P_2O_7}{222\times \text{Weight of organic compound}}\times 100$$

Determination of Molecular Mass

Silver salt method

This method is used for determining the molecular mass of organic acids. Most of the organic acids form insoluble silver salts, which upon ignition decompose to give residue of metallic silver.

$$\underset{\text{Silversalt}}{RCO_2H}\xrightarrow{NH_3}\underset{\text{Silver residue}}{RCO_2NH_4}\xrightarrow[-NH_4NO_3]{AgNO_3}RCOOAg\xrightarrow{\text{Heat}}Ag$$

Molecular mass of the acid $=\left[\left(\frac{w}{x}\times 108\right)-107\right]\times n$ (where n is the basicity of acid)

Platinichloride method

This method is used for determining the molecular masses of the bases. This method is based on the fact that organic bases, i.e., amines, combine with chloroplatinic acid, H_2PtCl_6, to form insoluble double salts known as chloroplatinates or platinichlorides. These salts when ignited leave a residue of metallic platinum.

$$2RNH_2 + H_2PtCl_6 \longrightarrow (RNH_3)_2PtCl_6$$

or $$2B + H_2PtCl_6 \longrightarrow B_2H_2PtCl_6$$

Molecular mass of base $=\frac{n}{2}\times\left[\left(\frac{2}{x}\times 195\right)-410\right]$ (where n is the acidity of base)

SOME IMPORTANT EXAMPLES

Example 1 An organic compound contains 49.3% carbon, 6.84% hydrogen, and its vapor density is 73. Molecular formula of the compound is:

(a) $C_3H_5O_2$ (b) $C_6H_{10}O_4$ (c) $C_3H_{10}O_2$ (d) $C_4H_{10}O_2$

Solution (b)

Element	%	Number of moles	Simple ratio
C	12	49.3/12 = 4.1	4.1/2.7 = 1.3 × 2 = 2.6 = 3
H	1	6.84/1= 6.84	6.84/2.7 = 2.5 × 2 = 5
O	16	43.86/16 = 2.7	2.7/2.7 = 1 × 2 = 2

Empirical formula = $C_3H_5O_2$

Empirical formula weight = $12\times3+1\times5+16\times2=73$

Molecular weight = Vapor density $\times 2 = 73\times 2 = 146$

$$n=\frac{\text{Molecular weight}}{\text{Empirical formula weight}}=\frac{146}{73}=2$$

Molecular formula = (Empirical formula)$_n$ $=(C_3H_5O_2)_2=C_6H_{10}O_4$.

Example 2 If 0.228 g of silver salt of dibasic acid gave a residue of 0.162 g of silver on ignition, then the molecular weight of the acid is:

(a) 70 (b) 80 (c) 90 (d) 100

Solution (c)

Mass of silver salt taken = 0.228 g

Mass of silver left = 0.162 g

Basicity of acid = 2

Step 1: To calculate the equivalent mass of the silver salt (E)

$$\frac{\text{Equivalent mass of silver salt}}{\text{Equivalent mass of silver}}=\frac{\text{Mass of acid taken}}{\text{Mass of silver left}}$$

$$=\frac{E}{108}=\frac{0.228}{0.162}$$

$$=E=\frac{0.228}{0.162}\times108$$

= ....

Step 2: To calculate the equivalent mass of acid.

Equivalent mass of acid

= Equivalent mass of silver salt – Equivalent mass of Ag + Basicity

= 152 – 108 + 1 = 152 – 109 = 43 (equivalent mass of acid)

Step 3: To determine the molecular mass of acid.

Molecular mass of the acid = Equivalent mass of acid × Basicity = 45 × 2 = 90.

Example 3 About 0.0833 mol of carbohydrate of empirical formula CH_2O contain 1 g of hydrogen. The molecular formula of the carbohydrate is:

(a) $C_5H_{10}O_5$ (b) $C_3H_4O_3$ (c) $C_{12}H_{22}O_{11}$ (d) $C_6H_{12}O_6$

Solution (d)

$\because$ 0.0833 mol carbohydrate has hydrogen = 1 g

$\therefore$ 1 mol carbohydrate has hydrogen $=\frac{1}{0.0833}=12$ g

Empirical formula (CH_2O) has hydrogen = 2 g

Hence $n=\frac{12}{2}=6$

Hence molecular formula of carbohydrate $= (CH_2O)_6$

$= C_6H_{12}O_6$

Example 4 A hydrocarbon contains 10.5 g carbon and 1 g hydrogen. Its 2.4 g has 1 L volume at 1 atm and $127^\circ C$. The hydrocarbon is:

(a) C_6H_7 (b) C_6H_8 (c) C_5H_6 (d) None of these

Solution (a)

$$C = 10.5\text{ g} = \frac{10.5}{12}\text{ mol} = 0.87\text{ mol}$$

$$H = 1\text{ g} = \frac{1}{1} = 1\text{ mol}$$

$$\therefore \quad (C_{0.87}H_1)_7 = C_{6.09}H_7 \approx C_6H_7$$

$$PV = nRT; \qquad PV = \frac{w}{m}RT$$

$$1 \times 1 = \frac{2.4}{m} \times 0.082 \times 400$$

$$m = 2.4 \times 0.082 \times 400 = 78.42 \approx 79$$

Example 5 An organic compound on analysis gave C = 48 g, H = 8 g, and N = 56 g. Volume of 1.0 g of the compound was found to be 200 mL at NTP. Molecular formula of the compound is:

(a) $C_4H_8N_4$ (b) $C_2H_4N_2$ (c) $C_{12}H_{24}N_{12}$ (d) $C_{16}H_{32}N_{16}$

Solution (a)

Element	%	Number of moles	Simple ratio
C	48	48/12 = 4	1
H	8	8/1 = 8	2
N	56	56/14 = 4	1

Empirical formula = CH_2N

Empirical formula mass = 28

Now, 200 mL of compound = 1 g

$$22400\text{ mL of compound} = \frac{1}{200} \times 22400 = 112$$

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{112}{28} = 4$$

$\therefore$ Molecular formula $= (CH_2N)_4 = C_4H_8N_4$.

OBJECTIVE QUESTIONS

1. About 116 mg of a compound on vaporization in a Victor Meyer's apparatus displaces 44.8 mL of air measured at STP. The molecular weight of the compounds is:

   (a) 116 (b) 232 (c) 58 (d) 44.8

2. A gas mixture contains 50% helium and 50% methane by volume. What is the percent by weight of methane in the mixture?

   (a) 19.97% (b) 20.05% (c) 50% (d) 80.03%

3. About 0.5 g of hydrocarbon gave 0.9 g water on combustion. The percentage of carbon in hydrocarbon is:

   (a) 75.8 (b) 80.0 (c) 56.6 (d) 28.6

4. Lassaigne's test for the detection of nitrogen fails in:

   (a) $NH_2CONHNH_2 \cdot HCl$ (b) $NH_2NH_2 \cdot HCl$

   (c) NH_2CONH_2 (d) $C_6H_5NHNH_2 \cdot HCl$

5. Camphor is often used in molecular mass determination because:

   (a) it is volatile

   (b) it is solvent for organic substances

   (c) It is readily available

   (d) it has a very high cryoscopic constant

6. In Kjeldahl's method, the nitrogen present in the organic compound is quantitatively converted into:

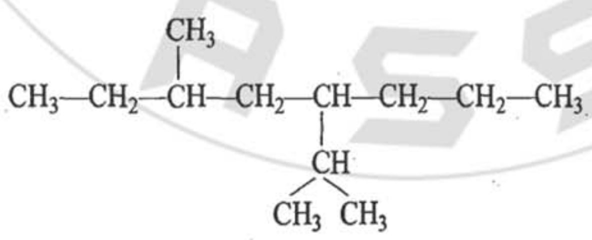
   (a) gaseous ammonia (b) ammonium sulphate

   (c) ammonium phosphate (d) ammonia

7. How many H-atoms are present in 0.046 g of ethanol?

   (a) 6×10^{20} (b) 1.2×10^{21} (c) 3×10^{21} (d) 3.6×10^{21}

8. IUPAC name of the compound:



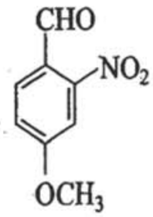
   (a) 4-isopropyl 1-6-methyl octane

   (b) 3-methyl-5-(1′-methylethyl) octane

   (c) 3-methyl-5-isopropyl octane

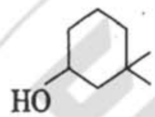
   (d) 6-methyl-4-(1′-methylethyl) octane

9. What is the correct IUPAC name?



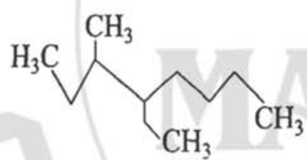
(a) 4-methoxy-2-nitrobenzaldehyde
(b) 4-formyl-3-nitro anisole
(c) 4-methoxy-6-nitrobenzaldehyde
(d) 2-formyl-5-methoxy nitrobenzene

10. The IUPAC name of the compound is:



(a) 3,3- dimethyl-1-cyclohexanol
(b) 1,1-dimethyl-3-hydroxy cyclohexane
(c) 3,3-dimethyl-1-hydroxy cyclohexane
(d) 1,1-dimethyl-3-cyclohexanol

11. Name of the compound given is:



(a) 5-ethyl-6-methyloctane (b) 4-ethyl-3-methyloctane
(c) 3-methyl-4-ethyloctane (d) 2,3-diethylheptane

12. The compound  is known by which of the following names:

(a) bicyclo-[2,2,2] octane (b) bicyclo-[2,2,1] octane
(c) bicyclo-[1,2,1] octane (d) bicyclo-[1,1,1] octane

13. Formula which represents a simple ratio of atoms of different elements present in a molecule of the substance is called:

(a) molecular formula (b) empirical formula
(c) structural formula (d) condensed formula

14. Actual number of atoms of different elements present in a molecule of a compound is given by:

(a) molecular formula (b) structural formula
(c) empirical formula (d) none of these

15. A compound contains $C = 90\%$ and $H = 10\%$. Empirical formula of the compound is:

(a) C_3H_{10} (b) CH_2 (c) C_3H_2 (d) C_3H_4

16. An organic compound contains $C = 36\%$, $H = 6\%$, and rest oxygen. Its empirical formula is:

(a) CH_2O (b) $C_2H_3O_3$ (c) CH_2O_2 (d) $C_2H_2O_2$

17. Empirical formula of a compound is CH_2O and its vapor density is 30. Molecular formula of the compound is:

(a) $C_3H_6O_3$ (b) $C_2H_4O_2$ (c) C_2H_4O (d) CH_2O

18. Insulin contains 3.4% sulphur. The minimum molecular weight of insulin is:

(a) 350 (b) 470 (c) 560 (d) 940

19. Which element is estimated by Carius method?

(a) Carbon (b) Hydrogen (c) Halogen (d) Nitrogen

20. On complete combustion 1.4 g hydrocarbon gave 1.8 g water. Empirical formula of the hydrocarbon is:

(a) CH (b) CH_2 (c) CH_3 (d) CH_4

21. In the estimation of sulphur, organic compound on treating with conc. HNO_3 is converted into:

(a) SO_2 (b) H_2S (c) H_2SO_4 (d) SO_3

22. In Carius method, 0.099 g organic compound gave 0.287 g AgCl. The percentage of chlorine in the compound will be:

(a) 28.6 (b) 71.7 (c) 35.4 (d) 64.2

23. About 0.24 g of an organic compound gave 0.22 g CO_2 on complete combustion. If it contains 1.66% hydrogen, then the percentage of C and O will be:

(a) 12.5 and 36.6 (b) 25 and 75 (c) 25 and 36.6 (d) 25 and 80

24. An organic compound contains $C = 74.0\%$, $H = 8.65\%$, and $N = 17.3\%$. Its empirical formula is:

(a) C_5H_8N (b) $C_{10}H_{12}N$ (c) C_5H_7N (d) $C_{10}H_{14}N$

25. An appropriate method for molecular weight determination of chloroform is:

(a) Regnault's method (b) diffusion method

(c) vapor pressure method (d) Victor Meyer's method

26. Molecular weight of an organic acid is given by:

(a) Equivalent weight × Basicity (b) $\frac{\text{Equivalent weight}}{\text{Basicity}}$

(c) $\frac{\text{Basicity}}{\text{Equivalent weight}}$ (d) Equivalent weight × Valency

27. If two compounds have the same empirical formulas but different molecular formulas, they must have:
   (a) different percentage composition
   (b) different molecular weight
   (c) same viscosity
   (d) same vapor density

28. Empirical formula of a compound is C_2H_5O and its molecular weight is 90. Molecular formula of the compound is:
   (a) C_2H_5O (b) $C_3H_6O_3$ (c) $C_4H_{10}O_2$ (d) $C_5H_{14}O$

29. The systematic name of $CH_3-CHBr-CH_2OH$ is:
   (a) 3-hydroxy-2-bromopropane (b) 2-bromopropanol-1
   (c) 2-bromo-3-propanol (d) 3-hydroxy isopropyl bromide

30. IUPAC name of acetyl salicylic acid is:
   (a) *m*-benzoic acid (b) 2-acetoxy benzoic acid
   (c) *p*-benzoic acid (d) *p*-acetyl benzoic acid

31. IUPAC name of CH_3CHO is:
   (a) acetaldehyde (b) methyl aldehyde
   (c) ethanol (d) ethanal

32. IUPAC name of $CH_3CH(OH)CH_2CH_2COOH$ is:
   (a) 4-hydroxy pentanoic acid (b) 1-carboxy-3-butanoic acid
   (c) 1-carboxy-4-butanol (d) 4-carboxy-2-butanol

33. IUPAC name of $CH_3-O-C_2H_5$ is:
   (a) ethoxymethane (b) methoxyethane
   (c) methylethyl ether (d) ethylmethyl ether

34. Which of the following compound has the functional group $-OH$?
   (a) 1,2-Ethandiol (b) 2-Butanone
   (c) Nitrobenzene (d) Ethanal

35. IUPAC name of $(CH_3)_2CHCH(CH_3)_2$ is:
   (a) 1,1,2,3-tetramethylethane (b) 1,2-di-isopropylethane
   (c) 2,3-dimethylbutane (d) 2,3,3-trimethylbutane

36. IUPAC name of the compound is:

$CH_3-CH-CH_2-CH(OH)-CH_3$
$\quad\quad|$
$\quad\;\; CH_2$
$\quad\quad|$
$\quad\;\; CH_3$

   (a) 4-ethyl-2-pentanol (b) 4-methyl-2-hexanol
   (c) 2-ethyl-2-pentanol (d) 3-methyl-2-hexanol

37. IUPAC name of compound $CH_3-CH=\underset{\displaystyle |\atop \displaystyle CH_2-CH_2}{C}-CH_3$ is:

(a) 2-ethyl-2-butene (b) 3-ethyl-2-butene

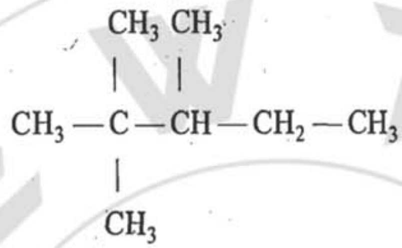
(c) 3-Methyl-3-pentene (d) 3-methyl-2-pentene

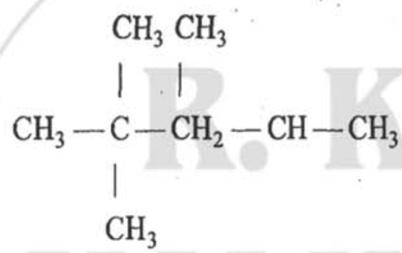
38. The IUPAC name of $CH_3C\equiv N$ is:

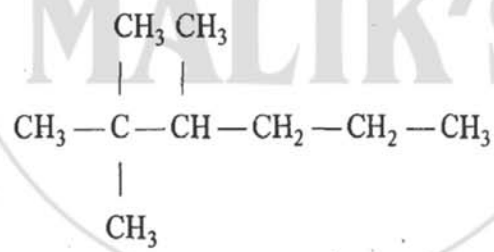
(a) acetonitrile (b) ethanenitrile

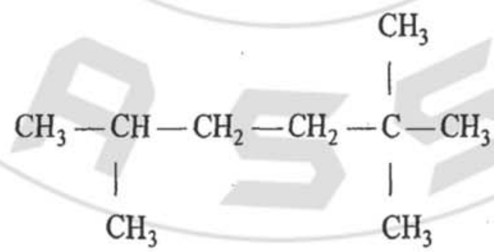
(c) methyl cyanide (d) cyanoethane

39. Which compound is 2,2,3-trimethylhexane?

(a) 

(b) 

(c) 

(d) 

40. The IUPAC name of $CH_3CH_2COCH_2CH_3$ is:

(a) 3-pentanone (b) 2-pentanone

(c) diethyl ketone (d) all the above

41. The IUPAC name of $CH_3COOC_2H_5$ will be:

(a) ethyl acetate (b) ethyl ethanoate

(c) methyl propanoate (d) none of these

42. IUPAC name of $(CH_3)_2CH-CH=CH-CH_3$ is:
   (a) 2-methyl-3-pentene (b) 4-methyl-2-pentene
   (c) 1,2-isopropyl-1-propene (d) 3-isopropyl-2-propene

43. IUPAC name of $CH_2=CH-CH(CH_3)_2$ is:
   (a) 1,1-dimethyl-2-propene (b) 3-methyl-1-butene
   (c) 2-vinyl propane (d) 1-isopropyl ethylene

44. Alicyclic compounds are:
   (a) aromatic (b) aliphatic
   (c) heterocyclic (d) aliphatic cyclic

45. The IUPAC name of $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_2CH_3$ is:
   (a) 4-methylhexane (b) 3-methylhexane
   (c) 2-propylbutane (d) 2-ethylpentane

HINTS AND SOLUTIONS

1. (c) 116 mg compounds means 116×10^{-3}g compound, since 1 mg contains 10^{-3}g.

   Molecular weight of compound

   $$=\frac{\text{Mass of the substance}}{\text{Volume of the vapor at STP}}\times22400$$

   $$=\frac{116\times10^{-3}}{44.8}\times22400 = 57.99\% \text{ or } 58.0\%$$

2. (d) Solution contains $He + CH_4$

   Molecular weight = 4 + 16 = 20

   $$\%\text{ Weight of } CH_4=\frac{\text{Weight of } CH_4}{\text{Total weight}}\times100=\frac{16}{20}\times100=80.0\%$$

3. (b) $$\%\text{ of H }=\frac{2}{18}\times\frac{\text{Weight of } H_2O}{\text{Weight of organic compound}}\times100$$

   $$=\frac{2}{18}\times\frac{0.9}{0.5}\times100=20\%$$

   Since percentage of hydrogen is 20. Therefore, remaining is carbon, i.e., 80%.

4. (b) Some compounds such as hydrazine (NH_2NH_2) although contain nitrogen, they do not respond to Lassaigne's test because they do not have any carbon and hence NaCN is not formed.

5. (a) Due to its volatile nature, camphor is often used in molecular mass determination.

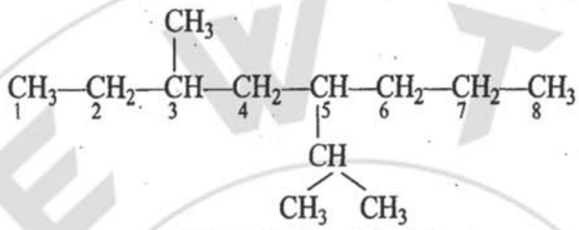
6. (d) In Kjeldahl's method, the nitrogen is estimated in the form of ammonia, which is obtained by heating compounds with NaOH.

$$CH_3CONH_2 + NaOH \xrightarrow{\Delta} CH_3COONa + H_2O + NH_3$$

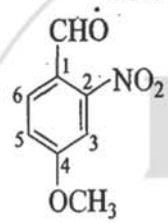
7. (d) Molecular weight of $C_2H_5OH = 2\times12+5+16+1=64$

$\because$ 48 g C_2H_5OH has H atom $= 6\times N_A$

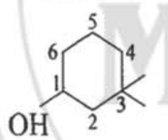
$\therefore$ 0.046 g C_2H_5OH has H atoms $= \dfrac{6\times6.02\times10^{23}\times0.046}{46} = 3.6\times10^{21}$

8. (b) 

3-Methyl-5-(1-methyl ethyl) octane

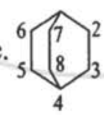
9. (a) 

4-Methoxy-2-nitrobenzaldehyde

10. (a) 

3,3-Dimethyl-1-cyclohexanol

11. (b) 4-Ethyl,3-methyl octane.

12. (a) Bicyclo-(2,2,2) octane. 

13. (b)

14. (a)

15. (d)

Elements	Number of moles	Simple ratio
C = 90%	90/12 = 7.5	7.5/7.5 = 1 × 3 = 3
H = 10%	10/1 = 10	10/7.5 = 1.33 × 3 = 4

$\therefore$ Empirical formula = C_3H_4

16. (a)

Element	%	Number of moles	Simple ratio
C	36	36/12 = 3	3/3 = 1
H	6	6/1 = 6	6/3 = 2
O	58	58/16 = 3.62	3.62/3 = 1

Therefore, empirical formula = CH_2O

17. (b) Empirical formula = CH_2O

Empirical formula mass = 12 + 2 + 16 = 30

Molecular mass = 2 × Vapor density = 2 × 30 = 60

$$n = \frac{\text{Molecular mass}}{\text{Emperical mass}} = \frac{60}{30} = 2$$

Molecular formula = (Emperical formula)$_n$

$$= (CH_2O)_2 = C_2H_4O_2.$$

18. (d) Minimum mass of sulphur = Weight of its one atom = 32

$\because$ 3.4 g of sulphur is present in 100 g

$\therefore$ 32 g of sulphur is present in 940 g $\left(= \frac{100 \times 32}{3.4} = 940\right)$

19. (c) Halogen is estimated by Carius method.

20. (b) $\because$ 1.8 g water is obtained from 1.4 g hydrocarbon

$\therefore$ 18 g water obtained from $= \frac{1.4}{1.8} \times 18 = 14\,g$.

Empirical formula mass = 14

$\therefore$ Empirical formula = CH_2.

21. (c) In Carius method, sulphur of organic compound is converted into H_2SO_4

$$S + H_2O + 3O \xrightarrow[HNO_3]{\Delta} H_2SO_4$$

22. (b) $\%\text{ of chlorine} = \frac{35.5}{143.5} \times \frac{\text{Mass of AgCl}}{\text{Mass of substance}} \times 100$

$$= \frac{35.5}{143.5} \times \frac{0.287}{0.099} \times 100 = 71.71\%.$$

23. (b) $\%\text{ of C} = \frac{12}{44} \times \frac{\text{Mass of } CO_2}{\text{Mass of substance}} \times 100$

$$= \frac{12 \times 0.22}{44 \times 0.24} \times 100 = 25;\ C = 25,\ H = 1.66$$

Total = 26.6 = 100 – 26.6 = 73.4.

24. (c)

Element	Number of moles	Simple ratio
C = 74	74/12 = 6.1	6.1/1.2 = 5.08 or 5
H = 8.65	8.65/1= 8.65	8.6/1.2 = 7.16 or 7
N = 17.3	17.3/14 = 1.2	1.2/1.2 = 1 or 1

Therefore, empirical formula C_5H_7N.

25. (d)

26. (a) Molecular mass of an acid = Equivalent weight × Basicity.

27. (b) If molecular formula is different, then molecular weight is also different.

28. (c) Empirical formula mass = $C_2H_5O = 24 + 5 + 16 = 45$.

$$n = \frac{\text{Molecular mass}}{\text{Empirical mass}} = \frac{90}{45} = 2$$

Molecular formula = $(C_2H_5O)_2 = C_4H_{10}O_2$.

29. (b)
30. (b)
31. (d)
32. (a)
33. (b)
34. (a)
35. (c)
36. (b)
37. (d)
38. (b)
39. (c)
40. (a)
41. (b)
42. (b)
43. (b)
44. (d)
45. (b)