Question Bank
Mole Concept and Stoichiometry

1. Fill in the blank spaces by choosing appropriate words from the brackets.

(i) The relative molecular mass is a number that represents how many times one _________ [atom/molecule] of a substance is heavier than $\frac{1}{12}$th mass of carbon$\left[{}^{12}_{6}C\right]$.

(ii) Whenever the gases react chemically, they do so in ___________ [weights/volumes] which bear a simple ratio to each other and to the products, if gaseous, provided the temperature and pressure of reacting gases and products remains the same.

(iii) An ____________ [atom/molecule] is the smallest unit of matter, which may or may not have an independent existence, but always takes part in a chemical reaction.

(iv) Equal volumes of all ____________ (liquids/gases), under similar conditions of temperature and pressure, contain equal number of molecules.

(v) The mass of substance containing particles equal to Avogadro's number is called ____________ . [molecule/mole] [5]

Ans. (i) molecule (ii) volumes (iii) atom (iv) gases (v) mole.

2. Give one word/words for the following statements :

(i) It is a number that represents how many times an atom of an element is heavier than $\frac{1}{12}$th mass of carbon atom.

(ii) The molecular weight of an element expressed in grams.

(iii) The number of atoms present in 12 g of carbon $\left[{}^{12}_{6}C\right]$.

(iv) Equal volumes of gases under similar conditions of temperature and pressure contain equal number of molecules.

(v) A formula of a chemical substance which tells the actual number of atoms in one molecule of a substance. [5]

Ans. (i) atomic weight (ii) gram-molecular weight (iii) Avogadro's number (iv) Avogadro's law (iv) molecular formula.

Numerical Problems on Gay-Lussac's Law

3. (a) Define atomic weight (relative atomic mass) of an element. [1]

(b) From the equation : $N_2 + 3H_2$ $2NH_3$.

Calculate the volume of ammonia gas formed when 6 litres of hydrogen reacts with excess of nitrogen, all volumes being measured at STP. [2]

Ans. (a) It is a number that represents how many times an atom of an element is heavier than $\frac{1}{12}$th mass of carbon atom.

(b) $N_2 + 3H_2 \longrightarrow 2NH_3$

By Gay-Lussac's Law :

1 vol 3 vols 2 vols

3 Vols of hydrogen produce ammonia gas = 2 vols

$\therefore$ 6 lt of hydrogen produce ammonia gas = $\frac{2 \times 6}{6}$ = 4 lt

4. 60 cm^3 of oxygen was added to 24 cm^3 of carbon monoxide and the mixture is ignited. Calculate (i) the volume of oxygen used up (ii) the volume of carbon dioxide formed. [2]

Ans. $2CO + O_2 \longrightarrow 2CO_2$

By Gay-Lussac's Law :

2 vols	1 vol	2 vols
1 vol	$\frac{1}{2}$ vol	1 vol
24 cm^3	12 cm^3	24 cm^3

∴ (i) The volume of oxygen used up = 12 cm^3.

(ii) The volume of carbon dioxide formed = 24 cm^3.

5. Ammonia is oxidised according to the following equation :

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

How many litres of nitric oxide are formed when 90 litres of oxygen reacts with ammonia? [2]

Ans. $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

By Gay-Lussac's Law :

4 vols	5 vols	4 vols
$\frac{4}{5}$ vols	1 vol	$\frac{4}{5}$ vols
$\frac{4}{5} \times 90$ lt	90 lt	$\frac{4}{5} \times 90$ lt
72 lt	90 lt	72 lt

∴ The volume of nitric oxide formed at STP = 72 Lt

6. Nitrogen monoxide (NO) reacts with oxygen to form nitrogen dioxide according to the equation :

$2NO + O_2 \longrightarrow 2NO_2$

What volume of nitrogen dioxide would be formed when 100 cm^3 of NO reacts with 50 cm^3 of oxygen, under same conditions of temperature and pressure? [2]

Ans. $2NO + O_2 \longrightarrow 2NO_2$

By Gay-Lussac's Law

2 vols	1 vol	2 vols
$\therefore$ 100 cm^3	50 cm^3	100 cm^3

$\therefore$ The volume of nitrogen dioxide formed = 100 cm^3.

7. Hydrogen and oxygen combine to form water according to the following equation :

$2H_2 + O_2 \longrightarrow 2H_2O$

A mixture of 22.4 litres of hydrogen and 22.4 litres of oxygen is ignited at 100 °C. Calculate the (i) volume of steam produced (ii) what volume of oxygen, will be present on cooling to room temperature? [3]

Ans. $2H_2 + O_2 \longrightarrow 2H_2O$ at 100 °C

2 vols	1 vol	2 vols

By Gay-Lussac's law :

1 vol	$\frac{1}{2}$ vol	1 vol
$\therefore$ 22.4 dm^3	11.2 dm^3	22.4 dm^3

(i) $\therefore$ The volume of steam formed at 100 °C = 22.4 dm^3

(ii) The volume of oxygen left at 100 °C = 22.4 – 11.2 = 11.2 dm^3.

∴ The volume of oxygen left at room temperature **will be less than 11.2 dm³** as volume decreases with the fall in temperature.

8. What volume of propane is burnt for every 100 cm^3 of oxygen used in the reaction?

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

The volumes of gases are measured at room temperature and pressure. [3]

Ans. $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

By Gay-Lussac's law :

1 vol 5 vols 3 vols

$\frac{1}{5}$ vol 1 vol

$\frac{1}{5} \times 100\ cm^3$ 100 cm^3

20 cm^3 100 cm^3

∴ The volume of propane burnt = **20 cm^3**.

Numerical Problems on Mole Concept and Avogadro's Law

9. (a) Explain what is meant by "molar volume of a gas." [1]

(b) Calculate the number of moles of nitrogen in 7 grams of nitrogen. [2]

Ans. (a) The volume occupied by 1 mole (1 gram-molecule) of a gas at STP is called molar volume of the gas. Its experimental value is 22.4 dm^3 at STP.

(b) 1 g-molecule of nitrogen = 2 × 14 = 28 g.

Now, 28 g of nitrogen = 1 mole

∴ 7 g of nitrogen = $\frac{7}{18}$ moles = **0.25 moles.**

10. (a) State Avogadro's law. [1]

(b) The mass of 5.6 litres of certain gas is 12 g. What is the relative molecular mass? [2]

Ans. (a) Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal number of molecules.

(b) 5.6 lt of gas at STP weighs = 12 g

$\therefore$ 22.4 lt of gas at STP weighs $= \frac{12 \times 22.4}{5.6} = 48$ g.

$\therefore$ Relative g-molecular mass of gas = 48 g

$\therefore$ Relative molecular mass of gas = **48 amu**.

11. From the equation for the burning of hydrogen and oxygen

$$2H_2 + O_2 \longrightarrow 2H_2O \text{ (Steam)}$$

Write down the number of mole (or moles) of steam obtained from 0.5 mole of oxygen. [2]

Ans. $2H_2 \quad + \quad O_2 \longrightarrow 2H_2O$ (Steam)

2 moles 1 mole 2 moles

1 mole of oxygen produces steam = 2 moles

$\therefore$ 0.5 mole of oxygen produces steam = 2 × 0.5 = **1 mole**.

12. A gas cylinder filled with hydrogen gas holds 5 g of the gas. The same cylinder holds 85 g of gas X under the same temperature and pressure. Calculate :

(i) vapour density of gas X (ii)molecular weight of gas X. [2]

Ans. (i) Vapour density of gas X

$$= \frac{\text{wt of gas X}}{\text{wt of the same volume of hydrogen}} = \frac{85}{5} = \mathbf{17}$$

(ii) Molecular weight of gas X = 2 × V.D = 2 × 17 = **34 amu**.

13. If 100 cm^3 of oxygen contains Y molecules, how many molecules of nitrogen will be present in 50 cm^3 of nitrogen under the same conditions of temperature and pressure. [2]

Ans. 100 cm^3 of oxygen contains number of molecules = Y

∴ **By Avogadro's Law** : 100 cm^3 of nitrogen contains number of molecules = Y

∴ 50 cm^3 of nitrogen contains number of molecules $= \frac{50Y}{5100} = \frac{Y}{2}$

14. (a) "The number of atoms in one mole of hydrogen is twice the number of atoms in 1 mole of helium at the same temperature and pressure." Why? [2]

(b) Calculate the volume occupied by 8 g of sulphur dioxide at STP [S = 32; O = 16] [2]

Ans. (a) It is because, hydrogen is a diatomic gas, whereas helium is monoatomic gas. As the number of atoms in one molecule of hydrogen are double, as compared to one molecule of helium, therefore, one mole of hydrogen has double the atoms, as compared to helium.

(b) Molecular mass of SO_2 = 32 + 32 = 64 g.

64 g of SO_2 occupies = 22.4 dm^3 at STP

∴ 8 g of SO_2 occupies $= \frac{22.4 \times 8}{64}$ = **2.8 dm^3 at STP**

15. Calculate the mass of 0.2 moles of water.
[H = 1; O = 16] [2]

Ans. 1 mole of water weighs = 2 + 16 = 18 g

∴ 0.2 moles of water weighs = 18 g × 0.2 = 3.6 g.

16. (a) What do you understand by the statement "vapour density of carbon dioxide gas is 22"? [2]

(b) Atomic weight of chlorine is 35.5. What is its vapour density? [2]

(c) A gas cylinder can hold 1 kg of hydrogen at room temperature and pressure.

(i) What weight of carbon dioxide it can hold under similar conditions of temperature and pressure?

(ii) If the number of molecules of hydrogen in the cylinder is X, calculate the number of carbon dioxide molecules in the cylinder. Give a reason for your answer. [3]

Ans. (a) It means, the ratio between the weight of certain volume of carbon dioxide gas and same volume of hydrogen is 22, provided the carbon dioxide gas and hydrogen are at the same temperature and pressure.

(b) Atomic weight of chlorine = 35.5.

∴ Molecular weight of chlorine = 2 × 35.5 = 71

$$\text{Vapour density of chlorine} = \frac{\text{Molecular wt}}{2} = \frac{71}{2} = \mathbf{35.5.}$$

(c) (i) Molecular weight of carbon dioxide = 44

$$\therefore \text{ V.D. of carbon dioxide} = \frac{44}{2} = 22$$

Now, V.D. =

$$\frac{\text{Wt. of carbon dioxide at certain temp. and pressure}}{\text{Wt. of same volume of hydrogen at same temp. and pressure}}$$

$$22 = \frac{\text{Wt. of carbon dioxide}}{1 \text{ kg}}$$

∴ Wt. of carbon dioxide = **22 kg**.

(ii) According to Avogadro's law, equal volumes of all gases, under similar conditions of temperature and pressure contain equal number of molecules.
Thus, if the number of molecules of hydrogen is X, then the number of molecules of carbon dioxide is also X.

17. (a) What is the volume of 7.1 g of chlorine at STP? [Cl = 35.5] [2]

(b) What is the mass of 56 cm^3 of carbon monoxide at STP? [C =12, O = 16] [2]

Ans. (a) Molecular weight of chlorine (Cl_2) = 71 g.

71 g of chlorine occupies = 22.4 dm^3 at S.T.P.

$\therefore$ 7.1 g of chlorine will occupy = $\frac{22.4 \times 7.1}{71}$ = **2.24 dm^3 at STP**

(b) Molecular weight of CO = 12 + 16 = 28.

22400 cm^3 of CO at STP weighs = 28 g.

$\therefore$ 56 cm^3 of CO at STP will weigh = $\frac{28 \times 56}{22400}$ = **0.07 g.**

Numerical Problems on Percentage Composition

18. Calculate the percentage of nitrogen in NH_4NO_3.
[N = 14; H = 1; O = 16] [2]

Ans. Molecular weight of NH_4NO_3 = 14 + 4 + 14 + 48 = 80 amu

Also, weight of nitrogen in NH_4NO_3 = 14 + 14 = 28 amu

$\therefore$ %age of nitrogen in NH_4NO_3 = $\frac{28}{80} \times 100$ = **35%**.

19. Urea is very important fertiliser. The formula is (CON_2H_4).
Calculate the percentage of nitrogen in urea.
[C = 12; N = 14; O = 16; H = 1] [2]

Ans. Molecular weight of urea

$[CON_2H_4] = [12 + 16 + 28 + 4) = 60$ amu

Also, weight of nitrogen in urea = 14 + 14 = 28 amu

$\therefore$ %age of nitrogen in urea $= \frac{28}{60} \times 100 =$ **46.67%.**

20. Calculate the percentage of water of crystallisation in washing soda [$Na_2CO_3 \cdot 10H_2O$]

[Na = 23; C = 12; O = 16; H = 1] [2]

Ans. Molecular weight of

$Na_2CO_3.10H_2O$= 46 + 12 + 48 + 180 = 286 amu.

Molecular weight of 10 molecules of water= 10 × 18 = 180 amu

$\therefore$ %age of water of crystallisation = $\frac{182}{286} \times 100 =$ **62.93%**.

21. Calculate the percentage of ion in $K_3Fe(CN)_6$

[K=39, Fe = 56, C = 12, N = 14]

Ans. Molecular weight of $K_3Fe(CN)_6$

= 3[K] + 1[Fe] +6(C) + 6(N)

= 3(39) + 1(56) + 6(12) + 6(14)

= 117 + 56 + 72 + 84 = 329

$\therefore$ %age of iron = $\frac{56}{329}$ = × 100 = 17.02%

22. Calculate which of the following has higher percentage of nitrogen. Calcium nitrate or ammonium sulphate
[Ca = 40, N = 14, O = 16, H = 1, S = 32]

Ans. For calcium nitrate

Molecular weight of $Ca(NO_3)_2$

$= 1(Ca) + 2(N) + 6(O)$

$= 1(40) + 2(14) + 6(16)$

$= 40 + 28 + 96 = 164$

$\therefore$ %age of nitrogen in $Ca(NO_3)_2 = \frac{28}{164} \times 100 = \mathbf{17.07\%}$

For ammonium sulphate

Molecular weight of $(NH_4)_2SO_4$

$= 2(N) + 8(H) + 1(S) + 4(O)$

$= 2(14) + 8(1) + 1(32 + 4(16)$

$= 28 + 8 + 32 + 64 = 126$

$\therefore$ %age of nitrogen in $(NH_4)_2SO_4 = \frac{28}{126} \times 100 = \mathbf{21.22\%}$

Thus, ammonium sulphate (21.22%) has higher percentage composition of nitrogen as compared to calcium nitrate (17.07%).

23. Calculate which one of the following is a better potash fertiliser.

(a) Potassium phosphate (b) potassium nitrate

[K=39, P = 31, O = 16, N = 14]

Ans. (a) **For potassium sulphate**

Molecular weight of K_3PO_4

$$= 3(39) + 1(31) + 4(16)$$

$$= 117 + 31 + 64 = 212$$

$\therefore$ %age of potassium in $K_3PO_4 = \frac{117}{212} \times 100 = 55.18\%$

(b) For potassium nitrate

Molecular weight of KNO_3

$$= 1(39) + 1(14) + 3(16)$$

$$= 39 + 14 + 48 = 101$$

$\therefore$ %age of potassium in KNO3 = $\frac{39 \times 100}{101}$ = **38.61**%

Potassium phosphate (K = 55.18%) is a better potash fertiliser than potassium nitrate (K = 38.61%)

24. Calculate the percentage of 55% pure sample of calcium carbonate [Ca = 40, C = 12, O = 16]

Ans. Molecular weight of pure $CaCO_3$

$$= 1(40) + 1(12) + 3(16)$$

$$= 40 + 12 + 48 = 100$$

$\therefore$ %age of carbon in 100% pure $CaCO_3 = \frac{12}{100} \times 100 = 12\%$

$\therefore$ %age of carbon in 55% pure $CaCO_3 = \frac{55}{100} \times 12\%$ = **6.6%**

Numerical Problems on V.D., Molecular Formula and Empirical Formula

25. A hydrocarbon contains 82.8 % of carbon and has a relative molecular mass of 58. Write (i) its empirical formula (ii) its molecular formula (iii) its two possible structural formulae.

[C = 12; H = 1] [5]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
C	*82.8*	*12*	*82.8 ÷ 12 = 6.9*	*6.9 ÷ 6.9 = 1 or 2*
H	*17.2*	*1*	*17.2 ÷ 1 = 17.2*	*17.2 ÷ 6.9 = 2.5 or 5*

Empirical formula of hydrocarbon = $\mathbf{C_2H_5}$

(ii) Empirical formula weight of hydrocarbon = 2 × 12 + 1 × 5 = 29

Molecular wt. of hydrocarbon = 58

Molecular weight = n × Empirical formula weight

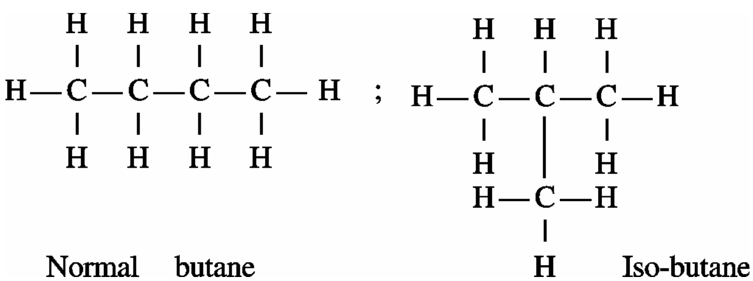
58 = n × 29

∴ n = 2

(iii) Molecular formula of hydrocarbon = 2 × Empirical formula

= 2 × C_2H_5 = C_4H_{10}

Possible structural formulae :



26. The following experiment was performed in order to determine the formula of hydrocarbon. The hydrocarbon X is purified by fractional distillation. 0.145 g of X was heated with dry copper (II) oxide and 224 cm^3 of carbon dioxide was collected at STP.

(i) Which elements does X contain? [1]

(ii) What was the purpose of copper (II) oxide? [1]

(iii) Calculate the empirical formula of X by the following steps :

1. Calculate the number of moles of carbon dioxide gas. [1]
2. Calculate the mass of carbon contained in this quantity of carbon dioxide and thus the mass of carbon in sample X. [1]
3. Calculate the mass of hydrogen in sample X. [1]
4. Deduce the ratio of atoms of each element in X (empirical formula). [2]

Ans. (i) Sample X contains **carbon** and **hydrogen** only.

(ii) Copper (II) oxide acts as oxidising agent.

(iii) 1. 22400 cm^3 of CO_2 at STP = 1 mole

$\therefore$ 224 cm^3 of CO_2 at STP = $\frac{224}{22400}$ = **0.01 mole**.

2. 22400 cm^3 of carbon dioxide contains carbon = 12 g

$\therefore$ 224 cm^3 of carbon dioxide contains carbon = $\frac{12 \times 224}{22400}$ = 0.12g

$\therefore$ Wt. of carbon in sample X = **0.12 g.**

3. Mass of hydrogen in sample X = Mass of hydrocarbon – Mass of carbon = (0.145 – 0.12) g = **0.025 g.**

4.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
C	0.120 g	12	0.120 ÷ 12 = 0.01	0.01 ÷ 0.01 = 1 or 2
H	0.025 g	1	0.025 ÷ 1 = 0.025	0.025 ÷ 0.01 = 2.5 or 5

∴ Empirical formula = $\mathbf{C_2H_5}$

27. (i) Find the empirical formula of a compound of carbon and hydrogen which contains 80% carbon. [2]

(ii) The molecular weight of the above compound is 30. What is its molecular formula? [1]

(iii) Name the compound and write down its structural formula.[1]

Ans. (i)

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
C	*80%*	*12*	*80 ÷ 12 = 6.66*	*6.66 ÷ 6.66 = 1*
H	*20%*	*1*	*20 ÷ 1 = 20*	*20 ÷ 6.66 = 3*

∴ Empirical formula of hydrocarbon = $\mathbf{CH_3}$.

(ii) Empirical formula weight of hydrocarbon = 12 + 3 = 15

Molecular weight = n × Empirical formula weight

30 = n × 15

∴ n = 2

∴ Molecular formula = n × Empirical formula = 2 × CH_3 = C_2H_6

(iii) The compound is ethane.

The structural formula of **ethane** is :

```
      H   H
      |   |
  H — C — C — H
      |   |
      H   H
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28. A compound is formed by 24 g of X and 64 g of oxygen. If X = 12 and O = 16, calculate the simplest formula of compound. [3]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
X	*24 g*	*12*	$24 \div 12 = 2$	$2 \div 2 = 1$
O	*64 g*	*16*	$64 \div 16 = 4$	$4 \div 2 = 2$

$\therefore$ Simplest formula (Empirical formula) = $\mathbf{XO_2}$.

29. (i) What do you understand by the empirical formula of compound? [2]

(ii) If the molecular formula of a compound is C_2H_6 , write down its empirical formula. [2]

(iii) A compound of empirical formula CH_2O has a vapour density of 30. Write down its molecular formula. [1]

Ans. (i) **Empirical formula** : The formula of a chemical substance which tells the simplest whole number ratio of atoms of different elements present in its one molecule is called empirical formula.

(ii) Molecular formula = C_2H_6

$\therefore$ Empirical formula = 2 × CH_3 = **C_2H_6.**

(iii) Empirical formula of compound = CH_2O

$\therefore$ Empirical formula weight of compound = 12 + 2 + 16 = 30 amu.

Molecular weight of compound = 2 × V.D. = 2 × 30 = 60 amu.

Molecular weight = n × Empirical formula weight

60 = n × 30

$\therefore$ n = 2

$\therefore$ Molecular formula of compound = n × Empirical formula = 2 × CH_2O = **$C_2H_4O_2$.**

30. Silicon (Si = 28) forms a compound with chlorine (Cl = 35.5) in which 5.6 g of silicon combines with 21.3 g of chlorine. Calculate the empirical formula of compound. [2]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
Si	*5.6*	*28*	*5·6 ÷ 28 = 0.2*	*0.2 ÷ 0.2 = 1*
Cl	*21.3*	*35.5*	*21.3 ÷ 35.5 = 0.6*	*0.6 ÷ 0.2 = 3*

$\therefore$ Empirical formula : **$SiCl_3$.**

31. A compound of carbon, hydrogen and oxygen is found to contain 40% of carbon, 6.67% of hydrogen and 53.3% of oxygen. Calculate its empirical formula. Its vapour density is 30, find its molecular formula. [3]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
C	*40*	*12*	*40 ÷ 12 = 3.33*	*3.33 ÷ 3.33 = 1*
H	*6.67*	*1*	*6.67 ÷ 1 = 6.67*	*6.67 ÷ 3.33 = 2*
O	*53.3*	*16*	*53.3 ÷ 16 = 3.33*	*3.33 ÷ 3.33 = 1*

∴ Empirical formula of compound= $\mathbf{CH_2O}$

∴ Empirical formula weight of compound = 12 + 2 + 16 = 30

Also, molecular weight of compound = 2 × V.D. = 2 × 30 = **60.**

Molecular weight = n × Empirical weight

60 = n × 30

N = 2

∴ Molecular formula of compound = n × Empirical formula

= 2 × CH_2O = $C_2H_4O_2$

32. (i) The molecular formula of an organic compound is $H_4C_2O_4$. What is its empirical formula? [1]

(ii) A hydrocarbon has the following percentage composition — Hydrogen 2.2%, carbon 26.6% and oxygen 71.2%. Calculate the empirical formula of the compound. If its molecular weight is 90, find its molecular formula. [H = 1; C = 12; O = 16] [3]

Ans. (i) Molecular formula of the compound = $H_4C_2O_4$

∴ Empirical formula of the compound = ($H_4C_2O_4$) ÷ 2 = $\mathbf{H_2CO_2}$

(ii)

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
C	*26.6*	*12*	*26.6 ÷ 12 = 2.22*	*2.22 ÷ 2.22 = 1*
H	*2.2*	*1*	*2.2 ÷ 1 = 2.2*	*2.22 ÷ 2.22 = 1*
O	*71.2*	*16*	*167 1.2 ÷ 16 = 4.45*	*4.45 ÷ 2.22 = 2*

∴ Empirical formula = $\mathbf{CHO_2}$

∴ Empirical formula weight = 12 + 1 + 32 = 45.

Molecular weight = n × Empirical formula weight

90 = n × 45

∴ n = 2

∴ Molecular formula = n × Empirical formula

= 2 × CHO_2 = $C_2H_2O_4$.

33. A compound of sodium, sulphur and oxygen has the following percentage composition :

Na = 29.11%; S = 40.51%; O = 30.38%. Find its empirical formula. [O = 16; Na = 23; S = 32]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
Na	*29.11*	*23*	*29.11 ÷ 23 = 1.26*	*1.26 ÷ 1.26 = 1 or 2*
S	*40.51*	*32*	*40.51 ÷ 32 = 1.26*	*2.26 ÷ 1.26 = 1 or 2*
O	*30.38*	*16*	*30.38 ÷ 16 = 1.89*	*1.89 ÷ 1.26 = 1.5 or 3*

∴ Empirical formula is $\mathbf{Na_2S_2O_3}$.

34. An acid of phosphorus has the following percentage composition; phosphorus = 38.27%; hydrogen = 2.47%; oxygen = 59.26%. Find the empirical formula of acid and its molecular formula, given that its relative molecular weight is 162. [P = 31; H = 1; O = 16]

Ans.

Element	*%age wt.*	*At. wt.*	*Relative no. of moles*	*Simple ratio of atoms*
P	*38.27*	*31*	*38.27 ÷ 31 = 1.23*	*1.23 ÷ 1.23 = 1*
H	*2.47*	*1*	*2.47 ÷ 1 = 2.47*	*2.47 ÷ 1.23 = 2*
O	*59.26*	*16*	*59.26 ÷ 16 = 3.70*	*3.70 ÷ 1.23 = 3*

∴ Empirical formula of compound = H_2PO_3

∴ Empirical formula weight = 2 + 31 + 48 = 81

Molecular weight = 162

Molecular weight = n × Empirical formula weight

162 = n × 81

∴ n = 2

Molecular formula = n × Empirical formula

= 2 × H_2PO_3

= $H_4P_2O_6$.

35. An inorganic compound contains 42% of nitrogen, 9% of hydrogen and 48% of oxygen. Calculate its empirical formula.

[N = 14; H = 1; O = 16] [2]

Ans.

Element	***%age wt.***	***At. wt.***	***Relative no. of moles***	***Simple ratio of atoms***
Nitrogen (N)	*42%*	*14*	*42 ÷ 14 = 3*	$\frac{3}{3} = 1$
Hydrogen (H)	*9%*	*1*	*9 ÷ 1 = 9*	$\frac{9}{3} = 3$
Oxygen (O)	*48%*	*16*	*48 ÷ 16 = 3*	$\frac{3}{3} = 1$

∴ Empirical formula is **NH_3O**.

Numerical Problems on Reacting Weights and Volumes

36. From the equation :

$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

[Take Cu = 64; H = 1; N = 14; O = 16]

Calculate : (i) the mass of copper needed to react with 63 g of nitric acid (ii) the volume of nitric oxide at STP that can be collected.
(1 gram-molecular volume of gas at STP = 22.4 litres) [4]

Ans. $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

3×64 $\quad 8 \times 63$ $\quad [2 \times 22.4\ dm^3]$

$= 192$ $\quad = 504$ $\quad = 44.8\ dm^3$ at STP

(i) When nitric acid is 504, the amount of copper required = 192

∴ When nitric acid is 63, the amount of copper required

$$= \frac{192 \times 63}{504} = \textbf{24 g.}$$

(ii) When nitric acid is 504, the volume of NO formed = $44.8\ dm^3$ at STP

∴ When nitric acid is 63, the amount of NO formed

$$= \frac{44.8 \times 63}{504} = \textbf{5.6 dm}^3 \textbf{ at STP}$$

37. Find the mass of iron in 20 tonnes of a sample of iron ore which contains 80% of pure Fe_2O_3. [Fe = 56; O = 16] [2]

Ans. Mass of impure iron ore = 20 tonnes

∴ Mass of pure iron = $\frac{20 \times 80}{100}$ = 16 tonnes

$Fe_2O_3 \longrightarrow 2Fe$

$112 + 48$ $\quad 2 \times 56$

$= 160$ g $\quad = 112$ g

160 g of pure Fe_2O_3 produces pure iron = 112 g

∴ 16 tonnes of pure Fe_2O_3 will produce pure iron

$$= \frac{112 \times 16}{160} = \mathbf{11.2\ tonnes}$$

38. From the equation,

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

Calculate : (i) the weight of calcium chloride obtained from 10 g of calcium carbonate (ii) the volume at STP of carbon dioxide obtained from 10 g of calcium carbonate.

(Ca = 40; C = 12; O = 16; H = 1; Cl = 35.5 and 1 mole of a gas at STP occupies 22.4 litres) [4]

Ans.

$CaCO_3$	+ $2HCl$ ⟶	$CaCl_2$	+ H_2O	+	CO_2
(40 + 12 + 48)	(40 + 71)				22.4 dm^3 at STP
= 100 g	= 111 g				22.4 dm^3 at STP

(i) 100 g of calcium carbonate produces calcium chloride = 111 g

∴ 10 g of calcium carbonate produces calcium chloride

$$= \frac{111 \times 10}{100} = \mathbf{11.1\ g}.$$

(ii) 100 g of calcium carbonate produces carbon dioxide

= 22.4 lt at STP

∴ 10 g of calcium carbonate produces carbon dioxide =

$$\frac{22.4 \times 10}{100} = \mathbf{2.24\ dm^3\ at\ STP}$$