CHAPTER

5 Mole Concept and Stoichiometry

IMPORTANT POINTS TO REMEMBER

1. **Gay Lussac's law**, whenever the gases combine chemically, they do so in volumes which bear a simple ratio to each other as well as to the product if gaseous, under the same conditions of temperature and pressure.
2. Gay Lussac published the result of his experiment on different gases under the name; **"The Law of Combining Volumes of Gases"**.
3. **Gay Lussac's law** is applicable only to **gases** and **not** to **solids** and **liquids**.
4. **Atomic weight** is the number which represents how many times one atom of a substance is heavier than $1/12^{th}$ the mass of an atom of Carbon –12.
5. **Molecular weight** is the number which represents how many times one molecule of a substance is heavier than $1/12^{th}$ the mass of an atom of Carbon –12.
6. Molecular weight expressed in grams is called **gram molecular weight**.
7. **Avogadro's Law** : According to Avogadro, under the similar conditions of temperature and pressure, equal volumes of all gases contain equal number of molecules.
8. The volume occupied by one mole of a gas at S.T.P. (Standard Temperature and Pressure) is called **molar volume**. It is equal to **22.4 dm^3** or **22.4 litres**.
9. The gram molecular weight of all gases at S.T.P. contains molecules equal to **Avogadro's number** which is **6.023×10^{23}** and it occupies a volume equal to **molar volume** which is **22.4 dm^3** or **22.4 litres.**
10. $$\text{Number of moles} = \frac{\text{Weight in grams of the substance(W)}}{\text{Molecular weight of the substance(M)}}$$
$$\Rightarrow \quad n = \frac{W}{M}$$
11. Number of molecules = No. of moles × Avogadro's number
12. **The relationship between mole, gram molecular weight, molar volume, and number of molecules can be summarized as follows :**

S. No.	*Name of the Gas*	*Mole*	*Gram Molecular Weight*	*Number of Molecules*	*Molar Volume*
(1)	O_2	1 mole	32 g	6.023×10^{23}	22.4 litres
(2)	N_2	1 mole	28 g	6.023×10^{23}	22.4 litres
(3)	H_2	1 mole	2 g	6.023×10^{23}	22.4 litres
(4)	CO_2	1 mole	44 g	6.023×10^{23}	22.4 litres

13. **Atomicity** is the number of atoms present in one molecule of an element.
14. **Metals** are **monoatomic**, *i.e.*, containing **one atom** in its molecule.

15. **Inert gases** are **monoatomic**.
16. Gases like **Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2)** are **diatomic**, *i.e.*, containing **two atoms** in its molecule.
17. The elements containing **more than two atoms** in its molecule are called as **polyatomic**.

Example - Ozone – O_3
Phosphorus – P_4
Sulphur – S_8

18. **Vapour density** is the ratio between the mass of certain volume of gas or vapour to the mass of same volume of hydrogen under the similar conditions of temperature and pressure.

$$\text{Vapour density} = \frac{\text{Mass of certain volume of gas or vapour}}{\text{Mass of same volume of Hydrogen}}$$

19. **Vapour density** is a ratio, so it has **no units**.
20. $$\text{Molecular weight} = 2 \times \text{Vapour density}$$
21. The **percentage composition of a compound** is defined as the percentage by weight of each element present in the molecule of a compound.

$$\text{Percentage composition of a compound} = \frac{\text{Weight of an element in a molecule of a compound}}{\text{Gram molecular weight of compound}} \times 100$$

22. **Empirical formula** is the formula of a chemical substance which tells the simplest whole number ratio of the atoms of different elements present in its one molecule.
23. **Molecular formula** is the formula of a chemical substance which represents the actual number of atoms of each element present in its single molecule.
24. In a **chemical equation, reactants** are written on the **left side** of the arrow and **products** are written on the **right side** of the arrow.

$$\text{Reactants} \longrightarrow \text{Products}$$

25. For the calculation of the numericals based on equation, the equation must be completely **balanced**.
26. The **molecular weights** of the **products** and **reactants** must be **calculated** which are required for **solving the numerical**.
27. **Unitary Method** is used to **find the weight of product** or **reactant** as per the requirement of the problem.
28. In case of gases, the **volume required** is **22.4 dm^3** for **every mole of a gas**.
29. $$\text{Relative Atomic Mass} = \frac{\text{Mass of one atom of an element}}{\text{1/12th of mass of an atom of carbon-12}}$$
30. **Relative atomic mass** can also be defined with respect to hydrogen. It is the number that represents, how many times one atom of an element is heavier than one atom of hydrogen, whose weight has been taken as unity.

$$\text{Relative Atomic Mass} = \frac{\text{Mass of one atom of an element}}{\text{Mass of one atom of hydrogen (weight taken as unity)}}$$

31. The **relative atomic mass** of **an element** expressed **in grams** is called **gram atomic mass** or **gram atom**.
32. $$\text{Relative Molecular Mass} = \frac{\text{Mass of one molecule of a substance}}{\text{Mass of 1/12 th of an atom of C-12}}$$

33. **Relative molecular mass** can also be defined with respect to hydrogen. It is the number that represents how many times one molecule of a substance is heavier than one atom of hydrogen whose weight is taken as unity.

34. The **relative molecular mass** expressed **in grams** is called as **gram molecular weight** or **gram molecular mass** or **gram molecule**.

PREVIOUS YEARS' QUESTIONS

2012

Q1. Choose the correct answer from the options given below :
The vapour density of carbon dioxide [C = 12, O = 16]
(a) 32 (b) 16 (c) 44 (d) 22 [1]

Ans. (d) 22

Q2. Concentrated nitric acid oxidises phosphorus to phosphoric acid according to the following equation :
$P + 5HNO_3$ (conc.) $\longrightarrow H_3PO_4 + H_2O + 5NO_2$
If 9.3 g of phosphorus was used in the reaction, calculate :

(i) Number of moles of phosphorus taken. [1]

(ii) The mass of phosphoric acid formed. [2]

(iii) The volume of nitrogen dioxide produced at STP.
[H = 1, N = 14, P = 31, O = 16] [2]

Ans. (i) The number of moles of phosphorous = $\frac{9.3}{31}$.

(ii) 31 gram of phosphorous = 98 g of phosphoric acid.

9.3 g of phosphorous = $\frac{98}{31} \times 9.3 = 29.4$ g

(iii) 31 gram of phosphorous = 5×22.4 dm^3 of NO_2.

9.3 g of phosphorous = $\frac{5 \times 22.4 \times 9.3}{31}$

= 33.6 dm^3.

Q3. (i) 67.2 litres of hydrogen combines with 44.8 litres of nitrogen to form ammonia under specific conditions as :
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$
Calculate the volume of ammonia produced. What is the other substance, if any, that remains in the resultant mixture ? [2]

(ii) The mass of 5.6 dm^3 of a certain gas at STP is 12.0 g. Calculate the relative molecular mass of the gas. [2]

(iii) Find the total percentage of Magnesium in magnesium nitrate crystals, $Mg(NO_3)_2.6H_2O$.
[Mg = 24; N = 14; O = 16 and H = 1] [2]

Ans. (i) Volume of Ammonia = 44.8 litres
Unused nitrogen = 22.4 litres

(ii) 5.6 dm^3 of certain gas has mass = 12 g at STP

22.4 dm^3 of certain gas has mass = $\frac{22.4 \times 12}{5.6}$

= 48 a.m.u.

(iii) % composition = $\frac{24 \times 100}{256} = 9.375\%$

2011

Q1. Calculate the volume of 320 g of SO_2 at STP (Atomic mass : S = 32, O = 16). [1]

Ans. Number of moles of sulphur dioxide = $\frac{320}{64}$

= 5 moles

Volume of $SO_2 = 5 \times 22.4 = 112.0$ dm^3

Q2. State Gay-Lussac's law of combining volumes. [2]

Ans. Whenever gases combine chemically they do so in volumes which bears a simple whole number ratio to each other as well as to the product, if gaseous, provided the conditions of temperature and pressure remains constant.

Q3. Calculate the volume of oxygen required for the complete combustion of 8.8 g of propane (C_3H_8) (Atomic mass : H = 1, C = 12, O = 16). [2]

Ans. $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$
50 g of C_3H_8 requires 5×22.4 dm^3 of O_2.

8.8 g of C_3H_8 requires $\frac{5 \times 22.4}{50} \times 8.8 = 19.712$ dm^3.

Q4. An organic compound with Vapour density of 94 contains C = 12.67%, H = 2.13% and Br = 85.11%. Find the molecular formula. [3]

Ans.

Element	%	Atomic mass	Relative number of atoms	Simple ratio
C	12.67	12	1.05	1
H	2.13	1	2.13	2
Br	85.11	80	1.06	1

Empirical formula = CH_2Br

Empirical formula weight = 94.

Molecular weight = 2 × Vapour density

= 2 × 94 = 188.

$$x = \frac{\text{Molecular weight}}{\text{Empirical formula weight}}$$

$$= \frac{188}{94}$$

$$= 2$$

Molecular formula = $C_2H_4Br_2$

Q5. Calculate the mass of

(i) 10^{22} atoms of sulphur.

(ii) 0.1 mole of carbon dioxide. [2]

[Atomic mass : S = 32, C = 12 and D = 16 and Avogadro's Number = 6×10^{23}]

Ans. (i) 6×10^{23} atoms weigh = 32 g

$$10^{22} \text{ atoms weighs} = \frac{32}{6\times10^{23}} \times 10^{22} = 0.53 \text{ g.}$$

(ii) 1 mole weighs = 44 g

0.1 mole weigh = 44 × 0.1 = 4.4 g

2010

Q1. (i) LPG stands for liquefied petroleum gas. Varieties of LPG are marketed including a mixture of propane (60%) and butane (40%). If 10 litre of this mixture is burnt, find the total volume of carbon dioxide gas added to the atmosphere. Combustion reactions can be represented as :

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

(ii) Calculate the percentage of nitrogen and oxygen in ammonium nitrate. [Relative molecular mass of ammonium nitrate is 80, H = 1, N = 14, O = 16]. [5]

Ans. (i) $\frac{10\times60}{100}$ = 6 litre of propane

$\frac{10\times40}{100}$ = 4 litre of butane

Propane

1 volume of propane = 3 volumes of CO_2

6 litre of propane = $\frac{3}{1}\times6$ = 18 litre of CO_2

2 volume of butane = 8 volumes of CO_2

4 litre of butane = $\frac{8}{2}\times4$ = 16 litre of CO_2

Total volume of CO_2 = 18 + 16 = 34 litre

(ii) % of N = $\frac{28}{80}\times100$ = 35%

% of O = $\frac{48}{80}\times100$ = 60%

Q2. 4.5 moles of calcium carbonate are reacted with dilute hydrochloric acid.

(i) Write the equation for the reaction.

(ii) What is the mass of 4.5 moles of calcium carbonate ? (Relative molecular mass of calcium carbonate is 100).

(iii) What is the volume of carbon dioxide liberated at STP ?

(iv) What mass of calcium chloride is formed ? (Relative molecular mass of calcium chloride is 111)

(v) How many moles of HCl are used in this reaction ? [5]

Ans.(i) $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

(ii) $n = \frac{w}{m} \Rightarrow w = n \times m$

$\Rightarrow w = 4.5 \times 100 = 450$ g.

(iii) 1 mole of $CaCO_3 \equiv 22.4$ litres of CO_2

4.5 moles of $CaCO_3 \equiv \frac{22.4}{1}\times4.5$

= 100.8 litres of CO_2

Or

100 g of $CaCO_3 \equiv 22.4$ litres of CO_2

450 g of $CaCO_3 \equiv \frac{22.4}{100}\times450$

= 100.8 litres of CO_2

(*iv*) 1 mole of $CaCO_3 \equiv 111$ g of $CaCl_2$

4.5 moles of $CaCO_3 \equiv \frac{111}{1} \times 4.5$

$= 499.5$ g of $CaCl_2$

or 100 g of $CaCO_3 \equiv 111$ g of $CaCl_2$

450 g of $CaCO_3 \equiv \frac{111}{100} \times 450$

$= 499.50$ g of $CaCl_2$

(*v*) 1 mole of $CaCO_3 \equiv 2$ moles of HCl

4.5 moles of $CaCO_3 \equiv \frac{2}{1} \times 4.5$

$= 9$ moles of HCl

2009

Q1. Select the correct answer from the choices A, B, C and D which are given :

A gas cylinder of capacity of 20 dm^3 is filled with gas 'X' the mass of which is 10 g. When the same cylinder is filled with hydrogen gas at the same temperature and pressure the mass of the hydrogen is 2 g, hence the relative molecular mass of the gas is [1]

(A) 5 (B) 10

(C) 15 (D) 20

Ans. B

Q2. (*i*) **Calcium carbide is used for the artificial ripening of fruits. Actually the fruit ripens because of the heat evolved while calcium carbide reacts with moisture. During this reaction calcium hydroxide and acetylene gas is formed. If 200 cm^3 of acetylene is formed from a certain mass of calcium carbide, find the volume of oxygen required and carbon dioxide formed during the complete combustion. The combustion reaction can be represented as below :**

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

(*ii*) **A gaseous compound of nitrogen and hydrogen contains 12.5% hydrogen by mass. Find the empirical formula of the compound [N = 14, H = 1].** [5]

Ans. (*i*) $2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$

2 vol. of $C_2H_2 \equiv 5$ vol. of O_2

200 cm^3 of $C_2H_2 \equiv \frac{5}{2} \times 200 = 500$ cm^3 of O_2

2 vol. of $C_2H_2 \equiv 4$ vol. of CO_2

200 cm^3 of $C_2H_2 \equiv \frac{4}{2} \times 200 = 400$ cm^3 of CO_2

(*ii*)

Element	%	Atomic weight	Relative no. of atoms	Simple ratio
Nitrogen	87.5	14	6.25	1
Hydrogen	12.5	1	12.5	2

Empirical formula = NH_2

Q3. Correct the statement.

Equal masses of all gases under identical conditions contain the same number of molecules. [1]

Ans. Equal **volumes** of all gases under identical conditions **of temperature and pressure** contain the same number of molecules.

Q4. (*i*) **A gas cylinder contains 24×10^{24} molecules of nitrogen gas. If Avogadro's number is 6×10^{23} and the relative atomic mass of nitrogen is 14, calculate :**

(1) Mass of nitrogen gas in the cylinder.

(2) Volume of nitrogen at STP in dm^3.

(*ii*) **Commercial sodium hydroxide weighing 30g has some sodium chloride in it. The mixture on dissolving in water and subsequent treatment with excess silver nitrate solution formed a precipitate weighing 14.3g. What is the percentage of sodium chloride in the commercial sample of sodium hydroxide? The equation for the reaction is**

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

[Relative molecular mass of NaCl = 58; AgCl = 143]

(*iii*) **A certain gas 'X' occupies a volume of 100 cm^3 at STP and weighs 0.5 g. Find its relative molecular mass.** [6]

Ans. (*i*)

(1) At STP, N_2

$28g \equiv 1$ mole $\equiv 22.4\ dm^3$

$\equiv 6 \times 10^{23}$ molecules

Molecules		Weight
6×10^{23}	$\equiv$	28 g
24×10^{24}	$\equiv$	$\frac{28}{6\times10^{23}} \times 24 \times 10^{24}$
		$= 1120$ g

Molecules		Volume
(2) 6×10^{23}	$\equiv$	$22.4\ dm^3$
24×10^{24}	$\equiv$	$\frac{22.4}{6\times10^{23}} \times 24 \times 10^{24}$
		$= 896\ dm^3$

(*ii*) $NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

143 g of AgCl $\equiv$ 58 g of NaCl

14.3 g of AgCl $\equiv \frac{58}{143} \times 14.3$ g of NaCl

$= 5.8$ g of NaCl

% of NaCl $= \frac{5.8}{30} \times 100 = 19.3\ \%$

(*iii*)

Volume		Weight
100 cm^3	$\equiv$	0.5 g
22400 cm^3	$\equiv$	$\frac{0.5}{100} \times 22400$
		$= 112$ a.m.u.

Q5. Define the term : Mole [1]

Ans. Mole is the amount of substance which contains as many particles as there are in 12.000 g of carbon - 12.

2008

Q1. (*a*) A compound has the following percentage composition by mass: Carbon 14.4%, Hydrogen 1.2% and Chlorine 84.5%. Determine the empirical formula of this compound. Work correct to 1 decimal place (H = 1, C = 12, Cl = 35.5). [3]

(*b*) The relative molecular mass of this compound is 168, so what is its molecular formula ? [2]

Ans. (*a*)

Element	*%*	*At. wt.*	*Relative number of atoms*	*Simplest ratio*
C	14.4	12	1.2	1
H	1.2	1	1.2	1
Cl	84.5	35.5	2.38≈2.4	2

Empirical formula = $CHCl_2$.

(*b*) Empirical formula weight = 12 + 1 + 71 = 84

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{168}{84} = 2$$

Molecular formula = $(CHCl_2)_n = (CHCl_2)_2 = C_2H_2Cl_4$.

Q2. From the equation:

$$C + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2$$

Calculate

(*i*) the mass of carbon oxidized by 49 g of sulphuric acid. (C = 12, relative molecular mass of sulphuric acid = 98)

(*ii*) The volume of sulphur dioxide measured at S.T.P., liberated at the same time. (Volume occupied by 1 mole of a gas at S.T.P. is 22.4 dm^3). [4]

Ans. (*i*) $C + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2$

12 g of carbon oxidized by 2×98 g of sulphuric acid

$\frac{12}{2\times98}$ g of carbon oxidized by 1 g of sulphuric acid

$\frac{12\times49}{2\times98}$ g of carbon oxidized by 49 g of sulphuric acid.

3 g of carbon oxidized by 49 g of sulphuric acid.

(*ii*) 2×98 g of $H_2SO_4 \equiv 2 \times 22.4\ dm^3$ of SO_2.

49 g of $H_2SO_4 \equiv \frac{2\times22.4}{2\times98} \times 49$

$= 11.2\ dm^3$ of SO_2.

Q3. Select the correct answer from the choices A, B, C, D which are given

The gas law which relates the volume of a gas to the number of molecules of the gas is

A : Avogadro's law B : Gay Lussac's law

C : Boyle's law D : Charles' law [1]

Ans. A

Q4. The equation for the burning of octane is

$$2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$$

(*i*) How many moles of carbon dioxide are produced when one mole of octane burns ?

(ii) What volume, at S.T.P., is occupied by the number of moles determined in (i) ?

(iii) If the relative molecular mass of carbon dioxide is 44, what is the mass of carbon dioxide produced by burning two moles of octane ?

(iv) What is the empirical formula of octane ? [5]

Ans. (i) 2 moles of $C_8H_{18} \equiv 16$ moles of CO_2

1 mole of $C_8H_{18} \equiv \frac{16}{2} \times 1 = 8$ moles of CO_2

(ii) Volume at S.T.P. = Number of moles × Molar volume

$= 8 \times 22.4\ dm^3 = 179.2\ dm^3$

(iii) $44 \times 16 = 704$ g.

(iv) C_4H_9.

2007

Q1. A sample of ammonium nitrate when heated yields 8.96 litres of steam (measured at S.T.P.)

$$NH_4NO_3 \longrightarrow N_2O + 2H_2O$$

(i) What volume of dinitrogen oxide is produced at the same time as 8.96 litres of steam ?

(ii) What mass of ammonium nitrate should be heated to produce 8.96 litres of steam ? (Relative molecular mass of ammonium nitrate is 80)

(iii) Determine the percentage of oxygen in ammonium nitrate. (O = 16) [5]

Ans. (i) $NH_4NO_3 \longrightarrow N_2O + 2H_2O$.

2 vol. of steam ≡ 1 vol. of N_2O

(According to the equation)

8.96 litres of steam $\equiv \frac{1}{2} \times 8.96 = 4.48$ litres of N_2O

(ii) 2×22.4 litres of steam ≡ 80 g of NH_4NO_3.

8.96 litres of steam $\equiv \frac{80}{2 \times 22.4} \times 8.96$

$= 16$ g of NH_4NO_3

(iii) In NH_4NO_3, % of oxygen $= \frac{48}{80} \times 100 = 60\%$

Q2. A compound 'X' consists of 4.8% carbon and 95.2% bromine by mass.

(i) Determine the empirical formula of this compound working correct to one decimal place. (C = 12, Br = 80)

(ii) If the vapour density of the compound is 252, what is the molecular formula of the compound ?

(iii) Name the type of chemical reaction by which 'X' can be prepared from ethane. [5]

Ans.(i)

Element	*%*	*At. wt.*	*Relative number of atoms*	*Simplest ratio*
C	4.8	12	0.4	1
Br	95.2	80	1.19	3

Empirical formula = CBr_3.

(ii) Empirical formula weight = $12 + 3 \times 80$

$= 12 + 240$

$= 252$ a.m.u

Relative molecular mass

= 2 × vapour density

$= 2 \times 252 = 504$ a.m.u

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

$$= \frac{504}{252} = 2$$

Molecular formula = $(CBr_3)_n = (CBr_3)_2 = C_2Br_6$

(iii) Substitution reaction.

2006

Q1. Determine the empirical formula of a compound containing 47.9% Potassium, 5.5% Beryllium and 46.6% Flourine by mass. (Atomic weight, Be = 9, F = 19, K = 39). [3]

Ans.

Element	*%*	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
K	47.9	39	1.2	2
Be	5.5	9	0.6	1
F	46.6	19	2.4	4

Empirical formula – K_2BeF_4.

Q2. Given that the relative molecular mass of copper oxide is 80, what volume of ammonia (measured at S.T.P.) is required

to completely reduce 120g of copper oxide ? The equation for the reaction is

$$3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$$

(Volume occupied by 1 mole of a gas at S.T.P. is 22.4 litres) [2]

ns. $3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$

3×80 g of copper oxide $\rightarrow 2 \times 22.4$ dm^3 of NH_3

120 g of copper oxide $\rightarrow \frac{2 \times 22.4}{3 \times 80} \times 120 = 22.4$ dm^3

Q3. Calculate the percentage of Sodium in Sodium aluminium flouride (Na_3AlF_6) correct to the nearest whole number (F = 19, Na = 23, Al = 27). [2]

ns. Molar mass of $Na_3AlF_6 = 3 \times 23 + 1 \times 27 + 6 \times 19$

$= 210$ a.m.u.

$$\% \text{ of Na} = \frac{69}{210} \times 100 = 32.8\ \% = 33\%$$

Q4. 560 ml of Carbon monoxide is mixed with 500 ml of oxygen and ignited. The chemical equation for the reaction is as follows :

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

Calculate the volume of oxygen used and carbon dioxide formed in the above reaction. [2]

ns.

$$\begin{array}{ccccc} 2CO & + & O_2 & \longrightarrow & 2CO_2 \\ 2 & : & 1 & : & 2 \\ 560 \text{ ml} & & 280 \text{ ml} & & 560 \text{ ml} \end{array}$$

Volume of oxygen used = 280 ml

Volume of CO_2 formed = 560 ml

Q5. (*a*) Calculate number of moles and number of molecules present in 1.4 g of Ethylene gas. What is the volume occupied by the same amount of Ethylene ?

(*b*) What is the vapour density of Ethylene ?

(Avogadro's number = 6×10^{23}, Atomic weight H = 1, C = 12, Molar volume = 22.4 litres at S.T.P.) [4]

ns. (*a*) Molar mass of $C_2H_4 = 2 \times 12 + 4 \times 1$

$= 24 + 4 = 28$ a.m.u.

$$\text{Number of moles} = \frac{1.4}{28} = 0.05$$

Number of molecules

= Number of moles × Avogadro's number

$= 0.05 \times 6 \times 10^{23} = 3 \times 10^{22}$ molecules

Volume occupied

= Number of moles × Molar volume

$= 0.05 \times 22.4 = 1.12$ litres

(*b*) $$\text{Vapour density} = \frac{\text{Molecular weight}}{2}$$

$$= \frac{28}{2} = 14.$$

2005

Q1. The volumes of gases A, B, C and D are in the ratio 1 : 2 : 2 : 4 under the same conditions of temperature and pressure.

(*i*) Which sample of gas contains maximum number of molecules ?

(*ii*) If the temperature and the pressure of gas 'A' are kept constant, then what will happen to the volume of 'A' when the number of molecules is doubled ?

(*iii*) If this ratio of gas volumes refers to the reactants and products of a reaction which gas law is being observed ?

(*iv*) If the volume of A is actually 5.6 dm^3 at S.T.P., calculate the number of molecules in the actual volume of D at S.T.P. (Avogadro's number 6×10^{23})

(*v*) Using your answer from (*iv*) state the mass of D if the gas is dinitrogen oxide (N_2O). (N = 14, O = 16). [5]

Ans. (*i*) Sample 'D' contains maximum number of molecules.

(*ii*) If the number of molecules of 'A' is doubled then the volume gets doubled.

(*iii*) Gay Lussac's Law.

(*iv*) If the volume of A is 5.6 dm^3

The volume of D = $4 \times 5.6 = 22.4$ dm^3

22.4 dm^3 of gas at S.T.P. contains 6×10^{23} molecules

22.4 dm^3 of gas D will contain

$$\frac{6 \times 10^{23}}{22..4} \times 22.4 = 6 \times 10^{23} \text{ molecules.}$$

(*v*) Gram molecular mass of $N_2O = 28 + 16 = 44$ g.

6×10^{23} molecules are present in 44 g of N_2O

$$6 \times 10^{23} \text{ molecules of D} = \frac{44}{6 \times 10^{23}} \times 6 \times 10^{23}$$

$= 44$ g.

Q2. Calculate the percentage of Nitrogen in Aluminium nitride (N = 14, Al = 27). [2]

Ans. Al N
27 + 14 = 41

$$\% \text{ of Nitrogen} = \frac{14}{41} \times 100 = 34.146\%$$

Q3. The equations given below relate to the manufacture of Sodium carbonate (molecular weight = 106)

1. $NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$

2. $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Questions (*a*) and (*b*) are based on the production of 21.2 g of Sodium carbonate.

(*a*) What mass of Sodium hydrogen carbonate must be heated to give 21.2 g of sodium carbonate (molecular weight of $NaHCO_3$ = 84) ? [3]

(*b*) To produce the mass of Sodium hydrogen carbonate calculated in (*a*) what volume of carbon dioxide, measured at S.T.P. would be required ? [3]

Ans. (*a*) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

106 g of $Na_2CO_3 \longrightarrow 2 \times 84$ g of $NaHCO_3$

21.2 g of $Na_2CO_3 \longrightarrow \frac{2 \times 84}{106} \times 21.2$

$= 33.6$ g of $NaHCO_3$

(*b*) $NaCl + NH_3 + H_2O + CO_2 \longrightarrow NaHCO_3 + NH_4Cl$

84 g of $NaHCO_3 \longrightarrow 22.4\ dm^3$

33.6 g of $NaHCO_3 \longrightarrow \frac{22.4}{84} \times 33.6 = 8.96\ dm^3$.

Q4. Define atomic weight. [1]

Ans. It is defined as the mass of one atom of an element on the scale on which C – 12 isotope of carbon weighs 12.000 units.

IMPORTANT QUESTIONS

Formula Based Questions

Question based on formula – I

Mass of 1 mole of compound
= Molecular weight of the compound (Unit-grams)

Q1. What is the mass in grams of 1 mole of

(*i*) Hydrogen gas H_2
(*ii*) Ammonia gas NH_3
(*iii*) Sulphuric acid H_2SO_4
(*iv*) Calcium carbonate $CaCO_3$
(*v*) Magnesium hydroxide $Mg(OH)_2$

Ans. (*i*) 2 g (*ii*) 17 g (*iii*) 98 g
(*iv*) 100 g (*v*) 58 g

Question based on formula – II

Mass of '*n*' moles of molecules of a compound
= *n* × molecular weight of the compound.

Q2. What is the mass in grams of

(*i*) 2 moles of water ?
(*ii*) 0.25 mole of Calcium carbonate ?
(*iii*) 0.5 mole of Nitric acid ?
(*iv*) 3 moles of Sodium hydroxide ?
(*v*) 10 moles of Glucose ?

Ans. (*i*) 36 g (*ii*) 25 g (*iii*) 31.5 g
(*iv*) 120 g (*v*) 1800 g

Question based on formula – III

Number of moles of a compound

$$= \frac{\text{Mass in grams of the compound}}{\text{Molecular weight of the compound}}$$

Q3. What is the number of moles in

(*i*) 1000 grams of Calcium carbonate ?
(*ii*) 12.8 grams of Methane ?
(*iii*) 11 grams of Carbon dioxide ?
(*iv*) 3.55 grams of Chlorine ?
(*v*) 270 grams of Water ?

Ans. (*i*) 10 (*ii*) 0.8 (*iii*) 0.25
(*iv*) 0.05 (*v*) 15

Question based on formula – IV

Number of molecules of a compound.

$$= \frac{\text{Mass in grams of the compound}}{\text{Molecular weight of the compound}} \times 6.023 \times 10^{23}$$

or

= Number of moles of a compound × Avogadro's number (6.023×10^{23})

Q4. What is the number of molecules in

(*i*) 10 grams of Calcium carbonate ?
(*ii*) 3.6 grams of Water ?

(iii) 19.6 grams of Phosphoric acid ?
(iv) 200 grams of Sodium hydroxide ?
(v) 1.5 grams of Ethane gas ?

Ans. For the convenience in calculation the Avogadro's number may be taken as 6×10^{23}.
(i) 6×10^{22} (ii) 1.2×10^{23}
(iii) 1.2×10^{23} (iv) 3×10^{24}
(v) 3×10^{22}

Question based on formula – V

Mass in grams of the compound $= \frac{\text{Number of molecules}}{6.023 \times 10^{23}} \times \text{Molecular weight}$

Q5. What is the mass in grams of the compounds in
(i) 4.2161×10^{23} molecules of Carbonic acid ?
(ii) 6.023×10^{23} molecules of Hydrogen peroxide ?
(iii) 1.2046×10^{21} molecules of Calcium carbonate ?
(iv) 3.0115×10^{23} molecules of Nitrogen dioxide ?
(v) 4.8184×10^{23} molecules of Acetic acid ?

Ans. (i) 43.4 g (ii) 34 g (iii) 0.2 g
(iv) 23 g (v) 48 g

Question based on formula – VI

Volume in litres of 1 mole of any gaseous compound at S.T.P. = 22.4 litres

Q6. What is the volume in litres at S.T.P. of 1 mole of
(i) Carbon monoxide gas ?
(ii) Nitrogen gas ?
(iii) Sulphur dioxide gas ?
(iv) Propane gas ?
(v) Carbon dioxide gas ?

Ans. (i) 22.4 litres (ii) 22.4 litres
(iii) 22.4 litres (iv) 22.4 litres
(v) 22.4 litres

Question based on formula – VII

Volume in litres of 'n' moles of a gaseous compound at S.T.P. = Number of moles of the compound × 22.4

Q7. What is the volume at S.T.P.
(i) in millilitres of 0.01 mole of Hexane gas $[C_6H_{14}]$?
(ii) in litres of 5 moles of Butane gas $[C_4H_{10}]$?
(iii) in millilitres of 0.2 mole of Benzene gas $[C_6H_6]$?

Ans. (i) 224 ml (ii) 112 litres
(iii) 4480 ml

Question based on formula – VIII

Number of moles (in a given volume in litres) of a gaseous compound at S.T.P. $= \frac{\text{Volume in litres}}{22.4}$

Q8. What is the number of moles in
(i) 22.4 litres of Ammonia gas at S.T.P. ?
(ii) 44.8 litres of Carbon dioxide at S.T.P. ?
(iii) 2.24 litres of Nitrous oxide at S.T.P. ?
(iv) 0.224 litres of Sulphur dioxide at S.T.P. ?

Ans. (i) 1 (ii) 2
(iii) 0.1 (iv) 0.01

Question based on formula – IX

Number of moles (in a given volume in millilitres) of a gaseous compound at S.T.P. $= \frac{\text{Volume in millilitres}}{22400}$

Q9. What is the mass in grams of
(i) 2.24 millilitres of propane at S.T.P. ?
(ii) 448 millilitres of Nitric oxide at S.T.P. ?

Ans. (i) 0.0001 g (ii) 0.02 g

Question based on formula – X

Mass in grams of a gaseous compound $= \frac{\text{Volume in litres at S.T.P.}}{22.4} \times \text{Mol.wt.}$

Q10. What is the mass in grams of
(i) 5.6 litres of Propane at S.T.P. ?
(ii) 560 ml of Methane at S.T.P. ?

Ans. (i) 11 g (ii) 0.4 g

Question based on formula – XI

Volume in litres at S.T.P. of a gaseous compound $= \frac{\text{Mass in grams}}{\text{Molecular weight}} \times 22.4$

Q11. What is the volume in litres (at S.T.P.) of
(i) 16 g of Methane gas ?
(ii) 0.14 g of Carbon monoxide gas ?
(iii) 1.8 g of Water vapour ?

Ans. (i) 22.4 litres (ii) 0.112 litres
(iii) 2.24 litres

Ans. Al N
27 + 14 = 41

$$\% \text{ of Nitrogen} = \frac{14}{41} \times 100 = 34.146\%$$

Q3. The equations given below relate to the manufacture of Sodium carbonate (molecular weight = 106)

1. $NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$

2. $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Questions (*a*) and (*b*) are based on the production of 21.2 g of Sodium carbonate.

(*a*) What mass of Sodium hydrogen carbonate must be heated to give 21.2 g of sodium carbonate (molecular weight of $NaHCO_3$ = 84) ? [3]

(*b*) To produce the mass of Sodium hydrogen carbonate calculated in (*a*) what volume of carbon dioxide, measured at S.T.P. would be required ? [3]

Ans. (*a*) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

106 g of $Na_2CO_3 \longrightarrow 2 \times 84$ g of $NaHCO_3$

21.2 g of $Na_2CO_3 \longrightarrow \frac{2 \times 84}{106} \times 21.2$

$= 33.6$ g of $NaHCO_3$

(*b*) $NaCl + NH_3 + H_2O + CO_2 \longrightarrow NaHCO_3 + NH_4Cl$

84 g of $NaHCO_3 \longrightarrow 22.4\ dm^3$

33.6 g of $NaHCO_3 \longrightarrow \frac{22.4}{84} \times 33.6 = 8.96\ dm^3$.

Q4. Define atomic weight. [1]

Ans. It is defined as the mass of one atom of an element on the scale on which C – 12 isotope of carbon weighs 12.000 units.

IMPORTANT QUESTIONS

Formula Based Questions

Question based on formula – I

Mass of 1 mole of compound
= Molecular weight of the compound (Unit-grams)

Q1. What is the mass in grams of 1 mole of

(*i*) Hydrogen gas H_2
(*ii*) Ammonia gas NH_3
(*iii*) Sulphuric acid H_2SO_4
(*iv*) Calcium carbonate $CaCO_3$
(*v*) Magnesium hydroxide $Mg(OH)_2$

Ans. (*i*) 2 g (*ii*) 17 g (*iii*) 98 g
(*iv*) 100 g (*v*) 58 g

Question based on formula – II

Mass of '*n*' moles of molecules of a compound
= *n* × molecular weight of the compound.

Q2. What is the mass in grams of

(*i*) 2 moles of water ?
(*ii*) 0.25 mole of Calcium carbonate ?
(*iii*) 0.5 mole of Nitric acid ?
(*iv*) 3 moles of Sodium hydroxide ?
(*v*) 10 moles of Glucose ?

Ans. (*i*) 36 g (*ii*) 25 g (*iii*) 31.5 g
(*iv*) 120 g (*v*) 1800 g

Question based on formula – III

Number of moles of a compound

$$= \frac{\text{Mass in grams of the compound}}{\text{Molecular weight of the compound}}$$

Q3. What is the number of moles in

(*i*) 1000 grams of Calcium carbonate ?
(*ii*) 12.8 grams of Methane ?
(*iii*) 11 grams of Carbon dioxide ?
(*iv*) 3.55 grams of Chlorine ?
(*v*) 270 grams of Water ?

Ans. (*i*) 10 (*ii*) 0.8 (*iii*) 0.25
(*iv*) 0.05 (*v*) 15

Question based on formula – IV

Number of molecules of a compound.

$$= \frac{\text{Mass in grams of the compound}}{\text{Molecular weight of the compound}} \times 6.023 \times 10^{23}$$

or

= Number of moles of a compound × Avogadro's number (6.023×10^{23})

Q4. What is the number of molecules in

(*i*) 10 grams of Calcium carbonate ?
(*ii*) 3.6 grams of Water ?

(iii) 19.6 grams of Phosphoric acid ?
(iv) 200 grams of Sodium hydroxide ?
(v) 1.5 grams of Ethane gas ?

ns. For the convenience in calculation the Avogadro's number may be taken as 6×10^{23}.
(i) 6×10^{22} (ii) 1.2×10^{23}
(iii) 1.2×10^{23} (iv) 3×10^{24}
(v) 3×10^{22}

Question based on formula – V

Mass in grams of the compound
$= \frac{\text{Number of molecules}}{6.023 \times 10^{23}} \times \text{Molecular weight}$

Q5. What is the mass in grams of the compounds in
(i) 4.2161×10^{23} molecules of Carbonic acid ?
(ii) 6.023×10^{23} molecules of Hydrogen peroxide ?
(iii) 1.2046×10^{21} molecules of Calcium carbonate ?
(iv) 3.0115×10^{23} molecules of Nitrogen dioxide ?
(v) 4.8184×10^{23} molecules of Acetic acid ?

Ans. (i) 43.4 g (ii) 34 g (iii) 0.2 g
(iv) 23 g (v) 48 g

Question based on formula – VI

Volume in litres of 1 mole of any gaseous compound at S.T.P. = 22.4 litres

Q6. What is the volume in litres at S.T.P. of 1 mole of
(i) Carbon monoxide gas ?
(ii) Nitrogen gas ?
(iii) Sulphur dioxide gas ?
(iv) Propane gas ?
(v) Carbon dioxide gas ?

Ans. (i) 22.4 litres (ii) 22.4 litres
(iii) 22.4 litres (iv) 22.4 litres
(v) 22.4 litres

Question based on formula – VII

Volume in litres of 'n' moles of a gaseous compound at S.T.P. = Number of moles of the compound × 22.4

Q7. What is the volume at S.T.P.
(i) in millilitres of 0.01 mole of Hexane gas $[C_6H_{14}]$?
(ii) in litres of 5 moles of Butane gas $[C_4H_{10}]$?
(iii) in millilitres of 0.2 mole of Benzene gas $[C_6H_6]$?

Ans. (i) 224 ml (ii) 112 litres
(iii) 4480 ml

Question based on formula – VIII

Number of moles (in a given volume in litres) of a gaseous compound at S.T.P. $= \frac{\text{Volume in litres}}{22.4}$

Q8. What is the number of moles in
(i) 22.4 litres of Ammonia gas at S.T.P. ?
(ii) 44.8 litres of Carbon dioxide at S.T.P. ?
(iii) 2.24 litres of Nitrous oxide at S.T.P. ?
(iv) 0.224 litres of Sulphur dioxide at S.T.P. ?

Ans. (i) 1 (ii) 2
(iii) 0.1 (iv) 0.01

Question based on formula – IX

Number of moles (in a given volume in millilitres) of a gaseous compound at S.T.P. $= \frac{\text{Volume in millilitres}}{22400}$

Q9. What is the mass in grams of
(i) 2.24 millilitres of propane at S.T.P. ?
(ii) 448 millilitres of Nitric oxide at S.T.P. ?

Ans. (i) 0.0001 g (ii) 0.02 g

Question based on formula – X

Mass in grams of a gaseous compound $= \frac{\text{Volume in litres at S.T.P.}}{22.4} \times \text{Mol.wt.}$

Q10. What is the mass in grams of
(i) 5.6 litres of Propane at S.T.P. ?
(ii) 560 ml of Methane at S.T.P. ?

Ans. (i) 11 g (ii) 0.4 g

Question based on formula – XI

Volume in litres at S.T.P. of a gaseous compound $= \frac{\text{Mass in grams}}{\text{Molecular weight}} \times 22.4$

Q11. What is the volume in litres (at S.T.P.) of
(i) 16 g of Methane gas ?
(ii) 0.14 g of Carbon monoxide gas ?
(iii) 1.8 g of Water vapour ?

Ans. (i) 22.4 litres (ii) 0.112 litres
(iii) 2.24 litres

Question based on formula – XII

Volume in litres (at S.T.P.) of a gaseous compound

$$= \left[\frac{\text{Number of molecules}}{6.023 \times 10^{23}}\right] \times 22.4$$

Q12. What is the volume (at S.T.P.) occupied by

(i) 6.023×10^{23} molecules of Sulphur dioxide?

(ii) 12.046×10^{23} molecules of Sulphur trioxide?

Ans. (i) 22.4 litres (ii) 44.8 litres.

Practice Problems

Q.1 (a) Calculate the empirical formula of the compound having 37.6 % Sodium, 23.1% Silicon and 39.3% Oxygen. (Answer correct to two decimal places)

(O = 16, Na = 23, Si = 28)

(b) The empirical formula of a compound is C_2H_5. It has a vapour density of 29. Determine the relative molecular mass of the compound and hence its molecular formula.

Ans.(a)

Element	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Sodium	37.6	23	37.6 ÷ 23 = 1.6	1.6 ÷ 0.8 = 2
Silicon	23.1	28	23.1 ÷ 28 = 0.8	0.8 ÷ 0.8 = 1
Oxygen	39.3	16	39.3 ÷ 16 = 2.4	2.4 ÷ 0.8 = 3

Empirical formula = Na_2SiO_3

(b) Molecular weight = 2 × Vapour density (V. D.)

= 2 × 29

= 58

Empirical formula weight of C_2H_5 = 24 + 5

= 29

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{58}{29} = 2$$

Thus, Molecular Formula = $(C_2H_5)_2 = C_4H_{10}$

Q2. Explain why following statement is incorrect :

1 gram of any gas occupies 22.4 litres at S.T.P.

Ans. 1 mole of a gas at S.T.P. occupies 22.4 litres.

Q3. Under the same conditions of temperature and pressure, you collect 2 litres of Carbon dioxide, 3 litres of Chlorine, 5 litres of Hydrogen, 4 litres of Nitrogen and 1 litre of Sulphur dioxide.

In which gas sample will there be

(a) the greatest number of molecules ?

(b) the least number of molecules ?

Justify your answer.

Ans. (a) Hydrogen

(b) Sulphur dioxide

The justification is in accordance to Avogadro's law that under the similar condition of temperature and pressure, equal volumes of all gases contain equal number of molecules. Therefore volume of Hydrogen is greater and so, it has greater number of molecules.

Q4. Find the total percentage of Oxygen in Magnesium Nitrate [$Mg(NO_3)_2.6H_2O$] crystals.

(H = 1, N = 14, O = 16, Mg = 24)

Ans. Molecular weight of $Mg(NO_3)_2 . 6H_2O$

$= 24 + 2 \times (14 + 48) + 6 \times 18$

$= 24 + 2 \times 62 + 108$

$= 24 + 124 + 108 = 256$ g

Weight of Oxygen $= 12 \times 16 = 192$ g

$$\% \text{ of Oxygen} = \frac{192}{256} \times 100$$

= 75% of Oxygen

Q5. A compound contains 87.5% by mass of Nitrogen and 12.5% by mass of Hydrogen. Determine the empirical formula of the compound.

Ans.

Element	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Nitrogen	87.5	14	87.5 ÷ 14 = 6.25	6.25 ÷ 6.25 = 1
Hydrogen	12.5	1	12.5 ÷ 1 = 12.5	12.5 ÷ 6.25 = 2

Empirical formula = NH_2

Q6. Complete the following sentence :

If two gases under the same conditions have the same number of molecules, then they must _____.

Ans. Have same volume

Q7. The following question refers to one mole of Chlorine. What is the volume occupied by this gas at S.T.P. ?

Ans. 22.4 dm^3.

Q8. An acid of Phosphorus has the following percentage composition :

2.47% of Hydrogen, 38.27% of Phosphorus, 59.26% of Oxygen.

Find the empirical formula of this acid and its molecular formula. Given that its relative molecular mass is 162.

Ans.

Element	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Hydrogen	2.47	1	2.47÷1 = 2.47	2.47÷1.2 = 2
Phosphorus	38.27	31	38.27÷31 = 1.2	1.2÷1.2 = 1
Oxygen	59.26	16	59.26 ÷ 16 = 3.7	3.7÷1.2 = 3

Empirical formula = H_2PO_3

Molecular weight = 162

Empirical formula weight of H_2PO_3

$= 2 + 31 + 48 = 81$

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

$$= \frac{162}{81} = 2$$

The molecular formula = $(H_2PO_3)_2$

$= H_4P_2O_6$

Q9. 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	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Sodium	29.11	23	29.11 ÷ 23 = 1.2	1.2 ÷ 1.2 = 1.0
Sulphur	40.51	32	40.51 ÷ 32 = 1.2	1.2 ÷ 1.2 = 1.0
Oxygen	30.38	16	30.38 ÷ 16 = 1.8	1.8 ÷ 1.2 = 1.5

To convert it into whole number

$1 \times 2 = 2$; $1 \times 2 = 2$; $1.5 \times 2 = 3$

Empirical formula = $Na_2S_2O_3$

Q10. What is the volume occupied by the following gases at S.T.P. ?

(a) 64 g of Oxygen.

(b) 32 g of Sulphur dioxide.

(c) 44 g of Carbon dioxide.

(d) 14 g of Nitrogen.

(e) 8 g of Hydrogen.

(H = 1, N = 14, O = 16, S = 32, C = 12)

Ans. (a) 32 g of O_2 at S.T.P. occupies 22.4 dm^3

64 g of O_2 occupies $= \frac{22.4}{32} \times 64 = 44.8\ dm^3$

(b) 64 g of SO_2 at S.T.P. occupies 22.4 dm^3

32 g of SO_2 occupies $= \frac{22.4}{64} \times 32 = 11.2\ dm^3$

(c) 44 g of CO_2 at S.T.P. occupies 22.4 dm^3

44 g of CO_2 occupies $= \frac{22.4}{44} \times 44 = 22.4\ dm^3$

(d) 28 g of N_2 at S.T.P. occupies 22.4 dm^3

14 g of N_2 occupies $= \frac{22.4}{28} \times 14 = 11.2\ dm^3$

(e) 2 g of H_2 at S.T.P. occupies 22.4 dm^3

8 g of H_2 occupies $= \frac{22.4}{2} \times 8 = 89.6\ dm^3$

Q11. How many molecules are present in (the numerical value of Avogadro's number can be used as 6×10^{23})

(a) 2.2 grams of Carbon dioxide ?

(b) 16 grams of Sulphur dioxide ?

(c) 2 grams of Oxygen ?

(d) 58.5 g of Sodium chloride ?

(C = 12, O = 16, Na = 23, S = 32, Cl = 35.5)

Ans. (a) 44 g of CO_2 contains 6×10^{23} molecules at S.T.P.

2.2 g of $CO_2 = \frac{6 \times 10^{23}}{44} \times 2.2$

$= 3 \times 10^{22}$ molecules

(b) 64 g of SO_2 contains 6×10^{23} molecules at S.T.P.

16 g of $SO_2 = \frac{6 \times 10^{23}}{64} \times 16$

$= 1.5 \times 10^{23}$ molecules

(c) 32 g of O_2 contains 6×10^{23} molecules at S.T.P.

2 g of $O_2 = \frac{6 \times 10^{23}}{32} \times 2$

$= 3.75 \times 10^{22}$ molecules

(d) 58.5 g of NaCl contains 6×10^{23} molecules at S.T.P.

58.5 g of NaCl contains $= \frac{6 \times 10^{23}}{58.5} \times 58.5$

$= 6 \times 10^{23}$ molecules

Q12. How many moles are present in

(a) 100 g of Calcium carbonate ?

(b) 16 g of Oxygen ?

(c) 12 g of Carbon dioxide ?

(d) 2.3 g of Sodium ?

(e) 80 g of Sodium hydroxide ?

(H = 1, C = 12, O = 16, Na = 23)

Ans. (a) Number of moles

$$= \frac{\text{Weight of the substance (W)}}{\text{Molecular weight (M)}}$$

Molecular weight of $CaCO_3 = 40 + 12 + 48$

$= 100$

$$\text{No. of moles} = \frac{100}{100} = 1 \text{ mole}$$

(b) Molecular weight of Oxygen $= 16 \times 2 = 32$

$$\text{No. of moles} = \frac{16}{32} = \frac{1}{2} = 0.5 \text{ mole}$$

(c) Molecular weight of $CO_2 = 12 + 32 = 44$

$$\text{No. of moles} = \frac{12}{44} = 0.27 \text{ mole}$$

(d) $$\text{No. of moles} = \frac{2.3}{23} = 0.1 \text{ mole}$$

(e) $$\text{No. of moles} = \frac{80}{40} = 2 \text{ moles}$$

Q13. Calculate the percentage of the following :

(a) Carbon in Ethyne (C_2H_2).

(b) Calcium in Calcium carbonate.

(c) Nitrogen in Ammonia (NH_3).

(d) Oxygen in water (H_2O).

(e) Nitrogen in Urea {$(NH_2)_2CO$}.

Ans. (a) Molecular weight of Ethyne (C_2H_2)

$= 2 \times 12 + 1 \times 2$

$= 24 + 2 = 26$

$$\% \text{ of Carbon} = \frac{24}{26} \times 100 = 92.30\%$$

(b) Molecular weight of Calcium carbonate ($CaCO_3$)

$= 40 + 12 + 48 = 100$

$$\% \text{ of Calcium} = \frac{40}{100} \times 100 = 40\%$$

(c) Molecular weight of Ammonia (NH_3)

$= 14 + 3 = 17$

$$\% \text{ of Nitrogen} = \frac{14}{17} \times 100 = 82.35\%$$

(d) Molecular weight of Water (H_2O)

$= 2 + 16 = 18$

$$\% \text{ of Oxygen} = \frac{16}{18} \times 100 = 88.88\%$$

(e) Molecular weight of Urea ($(NH_2)_2CO$)

$= 28 + 4 + 12 + 16$

$= 60$

$$\% \text{ of Nitrogen} = \frac{28}{60} \times 100 = 46.66\%$$

Q14. Galena, when roasted, reacts according to the following equation :

$$2PbS + O_2 \longrightarrow 2PbO + SO_2$$

Calculate :

(a) the weight of PbO formed when 478 g of PbS is roasted .

(b) the weight of PbS required to produce 5.6 litres of SO_2 at S.T.P.

(c) the number of moles of Oxygen required at the same time.

(Pb = 207, O = 16, S = 32)

Ans. $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

(a) Molecular weight of PbS $= 207 + 32$

$= 2 \times 239$

Molecular weight of PbO $= 207 + 16$

$= 2 \times 223$

2×239 g of PbS $= 2 \times 223$ g of PbO

$$478 \text{ g of PbS} = \frac{2 \times 223}{2 \times 239} \times 478$$

$= 446$ g of PbO

(b) 2×22.4 dm^3 of SO_2 is produced by 2×239 g of PbS

$$5.6 \text{ dm}^3 \text{ of } SO_2 \text{ is produced by } \frac{2 \times 239}{2 \times 22.4} \times 5.6$$

$= 59.75$ g

(c) 2×239 g of PbS requires 3 moles of O_2

$$478 \text{ g of PbS requires } \frac{3}{2 \times 239} \times 478 = 3 \text{ moles}$$

Q15. Calculate the empirical formula of the compound having following percentage composition :

N = 21.21%, H = 6.06%,

S = 24.24%, O = 48.48%

(H = 1, N = 14, S = 32, O = 16)

Ans.

Element	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Nitrogen	21.21	14	21.21 ÷ 14 = 1.50	1.5 ÷ 0.75 = 2
Hydrogen	6.06	1	6.06 ÷ 1 = 6.00	6.0 ÷ 0.75 = 8
Sulphur	24.24	32	24.24 ÷ 32 = 0.75	0.75 ÷ 0.75 = 1
Oxygen	48.48	16	48.48 ÷ 16 = 3.00	3.0 ÷ 0.75 = 4

Empirical formula = $N_2H_8S_1O_4$
= $(NH_4)_2SO_4$

Q16. A hydrocarbon of vapour density – 15 has 80% Carbon. Calculate the molecular formula of the Hydrocarbon.

Ans.

Element	%	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
Carbon	80	12	80 ÷ 12 = 6.6	6.6 ÷ 6.6 = 1
Hydrogen	20	1	20 ÷ 1 = 20	20 ÷ 6.6 = 3

Empirical formula = CH_3

Molecular weight = 2 × Vapour density (V.D.)
= 2 × 15 = 30

Empirical formula weight = 12 + 3 = 15

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

$$= \frac{30}{15} = 2$$

Molecular formula = $(CH_3)_2 = C_2H_6$

Q17. State :

(a) Avogadro's law.

(b) Gay Lussac's law.

Ans. (a) **Avogadro's Law –** Under the similar conditions of temperature and pressure equal volumes of all gases contain equal number of molecules.

(b) **Gay Lussac's Law –** Whenever the gases combine chemically, they do so in volume which bears a simple ratio to each other as well as to the product of gases, under the same conditions of temperature and pressure.

Numericals

Numericals to find percentage composition by weight of compound

Q1. Calculate the percentage composition by weight of the following compounds :

(i) Water – H_2O

(ii) Ammonia – NH_3

(iii) Methane – CH_4

(iv) Hydrochloric acid – HCl

(v) Ethane – C_2H_6

(vi) Calcium nitrate – $Ca(NO_3)_2$

(vii) Nitric oxide – NO

(viii) Magnesium chloride – $MgCl_2$

(ix) Calcium carbonate – $CaCO_3$

(x) Sodium peroxide – Na_2O_2

Ans. (i) Water : Chemical formula – H_2O

Relative molar mass = 2 + 16 = 18 a.m.u.

$$\% \text{ of Hydrogen} = \frac{2}{18} \times 100 = 11.11\ \%$$

$$\% \text{ of Oxygen} = \frac{16}{18} \times 100 = 88.88\ \%$$

(ii) Ammonia : Chemical formula – NH_3

Relative molar mass = 14 + 3 = 17 a.m.u.

$$\% \text{ of Nitrogen} = \frac{14}{17} \times 100 = 82.35\%$$

$$\% \text{ of Hydrogen} = \frac{3}{17} \times 100 = 17.64\%$$

(iii) Methane : Chemical formula – CH_4

Relative molar mass = 12 + 4 = 16 a.m.u.

$$\% \text{ of Carbon} = \frac{12}{16} \times 100 = 75\%$$

$$\% \text{ of Hydrogen} = \frac{4}{16} \times 100 = 25\%$$

(iv) Hydrochloric acid : Chemical formula – HCl

Relative molar mass = 1 + 35.5 = 36.5 a.m.u.

$$\% \text{ of Hydrogen} = \frac{1}{36.5} \times 100 = 2.73\%$$

$$\% \text{ of Chlorine} = \frac{35.5}{36.5} \times 100 = 97.26\%$$

(v) Ethane : Chemical formula – C_2H_6

Relative molar mass = 24 + 6 = 30 a.m.u.

$$\% \text{ of Carbon} = \frac{24}{30} \times 100 = 80\%$$

$$\% \text{ of Hydrogen} = \frac{6}{30} \times 100 = 20\%$$

(*vi*) Calcium nitrate :
Chemical formula – $Ca(NO_3)_2$
Relative molar mass = 40 + 28 + 96
= 164 a.m.u.

$$\% \text{ of Calcium} = \frac{40}{164} \times 100 = 24.39\%$$

$$\% \text{ of Nitrogen} = \frac{28}{164} \times 100 = 17.07\%$$

$$\% \text{ of Oxygen} = \frac{96}{164} \times 100 = 58.53\%$$

(*vii*) Nitric oxide : Chemical formula –NO
Relative molar mass = 14 + 16 = 30 a.m.u.

$$\% \text{ of Nitrogen} = \frac{14}{30} \times 100 = 46.66\%$$

$$\% \text{ of Oxygen} = \frac{16}{30} \times 100 = 53.33\%$$

(*viii*) Magnesium chloride :
Chemical formula – $MgCl_2$
Relative molar mass = 24 + 71 = 95 a.m.u.

$$\% \text{ of Magnesium} = \frac{24}{95} \times 100 = 25.26\%$$

$$\% \text{ of Chlorine} = \frac{71}{95} \times 100 = 74.74\%$$

(*ix*) Calcium carbonate :
Chemical formula – $CaCO_3$
Relative molar mass = 40 + 12 + 48 = 100

$$\% \text{ of Calcium} = \frac{40}{100} \times 100 = 40\%$$

$$\% \text{ of Carbon} = \frac{12}{100} \times 100 = 12\%$$

$$\% \text{ of Oxygen} = \frac{48}{100} \times 100 = 48\%$$

(*x*) Sodium peroxide :
Chemical formula – Na_2O_2
Relative molar mass = 46 + 32 = 78

$$\% \text{ of Sodium} = \frac{46}{78} \times 100 = 58.97\%$$

$$\% \text{ of Oxygen} = \frac{32}{78} \times 100 = 41.03\%$$

Numerical to find empirical formula of compound when its molecular formula is given

Q2. Write the empirical formula of the compounds whose molecular formulae are as follows :

(*i*) C_6H_6 (*ii*) B_6H_{12} (*iii*) $C_{10}H_{20}Fe_2$
(*iv*) N_2O_4 (*v*) C_6H_{12} (*vi*) C_4H_{10}
(*vii*) B_2H_6 (*viii*) C_8H_{18} (*ix*) C_4H_8
(*x*) Na_2CO_3

Ans. (*i*) CH (*ii*) BH_2 (*iii*) $C_5H_{10}Fe$
(*iv*) NO_2 (*v*) CH_2 (*vi*) C_2H_5
(*vii*) BH_3 (*viii*) C_4H_9 (*ix*) CH_2
(*x*) Na_2CO_3

Numericals to find empirical and molecular formulae of compound when its percentage composition by weight and its molecular weight is given.

Q3. The percentage composition by weight and the molecular weight of some compounds is given below. Find their empirical and molecular formula.

(*i*) C = 92.308%, H = 7.692%, Mol. wt. = 78
(*ii*) C = 40%, H = 6.67%, O = 53.33%, Mol.wt. = 180
(*iii*) C = 26.67%, H = 2.22%, O = 71.11% Mol.wt. = 90
(*iv*) H = 2.47%, P = 38.25%, O = 59.28% Mol.wt. = 161.94
(*v*) Cu = 84.11%, C = 15.89%, Mol.wt. = 151
(*vi*) K = 24.68%, Mn = 34.81%, O = 40.51%, Mol.wt. = 158
(*vii*) Ca = 34.48%, Si = 24.14%, O = 41.38%, Mol.wt. = 116
(*viii*) H = 5.88%, O = 94.12%, Mol.wt. = 34
(*ix*) P = 49.18%, O = 50.82%, Mol.wt. = 125.94
(*x*) B = 86.64%, H = 13.36%, Mol.wt. = 112.29
(*xi*) C = 52.17%, H = 13.04%, O = 34.78% Mol.wt. = 46
(*xii*) N = 30.43%, O = 69.57%, Mol.wt. = 92
(*xiii*) K = 31.85%, Cl = 28.95%, O = 39.20%, Mol.wt. = 122.45
(*xiv*) C = 40%, H = 6.67%, O = 53.33% Mol.wt. = 60
(*xv*) H = 3.078%, P = 47.668%, O = 49.254% Mol.wt. = 129.24

ns. (i)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
C	92.308	12	7.692	1
H	7.692	1	7.692	1

Empirical formula – CH

Empirical formula weight = 12 + 1 = 13

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

$$= \frac{78}{13} = 6$$

Molecular formula = n × Empirical formula

Molecular formula = C_6H_6.

ii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
C	40	12	3.33	1
H	6.67	1	6.67	2
O	53.33	16	3.33	1

Empirical formula – CH_2O

Empirical formula weight = 12 + 2 + 16 = 30

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

$$= \frac{180}{30} = 6$$

Molecular formula = n × Empirical formula

= $C_6H_{12}O_6$.

(iii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
C	26.67	12	2.22	1
H	2.22	1	2.22	1
O	71.11	16	4.44	2

Empirical formula – CHO_2

Empirical formula weight = 12 + 1+ 32 = 45

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

$$= \frac{90}{45} = 2$$

Molecular formula = n × Empirical formula

= $C_2H_2O_4$.

(iv)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
H	2.47	1	2.47	2
P	38.25	31	1.23	1
O	59.28	16	3.70	3

Empirical formula – H_2PO_3

Empirical formula weight = 2 + 31 + 48 = 81

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

$$= \frac{161.94}{81} = 1.99 \cong 2.$$

Molecular formula = n × Empricial formula

= $H_4P_2O_6$.

(v)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
Cu	84.11	64	1.3	1
C	15.89	12	1.3	1

Empirical formula – CuC.

Empirical formula weight = 64 + 12 = 76

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

$$= \frac{151}{76} = 1.98 \cong 2.$$

Molecular formula = n × Empricial formula

= Cu_2C_2.

(vi)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
K	24.68	39	0.63	1
Mn	34.81	55	0.63	1
O	40.51	16	2.53	4

Empirical formula – $KMnO_4$

Empirical formula weight = 39 + 55 + 64

= 158

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

$$= \frac{158}{158} = 1$$

Molecular formula = n × Empirical formula

= $KMnO_4$

(vii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
Ca	34.48	40	0.862	1
Si	24.14	28	0.862	1
O	41.38	16	2.58	3

Empirical formula – $CaSiO_3$

Empirical formula weight = 40 + 28 + 48

= 116

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{116}{116} = 1$$

Molecular formula = n × Empirical formula

= $CaSiO_3$.

(viii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
H	5.88	1	5.88	1
O	94.12	16	5.88	1

Empirical formula – HO

Empirical formula weight = 1 + 16 = 17

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

$$= \frac{34}{17} = 2$$

Molecular formula = n × Empirical formula

= H_2O_2.

(ix)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
P	49.18	31	1.58	1
O	50.82	16	3.17	2

Empirical formula – PO_2

Empirical formula weight = 31 + 32 = 63

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

$$= \frac{125.94}{63} = 1.99 \equiv 2.$$

Molecular formula = n × Empirical formula

= P_2O_4.

(x)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
B	86.64	11	7.87	1 × 3 = 3
H	13.36	1	13.36	1.69 × 3 = 5

Empirical formula – B_3H_5

Empirical formula weight = 33 + 5 = 38

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

$$= \frac{112.29}{38} = 2.9 \equiv 3.$$

Molecular formula = n × Empirical formula

= B_9H_{15}.

(xi)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
C	52.17	12	4.34	2
H	13.04	1	13.04	6
O	34.78	16	2.17	1

Empirical formula – C_2H_6O

Empirical formula weight = 24 + 6 + 16 = 46

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{46}{46} = 1$$

Molecular formula = n × Empirical formula

= C_2H_6O.

(xii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
N	30.43	14	2.17	1
O	69.57	16	4.34	2

Empirical formula – NO_2

Empirical formula weight = 14 + 32 = 46

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{92}{46} = 2$$

Molecular formula = n × Empirical formula = N_2O_4.

(xiii)

Element	%	At. wt.	Relative no. of atoms	Simplest ratio
K	31.85	39	0.81	1
Cl	28.95	35.5	0.81	1
O	39.20	16	2.45	3

Empirical formula – $KClO_3$

Empirical formula weight = 39 + 35.5 + 48

= 122.5

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

$$= \frac{122.45}{122.5} = 0.99 \equiv 1.$$

Molecular formula = n × Empirical formula

= $KClO_3$

(*xiv*)

Element	*%*	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
C	40	12	3.33	1
H	6.67	1	6.67	2
O	53.33	16	3.33	1

Empirical formula – CH_2O

Empirical formula weight = 12 + 2 + 16 = 30

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

$$= \frac{60}{30} = 2$$

Molecular formula = n × Empirical formula

= $C_2H_4O_2$.

(*xv*)

Element	*%*	*At. wt.*	*Relative no. of atoms*	*Simplest ratio*
H	3.078	1	3.078	2
P	47.668	31	1.53	1
O	49.254	16	3.07	2

Empirical formula – H_2PO_2

Empirical formula weight = 2 + 31 + 32 = 65

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

$$= \frac{129.24}{65} = 1.98 \equiv 2.$$

Molecular formula = n × Empirical formula

= $H_4P_2O_4$.

Q4. Calculate the percentage of underlined element in the following compounds.
(H = 1, C = 12, N = 14, O = 16, B = 11, Na = 23, Pt = 195)

(*i*) $(NH_4)_2$ Pt Cl_6

(*ii*) $Na_2B_4O_7.10H_2O$

Ans. (*i*) Molar mass of $(NH_4)_2$ Pt Cl_6

= (14 + 4) × 2 + 195 + 6 × 35.5

= 36 + 195 + 213

= 444

$$\% \text{ of Pt} = \frac{195}{444} \times 100$$

= 43.9%

(*ii*) Molar mass of $Na_2B_4O_7.10H_2O$

= 2 × 23 + 4 × 11 + 7 × 16 + 10 × 18

= 46 + 44 + 112 + 180

= 382 g

$$\% \text{ of B} = \frac{44}{382} \times 100$$

= 11.5%

❑❑

Let's Recall

Fill Your Answer in the Space Given for Each Question.

Q1. Match the following :

A.

Column-I (Organic Compounds)	Column-II (Percentage of Carbon(%))
(*i*) CH_3COOH	(*a*) 80
(*ii*) C_2H_5OH	(*b*) 54.54
(*iii*) CH_3CHO	(*c*) 52.17
(*iv*) C_2H_6	(*d*) 62.06
(*v*) CH_3COCH_3	(*e*) 40

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

B.

Column-I	Column-II
(*i*) Gay Lussac's law	(*a*) Simplest ratio
(*ii*) Avogadro's law	(*b*) 22.4 dm^3
(*iii*) Molar volume	(*c*) Volume-molecule relationship
(*iv*) Diatomic	(*d*) Combining volumes of gases
(*v*) Empirical formula	(*e*) Hydrogen

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

C.

Column-I (Weight of gas in grams)	Column-II (Number of moles)
(*i*) 23 g Nitrogen dioxide	(*a*) 80
(*ii*) 80 g of Sulphur dioxide	(*b*) 0.125
(*iii*) 7 g of Nitrogen	(*c*) 1.5
(*iv*) 4 g of Oxygen	(*d*) 0.5
(*v*) 106.5 g of Chlorine	(*e*) 0.25

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

Q2. Fill in the blanks.

(*i*) Number of moles = $\frac{\text{\_\_\_\_\_}}{\text{Molecular weight}}$.

(*ii*) Number of molecules = _____ × Avogadro's number.

(*iii*) Molecular formula = n × _____

(*iv*) $n = \frac{\text{Molecular weight}}{\text{\_\_\_\_\_}}$

Q3. Each question has four options, out of which only one option is correct. Dark the bubble for correct answer.

(*i*) Among the following Nitrogeneous fertilizers, which is the best fertilizer ?

(*a*) $(NH_4)_2SO_4$ (*b*) NH_4NO_3

(*c*) NH_2CONH_2 (*d*) None of these

Ans. (*a*) (*b*) (*c*) (*d*)

(*ii*) The volume occupied by one mole of a gas at S.T.P. is

(*a*) molecular volume (*b*) molar volume

(*c*) molecular formula (*d*) None of these

Ans. (a) (b) (c) (d)

(*iii*) Gay Lussac's law is applicable

(*a*) only to solids (*b*) only to liquids

(*c*) to both liquids and gases (*d*) only to gases

Ans. (a) (b) (c) (d)

(*iv*) The unit of vapour density is

(*a*) gram (*b*) ml

(*c*) cm^3 (*d*) None of these

Ans. (a) (b) (c) (d)

(*v*) The weight of 1 mole of CO_2 at S.T.P. is

(*a*) 22 g (*b*) 44 g

(*c*) 88 g (*d*) None of these

Ans. (a) (b) (c) (d)

(*vi*) A certain hydrocarbon has the following percentage composition C = 83.72%, H = 16.27%. The vapour density of the compound was found to be 43. The molecular formula of the compound is

(*a*) C_6H_8 (*b*) C_6H_2

(*c*) C_6H_{14} (*d*) C_6H_{12}

Ans. (a) (b) (c) (d)

(*vii*) The relative molecular mass of $Na_2S_2O_3.5H_2O$ is

(*a*) 250 a.m.u. (*b*) 250 g

(*c*) 248 a.m.u. (*d*) 248 g

Ans. (a) (b) (c) (d)

(*viii*) The gram molecular weight of $(NH_4)_2Cr_2O_7$ is

(*a*) 252 a.m.u. (*b*) 252 g

(*c*) 252 litre (*d*) 240 a.m.u.

Ans. (a) (b) (c) (d)

(*ix*) The volume of oxygen required and volume of nitric oxide formed when 100 ml of ammonia is catalytically oxidized according to the balanced chemical equation

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

(*a*) 125 ml of O_2 and NO (*b*) 100 ml of O_2 and NO

(*c*) 125 ml of O_2 and 100 ml of NO (*d*) 100 ml of O_2 and 125 ml of NO

Ans. (a) (b) (c) (d)

(*x*) The volume occupied by 15 g of ethane (C_2H_6) at S.T.P. is

(*a*) 5.6 dm^3 (*b*) 22.4 dm^3

(*c*) 11.2 dm^3 (*d*) 44.8 dm^3

Ans. (*a*) (*b*) (*c*) (*d*)

(*xi*) When 16.4 g of calcium nitrate is heated according to the chemical equation given

$$2Ca(NO_3)_2 \xrightarrow{\Delta} 2CaO + 4NO_2 + O_2$$

The weight of calcium oxide formed is

(*a*) 5.4 g (*b*) 5.6 g

(*c*) 1.12 g (*d*) 5.6 dm^3

Ans. (*a*) (*b*) (*c*) (*d*)

ANSWERS

1. A. (*i*) *e* (*ii*) *c* (*iii*) *b* (*iv*) *a* (*v*) *d*

B. (*i*) *d* (*ii*) *c* (*iii*) *b* (*iv*) *e* (*v*) *a*

C. (*i*) *d* (*ii*) *a* (*iii*) *e* (*iv*) *b* (*v*) *c*

2. (*i*) weight of the substance (*ii*) number of moles

(*iii*) empirical formula (*iv*) empirical formula weight

3. (*i*) *c* (*ii*) *b* (*iii*) *d* (*iv*) *d* (*v*) *b*

(*vi*) *c* (*vii*) *c* (*viii*) *b* (*ix*) *c* (*x*) *c*

(*xi*) *b*

SELF EVALUATION Test

Time : 30 minutes **Marks : 25**

Q1. State : 2

(*a*) Avogadro's law (*b*) Gay Lussac's law

Q2. Calculate : 3

(*i*) the number of moles

(*ii*) the number of molecules

(*iii*) the volume occupied by 52 g of ethyne (C_2H_2) at S.T.P.

Q3. 12 ml of Carbon monoxide and 8 ml of Hydrogen burn in Oxygen according to the equation given below to form Carbon dioxide and Water vapour respectively. Calculate the total volume of Oxygen required. 3

$$2CO + O_2 \longrightarrow 2CO_2 \qquad 2H_2 + O_2 \longrightarrow 2H_2O$$

Q4. Ammonium dichromate on heating decomposes according to the equation given below : 3

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + 4H_2O + Cr_2O_3$$

Calculate :

(*i*) weight of nitrogen evolved.

(*ii*) volume of nitrogen evolved at S.T.P.

(*iii*) weight of Cr_2O_3 formed.

when 126 g of Ammonium dichromate is heated.

Q5. Calculate the vapour density of the following : 4

(*i*) CO_2 (*ii*) C_2H_6

(*iii*) SO_2 (*iv*) O_2

Q6. Calculate the percentage of underlined element in the following compounds : 5

(*i*) Na_2CO_3 (*ii*) Cr_2O_3

(*iii*) H_2O_2 (*iv*) NH_3

(*v*) CO_2

At. wt: H = 1, C = 12, N = 14, O = 16, Na = 23, Cr = 52

Q7. A hydrocarbon has the following percentage composition :

C = 85.71% and H = 14.28%.

The vapour density of the hydrocarbon is 14. Calculate its molecular formula. 5

ANSWERS

2. (*i*) 2 moles (*ii*) 12×10^{23} (*iii*) 44.8 dm^3

3. 10 ml of Oxygen

4. (*i*) 14 g (*ii*) 11.2 dm^3 (*iii*) 76 g

5. (*i*) 22 (*ii*) 15 (*iii*) 32 (*iv*) 16

6. (*i*) 43.39 (*ii*) 68.42 (*iii*) 94.11

(*iv*) 82.35 (*v*) 27.27

7. C_2H_4