III. Long Answer Type Questions

Question 1. Calculate no. of carbon and oxygen atoms present in 11.2 litres of CO_2 at N.T.P.

Answer: Step I. Number of CO_2 molecules in 11.2 litres

22.4 litres of CO_2 at N.T.P. = 1 gram mol

$$11.2 \text{ litres of } CO_2 \text{ at N.T.P.} = \frac{(1 \text{ gram mol})}{(22.4 \text{ litres})} \times (11.2 \text{ litres}) = 0.5 \text{ gram mol}$$

Now 1 gram mole of CO_2 contain molecules = 6.022×10^{23}

$\therefore$ 0.5 gram mole of CO_2 contain molecules = $6.022 \times 10^{23} \times 0.5 = 3.011 \times 10^{23}$

Step II. *Number of carbon and oxygen atoms in 3.011×10^{23} molecules of CO_2*

1 molecule of CO_2 contains carbon atoms = 1

$\therefore$ 3.011×10^{23} molecules of CO_2 will contain carbon atoms = $\mathbf{3.011 \times 10^{23}}$

Similarly, 1 molecule of CO_2 contains oxygen atoms = 2

$\therefore$ 3.011×10^{23} molecules of CO_2 will contain oxygen atoms = $2 \times 3.011 \times 10^{23}$ = $\mathbf{6.022 \times 10^{23}}$ **atoms.**

Question 2. $KClO_3$ on heating decomposes to give KCl and O_2. What is the volume of O_2 at N.T.P liberated by 0.1 mole of $KClO_3$?

Answer: The chemical equation for the decomposition of $KClO_3$ is

$$\underset{2 \text{ mol}}{2KClO_3} \xrightarrow{\text{Heat}} 2KCl + \underset{\substack{3 \text{ mol} \\ (3 \times 22.4 \text{ L} = 67.2\text{L})}}{3O_2}$$

2 moles of $KClO_3$ evolve O_2 at N.T.P. = 67.2 L

$$1 \text{ mole of } KClO_3 \text{ evolve } O_2 \text{ at N.T.P.} = \frac{67.2}{2} \text{ L}$$

$$0.1 \text{ mole of } KClO_3 \text{ evolve } O_2 \text{ at N.T.P.} = \frac{67.2}{2} \times 0.1\text{L} = \mathbf{3.36 \text{ L}}$$

Question 3. 10 ml of a solution of NaCl containing KCl gave on evaporation 0.93 g of the mixed salt which gave 1.865 g of AgCl by reacting with $AgN0_3$solution. Calculate the quantity of NaCl in 10 mL of the solution.

Answer: The chemical equation for the reaction is:

$$AgNO_3 + \underset{23 + 35.5\ (= 58.5\ g)}{NaCl} \longrightarrow AgCl + \underset{108 + 35.5\ (= 143.5\ g)}{NaNO_3}$$

Let the mass of NaCl and KCl in the mixture be respectively a g and b g.

$\therefore\ a + b = 0.93$ (given)

Let us find AgCl formed on reacting NaCl and KCl with $AgNO_3$ solution.

58.5 g of NaCl give AgCl = 143.5 g

$$\therefore\ a \text{ g of NaCl will give AgCl} = \frac{(143.5\ g)}{(58.5\ g)} \times (a\ g)$$

Similarly, 74.5 g of KCl give AgCl = 143.5 g

$$b \text{ g of KCl will give AgCl} = \frac{(143.5\ g)}{(74.5\ g)} \times (b\ g)$$

But mass of AgCl actually formed = 1.865 g (given)

$$\therefore\quad \frac{143.5 \times a}{58.5} + \frac{143.5 \times b}{74.5} = 1.865; \quad \frac{143.5 \times a}{58.5} + \frac{143.5(0.93 - a)}{74.5} = 1.865$$

$$2.453\ a + 1.93(0.93 - a) = 1.865; 2.453\ a + 1.795 - 1.93\ a = 1.865$$

$$0.523\ a = 0.07 \quad \text{or} \quad a = \frac{0.07}{0.523} = 0.14$$

Mass of NaCl in the mixture = **0.14 g**

Mass of KCl in the mixture = (0.93 – 0.14) = **0.79 g.**

Question 4. The cost of table salt (NaCl) and table sugar ($C_{12}H_{22}O_{11}$) are Rs 1 per kg and Rs 6 per kg respectively.Calculate their cost per mole.

Answer:

(a) Cost of table salt (NaCl) per mole

Gram molecular mass of NaCl = 23 + 35.5 = 58.5 g Now, 1000 g of NaCl cost = Rs 2

$$\therefore\quad 58.5 \text{ g of NaCl will cost} = \frac{2}{(1000\ g)} \times (58.5\ g) = 0.117 \text{ Rupee}$$

$$= 0.117 \times 100 = \textbf{12 paise (approx.)}$$

(b) Cost of table sugar ($C_{12}H_{22}O_{11}$) per mole

Gram molecular mass of ($C_{12}H_{22}O_{11}$) = 12 x 12 + 22 x 1 = 16 x 1= 144 + 22 + 176 = 342 g

Now, 1000 g of sugar cost = Rs 6

$$\therefore\quad 342 \text{ g of sugar will cost} = \frac{6}{(1000\ g)} \times (342\ g) = 2.052$$

$$= \textbf{2.0 Rupees (approx.)}$$

Question 5. A flask P contains 0.5 mole of oxygen gas. Another flask Q contains 0.4 mole of ozone gas. Which of the two flasks contains greater number of oxygen atoms?

Answer:

1 molecule of oxygen (O_2) = 2 atoms of oxygen

1 molecule of ozone (O_3) = 3 atoms of oxygen

In flask P: 1 mole of oxygen gas = 6.022×10^{23} molecules

0.5 mole of oxygen gas = $6.022 \times 10^{23} \times 0.5$ molecules

= $6.022 \times 10^{23} \times 0.5 \times 2$ atoms = $\mathbf{6.022 \times 10^{23}}$ **atoms**

In flask Q: 1 mole of ozone gas = 6.022×10^{23} molecules

0.4 mole of ozone gas = $6.022 \times 10^{23} \times 0.4$ molecules

= $6.022 \times 10^{23} \times 0.4 \times 3$ atoms = $\mathbf{7.23 \times 10^{22}}$ **atoms**

$\therefore$ Flask Q has a greater number of oxygen atoms as compared to the flask P.

Question 6. Calculate the total number of electrons present in 1.6 g of methane.

Answer:

(*i*) Molar mass of methane (CH_4) = 12 + 4 × 1 = 16 g

16 g of methane contain molecules = 6.022×10^{23}

1.6 g of methane contain molecule = $\frac{6.022 \times 10^{23}}{(16\text{ g})} \times (1.6\text{ g}) = 6.022 \times 10^{22}$

(*ii*) *Number of electrons in 6.022×10^{22} molecules of methane*

1 molecule of methane contains electrons = 6 + 4 = 10

6.022×10^{22} molecules of methane contain electrons

$= 6.022 \times 10^{22} \times 10 = \mathbf{6.022 \times 10^{23}}$.

Question 7. The vapour density of a mixture of NO_2 and N_2O_4 is 38.3 at 27°C. Calculate the number of moles of NO_2 in 100 g of the mixture.

Answer:

Vapour density of the mixture of NO_2 and N_2O_4 = 38.3

Molecular mass of the mixture = 2 × Vapour density = 2 × 38.3 = 76.6 u = 76.6 g

Mass of the mixture = 100 g

No. of moles of the mixture = $\frac{100}{76.6}$

Let the mass of NO_2 in the mixture = x g

∴ Mass of N_2O_4 in the mixture = $(100 - x)$ g

Molar mass of NO_2 = 14 + 32 = 46 u = 46 g

Molar mass of N_2O_4 = 28 + 64 = 92 u = 92 g

No. of moles of NO_2 = $\frac{x}{46}$

No. of moles of N_2O_4 = $\frac{(100 - x)}{92}$

Total no. of moles in the mixture = $\frac{x}{46} + \frac{(100 - x)}{92}$

Equating (*i*) and (*ii*), $\frac{x}{46} + \frac{(100 - x)}{92} = \frac{100}{76.6}$

$$92x + 46(100 - x) = \frac{100}{76.6} \times 46 \times 92 = 5524.8$$

$$92x - 46x = 5524.8 - 4600 = 924.8.$$

Question 8. The Vapour Density of a gaseous element is 5 times that of oxygen under similar conditions. If the molecule is triatomic, what will be its atomic mass?

Answer: Molecular mass of oxygen = 32 u

Density of oxygen = $\frac{32}{2} = 16$ u

Density of gaseous element = 16 × 5 = 80 u

Molecular mass of gaseous element = 80 × 2 = 160 u

Atomicity of the element = 3

Atomic mass of the element = $\frac{\text{Molecular Mass}}{\text{Atomicity}} = \frac{160}{3}$ = **53.33 u.**

1/6th of its volume. Since equal volumes of gases have equal number of moles according to Avogadro's Law,

$$\therefore \quad \frac{\text{Moles of } CO_2}{\text{Moles of both gases}} = \frac{x}{(2x + y)} = \frac{1}{6}$$

or $6x = 2x + y$ or $4x = y$ or $\frac{y}{x} = 4$

∴ **Molar ratio of formic acid : oxalic acid = 4 : 1.**

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