

Problem Based on Graham's Law of Effusion / Diffusion

VERY SHORT ANSWER TYPE QUESTIONS :

VSA.1 How is density of gas related to its molar mass ?

Sol. Density of gas is directly proportional to molar mass.

VSA.2 How is molar mass of gas related to rate of diffusion ?

Sol. The rate of diffusion is inversely proportional to molecular weight.

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

VSA.3 State Graham's law of diffusion.

Sol. It states the rate of diffusion of gases is inversely proportional to square root of molecular weights at constant temperature and pressure.

VSA.4 Define effusion.

Sol. Effusion is process of diffusion taking place from a tiny hole.

SHORT ANSWER TYPE QUESTIONS :

SA.1 Equal volumes of two gases A and B diffuse through a porous pot in 20 and 10 seconds respectively. If molar mass of A be 80, find the molar mass of 'B'.

Sol.
$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}, V_1 = V_2$$

$$\frac{\frac{V}{t_1}}{\frac{V}{t_2}} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$$

$$\Rightarrow \frac{10}{20} = \sqrt{\frac{M_2}{80}} \Rightarrow \frac{1}{4} = \frac{M_2}{80}$$

$$\Rightarrow M_2 = 20 \text{ g ml}^{-1}.$$

SA.2 Through two ends of a glass tube of length 200 cm HCl and NH₃ gases are allowed to enter. At what distance ammonium chloride will first appear ?

Sol.
$$\frac{r_{\text{NH}_3}}{r_{\text{HCl}}} = \frac{\ell_1}{200 - \ell_1} = \sqrt{\frac{M_{\text{HCl}}}{M_{\text{NH}_3}}}$$

$$\Rightarrow \frac{\ell_1}{200 - \ell_1} = \sqrt{\frac{36.5}{17}}, \frac{\ell_1}{200 - \ell_1} = \sqrt{2.147} = 1.465$$

$$\ell_1 = 293 - 1.465 \ell_1$$

$$2.465 \ell_1 = 293$$

$$\ell_1 = \frac{293}{2.465} = 118.88 \text{ cm}$$

$$200 - \ell_1 = 200 - 118.88 = 81.12 \text{ cm from HCl end.}$$

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SA.3 For 10 minutes each, at 27°C, from two identical holes, nitrogen and an unknown gas are leaked into common vessel of 3L capacity. The resulting pressure is 4.81 bar and the mixture contains 0.4 mole of nitrogen. What is the molar mass of the unknown gas ?

Sol. Moles of N₂ diffused = 0.4 mole in 10 min.

Moles of unknown gas diffused = n₁ moles in 10 min

$$n = \frac{PV}{RT} = \frac{4.81 \times 3}{0.083 \times 300} = \frac{12.54}{24.90} = 0.5036$$

Number of moles of unknown gas = 0.5036 - 0.4 = 0.1036

$$\frac{r_{N_2}}{r_g} = \sqrt{\frac{M_g}{28}}$$

$$\Rightarrow \frac{r_{N_2}}{t} \times \frac{t}{n_g} = \sqrt{\frac{M}{28}}$$

$$\Rightarrow \frac{0.4}{0.1036} \times \frac{10}{10} = \sqrt{\frac{M}{28}}$$

$$\Rightarrow M = 417.18 \text{ g mol}^{-1}$$