

Solution

1. According to Charles' law,  $V \propto T$  or  $\frac{V}{T} = \text{constant} = \frac{1}{P}$

As in graph, slope at  $P_2$  is more than slope at  $P_1$ .

$$\therefore P_1 > P_2$$

2. RMS speed,

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$\text{Most probable speed, } v_p = \sqrt{\frac{2RT}{M}}$$

$$\text{So, } \frac{v_{\text{rms}}}{v_p} = \sqrt{\frac{3}{2}}; \text{ Hence, } v_{\text{rms}} = \sqrt{\frac{3}{2}} v_p$$

3. For 2 moles Helium, n moles Hydrogen

$$v_{\text{rms}} = \sqrt{2} v$$

$$\Rightarrow \sqrt{\frac{3RT}{M_{\text{mix}}}} = \sqrt{2} \sqrt{\frac{\gamma_{\text{mix}} RT}{M_{\text{mix}}}}$$

$$\Rightarrow \sqrt{3} = \sqrt{2} \sqrt{\gamma_{\text{mix}}} \Rightarrow 3 = 2\gamma_{\text{mix}} \quad \dots (i)$$

$$\text{As, } \gamma_{\text{mix}} = \frac{n_1 C_{p1} + n_2 C_{p2}}{n_1 C_{v1} + n_2 C_{v2}}$$

$$\Rightarrow \frac{3}{2} = \frac{\frac{5}{2} \cdot R \times 2 + n \times \frac{7R}{2}}{2 \times \frac{3R}{2} + n \times \frac{5R}{2}} \quad (\text{Using (i)})$$

$$\Rightarrow \frac{3}{2} = \frac{10R + 7nR}{6R + 5nR}$$

$$\Rightarrow 18R + 15nR = 20R + 14nR$$

$$\Rightarrow nR = 2R; n = 2$$

4. Mass,  $m = 5 \times 10^{-17}$  kg,  $T = 273$  K

$$K = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

$$v_{\text{rms}} = \sqrt{\frac{3KT}{m}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 273}{5 \times 10^{-17}}}$$

$$\Rightarrow v_{\text{rms}} = 15 \text{ mm s}^{-1}$$

5. Ratio of number of molecules is 1: 4.

As per ideal gas equation,  $PV = nRT$

V and T are same in both vessels.

$$\therefore \frac{P_1}{P_2} = \frac{n_1}{n_2} = \frac{1}{4}$$

$$\text{Ratio of rms velocities } \frac{v_{rms1}}{v_{rms2}} = \sqrt{\frac{T_1}{T_2}} = 1$$

6. For ideal gas,  $PV = nRT$ . So, the graph for  $PV \propto T$  is a straight line with positive slope.

$$7. v_{RMS} = \sqrt{\frac{3RT}{M}}$$

So,  $m_A < m_B < m_C$  and  $v_A > v_B > v_C$ ,

$$\text{or } \frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$$

8. For adiabatic expansion of an ideal gas;  $PV^\gamma = \text{constant} \Rightarrow \ln P + \gamma \ln V = \text{constant}$

On differentiating both sides

$$\left(\frac{dP}{P}\right) + \gamma \left(\frac{dV}{V}\right) = 0$$

So, fractional change in pressure,

$$\therefore \frac{dP}{P} = -\gamma \frac{dV}{V}$$

9. Number of moles of  $O_2$ ,

$$n_1 = \frac{16}{32} = 0.5 \text{ mole}$$

$$\text{Number of moles of } N_2 \text{ is } n_2 = \frac{28}{28} = 1 \text{ mole}$$

Number of moles of  $CO_2$ ,

$$n_3 = \frac{44}{44} = 1 \text{ mole}$$

Total number of moles,  $n = n_1 + n_2 + n_3$

$$\therefore \text{Now } n = 0.5 + 1 + 1 = \frac{5}{2} \text{ moles}$$

$$\text{Now, } PV = nRT, P = \frac{nRT}{V} = \left(\frac{5}{2}\right) \left(\frac{RT}{V}\right)$$

10.  $V = 500 \text{ cm}^3$ ,  $T = 300 \text{ K}$ ,  $P = 400 \text{ kPa}$

Say total number of moles is n. By using ideal gas equation,  $PV = nRT$

$$400 \times 10^3 \times 500 \times 10^{-6} = n \times 8.314 \times 300$$

$$n = \frac{2}{25}, n = n_O + n_H, \frac{2}{25} = \frac{M_O}{32} + \frac{M_H}{2}$$

$$M_O + M_H = 0.76 \quad (\text{Given})$$

$$\therefore \frac{M_O}{M_H} = \frac{16}{3}$$

$$11. \quad U = 3PV + 4, \frac{nFRT}{2} = 3PV + 4$$

$$\frac{F}{2}PV = 3PV + 4 \quad (\because PV = nRT)$$

$$F = 6 + \frac{8}{PV}$$

Since degree of freedom is more than 6, so gas is polyatomic.

$$12. \quad \text{Ideal gas equation, } PV = nRT$$

As temperature is constant.

$$PV = \text{constant} \Rightarrow P \frac{m}{\rho} = \text{constant}$$

$$P \propto \rho \quad (\text{for given } m)$$

$$13. \quad v_{\text{rms}} = \sqrt{\frac{3RT}{m}}$$

$$\Rightarrow \frac{(v_{\text{rms}})_{\text{He}}}{(v_{\text{rms}})_{\text{Ar}}} = \sqrt{\frac{40}{4}} = \sqrt{10} = 3.16$$

$$14. \quad \text{The final temperature of the mixture is}$$

$$T_{\text{mixture}} = \frac{T_1 n_1 + n_2 T_2 + n_3 T_3}{n_1 + n_2 + n_3}$$

$$15. \quad PV = nRT = \frac{m}{M} RT \Rightarrow PM = \rho RT$$

$$\frac{\rho_1}{\rho_2} = \frac{P_1 M_1}{P_2 M_2} = \left(\frac{P_1}{P_2}\right) \times \left(\frac{M_1}{M_2}\right) = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$$

Here  $\rho_1$  and  $\rho_2$  are the densities gases in the vessel containing the mixture.