DPP 04

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,

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

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

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

3. For 2 moles Helium, n moles Hydrogen

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

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

$$\Rightarrow \sqrt{3} = \sqrt{2}\sqrt{\gamma_{mix}} \Rightarrow 3 = 2\gamma_{mix} \qquad \ldots (i)$$

$$\text{As, } \gamma_{mix} = \frac{n_1C_{p1} + n_2C_{p2}}{n_1C_{v1} + n_2C_{v2}}$$

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

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

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

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

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

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

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

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

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

As per ideal gas equation, $PV = nRT$

V and T are same in both vessels.

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

Ratio of rms velocities $\frac{V_{rms_1}}{V_{rms_2}} = \sqrt{\frac{T_1}{T_2}} = 1$

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 $v_A > v_B > v_C$,

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,

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

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

Number of moles of CO_2,

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

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

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

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

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

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

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

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

$M_O + M_H = 0.76$ (Given)

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

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

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

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

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

12. Ideal gas equation, $PV = nRT$

As temperature is constant.

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

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

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

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

14. The final temperature of the mixture is

$T_{mixture} = \frac{T_1n_1 + n_2T_2 + n_3T_3}{n_1 + n_2 + n_3}$

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

$\frac{\rho_1}{\rho_2} = \frac{P_1M_1}{P_2M_2} = \left(\frac{P_1}{P_2}\right) \times \left(\frac{M_1}{M_2}\right) = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$

Here ρ_1 and ρ_2 are the densities gases in the vessel containing the mixture.