Question 11. A student forgot to add the reaction mixture to the round bottomed flask at 27 °C but instead, he/she placed the flask on the flame. After a lapse of time, he realized his mistake, and using a pyrometer, he found the temperature of the flask was 477 °C. What fraction of air would have been expelled out?
Answer:

Suppose volume of vessel $= V\ cm^3$

i.e., volume of air in the flask at 27°C $= V\ cm^3$.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}, \quad i.e., \quad \frac{V}{300} = \frac{V_2}{750} \quad \text{or} \quad V_2 = 2.5\ V$$

$$\therefore \quad \text{Volume expelled} = 2.5\ V - V = 1.5\ V$$

$$\therefore \quad \text{Fraction of air expelled} = \frac{1.5\ V}{2.5\ V} = \frac{3}{5}$$

Question 12.Calculate the temperature of 4.0 moles of a gas occupying 5 dm^3 at 3.32 bar (R = 0.083 bar $dm^3\ K^{-1}\ mol^{-1}$)
Answer:

$$PV = nRT \quad \text{or} \quad T = \frac{PV}{nR} = \frac{3.32\ \text{bar} \times 5\ \text{dm}^3}{4.0\ \text{mol} \times 0.083\ \text{bar dm}^3\ \text{K}^{-1}\text{mol}^{-1}} = \mathbf{50K}$$

Question 13. Calculate the total number of electrons present in 1.4 g of dinitrogen gas.
Answer:
Molecular mass of N_2 = 28g
28 g of N_2 has No. of molecules = 6.022 x 10^{23} 1.4 g of
N_2 has No. of molecules = 6.022 x 10^{23} x 1.4 g/28 g
= 3.011 x 10^{22} molecules.
Atomic No. of Nitrogen (N) = 7
1 molecule of N_2 has electrons = 7 x 2 = 14
3.011 x 10^{22} molecules of N_2 have electrons
= 14 x 3.011 x 10^{22}
= 4.215 x 10^{23} electrons.

Question 14. How much time would it take to distribute one Avogadro number of wheat grains if 10^{10} grains are distributed each second ?
Answer:

Time taken to distribute 10^{10}grains = 1s

$$\text{Time taken to distribute} = 6.022 \times 10^{23}\ \text{grains}$$

$$= \frac{1s \times 6.022 \times 10^{23}\ \text{grains}}{10^{10}\ \text{grains}}$$

$$= \frac{6.022 \times 10^{13}}{60 \times 60 \times 24 \times 365} = \mathbf{1.9 \times 10^6\ yr.}$$

Question 15. Calculate the total pressure in a mixture of 8g of oxygen and 4g of hydrogen confined in a vessel of I dm^3 at 27°C. R = 0.083 bar $dm^3\ K^{-1}\ mol^{-1}$.
Answer:

Molar mass of O_2 = 32 g mol^{-1} $\therefore$ 8 g $O_2 = \frac{8}{32}$ mol = 0.25 mol

Molar mass of H_2 = 2 g mol^{-1} $\therefore$ 4 g $H_2 = \frac{4}{2}$ = 2 mol

$\therefore$ Total number of moles (n) = 2 + 0.25 = 2.25

$$V = 1\ dm^3,\quad T = 27°C = 300\ K,\ R = 0.083\ bar\ dm^3\ K^{-1}\ mol^{-1}$$

$$PV = nRT$$

or

$$P = \frac{nRT}{V} = \frac{(2.25\ mol)(0.083\ bar\ dm^3 K^{-1} mol^{-1})(300\ K)}{1\ dm^3}$$

$$= \mathbf{56.025\ bar}$$

Question 16. Pay load is defined as the difference between the mass of the displaced air and the mass of the balloon. Calculate the pay load when a balloon of radius 10 m, mass 100 kg is filled with helium at 1.66 bar at 27°C (Density of air = 1.2 kg m^{-3} and R = 0.083 bar dm^3 K^{-1} mol^{-1}).

Answer:

Radius of the balloon = 10 m

$\therefore$ Volume of the balloon $= \frac{4}{3}\pi r^3 = \frac{4}{3}\times\frac{22}{7}\times(10\ m)^3 = 4190.5\ m^3$

Volume of He filled at 1.66 bar and 27 °C = 4190.5 m^3

Calculation of mass of He

$$PV = nRT = \frac{w}{M}RT$$

or

$$w = \frac{MPV}{RT} = \frac{(4\times10^{-3}\ kg\ mol^{-1})(1.66\ bar)(4190.5\times10^3\ dm^3)}{(0.083\ bar\ dm^3\ K^{-1}\ mol^{-1})(300\ K)}$$

$$= 1117.5\ kg$$

Total mass of the balloon alongwith He = 100 + 1117.5 = 1217.5 kg

Maximum mass of the air that can be displaced by balloon to go up = Volume × Density

$= 4190.5\ m^3 \times 1.2\ kg\ m^{-3} = 5028.6\ kg$

$\therefore$ Pay load = 5028.6 – 1217.5 kg = **3811.1 kg**

Question 17. Calculate the volume occupied by 8.8 g of CO_2 at 31.1 °C and 1 bar pressure. R = 0.083 bar LK^{-1} mol^{-1}

Answer:

$$\text{No. of moles of } CO_2\ (n) = \frac{\text{Mass of } CO_2}{\text{Molar mass}} = \frac{8.8\ g}{44 g\ mol^{-1}} = 0.2\ mol$$

Pressure of CO_2 (P) = 1 bar

R = 0.083 bar LK^{-1} mol^{-1}

Temperature (T) = 273 + 31.1 = 304.1 K

Since from gas eq. $PV = nRT$

$$V = \frac{nRT}{P} = \frac{0.2\times0.083\times304.1}{1\ bar}$$

$$= \mathbf{5.048\ L}$$

Question 18. 2.9 g of a gas at 95°C occupied the same volume as 0.184 g of hydrogen at 17°C at the same pressure. What is the molar mass of the gas ?

Answer:

As $P_1 = P_2$ and $V_1 = V_2$,

$\therefore$ $P_1V_2 = P_2V_2$, *i.e.*, $n_1RT_1 = n_2RT_2$ $\therefore$ $n_1T_1 = n_2T_2$

or $\frac{w_1}{M_1}T_1 = \frac{w_2}{M_2}T_2$

$$\frac{2.9}{M_x}\times(95+273) = \frac{0.184}{2}\times(17+273) \quad \text{or} \quad M_x = \frac{2.9\times368\times2}{0.184\times290} = \mathbf{40\ g\ mol^{-1}}$$

Question 19. A mixture of dihydrogen and dioxygen at one bar pressure contains 20% by weight of dihydrogen. Calculate the partial pressure of dihydrogen.

Answer: As the mixture H_2 and O_2 contains 20% by weight of dihydrogen, therefore, if H_2 = 20g, then O_2 = 80g

$$n_{H_2} = \frac{20}{2} = 10 \text{ moles}, \quad n_{O_2} = \frac{80}{32} = 2.5 \text{ moles}$$

$$p_{H_2} = \frac{n_{H_2}}{n_{H_2} + n_{O_2}} \times P_{total} = \frac{10}{10+2.5} \times 1 \text{ bar} = \mathbf{0.8\ bar}$$

Question 20. What would be the SI unit for the quantity PV^2T^2/n?
Answer:

$$\frac{(\mathrm{Nm}^{-2})\,(\mathrm{m}^3)^2\,(\mathrm{K})^2}{\mathrm{mol}} = \mathbf{Nm^4\ K^2\ mol^{-1}}$$

Question 21. In terms of Charles' law explain why -273°C is the lowest possible temperature.
Answer: At -273°C, volume of the gas becomes equal to zero, i.e., the gas ceases to exist.

Question 22. Critical temperature for Co_2 and CH_4 are 31.1°C and -81.9°C respectively. Which of these has stronger intermolecular forces and why ?
Answer: Higher the critical temperature, more easily the gas can be liquefied, i.e., greater are the intermolecular forces of attraction. Hence, Co_2 has stronger intermolecular forces than CH_4.

Question 23. Explain the physical significance of vander Waals parameters.
Answer: 'a' is a pleasure of the magnitude of the intermolecular forces of attraction, while b is a measure of the effective size of the gas molecules.

*********** END **********