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 = $V\ cm^3$.

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

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

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

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

Time taken to distribute = 6.022 × $10^{23}$ 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:

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

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

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

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

$$PV = nRT$$

or

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

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

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

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

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

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

$$= 1117.5 \text{ kg}$$

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

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

$$\therefore \quad \text{Pay load} = 5028.6 - 1217.5 \text{ kg} = \mathbf{3811.1 \text{ kg}}$$

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:

$$\text{No. of moles of } CO_2 \ (n) = \frac{\text{Mass of } CO_2}{\text{Molar mass}}$$

$$= \frac{8.8 \text{ g}}{44 \text{g mol}^{-1}} = 0.2 \text{ mol}$$

$$\text{Pressure of } CO_2 \ (P) = 1 \text{ bar}$$

$$R = 0.083 \text{ bar LK}^{-1} \text{ mol}^{-1}$$

$$\text{Temperature } (T) = 273 + 31.1$$

$$= 304.1 \text{ K}$$

$$\text{Since from gas eq. } PV = nRT$$

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

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

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.,* $n_1RT_1 = n_2RT_2 \quad \therefore \quad n_1T_1 = n_2T_2$

or

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

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

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

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

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

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

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

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 **********