Problem Based on Dalton's Law of Partial Pressure

VERY SHORT ANSWER TYPE QUESTIONS :

VSA.1 State Dalton's law of partial pressure.

Sol. It states whenever two or more gases which do not react chemically, are enclosed in vessel, the total pressure is equal to sum of partial pressure of each gas.

VSA.2 Give most common application of Dalton's law.

Sol. The air pressure decreases with increase in altitude. That is why jet aeroplane flying at high altitude need pressurization of the cabin so that partial pressure of oxygen is sufficient for breathing.

VSA.3 Why is moist air lighter than dry air ?

Sol. Moist air has water vapour which has lower vapour density (18/2 = 9) than dry air, which has vapour density, equal to 14.4 that is why moist air is lighter than dry air.

VSA.4 How is the partial pressure of a gas in a mixture related to the total pressure of the gaseous mixture ?

Sol. Partial pressure of a gas = mole fraction of that gas x total pressure.

SHORT ANSWER TYPE QUESTIONS :

SA.1 A 5.0 L flask contains 10g of SO_3 and 1.00 g of He at 20ºC. Calculate partial pressure of SO_3 and He and total pressure.

Sol. $nHe = \frac{m}{M} = \frac{1.0}{4.0} = 0.25$ ml,

$nSO_3 = \frac{m}{M} = \frac{10}{80} = 0.125$ mol

$PV = nRT$

$P_1 \times 5 = 0.25 \times 0.0821 \times 293$ K

$P_1 = 0.601$ atm.

$PV = nRT$

$P_2 \times 5 = 0.125 \times 0.0821 \times 293$

$\Rightarrow$ $P = 1.202$ atm.

$P = P_1 + P_2 = 0.601$ atm $+ 1.202$ atm $= 1.0803$ atm.

SA.2 What will be the pressure of gas mixture when 0.5 L of H_2 at 0.8 bar and 2.0 L of oxygen at 0.7 bar are introduced in the container at 27ºC.

Sol. $P_1V_1 = P_2V_2$

0.8×0.5 L $= 1$L $\times P_2$

$P_2 = 0.4$ bar

$P_1 V_1 = P_2 V_2$

0.7 bar $2.0 = P_2 \times 1$

$\Rightarrow$ $P_2 = 1.4$ bar

Total pressure = 0.4 bar + 1.4 bar = 1.8 bar.

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SA.3 A manometer is connected to a gas containing bulb. The open arm reads 43.7 cm whereas the arm connected to the bulb reads 15.6 cm. If the barometeric pressure is 743 mm mercury, what is the pressure of the gas in bar ?

Sol. Pressure of gas = Atmospheric pressure + Difference between levels of Hg

= 743 mm + (43.7 cm – 15.6 cm)

= 74.3 cm + 28.1 cm

P = 102.4 cm

P in bar = $\frac{102.4}{76}$ = 1.347 bar.

SA.4 A mixture of hydrogen and oxygen at one bar pressure contains 20% by weight of hydrogen. Calculate the partial pressure of hydrogen.

Sol. $pH_2 = \frac{n_{H_2} \times P}{n_{H_2} + n_{O_2}} = \frac{\frac{20}{2}}{\frac{20}{2} + \frac{80}{32}} \times 1$

$= \frac{10}{10 + \frac{5}{2}} \times 1 = \frac{10 \times 2}{25} = \frac{20}{25} = 0.8$ bar.

SA.5 A gaseous mixture contains 2.2 bar, He, 1.1 bar H_2 and 4.2 bar N_2. What is mole fraction of N_2?

Sol. Mole fraction of N_2 = $= \frac{4.2}{4.2 + 1.1 + 2.2} = \frac{4.2}{7.5} = 0.56$

SA.6 Pay load is defined as difference between the mass of displaced air and the mass of balloon. Calculate the pay load when a balloon of radius 10m, mass 100 kg is filled with helium at 1.66 bar at 27ºC. [Density of air 1.2 kg m^{-3} and R = 0.083 bar dm^3 K^{-1} mol^{-1}]

Sol. $V = \frac{4}{3}\pi r^3 = \frac{4}{3} \times \frac{22}{7} \times (10m)^3 = \frac{88000}{21} = 4190.476 m^3$

Mass of displaced air = V × D = 4190.476 m^3 × 1.2 kgm^{-3} = 5028.57 g

PV = nRT

1.66 × 4190.476 × 10^3 = n × 0.083 × 300

$n = \frac{1.66 \times 4190.476 \times 10^3}{0.083 \times 300} = \frac{6956.18}{24.9} = 279.36 \times 10^3$ moles

Mass of He = 279.36 × 10^3 × 4

Mass of He = 1117.44 kg, $\frac{\text{Mass of balloon} = 100.00\,\text{kg}}{\text{Total Mass} = 1217.44\,\text{kg}}$

Pay load = 5028.27 – 1217.52 = 3810.75.

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SA.7 A given mass of a gas occupies 919.0 ml in dry state at STP. The same mass when collected over water at 15ºC and 750 mm pressure occupies one litre volume. Calculate the vapour pressure of water at 15ºC.

Sol. **Step 1 :** To calculate the pressure of the dry gas at 15ºC and 750 mm pressure using the gas equation

Given conditions at STP	Final conditions
V_1 = 919 ml	V_2 = 1000 ml
P_1 = 760 mm	P_2 = ? (Dry state)
T_1 = 273 K,	T_2 = 273 + 15 = 288 K

By applying gas equation, we have

$$\frac{919 \times 760}{273} = \frac{P_2 \times 1000}{288}$$

or $$P_2 = \frac{919 \times 760 \times 288}{1000 \times 273} = 736.7 \text{ mm.}$$

Step 2 : To calculate the vapour pressure of water at 15ºC.

Vapour pressure of water = Pressure of the moist gas – Pressure of the dry gas,

= 750 – 736.7 = 13.3 mm.