2.7. Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the quantity of CO_2 in 500 mL of soda water when packed under 2.5 atm CO_2 pressure at 298 K.
Ans.:

$$= \frac{1000}{18} = 55.55 \text{ moles}$$

$$\therefore \; x_{H_2S} = \frac{0.195}{0.195 + 55.55}$$

$$= \frac{0.195}{55.745} = 0.0035$$

– Pressure at STP = 0.987 bar

Applying Henry's law,

$$P_{H_2S} = K_H \times x_{H_2S}$$

$$\Rightarrow \quad K_H = \frac{P_{H_2S}}{x_{H_2S}} = \frac{0.987}{0.0035} = 282 \text{bar}$$

2.8. The vapour pressure of pure liquids A and B are 450 and 700 mm Hg respectively, at 350 K. Find out the composition of the liquid mixture if total vapour pressure is 600 mm Hg. Also find the composition of the vapour phase.
Ans:

$$K_H = 1.67 \times 10^8 \text{ Pa}$$
$$P_{CO_2} = 2.5 \text{ atm} = 2.5 \times 101325 \text{ Pa}$$

$$\therefore \; x_{CO_2} = \frac{P_{CO_2}}{K_H} = \frac{2.5 \times 101325}{1.67 \times 10^8} = 1.517 \times 10^{-3}$$

For 500 mL of soda water, water present $\simeq$ 500 mL

$$= 500\text{g} = \frac{500}{18} = 27.78 \text{ moles}$$

$$\therefore \quad n_{H_2O} = 27.78 \text{ moles}$$

$$\therefore \quad \frac{n_{CO_2}}{27.78} = 1.517 \times 10^{-3}$$

$$n_{CO_2} = 42.14 \times 10^{-3} \text{ mole}$$
$$= 42.14 \text{ m mol}$$
$$= 42.14 \times 10^{-3} \times 44 \text{ g}$$
$$= 1.854 \text{ g}$$

2.9. Vapour pressure of pure water at 298 K is 23.8 m m Hg. 50 g of urea (NH_2CONH_2) is dissolved in 850 g of water. Calculate the vapour pressure of water for this solution and its relative lowering.
Ans:

$P^o = 23.8$ mm
$w_2 = 50$g, M_2 (urea) $= 60$g mol^{-1}
$w_1 = 850$ g, M_1 (water) $= 18$g mol^{-1}
To find: P_s and $(P^o - P_s)/P^o$
Solution: Applying Raoult's law,

$$\frac{P^o - P_s}{P^o} = \frac{n_2}{n_1 + n_2} = \frac{w_2 / M_2}{w_1 / M_1 + w_2 / M_2}$$

$$\therefore \quad \frac{P^o - P_s}{P^o} = \frac{50/60}{850/18 + 50/60}$$

$$= \frac{0.83}{47.22 + 0.83} = 0.017$$

Putting $P^o = 23.8$ mm, we have

$$\frac{23.8 - P_s}{P_s} = 0.017$$

$$\Rightarrow \quad 23.8 - P_s = 0.017 P_s$$
$$\text{or,} \quad 1.017 P_s = 23.8$$
$$\text{or,} \quad \mathbf{P_s = 23.4 \text{ mm}}$$

2.10. Boiling point of water at 750 mm Hg is 99.63°C. How much

sucrose is to be added to 500 g of water such that it boils at 100°C.
Ans:

Given $\Delta T_b = 100 - 96.63 = 3.37°$
Mass of water, $w_1 = 500$ g
Molar mass of water, $M_1 = 18 g\ mol^{-1}$
Molar mass of sucrose, $M_2 = 342 g\ mol^{-1}$
To find: Mass of sucrose, $w_2 = ?$
Solution: We know, $\Delta T_b = K_b \times m$

$$= K_b \times \frac{w_2}{M_2} \times \frac{1000}{w_1}$$

$$\Rightarrow w_2 = \frac{M_2 \times w_1 \times \Delta T_b}{1000 \times K_b} = \frac{342 \times 500 \times 3.37}{1000 \times 0.52}$$

$w_2 = 1108.2$ g
$\therefore$ Mass of solute, $w_2 = 1.11$ kg

2.11. Calculate the mass of ascorbic acid (Vitamin C, $C_6H_8O_6$) to be dissolved in 75 g of acetic acid to lower its melting point by 1.5°C. $K_f = 3.9$ K kg mol^{-1}.
Ans:
Given: $\Delta T_f = 1.5°$
Mass of CH_3COOH, $w_1 = 75$g

$$M_1 = 60\ g\ mol^{-1}$$
$$M_2 (C_6H_8O_6) = 176\ g\ mol^{-1}$$
$$K_f = 3.9\ K\ kg\ mol^{-1}$$

To find: $w_2 = ?$

Solution: Applying $M_2 = \frac{1000 K_f w_2}{w_1 \Delta T_f}$

or, $$w_2 = \frac{M_2 \times w_1 \times \Delta T_f}{1000 \times K_f}$$

$$w_2 = \frac{176 \times 75 \times 1.5}{1000 \times 3.9} = 5.077\ g$$

2.12. Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185,000 in 450 mL of water at 37°C.
Ans:

Given: $V = 450\,mL = 0.45\,L$

$T = 37°C = 310\,K$

$R = 8.314\,kPa\,L\,K^{-1}\,mol^{-1}$

To find: $\pi = ?$

Solution: Applying the formula,

$$\pi = CRT = \frac{n}{V}RT$$

$$n = \frac{1.0g}{185,000g\,mol^{-1}}$$

$$\therefore P = \frac{1}{185,000} \times \frac{1}{0.45} \times 8.314$$

$$\times 10^3\,Pa\,LK^{-1}\,mol^{-1} \times 310K$$

$$= 30.96\,Pa$$

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