2.q) Vapour pressure of pure water at 298 K is 23.8 mm Hg. 50g 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.

Sol: ~~According to~~ Raoult's law,

$P^0_A = 23.8$ mm, $W_B = 50g$, $W_A = 850g$

$M_B = 60 g\,mol^{-1}$, $M_A = 18 g\,mol^{-1}$

According to Raoult's law

$$\frac{P^0_A - P_S}{P_S} = \frac{n_B}{n_A} = \frac{W_B \times M_A}{W_A \times M_B}$$

$$\frac{P^0_A - P_S}{P_S} = \frac{50 \times 18}{60 \times 850} = 0.0176.$$

$$\frac{P^0_A}{P_S} - 1 = 0.0176 \Rightarrow \frac{P^0_A}{P_S} = 0.0176 + 1$$

$$\Rightarrow \frac{P^0_A}{P_S} = 1.0176$$

$$P_S = \frac{P^0_A}{1.0176}$$

$$P_S = \frac{P^\circ_A}{1.0176} = \frac{23.8 \text{ mm}}{1.0176} = 23.39 \text{ mm}$$

Relative lowering in vapour pressure $= \frac{P^\circ_A - P_S}{P^\circ_A}$

$$= \frac{23.8 - 23.39}{23.8}$$

$$= 0.0172$$

Q.10 Boiling ~~water~~ point of water at 750 mm Hg is 99.63°C. How much sucrose is to be added to 500g water such that it boils at 100°C. ($K_b$ for water = 0.52 K kg $mol^{-1}$)

Sol: ~~$T_b$ 99.63°C = 99.63°C + 273 = 372.63 K~~.

Molar mass of sucrose ($C_{12}H_{22}O_{11}$) ($M_B$) = 12×12 + 22×1 + 11×16 = 342 g $mol^{-1}$

Mass of water = 500 g = 0.5 kg

$\Delta T_b$ = 100°C − 99.63°C = 0.37°C = 0.37 K.

$K_b$ = 0.52 K · kg $mol^{-1}$ (learn it).

$$W_B = \frac{M_B \times \Delta T_b \times W_A}{K_b} = \frac{342 \times 0.37 \times 0.5}{0.52 K}$$

$$= 121.7 \text{ g}.$$

Q.11. Calculate the mass of ascorbic acid (V.t.C, $C_6H_8O_6$) to be dissolved in 75g of acetic acid to lower its melting point by 1.5°C. $K_f = 3.9\ K\,Kg\,mol^{-1}$.

Sol: Molar mass ascorbic acid = $6\times12 + 8\times1 + 6\times16$

$(M_B) = 72 + 8 + 96$

$= 80 + 96 = 176\ g\,mol^{-1}$.

Mass of acetic acid $(W_A) = 75g = 0.075\ kg$.

$\Delta T_f = 1.5°C = 1.5\ K$.

~~Molar mass of ascorbic~~

$K_f = 3.9\ K\,Kg\,mol^{-1}$.

$$W_B = \frac{M_B \times \Delta T_f \times W_A}{K_f}$$

$$= \frac{176 \times 1.5 \times 0.075}{3.9} = 5.08g.$$

Q.12. Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0g of polymer of molar mass 185,000 in 450 mL of water at 37°C.

Sol: Mass of polymer $(W_B) = 1.0\ g$

Molar mass of polymer $(M_B) = 185,000\ g\,mol^{-1}$.

Vol. of solution $(V) = 450ml = 0.450L$.

$T_2$ 37°C = 37 + 273 = 310 K.

$R = 8.314 \times 10^3\ Pa\ L\,K^{-1}\,mol^{-1}$.

$$\pi = \frac{1.0 \times 8.314 \times 10^{3} \times 310}{185000 \times 0.450}$$

$$= 30.96 \text{ Pa}$$