Relative Molecular Mass And Mole.

Q. 1. Why water cannot be separated completely from ethyl alcohol by fractional distillation?

Ans. Ethyl alcohol and water (95.4% ethyl alcohol and 4.6% water) form constant boiling mixture (azeotrope) boiling at 351.1 °K. Hence, further water cannot be separated completely from ethyl alcohol by fractional distillation.

Q. 2. Which colligative property is preferred for the molar mass determination of macro molecules ? Why ?

Ans. Osmotic pressure is preferred over all other colligative properties because:
(a) even in dil. soln the osmotic pressure values are appreciably high and can be measured accurately.
(b) osmotic pressure can be measured at room temp. on the other hand elevation in B. P. is measured at high temp. where the solute may decompose. The depression in freezing point is measured at low temp.

Q.3. The osmotic pressure of human blood is 7.65 atm at 37°C. For injecting glucose solution it is necessary the glucose solution has same osmotic pressure as of human blood. Find the molarity of glucose solution having same osmotic pressure as of human blood.

(Ans) $\pi = CRT = \frac{n}{v}RT$

$$7.65 = \frac{n}{v} \times 0.0821 \times (37 + 273\ K)$$

$$\frac{n}{v} = \frac{7.65}{0.0821 \times 310} = 0.30\ mol/L$$

$$\frac{n}{v} = \frac{moles}{Litre} = Molarity = 0.30$$

Q. 4. Ethylene glycol solution having molality 0.5 is used as coolant in a car. Calculate the freezing point of solution (given **K_f =1.86 °C/mole)**

Ans.

$$\begin{aligned} \Delta T_f &= k_f \times m \\ &= 1.86 \times 0.5 \\ &= 0.93°C. \\ \Delta T_f &= T_f^{\circ} - T_f \end{aligned}$$

or

$$\begin{aligned} T_f &= T_f^{\circ} - \Delta T_f \\ &= 0 - 0.93 \\ &= -0.93°C \end{aligned}$$

Q. 5. How did Van't Hoff explain the abnormal molecular masses of electrolytes like KCl in water and non-electrolytes like benzoic acid in benzene.

Ans. The molecular mass of KCl in aqueous medium has been observed to be almost half than expected and it has been explained as dissociation of KCl into K^+ ions and Cl^- ions when actual no. of particles become double and so become the colligative properties but since molecular mass is always inversely proportional to colligative property it becomes almost half.
In case of benzoic acid in benzene, association of molecules takes place when they dimerise and their no. becomes almost half and so molecular mass doubles as a result.

Q. 6. When a non-volatile solute is added to pure water its vapour pressure decreases by 4 mm Hg. Calculate molality of solution. (Vapour pressure of pure water is 40mm Hg)

Ans. Relative lowering of vapour pressure is equal to the mole fraction of non-volatilesolute.

$$\frac{\Delta p}{p^\circ} = x_B = \frac{4}{40} = 0.1$$

0.1This means solution has 0.1 moles of solute present in 0.9 moles of water.
Therefore, the mass of water in the solution = = 0.9 x 18 = 16.2gNo of moles of water x Molecular weight of water

Molality of solution $= \dfrac{\text{Moles of solute}}{\text{Mass of solvent in kg}} = \dfrac{0.1}{16.2/1000} = 6.17\ \text{m}$

Q. 7. 45 g of ethylene glycol ($C_2H_6O_2$) is mixed with 600 g water. Calculate: (a) freezing point depression (b) freezing point of solution given that K_f for water = 1.86 K kg mol^{-1}

Ans.

$$\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$$

$$\Delta T_f = \frac{1.86 \times 45 \times 1000}{62 \times 600} = 2.25$$

$$\Delta T_f = T_o - T_1 = 273 - T_1$$

$$T_1 = 273 - 2.25 = 270.5\ K$$

Q. 8. The vapour pressure of pure benzene at a certain temperature is 0.850 bar. A non volatile non-electrolyte solid weighing 0.5 g is added to 39 g of benzene. The vapour pressure of the solution is 0.845 bar. What is the molar mass of the solid substance ?

Ans. Given p° = 0.850 bar, p = 0.845 bar
Molar Mass of solvent (M_1) = 78 g/mol,
Mass of Solvent w_1
= 39 g
Mass of Solute w_2 = 0.5 g

$$\frac{P^0 - P}{P^0} = \frac{W_2 M_1}{M_2 W_1}$$

$$\frac{(0.850 - 0.845)}{0.850} = \frac{0.5 \times 78\ g/mol}{M_2 \times 39}$$

$$M_2 = 170\ g/mol \quad 3$$

Q. 9. 2g of C_6H_5COOH dissolved in 25 g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg mol^{-1} What is the percentage association of acetic acid if it forms dimer solution?

Ans.

$$\Delta T_f = K_f\ m$$

$$= K_f \frac{w_B}{M_B} \times \frac{1000}{w_A}$$

$$\therefore M_B = \frac{K_f \times 1000 \times w_B}{\Delta T_f \times w_A}$$

$$= \frac{4.9 \times 1000 \times 2}{1.62 \times 25}$$

$$= 241.98\ g\ mol^{-1}$$

Normal molar mass of benzoic acid = 122 g mol^{-1}

$$i = \frac{\text{Normal Molar Mass}}{\text{Observed Molar Mass}} = \frac{122}{241.98} = 0.504$$

$$2\,C_6H_5COOH \longrightarrow (C_6H_5COOH)_2$$

Initial $\quad 1 \quad\quad 0$

After

association $\quad 1-\alpha \quad\quad \frac{\alpha}{2}$

Therefore,

$$i = \frac{1-\alpha+\frac{\alpha}{2}}{1}$$

$$i = 1-\frac{\alpha}{2}$$

$$i = 1-\frac{\alpha}{2}$$

$$2i = 2-\alpha$$

$$\alpha = 2-2i$$

$$\alpha = 2-2 \times 0.504$$

$$= 2-1.008$$

$$= 0.992$$

$$\alpha = 99.2\%$$

Q. 10. Calculate the vapour pressure lowering of water when 5.67g of glucose ($C_6H_{12}O_6$) is dissolved in 25.23 g of water at 25°C. The vapour pressure of water at 25°C is 23.8 mmHg. What is the vapour pressure of the solution?

Ans.

$w_B = 5.67\text{ g}$

$w_A = 25.23\text{g}$

$M_B = 180\text{ gmol}^{-1}$

$M_A = 18\text{ gmol}^{-1}$

$n_B = \frac{5.67}{180} = 0.0315\text{ mol}$

$n_A = \frac{25.23}{18} = 1.40\text{ mol}$

$$\text{Mole fraction of glucose} = x_B = \frac{n_B}{n_A + n_B}$$

$$= \frac{0.0315}{0.0315 + 1.4}$$

$$= 0.022$$

$p^0_A = 23.8\text{ mmHg}$ at 25°C

We know that

Relative lowering of vapour pressure

$$\frac{p^0_A - p_A}{p^0_A} = x_B$$

$$\text{Vapour pressure lowering} = p^0_A - p_A = x_B . p^0_A$$

$$= 0.022 \times 23.8$$

$$= 0.524\text{ mmHg}$$

Also,

$$\frac{23.8 - p_A}{23.8} = 0.022$$

$$23.8 - p_A = 0.022 \times 23.8$$

$$= 0.524$$

$$p_A = 23.8 - 0.524$$

$$= 23.3\text{ mmHg}$$

Q. 11. (a) What are various ways of expressing concentration of a solution.
(b) What is osmosis and osmotic pressure?

Ans. (a) **(i) Mole fraction** of a component is the ratio of its number of moles to the total number of moles in a solution. Say N_1 = number of moles of solvent, N_2 = number of moles of solute Therefore,

$X_1 = N_1 /(N_1 + N_2)$,

$X_2 = N_2/(N_1 + N_2)$,

So, $X_1 + X_2 = N_1/(N_1 + N_2) + N_2/(N_1 + N_2)$

$= 1$, So $X_1 = 1 - X_2$, $X_2 = 1 - X_1$

[Where $N_1 = W/M$ = (wt. of solvent)/(molecular wt.), $N_2 = w/m$ = (wt. of solute)/(molecular wt. of solute)].

(ii) Normality (N) = It is the number of gm. equivalent of a solute per litre of a solution

(iii) Molarity (M) :- It is the number of moles of a solute per litre of the solution.

(iv) Molality (m) It is the number of moles of a solute per 1000 g of solvent

(b) **Osmosis** flow of a solution of lower concentration towards a solution of higher concentration through SPM.

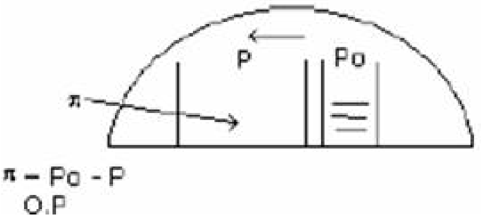
$\pi = (Po - P)$

P = It is the extra pressure (osmotic pressure) applied on a solution of higher concentration to check the flow of solution of lower concentration towards it through

SPM.

Or

it is the extra pressure applied on solution to check the flow of vapours of solvent towards it in vacuum.



Q. 12 Calculate the amount of KCl that must be added to 1 Kg of water so that freezing point is depressed by 3 K, Kf = 1.86º C.

Ans. KCl K^+ + Cl^-

i (Vant Hoff's factor) = 2, Now ΔTf = iKf **x** molality.

3 = 2 **x** 1.86 **x** wB **x** 1000/(MB **x** wA)

3 = 2 **x** 1.86 **x** wB **x** 1000/74.5 **x** 1000 or w = 60.08 g.