Chapter 2

Solutions

Solutions

SECTION - A

Objective Type Questions

(Binary Solution, Concentration Terms, Solubility)

1. 100 ml of 1 M NaOH is mixed with 50 ml of 1 N KOH solution. Normality of mixture is

(1) 1 N (2) 0.5 N (3) 0.25 N (4) 2 N

Sol. Answer (1)

$$N_{mixture} = \frac{N_1V_1 + N_2V_2}{V_1 + V_2} \Rightarrow \frac{100 + 50}{100 + 50} = \frac{150}{150} \Rightarrow 1N$$

$$\underset{(NaOH)}{N_1V_1} = 1 \times 100 = 100$$

$N_2V_2 = 1 \times 50 = 50$

2. Mass of NaCl required to prepare 0.01 m aqueous solution in 1 kg water is

(1) 0.01 g (2) 0.585 g (3) 58.8 g (4) 5.88 g

Sol. Answer (2)

$$M = \frac{\text{moles}}{\text{mass of solvent (kg)}} = \frac{w}{M_w \times W(kg)}$$

$$0.01 = \frac{w}{58.5 \times 1} \qquad [NaCl\ (M_w = 58.5]$$

$w = 0.01 \times 58.5$

$w \Rightarrow 0.585$ g

3. Which of the following concentration terms is temperature independent?

I. Molarity II. Molality III. Normality IV. Mole fraction

(1) I & II (2) I & III (3) II only (4) II & IV

Sol. Answer (4)

$PV = nRT$

$(V \propto T)$, P & n = constant

So molarity and normality depends on volume so also depends on temperature. But molality and mole fraction doesn't depend on volume so doesn't depend on temperature.

4. 1 molar aqueous solution is _____ concentrated than 1 m aqueous solution

(1) More (2) Less (3) Equally (4) Very less

Sol. Answer (1)

$\text{Molarity} \Rightarrow \frac{\text{Moles}}{\text{Volume}}$, $\text{Molality} = \frac{\text{moles}}{\text{Mass of solvent (in kg)}}$

$1 = \frac{\text{Moles}}{\text{Volume}}$, $1 = \frac{\text{moles}}{\text{W(kg)}}$

i.e., moles in 1 litre solution it is defined for solution so it is more than molality which is defined for solvent.

i.e. moles in 1 kg of solvent

5. Which gas is most soluble in water?

(1) He (2) H_2 (3) NH_3 (4) CO_2

Sol. Answer (3)

$NH_3 \rightarrow$Shows H-bonding with H_2O than rest 3-options so it is most soluble in water

6. What is the concentration of NO_3^- ions when equal volumes of 0.1 M $AgNO_3$ and 0.1 M NaCl are mixed together?

(1) 0.1 N (2) 0.25 M (3) 0.05 M (4) 0.2 M

Sol. Answer (3)

$\underset{0.1M}{AgNO_3} \longrightarrow Ag^+ + \underset{0.1M \rightarrow \text{volume}=V_1}{NO_3^-}$

NaCl

V_2

$M_1V_1 = M_2V_2$ Equal volume

$0.1 \times V = M_2 [V_1 + V_2]$ $[V_1 = V_2 = V]$

$0.1 \times V = M_2 [V + V]$

The NaCl can't effect the concentration of NO_3^- but its volume added in total volume in mixture.

$M_2 = \frac{0.1V}{2V} = 0.05$

7. 15 g urea and 20 g NaOH dissolved in water. Total mass of solution is 250 g. Mole fraction of NaOH in the mixture

(1) 0.036 (2) 0.62 (3) 0.5 (4) 0.4

Sol. Answer (1)

$\text{mole fraction of NaOH} \Rightarrow \frac{\text{moles of NaOH}}{\text{moles of NaOH} + \text{moles of urea} + \text{moles of } H_2O}$

$\text{moles of NaOH} = \frac{w}{M_w} = \frac{20}{40} \Rightarrow \frac{1}{2}$ [NaOH = 23 + 16 + 1 $\Rightarrow$ 40]

$\text{moles of urea} \Rightarrow \frac{w}{M_w} \Rightarrow \frac{15}{60}$

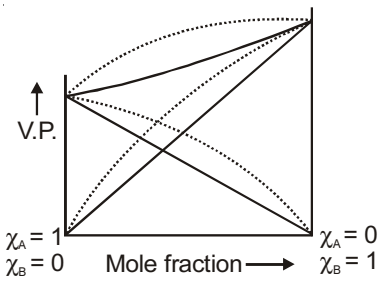
$\text{moles of } H_2O \Rightarrow \frac{w}{M_w} \Rightarrow \frac{215}{8}$ $\left[\underset{\text{urea}}{15} + \underset{\text{NaOH}}{20} + \underset{H_2O}{x} = \underset{\text{Total}}{250}\right]$

$x = 250 - 35 = 215$ g

$\text{Mole fraction of NaOH} \Rightarrow \frac{\frac{1}{2}}{\frac{1}{2} + \frac{15}{60} + \frac{215}{18}} \Rightarrow 0.03$

(Vapour Pressure of Liquid Solutions, Ideal and Non-ideal Solutions)

8. Vapour phase diagram for a solution is given below if dotted line represents deviation



Correct observation for this solution

(1) ΔH_{mix} : +ve (2) ΔS_{mix} : +ve (3) ΔV_{mix} : +ve (4) All of these

Sol. Answer (4)

Shown graph is positive deviation so

for positive deviation $\Delta H > 0 \Rightarrow$ positive

$\Delta V > 0 \Rightarrow$ positive

$\Delta S > 0 \Rightarrow$ positive

9. A mixture of two liquids A and B having boiling point of A is 70°C, and boiling point of B is 100°C, distills at 101.2°C as single liquid, hence this mixture is

(1) Ideal solution (2) Non ideal solution showing +ve deviation

(3) Non ideal solution showing –ve deviation (4) Immiscible solution

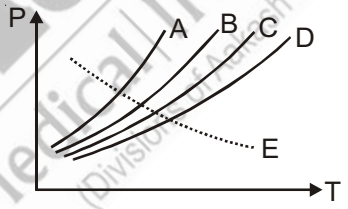
Sol. Answer (3)

$\left.\begin{matrix} A = 70°C \\ B = 100°C \end{matrix}\right]$ distils at 101.2°C *i.e.*, B.P of solution is greater than A/B

and it shows maximum boiling Azeotrope means

negative deviation [Vapour pressure of this solution is decreased]

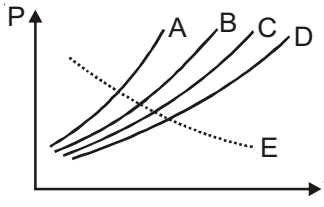
10. Vapour pressure diagram of some liquids plotted against temperature are shown below



Most volatile liquid

(1) A (2) B (3) C (4) D

Sol. Answer (1)



Vapour pressure of A, B, C, D

A > B > C > D

Vapour pressure of (A) is maximum so, it formed more vapours that's why it is more volatile.

11. During evaporation of liquid

(1) The temperature of liquid rises

(2) The temperature of liquid falls

(3) The temperature of liquid remains uneffected

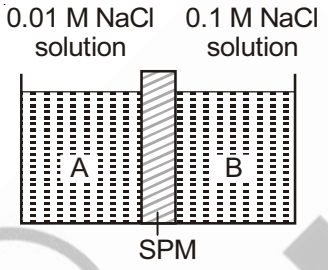
(4) The liquid molecules becomes inert

Sol. Answer (2)

During evaporation of liquid → liquid becomes cool i.e. its temperature decreases and temperature of surrounding increases.

(Colligative Properties, Abnormality in Molar Mass)

12. Two solutions marked as A and B are separated through semipermeable membrane as below. The phenomenon undergoing



(1) Na^+ moves from solution A to solution B

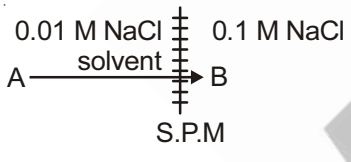
(2) Both Na^+ and Cl^- move from solution (A) to solution (B)

(3) Both Na^+ and Cl^- move from solution (B) to (A)

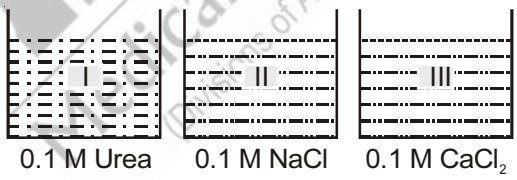
(4) Solvent molecules move from solution (A) to (B)

Sol. Answer (4)

Solvent molecules moves from lower concentrated solution to higher concentrated solution (osmosis)



13. Correct observation



(1) Vapour pressure of solution I is lowest

(2) Relative lowering of vapour pressure is maximum in III

(3) Freezing point is maximum for III

(4) Boiling point is minimum for II

Sol. Answer (2)

Urea	NaCl	$CaCl_2$
0.1 M	0.1 M	0.1 M
$i \Rightarrow 1$	2	3

→ max relative lowering of vapour pressure freezing point is minimum

$$\frac{\Delta p}{p^\circ} = i(x)$$

i increases = (Δp) increases = relative lowering of vapour pressure increases

14. An aqueous solution of sugar is taken in a beaker. At freezing point of solution

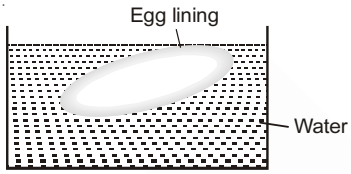
(1) Crystals of sugar separated (2) Crystals of glucose and fructose are separated

(3) Crystals of ice separated (4) Mixture of ice and some sugar crystals separated

Sol. Answer (3)

At freezing point of solution water get freeze but sugar cannot so water converted into ice so crystals of ice separated.

15. The phenomenon taking place



(1) Exosmosis (2) Endosmosis (3) Reverseosmosis (4) All of these

Sol. Answer (2)

Water (solvent) moves from their higher concentration to their lower concentration through S.P.M [i.e. from outside to inside] known as endosmosis

16. Osmotic pressure of solution containing 0.6 g urea and 3.42 g sugar in 100 ml at 27°C

(1) 492 atm (2) 4.92 atm (3) 49.2 atm (4) 28.1 atm

Sol. Answer (2)

Total mass of solution = 0.6 + 3.42 $\Rightarrow$ 4.02 g

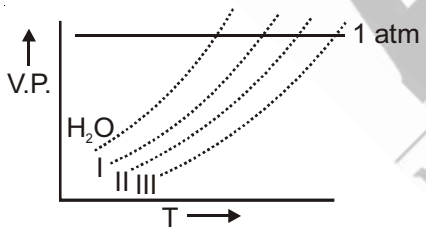
$\pi = i\left(\frac{n}{V}\right)RT$ $\therefore$ i = 1 [Both urea and sugar are nonelectrolyte]

$\pi = \frac{1\times n_{total}\times RT}{V}$ Total moles = moles of urea + moles of sugar

$= \frac{1\times 0.02\times 100\times 0.0821\times 300}{100} \Rightarrow 4.92$ $\Rightarrow \frac{W}{M_w}+\frac{w}{m_w} \Rightarrow \frac{0.6}{60}+\frac{3.42}{342}$

$\Rightarrow 0.01 + 0.01 \Rightarrow 0.02$

17.



Which is having highest elevation in boiling point?

(1) H_2O (2) Solution I (3) Solution II (4) Solution III

Sol. Answer (4)

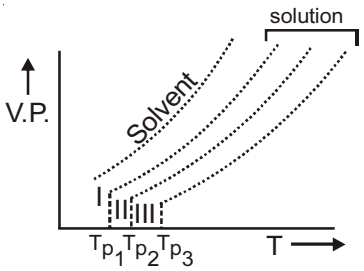
When nonvolatile solute is added in volatile solvent $\rightarrow$ vapour pressure of solvent decreases and B.P. increases

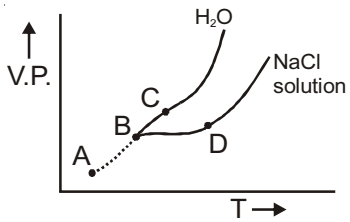
$T_{b_3} > T_{b_2} > T_{b_1}$

T_b = boiling point of solution

As vapour pressure decreases $\Rightarrow$ B.P. of solution increases

So, III have minium V.P. = maximum B.P. = Elevation in B.P.

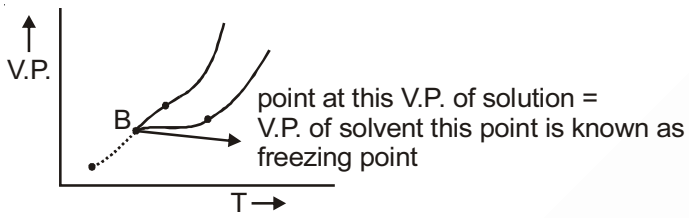


18. 

Freezing point of solution is marked as

(1) A (2) B (3) C (4) D

Sol. Answer (2)



19. van't Hoff factor for acetic acid in aqueous medium at infinite dilution is

(1) 2 (2) 1 (3) 1/2 (4) 3

Sol. Answer (1)

At infinite dilution CH_3COOH is completely dissociated

So $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

[i = 2] number of ions

20. Correct order of freezing point of given solution

I. 0.1 M glucose II. 0.2 M urea III. 0.1 M NaCl IV. 0.05 M $CaCl_2$

(1) I < II < III < IV (2) I > II > III > IV (3) III = II < IV < I (4) IV > II > III > I

Sol. Answer (3)

$\Delta T_f = i(K_f \times m)$, $T_f^\circ - T_f = i(K_f \times m)$

of solution $\boxed{T_f \propto \frac{1}{i}}$ when concentration is same

I. 0.1 M glucose $\Delta T_f \Rightarrow 1 \times K_f \times 0.1 = 0.1\ K_f$

III. 0.1 M NaCl $\longrightarrow$ $Na^+ + Cl^-$ (i = 1) non electrolyte

$\underset{i=1}{\text{glucose}} < \underset{i=2}{\text{NaCl}}$ so, T_f $\boxed{\text{NaCl} < \text{glucose}}$

(i = 2) $\Delta T_f \Rightarrow 2K_f \times 0.1 = 0.2\ K_f$

II. $0.2\ M\ urea \longrightarrow \Delta T_f \Rightarrow i \times K_f \times m \Rightarrow 1 \times K_f \times 0.2 = 0.2\ K_f$

IV. $0.05\ M\ CaCl_2 \longrightarrow \Delta T_f = 3 \times K_f \times 0.05 = 0.15\ K_f$

$CaCl_2 \longrightarrow \underset{(i=3)}{Ca^{2+}} + 2Cl^-$

$\underset{\text{same } 0.2\ K_f}{\underline{NaCl \equiv Urea}} < \underset{\Delta T_f = 0.15\ K_f}{CaCl_2} < \underset{\Delta T_f = 0.1\ K_f}{Glucose}$

21. Boiling point of 0.01 M AB_2 which is 10% dissociated in aqueous medium ($K_{b_{H_2O}} = 0.52$) as A^{+2} and B^-

(1) 273.006 K (2) 373.006 K

(3) 0.006 K (4) 272.006 K

Sol. Answer (2)

$AB_2 \longrightarrow A^{2+} + 2B^-$

1 0 0

$1-\alpha$ α 2α

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

$= 1+\frac{2\times 10}{100}$

$i = \Rightarrow 1.2$

$\Delta T_b = i(K_b \times m)$

$T_b - T_b^\circ = i(K_b \times m)$

$T_b - 373 = 1.2\ [0.52 \times 0.01]$

$T_b - 373 = 0.00624$

$T_b = 373.006$ K

22. At higher altitude, the boiling point of water is lowered because

(1) Atmosphere pressure is low

(2) Temperature is low

(3) Atmospheric pressure increases

(4) Water solidifies to ice

Sol. Answer (1)

At higher altitude the B.P. of H_2O is lowered because pressure is low so, H_2O easily boils i.e. easily achieve pressure which is equal to atm pressure.

23. If any solute 'A' dimerises in water at 1 atm pressure and the boiling point of this solution is 100.52°C. If 2 moles of A is added to 1 kg of water and k_b for water is 0.52°C/molal, calculate the percentage association of A

(1) 50% (2) 30%

(3) 25% (4) 100%

Sol. Answer (4)

$2A \underset{}{\overset{\text{dimerises}}{\rightleftharpoons}} (A)_2$

t = 0 1 0

$t = t_1$ $1-\alpha$ $\frac{\alpha}{2}$

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

$\Delta T_b = iK_b \times m$ $\quad m = \frac{\text{moles}}{w_{solvent} + (K_f)}$

$100.52 - 100 = \left(1+\frac{\alpha}{2}-\alpha\right)\left(0.52\times\frac{2}{1}\right)$

$0.52 = \left(1-\frac{\alpha}{2}\right)(0.52\times 2)$

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

$\frac{\alpha}{2} = 1-\frac{1}{2}, \quad \frac{\alpha}{2} = \frac{1}{2}$

$\alpha = 1$ or (100%)

24. Substance A tetramerises in water to the extent of 80%. A solution of 2.5 g of A in 100 g of water lowers the freezing point by 0.3°C. The molar mass of A is

(1) 122 (2) 31 (3) 244 (4) 62

Sol. Answer (4)

$$4A \underset{}{\overset{\text{tetramerises}}{\rightleftharpoons}} (A)_4$$

t = 0	1	0
$t = t_1$	$1 - \alpha$	$\frac{\alpha}{4}$

$$\alpha = \frac{80}{100} = 0.8$$

$$i = 1 - \alpha + \frac{\alpha}{4}$$

$$\Rightarrow 1 - 0.8 + \frac{0.8}{4}$$

$$i = 0.4$$

$$\Delta T_f = i(K_f \times m)$$

$$0.3 = 0.4\left[1.86 \times \frac{2.5 \times 1000}{M \times 100}\right]$$

$$M = 62 \text{ g}$$

25. $K_4[Fe(CN)_6]$ is supposed to be 40% dissociated when 1M solution prepared. Its boiling point is equal to another 20% mass by volume of non-electrolytic solution A. Considering molality = molarity. The molecular weight of A is

(1) 77 (2) 67 (3) 57 (4) 47

Sol. Answer (1)

$$K_4[Fe(CN)_6] \xrightarrow{(1)} 4K^+ + [Fe(CN)_6]^{-4}$$

t = 0	1	0	0
$t = t_1$	$1 - \alpha$	4α	α

$i = 1 - \alpha + 4\alpha + \alpha = 1 + 4\alpha$

$$\therefore \quad \alpha = \frac{40}{100} = 0.4$$

$i = 1 + 4 \times 0.4 \Rightarrow 2.6$

Given $(\Delta T_b)_1 = (\Delta T_b)_2$

$iK_b \times m_1 = iK_b \times m_2$

$$2.6 \times 1 = 1 \times \frac{w}{M \times V}$$

$$2.6 = \frac{20 \times 1000}{M \times 100}$$

$$M = \frac{200}{2.6} = 76.9 = 77 \text{ g}$$

(2)

20% mass by volume of non-electrolyte

$\Rightarrow$ 20 g in 100 ml of solution

$\therefore$ (i = 1)

molality = molarity

SECTION - B

Previous Years Questions

1. Which of the following is dependent on temperature? **[NEET-2017]**

(1) Molality (2) Molarity (3) Mole fraction (4) Weight percentage

Sol. Answer(2)

Molarity includes volume of solution which can change with change in temperature.

2. If molality of the dilute solution is doubled, the value of molal depression constant (K_f) will be **[NEET-2017]**

(1) Doubled (2) Halved (3) Tripled (4) Unchanged

Sol. Answer (4)

K_f (molal depression constant) is a characteristic of solvent and is independent of molality.

3. The van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide is **[NEET-Phase-2-2016]**

(1) 0 (2) 1 (3) 2 (4) 3

Sol. Answer (4)

$Ba(OH)_2 \longrightarrow Ba^{2(+)} + 2OH^{(-)}$

$\therefore$ van't Hoff factor = 1 + 2 = 3

4. Which one of the following is **incorrect** for ideal solution? **[NEET-Phase-2-2016]**

(1) $\Delta H_{mix} = 0$ (2) $\Delta U_{mix} = 0$

(3) $\Delta P = P_{obs} - P_{calculated\ by\ Raoult's\ law} = 0$ (4) $\Delta G_{mix} = 0$

Sol. Answer (4)

ΔG_{mix} for ideal solution is positive.

5. At 100°C the vapour pressure of a solution of 6.5 g of a solute in 100 g water is 732 mm. If $K_b = 0.52$, the boiling point of this solution will be **[NEET-2016]**

(1) 103°C (2) 101°C (3) 100°C (4) 102°C

Sol. Answer (2)

$\because \quad \frac{P_A^0 - P_S}{P_S} = \frac{n_B}{n_A}$

$\Rightarrow \quad \frac{760-732}{732} = \frac{W_B \times M_A}{M_B \times W_A} \quad \Rightarrow \quad \frac{28}{732} = \frac{6.5 \times 18}{M_B \times 100}$

$\therefore \quad M_B = 30.6$

$\therefore \quad \Delta T_b = 0.52 \times \frac{6.5 \times 1000}{30.6 \times 100} = 1.10$

$\therefore$ Boiling point = 100 + 1.1= 101.1°C $\approx$101°C

6. Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C. (Given, Vapour Pressure Data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa) **[NEET-2016]**

(1) Not enough information is given to make a prediction

(2) The vapour will contain a higher percentage of benzene

(3) The vapour will contain a higher percentage of toluene

(4) The vapour will contain equal amounts of benzene and toluene

Sol. Answer (2)

The component having higher vapour pressure will have higher percentage in vapour phase.

7. What is the mole fraction of the solute in a 1.00 m aqueous solution? **[Re-AIPMT-2015]**

(1) 0.0354 (2) 0.0177 (3) 0.177 (4) 1.770

Sol. Answer (2)

$\chi_{solute} = \frac{1}{55.5+1} = \frac{1}{56.5} = 0.0177$

8. Which one is not equal to zero for an ideal solution? **[AIPMT-2015]**

(1) $\Delta P = P_{observed} - P_{Raoult}$ (2) ΔH_{mix}

(3) ΔS_{mix} (4) ΔV_{mix}

Sol. Answer (3)

9. The boiling point of 0.2 mol kg^{-1} solution of X in water is greater than equimolal solution of Y in water. Which one of the following statements is true in this case? **[AIPMT-2015]**

(1) Y is undergoing dissociation in water while X undergoes no change

(2) X is undergoing dissociation in water

(3) Molecular mass of X is greater than the molecular mass of Y

(4) Molecular mass of X is less than the molecular mass of Y

Sol. Answer (2)

Dissociation increases the number of particles.

10. Which one of the following electrolytes has the same value of van't Hoff's factor (*i*) as that of $Al_2(SO_4)_3$ (if all are 100% ionised)? **[AIPMT-2015]**

(1) $K_4[Fe(CN)_6]$ (2) K_2SO_4 (3) $K_3[Fe(CN)_6]$ (4) $Al(NO_3)_3$

Sol. Answer (1)

11. Of the following 0.10m aqueous solutions, which one will exhibit the largest freezing point depression ? **[AIPMT-2014]**

(1) KCl (2) $C_6H_{12}O_6$ (3) $Al_2(SO_4)_3$ (4) K_2SO_4

Sol. Answer (3)

$\boxed{\Delta T_f = imk_f}$

KCl (i = 2)

$C_6H_{12}O_6$ (i = 1)

$Al_2(SO_4)$ (i = 5)

K_2SO_4 (i = 3)

12. p_A and p_B are the vapour pressure of pure liquid components, A and B, respectively of an ideal binary solution. If x_A represents the mole fraction of component A, the total pressure of the solution will be **[AIPMT (Prelims)-2012]**

(1) $p_B + x_A (p_B - p_A)$ (2) $p_B + x_A (p_A - p_B)$ (3) $p_A + x_A (p_B - p_A)$ (4) $p_A + x_A (p_A - p_B)$

Sol. Answer (2)

$P_T = p_A + p_B$

$= p_A^\circ x_A + p_B^\circ x_B \quad \therefore \; x_A + x_B = 1$

$= p_A^\circ x_A + p_B^\circ (1 - x_A) \quad x_B = 1 - x_A$

$= p_A^\circ x_A + p_B^\circ - p_B^\circ x_A$

$\boxed{P_T = p_B^\circ + x_A [p_A^\circ - p_B^\circ]}$

13. The van't Hoff factor *i* for a compound which undergoes dissociation in one solvent and association in other solvent is respectively **[AIPMT (Prelims)-2011]**

(1) Greater than one and greater than one (2) Less than one and greater than one

(3) Less than one and less than one (4) Greater than one and less than one

Sol. Answer (4)

For dissociation i > 1; e.g., $NaCl \longrightarrow Na^+ + Cl^-$ (number of ions increases)

For association i < 1; e.g., $2CH_3COOH \longrightarrow (CH_3COOH)_2$ (number of ions decreases)

14. The freezing point depression constant for water is –1.86° Cm^{-1}. If 5.00 g Na_2SO_4 is dissolved in 45.0 g H_2O, the freezing point is changed by –3.82°C. Calculate the van't Hoff factor for Na_2SO_4 **[AIPMT (Prelims)-2011]**

(1) 0.381 (2) 2.05 (3) 2.63 (4) 3.11

Sol. Answer (3)

$\Delta T_f = iK_f \times m$; $Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{-2}$

$\Rightarrow \quad 0-(-3.82) = i\left[1.86 \times \frac{w}{M \times w_{(solvent)}}\right]$; $M_{Na_2SO_4} = 2\times 23 + 96 = 46 + 96 = 142$ g

$\Rightarrow \quad +3.82 = i \times 1.86 \times \frac{5\times 1000}{142\times 45}$

$\therefore \quad i = \frac{3.82\times 142\times 45}{1.86\times 5\times 1000} = 2.62$

15. A 0.1 molal aqueous solution of a weak acid is 30% ionized. If K_f for water is 1.86°C/m, the freezing point of the solution will be **[AIPMT (Mains)-2011]**

(1) –0.36°C (2) –0.24°C (3) –0.18°C (4) –0.54°C

Sol. Answer (2)

	$\underset{\text{(weak acid}}{HX} \longrightarrow H^+ + X^-$	
t = 0	1	0 0
$t = t_1$	$1-\alpha$	α α

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

$\therefore \quad \alpha = \frac{30}{100} = 0.3$

i = 1 + 0.3 = 1.3

$\Delta T_f = iK_f \times m$

$= 1.3 \times 1.86 \times 0.1$

$\Delta T_f = 0.2418°C$

$T_f^\circ - T_f = 0.2418°C$

$0 - T_f = 0.2418°C$

$T_f = -0.2418°C$

16. 200 mL of an aqueous solution of a protein contains its 1.26g. The osmotic pressure of this solution at 300 K is found to be 2.57×10^{-3} bar. The molar mass of protein will be (R = 0.083 L bar mol^{-1} K^{-1}) **[AIPMT (Mains)-2011]**

(1) 31011 g mol^{-1} (2) 61038 g mol^{-1}

(3) 51022 g mol^{-1} (4) 122044 g mol^{-1}

Sol. Answer (2)

$\pi = i\frac{n}{V}RT$ | i = 1 protein (non-electrolyte)

$\Rightarrow \quad 2.57 \times 10^{-3} = \frac{1\times 1.26\times 0.0821\times 300}{M_w \times 200\times 10^{-3}}$

M_w = 61038 g/mol

17. A solution of sucrose (molar mass = 342 g mol^{-1}) has been prepared by dissolving 68.5 g of sucrose in 1000 g of water. The freezing point of the solution obtained will be (K_f for water = 1.86 K kg mol^{-1})

[AIPMT (Prelims)-2010]

(1) –0.372°C (2) –0.520°C (3) +0.372°C (4) –0.570°C

Sol. Answer (1)

$$\Delta T_f = i(K_f \times m) = 1 \times 1.86 \times \frac{68.5 \times 1000}{342 \times 1000}$$

$$T_f^\circ - T_f = 0.372$$

$$0 - T_f = 0.37$$

$\therefore$ $T_f = -0.372°C$

18. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase?

[AIPMT (Prelims)-2010]

(1) Addition of NaCl (2) Additon of Na_2SO_4

(3) Addition of 1.00 molal KI (4) Addition of water

Sol. Answer (4)

Addition of water will decrease the molality of KI, thus vapour pressure of solutions will increase

19. A 0.0020 m aqueous solution of an ionic compound $Co(NH_3)_5(NO_2)Cl$ freezes at –0.00732°C. Number of moles of ions which 1 mol of ionic compound produces on being dissolved in water will be (k_1 = –1.86°C /m)

[AIPMT (Prelims)-2009]

(1) 3 (2) 4 (3) 1 (4) 2

Sol. Answer (4)

$\Delta T_f = iK_f \times m$

$$i = \frac{\Delta T_f}{K_f \times m} = \frac{0.00732}{1.86 \times 0.0020} = 1.96 \simeq 2$$

20. 0.5 molal aqueous solution of a weak acid (HX) is 20% ionized. If K_f for water is 1.86 K kg mol sup–1, the lowering in freezing point of the solution is **[AIPMT (Prelims)-2007]**

(1) –0.56 K (2) –1.12 K (3) 0.56 K (4) 1.12K

Sol. Answer (4)

$HX \longrightarrow H^+ + X^-$

t = 0	1	0	0
$t = t_1$	$1 - \alpha$	α	α

(α = 20%) $i = \frac{1 - \alpha + \alpha + \alpha}{1} = 1 + \alpha$

$= 1 + 0.2 = 1.2$

$\Delta T_f = iK_f \times m$

$= 1.2 \times 1.86 \times 0.5$

$= 1.1$ K

Lowering in freezing point

21. A solution containing 10g per dm^3 of urea (molecular mass = 60 g mol^{-1}) is isotonic with a 5% solution of a non-volatile solute. The molecular mass of this non-volatile solute is **[AIPMT (Prelims)-2006]**

(1) 250 g mol^{-1} (2) 300 g mol^{-1} (3) 350 g mol^{-1} (4) 200 g mol^{-1}

Sol. Answer (2)

$M_1 = 10$, $V_1 = 1\ dm^3 = 1\ L$ | $\pi_1 = \pi_2$, $\therefore C_1 = C_2$, $\frac{10}{60\times1} = \frac{5\times1000}{M_w\times100}$ | $M_w = \frac{50\times60}{10}$, $\Rightarrow 300$ g/mol

22. 1.00 g of a non-electrolyte solute (molar mass 250g mol^{-1}) was dissolved in 51.2 g of benzene. If the freezing point depression constant, K_f of benzene is 5.12 K kg mol^{-1}, the freezing point of benzene will be lowered by **[AIPMT (Prelims)-2006]**

(1) 0.4 K (2) 0.3 K (3) 0.5 K (4) 0.2 K

Sol. Answer (1)

$$\Delta T_f = iK_f \times m = 1\times5.12\times\frac{1\times1000}{250\times51.2} = 0.4\ K$$

$\boxed{i = 1 \text{ (non-electrolyte}}$

23. A solution of acetone in ethanol **[AIPMT (Prelims)-2006]**

(1) Shows a negative deviation from Raoult's law (2) Shows a positive deviation from Raoult's law

(3) Behaves like a near ideal solution (4) Obeys Raoult's law

Sol. Answer (2)

Acetone decreases the intermolecular H-bonding in ethanol.

24. During osmosis, flow of water through a semi-permeable membrane is **[AIPMT (Prelims)-2006]**

(1) From solution having higher concentration only

(2) From both sides of semi-permeable membrane with equal flow rates

(3) From both sides of semi-permeable membrane with unequal flow rates

(4) From solution having lower concentration only

Sol. Answer (3)

FACT

25. The vapour pressure of two liquids P and Q are 80 and 60 torr, respectively. The total vapour pressure of solution obtained by mixing 3 moles of P and 2 moles of Q would be **[AIPMT (Prelims)-2005]**

(1) 140 torr (2) 20 torr (3) 68 torr (4) 72 torr

Sol. Answer (4)

$n_p = 3$, $n_Q = 2$ | $p_P^\circ = 80$ torr, $p_Q^\circ = 60$ torr | $p_T = p_P^\circ x_P + p_Q^\circ x_Q = 80\times\frac{3}{5} + 60\times\frac{2}{5} = 48 + 24 = 72$ torr

26. A solution of urea (mol. mass 60g mol^{-1}) boils at 100.18°C at the atmospheric pressure. If k_f and k_b for water are 1.86 and 0.512K kg mol^{-1} respectively, the above solution will freeze at **[AIPMT (Prelims)-2005]**

(1) –6.54°C (2) 6.54°C (3) 0.654°C (4) –0.654°C

Sol. Answer (4)

$\therefore \quad \Delta T_b = K_b \times m$

$\Rightarrow \quad 0.18 = 0.512 \times m$

$\therefore \quad m = \dfrac{0.18}{0.512}$

$\therefore \quad \Delta T_f = K_f \times m$

$\Rightarrow \quad = 1.86 \times \dfrac{0.18}{0.52} = 0.654$

$\therefore \quad T_f = 0 - 0.654 = -0.654°C$

27. A solution has a 1 : 4 mole ratio of pentane to hexane. The vapour pressure of the pure hydrocarbons at 20°C are 440 mm of Hg for pentane and 120 mm of Hg for hexane. The mole fraction of pentane in the vapour phase would be **AIPMT (Prelims)-2005]**

(1) 0.549 (2) 0.200 (3) 0.786 (4) 0.478

Sol. Answer (4)

$$\frac{n_{pentane}}{n_{hexane}} = \frac{1}{4}$$

$$p^{\circ}_{pentane} = 440 \text{ mm Hg}$$

$$p^{\circ}_{hexane} = 120 \text{ mm Hg}$$

$$\chi_{pentane} = \frac{p_{pentene}}{p_{total}}$$

$$= \frac{p^{\circ}_p . x_p}{p^{\circ}_p . x_p + p^{\circ}_n . x_n} = \frac{440 \times \frac{1}{5}}{440 \times \frac{1}{5} + 120 \times \frac{4}{5}} = \frac{88}{88+96} = \frac{88}{184} = 0.478$$

28. The mole fraction of the solute in one molal aqueous solution is **[AIPMT (Prelims)-2005]**

(1) 0.027 (2) 0.036 (3) 0.018 (4) 0.009

Sol. Answer (3)

Molality = 1 $\rightarrow$ 1 moles in 1 kg of solvent

$$x_{solute} = \frac{1}{1 + \frac{1000}{18}} = \frac{1}{1+55.5} = 0.018$$

29. Which of the following compounds can be used as antifreeze in automobile radiators?

(1) Methyl alcohol (2) Glycol

(3) Nitrophenol (4) Ethyl alcohol

Sol. Answer (2)

Glycol is anti freezing agent which reduces freezing of solution

30. Mole fraction of the solute in a 1.00 molal aqueous solution is

(1) 1.7700 (2) 0.1770

(3) 0.0177 (4) 0.0344

Sol. Answer (3)

Molality = 1 $\rightarrow$ 1 moles in 1 kg of solvent

$$x_{solute} = \frac{1}{1+\frac{1000}{18}} = \frac{1}{1+55.5} = 0.018$$

31. 1×10^{-3} m solution of $Pt(NH_3)_4Cl_4$ in H_2O shows depression in freezing point by 0.0054°C. The structure of the compound will be (Given $K_f = 1.860\ km^{-1}$)

(1) $[Pt(NH_3)_4]Cl_4$ (2) $[Pt(NH_3)_3Cl]Cl_3$

(3) $[Pt(NH_3)_2Cl_2]Cl_2$ (4) $Pt(NH_3)Cl_3]Cl$

Sol. Answer (3)

$\Delta T_f = iK_f \times m$

$0.0054 = i[1.86 \times 1 \times 10^{-3}]$

$i = 2.9 \simeq 3$

In (3) option $[Pt(NH_3)_2Cl_2]Cl_2 \rightarrow [Pt(NH_3)_2Cl_2]^{+2} + 2Cl^-$; has i = 3

32. Which of the following salt has the same value of van't Hoff's factor *i* as that of $K_3[Fe(CN)_6]$?

(1) Na_2SO_4 (2) $Al(NO_3)_3$

(3) $Al_2(SO_4)_3$ (4) NaCl

Sol. Answer (2)

$$K_3[Fe(CN)_6] \longrightarrow \underset{i=4}{3K^+ + [Fe(CN)_6]^{-3}}$$

(i) $Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{-2}$; (i = 3)

(ii) $Al(NO_3)_3 \longrightarrow Al^{+3} + 3NO_3^-$; (i = 4)

(iii) $Al_2(SO_4)_3 \longrightarrow 2Al^{+3} + 3SO_4^{-2}$; (i = 5)

(iv) $NaCl \longrightarrow Na^+ + Cl^-$; (i = 2)

33. At 25°C, the highest osmotic pressure is exhibited by 0.1 M solution of

(1) Glucose (2) Urea

(3) $CaCl_2$ (4) KCl

Sol. Answer (3)

$\pi = i(CRT)$

$\boxed{\pi \propto i}$ if C = constant

(3) have maximum (i) so,

It has maximum π

(1) Glucose, i = 1

(2) Urea, i = 1

(3) $CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$; (i = 3)

(4) $KCl \longrightarrow K^+ + Cl^-$; (i = 2)

34. According to Raoult's law, the relative lowering of vapour pressure for a solution is equal to

(1) Mole fraction of solute (2) Mole fraction of solvent

(3) Moles of solute (4) Moles of solvent

Sol. Answer (1)

$$\frac{\Delta p}{p^\circ} = x_A \longrightarrow \text{(mole fraction of solute)}$$

35. The concentration units, independent of temperature, would be

(1) Normality (2) Weight volume percent

(3) Molality (4) Molarity

Sol. Answer (3)

Molality depends on temperature as it is independent of volume of the solution.

36. In liquid-gas equilibrium, the pressure of vapours above the liquid is constant at

(1) Constant temperature (2) Low temperature

(3) High temperature (4) None of these

Sol. Answer (1)

Equilibrium constant is temperature dependent, i.e. liquid-gas equilibrium can be disturbed by changing temperature.

37. The vapour pressure of CCl_4 at 25ºC is 143 mm Hg. If 0.5 gm of a non-volatile solute (mol. weight = 65) is dissolved in 100 g CCl_4, the vapour pressure of the solution will be

(1) 199.34 mm Hg (2) 143.99 mm Hg

(3) 141.43 mm Hg (4) 94.39 mm Hg

Sol. Answer (3)

$$\frac{p^\circ - p}{p^\circ} = x \text{ (mole fraction of solute)}$$

$$\frac{143 - p_s}{143} = \frac{n_B}{n_A + n_B}$$

$$\Rightarrow \frac{143 - p_s^\circ}{143} = \frac{\frac{0.5}{65}}{\frac{0.5}{65} + \frac{100}{154}}; \qquad CCl_4 = 12 + 35.5 \times 4 = 12 + 142 = 154$$

$$\Rightarrow \frac{143 - p_s}{143} \simeq \frac{0.5}{\frac{100 \times 65}{154}}$$

$$\Rightarrow 143 - p_s = \frac{0.5 \times 154 \times 143}{100 \times 65} = \frac{110.11}{65 \times 100}$$

$\therefore$ p_s = 141.3 mm Hg

38. What is the molarity of H_2SO_4 solution, that has a density 1.84 gm/cc at 35ºC and contains 98% by weight of solute?

(1) 18.4 M (2) 18 M

(3) 4.18 M (4) 8.14 M

Sol. Answer (1)

98% by weight $\rightarrow$ 98 g H_2SO_4 in 100 g of solution

$$M = \frac{w}{M \times V} = \frac{98 \times 1.84 \times 1000}{98 \times 100} = 18.4$$

$(H_2SO_4 = 98\ g)$
molar mass

$$d = \frac{m}{V}$$

$$V = \frac{m}{d} = \frac{100}{1.84}\ cc$$

39. A 5% (w/v) solution of cane sugar (mol. wt. = 342) is isotonic with 1% (w/v) solution of a substance *X*. The molecular weight of *X* is

(1) 68.4 (2) 171.2

(3) 34.2 (4) 136.8

Sol. Answer (1)

(5%) of cane sugar $\equiv$ 1% of a substance (x)

for isotonic $\pi_1 = \pi_2$ $\pi = CRT$

$$C_1 = C_2$$

$$\Rightarrow \frac{n_1}{V} = \frac{n_2}{V}$$

$$\Rightarrow \frac{5}{342} = \frac{1}{M_w}$$

$$\therefore M_w = \frac{342}{5} = 68.4\ g$$

40. The vapour pressure of a solvent decreased by 10 mm of mercury when a non-volatile solute was added to the solvent. The mole fraction of the solute in the solution is 0.2. What should be the mole fraction of the solvent if the decrease in the vapour pressure is to be 20 mm of mercury?

(1) 0.4 (2) 0.6

(3) 0.8 (4) 0.2

Sol. Answer (2)

$$\frac{\Delta p}{p} = x_{solute}$$

$$\frac{10}{p} = 0.2 \qquad ...(i)$$

$$\frac{20}{p} = x \qquad ...(ii)$$

$$\frac{(i)}{(ii)}\ \frac{10}{p} \times \frac{p}{20} = \frac{0.2}{x}$$

$x = 0.4$

$[x_{solvent} + x_{solute} = 1]$

$x_{solvent} = 1 - x_{solute} = 1 - 0.4 = 0.6$

41. If 0.15 g of a solute, dissolved in 15 g of solvent, is boiled at a temperature higher by 0.216°C, than that of the pure solvent. The molecular weight of the substance, (Molal elevation constant for the solvent is 2.16°C) is

(1) 10.1 (2) 100 (3) 1.01 (4) 1000

Sol. Answer (2)

$\Delta T_b = i(K_b \times m)$

$$0.216 = 1\left[\frac{2.16 \times 0.15 \times 1000}{M_w \times 15}\right]$$

$M_w = 100$ g

42. The vapour pressure of benzene at a certain temperature is 640 mm of Hg. A non-volatile and non-electrolyte solid, weighing 2.175 g is added to 39.08 of benzene. The vapour pressure of the solution is 600 mm of Hg. What is the molecular weight of solid substance?

(1) 65.2 (2) 59.6

(3) 49.50 (4) 79.8

Sol. Answer (1)

$$\frac{p^\circ - p}{p^\circ} = x_B \text{ (Solute)}$$

$$\frac{p^\circ - p}{p^\circ} = \frac{n_B}{n_A + n_B} \simeq \frac{n_B}{n_B}$$

Benzene (mol. mass) = $C_6H_6 \Rightarrow 12 \times 6 + 6 \Rightarrow 78$

$$\frac{640 - 600}{640} = \frac{2.175 \times 78}{M_w \times 39.08}$$

$$\Rightarrow \frac{40}{640} = \frac{2.175 \times 78}{M_w \times 39.08}$$

$$\Rightarrow 0.06 = \frac{2.175 \times 78}{M_w \times 39.08}$$

$$\therefore M_w = \frac{2.175 \times 78}{39.08 \times 0.06} = 65.11\,g$$

43. From the colligative properties of solution which one is the best method for the determination of molecular weight of proteins and polymers?

(1) Osmotic pressure (2) Lowering in vapour pressure

(3) Lowering in freezing point (4) Elevation in boiling point

Sol. Answer (1)

Osmotic pressure is the best method

44. Molarity of liquid HCl, if density of solution is 1.17 gm/cc is

(1) 36.5 (2) 18.25

(3) 32.05 (4) 42.10

Sol. Answer (3)

$$M = \frac{w}{M_B \times V_L}; \qquad d = 1.17 \text{ g/cc}$$

$$\therefore \quad M = \frac{1.17 \times 1000}{36.5 \times 1} = 32.05$$

45. A solution contains non volatile solute of molecular mass M_2. Which of the following can be used to calculate the molecular mass of solute in terms of osmotic pressure? (m_2 - mass of solute, V - volume of solution, π - osmotic pressure)

(1) $M_2 = \left(\frac{m_2}{\pi}\right) VRT$ (2) $M_2 = \left(\frac{m_2}{V}\right) \frac{RT}{\pi}$

(3) $M_2 = \left(\frac{m_2}{V}\right) \pi RT$ (4) $M_2 = \left(\frac{m_2}{V}\right) \frac{\pi}{RT}$

Sol. Answer (2)

$\pi = CRT$

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

$\Rightarrow \pi = \frac{m_2 RT}{M_2 \times V}$ $\therefore M_2 = \left(\frac{m_2}{V}\right)\frac{RT}{\pi}$

46. A solution containing components A and B follows Raoult's law

(1) A - B attraction force is greater than A-A and B-B

(2) A - B attraction force is less than A-A and B-B

(3) A - B attraction force remains same as A-A and B-B

(4) Volume of solution is different from sum of volume of solute and solvent

Sol. Answer (3)

Raoults law

$\boxed{P_T = P_A + P_B}$

Solution which obey Raoult's law have same A-B attraction force as A-A and B-B attraction

47. Formation of a solution from two components can be considered as

(i) Pure solvent $\rightarrow$ separated solvent molecules, ΔH_1

(ii) Pure solute $\rightarrow$ separated solute molecules, ΔH_2

(iii) Separated solvent and solute molecules $\rightarrow$ solution, ΔH_3

Solution so formed will be ideal if

(1) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$ (2) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 - \Delta H_3$

(3) $\Delta H_{soln} = \Delta H_1 - \Delta H_2 - \Delta H_3$ (4) $\Delta H_{soln} = \Delta H_3 - \Delta H_1 - \Delta H_2$

Sol. Answer (1)

For ideal solution $\Delta H_{solution} = \Delta H_1 + \Delta H_2 + \Delta H_3$

48. Camphor is often used in molecular mass determination because

(1) It is readily available (2) It has very high cryoscopic constant

(3) It is volatile (4) It is solvent for organic substances

Sol. Answer (2)

Camphor is often used in molecular mass determination because it has very high cryoscopic constant

49. Which condition is not satisfied by an ideal solution?

(1) $\Delta_{mix} H = 0$ (2) $\Delta_{mix} V = 0$

(3) $\Delta_{mix} S = 0$ (4) Obeyance to Raoult's Law

Sol. Answer (3)

For ideal solution $\Delta H_{mix} > 0$, ΔH_{mix} = positive

$\Delta V_{mix} > 0$, ΔV_{mix} = positive

$\Delta S_{mix} > 0$

SECTION - C

Assertion-Reason Type Questions

1. A : Solubility of NaCl increases with temperature.

   R : Dissolution of NaCl is an endothermic process.

Sol. Answer (1)

Solubility [for endothermix reaction] increases as temperature increases. [$\Delta H_{solution\ (NaCl)}$ = +ve]

2. A : 10 ml of liquid A mixed with 20 ml of liquid B total volume of solution is 30 ml.

   R : A and B will form ideal solution.

Sol. Answer (1)

For ideal solution, DVmix = 0

$\Rightarrow V_f = V_1 + V_2$.

3. A : Lowering of vapour pressure depends upon concentration of solute.

   R : Relative lowering of vapour pressure is a colligative property.

Sol. Answer (1)

Lowering of V-P depends only upon the concentration of solute $\frac{P^\circ - P_5}{P^\circ} = x_{solute}$.

4. A : Boiling point of 0.1 M solution of NaCl is higher than that of 0.1 M solution of urea.

   R : Greater the value of van't Hoff factor, greater the elevation in boiling point of solution containing non volatile solute.

Sol. Answer (1)

$i_{NaCl} = 2$, $i_{urea} = 1$

$[\Delta T_b \propto i]$

5. A : Hexane and heptane form ideal solution.

   R : ΔH, ΔS and ΔG is zero for such type of solution.

Sol. Answer (3)

$\Delta H = 0$, $\Delta S > 0$, $\Delta G < 0$

6. A : Solution containing 1 gram equivalent of solute per litre is known as 1 N solution.

   R : N = M × n-factor.

Sol. Answer (2)

Both statements are true.

7. A : Observed molecular mass of $CaCl_2$ determined by any colligative property is less than ideal molecular mass.

   R : $CaCl_2$ gets ionised in water as it is a strong electrolyte.

Sol. Answer (1)

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$ and colligative properties depends upon the number of particle in the solution, i = 3.

8. A : Isotonic solutions must have same effective molarity.
R : Effective molarity = M × i

Sol. Answer (2)
Isotonic $\Rightarrow \pi_1 = \pi_2$
$iC_1RT = iC_2RT$
$[iC_1 = iC_2]$

9. A : Sum of mole fraction of all components in a mixture is 1.
R : Mole fraction is temperature dependent mode of concentration.

Sol. Answer (3)
Mole fraction is independent of temperature.

10. A : ΔH_{mix} and ΔV_{mix} for an ideal solution is zero.
R : A....B interaction in an ideal solution are same as between A.....A and B.....B.

Sol. Answer (1)
$E_{A-A} = E_{A-B} = E_{B-B}$.
$\Delta V_{mix} = 0 = \Delta H_{mix}$.

11. A : An azeotropic solution of two liquids has boiling point lower than either of them.
R : Solution shows +ve deviation from ideal behaviour.

Sol. Answer (1)
Fact.

12. A : On increasing temperature vapour pressure of solution increases.
R : Vapour pressure of ether is higher than alcohol.

Sol. Answer (2)
V.P. $\propto$ temperature.
and V.P of ether is higher than alcohol due hydrogen bonding.

13. A : Solubility of gas increases on increasing pressure.
R : Solubility of gas decreases on decreasing the temperature.

Sol. Answer (3)

$$\text{Solubility of gas} \propto \frac{1}{\text{Temperature}}$$

14. A : Raoult's law applicable for dilute solution only.
R : Henry's law is applicable for solution of gas in liquid.

Sol. Answer (2)
Both statement are true and are different.

15. A : $CuSO_4.5H_2O$ is a solution of liquid in solid.
R : Solution is a homogeneous mixture.

Sol. Answer (2)
$CuSO_4.5H_2O \rightarrow$ 5 water molecule is co-ordinated to $CuSO_4$.
Solution is always homogenious mixture.

16. A : 1 M solution and 1 molal solution contain same mass of solute.

R : 1 M and 1 m aqueous solution are equally concentrated.

Sol. Answer (3)

1 molar aqueous solution is less concentrated than 1 molar.

17. A : Boiling point of water at higher altitude is lower than 100°C.

R : Boiling point is a colligative property.

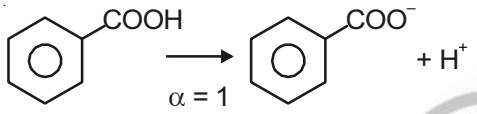
Sol. Answer (3)

Yes, external pressure is lower than 1 atm and elevation in boiling point is a colligative property not boiling point.

18. A : van't Hoff factor for benzoic acid in aqueous medium is 2 assuming complete ionisation.

R : van't Hoff factor for 100% ionised solute equal to the number of ions produces.

Sol. Answer (1)



$$\alpha = \frac{i-1}{n-1}(n=2)$$

$$\boxed{i=2}$$

$i - 1 = n - 1$

$$\boxed{i=n}$$

For 100% dissociation, van't Hoff factor is equal to number of ions produces.

❑ ❑ ❑