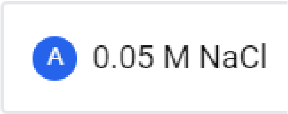
7

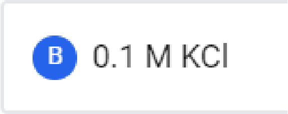
Solutions

Question: Which amongst the following aqueous solution of electrolytes will have minimum elevation in boiling point? Choose the correct option:

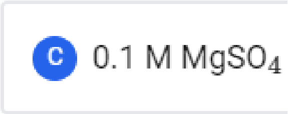
NEET 2023 Manipur



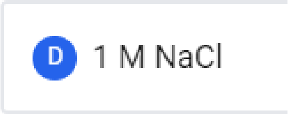
A 0.05 M NaCl



B 0.1 M KCl



C 0.1 M $MgSO_4$



D 1 M NaCl

Answer: A

Explanation

$\mathrm{i} \times \mathrm{M} \downarrow \Rightarrow \Delta T_b \downarrow$

Electrolyte	$\mathrm{i} \times \mathrm{M}$
NaCl	$2 \times 0.05 = 0.1$
KCl	$2 \times 0.1 = 0.2$
$MgSO_4$	$2 \times 0.1 = 0.2$
NaCl	$2 \times 1 = 2$

TOPIC 1

Expression of Concentration

01 Which of the following is dependent on temperature? **[NEET 2017]**

(a) Molality
(b) Molarity
(c) Mole fraction
(d) Weight percentage

Ans. *(b)*

Molarity and normality are temperature dependent because they involve volume of solutions. Volume is dependent on temperature.

$$\text{Molarity}\,(M) = \frac{\text{Moles of solute}}{\text{Volume of solution (in L)}}$$

Molality, mole fraction and weight percentage does not depend on temperature because they involve masses of solute and solvent.

02 What is the mole fraction of the solute in a 1.00 m aqueous solution? **[CBSE AIPMT 2015]**

(a) 0.177 (b) 1.770
(c) 0.0354 (d) 0.0177

Ans. *(d)*

$$\text{Molality}\,(m) = \frac{1000 \times n}{N \times M}$$

where, n = number of moles of solute
N = number of moles of solvent
M = molar mass of solvent

Given, $m = 1$

$$\therefore \quad 1 = \frac{1000 \times n}{N \times 18}$$

$$\Rightarrow \quad \frac{n}{N} = \frac{18}{1000}$$

$$\text{or} \quad \frac{n}{n+N} = \frac{18}{1018} = 0.0177$$

Alternate Method $N = \frac{1000}{18} = 55.5\,\text{mol}$

$n = 1$

[$\because$ 1 m solution implies that 1 mole of solute is present in 1 kg or 1000 g water]

$\therefore$ Mole fraction of solute

$$= \frac{n}{n+N} = \frac{1}{1+55.5} = 0.0177$$

03 25.3 g of sodium carbonate, Na_2CO_3 is dissolved in enough water to make 250 mL of solution. If sodium carbonate dissociates completely, molar concentration of sodium ion, Na^+ and carbonate ion, CO_3^{2-} are respectively (Molar mass of $Na_2CO_3 = 106\ \text{g mol}^{-1}$) **[CBSE AIPMT 2010]**

(a) 0.955 M and 1.910 M
(b) 1.910 M and 0.955 M
(c) 1.90 M and 1.910 M
(d) 0.477 M and 0.477 M

Ans. *(b)*

Molarity

$$= \frac{\text{Number of moles of solute}}{\text{Volume of solution (in mL)}} \times 1000$$

$$= \frac{25.3 \times 1000}{106 \times 250} = 0.9547 \approx 0.955\ \text{M}$$

Na_2CO_3 in aqueous solution remains dissociated as

$$\underset{x}{Na_2CO_3} \rightleftharpoons \underset{2x}{2\,Na^+} + \underset{x}{CO_3^{2-}}$$

Since, the molarity of Na_2CO_3 is 0.955 M, the molarity of CO_3^{2-} is also 0.955 M and that of Na^+ is $2 \times 0.955 = 1.910$ M

04 Concentrated aqueous sulphuric acid is 98% H_2SO_4 by mass and has a density of 1.80 g mL^{-1}. Volume of acid required to make one litre of 0.1 M H_2SO_4 solution is **[CBSE AIPMT 2007]**

(a) 11.10 mL (b) 16.65 mL
(c) 22.20 mL (d) 5.55 mL

Ans. *(d)*

Normality

$$= \frac{\text{Weight percentage} \times \text{density} \times 10}{\text{Equivalent weight}}$$

$$= \frac{98 \times 1.8 \times 10}{49} = 36\,\text{N}$$

$$N_2 = 2 \times 0.1\,\text{N} = 0.2\,\text{N}$$

$$N_1V_1 = N_2V_2$$

$$36 \times V = 0.2 \times 1000$$

$$V = \frac{0.2 \times 1000}{36}$$

$= 5.55$ mL (dissociation of acid)

05 The mole fraction of the solute in one molal aqueous solution is **[CBSE AIPMT 2005]**

(a) 0.027 (b) 0.036
(c) 0.018 (d) 0.009

Ans. *(c)*

Molality of solution = mole of solute per kg of solvent

So, 1 m = 1 mole of solute per 1000 g of solvent

Hence,

moles of solute in 1 m aqueous solution = 1

moles of solvent in 1 m aqueous solution

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

Mole fraction of solute in 1 m solution

$$= \frac{1}{1+55.55} = \frac{1}{56.55}$$

$$= 0.0176 \approx 0.018$$

06 1 M and 2.5 L NaOH solution is mixed with another 0.5 M and 3 L NaOH solution. Then, find out the molarity of resultant solution. **[CBSE AIPMT 2002]**

(a) 0.80 M (b) 1.0 M
(c) 0.73 M (d) 0.50 M

Ans. *(c)*

Moles of 2.5 L of 1M NaOH $= 2.5 \times 1 = 2.5$

Moles of 3.0 L of 0.5 M NaOH

$= 3.0 \times 0.5 = 1.5$

Total moles of NaOH in solution

$= 2.5 + 1.5 = 4.0$

(Total volume of solution $= 2.5 + 3.0 = 5.5$ L)

Thus, $M_1 \times V_1 = M_2 \times V_2$

$4 = M_2 \times 5.5$

∴ Molarity of resultant solution,

$$M_2 = \frac{4}{5.5}\text{ M}$$

$$\approx 0.73\text{ M}$$

07 Molarity of liquid HCl, if density of solution is 1.17 g/cc is **[CBSE AIPMT 2001]**

(a) 36.5 (b) 18.25
(c) 32.05 (d) 42.10

Ans. ***(c)***

Density = 1.17 g/cc = 1170 g/L

$$\text{Molarity of solution} = \frac{\text{Strength in g / L}}{\text{Molecular weight}}$$

$$= \frac{1170}{36.5}\text{ M}$$

$$= 32.05\text{ M}$$

08 How many gram of a dibasic acid (mol. wt. 200) should be present in 100 mL of the aqueous solution to give 0.1 N? **[CBSE AIPMT 1999]**

(a) 1 g (b) 2 g
(c) 10 g (d) 20 g

Ans. ***(a)***

Equivalent weight of dibasic acid

$$= \frac{\text{Molecular weight}}{2}$$

$$E = \frac{200}{2} = 100$$

Strength = 0.1 N, $m = ?$ $V = 100$ mL

$$\text{Normality } (N) = \frac{\text{Mass}}{E} \times \frac{1000}{V(\text{L})}$$

$$w = \frac{E\,NV}{1000} = \frac{100 \times 100 \times 0.1}{1000} = 1\text{g}$$

09 The volume strength of 1.5 N H_2O_2 solution is **[CBSE AIPMT 1997]**

(a) 4.8 (b) 5.2
(c) 8.4 (d) 8.8

Ans. ***(c)***

Normality = 1.5 N

Equivalent weight of H_2O_2 = 17

So,, strength of the solutions, $S = E \times N$

$= 17 \times 1.5 = 25.5$

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

$$= 2 \times 34 = 68\text{ g}$$

∵ 68 g of H_2O_2 produce O_2 at NTP = 22.4 L

∴ 25.5 g of H_2O_2 will produce

$$= \frac{22.4}{68} \times 25.5$$

$= 8.4$ L of O_2

10 Which one of the following modes of expressing concentration is independent of temperature? **[CBSE AIPMT 1995, 92]**

(a) Molarity (b) Molality
(c) Formality (d) Normality

Ans. ***(b)***

Molality is the best method of expressing concentration of solution because in molality we take mass of solvent which is independent of temperature, so molality of solution is independent of temperature.

TOPIC 2

Henry's Law and Raoult's Law

11 The correct option for the value of vapour pressure of a solution at 45°C with benzene to octane in molar ratio 3 : 2 is

[At 45°C vapour pressure of benzene is 280 mm Hg and that of octane is 420 mm Hg. Assume ideal gas]. **[NEET 2021]**

(a) 160 mm of Hg (b) 168 mm of Hg
(c) 336 mm of Hg (d) 350 mm of Hg

Ans. ***(c)***

Molar ratio of benzene to octane, $\frac{n_B}{n_O} = \frac{3}{2}$

Let $n_B = 3x$ mol, $n_O = 2x$ mol

Total number of moles

$= n_B + n_O = 3x + 2x = 5x$ mol

Mole fraction of benzene,

$$\chi_B = \frac{n_B}{n_B + n_0} = \frac{3x}{5x} = \frac{3}{5}.$$

Mole fraction of octane,

$$\chi_O = \frac{n_0}{n_B + n_0} = \frac{2x}{5x} = \frac{2}{5}$$

Vapour pressure of benzene,

$p_B^\circ = 280$ mm Hg

Vapour pressure of octane,

$p_O^\circ = 420$ mm Hg

Total vapour pressure of solution,

$$p_S = \chi_B p_B^\circ + \chi_O p_O^\circ$$

$$= \frac{3}{5} \times 280 + \frac{2}{5} \times 420$$

$$= 3 \times 56 + 2 \times 84$$

$$= 168 + 168$$

$= 336$ mm of Hg

12 A mixture of N_2 and Ar gases in a cylinder contains 7 g of N_2 and 8 g of Ar. If the total pressure of the mixture of the gases in the cylinder is 27 bar, the partial pressure of N_2 is

[Use atomic masses (in g mol^{-1}) : N = 14, Ar = 40] **[NEET (Sep.) 2020]**

(a) 12 bar (b) 15 bar
(c) 18 bar (d) 9 bar

Ans. ***(b)***

From Dalton's law of partial pressure of gases. We know,

$$p_i = \chi_i \times p$$

where,

p_i = partial pressure of ith component

χ_i = mole-fraction of ith component

p = total pressure = 27 bar

$$(\text{partial pressure})_{N_2} = (\text{mole-fraction})_{N_2} \times p$$

$$= \frac{n_{N_2}}{n_{N_2} + n_{Ar}} \times p$$

$$= \frac{\frac{7}{28}}{\frac{7}{28} + \frac{8}{40}} \times 27\text{ bar} = 15\text{ bar}$$

∴ Partial pressure of N_2 in the mixture is 15 bar.

13 The mixture which shows positive deviation from Raoult's law is **[NEET (Sep.) 2020]**

(a) Benzene + toluene
(b) Acetone + chloroform
(c) Chlorethane + bromoethane
(d) Ethanol + acetone

Ans. ***(d)***

Let us study the nature of binary solutions made of two volatile liquids:

(a) (Benzene + Toluene) Ideal solution, obeys Raoult's law.

(b) (Acetone + Chloroform) Non-ideal solution, shows negative deviation from Raoult's law.

(c) (Chloroethane + Bromoethane) Ideal solution, obeys Raoult's law.

(d) (Ethanol + Acetone) Non-ideal solution, shows positive deviation from Raoult's law.

14 The mixture that forms maximum boiling azeotrope is **[NEET (National) 2019]**

(a) ethanol + water
(b) acetone + carbon disulphide
(c) heptane + octane
(d) water + nitric acid

Ans. *(d)*

Key Idea *The binary liquid mixtures having the same composition in liquid and vapour phase and boil at constant temperature are called azeotropic mixtures or azeotropes.*

The solutions that show large negative deviation from Raoult's law forms maximum boiling azeotrope. For, e.g. nitric acid and water.

The remaining option containing different mixtures forms minimum boiling azeotrope.

15 Which of the following statements is correct regarding a solution of two compounds *A* and *B* exhibiting positive deviation from ideal behaviour? **[NEET (Odisha) 2019]**

(a) Intermolecular attractive forces between *A*—*A* and *B*—*B* are stronger than those between *A*—*B*.
(b) $\Delta_{\text{mix}} H = 0$ at constant T and p
(c) $\Delta_{\text{mix}} V = 0$ at constant T and p
(d) Intermolecular attractive forces between *A*—*A* and *B*—*B* are equal to those between A—B.

Ans. *(a)*

Solution exhibits positive deviation from ideal behaviour if the intermolecular interactions, i.e., *A*—*B* interactions are more stronger than in pure components, i.e. between *A*—*B* or *B*—*B*. Thus. option (a) is correct. The remaining options are valid only for ideal solutions.

16 In water saturated air the mole fraction of water vapour is 0.02. If the total pressure of the saturated air is 1.2 atm, the partial pressure of dry air is **[NEET (Odisha) 2019]**

(a) 1.18 atm (b) 1.76 atm
(c) 1.176 atm (d) 0.98 atm

Ans. *(c)*

Partial pressure of dry air = total pressure × mole fraction of dry air

$$\Rightarrow \quad p_{\text{dry air}} = p_{\text{total}} \times \lambda_{\text{dry air}}$$

Given, $\lambda_{\text{saturated air}} = 0.02$

$$\lambda_{\text{dry air}} = 1 - 0.02 = 0.98$$

$$p_{\text{total}} = 1.2 \text{ atm}$$

$$\therefore \quad p_{\text{dry air}} = 1.2 \text{ atm} \times 0.98 = 1.176 \text{ atm}$$

17 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. **[NEET 2016, Phase I]**

(Given, vapour pressure data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa)

(a) The vapour will contain a higher percentage of toluene
(b) The vapour will contain equal amounts of benzene and toluene
(c) Not enough information is given to make a prediction
(d) The vapour will contain a higher percentage of benzene

Ans. *(d)*

Since, component having higher vapour pressure will have higher percentage in vapour phase. Benzene has vapour pressure 12.8 kPa which is greater than toluene 3.85 kPa.

Therefore, the vapour will contain a higher percentage of benzene.

18 Which one of the following is incorrect for ideal solution? **[NEET 2016, Phase II]**

(a) $\Delta H_{\text{mix}} = 0$
(b) $\Delta U_{\text{mix}} = 0$
(c) $\Delta P = P_{\text{obs.}} - P_{\text{calculated by Raoult's law}} = 0$
(d) $\Delta G_{\text{mix}} = 0$

Ans. *(d)*

Key Idea *For this problem, the following expression can be used.*

$$\Delta G_{\text{mix}} = \Delta H_{\text{mix}} - T\Delta S_{\text{mix}}$$

For an ideal gas

$$\Delta H_{\text{mix}} = 0;\ \Delta U_{\text{mix}} = 0;\ \Delta S_{\text{mix}} \neq 0$$

Putting all these values in the expression,

$$\Delta G_{\text{mix}} = \Delta H_{\text{mix}} - T\Delta S_{\text{mix}}$$

$$\Rightarrow \quad \Delta G_{\text{mix}} = 0 - T\Delta S_{\text{mix}}$$

$$\therefore \quad \Delta G_{\text{mix}} \neq 0$$

Thus, option (d) is incorrect.

19 A gas such as carbon monoxide would be most likely to obey the ideal gas law at **[CBSE AIPMT 2015]**

(a) high temperatures and low pressures
(b) low temperatures and high pressures
(c) high temperatures and high pressures
(d) low temperatures and low pressures

Ans. *(a)*

Real gases show ideal gas behaviour at high temperatures and low pressures.

20 Which one is not equal to zero for an ideal solution? **[CBSE AIPMT 2015]**

(a) ΔH_{mix}
(b) ΔS_{mix}
(c) ΔV_{mix}
(d) $\Delta P = P_{\text{observed}} - P_{\text{Raoult}}$

Ans. *(b)*

For an ideal solution

(i) There will be no change in volume on mixing the two components i.e. $\Delta V_{\text{mixing}} = 0$
(ii) There will be no change in enthalpy so $\Delta H_{\text{mixing}} = 0$
So, $\Delta S_{\text{mix}} \neq 0$ for an ideal solution.

21 p_A and p_B are the vapour pressure of pure liquid components *A* and *B*, respectively of an ideal binary solution. If χ_A represents the mole fraction of component *A*, the total pressure of the solution will be **[CBSE AIPMT 2012]**

(a) $p_A + \chi_A(p_B - p_A)$ (b) $p_A + \chi_A(p_A - p_B)$
(c) $p_B + \chi_A(p_B - p_A)$ (d) $p_B + \chi_A(p_A - p_B)$

Ans. *(d)*

According to Raoult's law, if volatile liquid added in pure solvent, then total pressure equal to sum of the partial pressure of volatile liquid and solvent.

Total pressure, $p_T = p'_A + p'_B$ ...(i)

We know that, $p'_A = p_A\chi_A$

$p'_B = p_B\chi_B$

Substituting the values of p'_A and p'_B in Eq. (i)

$$p_T = p_A\chi_A + p_B\chi_B$$

Mole fraction, $\chi_A + \chi_B = 1 \Rightarrow \chi_B = 1 - \chi_A$

On substituting in above equation,

$$p_T = p_A\chi_A + p_B(1 - \chi_A)$$

$$= p_A\chi_A + p_B - p_B\chi_A$$

$$\therefore \quad p_T = p_B + \chi_A(p_A - p_B)$$

22 A solution of acetone in ethanol **[CBSE AIPMT 2006]**

(a) shows a negative deviation from Raoult's law
(b) shows a positive deviation from Raoult's law
(c) behaves like a near ideal solution
(d) obeys Raoult's law

Ans. *(b)*

A solution of acetone in ethanol shows a positive deviation from Raoult's law due to miscibility of these two liquids with difference of polarity and length of hydrocarbon chain.

23 A solution has 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 **[CBSE AIPMT 2005]**

(a) 0.549 (b) 0.200
(c) 0.786 (d) 0.478

Ans. ***(d)***

Total vapour pressure of mixture = Vapour pressure of pentane in mixture + vapour pressure of hexane in mixture

Since, the ratio of pentane to hexane = 1:4

$\therefore$ Mole fraction of pentane $=\frac{1}{5}$

Mole fraction of hexane $=\frac{4}{5}$

= (mole fraction of pentane × vapour pressure of pentane) + (mole fraction of hexane × vapour pressure of hexane)

$$=\left(\frac{1}{5}\times 440+\frac{4}{5}\times 120\right)=184\text{ mm}$$

$\because$ Vapour pressure of pentane in mixture = Vapour pressure of mixture × mole fraction of pentane in vapour phase

88 = 184 × mole fraction of pentane in vapour phase

$\therefore$ Mole fraction of pentane in vapour phase

$$=\frac{88}{184}=0.478$$

24 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 **[CBSE AIPMT 2005]**

(a) 140 torr (b) 20 torr
(c) 68 torr (d) 72 torr

Ans. ***(d)***

Mole fraction of $P=\frac{3}{3+2}=\frac{3}{5}$

Mole fraction of $Q=\frac{2}{3+2}=\frac{2}{5}$

Hence, total vapour pressure = Mole fraction of *P* × vapour pressure of P + mole fraction of *Q* × vapour pressure of *Q*

$$=\left(\frac{3}{5}\times 80+\frac{2}{5}\times 60\right)=48+24=72\text{ torr}$$

25 Formation of a solution from two components can be considered as **[CBSE AIPMT 2003]**

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

(a) $\Delta H_{\text{sol.}}=\Delta H_1-\Delta H_2-\Delta H_3$
(b) $\Delta H_{\text{sol.}}=\Delta H_3-\Delta H_1-\Delta H_2$
(c) $\Delta H_{\text{sol.}}=\Delta H_1+\Delta H_2+\Delta H_3$
(d) $\Delta H_{\text{sol.}}=\Delta H_1+\Delta H_2-\Delta H_3$

Ans. ***(c)***

For an ideal solution,

$$\Delta H_{\text{sol}}=\Delta H_1+\Delta H_2+\Delta H_3$$

26 A solution containing components *A* and *B* follows Raoult's law, when **[CBSE AIPMT 2002]**

(a) *A*-*B* attraction force is greater than *A*-*A* and *B*-*B*
(b) *A*-*B* attraction force is less than *A*-*A* and *B*-*B*
(c) *A*-*B* attraction force remains same as *A*-*A* and *B*-*B*
(d) volume of solution is different from sum of volumes of solute and solvent

Ans. ***(c)***

Raoult's law is valid for ideal solution only. The two components *A* and *B* follows the condition of Raoult's law only when the force of attraction between *A* and *B* is equal to the force of attraction between *A* – *A* and *B* – *B*.

While non-ideal solutions exhibit either positive or negative deviations from Raoult's law. When *A* – *B* attraction force is greater than *A* – *A* and *B* – *B*, then solution shows negative deviation and when *A*–*B* attraction force is less than *A*–*A* and *B*–*B*, the solution shows positive deviation.

27 According to Raoult's law, relative lowering of vapour pressure of a solution is equal to **[CBSE AIPMT 1995]**

(a) moles of solute
(b) moles of solvent
(c) mole fraction of solute
(d) mole fraction of solvent

Ans. ***(c)***

According to Raoult's law, the relative lowering of vapour pressure is equal to the mole fraction of solute, i.e.

$$\frac{p^\circ-p}{p^\circ}=\chi_B$$

χ_B = mole fraction of solute

28 The relative lowering of vapour pressure is equal to the ratio between the number of **[CBSE AIPMT 1991]**

(a) solute molecules to the solvent molecules
(b) solute molecules to the total molecules in solution
(c) solvent molecules to the total molecules in the solution
(d) solvent molecules to the total number of ions of the solute

Ans. ***(b)***

According to Raoult's law the relative lowering of vapour pressure is equal to mole fraction of solute, i.e. the ratio of number of moles of solute to total number of moles of all component in solution.

29 All form ideal solution except **[CBSE AIPMT 1988]**

(a) C_6H_6 and $C_6H_5CH_3$
(b) C_2H_5Cl and C_2H_5I
(c) C_6H_5Cl and C_6H_5Br
(d) C_2H_5I and C_2H_5OH

Ans. ***(d)***

When we mix C_2H_5I and C_2H_5OH, there is change in enthalpy and volume, so it is an example of non-ideal solution.

30 An ideal solution is formed when its components **[CBSE AIPMT 1988]**

(a) have no volume change on mixing
(b) have no enthalpy change on mixing
(c) have both the above characteristics
(d) have high solubility

Ans. ***(c)***

In ideal solution there is no change in enthalpy and volume after mixing, i.e.

$$\Delta V_{\text{mixing}}=0,$$
$$\Delta H_{\text{mixing}}=0$$
and $$T_{\text{mix}}=0$$

TOPIC 3

Colligative Properties

31 The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 mL of water (p_1), 10 g of urea (CH_4N_2O) in 250 mL of water (p_2) and 10 g of sucrose ($C_{12}H_{22}O_{11}$) in 250 mL of water (p_3). The right option for the decreasing order of osmotic pressure of these solutions is **[NEET 2021]**

(a) $p_2 > p_1 > p_3$ (b) $p_1 > p_2 > p_3$

(c) $p_2 > p_3 > p_1$ (d) $p_3 > p_1 > p_2$

Ans. ***(a)***

van't Hoff factor for glucose, urea and sucrose is one as all are non-ionic.

Mass of glucose = 10 g

Molar mass of glucose = 180 g mol^{-1}

Number of moles of glucose

$$= \frac{10}{180} = \frac{1}{18} \text{ mol} = 0.056 \text{ mol}$$

Mass of urea = 10 g

Molar mass of urea = 60 g mol^{-1}

Number of moles of urea $= \frac{10}{60} = \frac{1}{6}$ mol

$$= 0.167 \text{ mol}$$

Mass of sucrose = 10 g

Molar mass of sucrose = 342 g mol^{-1}

Number of moles of sucrose

$$= \frac{10}{342} = 0.029 \text{ mol}$$

Osmotic pressure is a colligative property which depends on the amount of solute present in the solution. As the amount of urea is more than that of glucose and sucrose.

Amount of solute : Urea > Glucose > Sucrose

$\therefore$Osmotic pressure, $p_2 > p_1 > p_3$

32 Isotonic solutions have same **[NEET (Oct.) 2020]**

(a) vapour pressure

(b) freezing temperature

(c) osmotic pressure

(d) boiling temperature

Ans. ***(c)***

Isotonic solutions have same osmotic pressure (π) at a given temperature.

$$\pi = CRT$$

When, two solution have same molar concentration (C) their osmotic pressure will be equal.

33 If 8 g of a non-electrolyte solute is dissolved in 114 g of *n*-octane to reduce its vapour pressure to 80%, the molar mass (in g mol^{-1}) of the solute is [Given that, molar mass of *n*-octane is 114 g mol^{-1}] **[NEET (Oct.) 2020]**

(a) 40 (b) 60 (c) 80 (d) 20

Ans. ***(*)***

Does not match with the options.

Here, relative lowering of given vapour pressure,

$$\frac{\Delta p}{p^\circ} = \frac{p^\circ - p^\circ \times 0.8}{p^\circ} = 0.2$$

Now, $$\frac{\Delta p}{p^\circ} = x_B = \frac{n_B}{n_B + n_A} = \frac{\frac{w_B}{M_B}}{\frac{w_B}{M_B} + \frac{w_A}{M_A}}$$

p° = vapour pressure of pure solvent (octane)

Mass of solute (w_B) = 8 g

Mass of solvent (w_A) = 114 g

Molar mass of solute (M_B) = ?

Molar mass of solvent (octane)(M_A)

$$= 114 \text{ g mol}^{-1}.$$

$$\Rightarrow 0.2 = \frac{8/M_B}{\frac{8}{M_B} + \frac{114}{114}} \Rightarrow M_B = 32 \text{ g mol}^{-1}$$

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

(a) doubled (b) halved

(c) tripled (d) unchanged

Ans. ***(d)***

For a dilute solution, the depression in freezing point (ΔT_f) is directly proportional to molality (m) of the solution.

$$\Delta T_f \propto m \quad \text{or} \quad \Delta T_f = K_f m$$

Where, K_f is called molal depression constant or freezing point depression constant or cryoscopic constant. The value of K_f depends only on nature of the solvent and independent of composition of solute particles, i.e. does not depend on the concentration of solution.

35 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, Phase I]**

(a) 100°C (b) 102°C

(c) 103°C (d) 101°C

Ans. ***(d)***

From Raoult's law of partial pressure,

$$\frac{\overset{\circ}{p_A} - p_S}{p_S} = \frac{n_B}{n_A}$$

$$\Rightarrow \frac{760 - 732}{732} = \frac{W_B \times M_A}{M_B \times W_A}$$

$$\Rightarrow \frac{28}{732} = \frac{6.5 \times 18}{M_B \times 100}$$

$$\Rightarrow M_B = 30.6$$

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

$\therefore$ Boiling point = 100 + 1.10 = 101.1°C

$$\approx 101^\circ \text{C}$$

36 An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase? **[CBSE AIPMT 2010]**

(a) Addition of NaCl

(b) Addition of Na_2SO_4

(c) Addition of 1.00 molal KI

(d) Addition of water

Ans. ***(d)***

Key Idea *Vapour pressure depends upon the surface area of the solution. Larger the surface area, higher is the vapour pressure.*

Addition of solute decreases the vapour pressure as some sites of the surface are occupied by solute particles, resulting in decreased surface area. However, addition of solvent, i.e. dilution, increases the surface area of the liquid surface, thus results in increased vapour pressure.

Hence, addition of water to the aqueous solution of (1 molal) KI, results in increased vapour pressure.

37 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}) **[CBSE AIPMT 2010]**

(a) – 0.372°C (b) – 0.520°C

(c) + 0.372°C (d) – 0.570°C

Ans. ***(a)***

Depression in freezing point,

$$\Delta T_f = k_f \times m$$

where, m = molality $= \frac{W_B \times 1000}{M_B \cdot W_A}$

$$= \frac{68.5 \times 1000}{342 \times 1000} = \frac{68.5}{342}$$

$$\Delta T_f = 1.86 \times \frac{68.5}{342} = 0.372\,^\circ\text{C}$$

$$\begin{aligned} T_f &= T_F^0 - \Delta T_F \\ &= 0 - 0.372^\circ\,\text{C} \\ &= -0.372^\circ\,\text{C} \end{aligned}$$

38 A solution containing 10 g 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 **[CBSE AIPMT 2006]**

(a) 250 g mol^{-1} (b) 300 g mol^{-1}
(c) 350 g mol^{-1} (d) 200 g mol^{-1}

Ans. ***(b)***

10 g per dm^3 of urea is isotonic with 5% solution of a non-volatile solute. Hence, between these solutions osmosis is not possible, so their molar concentrations are equal to each other.

Thus, molar concentration of urea solution

$$= \frac{10\text{ g}/\text{dm}^3}{\text{Molecular weight of urea}} = \frac{10}{60}\text{M} = \frac{1}{6}\text{M}$$

Molar concentration of 5% non-volatile solute

$$= \frac{50\text{ g}/\text{dm}^3}{\text{Molecular weight of non-volatile solute}} = \frac{50}{m}\text{M}$$

Both solutions are isotonic to each other, therefore

$$\frac{1}{6} = \frac{50}{m}$$

or $m = 50 \times 6 = 300\text{ g mol}^{-1}$

39 During osmosis, flow of water through a semipermeable membrane is **[CBSE AIPMT 2006]**

(a) from solution having higher concentration only
(b) from both sides of semipermeable membrane with equal flow rates
(c) from both sides of semipermeable membrane with unequal flow rates
(d) from solution having lower concentration only

Ans. ***(d)***

During osmosis, flow of water through a semipermeable membrane is from solution having lower concentration only.

40 1.00 g of a non-electrolyte solute (molar mass 250 g 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 **[CBSE AIPMT 2006]**

(a) 0.4 K (b) 0.3 K
(c) 0.5 K (d) 0.2 K

Ans. ***(a)***

Molality of non-electrolyte solute

$$= \frac{\dfrac{\text{Weight of solute in (g)}}{\text{molecular weight of solute}}}{\text{Weight of solvent in (kg)}} = \frac{\dfrac{1}{250}}{0.0512} = \frac{1}{250 \times 0.0512} = 0.0781\,\text{m}$$

$$\begin{aligned} \Delta T_f &= k_f \times \text{molality of solution} \\ &= 5.12 \times 0.0781 \approx 0.4\text{ K} \end{aligned}$$

41 A solution of urea (mol. mass 56 g mol^{-1}) boils at 100.18°C at the atmospheric pressure. If k_f and k_b for water are 1.86 and 0.512 K kg mol^{-1} respectively, the above solution will freeze at **[CBSE AIPMT 2005]**

(a) −6.54°C (b) 6.54°C
(c) 0.654°C (d) −0.654°C

Ans. ***(d)***

According to depression of freezing point,

$\Delta T_f = k_f \times$ molality of solution

According to elevation of boiling point,

$\Delta T_b = k_b \times$ molality of solution

or $$\frac{\Delta T_f}{\Delta T_b} = \frac{k_f}{k_b}$$

Given that

$\Delta T_b = T_2 - T_1 = 100.18 - 100 = 0.18$

k_b for water = 1.86 K kg mol^{-1}

k_b for water = 0.512 K kg mol^{-1}

$$\therefore \quad \frac{\Delta T_f}{0.18} = \frac{1.86}{0.512}$$

$$\Delta T_f = \frac{1.86 \times 0.18}{0.512} = 0.6539 \approx 0.654$$

$$\Delta T_f = T_1 - T_2$$

$$0.654 = 0^\circ\,\text{C} - T_2$$

$$\therefore \quad T_2 = -0.654^\circ\,\text{C}$$

($T_2 \rightarrow$ freezing point of aqueous urea solution)

42 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? **[CBSE AIPMT 2002]**

(a) $M_2 = \left[\frac{m_2}{\pi}\right] VRT$ (b) $M_2 = \left[\frac{m_2}{V}\right] \frac{RT}{\pi}$
(c) $M_2 = \left[\frac{m_2}{V}\right] \pi RT$ (d) $M_2 = \left[\frac{m_2}{V}\right] \frac{\pi}{RT}$

Ans. ***(b)***

For dilute solution,

$pV = nRT$ ($p = \pi$, osmotic pressure)

or $\pi V = nRT$ or $\pi = \frac{n}{V} RT$

$$\Rightarrow \quad \pi V = \frac{m_2}{M_2} RT \;\Rightarrow\; M_2 = \frac{m_2 RT}{\pi V}$$

where, π = osmotic pressure
V = volume of solution
n = number of moles of solute
m_2 = mass of solute
M_2 = molecular mass of solute

43 Pure water can be obtained from sea water by **[CBSE AIPMT 2001]**

(a) centrifugation (b) plasmolysis
(c) reverse osmosis (d) sedimentation

Ans. ***(c)***

Reverse osmosis The minimum external pressure applied to a solution separated from a solvent by semipermeable membrane to prevent osmosis, is called osmotic pressure. When the pressure applied to solution is more than osmotic pressure, solute will pass from the solution into solvent through the semipermeable membrane. This phenomenon is known as reverse osmosis.

The osmotic pressure of sea water is 25 atm at 15°C. When pressure greater than 26 atm is applied on sea water separated by a rigid semipermeable membrane, pure water is obtained. This is also called desalination of sea water.

44 Which of the following colligative property can provide molar mass of proteins (or polymers or colloids) with greatest precision? **[CBSE AIPMT 2000]**

(a) Osmotic pressure
(b) Elevation in boiling point
(c) Depression in freezing point
(d) Relative lowering of vapour pressure

Ans. *(a)*

Osmotic pressure is a colligative property which is used to find the molecular weight of polymer because other colligative properties give so low value of molecular weight that it cannot be measured accurately.

45 The vapour pressure of benzene at a certain temperature is 640 mmHg. A non-volatile and non-electrolyte solid, weighing 2.175 g is added to 39.08 g of benzene. If the vapour pressure of the solution is 600 mm Hg, what is the molecular weight of solid substance? **[CBSE AIPMT 1999]**

(a) 49.50 (b) 59.60 (c) 69.40 (d) 79.82

Ans. *(c)*

According to Raoult's law,

$$\frac{p^\circ - p}{p^\circ} = \frac{w \times M}{m \times W}$$

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

(M for $C_6H_6 = 78$)

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

$$= 69.45 \approx 69.4$$

46 If 0.15 g of 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 is (molal elevation constant for the solvent is 2.16°C) **[CBSE AIPMT 1999]**

(a) 1.01
(b) 10
(c) 10.1
(d) 100

Ans. *(d)*

$$w = 0.15\,\text{g}, \quad W = 15\,\text{g},$$

$$\Delta T_b = 0.216^\circ\,\text{C}\; k_b = 2.16,\; m = ?$$

$$m = \frac{1000 \times k_b}{\Delta T_b} \times \frac{w}{W}$$

$$= \frac{1000 \times 2.16 \times 0.15}{0.216 \times 15} = 100$$

47 A 5% solution of cane sugar (mol. wt. = 342) is isotonic with 1% solution of a substance *X*. The molecular weight of *X* is **[CBSE AIPMT 1998]**

(a) 34.2
(b) 171.2
(c) 68.4
(d) 136.8

Ans. *(c)*

Isotonic solutions are the solutions having same osmotic pressure.

Osmotic pressure of 5% cane sugar solution

$$(\pi_1) = C \times R \times T = \frac{50\text{ g / L}}{342} \times 0.0821 \times T$$

Osmotic pressure of 1% solution of substance

$$X(\pi_2) = \frac{10\,\text{g/L}}{M} \times 0.0821 \times T$$

Both are isotonic

So, $$\pi_1 = \pi_2$$

or $$\frac{50}{342} \times 0.0821 \times T = \frac{10}{M} \times 0.0821 \times T$$

$$\therefore M(\text{molecular weight of } X) = \frac{342}{5} = 68.4$$

48 The vapour pressure of a solvent decreased by 10 mm in two columns 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 **[CBSE AIPMT 1998]**

(a) 0.8 (b) 0.6 (c) 0.4 (d) 0.2

Ans. *(b)*

According to Raoult's law, the relative lowering of vapour pressure is equal to the mole fraction of solute, i.e.

$$\frac{p^\circ - p}{p^\circ} = \frac{n}{n+N} \text{ or } \frac{\Delta p}{p^\circ} = \frac{n}{n+N}$$

$$\frac{10}{p^\circ} = 0.2 \Rightarrow p^\circ = 50\text{ mm}$$

For other solution of same solvent

$$\frac{20}{p^\circ} = \frac{n}{n+N} \text{ or } \frac{20}{50} = \frac{n}{n+N}$$

$$0.4 = \frac{n}{n+N} \text{ (mole fraction of solute)}$$

$\because$ Mole fraction of solvent + mole fraction of solute = 1

So, mole fraction of solvent = 1 − 0.4 = 0.6

49 The vapour pressure, at a given temperature, of an ideal solution containing 0.2 mole of a non-volatile solute and 0.8 mole of solvent is 60 mm of Hg. The vapour pressure of the pure solvent at the same temperature is **[CBSE AIPMT 1996]**

(a) 150 mm of Hg (b) 60 mm of Hg
(c) 75 mm of Hg (d) 120 mm of Hg

Ans. *(c)*

We know that, according to Raoult's law

$$\frac{p^\circ - p}{p^\circ} = \chi_B$$

$$\frac{p^\circ - 60}{p^\circ} = \frac{n_B}{n_A + n_B} = \frac{0.2}{0.2 + 0.8}$$

$$= \frac{0.2}{1.0} = \frac{2}{10} = \frac{1}{5}$$

$$p^\circ - 60 = \frac{p^\circ}{5}$$

$$\Rightarrow \quad p^\circ - \frac{p^\circ}{5} = 60$$

$$\frac{5p^\circ - p^\circ}{5} = 60$$

$$4p^\circ = 60 \times 5$$

$$p^\circ = \frac{60 \times 5}{4} = \frac{300}{4} = 75\text{ mm of Hg}$$

50 Vapour pressure of benzene at 30°C is 121.8 mm. When 15 g of a non-volatile solute is dissolved in 250 g of benzene its vapour pressure decreased to 120.2 mm. The molecular weight of the solute is (mol. weight of solvent = 78) **[CBSE AIPMT 1995]**

(a) 356.2 (b) 456.8 (c) 530.1 (d) 656.7

Ans. *(a)*

Given, vapour pressure of pure benzene (p°) = 121.8 mm

Vapour pressure of solution (p) = 120.2 mm

Mass of solute (w_B) = 15 g

Mass of benzene (w_A) = 250 g

Molar mass of solvent (m_A) = 78

Molecular weight of solute (m_B) = ?

Hence, according to Raoult's law,

$$\frac{p^\circ - p}{p^\circ} = \frac{w_B \times m_A}{m_B \times w_A}$$

p° = vapour pressure of solvent

p = vapour pressure of the solution

$$\frac{121.8 - 120.2}{121.8} = \frac{15 \times 78}{m_B \times 250}$$

$$m_B = \frac{121.8 \times 15 \times 78}{250 \times (121.8 - 120.2)}$$

$$= \frac{142506}{250 \times 1.6} = \frac{142506}{400} = 356.26\text{ g mol}^{-1}$$

51 Which one is a colligative property? **[CBSE AIPMT 1992]**

(a) Boiling point
(b) Vapour pressure
(c) Osmotic pressure
(d) Freezing point

Ans. ***(c)***

Osmotic pressure is an example of colligative property because its value depends only on the number of moles of solute, not on their chemical nature.

52 Blood cells retain their normal shape in solutions which are **[CBSE AIPMT 1991]**

(a) hypotonic to blood
(b) isotonic to blood
(c) hypertonic to blood
(d) equinormal to blood

Ans. ***(b)***

When blood cells are placed in a solution of similar concentration as that of blood, then they neither swell nor shrink it means the concentration of solution is same as that of inside the blood cells, i.e. they are isotonic to each other.

TOPIC 4

Abnormal Molecular Masses and Distribution Law

53 The van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide is **[NEET 2016, Phase II]**

(a) 0 (b) 1 (c) 2 (d) 3

Ans. ***(d)***

Key Idea *Strong electrolytes dissociate completely in their solutions.*

van't Hoff factor = total number of ions after dissociation

So for $Ba(OH)_2 \rightleftharpoons Ba^{2+}(aq) + 2OH^-(aq)$

Number of ions 1 2

van't Hoff factor, $i = 1 + 2 = 3$

54 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? **[CBSE AIPMT 2015]**

(a) X is undergoing dissociation in water.
(b) Molecular mass of X is greater than the molecular mass of Y.
(c) Molecular mass of X is less than the molecular mass of Y.
(d) Y is undergoing dissociation in water while X undergoes no change.

Ans. ***(a)***

Molality of solution X = molality of solution $Y = 0.2$ mol/kg

We know that, elevation in the boiling point (ΔT_b) of a solution is proportional to the molal concentration of the solution i.e.

$$\Delta T_b \propto m \text{ or } \Delta T_b = K_b m$$

where, m is the molality of the solution and K_b is molal boiling point constant or ebullioscopic constant.

$\therefore$ By elevation in boiling point relation

$$\Delta T_b = iK_b m \text{ or } \Delta T_b \propto i$$

where, i is van't Hoff factor

Since, ΔT_b of solution X is greater than ΔT_b of solution Y.

(Observed colligative property is greater than normal colligative property).

$\therefore$ i of solution $X > i$ of solution Y

$\therefore$ Solution X undergoing dissociation

55 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)? **[CBSE AIPMT 2015]**

(a) K_2SO_4 (b) $K_3[Fe(CN)_6]$
(c) $Al(NO_3)_3$ (d) $K_4[Fe(CN)_6]$

Ans. ***(d)***

$Al_2(SO_4)_3 \rightleftharpoons 2\,Al^{3+} + 3\,SO_4^{2-}$

Value of van't Hoff's factor (i) = 5

(a) $K_2SO_4 \rightleftharpoons 2K^+ + SO_4^{2-}$ ($i = 3$)

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

(c) $Al(NO_3)_3 \rightleftharpoons Al^{3+} + 3\,NO_3^-$ ($i = 4$)

(d) $K_4[Fe(CN)_6] \rightleftharpoons 4\,K^+ + [Fe(CN)_6]^{3-}$ ($i = 5$)

Therefore, $K_4[Fe(CN)_6]$ has same value of i that of $Al_2(SO_4)_3$ i.e. $i = 5$.

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

(a) KCl (b) $C_6H_{12}O_6$
(c) $Al_2(SO_4)_3$ (d) K_2SO_4

Ans. ***(c)***

ΔT_f (freezing point depression) is a colligative property and depends upon the van't Hoff factor (i), i.e. number of ions given by the electrolyte in aqueous solution.

$$\Delta T_f = i \times k_f \times m$$

where, k_f = molal freezing point depression constant

m = molality of the solution

$\therefore$ k_f and m are constant,

$$\therefore \qquad \Delta T_f \propto i$$

van't Hoff factor for ionic solution.

(a) $KCl(aq) \rightleftharpoons K^+(aq) + Cl^-(aq)$,
(Total ions = 2 thus, $i = 2$)

(b) $C_6H_{12}O_6 \rightleftharpoons$ no ions[$i = 0$]
because glucose does not gives ions.

(c) $Al_2(SO_4)_3(aq) \rightleftharpoons 2Al^{3+} + 3SO_4^{2-}$
[Total ions = 5, thus, $i = 5$]

(d) $K_2SO_4(aq) \rightleftharpoons 2K^+ + SO_4^{2-}$
[Total ions = 3, thus, $i = 3$]

Hence, $Al_2(SO_4)_3$ will exhibit largest freezing point depression due to the highest value of i.

57 The van't Hoff factor, i for a compound which undergoes dissociation in one solvent and association in other solvent is respectively. **[CBSE AIPMT 2011]**

(a) less than one and less than one
(b) greater than one and less than one
(c) greater than one and greater than one
(d) less than one and greater than one

Ans. ***(b)***

Abnormality present due to dissociation and association of the solution.

For dissociation, van't Hoff factor is greater than one and for association, van't Hoff factor is less than one.

For dissociation, $i > 1$

For association, $i < 1$

58 The freezing point depression constant for water is $-1.86°C\ m^{-1}$. 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. **[CBSE AIPMT 2011]**

(a) 2.63 (b) 3.11 (c) 0.381 (d) 2.05

Ans. ***(a)***

According to depression in freezing point,

$$\Delta T_f = i \times k_f \cdot m$$

where, k_f = cryoscopic constant

$$\text{or} \quad i = \frac{\Delta T_f \times W_{\text{solvent}}}{k_f \times n_{\text{solute}} \times 1000}$$

$$= \frac{3.82 \times 45}{1.86 \times \left(\frac{5}{142}\right) \times 1000} = 2.63$$

59 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 mole of ionic compound produces on being dissolved in water will be ($k_f = -1.86°C$ / m) **[CBSE AIPMT 2009]**

(a) 2 (b) 3 (c) 4 (d) 1

Ans. *(a)*

Given, molality, $m = 0.0020$ m

$$\begin{aligned} \Delta T_f &= 0°\text{C} - 0.00732°\text{C} \\ &= -\,0.00732°\text{C} \\ k_f &= -\,1.86°\text{C / m} \\ \Delta T_f &= i \cdot k_f \times m \\ i &= \frac{\Delta T_f}{k_f \times m} \\ &= \frac{0.00732}{1.86 \times 0.0020} \\ &= 1.96 \approx 2 \end{aligned}$$

Since, the compound is ionic, so number of moles produced is equal to van't Hoff factor, *i*.

Hence, 2 moles of ions are produced.

$$\underset{1\,\text{mol}}{[\text{Co(NH}_3)_5\text{NO}_2]\text{Cl}} \longrightarrow \underbrace{[\text{Co(NH}_3)_5\text{NO}_2]^+ + \text{Cl}^-}_{2\text{ ions}}$$

60 0.5 molal aqueous solution of a weak acid (H*X*) is 20% ionised. If k_f for water is 1.86K kg mol^{-1}, the lowering in freezing point of the solution is **[CBSE AIPMT 2007]**

(a) –1.12 K (b) 0.56 K
(c) 1.12 K (d) – 0.56 K

Ans. *(c)*

$$\begin{array}{lccl} \underset{\text{Weak acid}}{\text{H}X} & \rightleftharpoons & \text{H}^+ + X^- & \\ 1 & & 0 \quad 0 & \text{(initially)} \\ 1-\alpha & & \alpha \quad \alpha & \text{(at equilibrium)} \end{array}$$

Total $= 1 - \alpha + \alpha + \alpha = 1 + \alpha$

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

$\alpha = 20\%$ dissociation

i.e. $\alpha = 0.2$

$$\begin{aligned} i &= 1 + \alpha = 1 + 0.2 = 1.2 \\ \Delta T_f &= i \times K_f \times m \\ &= 1.2 \times 1.86 \text{ K kg mol}^{-1} \times 0.5 \\ &= 1.12 \text{ K} \end{aligned}$$

61 Which of the following 0.10 M aqueous solution will have the lowest freezing point? **[CBSE AIPMT 1997]**

(a) $Al_2(SO_4)_3$ (b) $C_5H_{10}O_5$
(c) KI (d) $C_{12}H_{22}O_{11}$

Ans. *(a)*

Depression in freezing point ∝ number of particles.

In colligative properties ions behave like particles.

$Al_2(SO_4)_3$ provides five ions on ionisation as

$$Al_2(SO_4)_3 \longrightarrow 2\,Al^{3+} + 3SO_4^{2-}$$
$$KI \rightleftharpoons K^+ + I^-$$

while KI provides two ions and $C_5H_{10}O_5$ and $C_{12}H_{22}O_{11}$ are not ionised, so they have single particle

Hence, lowest freezing point is possible for $Al_2(SO_4)_3$.

62 At 25°C, the highest osmotic pressure is exhibited by 0.1 M solution of **[CBSE AIPMT 1994]**

(a) $CaCl_2$ (b) KCl
(c) glucose (d) urea

Ans. *(a)*

$CaCl_2$ is an electrolyte and dissociates to give three ions as

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$$

While KCl gives two ions and glucose and urea are non-electrolytes, so remains undissociated.

As osmotic pressure is a colligative property (i.e. depend only on number of particles), so highest for $CaCl_2$.

63 Which one of the following salts will have the same value of van't Hoff factor (*i*) as that of $K_4[Fe(CN)_6]$? **[CBSE AIPMT 1994]**

(a) $Al_2(SO_4)_3$
(b) NaCl
(c) $Al(NO_3)_3$
(d) Na_2SO_4

Ans. *(a)*

Both $K_4[Fe(CN)_6]$ and $Al_2(SO_4)_3$ gives 5 ions after dissociation, so they have same value of van't Hoff factor (*i*).

$$K_4[Fe(CN)_6] \longrightarrow 4K^+ + [Fe(CN)_6]^{4-}$$
$$Al_2(SO_4)_3 \longrightarrow 2Al^{3+} + 3SO_4^{2-}$$

64 In a pair of immiscible liquids, a common solute dissolves in both and the equilibrium is reached. Then, the concentration of the solute in upper layer is **[CBSE AIPMT 1994]**

(a) in fixed ratio with that in the lower layer
(b) same as the lower layer
(c) lower than the lower layer
(c) higher than the lower layer

Ans. *(a)*

According to Nernst distribution law when we mixed a common solute in a pair of immiscible liquids, then the ratio of amount of solute in both liquids is fixed at a fixed temperature.

65 Which of the following aqueous solutions has minimum freezing point? **[CBSE AIPMT 1991]**

(a) 0.01 m NaCl
(b) 0.005 m MgI_2
(c) 0.005 m C_2H_5OH
(d) 0.005 m $MgSO_4$

Ans. *(a)*

0.01 molal NaCl solution have minimum freezing point because its molality is more and it gives two ions after dissociation of one molecule.