CHAPTER 16

Solutions

Key Notes and Formulae

Solution

A solution is homogeneous mixture of two or more pure substances.

Raoult's Law

According to Raoult's law, the vapour pressure of a solution containing non-volatile solute is proportional to mole fraction of the solvent.

Molality

When molality of solution is one then,

$$\Delta T_b = k_b.$$

Osmotic Pressure

Osmotic pressure may be defined as the excess pressure which must be applied to a solution in order to prevent flow of solvent into the solutions through the semipermeable membrance.

Types of Solution

Two solutions having same osmotic pressure are called isotonic solutions. A solution having higher osmotic pressure than some other, is called hypertonic solution. A solution having lower osmotic pressure than other is called hypotonic solution.

Degree of Dissociation

$(\alpha)=\frac{i-1}{m-1}$ (m = number of particle per molecule).

Degree of Association

$$(\alpha)=\frac{i-1}{1/(m-1)}$$

Osmotic Coefficient

The ratio of Van't Hoff factor (i) to the number of ions furnished by one molecule of electrolyte n is known as the osmotic coefficient (g). Thus,

$$g=\frac{\text{Van't Hoff factor}, i}{n}$$

Ideal Solution

Solution which obeys Raoult's law over the entire range of concentration and temperature and during the formation of which no change in enthalpy or volume takes place. For an ideal solution,

$$P_A = P^0{}_A X_A, \Delta H_{\text{mixture}} = 0. \Delta V_{\text{mixture}} = 0$$

Azeotropic Mixture

A liquid mixture boils without changing composition is called azeotropic mixture.

Types of Colloids

(i) Lyophobic (solvent hating) sols. e.g. gold sol, silver sol, arsenous sulphide sol in water.

(ii) Lyophillic (solvent loving) sols. e.g. starch, gum, gelatin etc.

Peptization

Changing of a precipitate into colloidal particles by adding suitable electrolyte is known as peptization.

Tyndal Effect

Tyndal effect is due to scattering of light from the surface of colloidal particles.

Gold Number

The gold number is the weight in milligrams of a protective colloid which checks the coagulation of 10 ml of a given gold sol on adding 1 ml of 10% solution of sodium chloride. The smaller is gold number of a lyophilic colloid, greater is its protecting power.

Previous Years' Questions

NEET

1. The van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide is **[July 2016]**
   (a) 3 (b) 0
   (c) 1 (d) 2

2. The suspension of slaked lime in water is known as **[July 2016]**
   (a) Aqueous solution of slaked lime
   (b) Limewater
   (c) Quicklime
   (d) Milk of lime

3. 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 **[May 2016]**
   (a) 101 °C (b) 100 ° C
   (c) 102 °C (d) 103 °C

4. 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 = 3.85kPa) **[May 2016]**
   (a) The vapour will contain a higher percent age of benzene.
   (b) The vapour will contain a higher percent age of toluene.
   (c) The vapour will contain equal amount of Benzene and toluene.
   (d) Not enough information is given to make a prediction.

5. How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70 % HNO_3 **[2013]**
   (a) 70.0 g conc, HNO_3
   (b) 54.0 g conc, HNO_3
   (c) 45.0 g conc, HNO_3
   (d) 90.0 g conc, HNO_3

AIPMT

6. 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? **[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) Similar amounts of reactants and products

7. Pure water can be obtained from sea water by **[2015]**
   (a) centrifugation (b) plasmolysis
   (c) reverse osmosis (d) sedimentation

8. Of the following 0.10 m aqueous solutions, Which one will exhibit the largest freezing point depression? **[2014]**
   (a) KCl (b) $C_6H_{12}O_6$
   (c) $Al_2(SO_4)_3$ (d) K_2SO_4

9. 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 **[2012]**

(a) $P_A + x_A(P_B - P_A)$ (b) $P_A + x_A(P_A - P_B)$

(c) $P_B + x_A(P_B - P_A)$ (d) $P_B + x_A(P_A - P_B)$

10. The freezing point depression constant for water is $-1.86^0\ Cm^{-1}$. If 5.00 g Na_2SO_4 is dissolved in 45.0 g H_2O, the freezing point is changed by -3.82^0C. Calculate the van't Hoff factor for Na_2SO_4. **[2011]**

(a) 2.05 (b) 2.63

(c) 3.11 (d) 0.381

11. Mole fraction of the solute in a 1.00 molal aqueous solution is **[2011]**

(a) 0.1770 (b) 0.0177

(c) 0.0344 (d) 1.7700

12. A Solution of sucrose (molar mass = 342g 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 = 1.86K Kgmol^{-1}) **[2010]**

(a) -0.372^0C (b) -0.520^0C

(c) $+0.372^0C$ (d) -0.570^0C

13. A 0.0020 m aqueous solution of an ionic compound $[Co(NH_3)_5(NO_2)]$ Cl freezes at 0.00732^0C. Number of moles of ions which 1 mol of ionic compound produces on being dissolved in water will be ($K_f = -1.86^0$ C/m) **[2009]**

(a) 3 (b) 4

(c) 1 (d) 2

Answer key

1. (a)	2. (d)	3. (b)	4. (a)	5. (c)	6. (a)	7. (c)
8. (c)	9. (d)	10. (b)	11. (b)	12. (a)	13. (d)	

Detailed Solutions

1. **(a).** $Ba(OH)_2 \rightarrow Ba^{+2} + 2OH^- \Rightarrow i = 3.$

Each mole of Ba $(OH)_2$ in aq. solution will fully dissociate to yield 1 mole of Ba^{2+} and 2 moles of OH^-. As each mole of Ba $(OH)_2$ gives 3 moles of ions its van't Hoff factor is 1

2. **(d).** Suspension of slaked lime in water is called milk of lime.

3. **(b).** At B.P. $P_0 = 760$ torr

$$\frac{P^0 - P_s}{P_s} = \frac{W_A / M_A}{W_B / M_B}$$

$$\frac{760 - 732}{732} = \frac{6.5 / M}{100 / 18}$$

On solving M = 32.

for elevation of B.P.

$$\Delta T_B = 1K_b m = 1 \times 0.52 \times \frac{\left(\frac{6.5}{32}\right)}{100} \times 1000 = 1$$

$= 1$

So B.P. = 100 + $\Delta T_B = 101^0C$

4. **(a).** A → Benzene, B → Toluene

$$P_T = P^0{}_A X_A + P^o{}_B X_B$$
$$= 12.8 \times 0.5 + 3.85 \times 0.5$$
$$= 6.2 + 1.925$$
$$= 8.125$$

Also mole fraction of benzene in vapour form

$$Y_A = \frac{P^0{}_A X_A}{P_T} = \frac{6.2}{8.121} = 0.75$$

And mole fraction of Toluene in vapour form

$Y_B = 1 - 0.75 = 0.25.$

5. **(c).** Molarity = $\frac{W \times 1000}{M_W \times V_{sol(mL)}} \Rightarrow 2 = \frac{W}{63} \times \frac{1000}{250}$

$$w = \frac{63}{2} g$$

Mass of acid x $\frac{70}{100} = \frac{63}{2}$

Mass of acid = 45g

6. **(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 molar concentration of the solution i e.

$\Delta T_b \alpha m$ or $\Delta T_b = K_b m$

Where, m is the molality of the solution and K_b is molal boiling point constant

By elevation in boiling point relation

$\Delta T_b = iK_b m$ or $\Delta T_b \alpha i$

Where, i is vant Hoff is factor

since, ΔT_b of solution X is greater than ΔT_b of solution Y

(observed colligative property is greater than normal colligative property)

1 m of solution X > 1 m of solution Y

∴ Solution x undergoing dissociation

7. **(c).**

8. **(c).** $\Delta T_f = i \times K_f \times m$

So $\Delta T_f \alpha i$ (van' Hoff factor)

Salt	i
KCl	2
$C_6H_{12}O_6$	1
$Al_2(SO_4)_3$	5
K_2SO_4	3

Since i is maximum i,e , 5 for $Al_2(SO_4)_3$

It will exhibit the largest freezing point depression.

9. **(d).** Total presssure,

$P_T = P'_A + P'_B$ ---- (i)

We know that, $P'_A = P_A X_A$

$P'_B = P_B X_B$

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

$P_T = P_A X_A + P_B X_B$

$[X_A + X_B = 1 \Rightarrow X_A = 1 - X_B \text{ or } X_B = 1 - X_A]$

$= P_A X_A + P_B(1-X_A)$

$= P_A X_A + P_B - P_B X_A$

$P_T = P_B + X_A(P_A - P_B)$

10. **(b).** We know that $\Delta T_f = i \times K_f \times \frac{W_B \times 1000}{m_B \times W_A}$

Given $\Delta T_f = 3.82$, $K_f = 1.86$

$W_B = 5$, $m_B = 142$, $W_A = 45$

$$i = \frac{\Delta T \times m_B \times W_A}{Kf \times WB \times 1000} = \frac{3.82 \times 142 \times 45}{1.86 \times 5 \times 1000} = 2.63$$

11. **(b).** Mole fraction of solute

$$= \frac{\text{moles of solute}}{\text{moles of solute+moles of solvent}}$$

$= \frac{1}{1+55.56}$ Moles of solvent $= \frac{1000}{18} = 55.56$

$\frac{1}{55.56} = 0.0177$

12. **(a).** Depression in freezing point,

$\Delta T_f = K_f \times m$

Where, m = molality $= \frac{w_B \times 1000}{M_B . W_A}$

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

$\Delta T_f = 1.86 \times \frac{68.5}{342}$

$= 0.372°C$

$\Delta T_f = T^0 - T_s$

$= 0 - 0.372°C$

$= 0.372°C$

13. **(d).** The number of moles of ions produced by 1 mol of ionic compound = i

Applying $\Delta T_f = i \times K_f \times m$

$0.00732 = i \times 1.86 \times 0.002$

$$i = \frac{0.00732}{1.86 \times 0.002} = 1.96 \approx 2$$