IMPORTANT QUESTIONS CLASS – 12 CHEMISTRY
CHAPTER – 1 SOLUTIONS

Question 1- Differentiate between molality and molarity of a solution. What is the effect of change in temperature solution on its molality and molarity molality and molarity

Molality (m) = Moles of solute / Mass of solvent in kg

For example, 1.00 mol kg^{-1} (or 1.00 m) solution of KCl means that 1 mol (74.5 g) of KCl is dissolved in 1 kg of water.

Molarity (M) is defined as the number of moles of solute dissolved in one litre (or one cubic decimetre) of solution. It is a function of temperature (the volume depends on temperature and mass does not).

Molarity (M) = Moles of solute Molarity / Volume of solution in litre

For example, 0.25 mol L^{-1} (or 0.25 M) solution of NaOH means that 0.25 mol of NaOH has been dissolved in one litre (or one cubic decimetre).

Question 2- State Raoult's law. Non-ideal solutions exhibit either positive or negative deviations from Raoult's law. What are these deviations and why are they caused? Explain with one example for each type. Derive an expression for Raoult's law when the solute is non-volatile.

Answer: Raoult's Law: For a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction.

Thus,

For component 1

$p_1 \propto x_1$ and $p_1 = p^0{}_1 x_1$ (where $p^0{}_1$ is the vapour pressure of pure component 1 at the same temperature).

Similarly,

For component 2

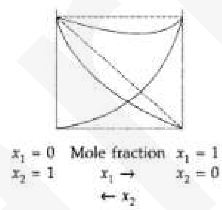
$p_2 = p_2{}^0 x_2$ (where $p_2{}^0$ represents the vapour pressure of the pure component 2).

According to Dalton's law of partial pressures, the total pressure (p_{total}) over the solution phase in the container will be the sum of the partial pressures of the components of the solution and is given as:

$p_{total} = p_1 + p_2$ Substituting the values of p_1 and p_2,

we get $\mathbf{p_{total} = p^o{}_1 + (p_2{}^o - p^o{}_1)\, x_2}$

Non-ideal solutions exhibit Negative deviation from Raoult's law: For any composition of the non-ideal solution, the partial vapour pressure of each component and total vapour pressure of the solution is less than expected from Raoult's law. Such solutions show a negative deviation.



Example: Mixture of $CHCl_3$ and acetone.

Non-ideal solutions show positive deviations from Raoult's law on mixing of two volatile components of the solution.

Example: Mixture of acetone and benzene solutions show positive deviation

Question 3- Define 'osmosis' and 'osmotic pressure'. What is the advantage of using osmotic pressure as compared to other colligative properties for the determination of molar masses of solutes in solutions?

Answer: Osmosis: The flow of the solvent molecules from the solvent to the solution or from a less concentrated solution to a more concentrated solution through a semipermeable membrane.

Osmotic pressure: The minimum excess pressure that has to be applied to the solution to prevent the entry of the solvent into the solution through the semipermeable membrane.

The advantage of using osmotic pressure as compared to other colligative properties for the determination of molar masses of solutes in solutions is that it uses molarities instead of molalities and it can be measured at room temperature.

Question 4-

(a) What is van't Hoff factor?

(b) A 1.00 molal aqueous solution of trichloroacetic acid (CCl_3COOH) is heated to its boiling point. The solution has a boiling point of 100.18°C. Determine the van't Hoff factor for trichloroacetic acid. (K_b for water = 0.512 K kg mol^{-1})

Answer: (a) In 1880 van't Hoff introduced factor i, known as the van't Hoff factor, to account for the extent of dissociation or association. This factor i is defined as:

i= Normal molar mass / Abnormal molar mass

i = Observed colligative property / Calculated colligative property

i= (Total number of moles of particles after association/dissociation) / (Number of moles of particles before association/dissociation)

(b) i = 0.3 (Hint- $\Delta T_b = iK_b m$)

Question 5- Define the following:

1. Mole fraction
2. Isotonic solutions
3. Hypertonic Solution

Answer: 1. Mole fraction: It is denoted by x and subscript used on the right-hand side of x denotes the component. It is defined as:

Mole fraction of a component = Number of moles of the component / Total number of moles of all the components

Mole fraction unit is very useful in relating some physical properties of solutions, say vapour pressure with the concentration of the solution and quite useful in describing the calculations involving gas mixtures.

2. Isotonic Solutions: Two solutions having the same osmotic pressure at a given temperature. When such solutions are separated by semipermeable membrane no osmosis occurs between them.

For example, the osmotic pressure associated with the fluid inside the blood cell is equivalent to that of 0.9% (mass/ volume) sodium chloride solution, called normal saline solution and it is safe to inject intravenously.

3. Hypertonic Solution: A solution with higher osmotic pressure than another solution. If we place the cells in a solution containing more than 0.9% (mass/volume) sodium chloride, water will flow out of the cells and they would shrink.

Question 6- State Henry's law and mention two of its important applications. What is the effect of temperature on the solubility of a gas in a liquid?

Answer: Henry was the first to give a quantitative relation between pressure and solubility of a gas in a solvent which is known as Henry's law. The law states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

Two important applications are:

1. To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.
2. Scuba divers must cope with high concentrations of dissolved gases while breathing air at high pressure underwater. Increased pressure increases the solubility of atmospheric gases in the blood. When the divers come towards the surface, the pressure gradually decreases. This releases the dissolved gases and leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates a medical condition known as bends, which are painful and dangerous to life. To avoid bends, as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen).

Question 7-18 g of glucose, $C_6H_{12}O_6$ (Molar mass – 180 g mol^{-1}) is dissolved in 1 kg of water in a saucepan. At what temperature will this solution boil? (K_b for water = 0.52 K kg mol^{-1}, boiling point of pure water = 373.15 K)

Answer: The boiling point of the solution is 373.202 K

Hint- ΔT_b= W_B/ M_B X (100x K_b/ wt. of solvent)

Question 8- 100 mg of a protein is dissolved in just enough water to make 10.0 mL of solution. If this solution has an osmotic pressure of 13.3 mm Hg at 25°C, what is the molar mass of the protein?

(R = 0.0821 L atm mol^{-1} K^{-1} and 760 mm Hg = 1 atm.)

Answer: Molar mass of protein = 13980.4 g mol^{-1}

Hint- Use the formula: M= wRT/ π V

Question 9- What mass of NaCl (molar mass = 58.5 g mol^{-1}) must be dissolved in 65 g of water to lower the freezing point by 7.5°C? The freezing point depression constant, K_f, for water is 1.86 K kg mol^{-1}. Assume van't Hoff factor for NaCl is 1.87.

Answer: Mass of NaCl to be dissolved, w_2 = 8.199 g

Hint- Use formula- $\Delta T_f = iK_f m$

Question 10- Define:

1. Hypotonic Solution
2. Ideal solution
3. Colligative properties

Answer:

1. Hypotonic Solution: A solution with lower osmotic pressure than another solution. If the salt concentration is less than 0.9% (mass/volume), the solution is said to be hypotonic. In this case, water will flow into the cells if placed in this solution and they would swell.

2. Ideal Solutions: The solutions which obey Raoult's law over the entire range of concentration. The ideal solutions have two other important properties. The enthalpy of mixing of the pure components to form the solution is zero and the volume of mixing is also zero, i.e.,

$\Delta_{mix}H = 0$, $\Delta_{mix}V = 0$

It means that no heat is absorbed or evolved when the components are mixed. Also, the volume of solution would be equal to the sum of volumes of the two components. At the molecular level, ideal behaviour of the solutions can be explained by considering two components A and B. In pure components, the intermolecular attractive interactions will be of types A-A and B-B, whereas in the binary solutions in addition to these two interactions, A-B type of interactions will also be present. If the intermolecular attractive forces between the A-A and B-B are nearly equal to those between A-B, this leads to the formation of an ideal solution. A perfectly ideal solution is rare but some solutions are nearly ideal in behaviour. The solution of n-hexane and n-heptane, bromoethane and chloroethane, benzene and toluene, etc. fall into this category.

3. Colligative properties: The properties which depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution. Such properties are called colligative properties (colligative: from Latin: co means together, ligare means to bind).