

**A.A.V. PATEL JUNIOR COLLEGE**  
**EXCELLENCE PROGRAM – SYJC – CHEMISTRY**

**SYNOPSIS**

**WEIGHTAGE : 05 MARKS**

**SOLUTIONS & COLLIGATIVE PROPERTIES**

- **Solution:** A solution is defined as a **homogeneous** mixture of two or more components.  
Solution = Solute (less amount) + Solvent (more amount)
- **Solvent:** The component of the solution which is present in larger amount by mass is called solvent. Eg. In glucose solution, water is the solvent.
- **Solute:** One or more components other than solvent present in the solution are called solutes. Eg. In glucose solution, glucose is the solute.
- **Binary solution:** A solution consisting of only two components, i.e. one solute and one solvent is called binary solution. Eg. Glucose solution
- **Dilute solution:** A solution which contains very small amount of solute in comparison with solvent is called dilute solution.
- **Concentrated solution:** A solution which contains large amount of solute in comparison with solvent is called concentrated solution.
- **Aqueous solution:** A solution in water is called aqueous solution.
- **Non-aqueous solution:** A solution using ether, benzene etc. as solvent is called non-aqueous solution.
- **A Coarse mixture:** it is formed when the sizes of the constituent components are relatively bigger, e.g. mixture of salt and sugar.
- **A colloidal dispersion:** it is formed when the sizes of the particles dispersed in solvent are in the range of  $10^{-7}$  cm to  $10^{-4}$  cm. Colloidal carry positive or negative charge which stabilizes colloidal dispersion e.g. ferric hydroxide sol, arsenic sulphide sol, etc. Colloidal solutions are heterogeneous and can be easily separated.
- **A true solution:** A true solution is formed when soluble substances are dissolved in the solvent. The sizes of the particles dissolved are very small of the order of  $10^{-8}$  cm. True solutions are homogeneous and cannot be separated into components by simple mechanical methods.

✚ **Different Ways Of Expressing the concentration of a solution (Units of concentration of solution):**

**Note:** Solute:  $w_2, v_2, x_2, n_2$

Solvent:  $w_1, v_1, x_1, n_1$

**Concentration:** The concentration of a solution may be defined as the amount of the solute present in the given quantity of the solution or the solvent.

- **Mass percentage (% w/w):** The mass percentage of a solute in a given solution is the mass of the solute present in **100g** of the solution. This can be written (expressed as) **w/w**.
- **Volume percentage (%v/v) :** When both the components of solution are liquids, it is convenient to express the concentration of that solution in terms of volume percentage. This can be expressed as **V/V**.
- **Molarity(M):** The molarity of a solution may be defined as the number of moles of the solute present per litre ( $\text{dm}^3$ ) of the solution. It is denoted by '**M**'.
- **Molality (m) :** The molality of a solution may be defined as the number of moles of the solute dissolved in 1000g (1kg) of the solvent. It is denoted by '**m**'.
- **Mole Fraction:** The mole fraction of a component of the solution may be defined as the ratio of the number of moles of that component to the total number of moles of all the components present in the solution. It is denoted by '**x**'.

**Thus,  $x_1 + x_2 = 1$**

- **Henry's Law:**

The law states that the solubility of a gas in a liquid at constant temperature is proportional to the pressure of the gas above the solution. If **S** is the solubility of the gas in  $\text{mol dm}^{-3}$

- **Applications of Henry's Law**

- i. **Production of carbonated beverages**
- ii. **Deep sea diving**
- iii. **Climbers and people living at high altitudes**
- iv. **Functioning of lungs**

- **COLLIGATIVE PROPERTIES**

The properties of the solution which depend only on the number of solute particles and not on the nature of the solute are called colligative properties.

- **Vapour pressure :**

The pressure exerted by the vapour of a liquid above the liquid surface in equilibrium with the liquid at a given temperature is called the vapour pressure of the liquid.

- **Lowering of vapour pressure: ( $p_1^0 - p_s$ )**

The difference between the vapour pressure of the solvent ( $p_1^0$ ) and the vapour pressure of the solution ( $p_s$ ) is called the lowering of vapour pressure.

- **Relative lowering of vapour pressure:**

It is defined as the ratio of the lowering of vapour pressure of the solution to the vapour pressure of the pure solvent at a given temperature.

$$\text{Relative lowering of vapour pressure} = \frac{p_1^0 - p_s}{p_1^0}$$

- **Roult's law:**

The law states that, at a particular temperature, the partial vapor pressure of each component of the solution is equal to the product of the vapor pressure of the pure liquid and its mole fraction.

$$p_A = p_A^0 \times x_1 \quad \text{And} \quad p_B = p_B^0 \times x_2$$

Thus net Vapor pressure of solution  $p = p_A + p_B$ .

- **Ideal Solution:** it is a kind of solution, which obeys Raoult's law under all conditions of temperatures and concentrations. For example, a solution of chlorobenzene and bromobenzene etc.

- **Non-Ideal Solution:** A non-ideal solution is the solution, which does not obey Raoult's law at any condition of temperature and concentration.

- **Boiling Point:** the boiling point of a liquid is the temperature at which its vapor pressure becomes equal to the atmosphere pressure.

- **Elevation In Boiling Point ( $\Delta T_b$ ):**

The difference in the boiling points of the solution ( $T_b$ ) and pure solvent ( $T_b^0$ ) is called the elevation in boiling point ( $\Delta T_b$ ).

$$\therefore \Delta T_b = T_b - T_b^0$$

- **Molal elevation constant or Ebbulioscope constant: ( $K_b$ )**

Molal boiling point elevation constant,  $K_b$  is defined as the elevation in boiling point for 1 molal solution i.e., a solution containing 1 gram mole of solute dissolved in 1000g of the solvent.

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

- **Freezing point:**

The freezing point of a substance may be defined as the temperature at which, the solid and liquid phases of that substance have the same vapor pressure.

- **Depression in freezing point:**

The depression in freezing point for a solution may be defined as the difference between the freezing point of the pure solvent and that of the solution. It is donated as  $\Delta T_f$ .

$$\therefore \Delta T_f = T_f^0 - T_f$$

- **Molal depression constant or cyroscopic constant:**

Molal depression constant or cyroscopic constant is defined as depression in freezing point of 1 molal solution i.e., a solution containing 1 gram mole of solute dissolved in 1000g of the solvent.

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

- **Isotonic Solutions:**

The solution of equimolar concentrations, at the same temperature, Having Same Osmotic pressure, are called Isotonic Solutions

- **Hypertonic Solutions:**

A solution having more osmotic pressure than some other solutions is called hypertonic solutions.

- **Hypotonic solutions:**

A solution having less osmotic pressure than the other solutions is called hypotonic solutions.

- **Osmosis:**

The spontaneous and unidirectional flow of the solvent molecules into the solution, through a semi permeable membrane is called osmosis.

- **Reverse Osmosis:**

If, a solution is separated from the pure solvent by a semi-permeable membrane and the pressure applied on the solution (more than the osmotic pressure) the solvent starts flowing from the solution towards the pure solvent. This phenomenon is known as reverse osmosis.

- **Osmotic Pressure: ( $\pi$ )**

The osmotic pressure may be defined as the excess external pressure which is applied on the solution, just to prevent the flow (passage) of the solvent molecules into the solution through a semi-permeable membrane.

- **Semi permeable membrane:**

A membrane which allows the solvent molecules to pass through it but not the solute particles is called a semi-permeable membrane.

e.g. bladder, cell membrane, parchment paper, copper ferrocyanide membrane  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$  (It is an artificial membrane.)

- **Boyle Van't Hoff Law:**

It states the "Temperature remaining constant, the osmotic pressure of a dilute solution is directly proportional to the molar concentration of the solution."

$$\pi \propto C \quad (\text{at constant temperature})$$

- **Van't Hoff Charles Law:**

It states that 'for a given concentration of a solution, the osmotic pressure is directly proportional to the absolute temperature'.

$$\pi \propto T \quad (\text{for a given concentration})$$

- **Van't Hoff Avogadro's law:**

This law states that, the equimolar quantities of different solutes, if they are dissolved in same volume of a solvent exert equal osmotic pressure (under identical conditions of temperature).

- **Abnormal Osmotic Pressure:**

In general, Observed, lower molecular masses of electrolyte solutes are due to dissociation of solute molecules or observed higher molecular masses of solutes in nonaqueous solvents are due to association/polymerization

- **Van't Hoff Factor: ( $i$ )**

It is defined as the ratio of observed colligative property produced by a given concentration of electrolyte solution to the property observed for the same concentration of non electrolyte solution

## **FORMULA LIST :**

1. **Mass percentage (% w/w) =  $\frac{w_{(2)}}{w_{(2)} + w_{(1)}} \times 100$**

2. **Volume percentage (% v/v) =  $\frac{v_{(2)}}{v_{(2)} + v_{(1)}} \times 100$**

3. **Molarity (M) =  $\frac{\text{number of moles of solute}}{\text{Volume of solution in litres (dm}^3\text{)}} \text{ or Molarity (M) = } \frac{\text{number of moles of solute}}{\text{Volume of solution in mL (cm}^3\text{)}} \times 1000$**

4. **Molality (m) =  $\frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}$  Or Molality (m) =  $\frac{\text{number of moles of solute}}{\text{Mass of solvent in grams}} \times 1000$**

5. Mole fraction of solute + Mole fraction of solvent = 1

Mole fraction of solute ( $X_2$ ) =  $\frac{n_1}{n_1 + n_2}$

Mole fraction of solvent ( $X_1$ ) =  $\frac{n_2}{n_1 + n_2}$

6. Henry law :  $S \propto P$  vi.e.  $S = KP$

7. Relation between Molar mass of Solute & Relative lowering in Vapour pressure:

$\therefore M_2 = \frac{w_2 \cdot M_1}{w_1} \left[ \frac{p_1^0}{p_1^0 - p_s} \right]$

8. Elevation in boiling point :  $\Delta T_b = T_b - T_b^0$

9. Molal elevation constant:  $\Delta T_b = K_b \times m$

10. Relation between Molar mass of Solute & Elevation in Boiling point :

$M_2 = \frac{K_b \times W_2 \times 1000}{\Delta T_b \times W_1}$

11. Depression in freezing point :  $\therefore \Delta T_f = T_f^0 - T_f$

12. Molal depression constant:  $\therefore \Delta T_f = K_f \times m$

13. Relation between Molar mass of Solute & Depression in freezing point :

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

14. Van't Hoff General Reaction : ( Relation between Molar mass of solute & Osmotic pressure):

$$M_2 = \frac{W_2 RT}{V \times \pi}$$

15. Van't Hoff Factor: (  $i$  )

$$i = \frac{(\Delta p \text{ observed})}{(\Delta p \text{ theoretical})} = \frac{(\Delta T_b \text{ observed})}{(\Delta T_b \text{ theoretical})} = \frac{(\Delta T_f \text{ observed})}{(\Delta T_f \text{ theoretical})} = \frac{(\pi \text{ observed})}{(\pi \text{ theoretical})}$$
$$i = \frac{M(\text{theoretical})}{M(\text{observed})}$$

16. Relation between Van't hoff factor( $i$ ) & Degree of Dissociation ( $\alpha$ ) :

$$\alpha = \frac{i-1}{n'-1}$$