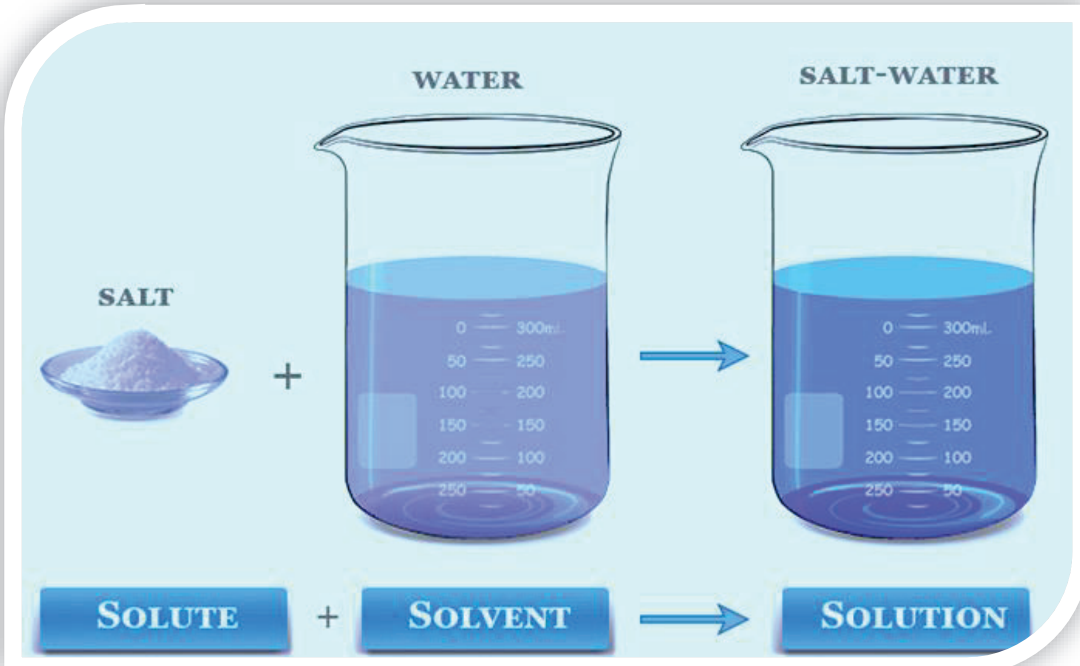
SOLUTIONS



SOLUTIONS

Introduction:

In this chapter, we will discuss about liquid solutions and their formation. This will be followed by studying the properties of solutions, like vapour pressure and colligative properties. We will begin with types of solutions and expressions for concentration of solutions in different units.

Thereafter, we will state and explain Henry's law and Raoult's law, distinguish between ideal and non-ideal solution and deviation of real solutions from Raoult's law. We will also discuss abnormal colligative properties alongwith association and dissociation of solute.

Types of Solutions

All the three states of matter (solid, liquid and gas) may behave either as solvent or solute. When a solution is composed of only two chemical substances, it is termed as binary solution. Depending upon the state of solute or solvent, binary solutions can be classified as

Type of Solutions	Solute	Solvent	Common Examples
Gaseous Solutions	Gas	Gas	Mixture of oxygen and nitrogen gases
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid Solutions	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid Solutions	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Copper dissolved in gold

Some Important Definitions

- **Mixture** - When two or more chemically non-reacting substances are mixed, they form mixture.
- **Heterogeneous Mixture** - It consists of distinct phases, and the observed properties are just the sum of the properties of individual phases.
- **Homogeneous Mixture** - It consists of a single phase which has properties that may differ from one of the individual components.
- **Solution** - The homogeneous mixture of two or more components such that at least one component is a liquid is called solution.

- **Solvent** - It is the constituent of solution which has same physical state as that of solution and generally present in greater amount than all the other components.

- **Solute** - The component of a solution other than solvent is called solute, may or may not have same physical state as that of solution. Generally it is in smaller amount.
  Example - In a sugar syrup (liquid solution) containing 60% sugar (solid) and 40% water (liquid), water is termed as solvent, due to same physical state as that of solution.

Expressing the Strength of Solution

For a given solution the amount of solute dissolved per unit volume of solution is called concentration of solute. Strength of solution is the amount of solute in grams dissolved in one litre of solution. It is generally expressed in g/litre.

Other methods of expressing the strength of solution are:

1. **Mass percentage –**

$$\text{Mass \% of solute} = \frac{\text{Mass of solute}}{\text{Total mass of solution}} \times 100$$

$$\text{Mass \% of solvent} = \frac{\text{Mass of solvent}}{\text{Total mass of solution}} \times 100$$

2. **Volume percentage –**

$$\text{Volume \% of solute} = \frac{\text{Volume of solute}}{\text{Total volume of solution}} \times 100$$

$$\text{Volume \% of solvent} = \frac{\text{Volume of solvent}}{\text{Total volume of solution}} \times 100$$

3. **Molality (m) -** It is no. of moles of solute dissolved in 1 kg of the solvent.

$$\text{m} = \frac{(\text{Number of moles of solute})}{(\text{Mass of solvent \{in kg\}})}$$

4. **Molarity (M) -** It is no. of moles of solute dissolved in 1 litre of solution.

$$\text{M} = \frac{(\text{Number of moles of solute})}{(\text{Mass of soution \{in litre\}})}$$

5. **Normality (N) -** It is no. of gram-equivalents of solute dissolved in 1 litre of solution

$$\text{N} = \frac{(\text{Number of gram equivalents of solute})}{(\text{Volume of solution \{in litre})}$$

6. **Formality -** Ionic solutes do not exist in the form of molecules. These molecular mass is expressed as Gram-formula mass. Molarity for ionic compounds is actually called as **formality.**

7. **Mole fraction –**

$$\text{Mole fraction of solute} = \frac{(\text{Number of moles of solute})}{(\text{Total moles of solution})}$$

$$\text{Mole fraction of solvent} = \frac{(\text{Number of moles of solvent})}{(\text{Total moles of solution})}$$

For a binary solution,

mole fraction of solute + mole fraction of solvent = 1.

8. **Parts per million (ppm) –**
   It is defined in two ways

$$\text{ppm} = \text{mass fraction} \times 10^6$$
$$\text{ppm} = \text{mole fraction} \times 10^6$$

Solubility

Solubility of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature. It depends upon the nature of solute and solvent as well as temperature and pressure. Let us consider the effect of these factors in solution of a **solid** or a **gas** in a **liquid**.

1. Solubility of Solid in Liquid

A solute dissolves in a solvent if the intermolecular interactions are similar in them, i.e., like dissolves like. Polar solute dissolves in polar solvent and non-polar solute in non-polar solvent. For e.g., sodium chloride and sugar dissolves readily in water and napthalene and anthracene dissolves readily in benzene.

Solute + Solvent ⟶ Solution

- **i. Dissolution:** When a solid solute is added to the solvent, some solute dissolves and its concentration increases in solution. This process is called **dissolution**.

- **ii. Crystallization**: Some solute particles collide with solute particles in solution and get separated out. This process is called **crystallization**.

- **iii. Saturated solution**: Such a solution in which no more solute can be dissolved at the same temperature and pressure is called a **saturated solution.**

- **iv. Unsaturated solution:** An unsaturated solution is one in which more solute can be dissolved at the same temperature.

- **v. Effect of temperature**: In general, if in a nearly saturated solution, the dissolution process is endothermic, the solubility should increase with rise in temperature, if it is exothermic, the solubility should decrease with rise in temperature.