Chemistry Study Materials for Class 12 (NCERT Based Notes of Chapter 02)

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SOLUTIONS

Solutions are homogeneous mixtures containing two or more components. Generally, the component that is present in larger quantity is called *solvent*. Solvent determines the physical state of the solution. One or more components present in the solution other than solvent are called *solutes*. [Or, the substance which is dissolved is called solute and the substance in which solute is dissolved is called solvent].

Solutions containing only two components are called *binary solutions*. Here each component may be solid, liquid or in gaseous state. Based on this, solutions are of the following types:

Types of Solution	Solute	Solvent	Examples
Gaseous solutions	Gas	Gas	Mixture of O_2 and CO_2
	Liquid	Gas	Chloroform mixed with nitrogen gas, water-vapour in air
	Solid	Gas	Camphor in nitrogen gas, naphthalene in air
Liquid solutions	Gas	Liquid	Oxygen dissolved in water, soda water
	Liquid	Liquid	Alcohol dissolved in water, dilute acids and alkalies
	Solid	Liquid	Salt in water, glucose in water
Solid solutions	Gas	Solid	Hydrogen in Pd, Pt, Ni etc
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Gold ornaments, alloys of metals

Concentration of Solutions

Composition of a solution can be expressed in terms of concentration. *Concentration is defined as the number of moles of solute present per litre of the solution*. The concentration of a solution can be expressed by several ways.

(i) **Mass percentage (w/w):** The mass percentage of a component in a solution is defined as the mass of the component present in 100 parts by mass of the solution.

i.e. $\text{Mass \% of a component} = \frac{\text{Mass of the component in the solution}}{\text{Total mass of the solution}} \times 100$

For e.g. 10% aqueous solution of glucose by mass means that 10 g of glucose is dissolved in 90 g of water resulting in a 100 g solution.

Concentration described by mass percentage is commonly used in industrial chemical applications.

(ii) **Volume percentage (v/v)**: The volume percentage is defined as the volume of a component present in 100 parts by volume of the solution.

i.e. $\text{Volume \% of a component} = \frac{\text{Volume of the component}}{\text{Total volume of solution}} \times 100$

For example, 10% ethanol solution in water means that 10 ml of ethanol is dissolved in 90 ml of water such that the total volume of the solution is 100 ml.

Concentration of solutions containing liquids is commonly expressed in this unit.

(iii) **Mass by volume percentage (w/v)**: It is the mass of solute dissolved in 100 ml of the solution It is commonly used in medicine and pharmacy.

$\text{Mass/volume \% of a component} = \frac{\text{Mass of the component in the solution}}{\text{Total volume of the solution}} \times 100$

(iv) **Parts per million (ppm)**: When a solute is present in trace quantities (i.e. very small amounts), its concentration is expressed in parts per million (ppm). It is defined as the number of parts of a particular component in million parts of the solution.

i.e. $\text{Parts per million (ppm)} = \frac{\text{Number of parts of the component} \times 10^6}{\text{Total number of parts of all the components of the solution}}$

Concentration in parts per million can be expressed as mass to mass, volume to volume and mass to volume. The concentration of pollutants in water or atmosphere is expressed in terms of μg mL^{-1} or ppm.

(v) **Mole fraction (x)**: It is defined as the ratio of the number of moles of a particular component to the total number of moles of solution.

$$\text{Mole fraction of a component} = \frac{\text{Number of moles of the component}}{\text{Total number of moles of all the components}}$$

For example, in a binary solution, if the number of moles of A and B are n_A and n_B respectively, then the mole fraction of A (x_A) = $n_A/(n_A + n_B)$

and that of the component B (x_B) = $n_B/(n_A + n_B)$ $x_A + x_B = 1$

i.e. in a given solution sum of the mole fractions of all the components is unity. If there are i components, then $x_1 + x_2 + x_3 + \quad + x_i = 1$

Mole fraction is useful in describing the calculations involving gas mixtures.

(vi) **Molarity (M)**: It is defined as the number of moles of solute dissolved per litre of solution.

$$\text{i.e. Molarity (M)} = \frac{\text{Number of moles of solute (n)}}{\text{Volume of solution in litre (V)}}$$

$$\text{Or, Molarity (M)} = \frac{\text{Mass of solute}}{\text{Molar mass of solute x Volume of solution in L}}$$

$$\text{Or, Molarity (M)} = \frac{\text{Mass of solute } (W_B) \text{ x } 1000}{\text{Molar mass of solute } (M_B) \text{ x Volume of solution in ml (V)}}$$

For example, 0.25 M solution of NaOH means that 0.25 mol of NaOH is dissolved in one litre of solution.

(vii) **Molality (m):** It is defined as the number of moles of the solute present per kilogram (kg) of the solvent.

$$\text{i.e. Molality (m)} = \frac{\text{Number of moles of solute(n)}}{\text{Mass of solvent in kg } (W_A)}$$

$$\text{Or, Molality (m)} = \frac{\text{Mass of solute } (W_B)}{\text{Molar mass of solute } (M_B) \text{ x Volume of solution in L (V)}}$$

$$\text{Or, Molality (m)} = \frac{\text{Mass of solute } (W_B) \text{ x } 1000}{\text{Molar mass of solute } (M_B) \text{ x Volume of solution in ml (V)}}$$

For example, 1 molal (m) solution of KCl means that 1 mol (74.5 g) of KCl is dissolved in 1 kg of water.

(vii) **Normality (N):** It is defined as the ~~no. of gram equivalents of solute~~ present per litre of the solution.

$$\text{i.e., Normality (N)} = \frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution in litre}}$$

$$\text{Or, Normality (N)} = \frac{\text{Mass of solute}}{\text{Equivalent mass of solute x Volume of solution in L}}$$

$$\text{Or, Normality (N)} = \frac{\text{Mass of solute x 1000}}{\text{Equivalent mass of solute x Volume of solution in ml}}$$

Among the different methods for expressing the concentration of solution, mass %, ppm, mole fraction and molality are independent of temperature; whereas molarity, normality and volume % are depend on temperature. This is because *volume depends on temperature and the mass does not*.

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