SOLUTION AND MEASUREMENTS CONCENTRATION

Solutions:

A solution can be formed by combining two or more substances. Alternatively, we can describe a solution as a homogeneous mixture of two or more substances. In this context, 'homogeneous' signifies uniformity throughout. Consequently, a homogeneous mixture, or a solution, will exhibit a consistent composition throughout.

Concentration:

The following concentration terms are used to expressed the concentration of a solution. These are:

1. Molarity (M)
2. Molality (m)
3. Mole fraction (x)
4. % Calculation
5. ppm

Keep in mind that all these concentration terms are interconnected. If you have information about one concentration term, you can derive the others as well. Let's go through each of them individually.

1. Molarity (M):

The concentration of a solution, known as its molarity, is determined by the number of moles of a solute dissolved in 1 liter (1000 ml) of the solution.

i.e., $$\text{Molarity of solution} = \frac{\text{Number of moles}}{\text{Volume of solutionin litre}}$$

Let a solution is prepared by dissolving w g of solute of mol. wt. M in V mL water.

$\therefore$ Number of moles of solute dissolved $= \frac{w}{M}$

$\therefore$ V mL water have mole $\frac{w}{M}$ of solute

$\therefore$ 1000 mL water have $\frac{w \times 1000}{M \times V(\text{ in mL})}$

$\therefore$ $$\text{Molarity (M)} = \frac{w \times 1000}{(\text{ Mol. wt of solute }) \times V(\text{ in mL})}$$

Ex. 149 gm of potassium chloride (KCl) is dissolved in 10 Lt of an aqueous solution. Determine the molarity of the solution (K = 39, Cl = 35.5)

Sol. Molecular mass of KCl = 39 + 35.5 = 74.5 gm

$\therefore$ $\text{Moles of KCl} = \frac{149gm}{74.5g} = 2$

$\therefore$ $\text{Molarity of the solution} = \frac{2}{10} = 0.2$ M

2. Molality (m):

The molality of a solution is defined as the number of moles of solute dissolved in 1000 g (1 kg) of a solvent.

i.e., $$\text{molality } \frac{\text{Number of moles solute}}{\text{mass of solvent Ingram}} = \times 100$$

Assuming y grams of a solute are dissolved in x grams of a solvent, where the molecular mass of the solute is m, there are y/m moles of the solute dissolved in x grams of the solvent.

$$\text{Hence Molality} = \times \frac{y}{m \times x} 1000$$

Ex. 225 gm of an aqueous solution contains 5 gm of urea. What is the concentration of the solution in terms of molality. (Mol. wt. of urea = 60)

Sol. Mass of urea = 5 gm

Molecular mass of urea = 60

Number of moles of urea = $\frac{5}{60} = 0.083$

Mass of solvent = (255 – 5) = 250 gm

$\therefore$ Molality of the solution = $\times \frac{\text{Number of moles of solute}}{\text{Mass of solvent in gram}}$

$1000 = \times \frac{0.083}{250} 1000 = 0.332.$

3. Mole Fraction (x):

The mole fraction of a given substance in a solution is defined as the ratio of the number of moles of the solute or solvent to the total number of moles present in the solution.

Let number of moles of solute in solution = n

Number of moles of solvent in solution = N

$\therefore$ Mole fraction of solute $(x_1) = \frac{n}{n+N}$

$\therefore$ Mole fraction of solvent $(x_2) = \frac{N}{n+N}$

$\Rightarrow$ also, $x_1 + x_2 = 1$

Ex. 0.5 g of a substance is dissolved in 25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Sol. Mass of substance = 0.5 g

Mass of solvent = 25 g

$\therefore$ percentage of the substance (w/w) = $\frac{0.5}{0.5+25} \times 100 = 1.96$

Ex. 20 cm^3 of an alcohol is dissolved in80 cm^3 of water. Calculate the percentage of alcohol in solution.

Sol. Volume of alcohol $= 20\ cm^3$

Volume of water $= 80\ cm^3$

$\therefore$ Percentage of alcohol = $\frac{20}{20+80} \times 100 = 20.$

4. Percentage (%) Calculation:

The concentration of a solution can also be represented in percentage terms as follows.

(i) Percentage (%) weight by weight (w/w): It is given as mass of solute present in per 100 g of solution.

i.e., % $\text{w/w} = \frac{\text{Mass of saluting}}{\text{Mass of solutioning}} \times 100$

[X % by mass means 100 g solution contains X g solute;

$\therefore$ (100 – X) g solvent

(ii) Percentage (%) weight by volume (w/v): It is given as mass of solute present in per 100 mL of solution.

i.e. $$\% \text{ w/v} = \frac{\text{Mass of saluting}}{\text{Volume of solution in mL}} \times 100$$

[X % means 100 mL solution contains X g solute]

(iii) Percentage (%) volume by volume (V/V): It is given as volume of solute present in per 100 mL solution.

Ex. $$\% \text{ V/V} = \frac{\text{Volume of salute}}{\text{Volume of solution in mL}} \times 100$$

5. Parts Per Million (ppm):

$$\frac{\text{Mass of salute}}{\text{Mass of solvent}} \times 10^6 \cong \frac{\text{Mass of salute}}{\text{Mass of solution}} \times 10^6$$