Methods of Expressing the Concentration of a Solution

The concentration of a solution can be expresses in a number of ways. The important methods are:

Mass/Weight Percentage or Per cent by Mass/Weight :

It is defined as the amount of solute in grams present in 100 grams of the solution.

$$Mass\ Percentage = \frac{Mass\ of\ Solute}{Mass\ of\ Solution} \times 100$$

$$= \frac{Mass\ of\ Solute}{Mass\ of\ Solute + Mass\ of\ Solvent} \times 100$$

$$= \frac{Mass\ of\ Solute}{Volume\ of\ Solution + Density\ of\ Solution} \times 100$$

- The ratio mass of solute to the mass of solvent is termed as **mass fraction**.
- Thus, Mass percentage of solute = Mass fraction × 100

Volume Percentage

- It is defined as the volume of solute in mL present in 100 mL solution.

$$Volume\ Percentage = \frac{Volume\ of\ Solute}{Volume\ of\ Solution} \times 100$$

- 10% solution of HCl by volume means that 10 mL of liquid HCl is present in 100 mLof the solution.

Mass by Volume Percentage

- It is defined as the mass of solute present in 100 mL of solution.

$$Mass\ by\ Volume\ Percentage = \frac{Mass\ of\ Solute}{Volume\ of\ Solution} \times 100$$

- A 10% mass by volume solution means that 10 gm solute is present in 100 mL of solution.

Molality

- Molality of a solution is defined as the number of moles of solute dissolved in 1 Kg of the solvent.

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

- Thus, if one gram molecule of a solute is present in 1 kg of the solvent, the concentration of the solution is said to be one molal.
- Units of molarity: mol kg^{-1}???
- Molality is the most convenient method to express the concentration because it involves the mass of liquids rather than their volumes. It is also independent of the variation in temperature.

Molarity

- The molarity of a solution gives the number of gram molecules of the solute present in one litre of the solution.

$$Molarity(M) = \frac{Number\ of\ moles\ of\ solute}{Volume\ of\ Solution\ in\ L}$$

- Thus, if one gram molecule of a solute is present in 1 litre of the solution, the concentration of the solution is said to be one molar.
- Units of molarity: mol L^{-1}

Molarity of dilution:

Before dilution After dilution

$M_1V_1 = M_2V_2$

Normality:

- The normality of a solution gives the number of gram equivalents of the solute present in one litre of the solution.

$$Normality\ (N) = \frac{Number\ of\ gram\ equivalents\ of\ solute}{Volume\ of\ Solution\ in\ L}$$

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Mole Fraction

- The mole fraction of any component in a solution is the ratio of the number of moles of that component to the total number of moles of all components .
- Total mole fraction of all the components of any solution is 1.
- For a binary solution of A and B

Mole Fraction of A (X_A) =

$$\frac{n_A}{n_A + n_B}$$

Parts per million (ppm):

- When a solute is present in trace quantities, it is convenient to express concentration in parts per million (ppm)

$$ppm = \frac{Number\ of\ parts\ of\ the\ component}{Total\ number\ of\ parts\ of\ the\ components\ in\ the\ solution} \times 10^6$$

- In case of mass it may be expressed as : (Mass of solute/Mass of solution)× 10^6
- In case of volume it may be expressed as: (Volume of solute/Volume of solution) × 10^6
- So, concentration in parts per million can be expressed as mass to mass, volume to volume and mass to volume form.
- Atmospheric pollution in cities is also expressed in ppm by volume. It refers to the volume of the pollutant in 10^6 units of volume. 10 ppm of SO_2 in air means 10 mL of SO_2 is present in 10^6 mL of air.

Formality

It is the number of formula mass in grams present per litre of solution. In case formula mass is equal to molecular mass, formality is equal to molarity. Like molarity and normality, the formality is also dependent on temperature. It is used for ionic compounds in which there is no existence of molecule. Mole of ionic compounds is called formole and molarity as formality.

$$Formality = \frac{Weight\ of\ solute(gm)}{Formula\ weight\ of\ solute} \times \frac{1}{Volume\ of\ solutions(L)}$$

$$F = \frac{w}{f} \times \frac{1}{V\ (L)}.(i)$$

$$F = \frac{w}{f} \times \frac{100}{V\ (mL)}.(ii)$$