MOLARITY (M)

Number of moles of solute present per litre of the solution is its molarity.

$$\text{Molarity } M = \frac{\text{Moles of solute}}{\text{Volume of solution (L)}}$$

If 0.1 mole of solute is present is 100ml (0.1L) solution then

$$\text{Molarity} = \frac{0.1}{0.1} = 1 \text{ mol/L}$$

$$\text{Moles of solute} = \text{Molarity} \times \text{Litres of solution}$$

$$\text{Millimoles of solute} = \text{Molarity} \times \text{mL of solution}$$

Example 6: Concentration of glucose ($C_6H_{12}O_6$) in normal blood is approximately 90 mg per 100 mL. What is the molarity of the glucose solution in blood?

Solution

$$\text{Mass of glucose} = 90\text{mg} = \frac{90}{1000} = 0.09\text{g}$$

$$\text{Moles of glucose} = \frac{0.09}{180} = 0.0005 \text{ mol}$$

$$\text{Volume of solution} = 100\text{mL} = 0.10\text{L}$$

$$\text{Molarity} = \frac{\text{Mole of solute}}{\text{Litres of solution}}$$

$$= \frac{0.0005}{0.10} = 0.005 \text{ M}$$

Effect of dilution on molarity

A solution can be made concentrated by dilution with solvent. If a solution is diluted from V_1 to V_2, the molarity of that solution changes according to the equation;

$$M_1 V_1 = M_2 V_2$$

Moles of solute in original solution 1= Moles of solute in diluted solution 2

The volume units must be the same for both volumes in this equation. In general, M_1 usually refers to as the initial molarity of the solution. V_1 refers to the volume that is being transferred. M_2 refers to the final concentration of the solution and V_2 is the final total volume of the solution.

Remember that the number of moles of solute does not change when more solvent is added to the solution concentration, however does change with the added amount of solvent.

Example 7: How do you prepare 100ml of 0.40 M $MgSO_4$ from a stock solution of 2.0M $MgSO_4$?

Solution

Given,

$$M_1 = 2.0 \text{ M } MgSO_4;\ V_1 = \text{Unknown}$$

$$M_2 = 0.40 \text{ M } MgSO_4;\ V_2 = 100\text{ml}$$

$$M_1 V_1 = M_2 V_2$$

$$V_1 = \frac{M_2 V_2}{M_1} = \frac{0.40 \times 100}{2} = 20 \text{ mL}$$

Effect of temperature on molarity

Molarity is affected by temperature because it is based on the volume of the solution, and the volume of a substance will be affected by changes in temperature. According to this, when temperature gets increased density get decreased. Then volume will increase when temperature increases, and vice versa.

$$\text{Molarity } \alpha \ \frac{1}{\text{Temperature}}$$

MOLALITY (m)

The molality of a solution is defined as the number of moles of solute per kilogram of solvent (mol kg^{-1}).

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent (kg)}}$$

The main advantage of using molality is that it is temperature independent because masses do not change when substances are heated or cooled. While the disadvantage of using molality are that amount of solution are measured by mass rather than by volume and that the density of the solution must be known to convert molality into molarity.

Relationship between Molality and Molarity

$$m = \frac{1000 \text{ M}}{1000 \text{ d} - \text{Mm}_1}$$

When

d = the density (g/ml)

m_1 = the molar mass of the solute

M = Molarity

m = molality

Example 8: 100g solution of urea in water has 40g urea (molar mass = 60g/mol). What is the molality of urea solution?

Solution

$$\text{Mass of urea and water} = 100\text{g}$$
$$\text{Mass of urea} = 40\text{g}$$

$$\text{Mole of urea} = \frac{40}{60} = 0.66$$

$$\text{Mass of water} = 60\text{g}$$

$$\text{Mole of water} = \frac{60}{18} = 3.333$$

$$\text{Weight of solvent (water) in kg} = \frac{60}{1000} = 0.06\text{kg}$$

$$\text{Molality (m)} = \frac{\text{Mole of urea}}{\text{Weight of solvent (kg)}}$$

$$= \frac{0.666}{0.06} = 11.11\text{mol/kg}$$

Equivalent Mass and Normality

All elements combine with each other according to the laws of chemical combination and the number of parts by which an element combines with one part by mass of hydrogen, eight parts by mass of oxygen or 35.5 parts by mass of chlorine is the value of the equivalent mass of the element.

$$\text{Equivalent mass} = \text{Mole (n)} \times \text{n factor}$$

NORMALITY

Concentration of the solution expressed in number of equivalent dissolved per litre of solution is called normality.

$$\text{Normality} = \frac{\text{Number of equivalent}}{\text{Litre of solution}}$$

Example 9: If 0.40g NaOH is dissolved in 100ml (0.1L) solution, what is normality of NaOH solution?

Solution

$$\text{Number of equivalent of NaOH} = \frac{0.40}{40} = 0.01 \quad \left(\because \text{Mole} \times \text{n factor} = \frac{\text{Weight}}{\text{Molecular weight}} \times \text{n factor} \right)$$

$$\text{Normality of NaOH solution} = \frac{0.01}{0.10} = 0.1\ \text{N}$$

Example 10: When 6g of a monobasic acid is dissolved in 100 ml solution, it is 1N. What is equivalent mass of the acid?

Solution

$$\text{Normality} = \frac{\text{Equivalent of substance}}{\text{Litre of solution}}$$

$$1\text{ N} = \frac{6/E}{0.1} \left(\because 1\text{N} = \frac{\text{Weight/Molecular weight} \times 1}{0.1} \right)$$

$$\frac{6}{E} = 0.1$$

$$E = 60 \text{ g equiv}^{-1}$$

Relationship between Normality and Molarity

Normality = Molarity × valence factor or n-factor.

(i) Valency factor for all phosphoric components or acids = n factor will be one less than no of oxygen atoms except H_3PO_3, its n factor will be one.

(ii) In all other acids n factor will be equal to no of hydrogen atoms

Example 11: 4.9 gram of H_2SO_4 is present in 500ml, of solution. Find the normality and molarity of the solution

Solution

$$\text{Equivalent weight} = 4.9/98 \times 2 = 0.1\text{N}$$

$$\text{N} = \frac{\text{Equvivalent weight}}{\text{Volumes (liters)}} = \frac{0.1 \text{ x } 1000}{500} = 0.2$$

$$\text{N} = \text{M} \times \text{n factor}$$

$$\text{M} = \frac{\text{Normality}}{\text{n factor}} = \frac{0.2}{2} = 0.1 \text{ M}$$