UNITS OF CONCENTRATION

Concentration may be expressed several different ways and some of the more common concentration units are:

1. Equivalent weight

2. Molarity

3. Molality

4. Normality

5.Formality

6. Percent solution (weight/weight)

7. Percent solution (weight/volume)

8. Percent solution (volume/volume)

How do we express concentrations of solutions:-

(1)-A:-Molarity concentration for solutions prepared from dissolving solid solute in liquid solvent:-

Molarity:- defined as a number of solute moles dissolved in solution volumes in liter.

$$\text{Molarity (M)} = \frac{\text{No. of mole solute}}{\text{solution volume (L)}} = \frac{\text{mole}}{\text{L}}$$

$$\text{Molarity (M)} = \frac{\text{No. of mmole solute}}{\text{solution volume (mL)}} = \frac{\text{mmole}}{\text{mL}}$$

$$M = \frac{\text{No of mole solute}}{\text{Volume solution (L)}} = \frac{\frac{\text{wt (g)}}{\text{M.wt }(\frac{g}{\text{mole}})}}{\frac{\text{V (mL)}}{1000\ (\frac{\text{mL}}{\text{L}})}} = \frac{\text{wt (g)}}{\text{M. wt }(\frac{g}{\text{mole}})} \times \frac{1000}{\text{V (mL)}}$$

Example :-A solution is prepared by dissolving 1.26 gm AgNO3 in a 250 mL volumetric flask and diluting to volume. Calculate the molarity of the silver nitrate solution. How many millimoles AgNO3 were dissolved.

Solution:

$$M = \frac{\text{wt (g)}}{\text{M. wt }(\frac{g}{\text{mol}})} \times \frac{1000}{\text{V (mL)}}$$

$$= \frac{1.26\ (g)}{169.9\ (\frac{g}{\text{mol}})} \times \frac{1000}{250\ (\text{mL})} = 0.0297\ \text{mol/L}$$

$$\text{Millimoles} = M\left(\frac{\text{mmol}}{\text{mL}}\right) \times V\ (\text{mL})$$

$$= 0.0297\left(\frac{\text{mmol}}{\text{mL}}\right) \times 250\ \text{mL}$$

$$= 7.42\ \text{mmole}$$

1)-B:-Molarity concentration for solution prepared from dissolved liquid solute in liquid solvent (specific gravity (sp.gr.) :

Density: is the weight per unit volume at the specified temperature, usually (gm/mL) or (gm.cm3) in 20C (is the ratio of the mass in (gm) and volume (mL).

Specific gravity (sp. Gr.): defined as the ratio of the mass of a body (e.g. a solution) usually at 20C to the mass of an equal volume of water at 4C (or sometimes 20C) or (is the ratio of the densities of the two substances).

$$M = \frac{\% \times sp.gr. \times 1000}{M.wt} = \frac{\% \times density \times 1000}{M.wt}$$

Example :-Calculate the molarity of 28.0% NH3, specific gravity 0.898.

Solution: M.wt NH3=14+(3×1)=17

$$M = \frac{\% \times sp.gr.\ (density) \times 1000}{M.wt}$$

$$M = \frac{\frac{28}{100} \times 0.898 \times 1000}{17} = 16.470 \frac{mol}{L} = 16.470 \frac{mmol}{mL} = 16.470\ M$$

1)-3:-Diluting Solutions:- We often must prepare dilute solutions from more concentrated stock solutions. For example ,we may prepare a dilute HCL solution from concentrated HCL to be used for titration .Or

,we may have a stock standard solution from which we wish to prepare a series of more dilute standards. The millimoles of stock solution taken for dilution will be identical to the millimoles in the final diluted solution.

M stock × V stock = M diluted × V diluted

Example :-You wish to prepare a calibration curve for the spectrophotometric determination of permanganate. You have a stock 0.100 M solution of $KMnO_4$ and a series of 100 mL volumetric flasks. What volumes of the stock solution will you have to pipet into the flasks to prepare standards of 1.00, 2.00, 5.00, and 10.0×10^{-3} M $KMnO_4$ solutions.

Solution1) 1.0×10^{-3} M

(M1 × V1)conc.= (M2 × V2)dilu.

0.1 (mmolmL)× V1=1.0 × 10^{-3} (mmolmL)×100 (mL)

V1=1.0 mL stock solution (conc.),Also to prepare 2.0, 5.0, 10.0×10^{-3} M

Example :-You wish to prepare 500 mL of 0.1 M $K_2Cr_2O_7$ solution from a 0.250 M solution. What volume of the 0.250 M solution must be diluted to 500 mL.

(2)Formal concentration(Formality) **F:- Chemists sometime use the term formality for solutions of ionic salts that do not exist as molecules in the solid or in solution. The concentration is given as formal(F).Formality is numerically the same as molarity.**

$$F = \frac{wt\ (g)}{F.wt\ (\frac{g}{mol})} \times \frac{1000}{V\ (mL)}$$

***(3) Normal concentration (Normality) N*:- The conc. of solution produce from dissolving number of equivalent solute in solution volume in liter**

$$N = \frac{No.\ of\ equivalent}{Solution\ Volumn\ (L)} = \frac{Equivalent\ Weight\ (\frac{gm}{eq})}{\frac{V\ (mL)}{1000\ (\frac{mL}{L})}}$$

$$N = \frac{wt}{Eq.wt} \times \frac{1000}{V\ (mL)}$$

$$N = (\frac{Eq}{L}) = (\frac{meq}{mL})$$

Equivalent weight (Eq.wt):- is the formula weight divided by the number of reacting units (H+ ,OH-)for acid-base and electron for oxidation-reduction reaction.

$$(Eq.wt)\ for\ acid-base\ reaction = \frac{formula\ weight\ (F.wt)}{No.\ of\ H^+\ or\ OH^-}$$

$$(Eq.wt)\ for\ oxidation-reduction\ reaction = \frac{formula\ weight\ (F.wt)}{No.\ of\ electron}$$

$$Number\ of\ equivalent\ (Eq) = \frac{wt\ (gm)}{Eq.wt\ (\frac{gm}{Eq})}$$

$$Number\ of\ equivalent\ (Eq) = N\left(\frac{Eq}{L}\right) \times Volume\ (L)$$

$$Number\ of\ milliequivalent\ (meq) = \frac{wt\ (mg)}{Eq.wt\ (\frac{mg}{mL})}$$

$$Number\ of\ milliequivalent\ (Eq) = N\left(\frac{meq}{mL}\right) \times Volume\ (mL)$$

Example: Calculate the equivalent weight of the following substances: (a) NH3, (b) $H_2C_2O_4$ (in reaction with NaOH), and (c) $KMnO_4$ [Mn(VII) is reduced to Mn^{2+}].

(a)

$$\text{Eq wt} = \frac{\text{Mwt}}{\text{No. of } H^+ \text{ or } OH^-} = \frac{17.03}{1} = 17.03 \text{ gm/Eq}$$

(b)

$$\text{Eq wt} = \frac{90.04}{2} = 45.02 \text{ gm/Eq}$$

(c)

$$MnO_4^- + 8H^+ + 5e = Mn^{+2} + 4H_2O$$

$$\text{Eq wt} = \frac{\text{M. wt}}{\text{No. of electron}} = \frac{158.04}{5} = 31.608 \text{ gm/Eq}$$

Example :-How many millilitres of a 0.25M solution of H_2SO_4 will react with 10mL of a 0.25M solution of NaOH.

Solution:

N=nM (n=No.of equivalent (H+,OH−,or electron)

$$N_{H_2SO_4} = 2\times0.25$$

$$= 0.5 \left(\frac{\text{Eq}}{\text{L}}\right) \text{ or } \left(\frac{\text{meq}}{\text{mL}}\right) \text{ or } N$$

$$N_{NaOH} = 1\times0.25 = 0.25 \text{ N}$$

$$(N \times V)_{H_2SO_4} = (N \times V)_{NaOH}$$

$$(0.5\times V)H_2SO_4 = (0.25\times10)NaOH$$

$$V_{H_2SO_4} = 5.0 \text{ mL}$$

Sl.No	Name	Units	Symbol
1.	Molarity	moles solute liters solution	M
2.	Normality	equivalents solute liters solution	N
3.	Molality	moles solute kilograms solvent	m
4.	Weight percent	grams solute 100 grams solution	% w/w
5.	Volume percent	mL solute 100 mL solution	% v/v
6.	weight-to-volume percent	grams solute 100 mL solution	% w/v

Example :-A solution contains 3.30 gm of Na_2CO_3.10H2O in each 15 ml. What is its molarity? What is its normality? With how many millilitres of 3.1N acetic acid,$HC_2H_3O_2$,with 25 ml of the carbonate react according to the equation

$$2H+CO_2 \longrightarrow H_2O+CO_2$$