predicted as to magnitude or or direction for any single measurement standing alone.

Express of concentration

1- Formal concentration

The gram formula weight (gfw) :

Is the summation of atomic weights, in grams, of all the atoms in the chemical formula of a substance. Thus the gram formula weight for H_2 is 2.016 (2 x 1.008) g; for NaCl it is (35.45 +22.99) = 58.44 g.

Formality :

Is defined as the number of gram – formula weights (gfw), of solute per liter of solution.

$$\mathbf{F} = \frac{wt}{\text{gfw}} \times \frac{1000}{V(ml)}$$

2- Gram molecular weight (gmw) :

Is employed rather than gram formula weight when we are concerned with a real chemical species. Thus, the gram molecular weight of H_2 is its gram formula weight 2.016g if we are dealing with the substance NaCl in water; we will not assign to it a gram molecular weight because this species is not found in aqueous media.

It is perfectly proper to assign gram molecular weights to Na^+ (22.99g) and Cl (35.45g) since these are real chemical entities (strictly, these should be called gramionic weights rather than gram molecular weights, although this terminology is seldom encountered).

Molarity or molar concentration :

Is defined as the number of molecular weights or moles of a solute per a liter of solution (or the number of millimoles per millimeter).

$$\mathbf{M} = \frac{wt}{\mathbf{gmw}} \mathbf{x} \frac{1000}{V(ml)}$$

Is defined as the number of gram

*Equivalent weight (equivalents) of a substance dissolved in one litter of solution (or milliequivalents per millimeter).

The equivalent weight of substance depends upon the type of reaction it undergoes.

3- Gram- equivalent weight $= \frac{\textbf{Molecular weight}}{\textbf{n(equivalency)}}$

Example of equivalency

Solute	n
Oxidation state	
NaCl	1 (where is of interest)
$BaCl_2$	2 (where Ba^{2+} is of interest)
$AlCl_3$	3 (where Al^{3+} is of interest)
Na_2SO_4	2 (where SO_4^{2-} is of interest)
Replaceable hydronium and hydroxide Ions	
HCl	1

HNO_3	1
H_2SO_4	1 (where product is HSO_4^-)
	2 (where product is SO_4^{2-})
NaOH	1
KOH	1
$Ba(OH)_2$	2
Change in oxidation state	
$FeCl_3$	1 (where product is Fe^{2+})
MnO_4^-	5 (where product is Mn^{2+})
$SnCl_4$	2 (where product is Sn^{2+})

$$\text{gram- equivalent weight} = \frac{\text{Grams of solute}}{\text{Gram– equivalent weight of solute}}$$

$$\mathbf{N} = \frac{\mathbf{Wt}}{\mathbf{Eqwt}} \text{ X } \frac{\mathbf{1000}}{\mathbf{V(ml)}}$$

$$\mathbf{M} = \frac{\mathbf{Wt}}{\mathbf{Mwt}} \text{ X } \frac{\mathbf{1000}}{\mathbf{V(ml)}}$$

$$\mathbf{Eqwt} = \frac{\mathbf{Mwt}}{\mathbf{Nomber\ of\ H\ \ or\ OH}}$$

Ex_1: prepare 500 ml of 0.1N Ca $(OH)_2$? Ca = 40 O =16 H =1

$$\mathbf{N} = \frac{\mathbf{Wt}}{\mathbf{Eqwt}} \text{ X } \frac{\mathbf{1000}}{\mathbf{V(ml)}}$$

$$\text{Wt} = \frac{\text{N x V(ml) x eq. wt}}{1000}$$

$$\text{Eqwt} = \frac{\text{Mwt}}{\text{Nomber of H or OH}}$$

$$\text{Eqwt} = \frac{(40\text{x}1)+(16x2)+(2x1)}{2}$$

$$\text{Eqwt} = \frac{74}{2} = 37$$

$$\text{Wt} = \frac{0.1 \text{ x } 500(\text{ml}) \text{ x } 37}{1000}$$

Wt = 1.85 gm

Weight 1.85 gm of $Ca(OH)_2$ using a watch glass, transfer in the beaker, add distilled water (mix using a stirrer) transfer the solution into a volumetric flask of 500 ml .

Ex_2: prepare 250 ml of 0.3M KOH ? K =39 O = 16 H =1

$$\mathbf{M} = \frac{\mathbf{Wt}}{\mathbf{M.wt}} \text{ X } \frac{\mathbf{1000}}{\mathbf{V(ml)}}$$

$$\text{Wt} = \frac{\text{M x V(ml) x M. wt}}{1000}$$

$$\text{M. wt} = (39\text{x}1) + (16x1) + (1x1)\backslash$$

$$\text{M. wt} = 39 + 16 + 1 = 56 \text{ gm}$$

$$\text{Wt} = \frac{0.3 \text{ X}250(\text{ml}) \text{ x}56}{1000}$$

Wt = 4.2 gm

Weight 4.2 gm of KOH using a watch glass, transfer in a volumetric flask, add distilled water until the mark 250ml (mix using a stirrer) .

dilutions low

$C_1V_1 = C_2V_2$

Ex$_3$: prepare 250 ml of 0.3N from H_2SO_4 5N ?

$$\frac{C_1V_1}{\text{Dil.solu}} = \frac{C_2V_2}{\text{Conc.solu}}$$

$250 \times 0.3 = 5 \times V_2$

$$V_2 = \frac{250\ X 0.3}{5}$$

$V_2 = 15$ ml

Put 15 ml from H_2SO_4 5N in **a** volumetric flask, add distilled water until the mark 250ml (mix well) .

Parts per million ; part per billion :

For very dilute solutions, it is convenient to express concentrations in term of :

$$\text{Part per million (ppm)} = \frac{\textbf{Weight of solute}}{\textbf{Weight of solution}} \times 10^6$$

$$\textbf{ppm} \approx \frac{\textbf{mg}}{\textbf{Liter solution}}$$

$$\text{part per billion (ppb)} = \frac{\textbf{Weight of solute}}{\textbf{Weight of solution}} \times 10^9$$

p- function :

In some circumstances it is convenient to express the concentration. The most common p- function is

$P = - \log [H_3O^+]$

The term in brackets is the molar hydronium ion concentration.

Density and Specific Gravity :

The density of a substance measure its mass per unit volume and has units of Kg /Liter or g /ml.

Specific gravity of a material is the ratio of its mass to that of an equal volume of water at 4Cº. Specific gravity is unit less because water at 4Cº has a density of exactly 1g / ml .

Percentage concentration :

Weight percent (w / w)= $\frac{\text{wt of solute}}{\text{wt of solution}}$ **x100**

Weight percent (v / v)= $\frac{\text{volume of solute}}{\text{volume of solution}}$ **x100**

Weight percent (w/ v)= $\frac{\text{wt of solute}}{\text{volume of solution}}$ **x100**

Solution – diluent volume ratios:

The composition of a dilute solution is sometimes specified in terms of the volume of a more concentrated reagent and the volume of solvent to be used in diluting it .Thus a 1:4 HCl solution contains four volumes of water for each volume of concentrated Hydrochloric acid taken.

$V_1C_1 = V_2C_2$

$$N = \frac{D \times \% \times 10}{Eq.wt}$$

$$M = \frac{D \times \% \times 10}{M.wt}$$

Molall solution contains a gram – molecular weight of solute dissolved in 1000 g of solvent.

Chemical Equilibrium

In a solution of acetic acid, two reactions occurring simultaneously :

$$CH_3COOH + H_2O \longrightarrow H_3O^+ + CH_3COO^- \quad .....(1)$$

and

$$H_3O^+ + CH_3COO^- \longrightarrow CH_3COOH + H_2O \quad .....(2)$$

When the rate which the ions are formed by reaction (1) is equal to the rate at which they disappear by reaction (2),there concentrations in the solution will no change with time . in fact ,the concentration of all the species will remain constant from this point on, this call equilibrium.

To indicate chemical equilibrium in a reacting system we use a set of double arrow $\rightleftharpoons$ in the chemical equation. Thus the equilibrium that we have been discussing is expressed as

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

The use of this notation implies that the forward reaction (the reaction going from to right) is occurring at the same rate as the reverse reaction (the reaction from right to left) .

For strong electrolytes, the reverse reaction does not occur, for e.g. NaCl would write simply

$$NaCl \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$

Equilibrium constant

The generalized equation for a chemical equilibrium

$$aM + bN \longrightarrow cP + dQ$$

The equilibrium – constant expression for this reaction is