Molar Methods : A solution containing 1 mole of solute per liter of solution is defined as a (Molar solution).

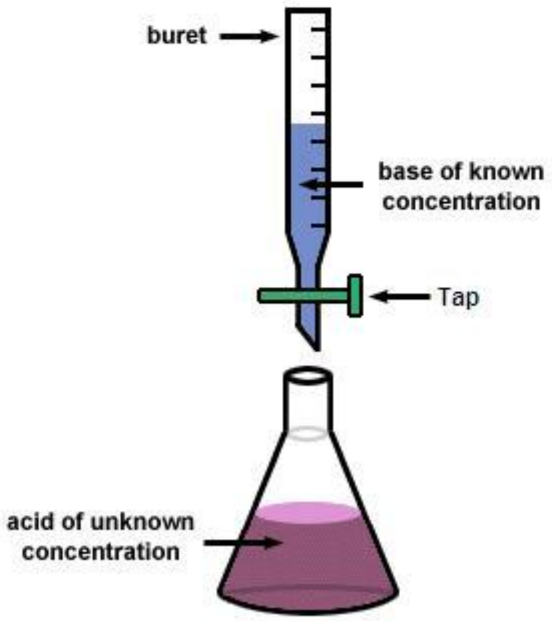
Molarity of solution : The number of moles of solute per liter of solution.

$$\text{Molarity[M]} = \frac{number\ of\ moles\ solute}{liters\ of\ solution}$$

$$\text{Molarity[M]} = \frac{grams\ of\ solute}{molecular\ weight} \times \frac{1}{litersof\ solution}$$

Moles of solute = molarity x liters of solution

Grams of solute = molarity x literes of solution x molecular weight.



Ex / Calculate the molar concentration of ethanol in an aqueous solution that contains 2.30 gm of C_2H_5OH(46.07 gm /mole) in 3.50 L of solution.

Solution /

$$[C2H5OH] = \frac{number\ of\ moles}{liter\ of\ solution}$$

$$\text{No.mol C2H5OH} = 2.30\ \text{gm}\ C_2H_5OH \times \frac{1\ mol\ C2H5OH}{96.07\ gm\ C2H5OH}$$

$$= 0.0499\ \text{mol}\ C_2H_5OH$$

$$[\ C_2H_5OH] = \frac{0.0499\ mol}{3.5L} = 0.0143\ \text{mol / L} = 0.0143\ \text{M}$$

EX/Calculate the analytical and equilibrium molar concentration of the solute species in an aqeous solution that contains 285.0 mg of trichloroacetic acid , Cl_3CCOOH(163.4gm / mol) , in 10.0ml.

Solution/ $Cl_3CCOOH \equiv HA$

No. mol HA = 285.0 ~~mg HA~~ x $\frac{1\cancel{gm\ HA}}{1000\cancel{mgHA}}$ X $\frac{1mol\ HA}{163.4\ \cancel{gm\ HA}}$

= $1.744 \text{ X } 10^{-3}$ mol HA

[HA] = $\frac{1.744\ X\ 1000\ molHA}{10.0\ ml}$ x $\frac{1000ml}{L}$

= 0.174 mol HA / L = 0.174 M

EX/ How many grams of $AgNO_3$(169.9 gm/mol) must be used to prepared 500.0 ml of 0.125 M?

Solution/

$$M = \frac{wt}{M.wt} \text{ X } \frac{1000}{Vml}$$

$$Wt = \frac{M\ X\ M.wt\ x\ Vml}{1000}$$

$$= \frac{0.125\cancel{mmol}/\cancel{ml}\ x\ 169.9mg/\cancel{mmol}\ x\ 500\cancel{ml}}{1000} =$$

10.62mg

<u>Equivalent Methods:</u>

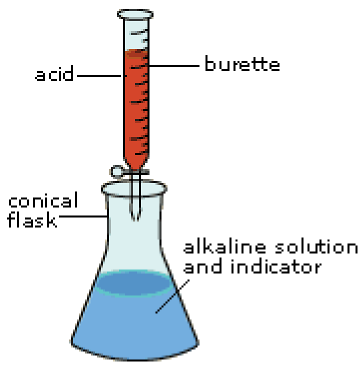
The equivalent weight (eq) is defind , for neutralization reactions , as the weight in grams that will furnish or react with one gram-atomic weight of hydrogen ion.

Equivalent weight = $\frac{molecular\ weight}{n} = \frac{M.Wt}{n}$

n = no.H^+ for acid

= no.OH^- for base

= no. electrons in the reaction.



Titration

Example /

Equivalent weight of HCl = $\frac{MHCl}{n} = \frac{36.5}{1} = 36.5$

For eq.wt NaOH = $\frac{MNaOH}{n} = \frac{40}{1} = 40$

For eq.wt Ba $(OH)_2$ = $\frac{MBa(OH)2}{n} = \frac{171}{2} = 85.5$

For eq.wt H_3PO_4

$H_3PO_4 \leftrightarrow H^+ + H_2PO_4^- = \frac{97}{1} = 97$

$H_3PO_4 \leftrightarrow 2H^+ + HPO_4^{-2} = \frac{96}{2} = 48$

$H_3PO_4 \leftrightarrow 3H^+ + PO_4^{-3} = \frac{95}{3} = 31.7$

Equivalent weight = $\frac{molecular\ weight}{no.of\ valency} = \frac{M.wt}{n}$

Normality(N) = $\frac{EquivalentS\ Solute}{liters\ of solution}$

Normality(N) = $\frac{grams\ solute}{\frac{molecular\ weight}{hydrogen\ equivalents\ per\ mole}} \times \frac{1}{liters\ of\ solution}$

liters of solution x normality = Equivalents of solute

liters of solution x normality x equivalent weight = grams solute

Preparation of solution

Most solution are prepared by dissolving a weighed amount of solid and adding sufficient water to make the desired volume.

Calculation of the Normality and Molarity of standard solution

Ex/How many grams of pure sodium hydroxide (M.wt 40.0g/mol) are needed for preparation of 500.0 ml 0.100N solution?

Solution/ $NaOH \rightarrow Na^+ + OH^-$

$$N = \frac{Equivalents\ of\ solute}{liters\ of\ solution}$$

Equivalents of solute = normality x volume in liters

= 0.100 eq / ~~liter~~ x 0.500 ~~liter~~

= 0.0500 eq

$$\text{Equivalents of solute} = \frac{weight\ in\ grams}{\frac{molecular\ weight}{no.of\ valency}}$$

$$0.0500\ \cancel{eq} = \frac{Wt}{\frac{40.0\ g/\cancel{mol}}{1\ \cancel{eq}/\cancel{mol}}}$$

Wt = 2.00 gm

طريقة اخرى للحل

$$N = \frac{Wt}{eq.wt} \times \frac{1000}{Vml}$$

$$0.100 eq/L = \frac{wt}{\frac{M.wt}{n}} \times \frac{1000}{500\ ml}$$

$$0.100\cancel{eq}/\cancel{L} = \frac{wt}{\frac{40.0gm/\cancel{mol}}{1\cancel{eq}/\cancel{mol}}} \times \frac{1000\cancel{ml}/\cancel{L}}{500\cancel{ml}}$$

Wt = 2.00 gm

Ex/What is the normality of a solution prepared by dissolving 25.20 gm oxalic acid ($H_2C_2O_4.2H_2O$)(126.1gm/mol) in sufficient water to give 1.200 liters of solution ?What is the molarity of this solution?

Solution/ $H2C_2O_4.2H_2O \rightarrow 2H^+ + C_2O_4^{-}$
2

$$N = \frac{Equivalents\ of\ solute}{liters\ of\ solution}$$

$$\text{Number of equivalents} = \frac{weight\ of\ solute}{\frac{molecular\ weight}{no.of\ valency}}$$

$$= \frac{25.20\cancel{gm}}{\frac{126.1\cancel{gm}/\cancel{mol}}{2eq/\cancel{mol}}} = 0.3996\ eq$$

The Normality is :

$$N = \frac{0.3996\ eq}{1.200L} = 0.3330\ eq/liter$$

The Molarity is:

$$M = \frac{N}{n} = \frac{0.3330\ \cancel{eq}/liter}{2\cancel{eq}/mol} = 0.1665\ mol/liter$$

Ex/How many grams of pure sodium sulfate Na_2SO_4 (M.wt 142.0g/mol) are needed for preparation of 200.0 ml 0.500N solution?

Solution/ $Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{-2}$

$$N = \frac{wt}{eq.wt} \times \frac{1000}{Vml}$$

$$0.500\cancel{eq}/\cancel{L} = \frac{wt}{\frac{142gm/\cancel{mol}}{2\cancel{eq}/\cancel{mol}}} \times \frac{1000\cancel{ml}/\cancel{L}}{200\cancel{ml}}$$

Wt = 7.1 gm

Ex/Describe the preparation of 5.000 L of 0.1000M Na_2CO_3 (105.99g/mol) from the primary standard solid?

Solution/

$$\text{Molarity} = \frac{number\ of\ moles\ solute}{liters\ of\ solution}$$

Moles of solute = M X V

$= 0.1000mol/\cancel{L} \times 5.000\cancel{L} = 0.5000mol$

$$\text{Grams of solute} = 0.500\cancel{mol} \times \frac{105.999gm}{\cancel{mol}}$$

$= 53.00$ gm Na_2CO_3

Therefore the solution is prepared by dissolving 53.00 gm of Na_2CO_3 in water and diluting to exactly 5.00 L.

Ex/

Astandard 0.0100 M solution of Na^+ is required for calibrating a flame photometric method for determining the element. Describe how 500.0 ml of this solution can be prepared from primary standard Na_2CO_3?

Solution/ $\mathbf{Na_2CO_3 \longrightarrow 2Na^+ + CO_3^{-2}}$

$$\text{No.mol } Na^+ = 500.0\cancel{ml} \times \frac{0.01mmol}{\cancel{ml}} = 5mmol$$

$$\text{Moles of } Na_2CO_3 = 5\ \cancel{mmol\ Na^+} \times \frac{1\ mmolNa2CO3}{2\ \cancel{mmolNa+}} = 2.5\ mmol$$

Grams of Na_2CO_3 = 2.5 $\cancel{mmol}$ x 0.10599 gm/$\cancel{mmol}$ = 0.265 gm

The solution is therefore prepared by dissolving 0.265 gm of Na_2CO_3 in water and diluting to 500.0ml.

Density and specific gravityof solution

Density and specific gravity are terms of encountered in the analytical literature . The density of a substance is its mass per unit volume , where as its specific gravityis the ratio of its mass to the mass of an equal volume of water. Density has units of kilograms per liter or grams per milliliter in the metric system.

Ex/ Calculate the molar concentration of HNO_3 (63.0gm/mol) in a solution that has a specific gravity of 1.42 and is 70% HNO_3(W/W).

Solution/

$$M = \frac{SP.gr\ x\ \%\ x\ 1000}{M.wt}$$

$$M = \frac{1.42\ X\ 1000\cancel{gm\ reagent}\ x\ 70\cancel{gm\ HNO3}\ X\ 1\ mol\ HNO3}{L\ reagent\ x\ 100\ \cancel{gm\ reagent}\ x\ 63\ \cancel{gm\ HNO3}}$$

= 15.8mol/L = 15.8 M

Ex/ Calculate the Normality of H_2SO_4 (98.08gm/mol) in a solution has a specific gravity of 1.84 and is 98% H_2SO_4(W/W).

Solution/

$$N = \frac{SP.gr\ x\ \%\ x\ 1000}{eq.wt}$$

$$N = \frac{1.84\ X\ 1000\cancel{gm\ reagent}\ x\ 98\cancel{gm\ H2SO4}\ X\ 1\ eq\ H2SO4}{L\ reagent\ x\ 100\ \cancel{gm\ reagent}\ x\ 49.04\ \cancel{gm\ H2SO4}}$$

N = 36.8eq/L =36.8 N

Ex/Sulfuric acid of density 1.3028gm per milliliter,40.0 percent H_2SO_4 By weight. Compute the normality and molarity of the solution?

Solution/

$$N = \frac{SP.gr\ x\ \%\ x\ 1000}{eq.wt}$$

N =

$$\frac{1.3028\ X\ 1000\cancel{gm\ reagent}\ x40.0\cancel{gm\ H2SO4}\ X\ 1\ eq\ H2SO4 L\ reagent}{L\ reagent\ x\ 100\ \cancel{gm\ reagent}\ x\ 49.04\ \cancel{gm\ H2SO4}}$$

N = 10.63eq/L = 10.63 N

$$M = \frac{N}{Valency} = \frac{10.63 eq/L}{2 eq/mol}$$ = 5.31 mol/L = 5.31 M

Ex/A sample of impure oxalic acid ($H_2C_2O_4.2H_2O$)(126.1gm/mol) which weighs 0.4750 gm requires 35.60 ml 0.2000N solution hydroxide for its titration. Calculate the percentage of oxalic acid in the sample.

Solution/ $H_2C_2O_4.2H_2O + 2NaOH \longrightarrow Na_2C_2O_4 + 4H_2O$

$$N = \frac{Equivalents\ of\ solute}{liters\ of\ solution}$$

Equivalent Base = Equivalent Acid

Equivalent NaOH = Equivalent $H_2C_2O_4$

Milliequivalent NaOH = N x liter of solution

= 0.200 meq/~~ml~~ x 35.60 ~~ml~~

= 7.12~~meq~~ x eq/1000~~meq~~

$= 7.12 \times 10^{-3}$ eq

Weight($H_2C_2O_4$) = equivalent of acid x equivalent weight

$= 7.12 \times 10^{-3}\ \cancel{eq} \times \frac{126.1\ gm/\cancel{mol}}{2\cancel{eq}/\cancel{mol}}$

= 0.4489 gm

Percentage $= \frac{grams\ of\ oxalic\ acid}{weight\ of\ sample} \times 100$

$= \frac{0.4489\ gm}{0.4750\ gm} \times 100 = 94.51\ \%$