Analytical Chemistry

Mosul University / College of Science

New & Renewable Energy Dep

Assist. Prof. Dr. Lamya A. Sarsam

1st Class

General Introduction

Define Chemistry:

Chemistry is the science which deals with materials (elements or compounds) and their reactions.

Classified the Chemistry:

1. ***Analytical chemistry:*** is the science which deal with the analysis of substances qualitatively and quantitatively.
2. ***Biochemistry:*** interest with studying the bio compounds which exist inside the living organisms.
3. ***Organic chemistry:*** studying of carbon compounds and their reactions.
4. ***Inorganic chemistry:*** studying of all elements in periodic table except carbon.
5. ***Physical chemistry:*** deals with physical properties substances during reaction such as: heat, solubility, and conductivity…etc.
6. ***Industrial chemistry:*** this branch deals with manufacturing of materials and their use in our life.

Analytical Chemistry

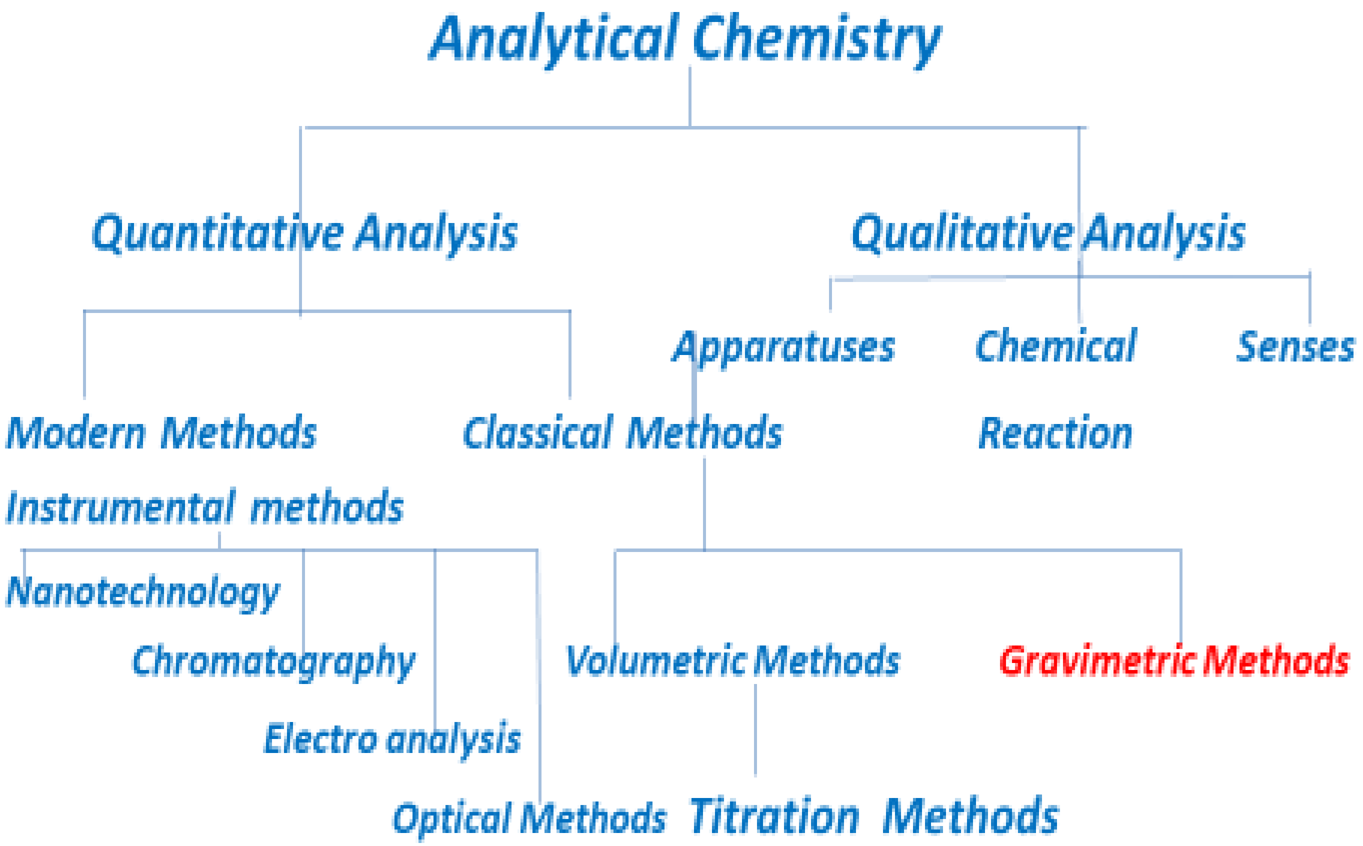
Define Analytical Chemistry

Is a branch of chemistry science which defined as the means that are detected elements and materials and the method of separated and know the compounds of those substances in a mixture of them in addition to determined of those components quantitatively.

Classification of Analytical Chemistry

The following scheme for the classification of analytical chemistry.

Classification of Analytical Chemistry



Analytical Chemistry

Quantitative Analysis

Qualitative Analysis

Apparatuses

Chemical Reaction

Senses

Modern Methods

Instrumental methods

Classical Methods

Nanotechnology

Chromatography

Electro analysis

Optical Methods

Volumetric Methods

Gravimetric Methods

Titration Methods

- Analytical chemistry deals with separating, identifying, and quantifying the relative amounts of the components of an analyte.

- ***Analyte*** : the thing to analyzed; the component(s) of a sample that are to be determine

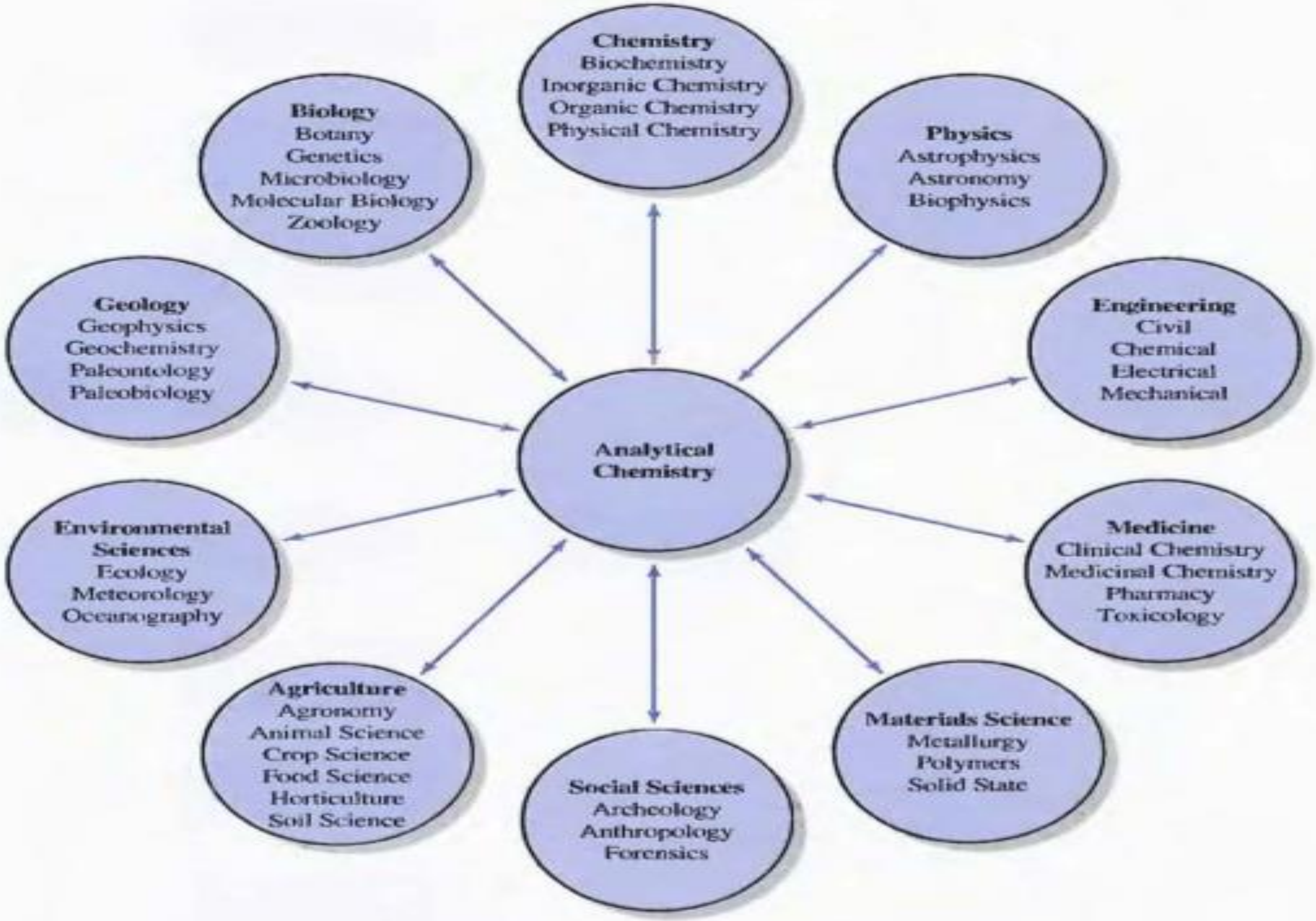


Figure 1-1 The relationship between analytical chemistry, other branches of chemistry, and the other sciences. The central location of analytical chemistry in the diagram signifies its importance and the breadth of its interactions with many other disciplines.

Steps of Analysis:

1. The aim of analysis (determination, identification, separation)
2. Select the analysis method (which depends on: Accuracy in analysis, time, amount of sample to be determined.
3. Prepare the sample.
4. Using separation technique if it’s necessary.
5. Analysis.
6. Results and discussion.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Solutions

A homogeneous mixture of two or more of substances.
That is mean: overlapping molecules or ions of solute between molecules or ions of solvent, the product called ***Solution***.

Solution = Solute + Solvent

There are different types of solution:

A. According to the size of atoms or molecules:

1. ***Real Solution***: The solution which it’s molecules pass through the filter paper fully and easily.
2. ***Suspension solution***: In this solution some of the molecules don’t pass through the filter paper fully and easily.
3. ***Colloidal solution***: In this solution the molecules don’t pass through the filter paper as well as don’t precipitate if let the solution to stable.

B. According to the concentration of solute:

- ***Unsaturated Solution (Normal solution):***

  The solution which can added more amount of solute in it at room temperature.

- ***Saturated Solution:*** The solution which contain the solute in dynamic equilibrium state with solvent at room temp.

- ***Super Saturated Solution:*** The solution that contains more amount of solute than those found in saturated solution at high temperature when return to room temperature some of the solute will be precipitate.

Concentrated Solution:

That is mean the solution contains amount of solute.

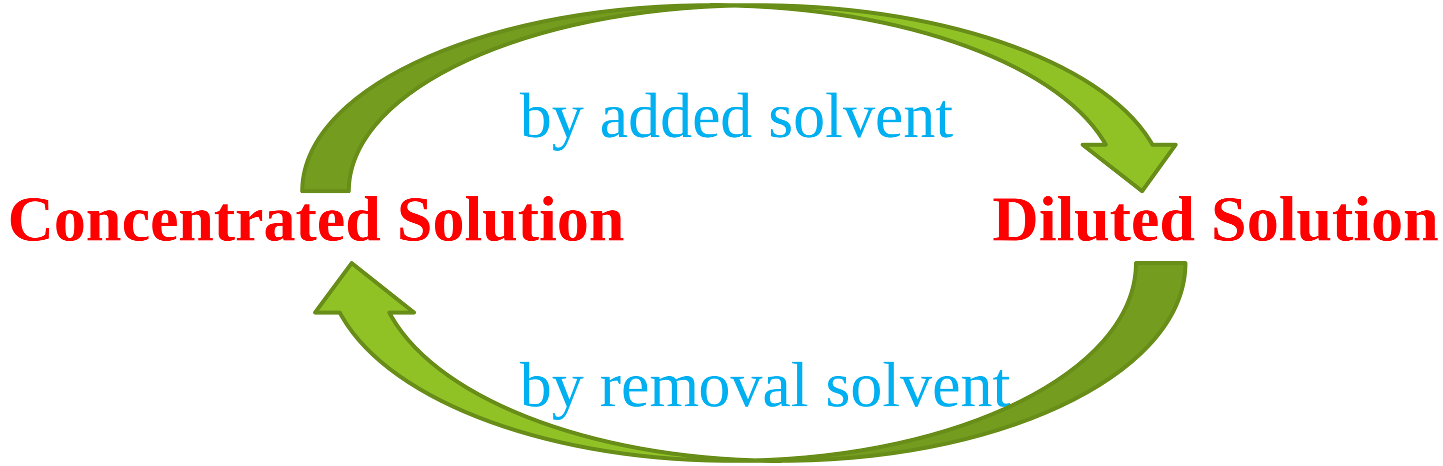
Diluted Solution:

It is opposite the concentrated solution that is mean the solution contains less amount of solute.

C. According to the Nature of Solvent:

Liquid Solution , Organic Solution

How can change concentrated solution to the diluted one :



by added solvent

Concentrated Solution

Diluted Solution

by removal solvent

Standard Solutions:

Is a reagent of exactly known concentration which come from dissolve exactly weight of primary standard material in known volume of solvent.

There are two types of standard materials:

I. Primary Standard Material:

Is a highly purified compound that serves as reference material for a titrimetric method of analysis and which can directly prepared primary standard solution.

Such as: ***Na_2CO_3, KCl, NaCl, Na_2SO_4, $MgSO_4.7H_20$…ect.***

II. Secondary Standard Material:

Is a compound whose purity has been established by chemical analysis that serves as the reference material for a titrimetric method analysis. And can't prepared primary standard directly from these compound unless standardization it .

Such as: ***NaOH, H_2SO_4, KOH, HCl, $KMnO_4$…ect..***

Important requirements for a primary standard material are the following:

1. High purity establish methods for confirming purity should be available.
2. Atmospheric stability.
3. Absence of hydrate water so that the confirming of the solid does not change with variations in humidity.
4. Modest cost.
5. Reasonable solubility in the titration medium.
6. Reasonably large molar mass so that the relative error associated with weighing the standard is minimized.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Aqueous Solution and Chemical Equilibria

Electrolysis: are solutes which are ionized in solution to produce an electrically conducting medium. There are two types of electrolytes.

Strong electrolytes: the compounds which are completely ionized or dissociate in solution.

$$HCl \rightarrow H^{+} + Cl^{-}$$

Weak electrolytes: the compounds which are partially dissociate in solution.

$$CH_3COOH \rightleftharpoons CH_3COO^{-} + H^{+}$$

Conjugate Acids and Bases

$$Acid_1 \rightleftharpoons Base_1 + H^+$$

(Conjugate base of the parent acid)

$$Base_2 + H^+ \rightleftharpoons Acid_2$$

(Conjugate acid of the parent base)

The result in an acid /base or neutralization reaction :

$$Acid_1 + Base_2 \rightleftharpoons Base_1 + Acid_2$$

A conjugate acid: is formed when a base accepts aproton.

A conjugate base: is formed when an acid losses a proton.

e.g. acetate ion is conjugate base of acetic acid.

Neutralization Reaction:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$HCl \longrightarrow H^+ + Cl^-$$

$$NaOH \longrightarrow Na^+ + OH^-$$

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Conjugated of NH_3 Conjugated base of H_2O

NH_3 , NH_4^+ are conjugate pair.


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Chemical Equilibrium

Many reaction used in analytical Chemistry never result in complete conversion of reactants to products.

Instead, they proceed to a state of chemical equilibrium that describe the concentrations of reactants existing among reactants product is constant.

Equilibrium constant expressions are algebraic equation that describe the concentration relationships existing among reactants and products at equilibrium.

Equilibrium- Constant Expressions:

A generalized equation for a chemical equilibrium is:

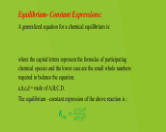
$$aA + bB \rightleftharpoons cC + dD$$

where the capital letters represent the formulas of participating chemical species and the lower case are the small whole numbers required to balance the equation.

a,b,c,d = mole of A,B,C,D.

The equilibrium –constant expression of the above reaction is :

$$K_{eq.} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$



Ex.1.:

$$S_2O8 + 3I^{-} \rightleftharpoons 2SO_4^{-2} + I_3^{-}$$

H.W

Ex.2. :

Calculate the concentration of each of A,B of equilibrium state of 0.1 M AB solution (AB: weak electrolyte). $K_{eq} = 3\times10^{-6}$.

$$AB \rightleftharpoons A^{+} + B^{-}$$

$$0.1\text{-}X \qquad X \qquad X$$

$$Keq. = \frac{[A^{+}]\,[B^{-}]}{[AB]}$$

$$3\times10^{-6} = \frac{X^2}{0.1 - X}$$

Neglect

$$\sqrt{X^2} = \sqrt{3\times10^{-7}}$$

$X = 5.5 \times 10^{-4}$ M So $[A^{+}] = [B^{-}]$ at equilibrium

Solubility Product Constant

Solubility: is the amount of solute can be dissolved in a volume of solvent.

When one substance (solute) dissolves in any solvent, it is said to be ***soluble***. When one substance does not dissolve in another it is said to be ***insoluble***. Solubility depends on type of solvent, temperature and acidity (pH) of media.

The solubility can be determined by solubility product constant **(*K_{SP}*).**

In saturated solution of AxBy salt.

$$A_xB_y \rightleftharpoons xA^+ + yB^-$$

$$K = \frac{[A^+]^x[B^-]^y}{[A_x\,B_y]}$$ at equilibrium state

∵ Conc. of solid compound is constant

∴ $K = [A^+]^x\ [B^-]^y$

For $$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$$

∴ $Ksp = [Ag^+]\ [Cl^-]$

For $$CaF_2 \rightleftharpoons Ca^{+2} + 2F^-$$

∴ $Ksp = [Ca^{+2}]\ [F^-]^2$

Ex.1

Calculate the amount of solubility in mole/liter of AgCl? $K_{sp} = 1.8\times10^{-10}$.

H.W

Ex.2

The amount of solubility of $BaSO_4$ is 1.14×10^{-5}M.Calculate the solubility product constant?

$$BaSO_4 \rightleftharpoons Ba^{+2} + SO_4^{-2}$$

$$Ksp = [Ba^{+2}]\,[SO_4^{-2}]$$

$$[Ba^{+2}] = 1.14 \times 10^{-5}\ M \quad = \quad [SO_4^{-2}]$$

$$Ksp = [1.14 \times 10^{-5}]\,[1.14 \times 10^{-5}]$$

$$Ksp = 1.30 \times 10^{-10}\ \ M$$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Dissociation Constant

Applying the Ion- Product for Water

Aqueous solutions contain small concentrations of hydronium and hydroxide ion as a consequence of the dissociation.

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

Or

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$K = \frac{[H_3O^+]\,[OH^-]}{[H_2O]^2}$$

$K[H_2O]^2 = Kw = [H_3O^+][OH^-]$

At: 25C°

$K_w = 1\times 10^{-14}$

At pure H_2O $[H^+] = [OH^-] = 10^{-7}$

$pK_w = pH + pOH = 14$

$-\log[H^+] = -\log [OH^-] = 7$

$pH = pOH = 7$

Example:

Calculate the hydrogen or hydronium ion concentration in solution contain $[OH^-]$ (a). 0.01mole/L, (b) 2×10^{-9} mole/L, and describe the solution?

$$K_w = [H^+]\,[OH^-] = 1\times 10^{-14}$$

(a). $[H^+] = \dfrac{Kw}{[OH^-]} \rightarrow [H^+] = \dfrac{1\times 10^{-14}}{0.01}$

$[H^+] = 1\times 10^{-12}$ M , pH = -log $[H^+]$ → pH = -log 1×10^{-12} , pH =12

∴ The solution is Alkaline $[OH^-] > [H^+]$

(b). $[H^+] = \dfrac{1\times 10^{-14}}{2\times 10^{-9}}$

$[H^+] = 5\times 10^{-6}$ M , pH = -log $[H^+]$ → pH = -log 5×10^{-6} , pH =5.3

∴ The solution is Acidic $[H^+] > [OH^-]$

Dissociation of weak acid and weak base:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

$pK_w = pH + pOH$

$pH = pKw - pOH$

$pH = ½\ pKa - ½ \log C$

$pOH = ½\ pKb - ½ \log C$

$pH = pKw - ½\ pKb + ½ \log C$

$pOH = pKw - ½\ pKa + ½ \log C$

Example

Calculate the pH value at 25C° of (0.1M) solution (of weak base) tri methyl amine $(CH_3)_3N$? Kb = 5.3×10^{-5}.

$$pH = pKw - \frac{1}{2}\, pKb + \frac{1}{2}\log C$$

$$pH = 14 - \frac{1}{2}(-\log Kb) + \frac{1}{2}\log 0.1$$

$$pH = 14 - \frac{1}{2}(-\log 5.3\times 10^{-5}) + \frac{1}{2}\log 0.1$$

$$pH = 14 - (2.14) + \frac{1}{2}(1)$$

$$pH = 11.36$$


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There are ***Two*** types of the methods for expressing the concentration:

First: Physical methods for expressing concentration:

I. Percentage %:

A. Weight percent : W/W %

The number of grams of solute in 100 gram of solution.

$$W/W\ \% = \frac{Weight\ (wt) solute\ (g)}{weight\ (wt)\ solute\ (g)} \times 100$$

Weight solution would be more properly called mass percent and abbreviated m /m.

B. Volume percent :V/V %

The number of milliliters of solute in 100 milliliter of solution.

$$V/V\ \% = \frac{Volume\ solute\ (mL)}{Volume\ solution\ (mL)} \times 100$$

Volume of solution = V. of solute + V. of solvent

C. Weight – Volume percent : W/V%

The number of grams of solute in 100 mL of solution.
It’s used for two miscible and diluted liquids.

$$W/V\ \% = \frac{\text{Weight solute }(g)}{\text{Volume solution }(mL)} \times 100$$

Example 1.:

How many grams of NaCl needed to prepare 500mL of normal saline solution in concentration W/V= 70%?

H.W

Example 2.

Calculate the weight percent of solution prepared by dissolve 5g of $AgNO_3$ in 100 mL of water? Note; water density =1.

$$W/W\ \% = \frac{Weight\ (wt) solute\ (g)}{weight\ (wt)\ solute\ (g)} \times 100$$

$$Mass = Density \times Volume$$

$$Mass = 1 \times 100 \quad = \quad 100$$

Weight of solution = Wt.of Solute + Wt.of Solvent

Weight of solution = 5 +100 = 105

$$W/W\ \% = \frac{5}{105} \times 10$$

$$W/W\ \% = 4.76\ \%$$


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Methods of Expressing Concentration:

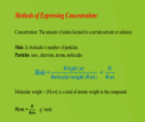
Concentration: The amount of solute located in a certain solvent or solution.

Mole: Is Avokadro’s number of particles.
Particles: ions, electrons, atoms, molecules.

$$\mathbf{Mole} = \frac{\boldsymbol{Weight\ (w)}}{\boldsymbol{Molecular\ weight\ (M.wt.)}} = \frac{\boldsymbol{W}}{\boldsymbol{M.wt.}}$$

Molecular weight = (M.wt): is a total of atomic weight in the compound.

M.wt. = $\frac{\boldsymbol{W}}{\boldsymbol{Mole}}$ g / mole



Example 1

Calculate the M.wt. of benzoic acid $C_7H_6O_2$?

A.wt.: C=12, H= 1, O= 16

H.W

Example 2

How many grams of sodium ion Na^+ are contained in 20g. of sodium carbonate Na_2CO_3 A.wt.: Na = 23, C=12, O =16.

Mole of (Na_2CO_3) = $\frac{wt.}{M.wt} = \frac{20}{106}$ = 0.188 Mole of Na_2CO_3

$$Na_2CO_3 \rightarrow 2\,Na^+ + CO_3^{-2}$$

Mole (Na^+) = 2 × 0.188 = 0.376 mole

Mole = $\frac{wt.}{M.wt}$ = 0.376 = $\frac{wt.}{23}$

Wt, = 8.679 g.

Or

Na	**Na_2CO_3**
A.wt. × no. of mole	M.wt
23 × 2	106
g	20

Wt. = $\frac{20 \times 46}{106}$ = 8.679 g

Specific gravity (Sp.gr.):

It’s the ratio between density of substance to the density of water

$$\text{Sp.gr.} = \frac{Density\ of\ Substance}{Density\ of\ Water}$$

.

Density of Water = 1 g/L

$$d = \text{Sp.gr.} = \frac{1}{1}$$
$$= 1$$

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II. Parts per thousand, Parts per million and Parts per billion:

$$Cppt = \frac{Wt.g}{V.mL} \times 10^3$$

(which used specially in oceanography).

For very dilute solution part per million (ppm) is a convenient way to express concentration.

$$Cppm = \frac{Wt.g}{V.mL} \times 10^6$$

For aqueous solution.

$$ppm = 1.0\ mg/L \equiv 1.0\ \mu g / mL$$

$$Cppb = \frac{Wt.g}{V.mL} \times 10^9$$

Example:

Calculate the number of grams of KCl to prepare solution in volume 500mL, the concentration of KCl in the solution is 250 ppm?

H.W

III. P- Function:

Sometimes it's suitable to expressing concentration of ion by logarithm.

The most well known p-function is pH which it is negative logarithm of [H^+]. (H^+ concentration).

$$pH = -\log [H^+]$$

$$pH = -\log [OH^-]$$

$$pH = -\log [X^-]$$

Example:

$$NaCl \rightarrow Na^+ + Cl^-$$

0.1 M   0.1M   0.1 M

$pNa^+ = -\log [Na^+]$

$= -\log [0.1]$ $0.1 = 10^{-1}$

$= 1$

Second: Chemical Methods for Expressing concentration

I. Molarity (M): Is the total number of moles of a solute in 1L of solution.

Or the total number of millimoles in 1 mL.

$$M = \frac{no.moles\ (solute)}{V.\,Soln.L}$$

No. = number.

Soln. = Solution.

$$Moles = \frac{W}{M.wt.}$$

$$M = \frac{\frac{W}{M.Wt.}}{V} \leftrightarrow \frac{W}{M.wt. \times V.L}$$

$$M = \frac{W \times 1000}{M.Wt. \times VmL}$$

This law used for ***solid state*** material

mole/L, mmol/mL → Molar

No. of moles = M × $V_{(L)}$

No. of millimoles = M ×$V_{(mL)}$

$$M = \frac{Sp.gr. \times \% \times 10}{M.Wt.}$$

Molarity of ***liquid state*** solution

Specific gravity :

$$\mathbf{Sp.gr.} = \frac{\textbf{Density of Substance}}{\textbf{density of Water}}$$

∵Density of water (H_2O)   d (H_2O) = 1   ∴

Sp.gr. = d

Dilution Law

Number of moles of concentration solution = number of moles of dilution solution.

Conc. Soln.		***dil. Soln,***
no. of moles	=	no. of moles
no. of millimoles	=	no. ofmillimoles

$$M_1 . V_1 = M_2 . V_2$$

Ex.1. Prepare 0.1M of calcium carbonate $CaCO_3$ in 2 litter?

A.wt. : Ca = 40, C= 12, O =16.

$$M = \frac{W \times 1000}{M.Wt. \times VmL}$$

1L = 1000 mL

$$0.1 = \frac{W \times 1000}{100 \times 2000}$$

$$W = 20 \text{ g of } CaCO_3 \text{ in 2 litter}$$

Ex.2. Calculate the volume of NH_3 conc. which used to prepare 500 mL of 0.1 M NH_3, sp.gr. of concentrated solution = 0.9 and the percentage = 28%, M.wt. = 17.?

$$M = \frac{Sp.gr.\times\%\times 10}{M.Wt.}$$

$$M = \frac{0.9.\times 28\times 10}{17}$$

$$M = 14.8\ M\ of\ NH_3\ conc.$$

$$M_1\ V_1 = M_2\ V_2$$

$$14.8 \times V_1 = 0.1 \times 500$$

$$V_1 = \frac{0.1.\times 500}{14.8}$$

V_1 = 3.33 mL dilute to 500mL by D.W to give 0.1 M NH_3

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II. Formality (F): It is number of formula weight solute in liter of solution.

$$F = \frac{W \times 1000}{F.Wt. \times VL}$$

F= F.w/L, m.Fw./mL → Formal

III. Normality (N): It is the number of equivalents of solute in liter of solution.

$$N = \frac{no.of\ equivalent}{Vol.of\ solution\ (L)}$$

$$no.eq. = \frac{Wt.}{eq.Wt.} \quad ....$$

The equivalent weight (eq.wt.) of a substance is not a constant quantity, but it's value depend upon the reaction, in which it is taken part.

Since; $Eq.wt = \frac{Mwt.}{n}$ n : the reacting units

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

For ***solid state*** *material.*

N= eq/L, m.eq./mL → Normal

$$N = \frac{Sp.gr. \times \% \times 10}{eq.wt.}$$

For ***liquid state*** *solution.*

To calculate the equivalent weight (eq.wt.):

$$eq.wt. = \frac{M.wt.}{n}$$

n =active unite.

n = H^{+} (acids).

n = OH^{-} (bases).

n = charge × number of ions (salt).

n = no. of electrons lost or gained (oxidation –reduction).

Calculate the equivalent weight:

A. Of Element

$$eq.wt. = \frac{A.wt.}{no.of\ oxidant}$$

Ex. What is the eq.wt. of Mg? A.wt. = 24

$$\text{Eq.wt.} = \frac{\text{A.wt.}}{\text{no.of oxidant}}$$

$$= \frac{24}{2}$$

$$= 12$$


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B. Of Acid

$$eq.wt. = \frac{M.wt.}{no.of\ hydrogen\ atoms\ interacting}$$

Ex.1. Calculate the equivalent weight of HCl? M.wt. = 36.5

$$HCl \rightarrow H^{+} + Cl^{-}$$

$$\text{eq.wt. of HCl} = \frac{\text{M.wt.}}{\text{no.of proton replacable of base}}$$

$$\text{eq.wt. of HCl} = \frac{36.5}{1}$$

$$= 36.5$$

Ex.2. Calculate the equivalent weight of H_2SO_4? M.wt. = 98.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^-$$

$$\text{eq.wt. of } H_2SO_4 = \frac{\text{M.wt.}}{\text{no.of proton replacable of base}}$$

$$\text{eq.wt. of } H_2SO_4 = \frac{98}{2}$$

$$= 49$$

So, H_2SO_4 has two reacting units of proton ; there are two equivalents of proton in each mole. While HCl has one reacting unit of proton, there is one equivalent of proton in each mole. So the normality of H_2SO_4 solution is twice its molarity.

$$N_{\text{of } H2SO4} = M \times 2$$

C. Of Base

$$eq.wt. = \frac{M.wt.}{no.of\ reactivehydroxil\ groups}$$

Ex.1. Calculate the equivalent weight of NaOH? M.wt. = 40

$$\text{eq.wt. of NaOH} = \frac{\text{M.wt.}}{\text{no.of reactivehydroxil groups}}$$

$$\text{eq.wt. of NaOH} = \frac{40}{1}$$

$$= 40$$

Ex.2. Calculate the equivalent weight of $Mg(OH)_2$? M.wt.58

$$\text{eq.wt. of } Mg(OH)_2 = \frac{\text{M.wt.}}{\text{no.of reactivehydroxil groups}}$$

$$\text{eq.wt. of } Mg(OH)_2 = \frac{58}{2} = 29$$

D. Of Salt

$$\textbf{eq.wt.} = \frac{M.wt.}{number\ of\ metal\ atoms \times no.of\ charge\ or\ no.of\ oxidant}$$

***Ex*.:** Calculate the eq.wt. of Na_2CO_3?M.wt. = 106

$$\text{eq.wt. of } Na_2CO_3 = \frac{M.wt.}{2\times(+1)}$$

$$= \frac{106}{2\times(+1)}$$

$$= 53$$


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E. Of material that suffer oxidation reduction

$$\text{eq.wt. of oxidation} = \frac{M.wt.}{\text{number of loss electrons}}$$

$$\text{eq.wt. of reduction} = \frac{M.wt.}{\text{number of gain electrons}}$$

Ex.: Calculate the eq.wt. of manganese Mn^{+2} and ferrous Fe^{+2} in the equation below?

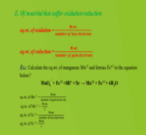
$$\mathbf{MnO_4^{-} + Fe^{+2} + 8H^{+} + 5e^{-} \rightarrow Mn^{+2} + Fe^{+3} + 4H_2O}$$

$$\text{eq.wt. of } Mn^{+2} = \frac{M.wt.}{\text{number of gain electrons}}$$

$$\text{eq.wt. of } Mn^{+2} = \frac{M.wt.}{5}$$

$$\text{eq.wt. of } Fe^{+3} = \frac{M.wt.}{\text{number of loss electrons}}$$

$$\text{eq.wt. of } Fe^{+3} = \frac{M.wt.}{1}$$



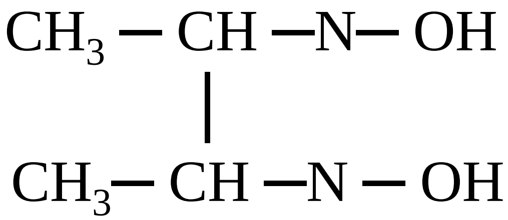
F. Of Complex Formation Reaction

$$\text{eq.wt.} = \frac{\text{A.wt.}}{\text{no.of oxidant of ion which contact with ligand}}$$

Ex.: Calculate the eq.wt. of Nickle Ni^{+2} in the equation below?

$$Ni^{+2} + 2DMG \rightarrow Ni(DMG)_2\downarrow$$

DMG:



$$\begin{array}{l} CH_3 - CH - N - OH \\ \qquad\quad\ | \\ CH_3 - CH - N - OH \end{array}$$

$$\text{eq.wt.} = \frac{\text{At.wt.}}{\text{no.of oxidant of ion which contact with ligand}}$$

$$\text{eq.wt. Ni} = \frac{\text{At.wt.}}{2}$$

- What is the relationship between Molarity or Normality with part per million ppm?

$$C\ ppm = \frac{Wt.g}{V.mL} \times 10^6$$

$$M = \frac{W \times 1000}{M.Wt. \times VmL}$$

Multiple denominator and numerator by 10^6

$$M = \frac{W \times 1000}{M.Wt. \times VmL} \times \frac{10^6}{10^6}$$

$$M = \frac{ppm \times 1000}{M.Wt. \times 10^6}$$

$$M = \frac{ppm}{M.Wt. \times 1000}$$

$\therefore$ ppm = M × M.wt. × 1000

ppm = N × eq.wt. × 1000


Thank You

Analytical Chemistry

Mosul University / College of Science
New & Renewable Energy Department

Ass.Prof. Dr. Lamya A. Sarsam

1st Class

IV. Molality (m): It is number of moles of solute in kilogram of solvent.

Or no. of millimoles of solute in (g) of solvent.

$$m = \frac{W \times 1000}{M.wt. \times W\ solvent\ kg}$$

In dilute aqueous solution:

$$M = m$$

Weight of solution = Weight of solvent = Volume of solution.

Molar Fraction (X):

It's the ratio between numbers of solute moles to number of moles of all solution contains.

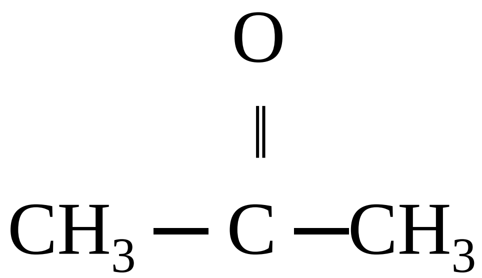
$$\textit{Mole of Fraction of Solute(X)} = \frac{no.moles\ of\,(solute)}{no.moles\ of\ (solution)}$$

no. of moles of solution = no. of solute moles + no. of solvent moles

$$\textit{Mole of Fraction of solvent(X)} = \frac{no.moles\ of\ (solvent)}{no.moles\ of\,(solution)}$$

X solute + X solvent = 1

Ex.: Calculate the mole fraction of 5.8g acetone solution



$$CH_3-\overset{\overset{O}{\|}}{C}-CH_3$$

with 90g water? A.wt.: C = 12, O = 16, H = 1

$$\textit{Mole of Fraction of Solute}_{\text{Acetone}}(X) = \frac{no.moles\ of\ (solute)}{no.moles\ of\ (solution)}$$

$$\text{Moles (solute)} = \frac{Wt.}{M.wt.}$$

$$= \frac{5.8\ g}{(3\times12)+(1\times16)+(6\times1)=58g/mol}$$

$$\text{Mole}_{\text{(solute)}} = 0.1 \text{ mole}$$

$$\text{Mole}_{\text{(solvent)}} = \frac{90}{18} = 5 \text{ mole}$$

no.of solution moles = 5.0 +0.1 = 5.1 mole

Mole Fraction of Solute = $\frac{\boldsymbol{no.moles\ of\,(solute)}}{\boldsymbol{no.moles\ of\ (solution)}}$

X solute = $\frac{\mathbf{0.1}}{\mathbf{5.1}}$

X = 0.0196

Mole Fraction of Solvent = $\frac{\mathbf{5.0}}{\mathbf{5.1}}$

X = 0.9804

Total Mole Fraction = 0.9804 + 0.0196

= 1.0


Thank You