First class

General chemistry

First lecture

Article teacher

M.s.c Roaa wahhab

Chemistry is the science that studies matter and the changes that occur to it, specifically by studying its properties, structure, composition, behavior, interactions and what happens through it. Chemistry studies atoms and the bonds that occur between them to form molecules, and how these molecules are subsequently linked to form matter. It also studies the interactions that occur between them

branches of chemistry

physical chemistry, **organic** chemistry, **inorganic** chemistry, **biochemistry**,**analytical** chemistry

Analytical chemistry :

Which uses quantitave and qualitative analysis to identify and measur the physical and chemical properties of substance .

Organic chemistry

It studies compounds that contain carbon in its composition.

Bio chemistry

is abranch of natural science specialized in studying the chemical composition of cell parts in various simple and complex organisms.

Atom

atoms are the basic units of matter and It's the smallest unit of substance

Each atom consists of three basic components

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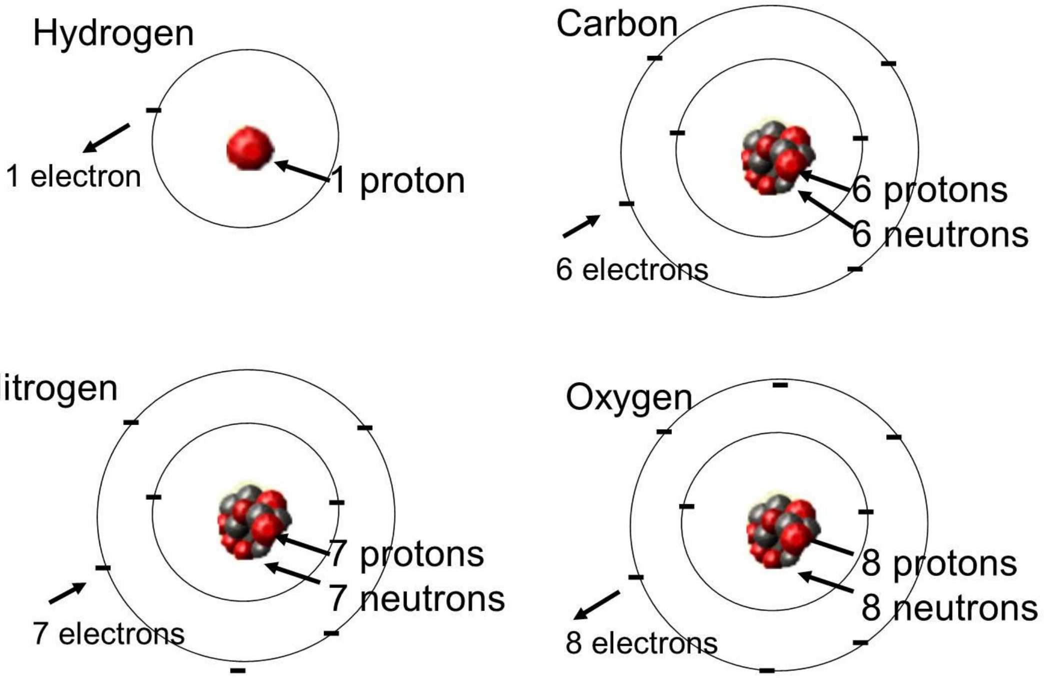
1 – <u>the protons</u> have <u>apositive</u> electric charge

2 – <u>the Electrons</u> have a <u>negative</u> electric charge

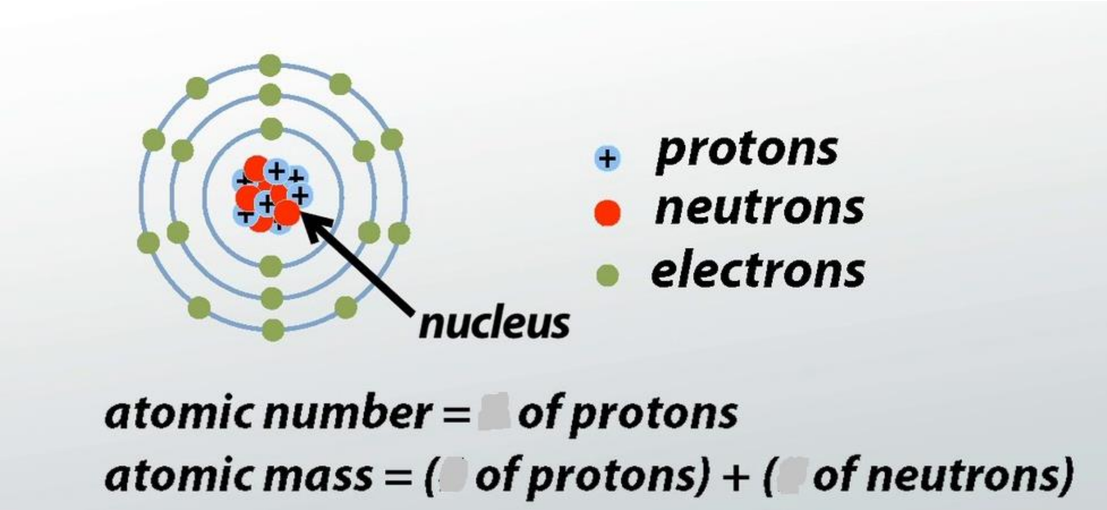
3 – <u>the Neutrons</u> have <u>no electric</u> charge



- All atoms are electrically neutral, because every atom has an equal number of electrons and protons.

- Nearly all of the atom's mass is located in the nucleus.

The nucleus is tiny compared with the total size of the atom.



Nucleus :

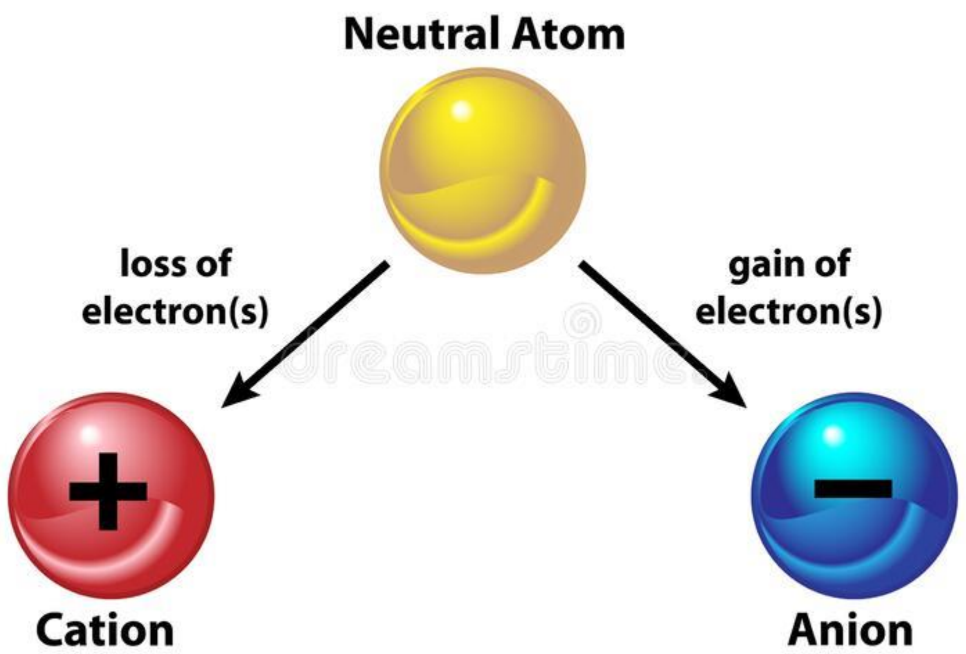
Small dense center of atom and contains almost the mass of the atom and contains protons and neutrons.

Electrons

It is subatomic particle that is almost spherical in shape of an atom and carries a negative electric charge.

- If the number of protons It is a and electrones are equal , electrically neutral.
- If the atom has mor protons than electrones it will has a positive charge.

- While if the electrons number mor than protons the atom has a negative charge

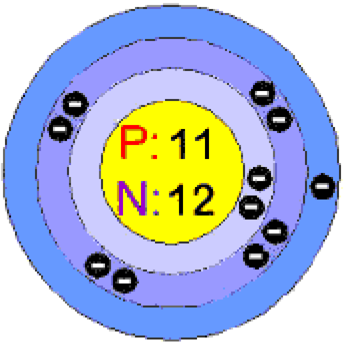


Atoms can attach to another one or mor by chemical bound to form chemical compounds such as **molecules**

Elements

Composed of one type of atoms .

My be define as , apure substance that cannot be changed into a simple form of matter by any chemical reaction



SODIUM (Na)

Each element is identifide by two numbers:

Atomic number

Atomic weight (mass number)

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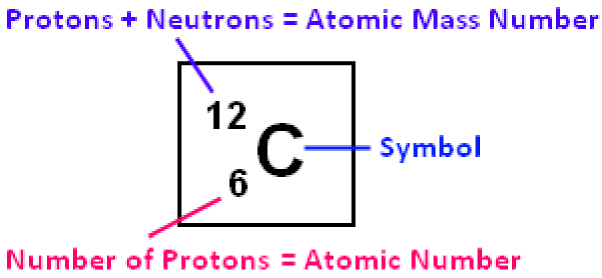
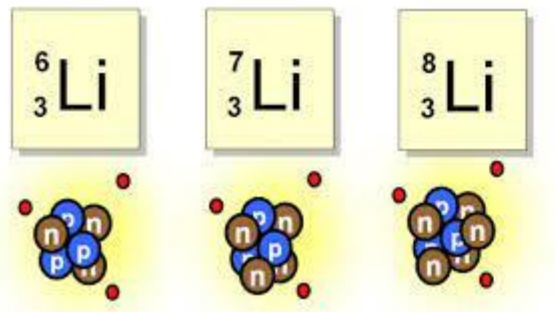


What are the isotop?

The atoms that have the same number of protons and diffferent number of neutrones (atoms with same atomic number and different atomic weight)



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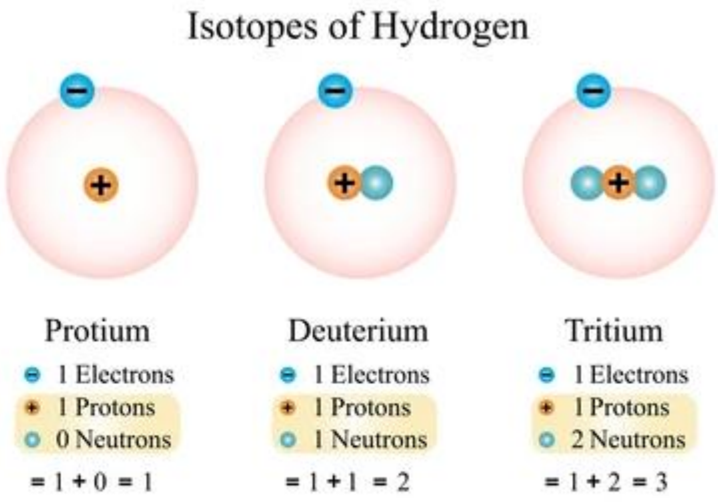
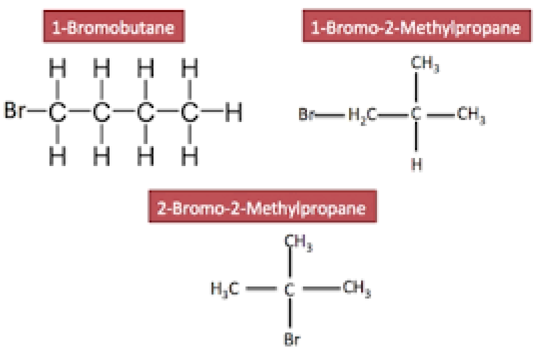


Isomers : are molecules that have the same molecular formula, but have a different arrangement of the atoms in space.



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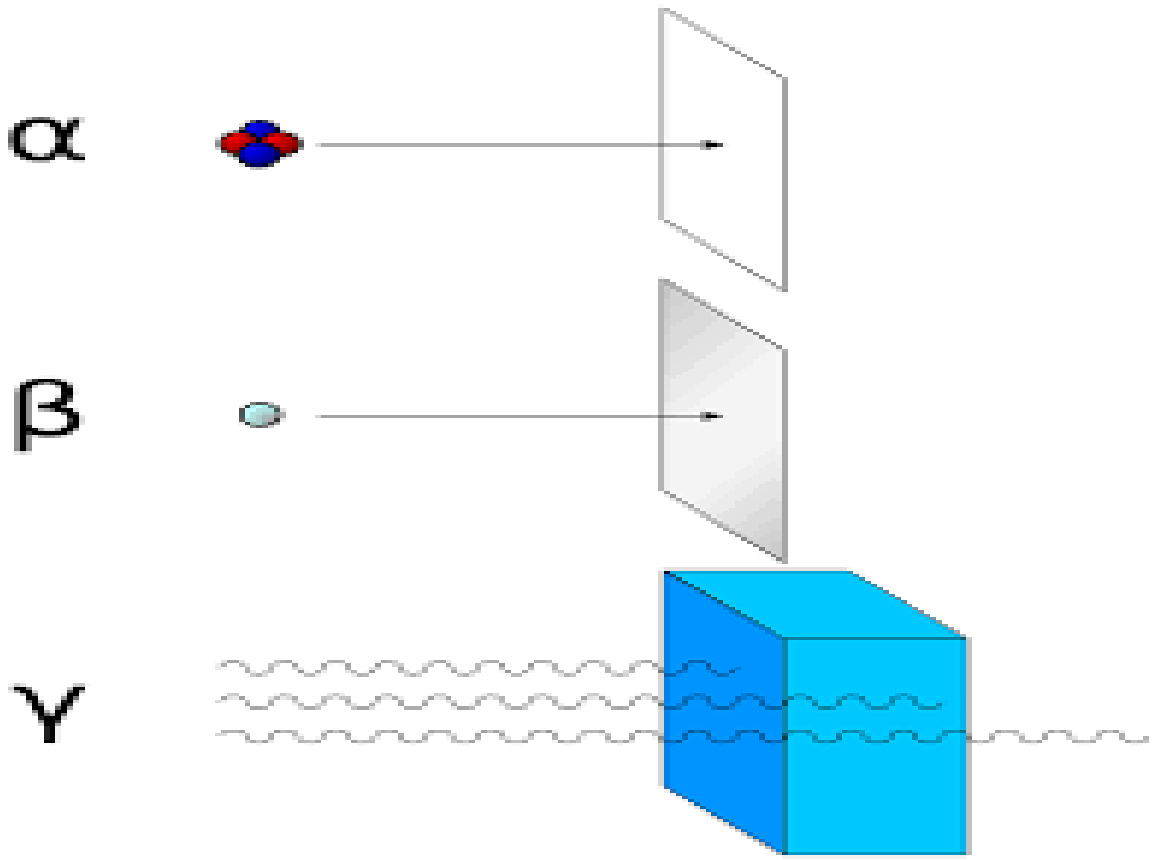
Radioactivity : is the property of emitting radiation from the nucleus of an atom.



The three types of radiation are

1 - **alpha** particles are positively charged helium nuclei

2- **Beta** particles high speed electrons and negatively charged

3- **gamma** r high - energy from electromagnetic radiation and

have no charge

First class

General chemistry

Second lecture

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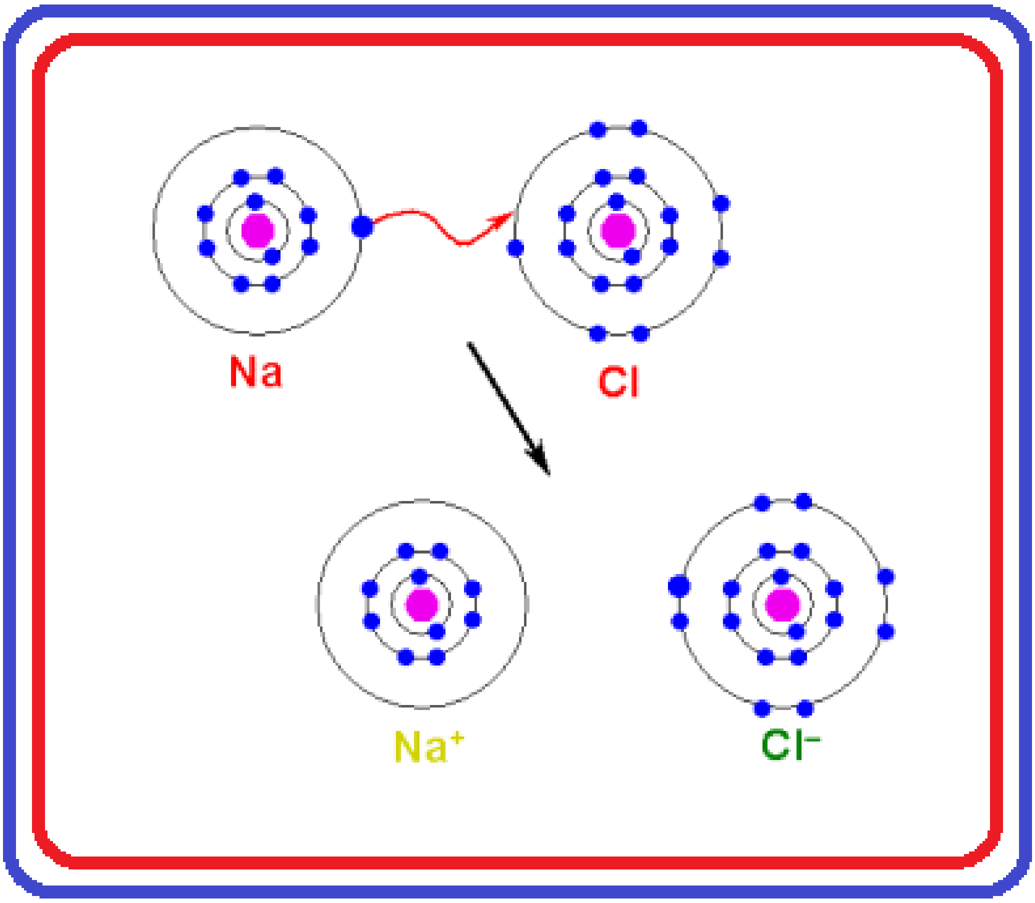
CHEMICAL BONDS:

is a lasting attraction between atoms, ions or molecules that enables the formation of chemical compounds. The bond may result from the electrostatic force of attraction between oppositely charged ions as in ionic bonds or through the sharing of electrons as in covalent bonds. The strength of chemical bonds varies considerably; there are "strong bonds" or "primary bonds" such as covalent, ionic and metallic bonds, and "weak bonds" or "secondary bonds" such as dipole–dipole interactions , the van der Waals forces and hydrogen bonding.

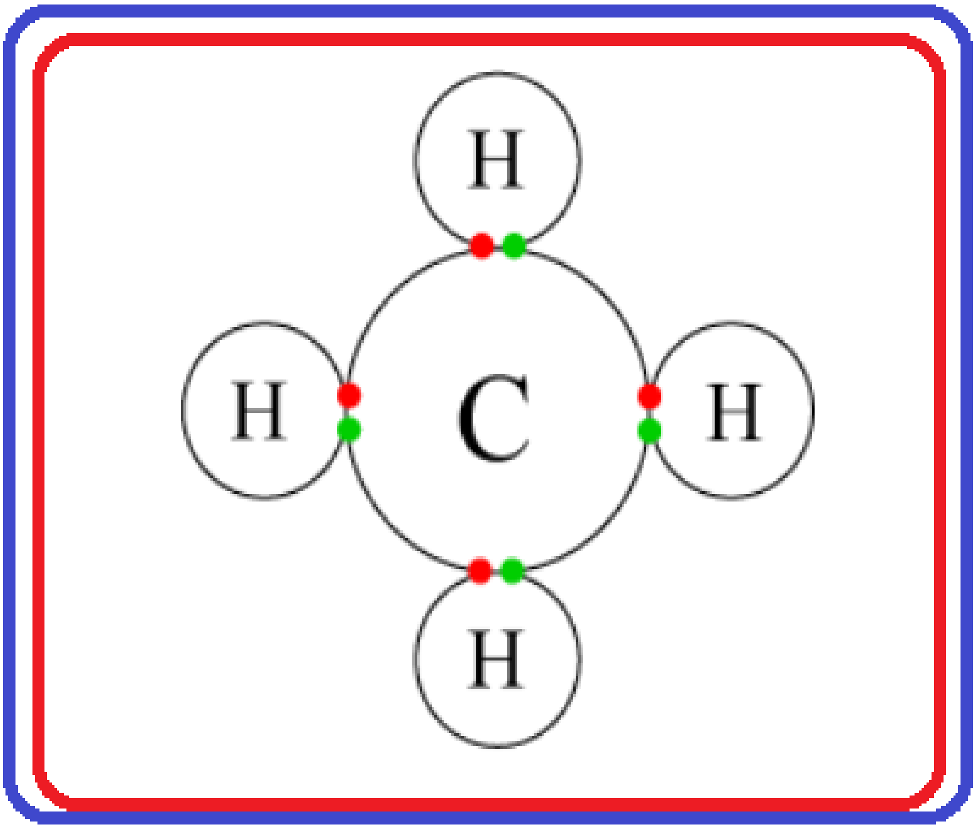
1-Ionic bond :

type of linkage formed from the electrostatic attraction between oppositely charged ions in a chemical compound. Such a bond forms when the valence electrons of one atom are transferred permanently to another atom. The atom that loses the electrons becomes a positively charged ion (cation), while the one that gains them becomes a negatively charged ion (anion).



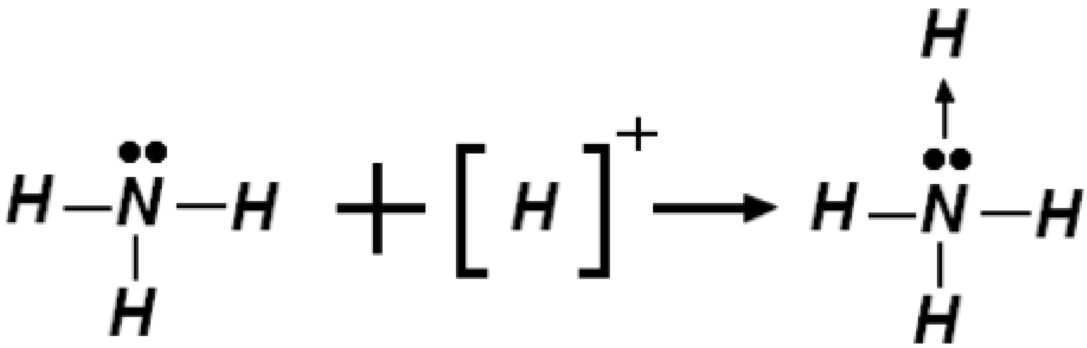
2- Covalent bond:

the interatomic linkage that results from the sharing of one electron or pair between two atoms. The binding arises from the electrostatic attraction of their nuclei for the same electrons. A covalent bond forms when the bonded atoms have a lower total energy than that of widely separated atoms.



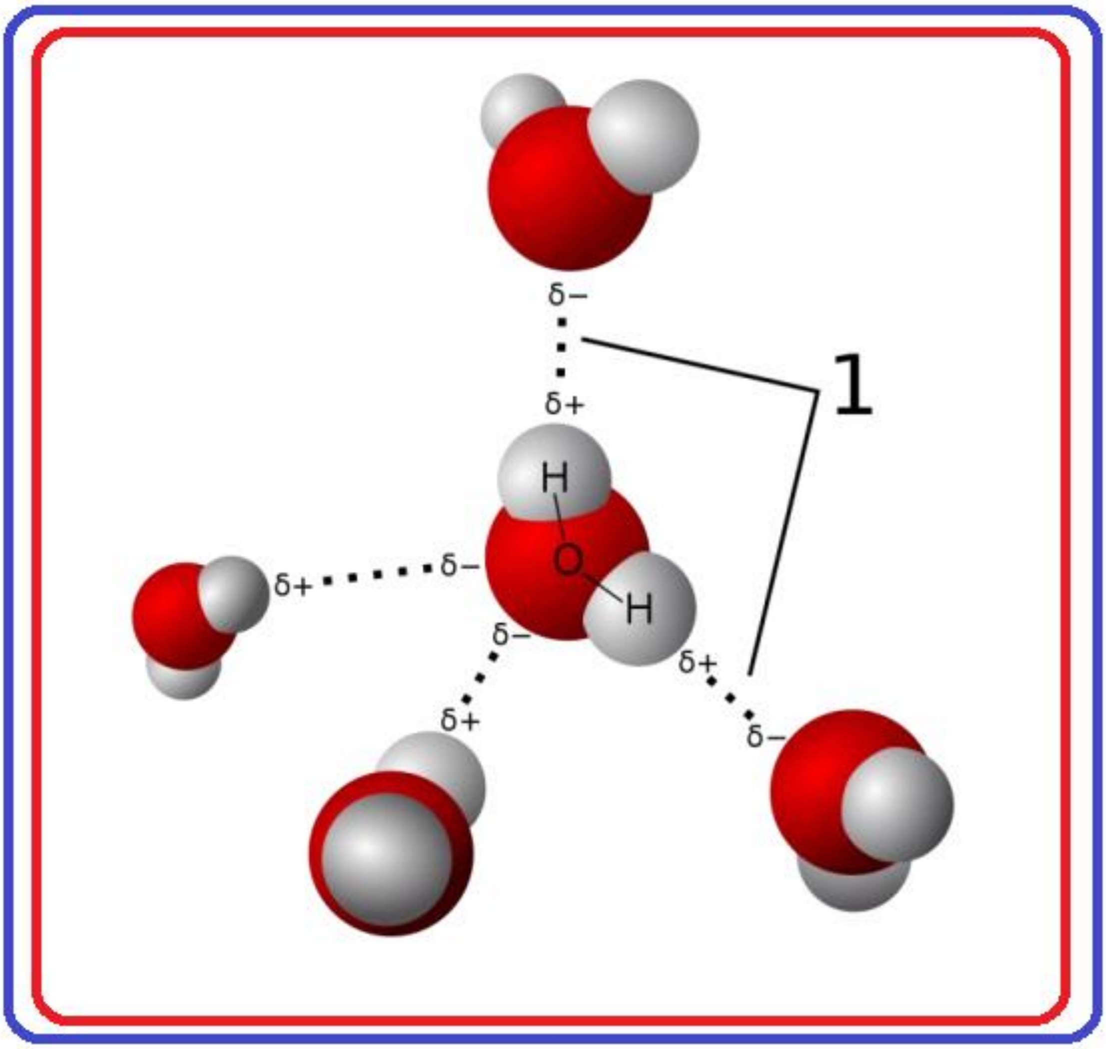
3- coordinate covalent bond (Dipolar bond):

is a kind of covalent bond in which the two electrons derive from the same atom.



4- hydrogen bond:

Hydrogen bonding is a special type of dipole-dipole attraction between molecules, not a covalent bond to a hydrogen atom. It results from the attractive force between a hydrogen atom covalently bonded to a very electronegative atom such as a N, O, or F atom and another very electronegative atom.



METHODS OF ANALYSIS:

Analytical chemistry studies and uses instruments and methods used to separate, identify, and quantify matter.

- QUALITATIVE AND QUANTITATIVE ANALYSIS:

- Qualtitative analysis:

Qualitative analysis determines the presence or absence of a particular compound, but not the mass or concentration. By definition, qualitative analyses do not measure quantity.

- Quantitative analysis:

Quantitative analysis is the measurement of the quantities of particular chemical constituents present in a substance. Quantities can be measured by mass (gravimetric analysis) or volume (volumetric analysis).
- statistical methods of quantitative analysis: Modern analytical chemistry is concerned with the detection, identification, and measurement of the chemical composition of unknown substances using existing instrumental techniques, and the development or application of new techniques and instruments. It is a quantitative science, meaning that the desired result is almost always numeric.

- Accuracy & Precision:

Two terms of importance in any measurement are accuracy and precision, and it is important to distinguish between them since these terms have highly specific meanings when applied to scientific measurement.

1- Accuracy

Accuracy is defined as the closeness of a result to the true value. This can be applied to a single measurement, but is more commonly applied to the mean value of several repeated measurements, or replicates.

2- Precision :

Precision is defined as the extent to which results agree with one another and is usually evaluated in terms of the range or spread of results this means that precision is inherently related to the standard deviation of the repeated measurements.

errors in quantitative analysis:

the primary aim of such discussion in analytical chemistry is to determine (a) how close a result is to the 'true' value (the accuracy) and (b) how well replicate values agree with one another (the precision) .

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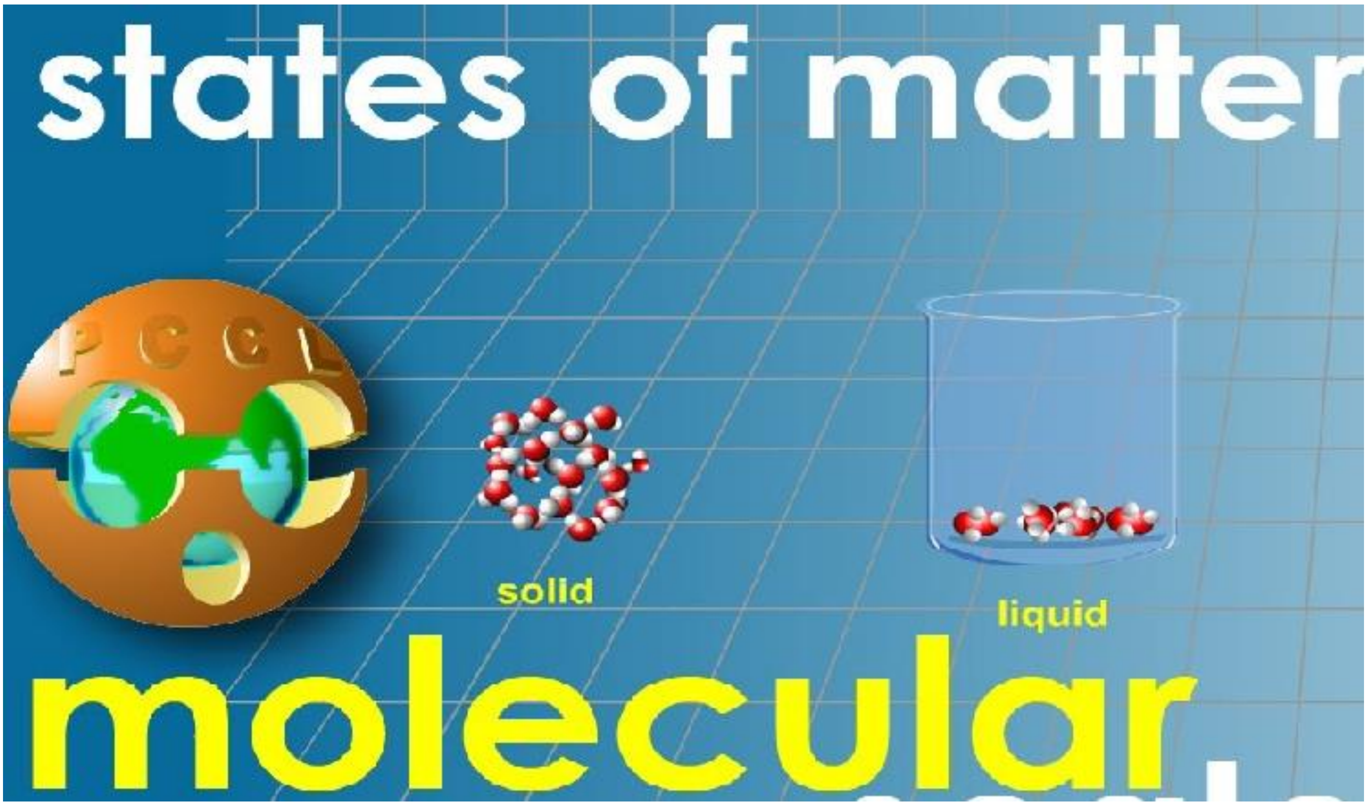
First class

General chemistry

The third lecture



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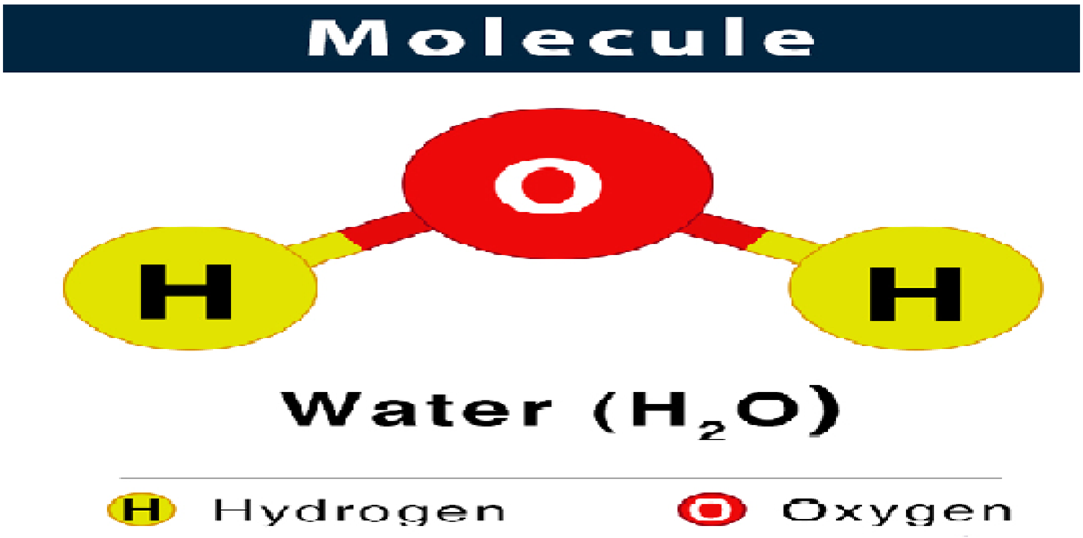
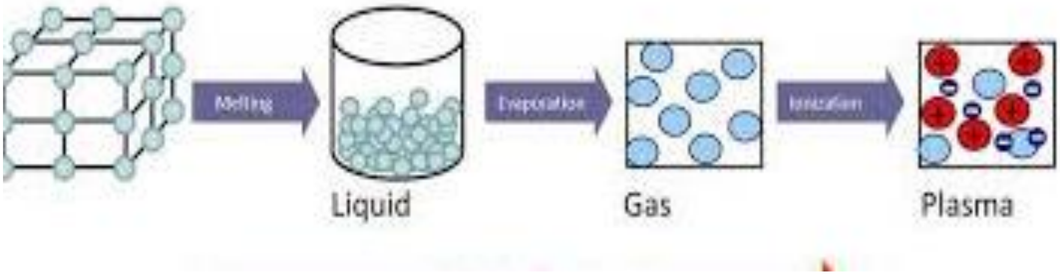
RELATIONSHIP BETWEEN ATOMS AND MOLECULES

Molecules : are joining of two or more atoms , which are the most basic unite of physical matter .



Matter : anything that it can take place or anything that has mass and volume .



What is the state of matter?

Solid :a state of matter that has a definite shape and volume .

Liquid : A state of matter that has no definite shape but has a definite volume .

Gas : a state of matter that has no definite shape or volume .

Plasma : a state of matter that are have very large of energy (the electrons of atoms cannot stay in orbitals around one atomic nucleus.

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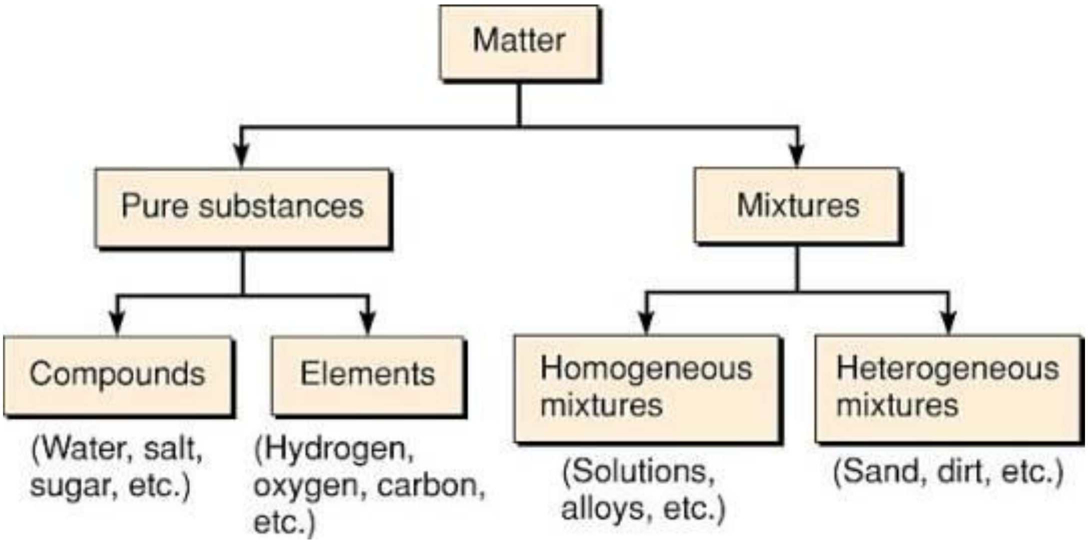
classification of matter



Debroley equation

The de Broglie equation is an equation used to describe the wave properties of matter, specifically,

The Debroley concluded that electrons might have wavelength by first

combining tow relationships, one derived by

Einstein, the other by plank.

De Broglie's Equation

$$\lambda = \frac{h}{mv}$$

Where
λ = wavelength in meters
v = the velocity in meters/sec
m = the mass in kilograms
h = Plancks's constant in J/Hz

E = hf ………………. 1 (Plank eq)

E = mc^2……………….2 (Einstein eq)

From eq1 and eq 2 hf = mc^2

And $f = (cv/\lambda)$

$(hcv/\lambda\ ) = mc^2$

$(hv/\lambda) = mc$

$h = \lambda mc$, $c= v\backslash v$

$\lambda= (h/(mv\ )$

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General chemistry

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Solution Concentration

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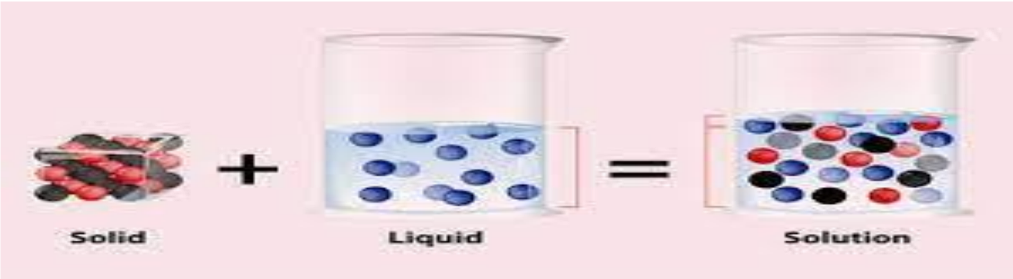
<u>Solution</u> : is a special type of homogeneous mixture composed of two or more substances



Types of solutions

1. True solution.
2. Suspended solution.
3. Colloidal solution ratio to atoms or molecules or ions the solute to solvent.
4. Saturated solution.
5. Unsaturated solution.

6. Supper saturated solution

Methods for expressing chemical concentrations

1- Formality and Formal concentration (F)

2- Morality and Molar concentration (M)

3- Normality and Normal concentration (N)

4- Percent Composition

5- Parts per million (ppt)

6-Molality (L)

Molar concentration or morality is most commonly expressed in units of moles of solute per liter of solution

Molarity

- Molarity is defined as the amount of moles of a compound dissolved in an amount of solvent (usually water).

- It can be solved with the equation:

$$\text{Molarity (M)} = \frac{\text{moles solute}}{\text{liters of solution}}$$

Normality and Normal concentration (N)

Normality is a measure of concentration equal to

the gram equivalent weight per liter of solution.

Normality, N

Formula

$$N = \frac{wt(g) \times 1000}{\text{Equivalent weight} \times V} \Rightarrow \frac{wt(g) \times 1000}{Eq.wt. \times V}$$

$$\text{Equivalent weight} = \frac{\text{Molecular weight}}{\text{Number of } H^{+} \text{ in acid or } OH^{-} \text{ in base}} \Rightarrow \frac{M.W}{n}$$

Molality : (L)

Molality is a measure of number of moles of solute

present in 1 kg of solvent

$$Molality = m = \frac{moles\ of\ solute}{kg\ of\ solvent}$$

$$m = \frac{mol}{kg}$$

Percent Composition

$$\text{weight percent (w/w)} = \frac{\text{weight solute}}{\text{weight solution}} \times 100\%$$

$$\text{volume percent (v/v)} = \frac{\text{volume solute}}{\text{volume solution}} \times 100\%$$

$$\text{weight/volume percent (w/v)} = \frac{\text{weight solute, g}}{\text{volume solution, mL}} \times 100\%$$

Parts per million (ppt)

ppm (parts per million)

used to represent very dilute solutions

ppm: one part solute in 1,000,000 parts water

$$\text{ppm} = \frac{\text{mass solute}}{\text{mass solution}} x 10^6$$

First class

General chemistry

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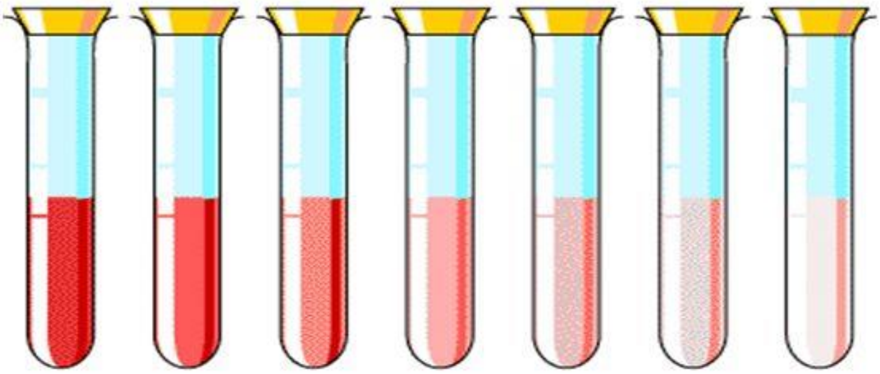

Dilutions

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Dilution of concentration solution

refers to the process of adding additional solvent to a solution to decrease its concentration.

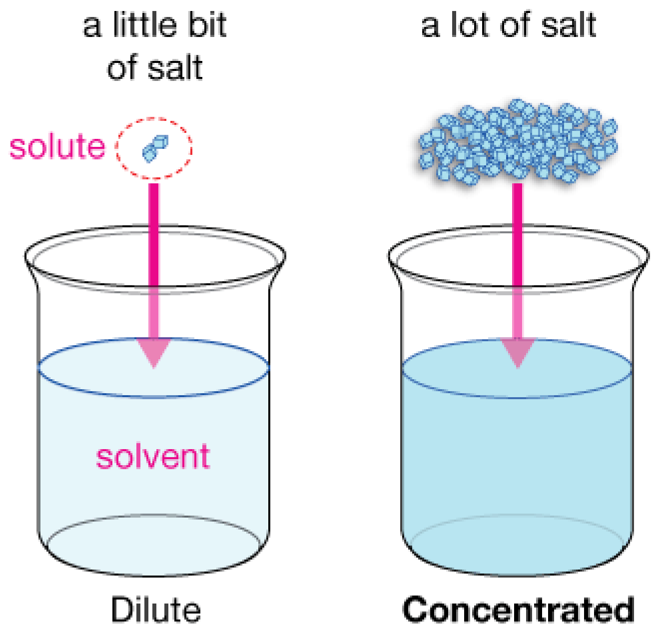
This process keeps the amount of solute constant, but increases the total amount of solution, thereby decreasing its final concentration.

A concentrated solution is one that has a relatively large amount of dissolved solute.

A dilute solution is one that has a relatively small amount of dissolved solute.

However, these terms are relative, and we need to be able to express concentration in a

more exact, quantitative manner



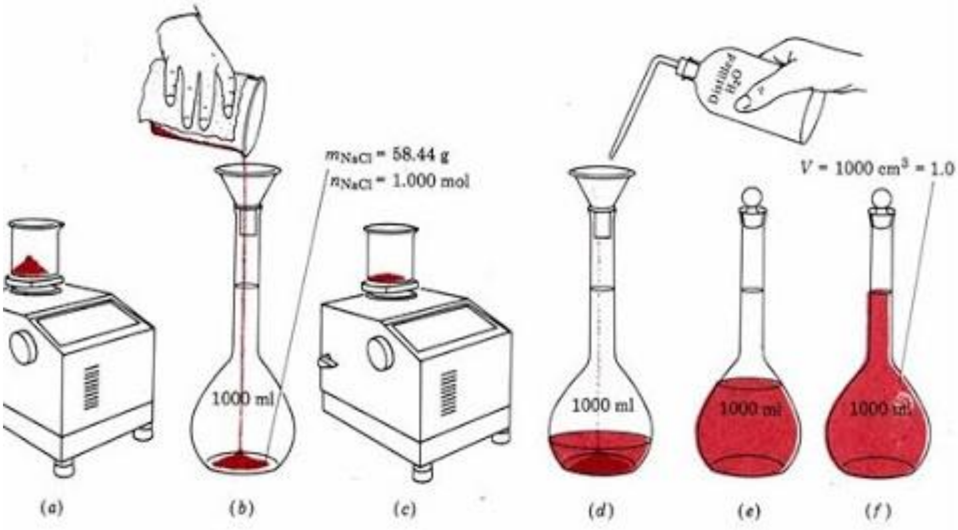
the following steps describe the procedure for making a solution of a specific molarity

from a pure, solid substance.

1 - First, weigh out the correct mass of solute.

2- Dissolve the solute in water, keeping the volume less than the desired total volume of solution.

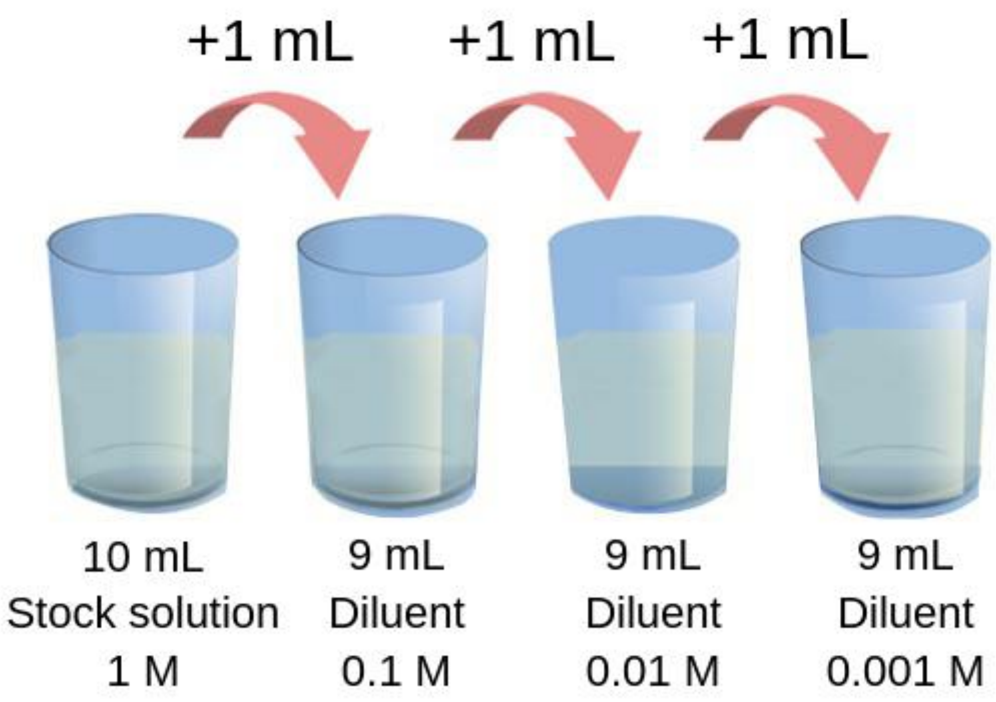
3- Dilute the solution to the desired total volume of solution.



<u>stock solution</u> is a concentrated solution that will be diluted to some lower concentration for actual use.

Stock solutions are used to save preparation time, conserve materials, reduce storage space,

and improve the accuracy with which working lower concentration solutions are prepare



preparation of molar solution

Molar solutions are prepared by dissolving the gram molecular weight of the solute making 1 liter of solution.

It means, to prepare 1 liter solution, we have to dissolve the solute equal to the molecular weight of the solute in grams in one liter of solvent .

Example :

Preparation of 1M solution of H_2SO_4

molecular weight of H_2SO_4=2 (1)+32+64 = 98

We require 98 grams of H_2SO_4 to prepare 1liter of 1M H_2SO_4 solution.

Example :

Preparation of 1M solution of NaOH

molecular weight of NaOH = 23 +16 +1 = 40

we require 40 gm of NaOH to prepare 1liter of 1M NaOH solution.

<u>Normal solutions</u> are prepared by dissolving gram equivalent weight of solute making 1 liter of solution. It means, to prepare 1 liter solution, we have to dissolve the solute equal

to the equivalent weight of the solute in grams.

Q \ Calculate the expressions for a solution of HCl in water if (0.5eq HCl) is dissolved in an amount of water so that the volume of the solutions becomes (500mL)?

$$\text{Normality} = \frac{EQ}{V} \times 1000 \qquad \therefore \text{Normality} = \frac{0.5}{500} \times 1000 = 1\ N$$

Q\ Calculate the titer of the solution resulting from dissolving 19.5g of H_2SO_4 in water to form a solution of volume of 800mL.

Atomic weights: (H=1 , O = 16 , S = 32) ?

$$M_{H_2SO_4} = (2 \times 1) + 32 + (4 \times 16) = 98\ g/mol$$

$$n = \frac{m}{M} = \frac{19.6}{98} = 0.2\ mol$$

$$EQ = n \times a \qquad \therefore EQ = 0.2 \times 2 = 0.4\ eq$$

$$\text{Normality} = \frac{EQ}{V} \times 1000 \qquad \therefore \text{Normality} = \frac{0.4}{800} \times 1000 = 0.5\ N$$

Q \ Howe many grams of NaCl should be used to prepare 300ml of 0.2 M solution ?

Step 1: $0.20\ M\ NaCl\ = \frac{x\ mol}{0.3\ L\ solvent}$

$$x\ = 0.20\ M\ NaCl \times 0.3\ L\ solvent$$
$$= 0.06\ mol\ NaCl$$

Step 2:

The molar mass of NaCl is 58.44 g/mol.

$$0.06 \text{ mol NaCl} \times \frac{58.44\ g\ NaCl}{1\ mol\ NaCl} = 3.51\ g\ NaCl$$

Percent composition : is calculated from a molecular formula

Wight solute\ wight solution

Volume solute \ volume solution

Wight solute \volume solution

. This value is presented as a percentage

$$\text{weight percent (w/w)} = \frac{\text{weight solute}}{\text{weight solution}} \times 100\%$$

$$\text{volume percent (v/v)} = \frac{\text{volume solute}}{\text{volume solution}} \times 100\%$$

$$\text{weight/volume percent (w/v)} = \frac{\text{weight solute, g}}{\text{volume solution, mL}} \times 100\%$$

Q \ Calculate the mass of water needed to dissolve 10g of ethyl alcohol if you know that the alcohol by weight is 32%?

$$Wt\,\% = \frac{m_1}{m_{sol}} \times 100 \qquad \therefore 32 = \frac{10}{m_{sol}} \times 100$$

$$m_{sol} = \frac{10}{32} \times 100 = 31.25\text{ g}$$

$$m_2 = 31.25 - 10 = 21.25\text{ g}$$

Q \ Calculate the weight ratio of sodium sulfate Na_2SO_4 when 142g is dissolved in 25mol of water ?

$$M_{H_2O} = (2 \times 1) + 16 = 18\ g/mol$$

$$m_2 = n \times M \qquad \therefore m_2 = 25 \times 18 = 450\ g$$

$$m_{sol} = m_1 + m_2 \qquad \therefore m_{sol} = 142 + 450 = 592\ g$$

$$Wt\% = \frac{m_1}{m_{sol}} \times 100 \qquad \therefore Wt\% = \frac{142}{592} \times 100 = 24\%$$

<u>parts per million (ppm)</u> :is the number of units of mass of a contaminant per million units of total mass.

More: ppm is used to measure the concentration of a contaminant in soils and sediments. In that case 1 ppm equals 1 mg of substance per kg of solid (mg/kg).

$$ppm\ (m/m) = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6$$

Q \ If you have 25 moles of water H_2O and you want to get 90,000 of HCL , what mass of acid is needed?

Ppm (90,000) = $\frac{x}{(16+2)*25} * 10^{6}$

X = 44,51 gm

<u>Molality :</u> is a measure of the number of moles of solute in 1 kg or 1000 g of solvent

$$Molality = m = \frac{moles\ of\ solute}{kg\ of\ solvent}$$

$$m = \frac{mol}{kg}$$

Q \ When dissolving 20 g of Sodium chloride NaCl in amount of water so that the mass of the solution becomes 90 g.

Calculate the molality of the solution?(Note that the atomic masses: (Na =23, Cl = 35.5)?

$$Mw_{NaCl} = 23 + 35.5 = 58.5 \text{ g/mol}$$

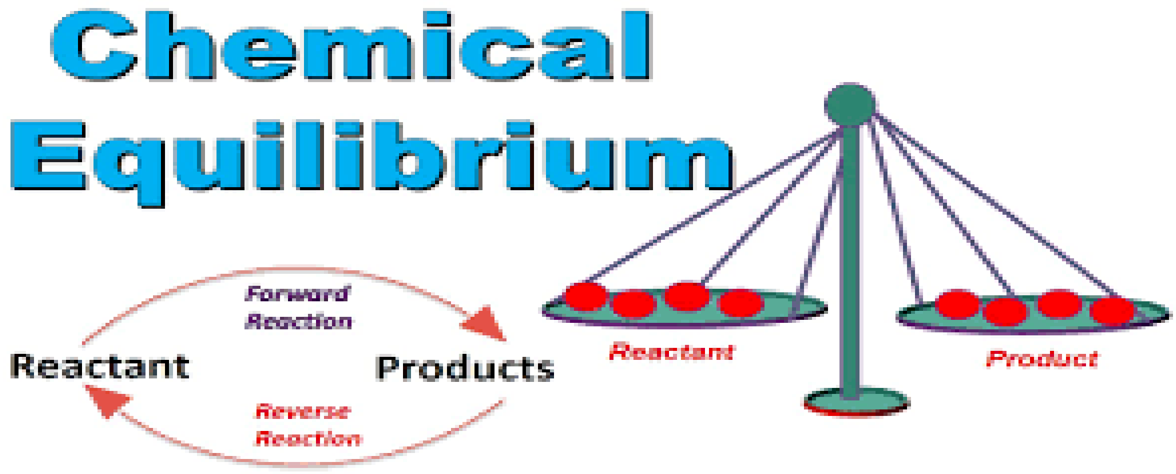
$$n_{NaCl} = \frac{m}{Mw} = \frac{20}{58.5} = 0.34 \text{ mol}$$

$$m_2 = m_{sol.} - m_1$$

$$m_2 = 90 - 20 = 70 \text{ g}$$

$$\text{molality} = \frac{n_1}{m_2} \times 1000$$

$$\text{molality} = \frac{0.34}{70} \times 1000 = 4.86 \text{ molal}$$



Sixth lecture

Article teacher

M.s.c Roaa wahhab

chemical equilibrium

In a chemical reaction, chemical equilibrium is the state in which both reactants and products are present in concentrations which have no further tendency to change with time, The reaction

rates of the forward and backward reactions are generally not zero .

there are no net changes in the concentrations of the reactants and products. Such a state is known as dynamic equilibrium

chemical equilibrium, condition in the course of a reversible chemical reaction in which no change in the amounts of reactants and products occurs. ...

At equilibrium, the two opposing reactions go on at equal rates, or velocities, and hence there is no change in the amounts of substances involved .

Types of chemical Equilibrium:

There are two types of chemical Equilibrium

<u>Homogeneous Equilibrium</u>

In this type of equilibrium, all reactants and all products are in the same phase.

In homogeneous gaseous equilibrium, all reactants and all products are in a gaseous state.

$H2(g) + I2(g) \rightleftharpoons 2HI\ (g)$

$N2(g) + O2(g) \rightleftharpoons 2NO\ (g)$

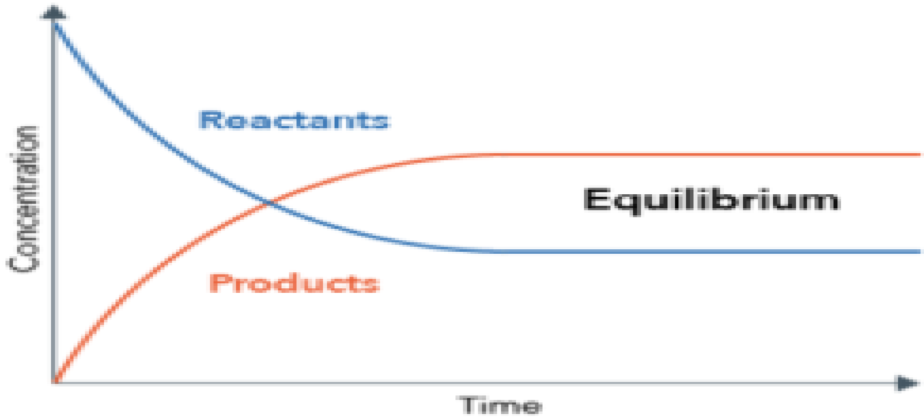
In homogeneous liquid equilibrium, all reactants and all products are in liquid state.

$CH_3COOH(l)+C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) +H_2O(l)$

Heterogeneous Equilibrium

In this type of reaction, reactants and products are in two or more phases.

$3Fe + 4H_2O(l) \rightleftharpoons Fe_3O_4(l) + 4H_2(g)$



Since the ionization of a weak acid is an equilibrium, a chemical equation and an equilibrium constant expression can be written:

$$HA(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + A^-(aq)$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

The equilibrium constant for the ionization of an acid is called the acid ionization constant (Ka) . ... A stronger acid will be a better proton donor

Strong and Weak Acids and Acid Ionization Constant

Acids are classified as either strong or weak, based on their ionization in water.

A strong acid is an acid which is completely ionized in an aqueous solution.

Hydrogen chloride (HCl) ionizes completely into hydrogen ions and chloride ions in water.

HCl (g) $\longrightarrow$ H+(aq) + Cl(aq)

A weak acid is an acid that ionizes only slightly in an aqueous solution.

Acetic acid (found in vinegar) is a very common weak acid. Its ionization is shown below.

CH3COOH(aq) $\rightleftharpoons$ H^+(aq) + $CH3COO^-$(aq)

The ionization of acetic acid is incomplete, and so the equation is shown with a double arrow.

Weak acids, like strong acids, ionize to yield the H^+ ion and a conjugate base.

Because HCl is a strong acid, its conjugate base (Cl^-) is extremely weak. The chloride ion is incapable of accepting the H^+ ion and becoming HCl again.

In general, the stronger acid, its have weaker conjugate base.

Likewise, the weaker acid, its have stronger conjugate base .

pH and Equilibrium

According to the Arrhenius theory of acids and bases, when an acid is added to water, it donates an H^+ ion to water to form $H3O^+$ (often represented by H^+).

The higher concentration of $H3O^+$ (or H^+) in a solution, the Arrhenius acids

And Arrhenius base is a substance that agenerates hydroxide ions, OH-, in water.

Pure water undergoes a reversible reaction in which both H+ and OH- are generated

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

The equilibrium constant for this reaction, called the water dissociation constant, Kw, is 1.01×10^{-14} at 25 °C.

$$Kw = [H^+][OH^-] = 1.01 \times 10^{-14} \text{ at } 25\ °C$$

Because every H^+ ($H3O^+$) ion that forms is accompanied by the formation of an OH^- ion, the concentrations of these ions in pure water are the same and can be calculated from Kw.

$$Kw = [H^+][OH^-] = (x)(x) = 1\times 10^{-14}$$

$x = [H^+] = [OH^-] = 10^{-7}$ M

<u>EXAMPLE 1</u> –

Determining the Molarity of Acids and Bases in Aqueous Solution: Determine the molarities of H^+ and OH^- in a 0.025 M HCl solution at 25 °C.

<u>Solution</u>

$[H^+] = 0.025$ M

We can calculate the concentration of OH^- by rearranging the water dissociation constant expression to solve for [OH-] and plugging in 1.01×10^{-14} for Kw and 0.025 for $[H^+]$

$$[OH^-] = \frac{K_W}{[H^+]} = \frac{1.01 \times 10^{-14}}{0.025} = \mathbf{4.0 \times 10^{-13}\ M\ OH^-}$$

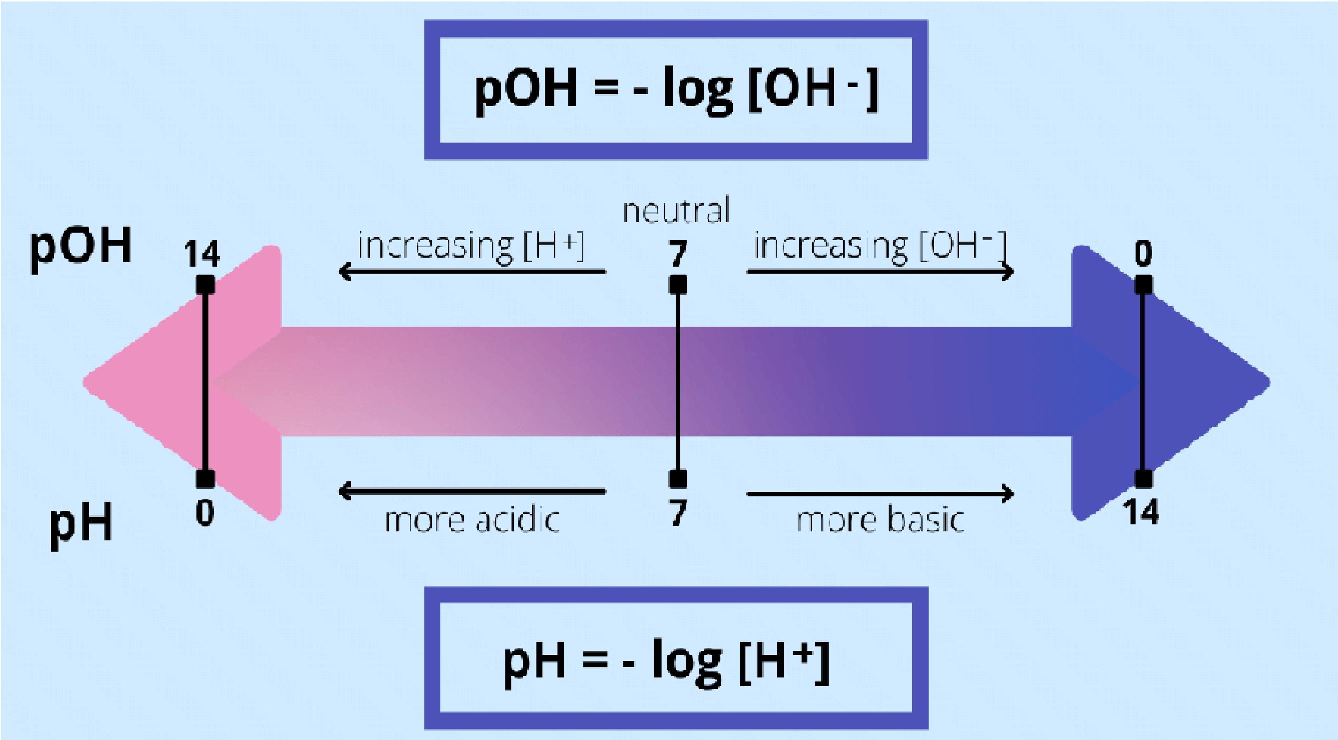
pH and pOH

Adding an acid to water increases the $H3O^{+}$ ion concentration and decreases the OH^{-} ion concentration.

Adding a base does the opposite.

Regardless of what is added to water, however, the product of the concentrations of these ions at equilibrium is always 1.0×10^{-14} at $25C^{o}$.

$$[H3O^{+}][OH^{-}] = 1.0 \times 10^{-14}$$



EXAMPLE 2 - Determining the Molarity of Acids in Aqueous Solution (molarities of H^+) in a 2.9×10^{-3} M NaOH solution at 30 °C.

Solution:

Kw = 1.47×10^{-14} at 30 °C

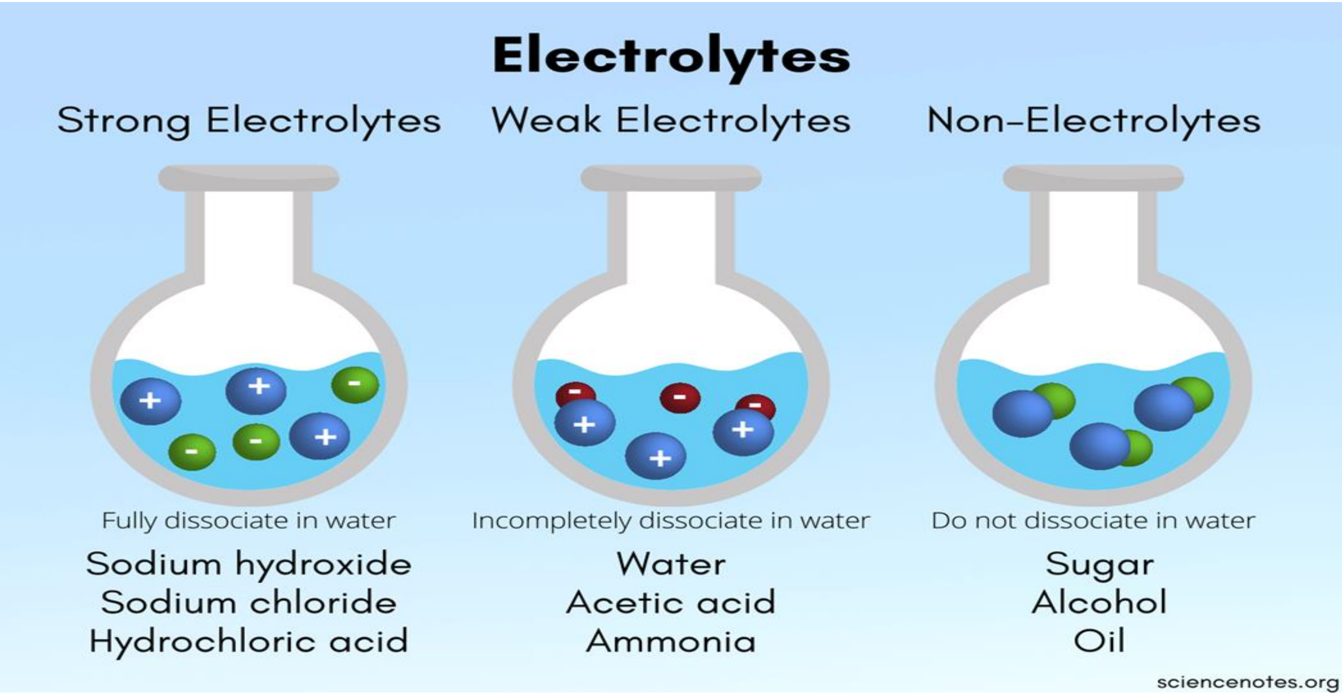
Sodium hydroxide is a water-soluble ionic compound and a strong electrolyte, so we assume that it is completely ionized in water,

making the concentration of OH- equal to the NaOH concentration.

$$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.47 \times 10^{-14}}{2.9 \times 10^{-3}} = \mathbf{5.1 \times 10^{-12}\ M\ H^+}$$

Electrolyte

An electrolyte is any substance that contains free ions that form an electrical medium. Electrolytes are usually found in acide, alkaline, or saline solutions.



Ionization of electrolytes

Substances that give ions when dissolved in water are called electrolytes. ... Strong electrolytes completely ionize when dissolved, and no neutral molecules are formed in solution

Does a weak electrolyte ionize in a solution?

Electrolytes are substances which, when dissolved in water, break up into cations (plus-charged ions) and anions (minus-charged ions). We say they ionize.

Strong electrolytes ionize completely (100%), while weak electrolytes ionize only partially (usually on the order of 1–10%)

Why water is a weak electrolyte?

The pure water molecules do not contain enough ions to transfer to the electrons from one end to another end.

This property makes water a weak electrolyte.

To be a strong electrolyte it must ionize into its constituent ion but in case of pure water, it ionizes very slightly into its ions making it a weak electrolyte

What is weak electrolyte in chemistry?

A weak electrolyte is an electrolyte that does not completely dissociate in aqueous solution.

The solution will contain both ions and molecules of the electrolyte.

Weak acids and base

$$HCL + H_2O \longrightarrow H_3O^+ + CL^-$$

0.05M   0.05M

PH = - Log [H3O+]   PH + POH = 14

POH = - Log [OH^-]   PH = 14 – POH

POH = 14 – PH

$$HF + H_2O \rightleftharpoons H_3O^+ + F^-$$

$$Ka = \frac{[H3O+][F-]}{[HF]}$$

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

$$Kb = \frac{[NH4+][OH-]}{[NH3]}$$

POH = -Log[OH]   PH = 14 – POH

KW = Ka . Kb = 1×10^{-14} at 25 C^0

At same time $[H_3O^+] = 10^{-PH}$

$[OH^-] = 10^{-POH}$

$[H3O+][OH-] = 1\times10^{-14}$

Acid strength ↑ Ka ↑ pka ↓

Pka = -log ka pkb =-log kb

Pka + pkb = 14

%Ionization = $\frac{x}{[HA]}$ **×100**

X = [H3O^{+}] acid X = [OH^{-}] Base

Example

What is the PH of 0.075M HC2H3O2 solution? ka= 18×10^{-5}

HC2H2O2 + H2O	⇌	**H3O^{+}**	**+ C2H3O2**
0.75M		**0**	**0**
-X		**+X**	**+X**
0.75 – X		**X**	**X**

Ka = $\frac{[H3O+][C2H3O2-]}{[HC2H2O2]}$

1.8 ×10^{-5} = $\frac{[X][X]}{0.75-X}$ ⟹ **1.8 ×10^{-5} =** $\frac{X2}{0.75}$

X^2= 1.35 ×10^{-5} X =3.674×10 $^{-3}$ M

[H3O+] = X

PH =-Log[H30+]

PH = -Log[3.674×10^{-3}] PH = 2.43

Q \ what is the PH of o.40 M NH4CL Solution ? kb of NH3 = 1.8 ×10 $^{-5}$ PH = 8.6

Seventh lecture

Article teacher

M.s.c Roaa wahhab

Buffer solution

A buffer is a chemical solution that resists any change in the concentration of the hydronium ion and the hydroxide ion, when small amounts of a strong acid or base are added to it, or when the solution is diluted. Thus, it "regulates", maintains the pH at a constant value.

A buffer solution consists of a mixture of a weak acid and one of its salts, or a mixture of a weak base and one of its salts.

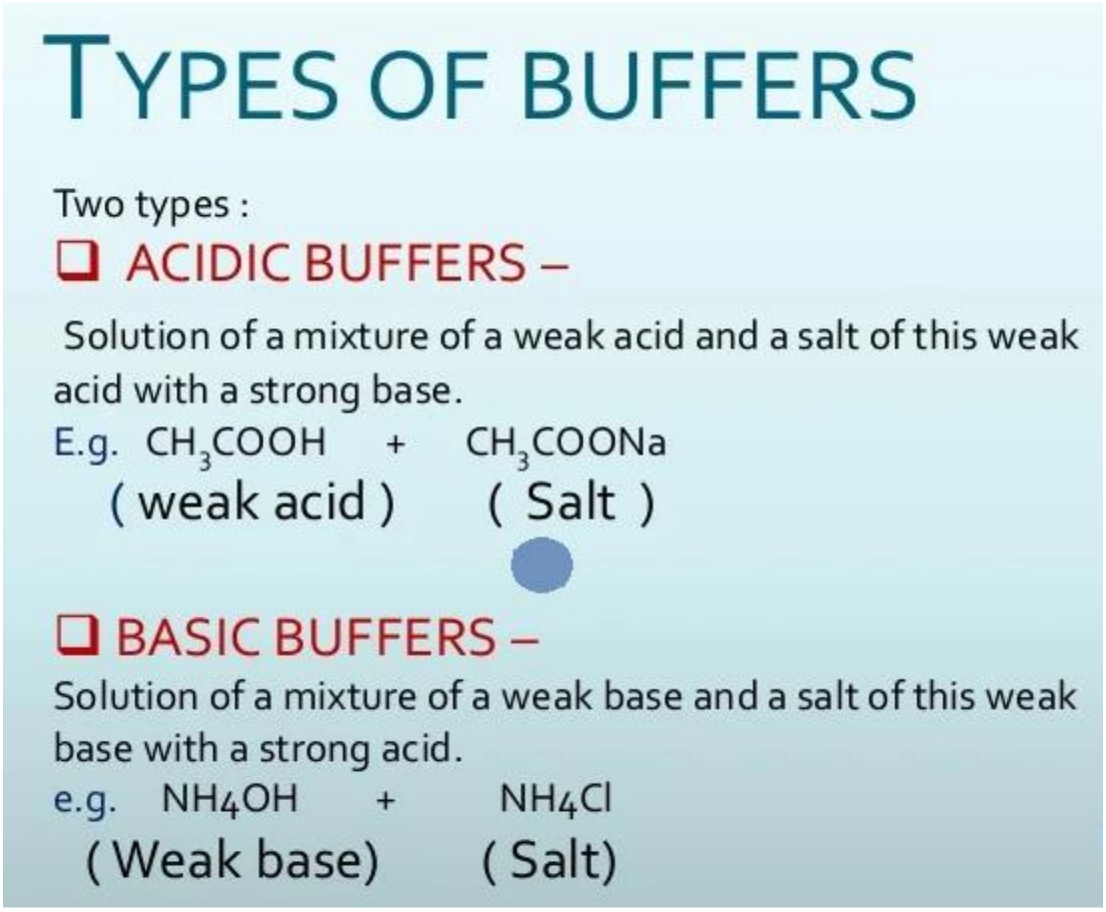
A buffer solution is a solution that only changes

slightly when an strong acid or a base is added to it.

ther are two type of buffer solution

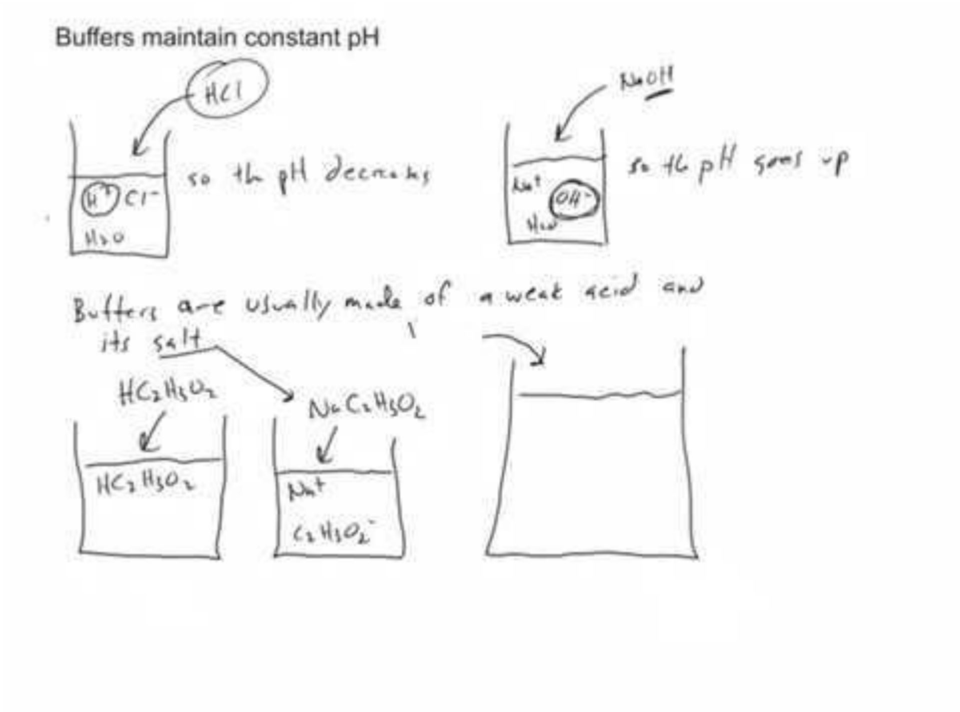
its dived into two types – **acidic** and **alkaline** buffer solutions.

Acidic buffers are solutions that have a pH below 7 and contain a weak acid and one of its salts. For example, a mixture of acetic acid and sodium acetate acts as a buffer solution with a pH of about 4.75 , and mixture of ammonium chloride and ammonium hydroxide acts as a buffer solution with a of about 9.25.



How is buffer solution made?

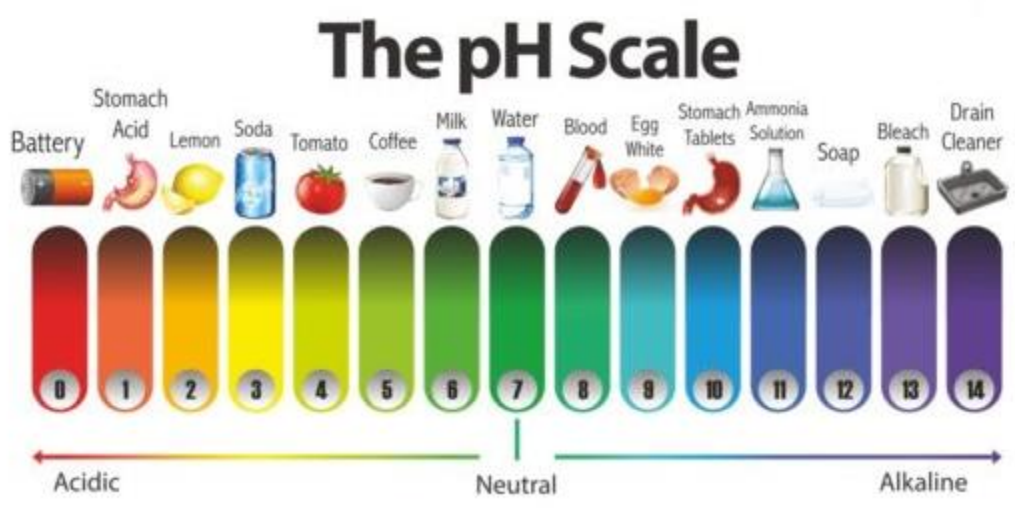
How Do You Make a Buffer? A buffer is made by mixing a large volume of a weak acid or weak base together with its conjugate base or acid.



PH(buffer)

May be defined as the negative logarithm of the hydrogen ion concentration .

PH= -log [H+]



Example:

What is the value pH of HCl 0.0001 M .

$PH = -\ Log\ [H^+]$

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

0.0001M 0.0001M 0.0001

$[H^+] = 10^{-4}$

$PH = -\ Log\ [10^{-4}] = Log\ 10^{-4} = -(-4) = 4$

Q/What is the PH of 0.002 M HCl solution .

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

$[H^+] = 0.002M = 2\times10^{-3}$

$PH = -Log\ [H^+] = -Log\ [2 \times 10^{-3}] = -\ Log\ 2 - Log\ 10^{-3}$

$PH = -0.3 + 3 = 2.7$

Dissociation of weak electrolyte buffer solutions

Weak acid and base

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

Acetic acid

$$Ka = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$ weak acid $pKa = -Log\ Ka$

$NH_4OH \rightleftharpoons NH_4^- + OH^-$

$$Kb = \frac{[NH_4^-][OH^-]}{[NH_4OH]}$$ weak base $pKb = -Log\ Kb$

Buffer calculation

pH = pka + log (salt)/(acid)

PoH = pkb+ log(salt)/(base)

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Example : What ratio of acetic acid to salt or acetate is needed to form a buffer whose $[H^+] = 2\times10^{-6}$ M and $Ka = 1.8 \times 10^{-5}$

$$[H^+] = Ka \times \frac{[\text{ acid }]}{[\text{salt}]} \rightarrow \quad \frac{[\text{acid}]}{[\text{salt}]} = \frac{[H^+]}{Ka} = \frac{2\times10^{-6}}{1.8\times10^{-5}} = \frac{1}{9}$$

Example : A buffer solu. Is prepared by mixing benzoic acid and benzoate salt conc. Of both 0.1 M .What is pH of this buffer? $Ka = 6.5\times10^{-5}$, $\text{Log } 6.5 = 0.8$

$pKa = -\text{Log } Ka$

$pKa = -\text{Log } 6.5 - \text{Log}10^{-5}$

$pKa = -\text{Log } 6.5 + 5$

$pKa = 4.19$

$$pH = pKa + \text{Log} \frac{[\text{salt}]}{[\text{acid}]} \qquad pH = 4.19 + \text{Log} \frac{0.1}{0.1}$$

$pH = 4.19$

First class

general chemistry

Eighth lecture

Volumetric Analysis: Titration

Article teacher

M.s.c Roaa wahhab

<u>Volumetric analysis</u> :

A quantitative analysis based upon the measurement of volume.

The analytical method where in the concentration of a substance in a solution is estimated by adding exactly the same number of equivalents of another substance present in a solution of known concentration is called **volumetric analysis**. ... Another name for <u>volumetric analysis</u> is <u>titrimetric analysis</u>

<u>Titration</u> :is the process by which the quantity of analyte in a solution is determined from the amount of a standard reagent it consumes .

Standard solution : the reagent of exactly known concentration that is used in a titration .

Volumetric analysis refers to any procedure in which the volume of reagent needed to react with the analyte is being measured.

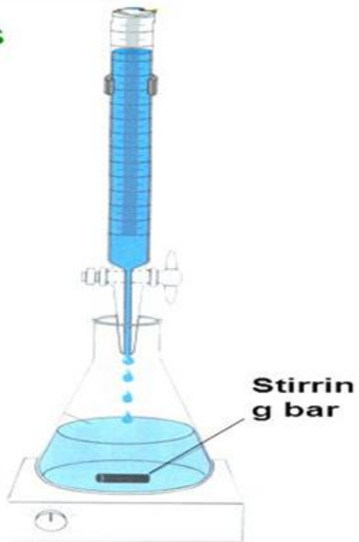
In this chapter we will learn:

- the principles in volumetric procedure
- methods in volumetric analysis

One method in volumetric analysis is **titration**

In titration:

- substance to be analysed is known as the ***analyte***
- the solution added to the analyte is known as the ***titrant***
- titrant is usually delivered from a buret



Principles of Volumetric analysis

A titration is a process whereby a known standard reagent is delivered from a buret to the analyte until the reaction is complete. Titrations may be based on a variety of chemical reactions such as acid/base, redox, complexation, or precipitation.

Titrant : solution of a known concentration, which is added to another solution whose concentration has to be determined.

A primary standard solution : is a highly purified compound that serve as a reference material in all volumetric titrimetric methods.

Important requirements for a primary standard are

1-High purify.

2-Stability toward air.

3-Absence of hydrate water.

4-Ready availability at modest cost.

5-Reasonable solubility in the titration medium.

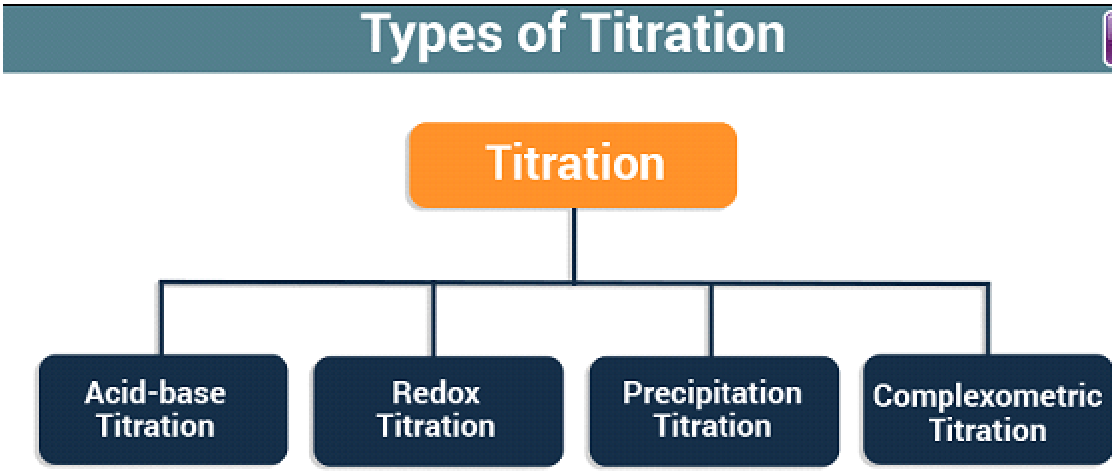
6-Reasonable large molar mass .

Titrand or(analyte): the solution whose concentration has to be determined

Types of titrations

- **Acid-base titration**
- **Precipitation titration**
- **Redox titration**

- **Complexometric titration**

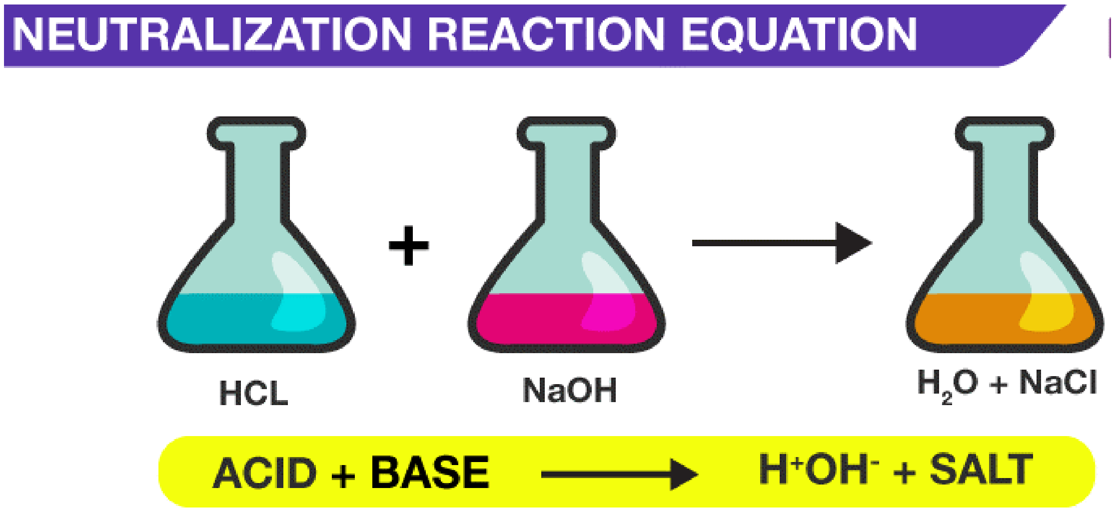


Neutralization Reaction

What is a Neutralization Reaction?

A neutralization reaction can be defined as a chemical reaction in which an acid and base quantitatively react together to form a salt and water as products.

In a neutralization reaction, there is a combination of **H**$^{+}$ ions and **OH**$^{-}$ ions which form water.



Application of Neutralization Reaction (Titration methods):

The method of chemical titration is employed to find unknown concentrations of acids or bases by finding their neutralization point.

when an acid and a base react to form water and a salt and involves the combination of

(**H+** ions and **OH-** ions).

- The neutralization of a strong acid and strong base has a **pH** equal to **7.**

- The neutralization of a strong acid and weak base will have a **pH** of **less than 7**

- conversely, the resulting **pH** when a strong base neutralizes a weak acid will be **greater than 7**

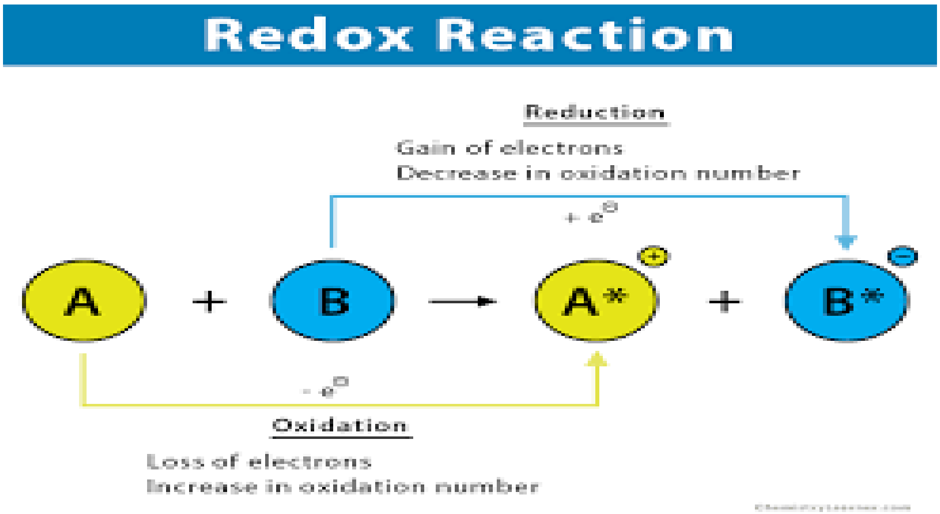
Oxidation-Reduction Reactions

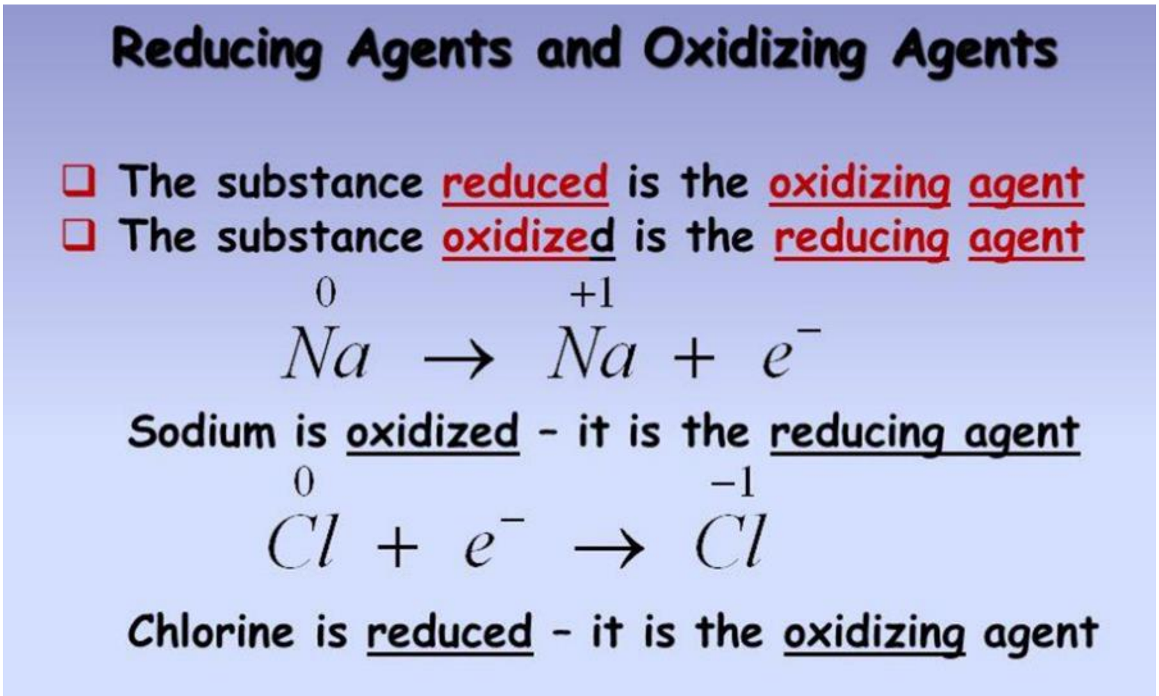
(redox) reaction

is a type of chemical reaction that involves a transfer of electrons between two species.

An oxidation�reduction reaction is any chemical reaction in which

the oxidation number of a molecule, atom, or ion changes by gaining or losing an electron.





<u>Types of Redox Reactions</u>.

The five main types of redox reactions are

Combination **combustion**

Decomposition **dis proportion**

displacement

combination reactions : two elements are combined.

A + B $\longrightarrow$ AB

decomposition reactions: a compound is broken

down into its constituent parts.

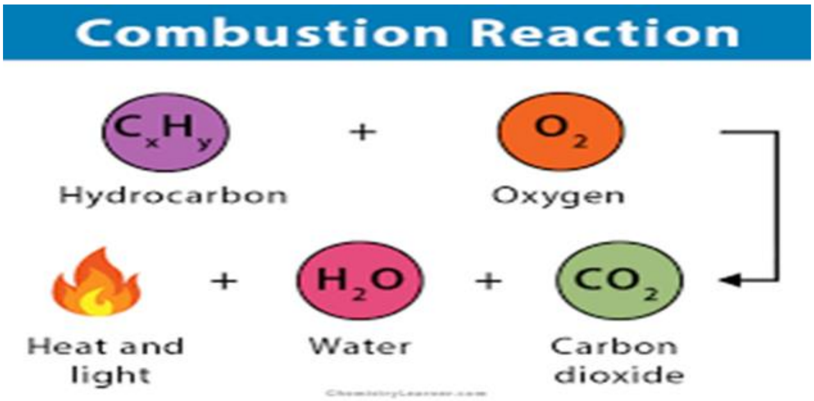
AB $\longrightarrow$ A + B.

displacement reactions: one or more atoms is swapped out for another.

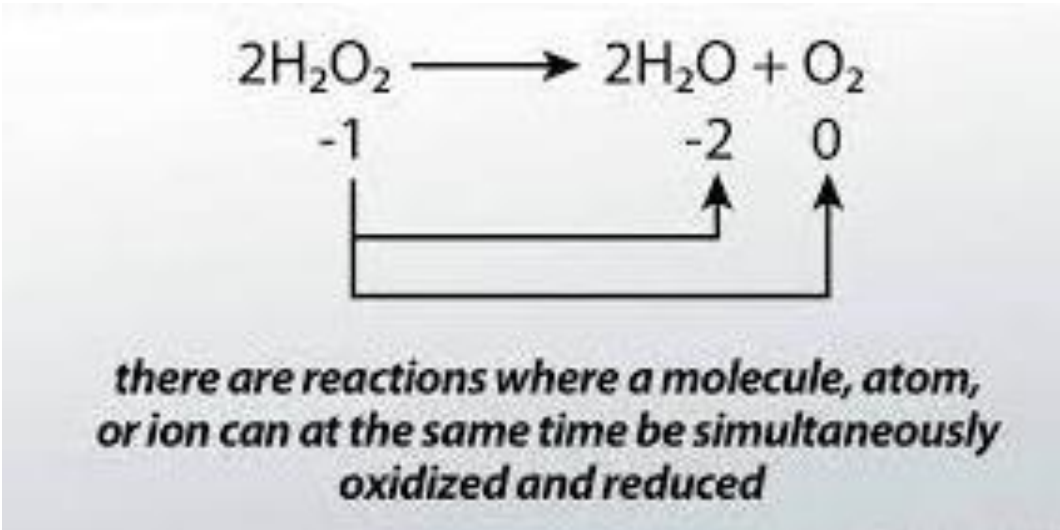
AB + C $\longrightarrow$ A + CB

combustion reactions: a compound reacts with oxygen to produce carbon dioxide,

water, and heat.



disproportionation reactions:



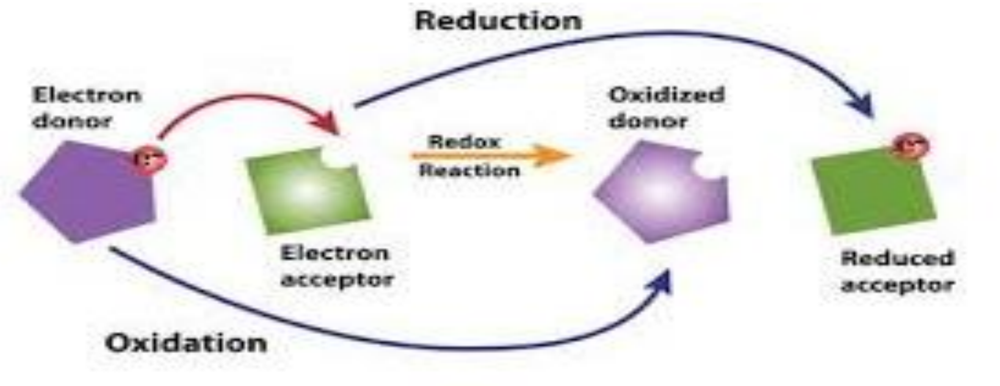
Application of redox titrations

A volumetric method of analysis

which relies on oxidation or reduction of the analyte using redox indicators or potentiometriy.

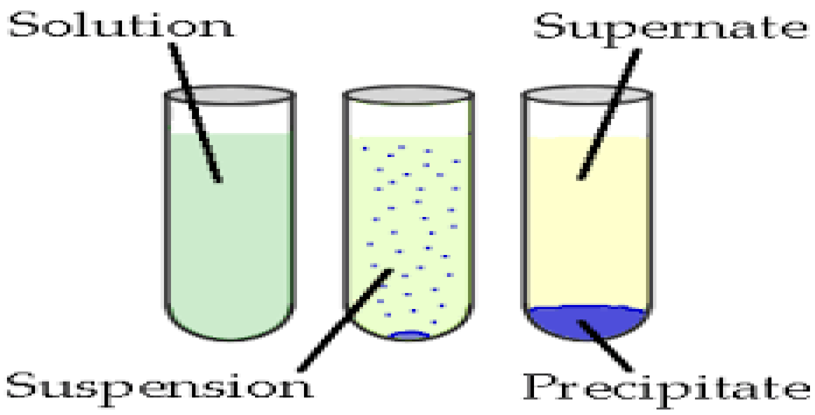
changes in solution potential

during a titration basic calculations methods of sample preparation.



precipitation reactions

Precipitation reactions occur when cations and anions in aqueous solution combine to form an insoluble ionic solid called a precipitate. Whether or not such a reaction occurs can be determined by using the solubility rules for common ionic solids.



Precipitation Reactions

- Result when two soluble compounds mix and an insoluble (solid) compound is produced.

$$AgNO_{3\,(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$$

This is the insoluble compound (precipitate). Precipitation is established by looking at the solubility table. Insoluble compounds are designated (s) for solid.

This compound is soluble. The (aq) designates that it dissolves in water.

<u>precipitation titration</u>

Precipitation titration is a type of titration which involves the formation of precipitate during the titration technique.

In precipitation titration, the titrant reacts with analyte and forms an insoluble substance called precipitate.

It continues till the last amount of analyte is consumed.

INDICATORS

Theory of Indicator:

- An indicator is a substance which is used to determine the end point in a titration.
- In acidbase titrations, organic substances (weak acids or weak bases) are generally used as indicators.
- They change their colour within a certain pH range.

a theory of acid base indicators which gives an explanation for the colour change with change in pH.

According to this theory, a hydrogen ion indicator is a weak organic acid or base. The un dissociated molecule will have one colour and the ion formed by its dissociation will have a different colour .

acid-base indicator table

indicator	pH range	color for weak acid	color for conjugate base
methyl orange	4-6	orange	yellow
bromophenol blue	6-7	yellow	blue
thymol blue	8-9	yellow	blue
phenolphthalein	9-10	colorless	pink
alizarin yellow	10-12	yellow	red

Indicators of chemical reactions

Emission of light or heat

Formation of a gas

Formation of a precipitate

Color change

Emission of odor

The first class

general chemistry

The ninth lecture

Msc: Roaa wahhab

Colorimetric analysis

Colorimetric analysis

In this student can determine the concentration from absorbance with a colorimeter , in this method they must first calibrate with solution of known concentration , they must decide which wavelength to use for these measurements.

- This method is similar to

  UV-VISIBLE SPECTROSCOPY in that it uses a light beam to measure light absorption

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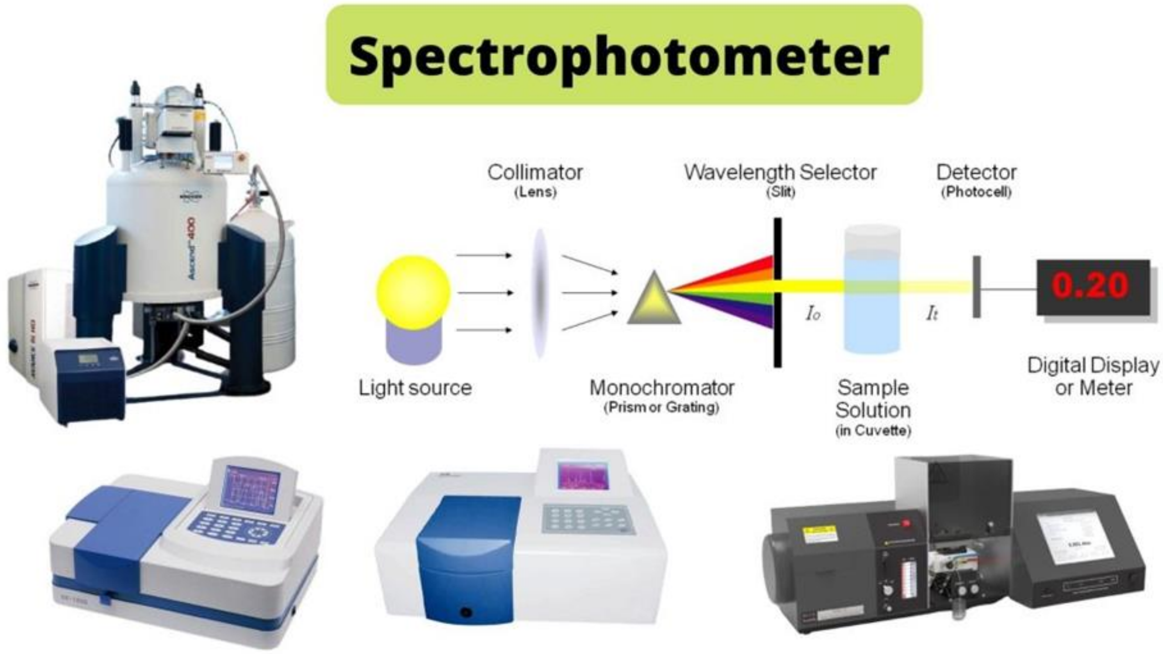


Spectrophotometer

spectrophotometer is an instrument that measures the amount of photons (the intensity

of light) absorbed after it passes through sample solution.

With the spectrophotometer, the amount of a known chemical substance

(concentrations) can also be determined by measuring the intensity of light detected

<u>Spectrophotometer Principle</u>

A Spectrophotometer is based on the principle of turbidity determination.

Turbidity or optical density is the cloudiness of the suspension.

The more turbid a suspension, the less light will be transmitted through it. In other words, the amount of light absorbed and scattered is proportional to the mass of cells in the light path.

<u>What is the function of a spectrophotometer</u>?

Spectrophotometers measure light intensity as a function of wavelength and are commonly used to measure the concentration of a compound in an aqueous solution

<u>Components of spectrophotometer</u>

A spectrophotometer contain these following components;

Light Source: The light source is required to generate lights within the spectrophotometer.

lens: This lens points the light to a monochromator or prism from the light source.

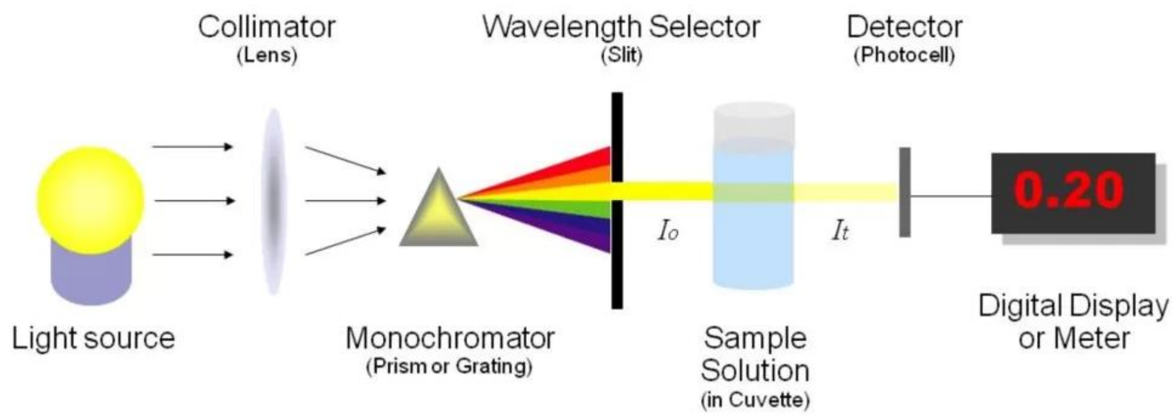
A monochromator (Prisms): It is used to separate the polychromatic radiation into component wavelength (or) bands of wavelengths

Wavelength selector (slit): It selects a particular wavelength of light from the splited

wavelengths and passes it through the cuvette.

(cuvettes): The cuvette is used to hold the sample to be studied. It is made up of Quartz.

A Photosensitive detector and an associated readout system



Beer – Lambert law

What is the Beer-Lambert Law?

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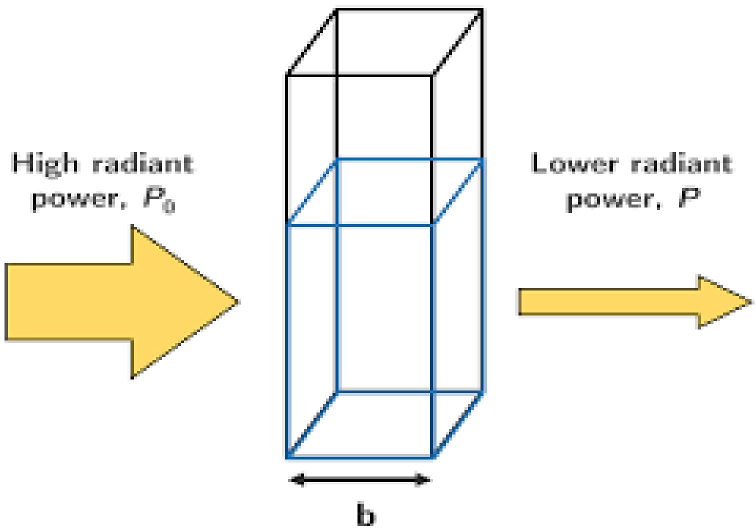
The Beer-Lambert law is a linear relationship between the absorbance and the concentration, molar absorption coefficient and optical coefficient of a solution



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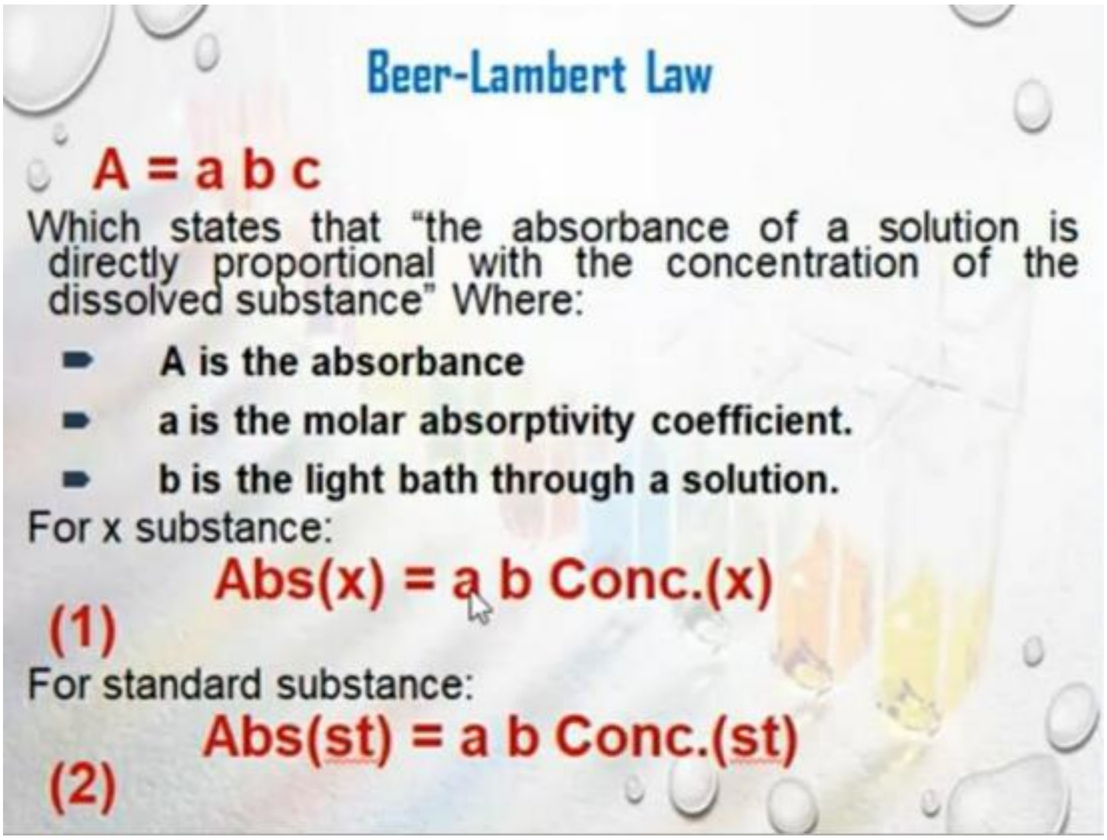

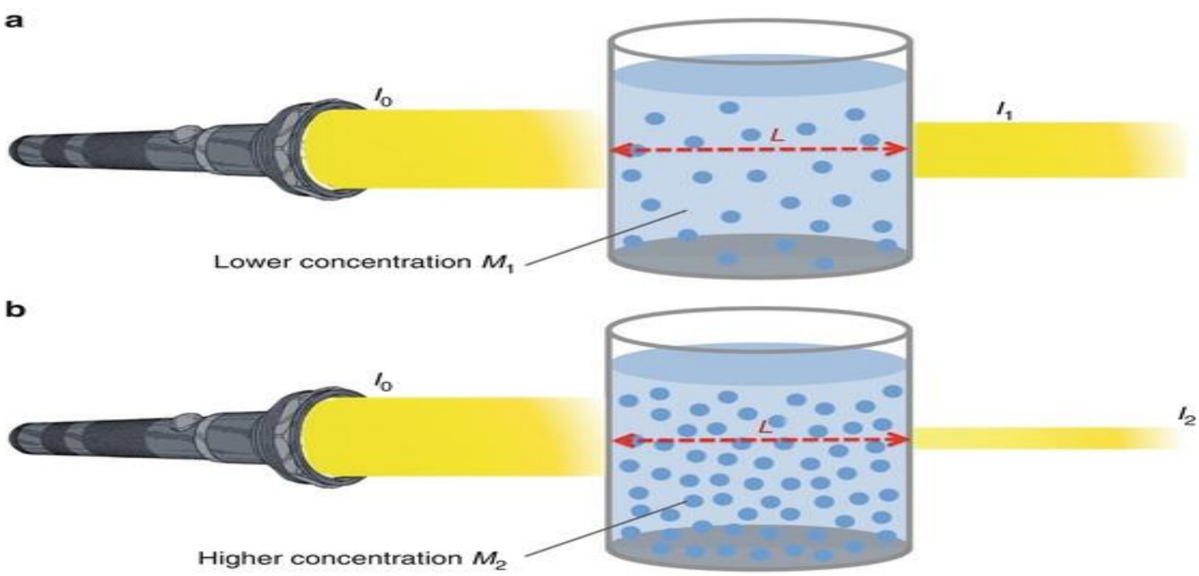

in analytical chemistry, a calibration curve, also known as a standard curve, is a general method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration

Standard curve

A standard curve, also known as a calibration curve or calibration line, is a type of graph used as a quantitative research technique.

Multiple samples with known properties are measured and graphed, which then allows the same properties to be determined for unknown samples by interpolation on the graph.