جامعة الفرات الاوسط التقنية
كلية التقنيات الصحية والطبية كوفة
قسم تقنيات صحة المجتمع
المرحلة الاولى
مادة الكيمياء السريرية
الفصل الدراسي الاول

1- اسم المادة : الكيمياء السريرية (Clinical chemistry)
2- السنة الدراسية : الاولى
3- عدد الساعات الدراسية (الكلي)/ عدد الوحدات (الكلي) 6/ 8
4- اسم مسؤول الحقيبة الدراسية
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5- اهداف المقرر

اهداف الدراسية	**الهدف العام:** **ان يكون الطالب قادرا على ان يتمكن من فهم مبادئ الكيمياء السريرية وتطبيقاتها .** **الهدف الخاص:** **ان يكون الطالب قادرا على معرفة اهمية الكيمياء السريرية وكيفية تشخيص بعض الامراض والسيطرة عليها.**

6- المفردات النظرية – الكيمياء السريرية – المرحلة الاولى – الفصل الاول

الأسبوع	الساعات (النظرية)		اسم الوحدة او الموضوع		
1	2		Structure of matter		
2-3	2		Chemical bonding		
4-5	2		Chemical equation and reaction		
6-7	2		The gaseous state		
8	2		Air pollution		
9	2		Oxidation -reduction		
10-11	2		Liquid mixtures		
12-13	2		solutions		
14-15	2		Acids-bases and salts		

ATOMS AND ELEMENTS

An atom is the basic structure from which all matter is composed.

Atoms are made of small particles called protons , neutrons , and electrons. An **atom** is composed of two regions : the nucleus , which is in the center of the atom and contains protons and neutrons, and the outer region of the atom, which holds its electrons in orbit around the nucleus.

* **Proton:** is a positively charged particle in an atom .

* **Elctron:** is a negatively charged particle in an atom .

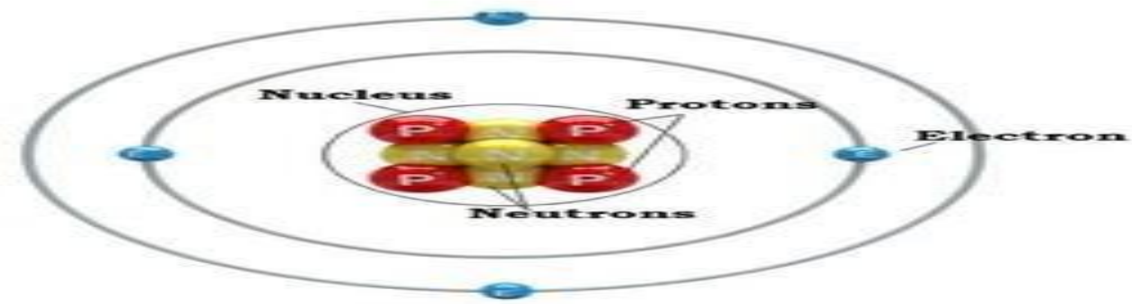
* **Neutron:** is a neutral (neither negative nor positive) particle in an atom .

* **The Atomic Number:** is the number of protons in an atom .
(It is the number of protons in the nucleus that determines the chemical properties of an atom)

* **Mass Number** (or ***Atomic Weight***) **:** is the number of protons and the number ofneutrons in an atom .

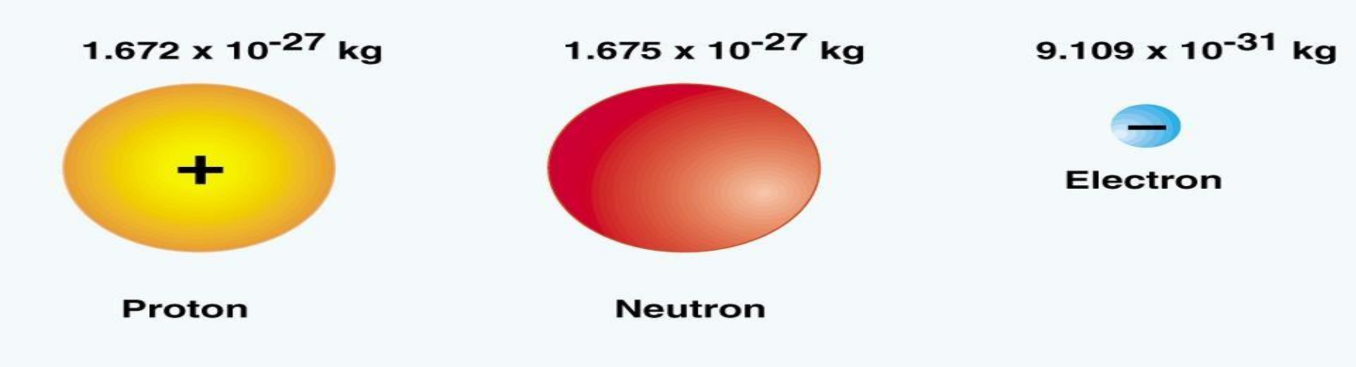
$$n^0 = \textit{Atomic Weight (A) - Atomic number (Z)}$$

* **Ex:- Fe** nucleus which has **(*26 p*$^+$)** and **(*30 n*^{0})**, is denoted as $^{56}_{26}$**Fe**.



The proton and neutron have roughly the same mass and have approximately one

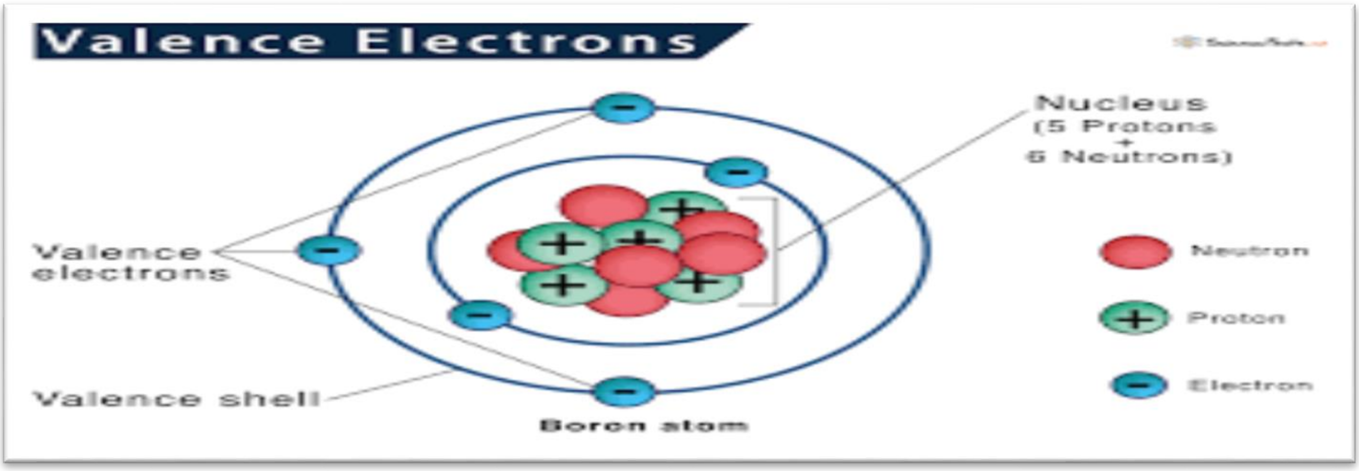
thousand times the mass of the electron.



- In an atom the protons and neutrons clump to gether in the center and are called **the nucleus .**

- **Because** the protons are positively charged, the nucleus has a positive electric charge.

- The electrons of the atom move rapidly around the nucleus.

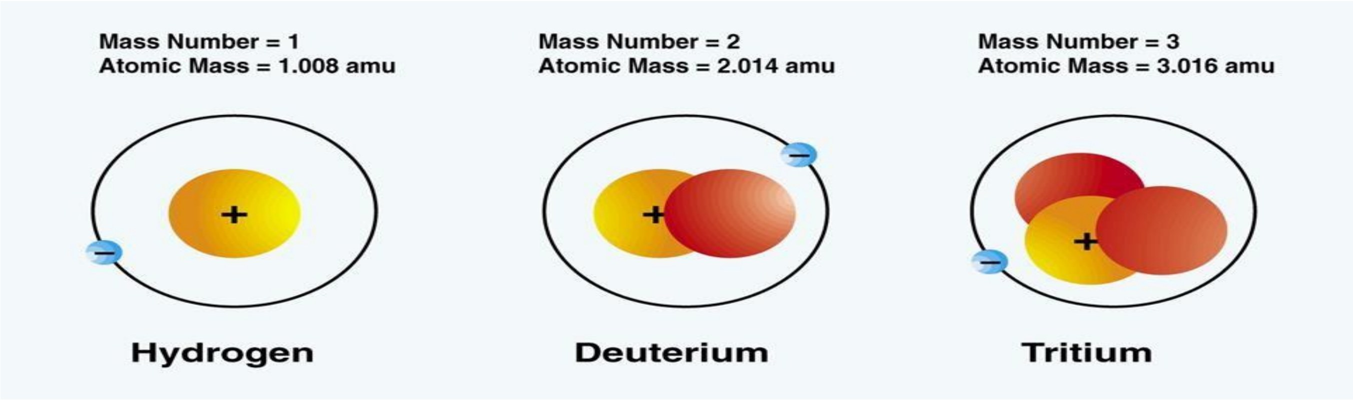


- Atoms interact with other atoms by sharing or transferring electrons that are farthest from the nucleus. These electrons are sometimes called **valence electrons** . These outer electrons determine the chemical properties of the element .

Isotopes

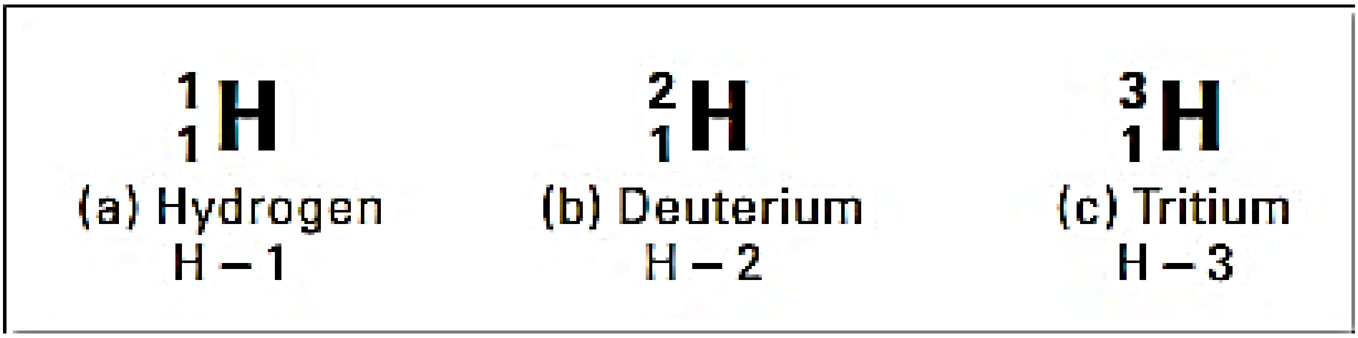
- **Are atoms of the same element that differ only in the number of neutrons (mass number)**

- All isotopes of one element have identical **chemical properties**. This means it is difficult to separate isotopes from each other by chemical processes. However, the **physical properties** of the isotopes, such as their masses, boiling points, and freezing points, are different. Isotopes can be most easily separated from each other usingphysical processes.



Mass Number and Atomic Mass of Hydrogen, Deuterium,and Tritium

Hydrogen Isotopes



PERIODIC TABLE

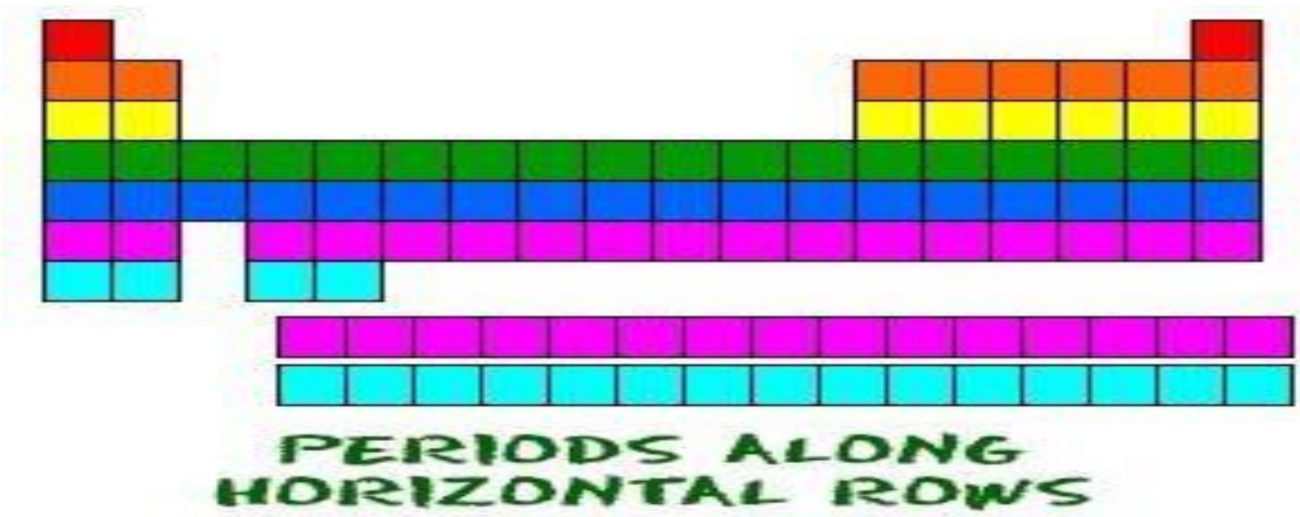
WHAT IS THE PERIODIC TABLE ?

The **periodic table** is a table that logically organize all the known elements. Each **element** has a specific location according its atomic structure. Each row and column has specific characteristics.

Period

In the modern periodic table each row of the table's horizontal rows is called a **period** where all of the elements have the same number of atomic orbitals For example, every element in the top row (**the first period**) has one orbital

(**S orbital**)for its electrons. All of the elements in the second row (**the second period**) have two types of orbitals (**S and P orbital**) for their electrons. The periodic table consists of **seven periods**.

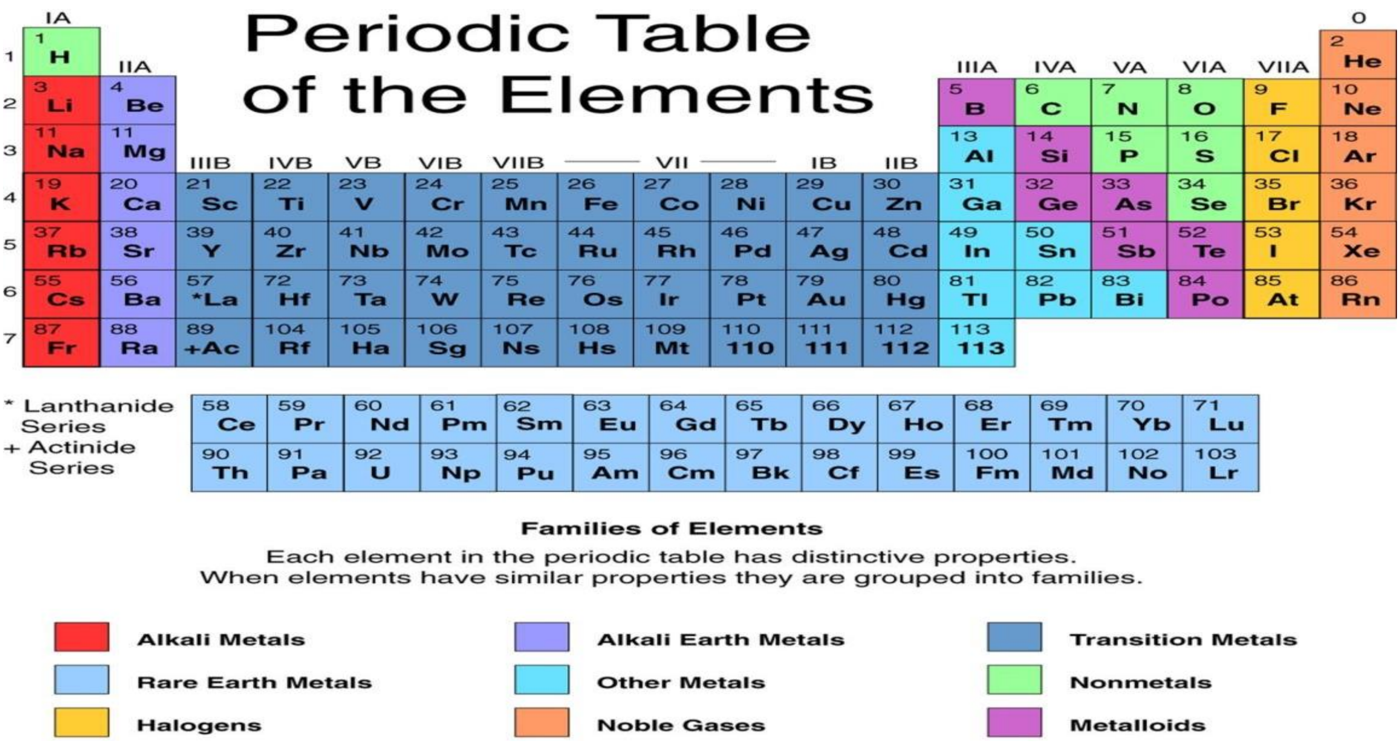


GROUPS OR FAMILIES

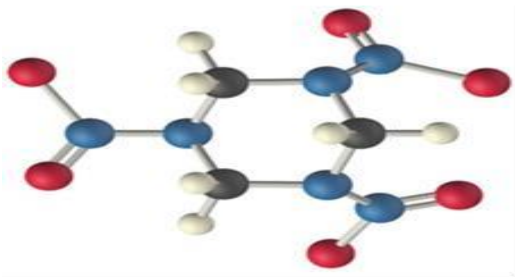
The modern periodic table of the elements contains 18 groups, Just as members of a family have similar characteristics chemical and physical properties **because** they have the same number of outer electrons.

- For instance, the **noble gasses** have their outermost orbit filled and therefore atoms from this family do not bond with other atoms.

- Every element in the first column **(group one)** has one electron in itsouter shell. Every element in the second column **(group two)** has two electrons in the outer shell.



Chemical Bonding



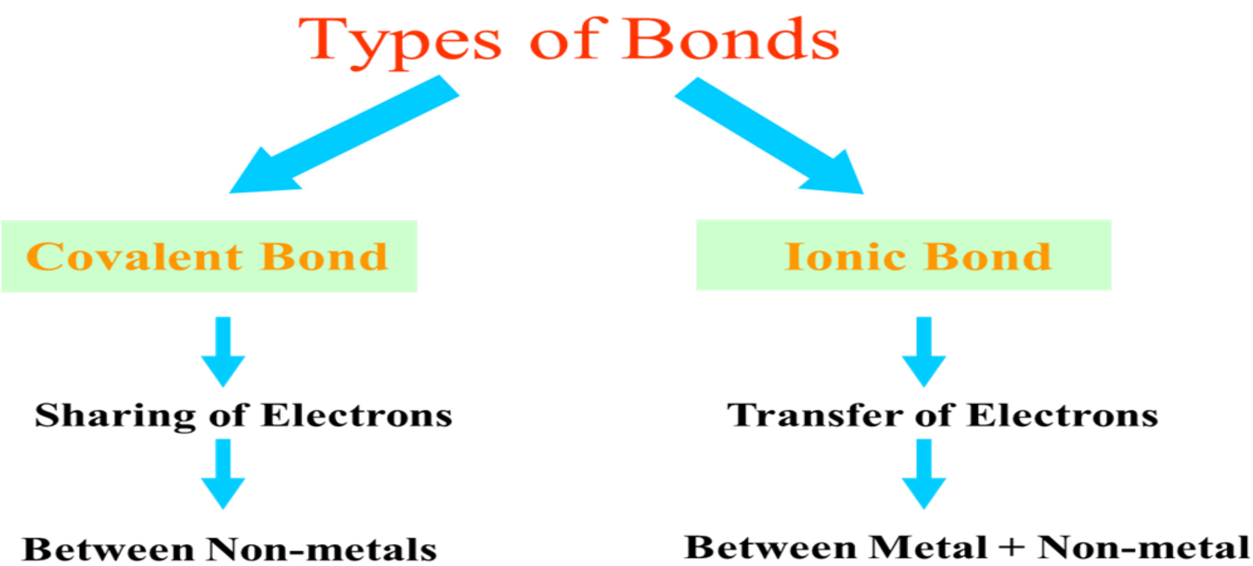
The Electronic Structure of Noble Gases

- The noble gases like **helium** , **neon** and **argon** , which are in **Group 0** of thePeriodic Table, are **very unreactive**.

- They do not form bonds with other atoms.

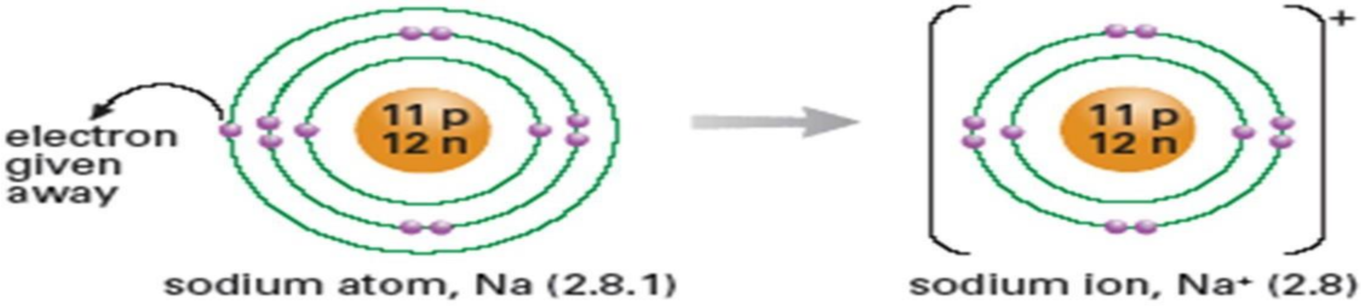
- They have fully **filled** outermost (valence) shells.

- Atoms of other elements become stable like the noble gases by **(losing orgaining electrons or by sharing electrons)** .They achieve this by forming bonds with other atoms.

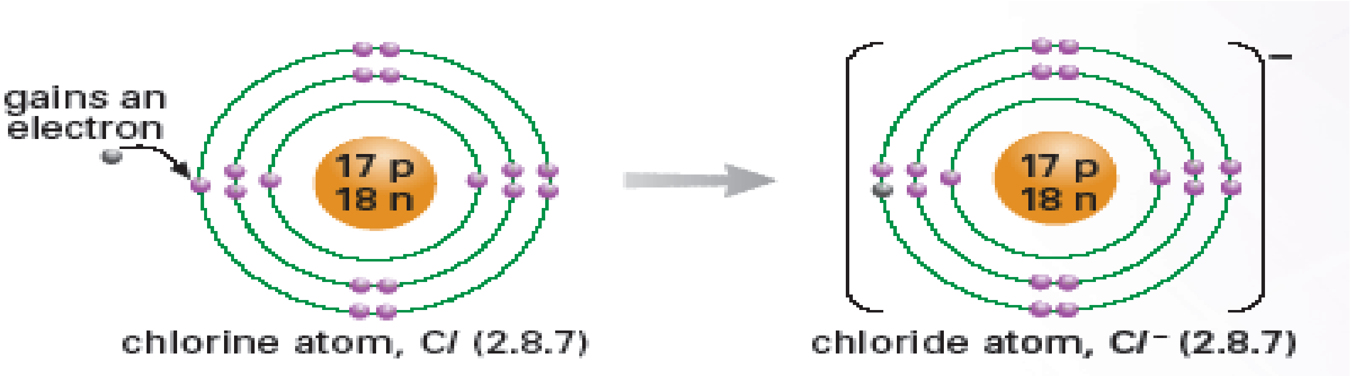


Ionic Bonds

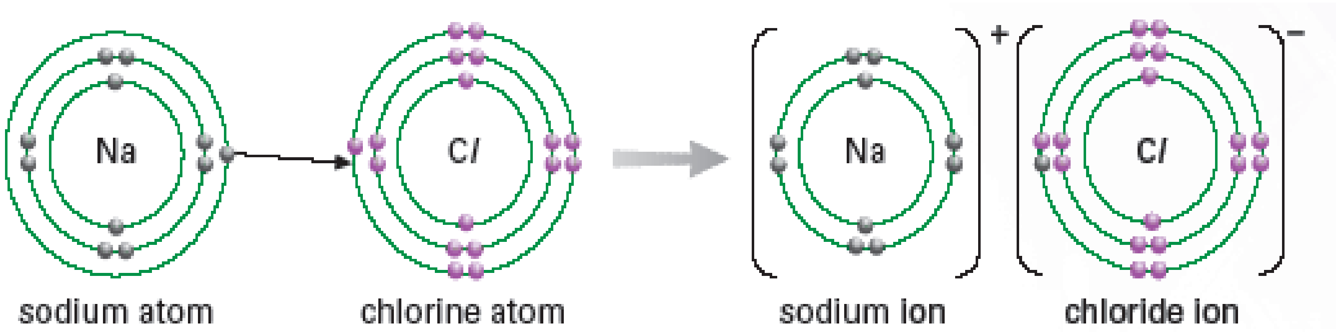
- When sodium reacts with chlorine, the sodium atom **loses** an electron tobecome **a positively charged** sodium ion:



- The chlorine atom **gains** an electron to become **a negatively charged** chloride ion



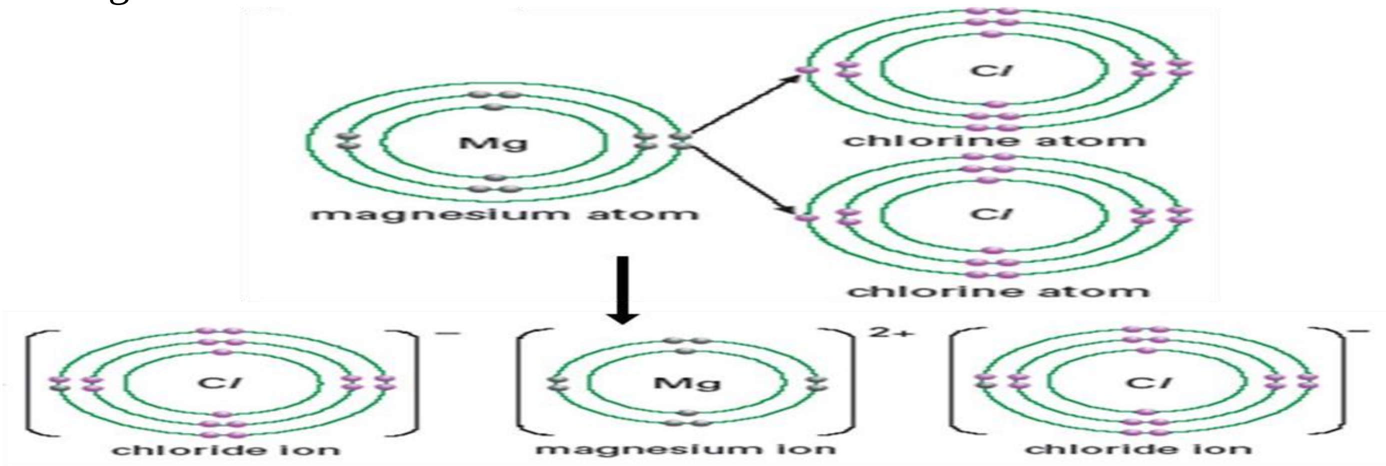
- The positive sodium ion and the negative chloride ion then attract eachother to form sodium chloride.



- Sodium chloride is called an **ionic compound** .

Other ionic compounds

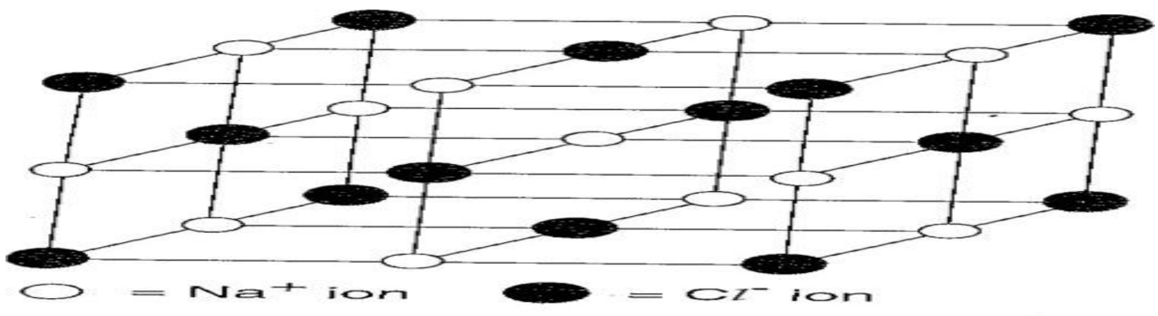
- Another example of an ionic compound isthat formed between magnesium and chlorine.
- Each magnesium atom transfers 2 electrons, one to each chlorine atom, toform magnesium chloride .



The formula of magnesium chloride is therefore given as $MgCl_2$.

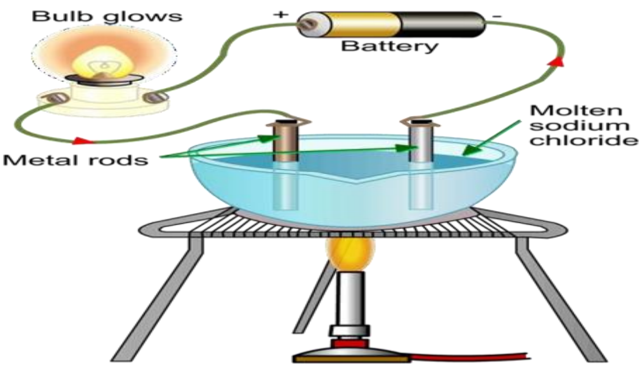
Properties of Ionic Compounds

❖ The electrostatic forces between the oppositely-charged ions are **very strong** so ionic compounds have **very high melting points** and **boiling points**.



❖ Most ionic compounds are **soluble in water**.

❖ Ionic compounds **conduct electricity** when **molten or dissolved in water**. This is because the ions can move about and conduct electricity.



Molten sodium chloride conducts electricity.

Exercis

1. Ionic bonds are formed between a ....and a ....

2.A metal atom .... an electron to form a positive ion while a non-metal .... an electron to become a negative ion.

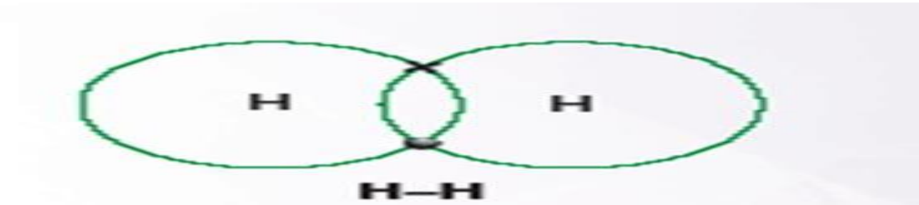
3.The two oppositely charged ions attract each other to form an .... compound.

4.An ionic bond is formed by the .... of electrons.

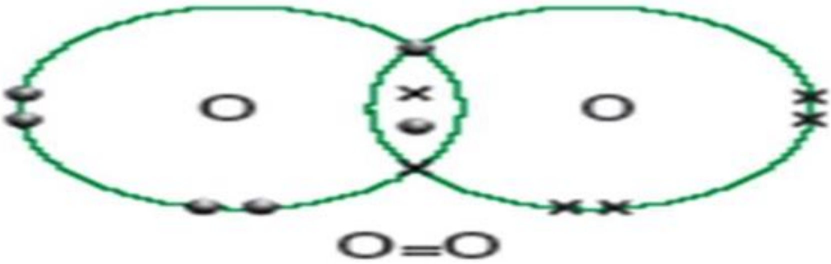
5. Is aluminium oxide ($AlCl_3$) an ionic or covalent compound ?

Covalent Bonds

- A hydrogen atom has only one electron in its first shell.
- So two hydrogen atoms join together and share their electrons. Ahydrogen molecule is formed.

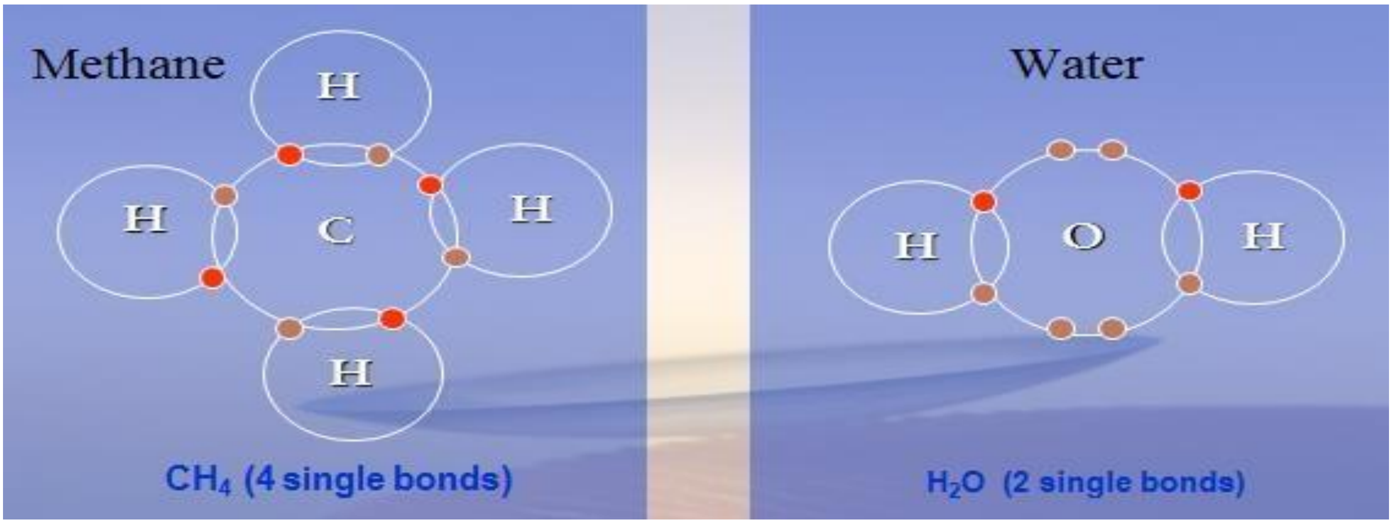


- This sharing of electrons is called **<u>covalent bonding</u>**.
- In an oxygen atom, the outer shell has 6 electrons, two oxygen atoms combine to share **4 electrons**.



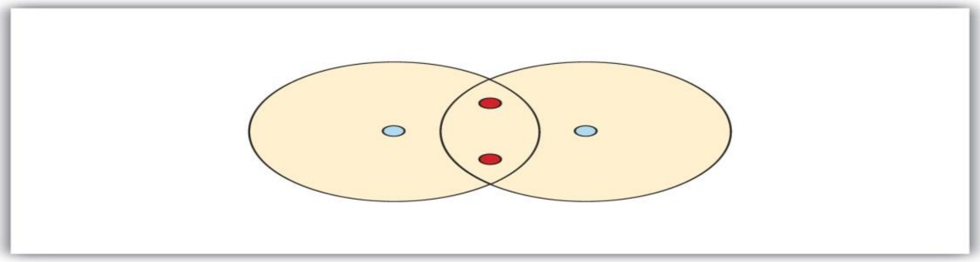
This is called a ***double bond***

Other covalent molecules

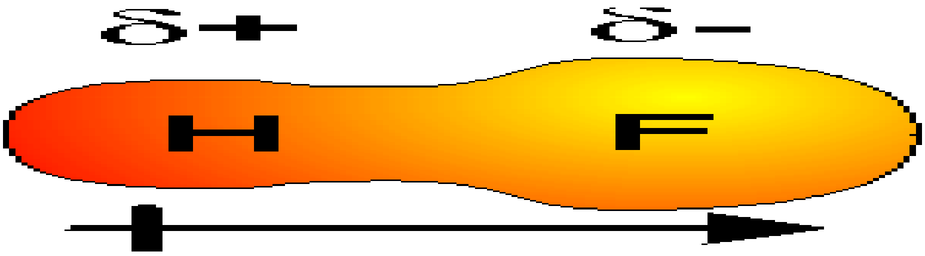


Types of Covalent Bonds

- **Nonpolar covalent bond – electrons are shared equally**



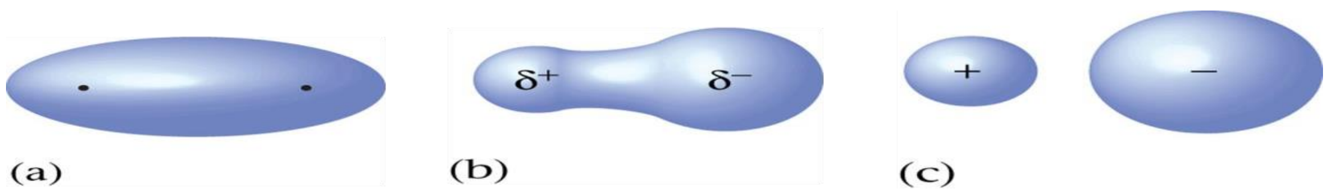
- **Polar covalent** – electrons are not shared equally because one atom attracts the shared electrons more than the other atom.



Classifying Chemical Bonds

- **The polarity of a bond depends on the difference between the electronegativity values of the atoms forming the bonds.**

- Nonpolar covalent – **0 to 0.3**
- Polar covalent – **0.4 to 1.7**
- Ionic – greater than **1.8**



Properties of Covalent Compounds

- The **intermolecular forces between the molecules are weak** so covalent compounds have **low melting and boiling points**.
- Covalent compounds do **not conduct electricity** in any state.
- Most covalent compounds **are insoluble in water**. Instead they aresoluble in **organic solvents**.

Ionic Compounds	Covalent Compounds
Have very high melting and boiling points	Have low melting and boiling points
Conduct electricity when molten or in aqueous solution	Cannot conduct electricity in any state
Are usually soluble in water, but insoluble in organic solvents	Are usually insoluble in water, but soluble in organic solvents

Differences between Ionic and Covalent Compounds

Exercis

1.The joining of atoms to form a molecule is called ....

2.Covalent bonds are formed by the .... of electrons.

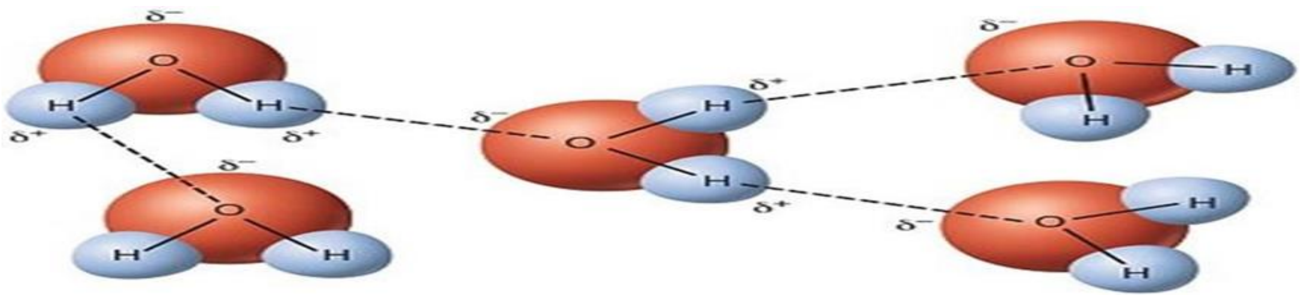
4.Covalent compounds have .... forces of attraction between the molecules, so they have low melting points and low boiling points.

5.Ionic compounds have very .... forces of attraction between the oppositely charged ions, so they have very .... melting points and high boiling points.

6.All covalent compounds cannot ....

7.All ionic compounds can conduct .... when they are molten ordissolved in water.

Hydrogen bonding

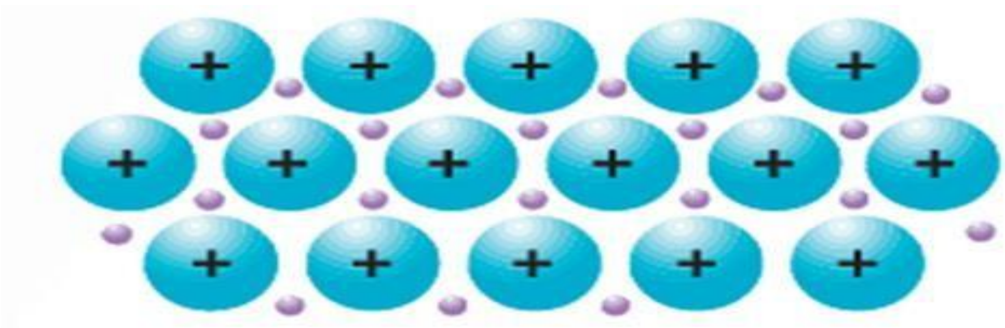


- **Water** is a great example of a molecule that experiences hydrogen bonding, which gives rise to the many unique properties of this universal solvent!

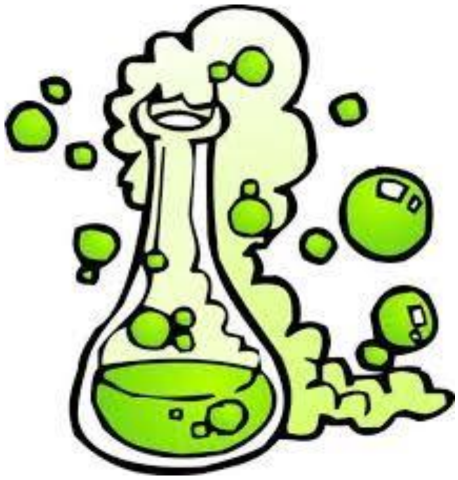
- Hydrogen bonding arises only between molecules that have **hydrogen atoms** directly bonded to a very electronegative atom, specifically either **fluorine, oxygen or nitrogen.**

Metallic bonding

- Metals are also made up of very large lattice structures.
- The **free electrons** are able to move and **conduct electricity and heat** . This explains why metals are good conductors of heat and electricity.



Chemical Reaction



A process in which one or more substances, the reactants, are converted to one or more different substances, the products.

Evidence of Chemical reactions

1. Color change.
2. Precipitate formation .
3. Gas bubbles .
4. Large energy changes , Container becomes very hot or cold.
5. Emission of light .

Chemical equation

A **chemical equation** is the symbolic representation of a **chemical reaction** in the form of symbols and formulae.

Reactants $\longrightarrow$ **Products**

❖ **To write an accurate chemical equation, two things must occur:**

1. Each product and reactant must be written using its **chemical formula**
2. The number of atoms of each element must be **equal** on both sides of the equation. Coefficients are used in front of the chemical formulas in order to help balance the number of atoms.

$$2Mg + O_2 \longrightarrow 2MgO$$

Symbols used in equations

(*g*) = gas **(*l*) = liquid** **(*aq*) = aqueous (dissolved in water) (*s*)= Solid** **Δ = heat** ***hv* = light**

Reaction Types

1-Acid-base reaction

- Also called **neutralization reactions** .
- In the reaction of an acid with a base the **H^{+1}** from the **acid** combines with the **OH^{-1}** from the **base** to make water.

$$H^{+1}_{(aq)} + OH^{-1}_{(aq)} \longrightarrow H_2O_{(l)}$$

Acid + Base $\longrightarrow$ Salt + Water

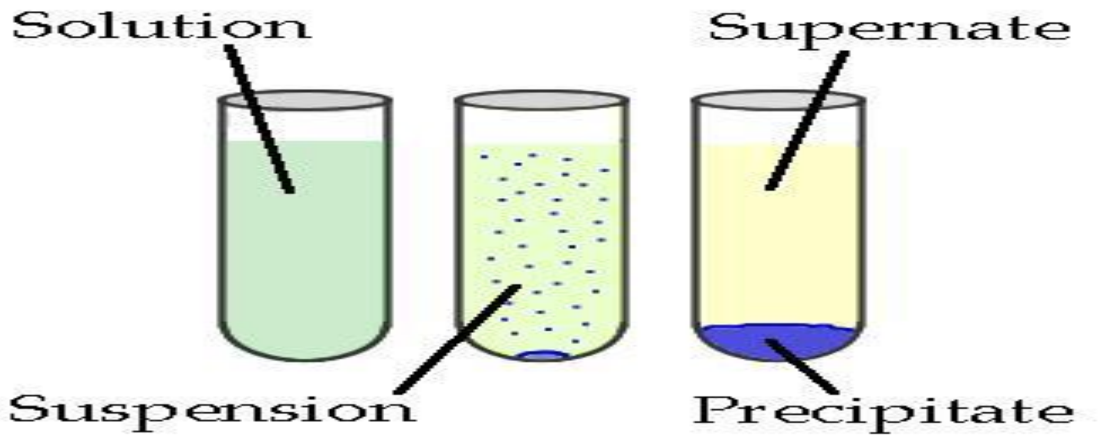
e.g.

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O$$

$$2HNO_{3\,(aq)} + Ca(OH)_{2\,(aq)} \longrightarrow Ca(NO_3)_{2\,(aq)} + 2H_2O_{(l)}$$

2-Precipitation Reactions

Precipitation reactions occur when cations and anions in aqueous solution combine to form an insoluble ionic solid called a **precipitate** . and the remaining liquid is called the **supernate**.



Example :: $AgNO_{3\,(aq)} + NaCl_{(aq)} \longrightarrow NaNO_{3(aq)} + AgCl_{(s)}$

3- Oxidation - Reduction (Redox) Reactions

A redox reaction occurs when the oxidation number of atoms involved in the reaction are changed .

- **Oxidation** is the process by which an atom's oxidation number is increased.
- **Reduction** is the process by which an atom's oxidation number is decreased.
- An atom that undergoes oxidation is called the **reducing agent**.
- The atom that undergoes reduction is called the **oxidizing agent**.

Example : $H_{2\,(g)} + F_{2\,(g)} \longrightarrow 2HF_{(g)}$

4-The formation of complexes

Most metal ions react with electron-pair donors to form coordination compounds or complexes. The donor species, or **ligand,** must have at least one pair of unshared electrons available for bond formation.

$$Cu^{2+} + 4NH_3 \longrightarrow Cu(NH_3)^{2+}$$

Exercis

Classify each of the following processes as a precipitation, acid–base neutralization , or redox reaction ?

1- $AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$

2- $2P_{(s)} + 3Br_{2(l)} \longrightarrow 2PBr_{3(l)}$

3- $Ca(OH)_{2(aq)} + 2HNO_{3(aq)} \longrightarrow 2H_2O_{(l)} + Ca(NO_3)_{2(aq)}$

4- $Al(OH)_3\ (aq) + HCl\ (aq) \rightarrow AlCl_3\ (aq) + H_2O\ (l)$

5- $MnO_2 + 4H^+ + 2Cl^- \rightarrow Mn^{2+} + 2H_2O\ (l) + Cl_2\ (g)$

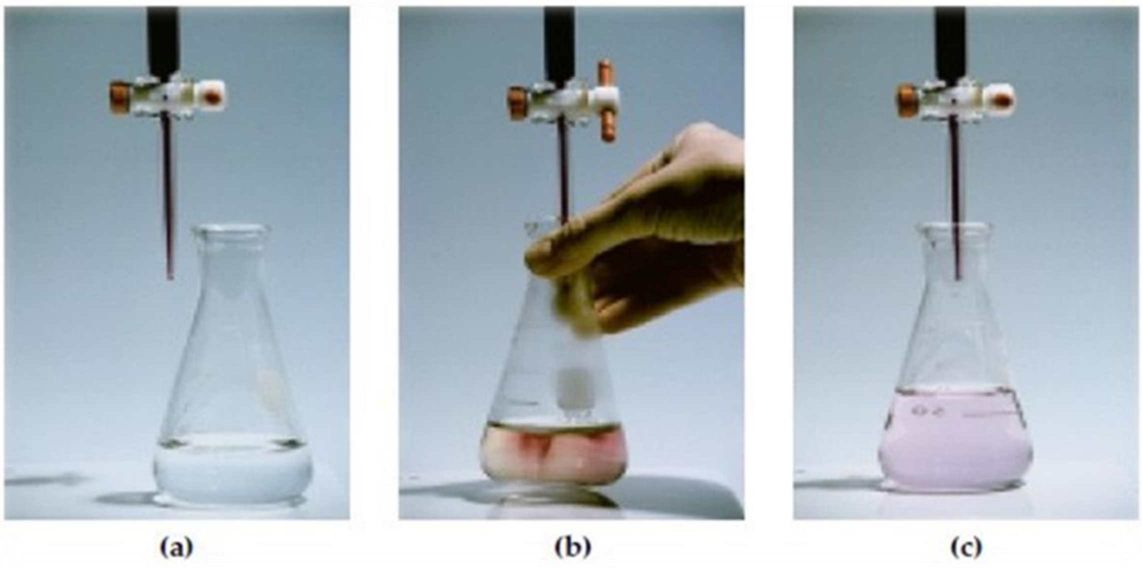
6- $P_4\ (s) + Cl_2\ (g) \rightarrow PCl_3\ (l)$

7- $Ca\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + H_2\ (g)$

8- $AgNO_3\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (s) + NaNO_3\ (aq)$

Titration

A **titration** is a common laboratory method of **quantitative chemical analysis** that is used a solution of known concentration to determine some information (**such as concentration and mass**) about an unknown substance.



A titration may involve any type of reaction

a. Neutralization (acid- base) titrations.
b. Oxidation- reduction (redox) titrations.
c. Precipitation titrations.
d. Complex formation titrations.

Catalyst

A **catalyst** is a substance that increases the speed of a reaction but is not consumed by the reaction .

Oxidation - Reduction

Oxidation is defined as a loss of electrons to give a higher oxidation state (more positive).

Reduction is defined as a gain of electrons to give a lower oxidation state (more negative).

OXIDATION NUMBERS The following rules predict the oxidation number for each of the atoms/ions in a compound or ion.

General Rules (Always applicable–No exceptions)

1. For any uncombined element, the oxidation number is zero.

Examples: Fe, Xe, O_2, H_2 (0 for all of these)

2. For any monatomic ion, the oxidation number is equal to the charge on the ion. Examples: Fe^{2+}, F^-, O^{2-}, H^+ (+2, -1, -2, and +1 respectively)

3. For any compound, the sum of the oxidation numbers must be zero.

Examples: $NaCl = Na^+ + Cl^- = +1 + (-1) = 0$

$MgF_2 = Mg^{2+} + 2\ F^- = +2 + 2(-1) = 0$

Q – Calculate the oxidation number for the central atom in the following compounds.

H_2SO_4 : $(+1\times2)+(S)+(-2\times4) = 0$ $\quad$ S = + 6

Q – Calculate the oxidation number for the central atom in the following compounds.

$KMnO_4$, H_2O_2 , HNO_3

Elements	Oxides of the elements		Chlorides of the elements	
	Formula	Oxidation Number	Formula	Oxidation Number
Na	Na_2O	+1	NaCl	+1
Mg	MgO	+2	$MgCl_2$	+2
Al	Al_2O_3	+3	Al_2Cl_6 ($AlCl_3$)	+3
Si	SiO_2	+4	$SiCl_4$	+4
P	P_4O_6 P_4O_{10}	+3 +5	PCl_3 PCl_5	+3 +5
S	SO_2 SO_3	+4 +6	–	–

Oxidizing agent

An oxidizing substance which tend to take on anelectron or electrons and be reduced to a lower oxidation state.

For example $M^{a+} + ne^- \longrightarrow M^{(a-n)+}$

$Ce^{4+} + e^- \longrightarrow Ce^{3+}$

Reducing agent

An reducing substance which tend to give up an electron or electrons and be oxidized to a higher oxidation state.

For example $M^{a+} \longrightarrow M^{(a+n)+} + ne^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

REDUCTION - OXIDATION REACTION

Is one that occurs between a reducing and an oxidizing agent ,For example

$$Ox_1 + Red_2 \longrightarrow Red_1 + Ox_2$$

$$Ce^{4+} + Fe^{2+} \longrightarrow Ce^{3+} + Fe^{3+}$$

$$2H^{+} + Zn_{(s)} \longrightarrow H_{2(g)} + Zn^{2+}$$

Redox reaction as two half reaction

This can be suitably illustrated by the reaction between iron (III) and tin (II).

$$2Fe^{3+} + Sn^{2+} \longrightarrow Sn^{4+} + 2\,Fe^{2+}$$

This reaction can be divided into two half reactions show below

$$2Fe^{3+} + 2e^{-} \longrightarrow 2\,Fe^{2+} \quad \text{(reduction)}$$

$$Sn^{2+} \longrightarrow Sn^{4+} + 2e^{-} \quad \text{(oxidation)}$$

$$\text{Total} \quad 2Fe^{3+} + Sn^{2+} + \cancel{2e^{-}} \longrightarrow Sn^{4+} + 2\,Fe^{2+} + \cancel{2e^{-}}$$

No half reaction occur by itself there must be an electron donor **(reducing agent)** and an electron accepter **(an oxidizing agent)** , **Fe^{3+} oxidizing agent**

Sn^{2+} reducing agent .

What is the importance of oxidation and reduction in biology ?

Oxidation-reduction (redox) reactions are important because they are the principal sources of energy. Oxidation of molecules by removal of hydrogen or combination with oxygen normally liberates large quantities of energy.

Questions

1- What is an oxidizing agent ? A reducing agent ?

2 - The element that undergoes oxidation is: $2H_2 + O_2 \longrightarrow 2H_2O$

States of Matter

Introductio

Matter has three possible states:

- **Solids**
- **Liquids**
- **Gases**

Some Characteristics of Gases, Liquids and Solids and the Microscopic Explanation for the Behavior

gas	liquid	solid
assumes the shape and volume of its container particles can move past one another	assumes the shape of the part of the container which it occupies particles can move/slide past one another	retains a fixed volume and shape rigid - particles locked into place
compressible lots of free space between particles	not easily compressible little free space between particles	not easily compressible little free space between particles
flows easily particles can move past one another	flows easily particles can move/slide past one another	does not flow easily rigid - particles cannot move/slide past one another

The gas laws

For gases, simple mathematical equations can be derived that relate a gas's volume, pressure and temperature.

❖ **Pressure** : is defined as the force applied per unit area to a surface.

Unites of measuring the pressure

- **1 atm = 760 torr = 760 mmHg**
- **1 atm = 101325 Pa (1 Pa = 1 $N.m^{-2}$)**

❖ **Temperature :** scale that must be used in gas law equations is the **Kelvin** scale.

$$T(K)=t(C^{\circ})+273$$

❖ **Volume :** Unites of measuring the Volume

1L=1000 mL
1L=1000 Cm^3
1mL = 1Cm^3

Boyle's Law

(**At constant temperature, the pressure of a fixed amount (i.e., number of moles) of gas varies inversely with its volume**).

$$P_1V_1 = P_2V_2$$

(Temperature and mass of the gas constant)

Exercise: A 2.5 L container has a gas pressure of 4.6 atm. If the volume is decreased to 1.6 L, what will be the new pressure inside the container ?

Charles's Law

"At constant pressure, the volume of a given mass of a gas is directly proportional toits absolute **temperature".**

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Exercise: A 3.5 L flexible container holds a gas at 250 K. What will the new volume beif the temperature is increased to 400 K ?

Gay-Lussac’s law

This law states that “*at constant volume, the pressure of a given mass of a gas is directly proportional to its absolute temperature*”

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Exercise: The pressure of a gas in a rigid container is 125 atm at 300 K. What is the new pressure if the temperature increases to 900 K?

Combined Gas

Boyle , Charles’ and Gay-Lussac’s Laws can be combined to give the combined gas law equation.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Exercise: A 200 *mL* sample of oxygen gas is collected at 26°C and a pressure of 690 Torr. What volume will the gas occupy at STP (0°C and 760 Torr) ?

Avogadro's Law

Equal volumes of different gases measured at the same temperature and pressure contain equal numbers of molecules of gas.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Exercise: If a the volume of 2mol of holiume gas is 44.8L what is the volume of o.5 moles of the same gas ?

The Ideal Gas Law

The combined gas law works only if the number of gas molecules remains unchanged in going from the initial to the final states.

$$P\,V = n\,R\,T$$

The pressure is in atmosphere (atm)

Volume in liter (L)

Number of moles (n)

Temperature is in kelvin (K)

- **R = 0.082 L.atm/mol.K** **R = 8.314 J/(mol.K)** **R = 1.98 cal/mol.K**

Exercise: Calculate the volume of one mole of a perfect gas under atmospheric pressure 1 atm and temperature 0 ^{O}C (273 K) ?

Dalton's

Dalton's Law of partial pressures states that for a mixture of gases at a fixed volume and temperature, each gas will contribute to the total pressure in proportion to its number:

$$P_T=P_1+P_2+P_3$$

Questions

Q1/ What volume will be occupied by a sample of gas at 40 ^{o}C and 720 mmHg if the volume at 20 ^{o}C and 750 mmHg was 250 ml ?

Q2/ To what temperature must a (1 L)sample of a perfect gas be cooled from 25^{o}C in order to reduce its volume to 100 cm^3?

Q3/ A sample with 0.15 moles of gas has a volume of 2.5 L . what is the volume if the sample is increased to 0.55 moles ?

Air pollution

Classification of air pollutants

Air pollutants are classified into two categories of primary pollutants and secondary pollutants.

A. **Primary pollutants** are those that are emitted directly from the sources. A general list of primary air pollutants are:

1- Particulate matter such as smoke, dust , fumes, and fog .

2- Inorganic gases such as sulfur dioxide, hydrogen sulfide, nitric acid, ammonia, and carbon dioxide .

3- Aromatic hydrocarbons.

4- Radioactive compound.

B. **Secondary Pollutants** are those that are formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric constituents. Pollutants such as sulfur trioxide, nitrogen dioxide, aldehydes, ketones and sulfate and nitrate salts.

Air borne

Air born particles can be classified as:

- **Dust**
- **Smoke**
- **Fume**
- **Mist**
- **Fog**
- **Aerosol**

What is the main cause of air pollution?

Vehicle emissions, fuel oils and natural gas , by-products of manufacturing and power generation, and fumes from chemical production .

What are effects of air pollution?

Health effects from air pollution include **heart disease**, **lung cancer**, and **respiratory diseases**. Also effects **brain**, **kidneys**, **liver** and cause **birth defects**.

Ozone layer

The ozone layer or ozone shield is a regio of Earth's stratosphere that absorbs most of the Sun's ultraviolet radiation.

Why is ozone important ?

The ozone layer acts as a shield for life on Earth. Ozone is good at trapping a type of radiation called UV light, which can penetrate like skin. This then may damage DNA molecules.

What causes depletion of ozone layer ?

The main cause of ozone depletion is manufactured chemicals, solvents, propellants.

Liquid Mixture-Solutions

Mixtures

A mixture is a material system made up by two or more different substances which are mixed together but are not combined chemically.

e,g. The **air** is a mixture of gases .

Liquid Mixtures

There are 4 types:

1. Solutions
2. Suspensions
3. Colloids
4. Emulsions

1-Solutions

A solution is a homogenous mixture of two or more substances evenly distributed in each other.

Solute + Solvent = Solution

Properties of a Solution

1)Consists of a solute and a solvent

2)Clear

3)Homogenous

4)Can pass through filter paper

Factors affecting solubility of a solute

1. Temperature:

Most solid solutes are **more soluble** in hot water than in cold water.

2. Pressure:

The greater the pressure, the greater the solubility of a gas in a liquid.

3. Surface area:

The greater the amount of surface area, the quicker a solute will dissolve in a solvent.

4. Stirring:

The process of stirring brings fresh solvent in contact with solute and so permits more ra

solution.

5. Nature of solvent:

In general, polar liquids dissolve polar compounds, and non-polar liquids dissolve non-p

compounds.

2- Suspensions

A suspension is a heterogeneous mixture of large solid substance in another substance made by mechanical agitation.

Properties of a Suspension

1)Consists of a solid in a solvent.

2)Heterogeneous.

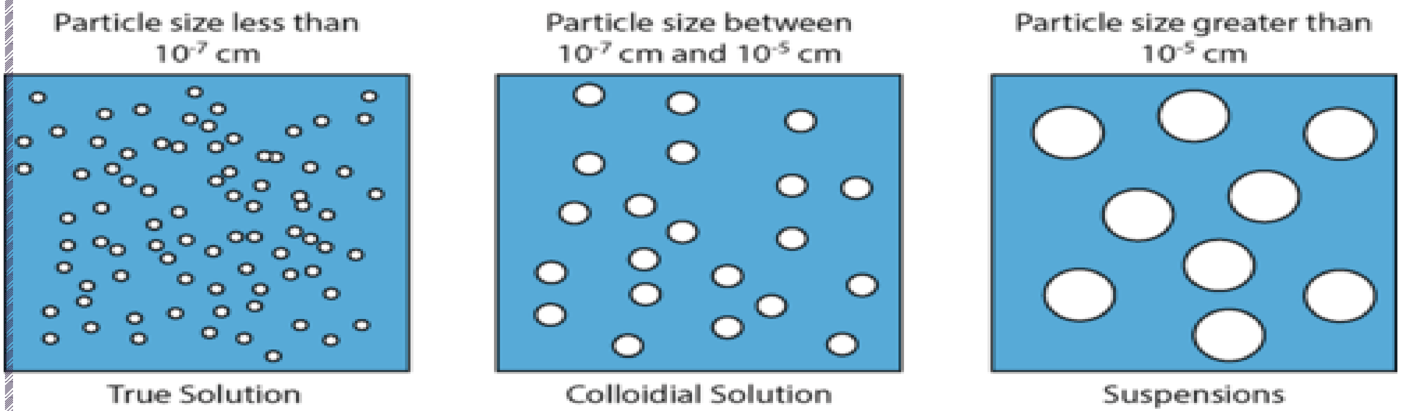
3)Not clear .

4)Do not pass through filter paper or membranes.

3- Colloids

Is a homogeneous solution with intermediate particle size between a solution and a suspension.

E.g. **Foam**(Whipped cream), **Gel** (jelly) .



Properties of a Colloid

1)Can be homogenous

2)Pass through filter paper

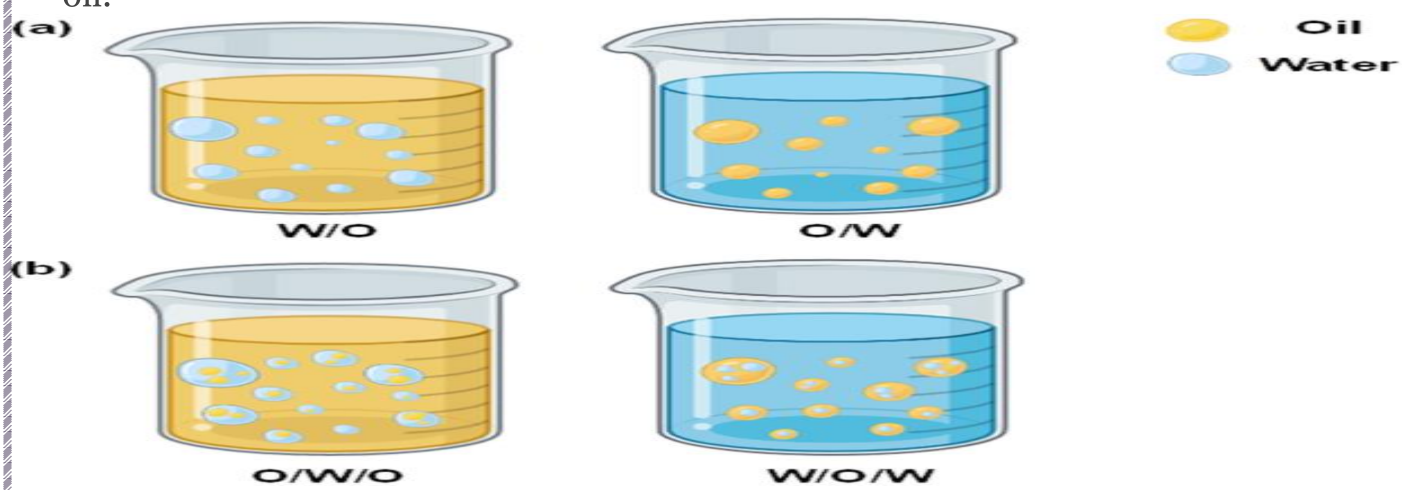
4-Emulsions

Emulsion is a mixture consists of two or more liquids that do not mix.
E.g. oil and vinegar.

Types of Emulsions

Emulsions are classified into two types,

1. **Oil in water type**: In oil in water type emulsion, oil is dispersed in medium water.
2. **Water in oil type**: In the water in oil type emulsion, water is dispersed in the medium oil.



Properties of emulsion

- They have a cloudy appearance.
- It shows the Tyndall effect.
- Both the phases of emulsion may get separated if they are kept undisturbed for a long period of time .

Questions

Q1/ What is Mixtures ?

Q2/ What are 5 examples of liquid mixtures ?

Solution

A solution is a homogenous mixture of two or more substances evenly distributed in each other.

Solute (lesser amount) + Solvent (larger amount) $\rightarrow$ Solution

Solute + Solvent = Solution

Concentrated Solution has a large amount of solute.

Dilute Solution has a small amount of solute.

Solute	Solvent		
	Gas	**Liquid**	**Solid**
Gas	$O_{2(g)}$ in $N_{2(g)}$, Air	$CO_{2(g)}$ in $H_2O_{(L)}$, Soda	$H_{2(g)}$ in $Pd_{(s)}$, H_2 catalyst
Liquid	Perfume	$Alcohol_{(L)}$ in $H_2O_{(L)}$	$Hg_{(L)}$ in $Ag_{(s)}$, Dental filling
Solid	Dust air, Smoke industry	$NaCl_{(s)}$ in $H_2O_{(L)}$, salt water, saline sol.	$Zn_{(s)}$ in $Cu_{(s)}$, Brass alloy

Classification of solutions according to amount of solute:

(1) Unsaturated solutions: if the amount of solute dissolved is less than the solubility limit.

(2) Saturated solutions: is one in which no more solute can dissolve in a given amount of solvent at a given temperature.

(3)Super saturated solutions: solution that contains a dissolved amount of solute that exceeds the normal solubility limit (saturated solution).

Stoichiometric Calculations

Mole Concept: Mole

$$\textbf{Mole} = \frac{\textbf{Mass(g)}}{\textbf{formula mass(g/mol)}}$$

- Where formula mass represents the atomic or molecular weight of the substance.

Example (1):- Calculate the number of grams in one mole of $CaSO_4.7H_2O$?

(A.wt H= 1 , O=16 , S=32 , Ca=40)

Solution:

M $(CaSO_4.7H_2O) = 40*1 + 32*1 + (16 \times 4) + 7[(2 \times 1) + 16*1] = 262$ g/mol.

$n=m/M \longrightarrow m=n*M \longrightarrow m=1*262=262$ g

Example (2): Calculate the number of mole of H_2 in 25 g **? (A.wt H= 1)**

Solution:

M(H_2)= 2*1=2 g/mol

$$\text{moles } H_2 = \frac{m\ (g)}{M} = \frac{25\ g}{2\ \frac{g}{mole}} = 12.5 \text{ mole}$$

Example (3):- Calculate the mass in 0.250 mole of Fe_2O_3 ? **(A.wt O= 16 , Fe = 56)**

Solution:

M(Fe_2O_3) = 56×2 + 16 × 3= 160 g/mol

$$m\,(g) = mole \times M\ \left(\frac{g}{mol}\right)$$

$$= 0.250\ mole \times 160\frac{g}{mol} = 40\ g$$

Questions

Q1: Find the moles in 167.2 g of $Na_2B_4O_7 . 10H_2O$? **(A.wt H= 1 , O=16 , B=11 , Na=23)**

Q2- What is the mass in grams of **a-** 7.1 mol of KBr **b-** 3.76 mol of $MgSO_4$
(A.wt H= 1 , O=16 , Mg=24 , S=32 , K=39 , Br=80)

How do we express concentrations of solutions

The Molarity Concentration

Also called (Molarity, amount of concentration or substances concentration)**,** having the ur symbol (mol./L).

$$\textbf{Molarity} = \frac{\textbf{Mole solute (mole)}}{\textbf{Solution volume (L)}}$$

Exercise: A solution is prepared by dissolving 1.26 g $AgNO_3$ in a 250 mL. Calculate the molarity of t silver nitrate solution**? (Awt Ag = 107.9 , N = 14 , O= 16) ?**

Diluting Solutions

$$M_{stock} \times V_{stock} = M_{diluted} \times V_{diluted}$$

Exercise: You wish to prepare 500 mL of 0.1 M $K_2Cr_2O_7$. What volume of the 0.25 M solution must be diluted to 500 mL ?

Normal concentration

Normality (N): ***Number of equivalent solute in solution volume in litre.***

$$\text{Normality(N)} = \frac{\text{NO.of equivalent solute (eq)}}{\text{solution volume (L)}}$$

Exercise: What volume of a 0.232 N solution contains 3.17 eq of solute **?**

Concentration by percent

$$\%(w/w) = \frac{\text{mass solute (g)}}{\text{mass solution (g)}} * 100\% \longrightarrow \%(w/w) = m_1 / m_T * 100\%$$

$$\%(v/v) = \frac{\text{volume solute (L)}}{\text{volume solution (L)}} * 100\% \longrightarrow \%(V/V) = V_1 / V_T * 100\%$$

Exercise: Calculate the weight percentage of solution prepare by mixing 5g $AgNO_3$ with 75g water (density of water 1g/cm^3) ?

Exercise: Calculate the volume of ethanol in litter solution consists of ethanol and water 0.9 (V/V%) ?

Mole fraction concentration (X)

$$\text{Mole fraction for solute } (X_1) = \frac{\text{no. mole solute } (n_1)}{\text{no. mole solute } (n_1) + \text{no. mole solvent } (n_2)}$$

Exercise: A solution contains 116 g (CH_3COCH_3) , 138 g (C_2H_5OH) , and 126 g (H_2O) . Determine the mole fraction of each ?

Mol $_{acetone}$ **= m / M.wt** → **116 / 58 = 2 mol**

Mol $_{C2H5OH}$ **= m / M.wt** → **138 / 46 = 3 mol**

Mol $_{water}$ **= m / M.wt** → **126 / 18 = 7 mol**

Sum of mole = 2 + 3 + 7= 12 mole

$$\text{Mole fraction for acetone}(X_1) = \frac{2\text{mole}}{12 \text{ mole}} = 0.166$$

$$\text{Mole fraction for } C_2H_5OH(X_2) = \frac{3\text{mole}}{12 \text{ mole}} = 0.25$$

$$\text{Mole fraction for water}(X_3) = \frac{7 \text{ mole}}{12 \text{ mole}} = 0.583$$

$$X_1+X_2+X_3= 1 \quad , \qquad 0.166 + 0.25 + 0.583$$

Acid-Base Equilibria

Acid-base theories:-

1) Arrhenius Theory (H^+ and OH^-):-

Acid:-any substance that ionizes (partially or completely) in water to give hydrogen ion (which associate with the solvent to give hydronium ion H_3O^+) :

$$HA + H_2O \leftrightarrow H_3O^+ + A^-$$

Base:-any substance that ionizes in water to give hydroxyl ions. Weak (partially ionized) to generally ionize as follows:-

$$B + H_2O \leftrightarrow BH^+ + OH^-$$

This theory is obviously restricted to water as the solvent.

2) Bronsted-Lowry Theory (taking and giving protons, H^+):-

Acid:- any substance that can donate a proton.

Base:- any substance that can accept a proton.

Thus, we can write a half reaction: **Acid = H^+ + Base**

The acid and base of half reaction are called **conjugate pairs.**

3) Lewis Theory (taking and giving electrons):-

Acid:-a substance that can accept an electron pair.

Base:-a substance that can donate an electron pair.

$H_2O + H^+ \leftrightarrow H_2O{:}H^+ \quad (H_3O^+)$ $\qquad\qquad$ $HO{:}^- + H^+ \leftrightarrow H{:}OH$

$$AlCl_3 + {:}O\begin{matrix} \diagup R \\ \diagdown R \end{matrix} \longrightarrow Cl_3Al{:}O\begin{matrix} \diagup R \\ \diagdown R \end{matrix}$$

Acid-Base Equilibria in water:-when an acid or base is dissolved in water, it will dissociate, or ionize, the amount of ionization being dependent on the strength of the acid or base. A strong electrolyte is completely dissociated, while a weak electrolyte is partially dissociated.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^- \text{ (strong acid, completely ionized)}$$

$$HOAc + H_2O \leftrightarrow H_3O^+ + OAc^- \text{ (weak acid, partially ionized, a few percent)}$$

Strong and Weak Acids/Bases

A **strong acid is an acid which dissociates completely in water.** That is, ***all*** the acid molecules break up into ions and solvate (attach) to water molecules.

Strong Acid	Formula
Perchloric acid	$HClO_4$
Nitric acid	HNO_3
Sulfuric acid	H_2SO_4
Hydrohalic acids	HCl, HBr, HI

A **strong base is an base which dissociates completely in water.** That is, all the base molecules break up into ions and solvate (attach) to water molecules.

Strong Base	Formula
Lithium hydroxide	**$LiOH$**
Sodium hydroxide	**$NaOH$**
Potassium hydroxide	**KOH**
Rubidium hydroxide	**$RbOH$**
Cesium hydroxide	**$CsOH$**
Calcium hydroxide	**$Ca(OH)_2$**
Strontium hydroxide	**$Sr(OH)_2$**
Barium hydroxide	**$Ba(OH)_2$**

Properties of Acids and Bases

Acids and bases have very different properties, allowing them to be distinguished by observation.

Physical properties

Bases	Acids	
bitter	sour	**Taste**
slippery	stinging	**Feel**
odorless	sharp	**Odor**

Chemical Reactions

Neutralization

Acids will react with bases to form a **salt** and **water**.

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Uses of Acids

Used in industry and lab works in large amts .

HCl : found in gastric juices for proper digestion of proteins in the stomach .

HNO_3 (Nitric Acid): Protein coagulator used to test for the presence of albumin in urine .

Acetylsalicylic Acid (ASPIRIN): Analgesic + antipyretic .

Uses of bases

Calicium hydroxide solution ;$Ca(OH)_2$: Commonly known **as** lime water ,is used to overcome excess acidity in the stomach .It is also used to medically as an antidote .

Magnesium hydroxide;$Mg(OH)_2$: Is commonly known as milk of magnesia .In dilute solutions it is used as antacid for the stomach.

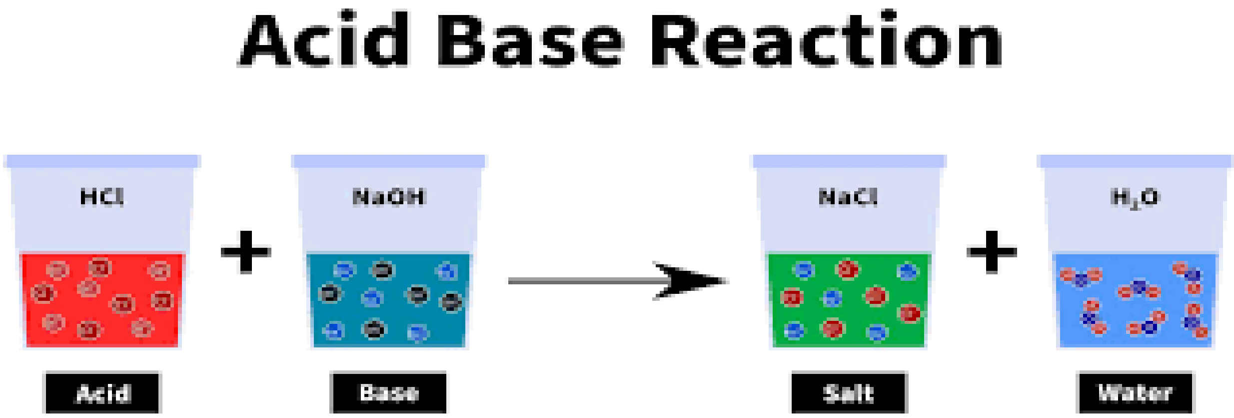
Ammonium hydroxide ; NH_4OH : Is also called spirit of ammonia ,it is used as a heart and respiratory stimulant .

Sodium hydroxide ; NaOH : It is used for removing and dissolving fats

Salts

Salts : are ionic compounds composed of cations and anions held together by ionc bonds.

Salts are formed by the reaction of an acid and a base .



Uses of Salts

Iron salts : Are necessary for the formation of hemoglobin .

Iodine salts : Are necessary for the proper functioning of the thyroid gland .

Calcium and phosphorus salts : Are necessary for the formation of bones and teeth .

Sodium and potassium salts : regulate the irritability of nerve and muscle cells , regulate the beating of the heart .

Types of Salts

1. Normal salt : A salt that does not contain any replaceable hydrogen atoms or hydroxyl groups .

Examples

Na_2SO_4 obtained in the reaction between H_2SO_4 and NaOH is a normal salt **because** it is formed by the complete replacement.

2. Acid salt : A salt that contains replaceable hydrogen atoms. For example, the salt **$NaHSO_4$** produced in the reaction between NaOH and H_2SO_4 .

$$H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$$
$$NaHSO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$$

3. Basic salt : When a polyacidic base reacts with lesser amount of acid than is necessary for complete neutralization, the salt produced contain hydroxyl group(s) (OH) also.

Examples :

$$Pb(OH)_2 + HCl \rightarrow \underset{\text{lead oxychloride}}{Pb(OH)Cl} + H_2O$$

4. Double salt : In a double salt, there are two different negative ions and/or positive ions. For example, the mineral dolomite, $K_2SO_4 \cdot Al_2(SO_4)_3.24H_2O$.

Acid-Base Titrations

An Acid-Base titration involves a neutralization reaction in which an acid is reacted with an equivalent amount of base at equivalence point or endpoint.

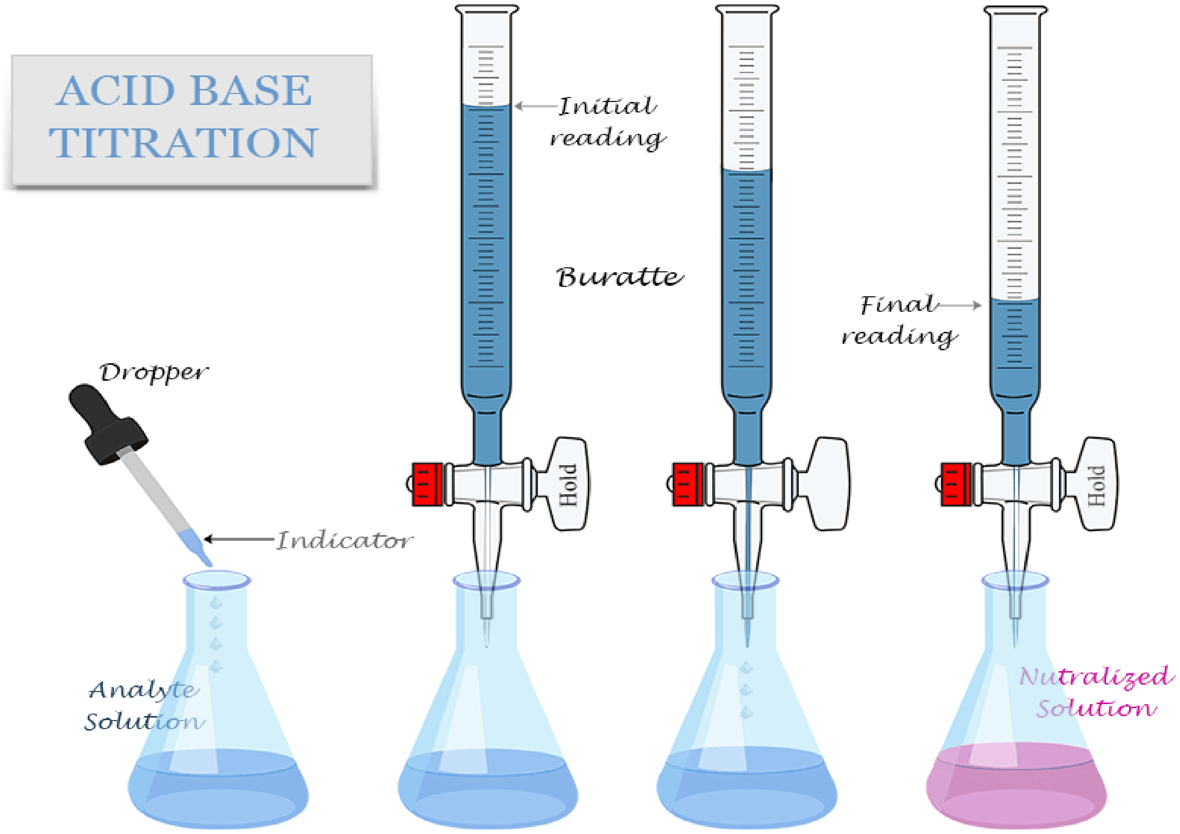
The titration is always a strong acid or strong base

A) Titration of strong acid versus strong base.

$$H^+Cl^- + Na^+OH^- \rightarrow Na^+Cl^+ + H_2O$$

$$HCl + NaOH \rightarrow NaCl + H_2O$$

The **equivalence point** is where the reaction is theoretically complete while the **endpoint** where the colour of indicator were changed.



7- المفردات العملية – الكيمياء السريرية – المرحلة الاولى – الفصل الاول

الأسبوع	الساعات (العملي)		اسم الوحدة او الموضوع		
1	4		التعرف على الادوات المختبرية		
2-5	4		طرق تحضير المحاليل – النسبة المئوية – المولاري – طرق التخفيف –النورمالي		
6-7	4		قياس الحوامض والقواعد في الماء والدم		
8-10	4		التحليل الحجمي – التسحيح-تفاعلات الاكسدة والاختزال- تفاعلات الترسيب		
11	4		اختبار		
12-13	4		فصل المواد العضوية –الترسيح-الاستخلاص-التسامي- التقطير		
14-15	4		الكشف عن الكحولات		

Solute-the substance which dissolves in a solution.

Solvent- the substance which dissolves another to form a solution. For example, in a sugar and water solution, water is the solvent; sugar is the solute.

Solution- a mixture of two or more pure substances. In a solution one pure substance is dissolved in another pure substance homogenously. For example, in a sugar and water solution .

Solubility:

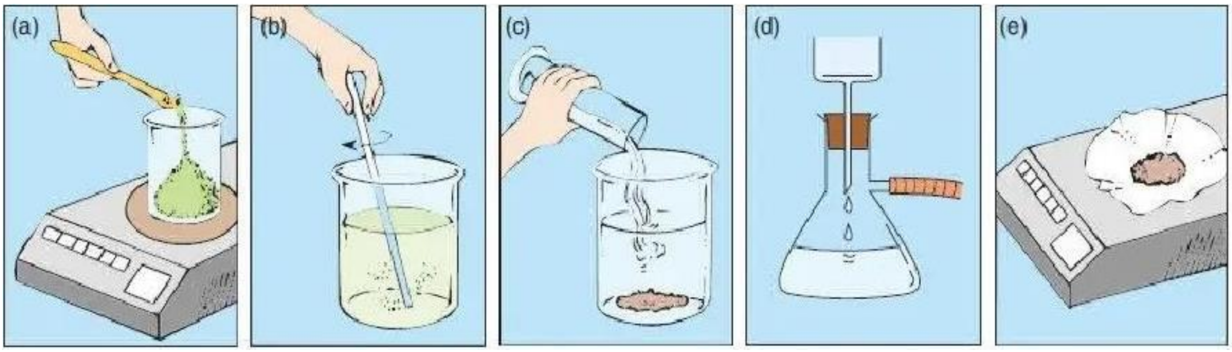
The quantity of solute which will dissolve in a specified quantity of solvent to produce a concentrated solution.

Dilute solution:

It contains a small amount of solute per solvent.

Concentrated solution:

It contains a large a mount of solute per solvent.



Kinds of solutions

Solutions are defined as homogeneous mixtures, it isn't surprising that almost any (***gas, liquid, or solid***) will act as a solvent for other (***gases, liquids, and solids***) thereby forming a solution.

Methods of expressing concentrations

Concentration represents the amount of dissolved substance (solute) per unit amount of solution , It can be expressed by :

1) **Chemical units : equivalent weight - Molecular weight(mole).**
2) **Physical units : mass – volume**

1. Chemical Units:

<u>The mole</u>:

Is a unit for the amount of a chemical species , always associated with a chemical formula and represents Avogadro's number (6.022×10^{23}) of particles representedby that formula .

<u>Molar Mass</u>

Is the mass in grams of 1 mole of the substance ,it is calculated bysumming the atomic masses of all the atoms appearing in a chemical formula .

Molar mass (M) = $\sum atomic\ molar\ mass$

Example :- The molar mass for formaldhyde CH_2O is :

$M(_{CH}20\ ) = \sum(1mole\ carbon + 2mole\ hydrogen + 1mole\ oxygen)atom$

$M\ _{CH}20 = 1\ x\ 12g + 2\ x\ 1g + 1\ x\ 16g$

$= 30\ \ g/mol\ of$ CH_2O

Example :- Molar mass of glucose $C_6H_{12}O_6$:

$M\ \ _{C}6H1206 = \sum(6mole\ carbon + 12mole\ hydrogen + 6mole\ oxygen)$

$M\ _{C}6H1206 = 6\ x12 + 12\ x\ 1 + 6\ x\ 16 = 180$ g/mol

M = g /mole or mg /mmole

$$\text{moles} = \frac{m(g)}{M\ (g/mol)}$$

Example: How many grams of Na^+ (M.wt =22.99 g /mol) are contained in (25.0 g) of Na_2SO_4 (M = 142 g /mol) ?

Solution:

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

1mole 2mole 1mole

n Na_2SO_4 = m/M= 0.25/142 = 0.176 mole

n_{Na^+} = 0.176 x 2 = 0.352 moles Na^+

Mass (g) = no. of moles x molar

mass(g/mol)mass Na^+(g) = moles Na^+ x

22.99(g) Na^+ mass Na^+ (g) = 0.352 x

22.99 = 8.1 g

Methods of expressing concentration of solutions:

- **Percentage (%).**
- **Molarity.**
- **Mole Fraction.**
- **Molality.**
- **Normality.**

1. Percentage (%):

The use of percentages is a common way of expressing the concentration of a solution. One way of expressing concentrations, is by volume percent. Another is by weight percent.

- **Usually for solids dissolved in liquids (solution is as apercent by weight)**

% w/w = weight of solute/weight of solution * 100

- **Usually for solids dissolved in liquids**

% w/v = weight of solute/volume of solution * 100

- **Usually for liquids dissolved in liquids**

% v/v = volume of solute/volume of solution * 100

Examples:

What is the weight percent of glucose in a solution madeby dissolving 4.6 g of glucose in 145.2 g of water ?

Total weight of solution = 4.6 +145.2 = 149.8 g

Calculate percent:

(w/w) % glucose = 4.6 g glucose/ 149.8 g solution * 100

= 3.1% glucose

Examples:

Many people use a solution of Na_3PO_4 to clean walls before putting up wallpaper. The recommended concentration is 1.7% (m/v). What mass of Na_3PO_4 is needed to make 2 L of solution ?

(m/v) % = Mass of solute/volume of solution * 100

1.7% = mass of solute/2000ml * 100

Mass of solute = 34g

Examples:

Determine the volume of liquid Glycerin required toprepare 500 ml of a

20% by volume solution. What volume of water is required?

Answer:

Determine the volume of Glycerin from the definitionof volume %

(v/v) % by volume = volume of solute / volume ofsolution * 100

20 = volume of Glycerin / 500 ml solution * 100

volume of Glycerin = 20 * 500/100 = 100 ml Glycerinrequired

Determine the volume of water

Total volume of solution = volume of Glycerin + volume of water

500 = 100 + volume of water

Volume of water = 500 - 100 = 400 ml

Q1. Prepare a 20 mL of 5% KCl solution(w)% from pure solid KCl ?

2. Molarity:

The molarity (M) of a solution is the number of moles ofsolute per liter of solution.

M = moles of solute / liters of solution

Example:

Calculate the molarity of a solution, 2 liters of whichcontain 2.6 moles of solute ?

M = moles of solute / liters of solution

M = 2.6 mol / 2 L

M = 1.3 M

Example:

Calculate the molar concentration of KNO_3 aqueous solution that contains (2.02 g) of KNO_3 (M.wt =101 g /mole) in (2 L) of solution ?

$$\textbf{Molarity(M)} = \frac{m(g)}{M \times V_L} = \frac{2.02(\,g\,)}{101 \times 2L} = 0.1\ M$$

Q2. Calculate the weight in grams of solid NaCl (58.5 g/mol) required to prepare 250 mL of 0.04 M aqueous solution of Na^+ ?

3. Mole fraction :

The mole fraction χ, (also called *molar fraction*) is the number of moles of a compound divided by the total number of moles of all components in the solution.

χ solute = (moles of solute/total moles of all components)

$$X_A = \frac{x\ \text{mol}A}{x\ \text{mol}A + y\ \text{mol}B} \qquad X_B = \frac{y\ \text{mol}B}{x\ \text{mol}A + y\ \text{mol}B}$$

$$X_A + X_B = \frac{x\ \text{mol}A}{x\ \text{mol}A + y\ \text{mol}B} + \frac{y\ \text{mol}B}{x\ \text{mol}A + y\ \text{mol}B} = \frac{x\ \text{mol}A + y\ \text{mol}B}{x\ \text{mol}A + y\ \text{mol}B} = 1$$

$X1 = \frac{n1}{n1 + n2}$	$X2 = \frac{n2}{n1 + n2}$

Example:

What is the mole fractions of the components of the solution formed when 92 g glycerol is mixed with 90 g water ?
(Molecular weight water = 18 g/mol ; Molecular weight of glycerol = 92g/mol)

Answer

$n_{(Water)}$ = 90 g / 18 g/mol = 5 mole

$n_{(Glycerol)}$ = 92 g / 92 g/mol = 1 mole

Total moles = 5 + 1 = 6 mole

***x* water = 5 mole / 6 mole = 0.833**

***x* glycerol = 1 mole / 6 mole = 0.167**

Q3. Calculate the mole fraction for each of solute and solvent in a solution if the solute is (2 mole) and the solvent in (3 mole) ?

4. Molality:

The molality (*m*) is the number of moles of solute perweight of solvent.
If you are given solute in grams, you must convert to moles first.
If you are given solvent in grams, you must convert to kilograms first.

Molality = moles of solute / Kg of solvent

Example:

An aqueous solution of hydrofluoric acid is 30% HF, bymass. What is the molality of HF in this solution ? (Molecular weight HF = 20g/mol)

Let us assume 100 g of solution . Therefor : 30 g is HF 70 g is H_2O

Calculate the moality:

Moles HF = 30 g / 20 g/mol = 1.49956 mol

Mass of water = 0.07 kg

Molality = 1.49956 mol/ 0.07 kg = 21.4 mol/ k

Q4. Determine the molality of a solution prepared by dissolving 75 g of solid $Ba(NO_3)_2$ (261.32 g/mol) into 374g of water ?

(1) Preparation 0.1 M sodium carbonate (Na_2CO_3) solution 250ml .

Calculation:

M= moles of solute / Kg of solvent

0.1= n / 0.25_

n= 0.1*0.25 = 0.025 mol

M (Na_2CO_3) = 23x2 + 12 + 3x16 = 106 g/mol

Mole=m/M

mass = 0.1 x 106 x 250ml /1000 = 2.65g of sodium carbonate

procedure:

1. So weight 2.65g of sodium carbonate (using a watch glass).
2. Transfer into a beaker, add 100ml of distilled water by using funnel (mix the solution by using a stirrer).
3. Transfer the solution into a volumetric flask of 250ml. then add water to the mark.

(2) **preparation 1 M NaOH in 100ml of solution._**

Calculation:

M= moles of solute / Kg of solvent

1= n / 0.1_

n=1*0.1 = 0.1mol

M (NaOH) = 23 + 16+ 1= 40g/mol

Mole=m/M
mass = 0.1*40= 4g of sodium hydroxide

procedure: using the same upper procedure, but 4g dissolve in 60ml water, then complete to 100ml.

5. Normality :

Normality **(1N**) solution contains one gram-equivalentweight of solute per liter of solution.

$$\text{Normality (N)} = \frac{\text{Weight x 1000}}{\text{Eq. wt x V (ml)}}$$

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

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

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

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

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

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

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

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

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

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

Example:

Calculate the equivalent weight of the following substances: (a) NH_3, (b) $H_2C_2O_4$ (in reaction with NaOH)

(a)

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

(b)

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

(c)

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

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

Example:

Calculate the normality of the solutions containing the following: (a) 5.3g/L Na_2CO_3 (when the CO_3^{-2} reacts with two protons), (b) 5.267 g/L $K_2Cr_2O_7$
(the Cr is reduced to Cr^{3+}).

(a)

$$\text{N} = \frac{\text{wt}}{\text{Eq. wt}} \times \frac{1000}{\text{V (mL)}} = \frac{5.3}{\frac{105.99}{2}} \times \frac{1000}{1000} = 0.10 \text{ Eq/L}$$

(b)

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

$$= \frac{5.267}{\frac{294.19}{6}} \times \frac{1000}{1000} = 0.1074 \text{ Eq/L}$$

Dilution calculations

Solutions are prepared by diluting a more concentrated solution.

$$\underline{M}_{con} \times V_{con} = \underline{M}_{dil} \times V_{dil}$$

***Example*:-**

How many mL of permanganate $KMnO_4$ (0.1 M) should be used to prepare 100 mL of 1.0×10^{-3} M solution ?

$$(M_1 \times V_1)_{conc.} = (M_2 \times V_2)_{dilu.}$$

$$0.1 \left(\frac{\text{mmol}}{\text{mL}}\right) \times V_1 = 1.0 \times 10^{-3} \left(\frac{\text{mmol}}{\text{mL}}\right) \times 100 \text{ (mL)}$$

$V_1 = 1.0$ mL stock solution (conc.),Also to prepare 2.0, 5.0, 10.0×10^{-3} M

Example:

A chemist starts with 50 ml of a 0.4 $\underline{M}$ NaCl solution and dilutes it to 1000 ml. What is the concentration of NaCl in the new solution?

$$\underline{M}_{con} \times V_{con} = \underline{M}_{dil} \times V_{dil}$$

$$0.4\ \underline{M} \times 50 \text{ ml} = \underline{M}_{dil} \times 1000 \text{ ml}$$

$$0.02\ \underline{M} = \underline{M}_{dil}$$

Q5. A chemist wants to make 500 ml of 0.05 $\underline{M}$ HCl by diluting a 6 $\underline{M}$ HCl solution. How much of that solution should be used ?

Homework

- How many grams Na_2SO_4 should be weight out to prepare 500 mL of a 0.1 M solution ?

- Calculate the normality of a solution of 0.25 g/L $H_2C_2O_4$, both as an acid and as a reducing agent ?

- Calculate the weight percentage of solution prepare by mixing 5g $AgNO_3$ with 100g water ?

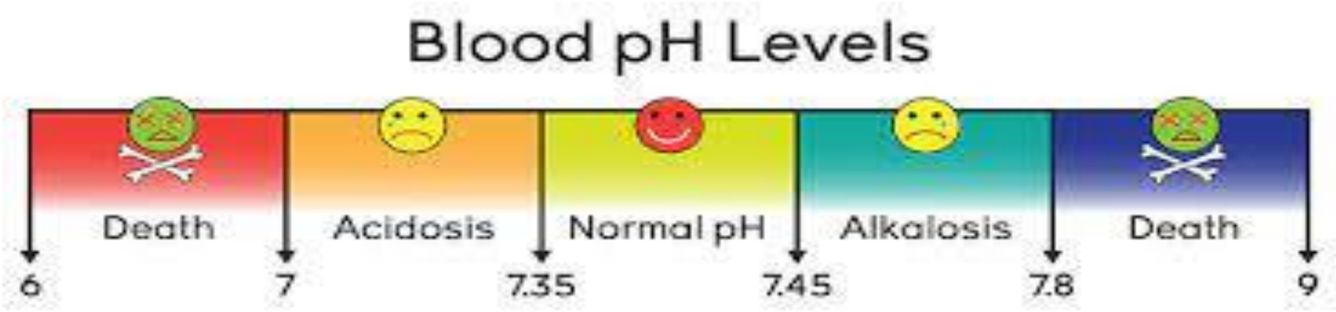
Acid/Base Balance

Blood hydrogen ion concentration lies within the range **pH 7.35 — 7.45.**

In **acidosis**, there is an accumulation of acid or a loss of a base causing a fall or a tendency to a fall in the pH. The converse occurs in **alkalosis**.

What is the significance of acids and bases ?

Your blood needs the right balance of acidic and basic (alkaline) compounds to function properly. This is called the **acid-base balance** . Your **kidneys** and **lungs** work to maintain the acid-base balance .



❖ Acidity/alkalinity is measured on pH scale (1pH unit = 10 fold change in [H+])

PH of 7 is neutral

PH < 7: more H+, fewer OH **PH> 7: fewer H+, more OH**

❖ Slight changes in pH can be fatal .

≤7 or ≥7.8 is fatal

❖ Body is protected against large changes in pH in **two step process**:

1. **Buffers** – absorb excess hydrogen or hydroxyl ions to prevent drastic changes in Ph .
2. **Elimination** – acids (or bases) are removed from body by:
   - **Kidneys - can secrete H^+ and HCO_3**
   - **Hungs – as CO_2 is eliminated H_+ are converted to water**
   - **Skin – can excrete some acids in sweat**

Buffers

A buffer is a substance that prevents marked changes in pH of a solution when acids or bases are added .

eg. 1 drop of HCl in pure water

PH = 7 ⟶ 3.5

1 drop of HCl in plasma

PH = 7.41 ⟶ 7.27

Major buffers in body fluids:

- **Bicarbonate**
- **Phosphate**
- **Hemoglobin**
- **Plasma proteins**

At some point the acids and bases must actually be removed from the body

Two main removal systems:

1. Respiratory Mechanisms

2. Excretory Mechanisms

1-Respiratory Mechanisms

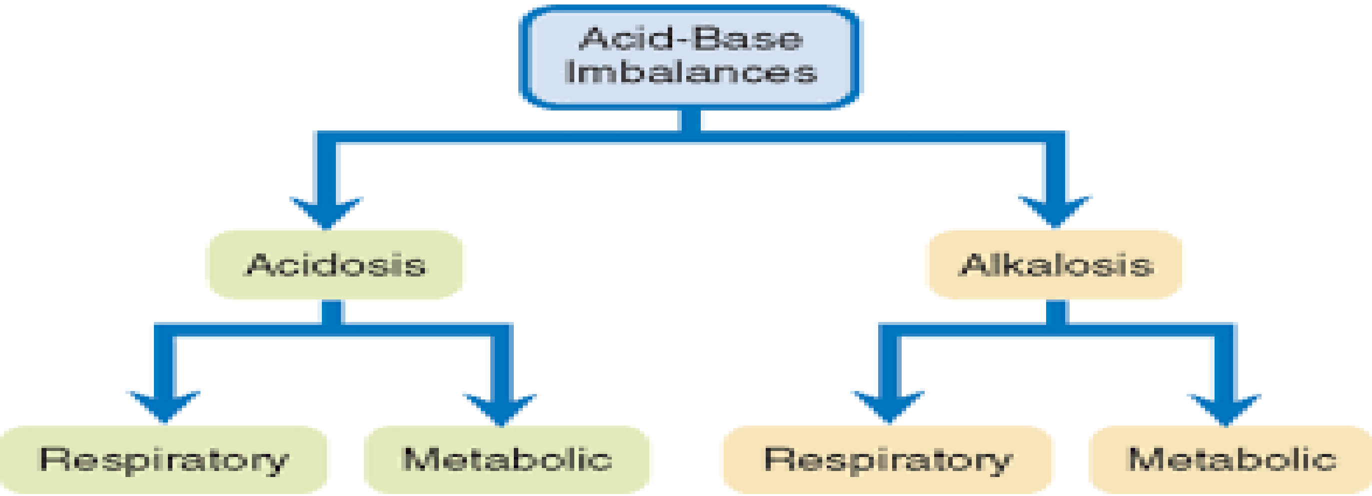
respiration plays vital role in removing excess acids with each expiration, CO_2 and therefore H^+ are removed .

$$CO_2 + H_2O \xrightarrow{\text{carbonic anhydrase}} H_2CO_3 \longrightarrow H^+ + HCO_3$$

2- Excretory Mechanisms

More efficient mechanism than respiratory system usually urine is slightly acidic. **Normal diet produces more acid than alkaline waste products.**

Acid/Base Imbalances



1. Acidosis

Caused by

→ **overproduction of acid that builds up in the blood**

→ **excessive loss of bases**

→ **buildup of carbon dioxide in the blood**

a. Respiratory Acidosis

factors that cause buildup of CO_2 in blood generally due to factors that hinder pulmonary ventilation.

Symptoms:

- labored breathing
- cyanosis
- depression
- coma

can be compensated for by kidneys

b. Metabolic Acidosis

accumulation of non-respiratory acids or excessive loss of bases caused by

- **poor kidney function**
- **diarrhea**
- ***severe* vomiting**

2. Alkalosis

Caused by

→ **overproduction of bases that builds up in the blood**
→ **excessive loss of acids**

a. Respiratory Alkalosis

caused by **hyperventilation anxiety , fever, some poisonings**

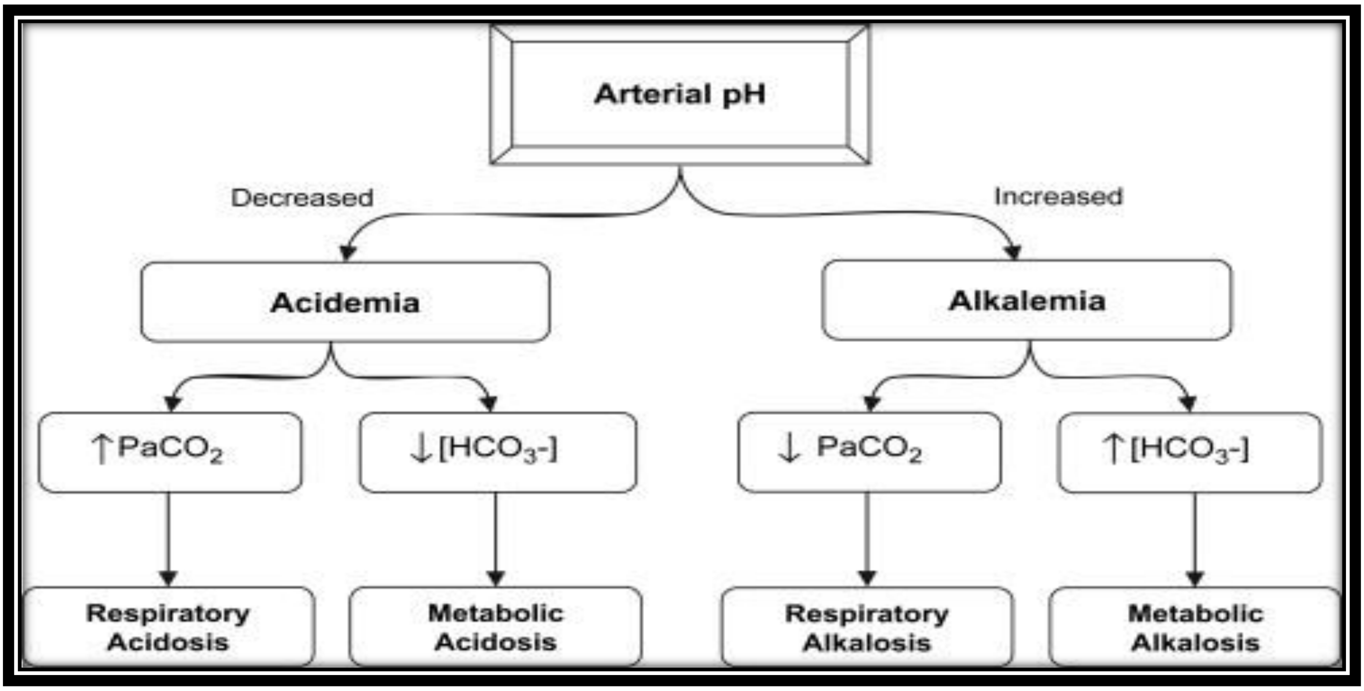
Symptoms:

- agitation
- tingling
- dizziness

b. Metabolic Alkalosis

caused by**:**

Metabolic alkalosis is caused by too much bicarbonate in the blood. It can also occur due to certain **kidney diseases**, and from **prolonged vomiting**.



Arterial Blood Gas (ABG)

Q/ What is the test for acid base balance ?

An acid-base analysis can be performed by looking at the results of an **arterial blood gas (ABG)** .

Q/ What is an arterial blood gas (ABG) test ?

It's a test that measures the blood levels of oxygen **(PaO_2)**, carbon dioxide **($PaCO_2$)**, bicarbonate **(HCO_3)**, and acid-base balance **(pH)** in the body.

Important Normal Values on ABG

pH	7.35	-	7.45
pCO_2	35 mmHg	-	45 mmHg
pO_2	75 mmHg	-	100 mmHg
HCO_3^-	22 mEq/L	-	26 mEq/L
O_2 Sat	Greater than 95%		

Q/ What is it used for (ABG) Test ?

An ABG test is used to help:

- **Check your acid-base balance .**
- **Diagnose serious problems with your lungs and breathing .**
- **Diagnose kidney disorders .**

Homework

Q1/ What causes alkalosis ?

Q2/ What causes acidosis ?

Q3/ Choose the correct answer ?

1- What is the normal range of PH in the body ?

A)35-45 B)22-26 C)7.35-7.45 D)Not listed

2- If the HCO_3 caused the acidosis or the alkalosis, it is What ?

A)Metabolic B)Respiratory C)Combined D)None

3- If the CO_2 caused the acidosis or the alkalosis, it is What ?

A)Metabolic B)Respiratory C)Combined D)None

Volumetric Analysis

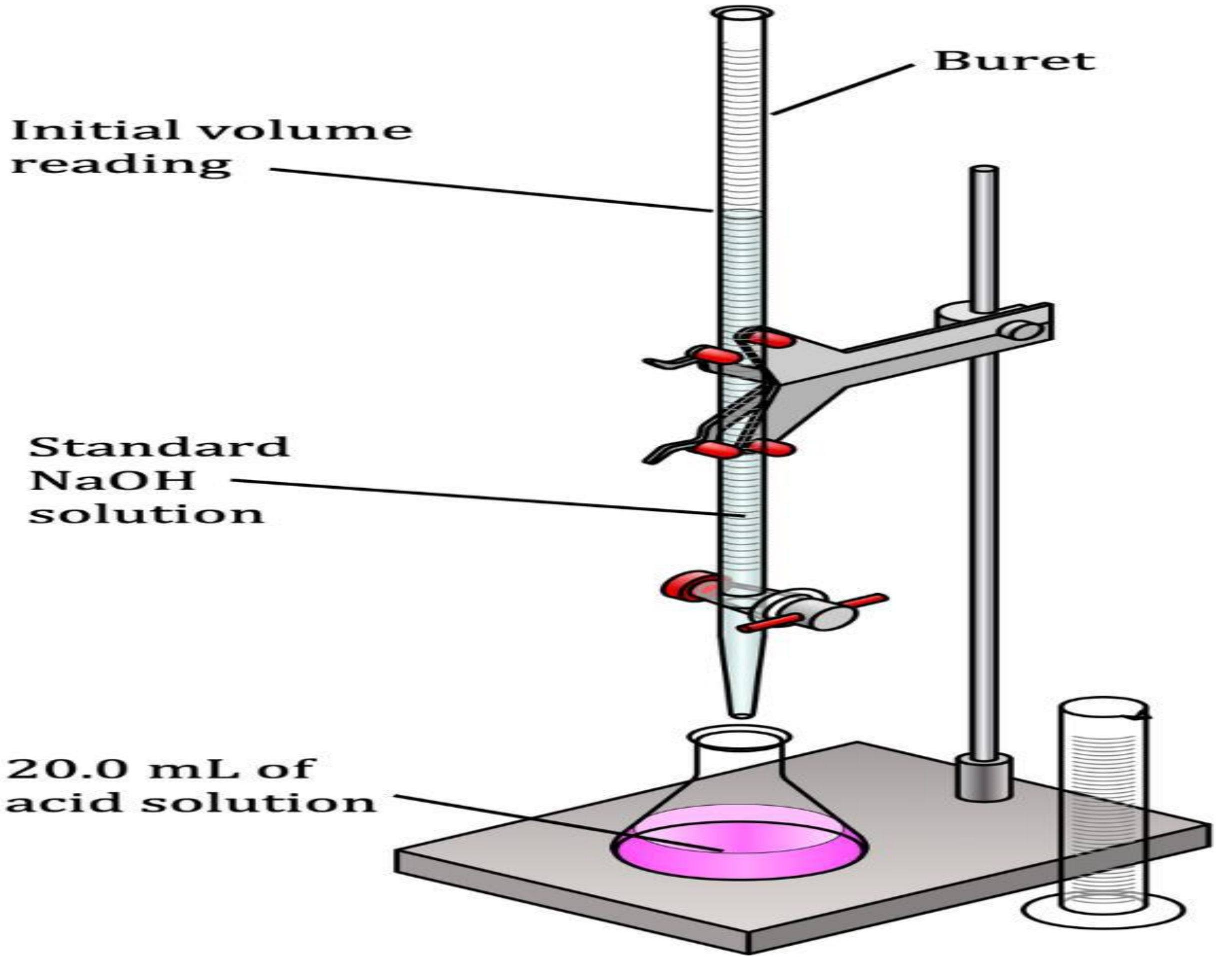
Volumetric analysis is a quantitative analytical method used to measure volume of a solution whose **concentration** is known.

Titration :

Is a common laboratory method of quantitative chemical analysis that is used to determine the unknown concentration of a known reactant.

Principle of Titration:

It is based on the complete chemical reaction between the analyte and the reagent (**titrant**) of known concentration.



SOME TERMS USED IN TITRATION

Equivalence point (Veq):

The point in a titration where stoichiometrically equivalent amounts of analyte andtitrant react (theoritical end of titration).

End point (Vep):

The point of titration at which the completion of a reaction is practically observed.

Titration error:

The difference between the end point and the equivalence point

$$Et = Vep - Veq$$

Titrant

The standard solution of known concentration added from the burette.

Analyte

An unknown solution which is to be determined .

Standardization

The process of finding the actual concentration of the secondary standard solution by titrating it with a suitable primary standard solution.

Indicator

A colored compound reagent added to the analyte solution to produce an observable physical change (usually change in color) at or near the equivalence point e.g: Phenolphthalein, Methyl Orange, Methyl red, etc.

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

Standard Solution

A reagent of known concentration used to carry out a titrimetric analysis(titration).

Types of standard solution

- Primary standard solution
- Secondary standard solution

REQUIREMENTS FOR THE PRIMARY STANDARD MATERIAL

1. Highest purity

2.Atmospheric stability

3.High solubility

4.High formula weight

5.Easily available at reasonable cost

Types of Titrations

- Acid-base titrations
- Complexometric titrations
- Redox titrations.
- Precipitation titrations

Acid- Base titrations

It is acid react with base to obtain salt and water:-

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HCI + NaOH \longrightarrow NaCI + H2O$$

Many compounds, both inorganic and organic, are either acids or bases and can be titrated with a standard solution of a strong base or a strong acid. The end points of these titrations to detect, by means of an indicator. The point at which the indicator changes color is called the end point .

Determination normality of sodium hydroxide solution by a standard solution of hydrochloric acid

Materials

- ❑HCl solution (standard) known normality.
- ❑NaOH solution of unknown normality.
- ❑Phenol naphthalene indicator.

Procedure

1- Transfer by a pipette **5 ml** of unknown **NaOH** solution to a conical flask.

2- Add to the conical flask two or three drops of phenol naphthalene indicator.

3- Fill the burette with **HCl** solution to zero mark.

4- Titrate NaOH against HCl until the color of solution changes from **colorless to pink**.

5- Repeat the experiment **three** times and record your results.

Calculations

1. Titrations results

Titrations	**1(trial)**	**2**	**3**
Final burette reading(ml)			
Initial burette reading(ml)			
Volume of HCI (ml)			

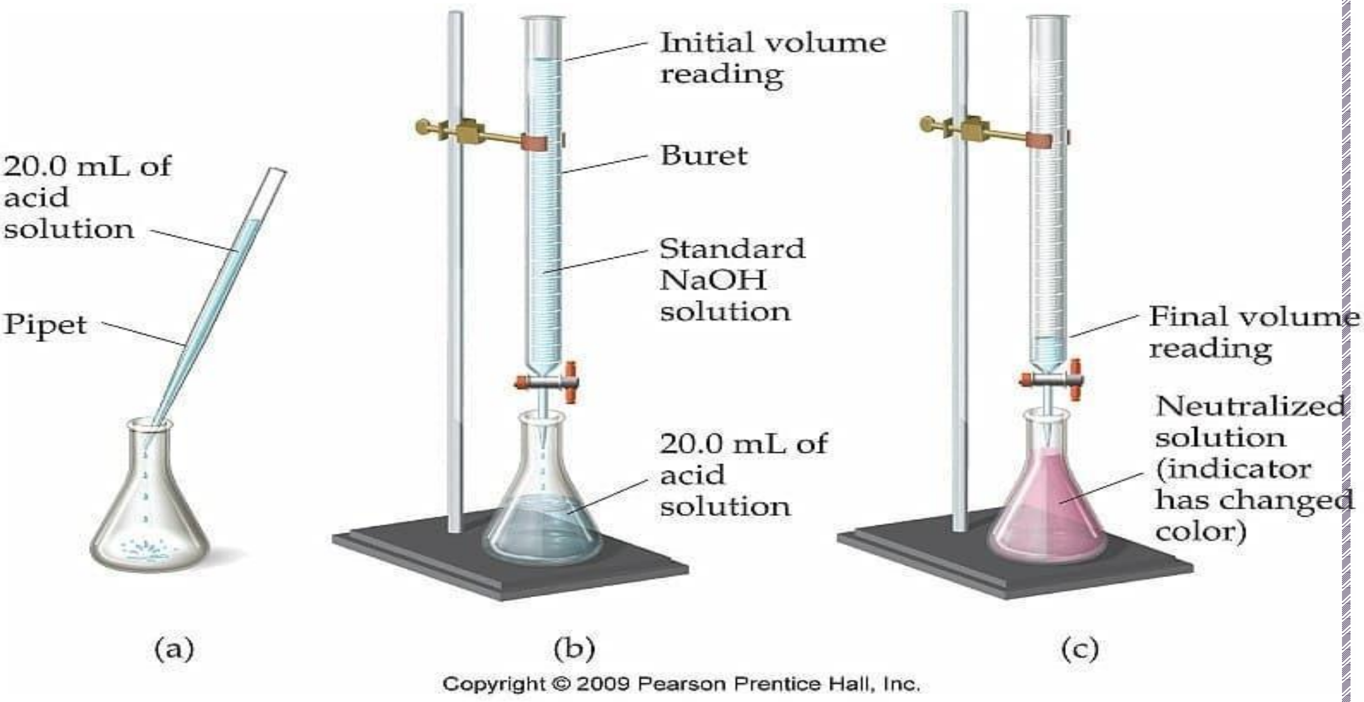
The volume of NaOH used in three times is **5 ml.**

2-Average volume of HCl used = (calculated from burette)

$$V\ average = V1 + V2 + V3$$

3-Then the unknown concentration calculated by using the law

$$(N1 \times V1)HCI = (N2 \times V2)NaOH$$



Complexometric titrations

Compound results from the combination of metal ion as (**acceptor**) with donor molecules (**ligand**) through coordinated bonds (donor→ acceptor) .

Metal ion + Ligand→ Coordination compound (complex)
(Lewis acid) **(Lewis base)**

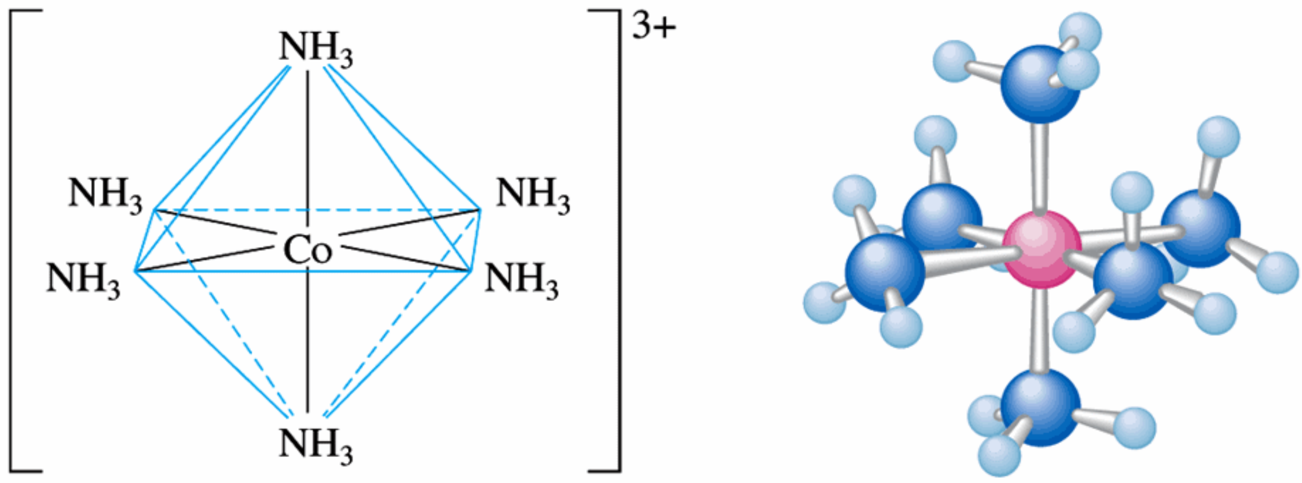
$$M^{n+} + L = (L \longrightarrow M)$$

Examples: $[Ag(NH_3)_2]^+$

Complex Ion = Transition Metal Cation Surrounded by Ligands
Ligand = Molecule or Ions of Nonbonding Electron Pairs
Bonding is Called "Coordination"

For the complex $[Co(NH_3)_6]^{3+}$

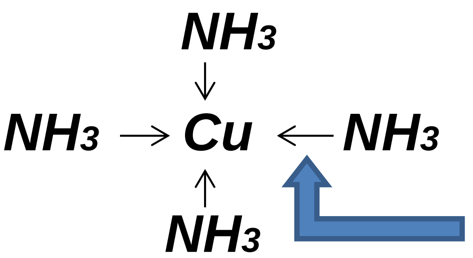
Co^{3+} is the electron acceptor and shares a pair of electrons with each of N-atom in NH_3



The $Co(NH_3)_6^{3+}$ ion

Complexometry

A volumetric titration involves the formation of soluble complex between metal ion (as acceptor) and ligand (as donor) to form coordination bonds.



Coordination bond

- **The metal ion is known as Central metal atom.**
- **The anion or neutral molecule is known as Ligand .**

Type of complexing agents (ligands)

This classification is according to the no. of sites attached to the metal ion

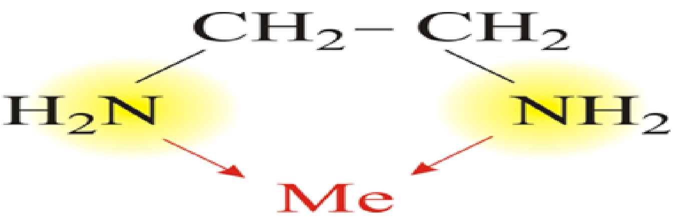
1. Monodentate Ligand or "Simple Ligand"

The ligand attached to metal at one site e.g. **H_2O , NH_3 , CN^-, Cl^-, I^-, Br^-**

$$H_3N \rightarrow Ag \leftarrow NH_3$$

2. Bidentate Ligands

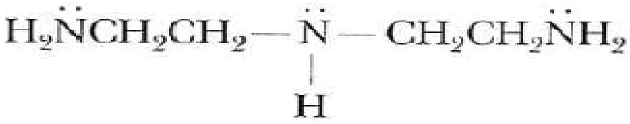
The ligand attached to metal at two sites.



Ethylene diamine

3. Tridentate Ligands

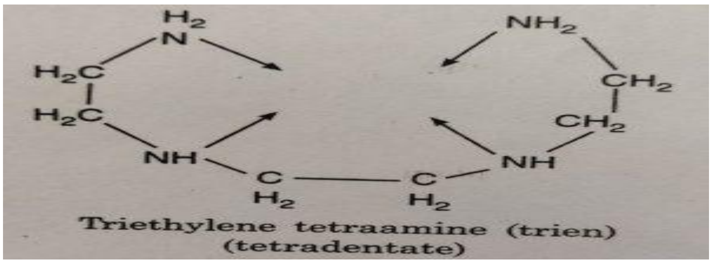
The Ligand attached to metal at 3 sites



Diethylenetriamine, dien

4. Tetradentate Ligands

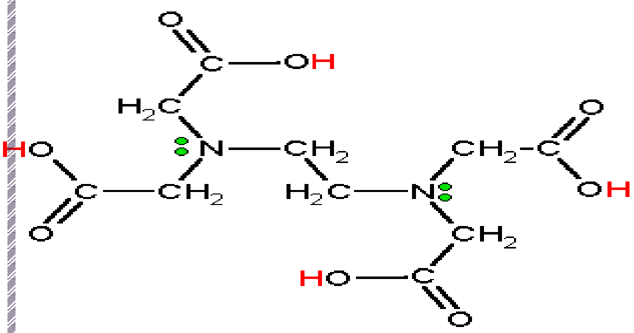
The Ligand attached to metal at 4 sites



Triethylene tetraamine (trien) (tetradentate)

5. Multidenate Ligands (Chelating Agent)

Substance with multiple sites available for coordination bonding with metal ions.



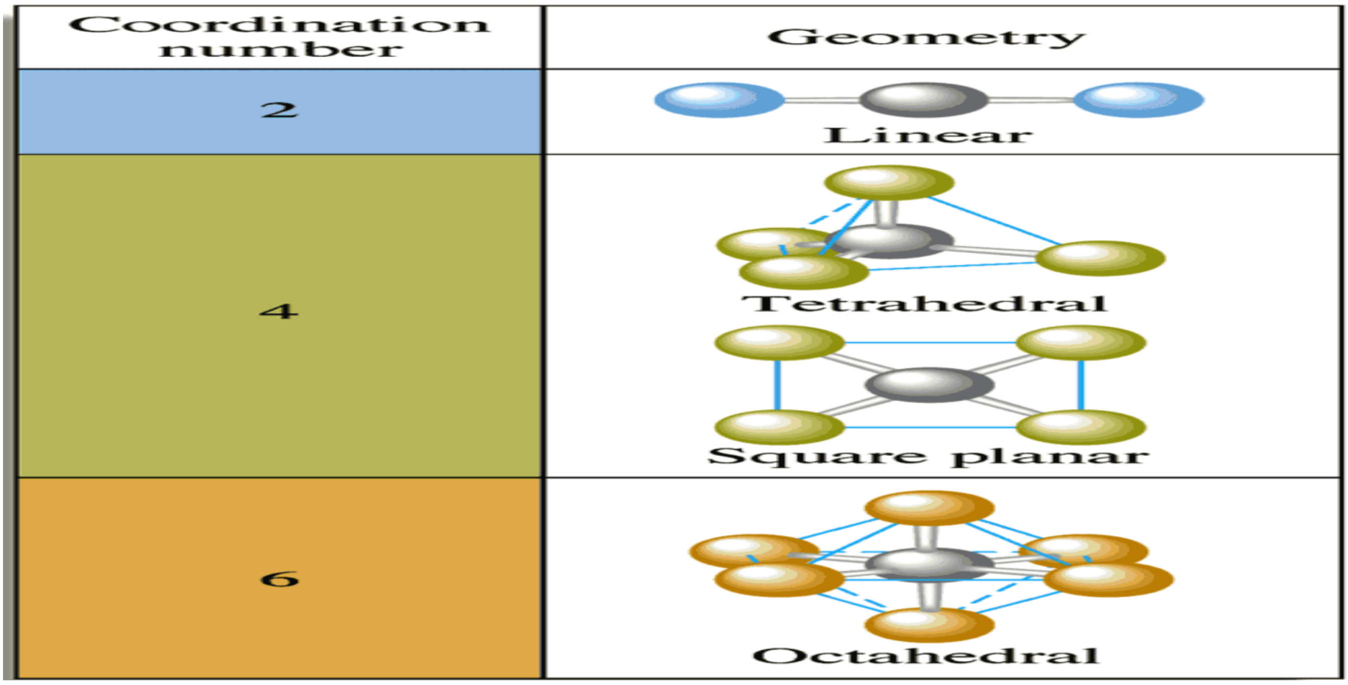
Ethylene Diamine Tetra acetic Acid (EDTA)

EDTA has the widest general application because:

1.It has low price 2.The special structure, which has six ligands atoms

Coordination Number

- The no. of coordinate bonds formed to a metal ion by their ligands.
- It could be 2, 4, 6, depending on the metal ion and its oxidation number.



Coordination number	Geometry
2	Linear
4	Tetrahedral Square planar
6	Octahedral

Reduction-Oxidation (Redox) titrations

- **Oxidation:** It can be defined as loss of electrons or increase in oxygen content.
- **Reduction:** It can be defined as gain of electrons or increase of hydrogen content.
- **Oxidizing agent:** substance which get reduced.
- **Reducing agent:** substance which get oxidized.

• Both processes are combined and occur together so we combine them in one word as **REDOX reaction** .

Oxidation-Reduction (Redox)

Reaction of ferrous ion with ceric ion

$Fe^{2+} + Ce^{4+} \longrightarrow Fe^{3+} + Ce^{3+}$

$Fe^{2+} — e \longrightarrow Fe^{3+}$ (Loss of electrons: **Oxidation**)

$Ce^{4+} + e \longrightarrow Ce^{3+}$ (Gain of electrons: **Reduction**)

- **In every redox reaction, both reduction and oxidation must occur.**
- **Substance that gives electrons is the reducing agent or reductant.**
- **Substance that accepts electrons is the oxidizing agent or oxidant.**

Oxidation Number (O.N)

- **The O.N of atoms in free un-combined elements = zero**
- **The O.N of an element in a compound may be calculated by assigning the O.N to the remaining elements of the compound using following rules:**

□The algebraic sum of the positive and negative O.N. of the atoms represented by the formula for the substance = zero.

□The algebraic sum of the positive and negative O.N. of the atoms in a polyatomic ion = the charge of the ion.

Oxidation Numbers of Some Substances

Substance	Oxidation Numbers
NaCl	**Na = +1 , Cl= -1**
LiH	**Li = +1, H = -1**
SO_4^{2-}	**O = -2 , S = +6**

Homework

Calculate The Oxidation Number of an Element

1) MnO_4^{-1} 2) H_2SO_4 3) $[Fe(CN)_6]^{-3}$

Precipitation titrations

In this type of titration, the titrant forms a precipitate with the analyte. Again, indicators can be used to detect the end point,...

e.g. $Cl^- + Ag^+ \rightarrow AgCl_{(s)}$ (white ppt)

1- The number of gm-equivalent of the solute per liter of solution is known as
   a) Normality b) Molality c) Molarity d) Mole fraction

2- The number of gm-mole of the solute per liter of solution is known as
   a) Normality b) Molarity c) Molality d) Mole fraction

3- The ratio of number of gm- mole of a component to total number of gm-mole in mixture or solution is known as
   a) Normality b) Molarity c) Molality d) Mole fraction

4- The process of adding known concentration until it complete thereaction with known volume is called as
   a)Titrant b)Analysis c)Titration d)Titrend

5- Both processes are combined and occur together so we combine them in one word as
   a) Oxidation b) Reduction c) Oxidizing agent d) REDOX reaction

PURIFICATION AND SEPARATION OF ORGANIC COMPOUNDS

Organic compounds, whether solids , liquids or gaseous, when are separated from organic reactions are seldom pure.

These organic compounds have to be purified before using them in other chemical reaction. Several methods of purification have to be :

1- Filtration.

2- Crystallization.

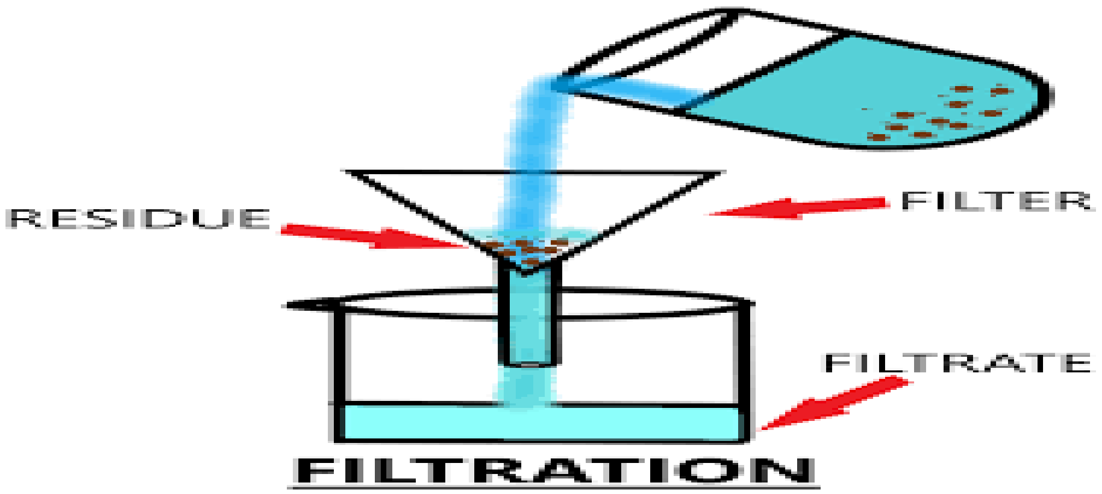
3- Sublimation.

4- Extraction.

5- Distillation.

1- Purification of organic compound by Filtration:

This method is used to separate two solids advantage is taken of the fact that one component of a mixture of two substances may be readily soluble in a given solvent , whereas the other components (impurities) may be relatively insoluble . the **less insoluble** components will remain on filter paper .



2- Purification of organic compound by Crystallization:

Crystallization is one phenomena which is involved in the production of pure crystals form solution, after dissolving the impure substance in a suitable solvent or mixture of solvents.

The choice of the solvent is very important in this process, water or any other organic solvent (ethyl alcohol, methyl alcohol, acetone, ………..etc.)

- **Ether could be avoided whenever possible for its high inflammability.**

It is also assumed that:-

1- The solvent should not react chemically with the substance to be purified.

3- It should dissolve the substance readily.

EXPERIMENTAL PROCEDURE:-

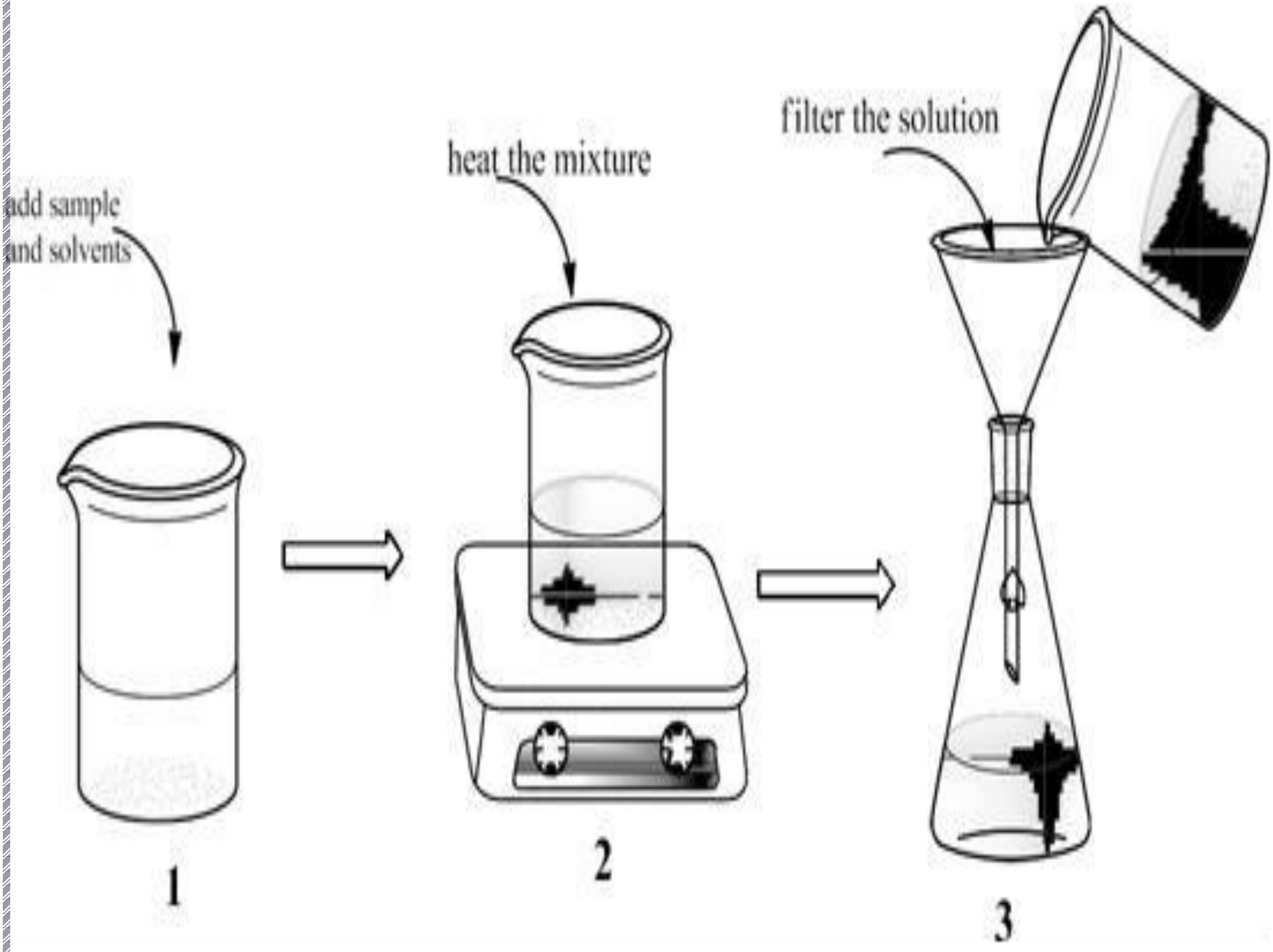
1- Weight about 0.5g of sample (impure benzoic or salicylic acid).

2- Add about 10 ml of solvent (distilled water)

3- Warm the solution of mixture till most of sample dissolve (except impurities)

4- Filter the mixture and examine the residues on filter paper.

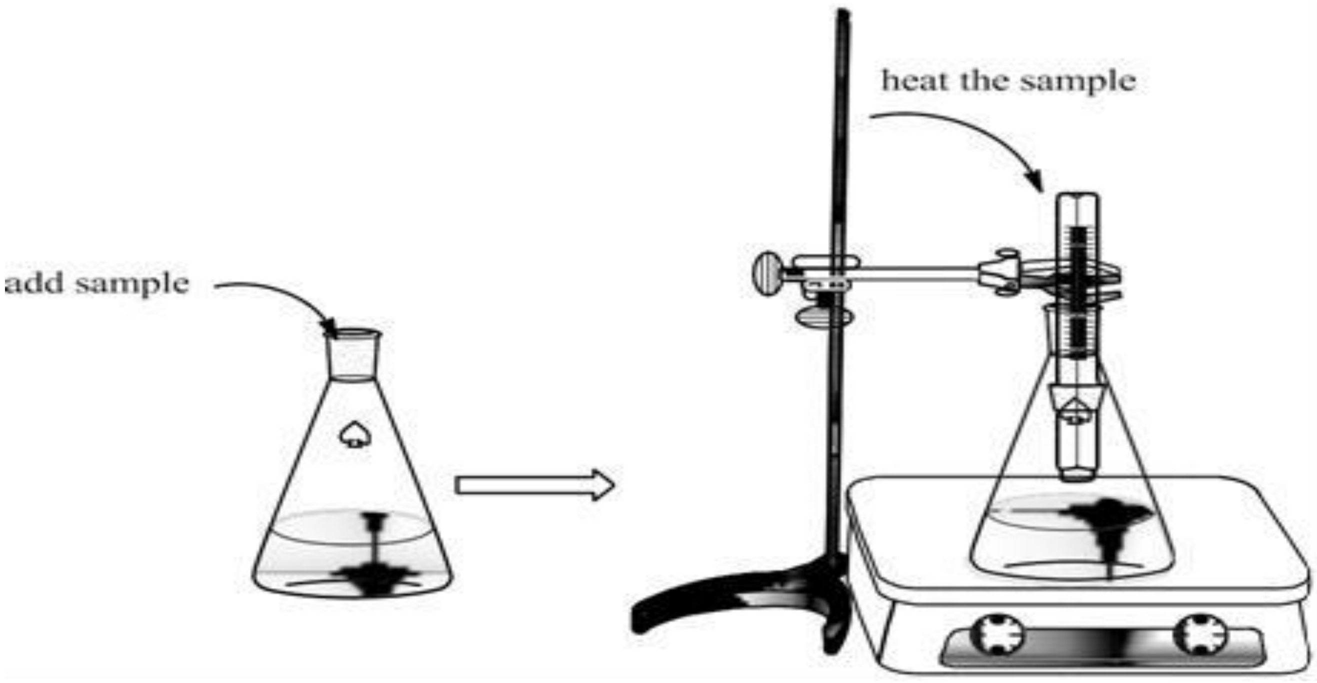
5- Allow the solution to cool and note appearance of pure crystals of the pure sample.



4- Purification of solid organic compound by

Sublimation:

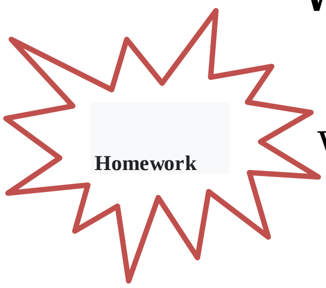
Sublimation :- is the transformation of certain solid organic compound directly to the vapour state at high temperature, then condensing on a cold surface to the solid state without passing through the intermediate liquid state.



1) Weight about 0.5g of sample (benzoic and sugar).
2) Transfer sample into conical flask.
3) Fix test tube in the top of the conical and full the tube with cold water.
4) Heat the conical flask and note the result.

Calculations

$$\% \text{ Yield} = \frac{\text{Weight of product}}{\text{Weight of sample}} \times 100$$



What is the compounds which purification by sublimation ?

4. Separation and Purification of Organic Compounds by

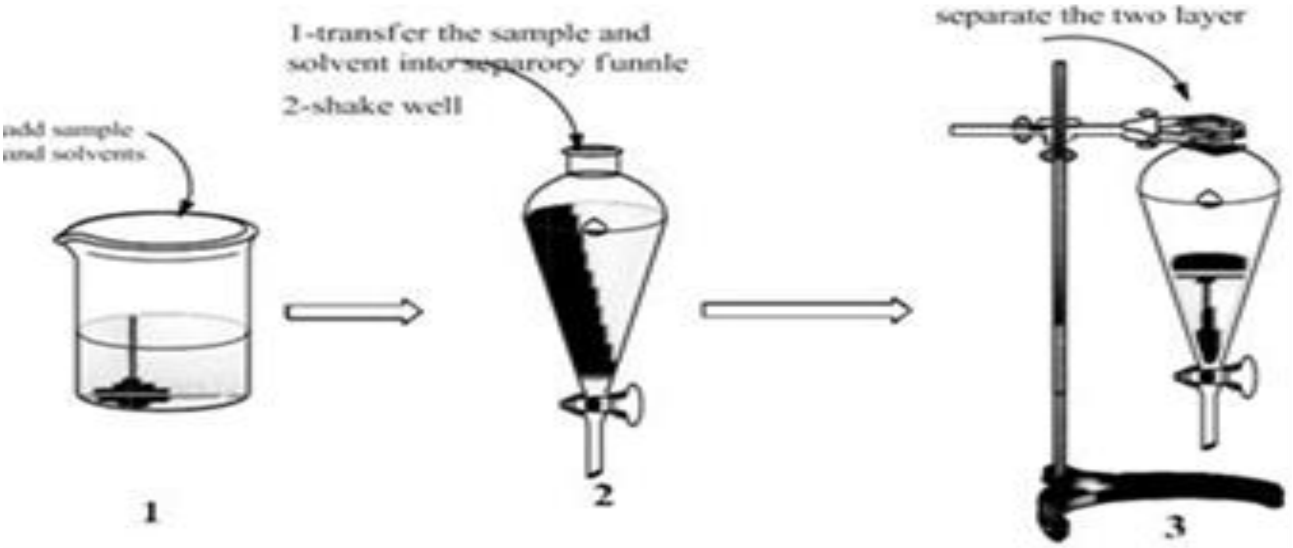
Extraction with Solvents:

This method is used for separation of two immiscible liquids (differs in density) or two solids dissolved in two immiscible liquids. means that they will form two layers when added together .

- **The lighter liquids on the top and the heavier liquid on the bottom .**

Procedure:

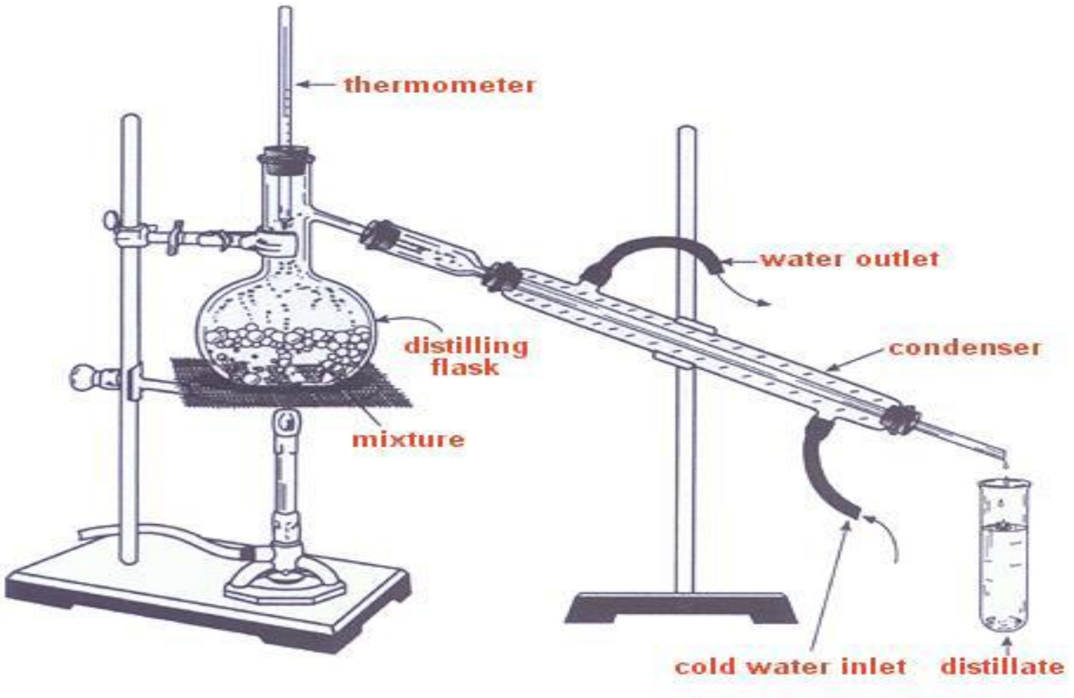
1) Weight about 0.5g of sample (benzoic or salicylic acid and sugar) and mix them.
2) Add 5 ml of each the two solvent (sugar dissolve in water while benzoic or salicylic acid dissolve in organic solvent such as Chloroform, dichloromethane , ethyl acetate).
3) Transfer the solution of mixture to the separating funnel and shake well.
4) Allow the two liquids to separate into clear layers and then separate the water and chloroform.
5) Pour chloroform layer into small beaker and evaporate till dryness.



5- Separation and Purification of Organic Compounds by

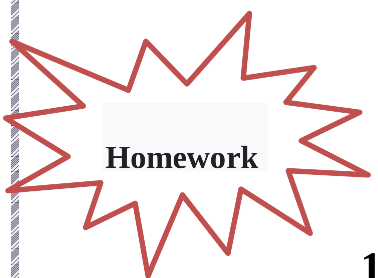
Distillation:

It is the process of heating a liquid until it boils, then condensing and collecting the resultant hot vapors.



Distillation apparatus

❖ **Distillation fall into two main kinds:** simple and fractional distillation.



1- Define the extraction ?

2-What is the principle of extraction ?

3-Define the Distillation ?