Acids, Bases and Salts of Medical Interestes

Acids:

An acid is any coumpound that ionized in water to form hydrogen ions. Certain acids ionize completely when dissolved in water such acids are called **strong acids**such as (HCl, HBr, HI, HNO_3 and H_2SO_4 are strong acids).

Other acids ionized only slightly when dissolved in water such acids are called **weak acids**. An example is acetic acid (CH_3COOH), when dissolved in water 2% of the molecules ionize to form hydrogen and acetate ions according to the following equation:

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

(H_2CO_3, HF, and HCN are also weak acids).

Another way of classifying acids is by the number of hydrogen ions they form when dissolved in water.one H in a molecule that can form hydrogen ions is called a monoprotic acid, e.g. $H^+ Cl^-$ A diprotic acid will give two H^+ , e.g. H_2SO_4 . A triprotic acid will give three H^+ e.g acid is phosphoric acid, H_3PO_4.

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

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{-2}$ Diprotic acid

$H_3PO_4 \longrightarrow 3H^+ + PO_4^{-3}$ Triprotic acid

The two hydrogen ions of H_2SO_4 are formed in two separate steps as shown by the following equations:

$$H_2SO_4 + H_2O \longrightarrow \underset{\text{Bisulfate ion}}{HSO_4^-} + H_3O^+$$

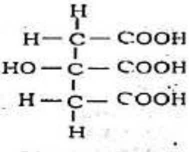
$$HSO_4^- + H_2O \longrightarrow \underset{\text{Sulfate ion}}{SO_4^{-2}} + H_3O^+$$

The strength of an acid depends on the concentration of H^+ ions formed in solution. Strong acids produce a high concentration of H^+ ions whereas weak acids produce a low H^+ concentration in solution.

Properties of Acids:

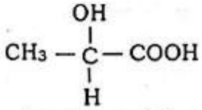
1-The hydrogen atoms of an acidic molecule that are released to form ions in water are called ***acidic hydrogens***. In acids such as HCl, H_2SO_4, and HNO_3, all the hydrogens in the compound are acidic. In acetic acid (CH_3COOH), only one of the hydrogens is acidic.

2-Not all the acids are liquids, also there are many solid acids, like boric acid (H_3BO_4) and citric acid.



Citric acid:

3-The acid taste of the acids is due to the hydrogen ions produced when these acids dissolved in water. So citric acid is responsible for the acidictaste of lemon and grapfruit juices. Acitic acid is responsible for the acidity of vinegar. Lactic acid is responsible for the acidity of yogurt.



$$CH_3-\overset{\overset{\large OH}{|}}{\underset{\underset{\large H}{|}}{C}}-COOH$$

Lactic acid

4-When acids react with certain compounds, these compounds change in color. Substances that change in color in the presence of acids are called **indicators**.One of the most indicators for acids is **litmus**. Blue color of litmus paper converted to red color in the presence of an acid. Another common indicator – **phenonlphthalein** turns from red to colorless in the presence of an acid.

Chemical Reactions of Acids:

1-Acids react with metal oxides and hydroxides to form water and a salt. (in neutralization reaction solution is neither Basic)

$$2HCl + MgO \longrightarrow MgCl_2 + H_2O$$

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

2-Acid react with Na, Ca, Mg, Zn, Fe, Sn, and Pb to produce hydrogen gas and a salt.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2 \uparrow$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2 \uparrow$$

So acids cannot be stored in containers made of these metals.

Iron can react with acids, therefore, acids slould not be allowed to come in the content of sugrical and dental insutruments.

3-Acids react with carbonate and bicarbonate to produce carbon dioxide, water, and salt.

$$2HCl + CaCO_3 \longrightarrow CaCl_2 + H_2CO_3$$

$$H_2SO_4 + 2NaHCO_3 \longrightarrow Na_2SO_4 + 2H_2CO_3$$

Where,

$$H_2CO_3 \longrightarrow CO_2 + H_2O$$

Ionization of acid

The degree of ionization of any acid is given by its *ionization* constant (K_a). The equilibrium constant for the ionization of an acid in water is defined as its ionization constant.

$$C_2H_3O_2H + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$$

$$K = \frac{[H_3O^+][C_2H_3O_2^-]}{[H_2O][C_2H_3O_2H]} \qquad [H_3O^+] = [H^+]$$

$$K\,[H_2O] = K_a = \frac{[H^+][C_2H_3O_2^-]}{[C_2H_3O_2H]} \qquad \text{"ionization constant"}$$

$$H_2CO_3 + H_2O \rightleftharpoons H_3O^+ + HCO_3^- \qquad K_{a1} = \frac{[H^+][HCO_3]}{[H_2CO_3]}$$

$$HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^- \qquad K_{a2} = \frac{[H^+][CO_3^-]}{[H_2CO_3]}$$

- Strong acids have large value of K_a.
- Weak acids have small value of K_a.

  $PK_a = -\log K_a$

Uses of Acids:

1- HCl: Pateint who have a lower than normal amount of hydrochloric acid in the stomach, condition called hypoacidity, are given dilute hydrochloric acid orally before meals to overcome this deficiency.

2- Acetylsalisalic acid (aspirin): Aspirin is frequently taken by people with a cold to relieve headache, muscle pain, and fever.

3- Ascorbic acid (Vitamin C): Is found in oranges and used mainly in the treatment of scurvy,absorption of iron and the maintenance of bones, and **teeth**. Vitamin C is one of many ***antioxidants*** that can protect against damage caused by *free radicals*, as well as toxic chemicals and pollutants like cigarette smoke. Deficiency of vitamin C causes loose **teeth**

Acids Effect on Teeth

1-Dental erosion is the loss of the surface of the teeth due to acidic food and acidic drink or acids coming up from the stomach. These acids can dissolve the crystals that make up the teeth, leading to tooth surface loss. These acids can also soften the tooth surface

2-After consuming something sugary or starchy, oral bacteria eats whatever food remains in the mouth after meals and produces acid as a waste product.

3- people who suffer from strong acid reflux or who vomit regularly also expose their teeth to their own strong stomach acid, which can increase tooth decay.

4- Enamel and hard tooth structures demineralize at pH of 5 or 5.5. During the demineralization process, calcium ions from our teeth leave enamel and make them weak or porous.

Arrhenius's base**:**

A base is any compund that increase the hydroxide ion concentration in water. Bases are also called alkaline substances(An alkali is a solution of a base in water). Sodium hydroxide (NaOH) is a common example of a base. When dissolved in water, hydrated sodium ions and hydroxide ions are formed.

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

Other common bases are potassium hydroxide (KOH), Calcium hydroxide ($Ca(OH)_2$) and magnesium hydroxide ($Mg(OH)_2$). These bases all exist as ions in aqueous solution and are all called strong bases.

Calcium hydroxide and magnesium hydroxide differ from Sodium hydroxide and potassium hydroxide, they are both only slightly soluble in water.

Weak bases such as

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

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

$$C_5H_5N + H_2O \rightleftharpoons C_5H_5NH^+ + OH^-$$

Properties and Reactions of Bases:

1-Soluble bases are called alkalis, e.g. sodium hydroxide, NaOH , potassium hydroxide, KOH, and ammonium hydroxide, NH4OH.

2-. Bases are oxides or hydroxides of metallic elements.

3-Bases and alkalis will react with acids to neutralize them, forming salts plus water:

Acid + Base → Salt + water
Acid + alkali → Salt + water

4-All alkalis contain a hydroxide ion, OH^- , that will react with and 'pick up' a H^+ ion to form a water molecule.

5-Bases are produced when metalic oxides are dissolved in water.

$$\underset{\text{Calicium oxide}}{CaO + H_2O} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

6-Bases react with indicators. They turn litmus color from red to blue, turn methyl orange from red to yallow, and turn phenolphthalein from colorless to red.

7-Bases neutralize acids to form water and salt.

$$Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + H_2O$$

8- Strong bases react with certain metals to produce hydrogen gas.

$$2Al^{+3} + 6NaOH + 6H_2O \longrightarrow 3H_2 + \underset{\text{Sodium aluminate}}{2Na_3Al(OH)_6}$$

Thus a strong base such as (NaOH) can not stored in an aluminum container because it will react with it and dissolve the container.

9-Strong bases can dissolve lipids and proteins.

Ionization of Base

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

$$K = \frac{[NH_4^+][OH^-]}{[H_2O][NH_3]}$$

$$K[H_2O] = K_b = \frac{[NH_3][OH^-]}{[NH_3]}$$

$$PK_b = -\log K_b$$

- Weak bases have small K_b.
- Strong bases have large K_b.

Uses of Bases:

1-Calcium hydroxide solution $Ca(OH)_2$: It is used to overcome excess acidity in the stomach.

2-Magnesium hydroxide $Mg(OH)_2$: It is used as a laxative.

3-Bases referred to in medicine and biology usually contain nitrogen atoms (nitrogenous bases', which is a term often used in relation to amines, amino acids and proteins)that have the ability to pick up a proton and become a positive ion:

Amphoteric substances: *are substances which can react as both an acid .and a base like water (H_2O)*

$$HNO_2 + H_2O \rightarrow NO^-_2 + H_3O^+.$$

Acid1 base2 base1 acid2

$$NH_3 + H_2O \rightarrow NH^-_4 + OH^-$$

Base1 acid2 acid1 base2

Bronsted Acids and Bases

- Acid any compound or ion that donates a proton.
- Base any compound or ion that accepts a proton.

Hydrogen chloride HCl/ conjugate acid- base pair

$$HCl + H_2O \rightleftharpoons H_3O + Cl^-$$

Conjugate acid-base pair

Conjugate acid-base pair

$$NH_3 + H_3O \rightleftharpoons H_2O + NH_4^+$$

Conjugate acid-base pair

$$H_2O + H_2O \leftrightarrows H_3O^+ + OH^-$$

Acid1 base2 acid2 base1

$$HCO_3^- + H_3O^+ \rightleftharpoons H_2O + H_2CO_3$$ "Amphoteric behavior "

Base1 acid2 base2 acid1

$$HCO_3^- + OH^- \rightleftharpoons H_2O + CO_3^{-2}$$

Acid1 base2 acid2 base1

$$H_2O + HCl \rightleftharpoons H_3O^+ + Cl^-$$

The stronger the acid, the weaker is its conjugate base. The weaker an acid, the stronger is its conjugate base.

Lewis acids and bases

A Lewis acid is defined to be any species that accepts one pair electrons.

- A Lewis base is any species that donates one pair electrons.

salts

A salt is any ionic compound composed of positively charged cations and negatively charged anions, so that the product is neutral and without a net charge. These ions can be inorganic (Cl^-) as well as organic ($CH3COO^-$) and monoatomic (F^-) as well as polyatomic ions ($SO4\ 2^-$). Salts are formed (as well as water) when acids and bases react.

Classification of salts

1- Neutral salts:When strong acid reacts with strong base the products will be neutral salt and water for that the solution pH will 7 such as NaCl and Na_2SO_4

$HCl + NaOH \rightarrow NaCl$ (neutral)

2- Basic salts: When weak acid reacts with strong base the products will be basic salt and water for that the solution pH will more than 7 such as $C_2H_3O_2Na$ (weak acid and strong base)

3- Acidic salts: When strong acid reacts with weak base the products will be acidic salt and water for that the solution pH will less than 7 such as NH_4Cl

<u>Ionization of water</u>

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

Ionization

$[H_3O^+] = [H^+] = 1 X 10^{-7}$ M and $[OH^-] = 1 X 10^{-7}$ M

K= ¿¿

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

$H_2O \leftrightharpoons H^+ + OH^-$ $[H_3O^+] = [H^+]$

$K = K_w = [H^+][OH^-]$

$= [1X10^{-7}][1X10^{-7}] = 1X10^{-14}$

An aqueous solution in which $[H^+]$ is greater than $[OH^-]$ is "acidic solution". In a basic solution $[OH^-]$ is greater than $[H^+]$.

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

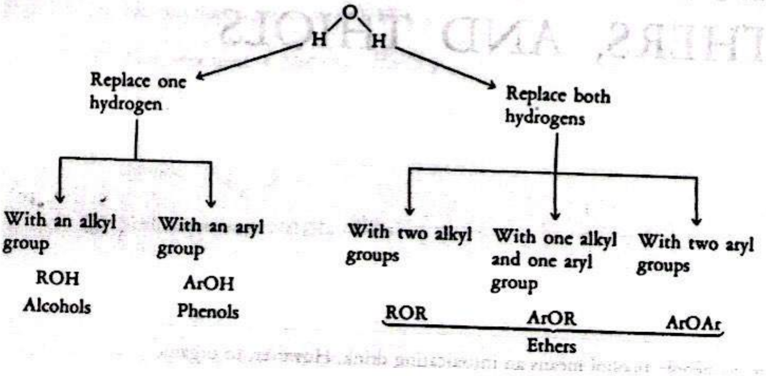
$pOH=-\log[OH^-]$

$pH+pOH=14$ (neutral solution)

An aqueous solution in which pH is less than 7 is "acidic solution". In a basic solution pH is greater than 7.

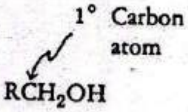
Alchols

Alcohols can be viewed as organic analogues of water in which one hydrogen is replaced by an alkyl group(R-OH)

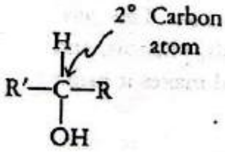


Classification of alcohols

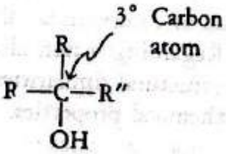
Primary alcohol is a compound in which the hydroxyl group is bonded to a primary carbon.In a secondary alcohol the hydroxyl group is bonded to secondary carbon .In the tertiary alcohol the hydroxyl group is bonded to tertiary carbon.



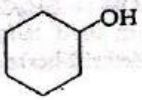
Primary alcohol



Secondary alcohol



Tertiary alcohol

CH_3OH	CH_3CH_2OH	$CH_3CH_2CH_2CH_2OH$
Methyl alcohol	Ethyl alcohol	Butyl alcohol
$CH_2{=}CHCH_2OH$	$(CH_3)_3CCH_2OH$	
Allyl alcohol	Neopentyl alcohol	Cyclohexyl alcohol

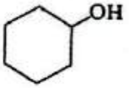
Naming of alcohols

Alcohols containing more than five carbons are best named by the IUPAC rules. The following additions to the rules set out in Chapter 11 are needed to deal with alcohols:

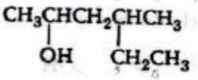
1. The longest continuous chain of carbon atoms that contains the hydroxy group is taken as the parent chain.
2. The parent name is obtained by substituting the ending *-ol* for the ending *-e* of the corresponding alkane.
3. The chain is numbered to give the lowest number to the carbon bonded to the hydroxyl group.
4. The suffix *-ol* is used for one hydroxy group; *-diol*, for two; *-triol*, for three, and so forth.

CH_3CH_2OH

Ethanol



Cyclohexanol



$$\underset{OH}{CH_3\overset{|}{C}HCH_2}\underset{CH_2CH_3}{\overset{|}{C}HCH_3}$$

4-Methyl-2-hexanol

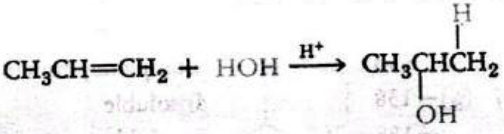
$CH_2{=}CHCH_2OH$

2-Propen-1-ol

Notice that when a double bond (or a triple bond) is part of the parent chain, the hydroxy group is given the lowest number.

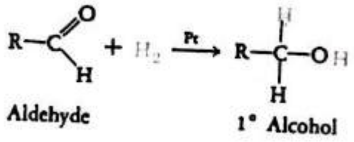
Preparing Alcohols

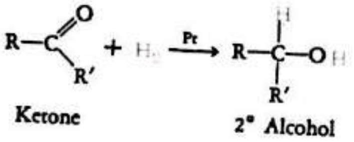
1-hydration of alkene



$$CH_3CH{=}CH_2 + HOH \xrightarrow{H^+} CH_3\underset{OH}{C}H\overset{H}{C}H_2$$

2-reduction of carboxyl compounds

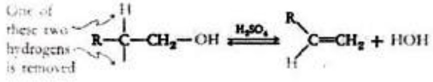


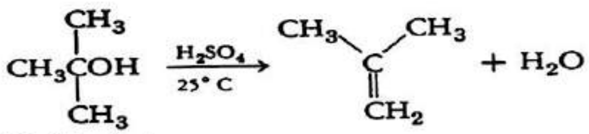


Reactions of Alcohols

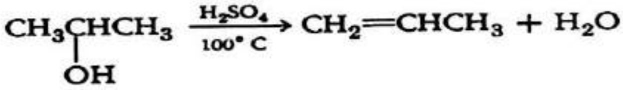
Dehydration

Alcohols react with concentrated sulfuric acid (H_2SO_4) to eliminate a molecule of water to form an alkene, as shown by the following equation:





3° Alcohol



$$CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_3 \xrightarrow[100°\,C]{H_2SO_4} CH_2{=}CHCH_3 + H_2O$$

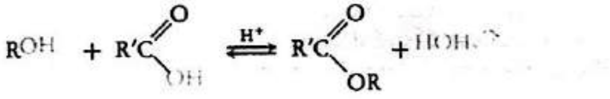
2° Alcohol

$$CH_3CH_2OH \xrightarrow[150°\,C]{H_2SO_4} CH_2{=}CH_2 + H_2O$$

1° Alcohol

Ester Formation

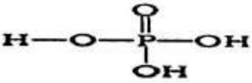
Alcohols react with carboxylic acids in the presence of a strong acid catalyst to form a class of compounds called esters. The general equation for this reaction is the following:



Alcohol Carboxylic acid Ester

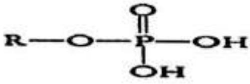
Alcohols also react with mineral acids to form compounds that are called esters of inorganic acids. In these compounds the acidic hydrogen of the inorganic acid is replaced by an alkyl group. Alkyl phosphates are an important class of such compounds in living systems. Their relation to phosphoric acid is clear from the following example:

Phosphoric acid



$$\mathrm{H{-}O{-}\underset{\displaystyle OH}{\overset{\displaystyle O}{\overset{\|}{\underset{|}{P}}}}{-}OH}$$

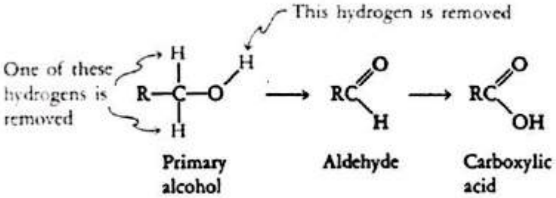
Alkyl phosphate

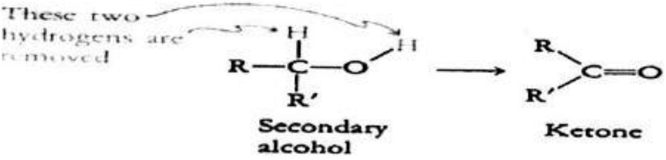


$$\mathrm{R{-}O{-}\underset{\displaystyle OH}{\overset{\displaystyle O}{\overset{\|}{\underset{|}{P}}}}{-}OH}$$

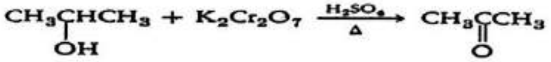
Oxidation

The products of oxidation of alcohols depend on the structure of the alcohol. Primary alcohols are first oxidized to aldehydes, which are further oxidized to carboxylic acids. Secondary alcohols form ketones on oxidation, and tertiary alcohols are not easily oxidized.





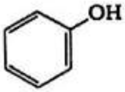
$$CH_3CH_2CH_2OH + KMnO_4 \xrightarrow[\Delta]{KOH} CH_3CH_2CO_2H$$



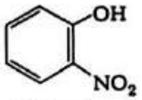
$$CH_3\underset{OH}{\underset{|}{C}}HCH_3 + K_2Cr_2O_7 \xrightarrow[\Delta]{H_2SO_4} CH_3\underset{O}{\underset{\|}{C}}CH_3$$

Phenols

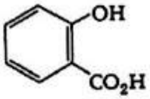
Phenols are compounds that contain a hydroxy group bonded to a benzene ring. The following are examples of phenols:



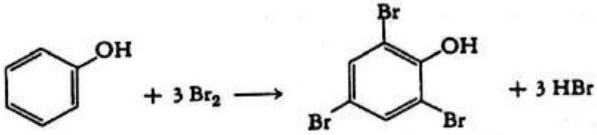
Phenol



2-Nitrophenol



Salicylic acid

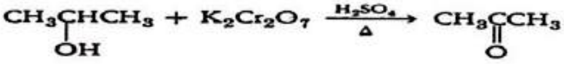


Phenol

2,4,6-Tribromophenol

Phenols differ from alcohols in one important way.Phenols are much stronger acids than are alcohols.

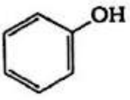
$$CH_3CH_2CH_2OH + KMnO_4 \xrightarrow[\Delta]{KOH} CH_3CH_2CO_2H$$



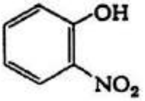
$$\underset{OH}{CH_3CHCH_3} + K_2Cr_2O_7 \xrightarrow[\Delta]{H_2SO_4} \underset{O}{\overset{}{CH_3CCH_3}}$$

Phenols

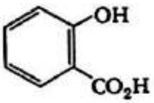
Phenols are compounds that contain a hydroxy group bonded to a benzene ring. The following are examples of phenols:



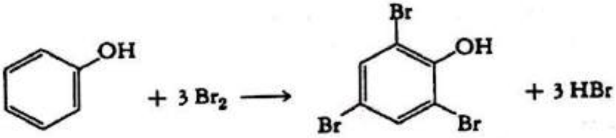
Phenol



2-Nitrophenol



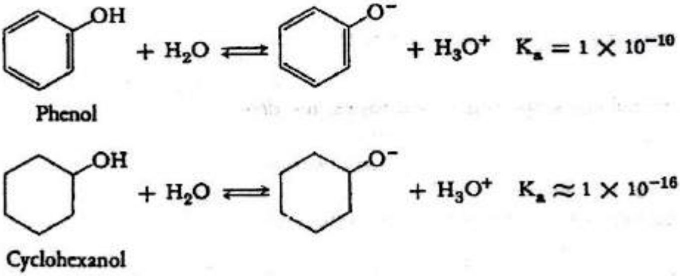
Salicylic acid



Phenol

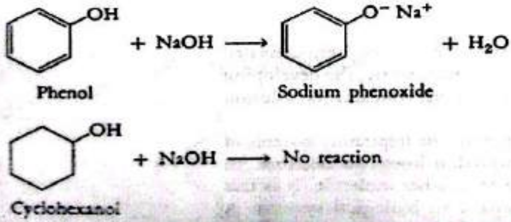
2,4,6-Tribromophenol

Phenols differ from alcohols in one important way.Phenols are much stronger acids than are alcohols.

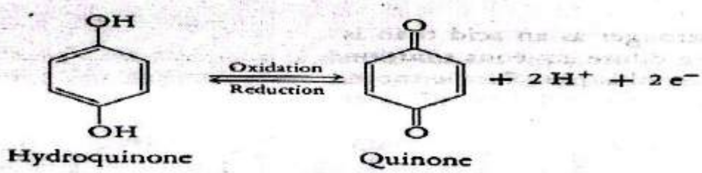


Dilute aqueous solution of phenol is acidic, whereas cyclohexanol not.

Phenol reacts with bases such as hydroxide ion , whereas cyclohexanol not.



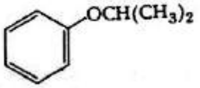
Reduction of quinone



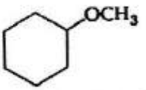
Ethers are compounds that contain an oxygen atom bonded to two alkyl groups, two aryl groups, or one aryl and one alkyl group. Ethers, like most other classes of organic compounds, can be named either by a common method or by IUPAC rules. The simpler ethers are usually known by their common names. By this method, the word ether is used as a root, and the names of the two groups bonded to the oxygen are prefixed alphabetically. The following examples illustrate this method:

$CH_3CH_3OCH_2CH_3$

Diethyl ether



Isopropyl phenyl ether

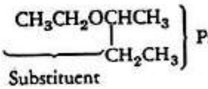


Cyclohexyl methyl ether

Notice that the individual parts of the name are separated by a space.

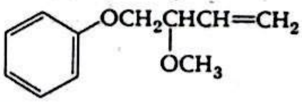
To name ethers by the IUPAC rules, the more complicated group attached to the oxygen is chosen as the parent. By complicated, we mean the group that is the most branched or the most substituted or has the longest chain. The other group and the oxygen are considered as substituents on this chain. For example:

$\underbrace{CH_3O}_{\text{Substituent}}\underbrace{CH_2CH{=}CH_2}_{\text{Parent chain}}$

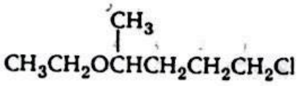


$\underbrace{CH_3CH_2O}_{\text{Substituent}}\left.\begin{array}{l}CHCH_3\\ |\\ CH_2CH_3\end{array}\right\}$ Parent chain

The substituent is named as a prefix, and its name is constructed by replacing the *-yl* of the alkyl name or phenyl by *-oxy*. In this way, $CH_3O—$ is called methoxy; $C_6H_5O—$, phenoxy; $CH_3CH_2O—$, ethoxy, and so forth. The following examples illustrate the application of these rules:



3-Methoxy-4-phenoxy-1-butene

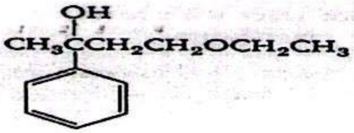


$CH_3CH_2O\overset{CH_3}{\overset{|}{C}}HCH_2CH_2CH_2Cl$

1-Chloro-4-ethoxypentane

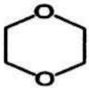
$CH_3OCH_2CH_3$

Methoxyethane



4-Ethoxy-2-phenyl-2-butanol

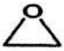
The following cyclic ethers have widely used common names:



Dioxane

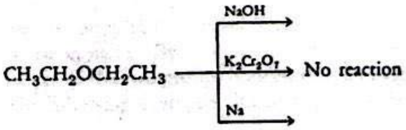
Tetrahydrofuran

Pyran



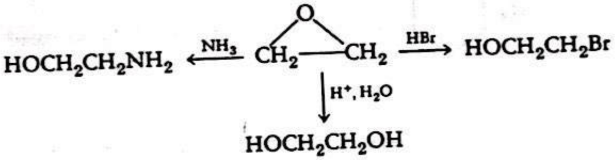
Ethylene oxide

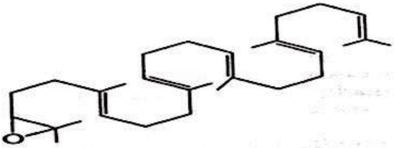
Ethers are quite unreactive. For example, they do not react with bases, most oxidizing reagents, or metals such as sodium or magnesium.



However, ethers do react with acids. The products of the reaction with hydroiodic acid (HI) are an alkyl iodide and an alcohol. For example:

$$\underset{\text{Diethyl ether}}{CH_3CH_2OCH_2CH_3} + \underset{\text{Hydroiodic acid}}{HI} \xrightarrow{\Delta} \underset{\text{Ethyl iodide}}{CH_3CH_2I} + \underset{\text{Ethyl alcohol}}{CH_3CH_2OH}$$





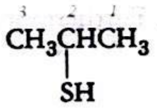
Squalene 2,3-epoxide

Thiols

Thiols are the sulfur analogues of alcohols and contain the $-\underset{|}{\text{C}}-\text{SH}$ functional group. The IUPAC names of thiols are formed by adding the suffix *-thiol*, *-dithiol*, and so forth to the name of the parent hydrocarbon. Common names are obtained by first naming the alkyl group followed by the word ***mercaptan***. It is sometimes necessary to name the functional group by the prefix ***mercapto-***. The following examples illustrate these rules:

CH_3CH_2SH

Ethanethiol
(ethyl mercaptan)



$CH_3CH(SH)CH_3$

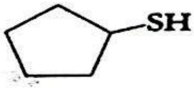
2-Propanethiol
(isopropyl mercaptan)

$HSCH_2CH_2SH$

Ethanedithiol

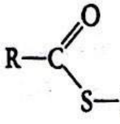
$CH_3CH(SH)CH_2OH$

2-Mercapto-1-propanol



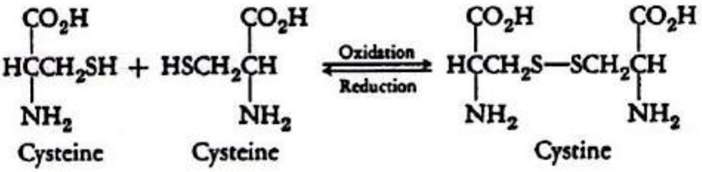
Cyclopentanethiol

Thiols are more volatile than are the corresponding alcohols and have a very disagreeable odor. Various thiols are found in nature. A number of thiols are responsible for the odor of a skunk; 1-propanethiol is released when an onion is peeled, and thiols are responsible for the odor of garlic. Thiols are highly reactive and are present in small quantities in living systems, where they play key roles.



$$\underset{\text{Thiol}}{4\,RCH_2SH} + O_2 \xrightarrow{Fe} \underset{\text{Disulfide}}{2\,RCH_2SSCH_2R} + 2\,H_2O$$

Notice that the oxidation of a thiol occurs at the sulfur atom, whereas oxidation of an alcohol occurs at the carbon atom.

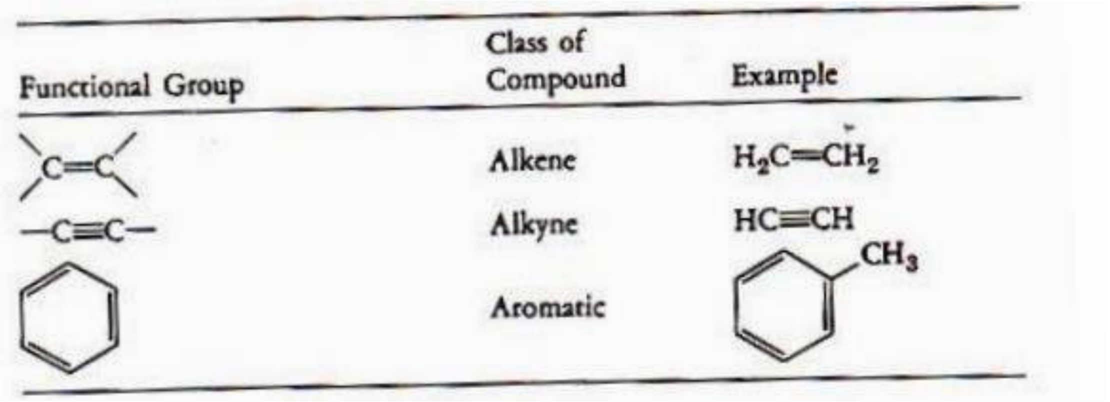


$$\underset{\text{Cysteine}}{\mathrm{H}\overset{\mathrm{CO_2H}}{\underset{\mathrm{NH_2}}{\mathrm{C}}}\mathrm{CH_2SH}} + \underset{\text{Cysteine}}{\mathrm{HSCH_2}\overset{\mathrm{CO_2H}}{\underset{\mathrm{NH_2}}{\mathrm{C}}}\mathrm{H}} \underset{\text{Reduction}}{\overset{\text{Oxidation}}{\rightleftharpoons}} \underset{\text{Cystine}}{\mathrm{H}\overset{\mathrm{CO_2H}}{\underset{\mathrm{NH_2}}{\mathrm{C}}}\mathrm{CH_2S{-}SCH_2}\overset{\mathrm{CO_2H}}{\underset{\mathrm{NH_2}}{\mathrm{C}}}\mathrm{H}}$$

Cystine is important in protein structure because its disulfide bond serves as a covalent cross-link between two polypeptide chains. This reaction is reversible. Many mild reducing agents break the disulfide bond of cystine to form two molecules of cysteine.

Functional Groups

The chemical reactions of organic compounds occurred at specific sites in the molecules. These sites usually contained specific atoms or groups of atoms bonded to carbon. These groups at which reactions occur are called functional group.



Functional Group	Class of Compound	Example
$>C=C<$	Alkene	$H_2C=CH_2$
$-C\equiv C-$	Alkyne	$HC\equiv CH$
	Aromatic	CH_3

Alkanes

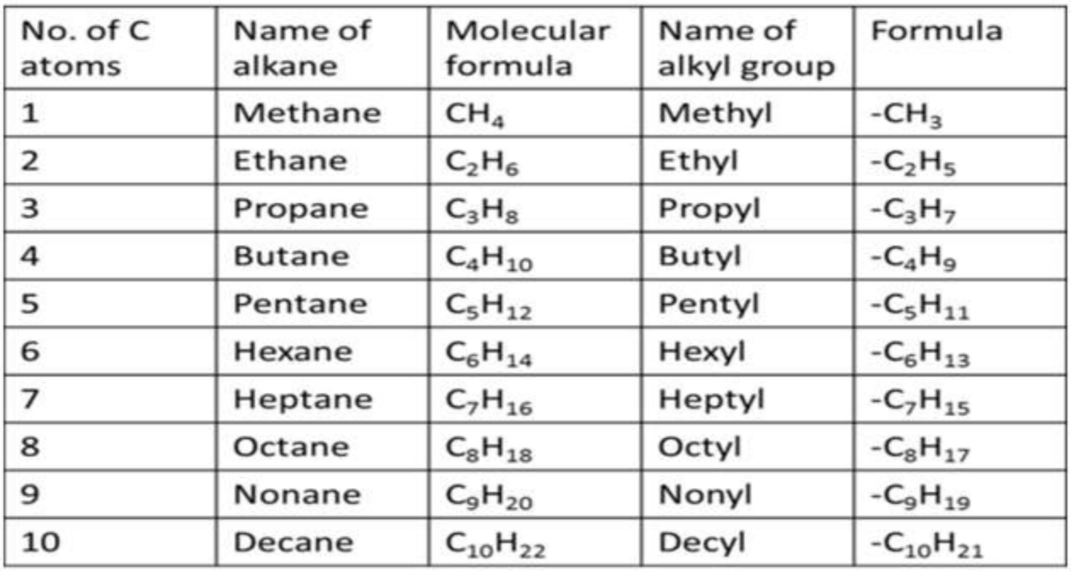
Alkanes are alphatic organic compounds that consist of single-bonded carbon(C-C) and hydrogen atoms(H-C) and lack any other functional groups. Alkanes have the general formula (CnH2n+2). Alkanes are also *saturated hydrocarbons*. Alkanes are the simplest and least reactive hydrocarbon species containing only carbons and hydrogens.

CnH2n+2 (n=1) → $C_1H_{2x1+2}=CH_4$ methane , (n=2) $C_2H_{2x2+2}=C_2H_6$ ethane

Alkyl Groups(R)

An alkyl group(R) is formed by removing one hydrogen from the alkane chain and is described by the formula (C_nH_{2n+1}). The removal of this hydrogen results in a stem change from **-ane** to **-**

yl. CnH2n+1 (n=1) → $C_1H_{2x1+1}=CH_3$ methyl , (n=2) $C_2H_{2x2+1}=C_2H_5$ ethyl . for that the alkane is (R-R or R-H)



No. of C atoms	Name of alkane	Molecular formula	Name of alkyl group	Formula
1	Methane	CH_4	Methyl	$-CH_3$
2	Ethane	C_2H_6	Ethyl	$-C_2H_5$
3	Propane	C_3H_8	Propyl	$-C_3H_7$
4	Butane	C_4H_{10}	Butyl	$-C_4H_9$
5	Pentane	C_5H_{12}	Pentyl	$-C_5H_{11}$
6	Hexane	C_6H_{14}	Hexyl	$-C_6H_{13}$
7	Heptane	C_7H_{16}	Heptyl	$-C_7H_{15}$
8	Octane	C_8H_{18}	Octyl	$-C_8H_{17}$
9	Nonane	C_9H_{20}	Nonyl	$-C_9H_{19}$
10	Decane	$C_{10}H_{22}$	Decyl	$-C_{10}H_{21}$

Naming Alkanes and Cycloalkanes

1-Identify the longest carbon chain. This chain is called the parent chain.

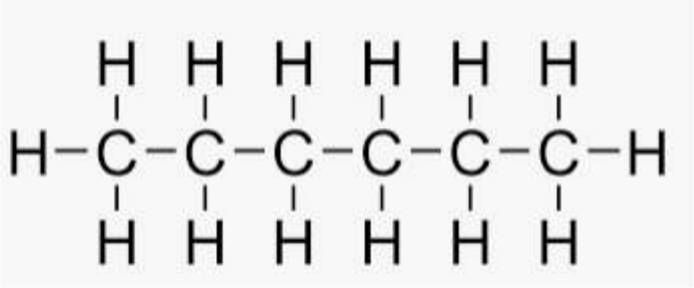
2-Identify all of the substituents (groups appending from the parent chain).

3-Number the carbons of the parent chain from the end that gives the substituents the lowest numbers. When compairing a series of numbers, the series that is the "lowest" is the one which contains the lowest number at the occasion of the first difference. If two or more side chains are in equivalent positions, assign the lowest number to the one which will come first in the name.

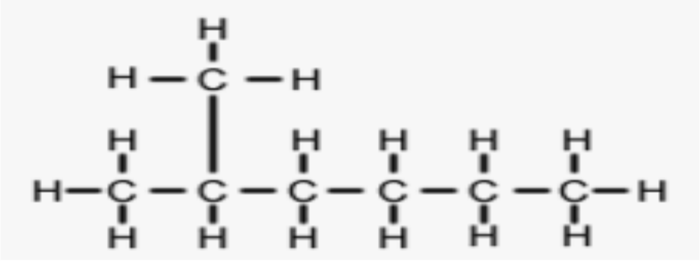
4-If the same substituent occurs more than once, the location of each point on which the substituent occurs is given. In addition, the number of times the substituent group occurs is indicated by a prefix (di, tri, tetra, etc.).

5-If there are two or more different substituents they are listed in alphabetical order using the base name (ignore the prefixes). The only prefix which is used when putting the substituents in alphabetical order is iso as in isopropyl or isobutyl. The prefixes sec- and tert- are not used in determining alphabetical order except when compared with each other.

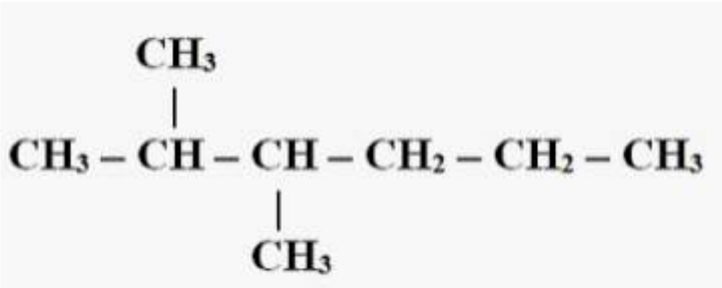
Hexane (Hex + ane)



2-methyl hexane

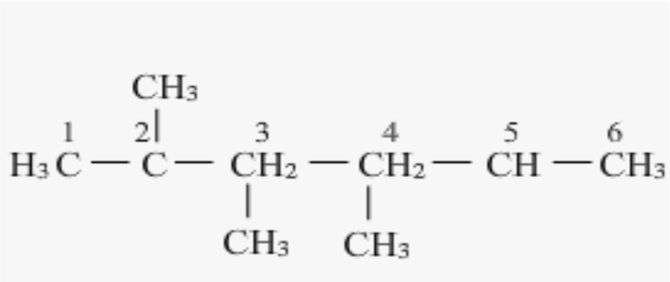


2,3-dimethyl hexane



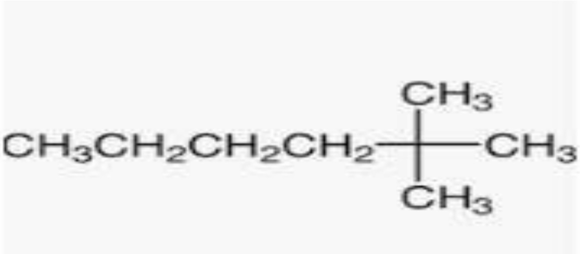
$$\begin{array}{cccccc} & CH_3 & & & & \\ & | & & & & \\ CH_3 - & CH - & CH - & CH_2 - & CH_2 - & CH_3 \\ & & | & & & \\ & & CH_3 & & & \end{array}$$

2,3,4-trimethylhexane



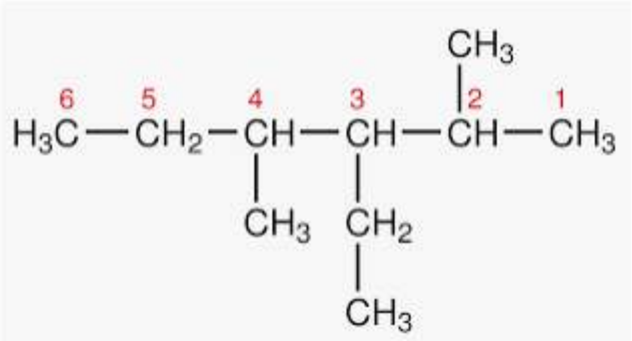
$$\begin{array}{cccccc} & CH_3 & & & & \\ 1 & 2| & 3 & 4 & 5 & 6 \\ H_3C - & C - & CH_2 - & CH_2 - & CH - & CH_3 \\ & & | & | & & \\ & & CH_3 & CH_3 & & \end{array}$$

2,2-dimethyl hexane



$$\begin{array}{cc} & CH_3 \\ CH_3CH_2CH_2CH_2 - & C - CH_3 \\ & CH_3 \end{array}$$

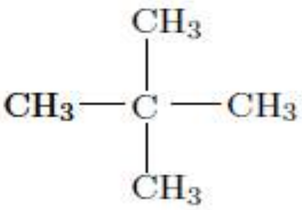
3-ethyl-2,4-dimethylhexane



$$\begin{array}{cccccc} & & & & CH_3 & \\ 6 & 5 & 4 & 3 & |2 & 1 \\ H_3C - & CH_2 - & CH - & CH - & CH - & CH_3 \\ & & | & | & & \\ & & CH_3 & CH_2 & & \\ & & & | & & \\ & & & CH_3 & & \end{array}$$

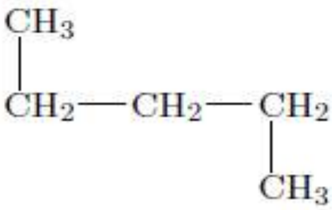
Common naming for alkane

neopentane

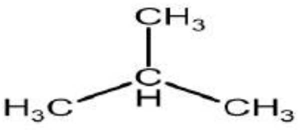


$$\begin{array}{ccc} & CH_3 & \\ & | & \\ CH_3 - & C & - CH_3 \\ & | & \\ & CH_3 & \end{array}$$

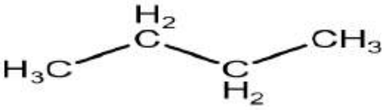
n-pentane



$$\begin{array}{ccc} CH_3 & & \\ | & & \\ CH_2 - & CH_2 - & CH_2 \\ & & | \\ & & CH_3 \end{array}$$



isobutane

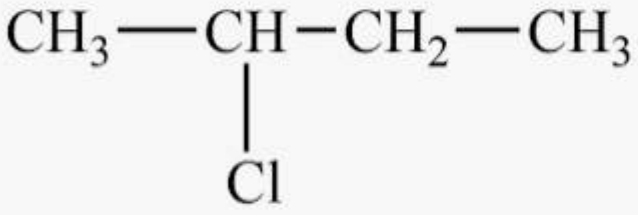


n-butane
butane

Alkyl halides

The halogen is treated as a substituent on an alkane chain. The halo- substituent is considered of equal rank with an alkyl substituent in the numbering of the parent chain. The halogens are represented as follows:

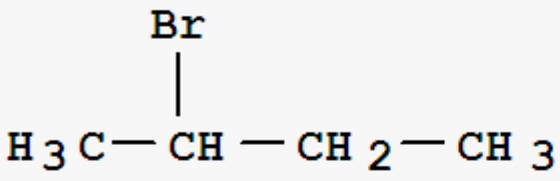
(F) fluoro- , (Cl) chloro- , (Br) bromo- , (I) iodo-



$$CH_3-\underset{\displaystyle Cl}{\underset{|}{CH}}-CH_2-CH_3$$

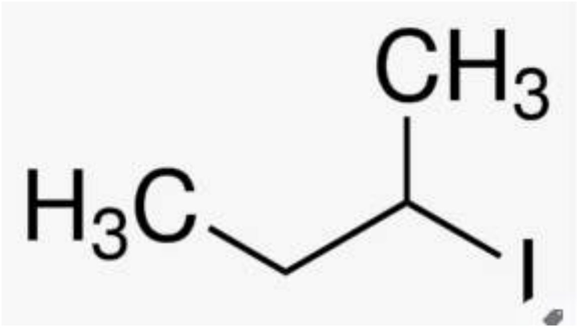
2-chlorobutane

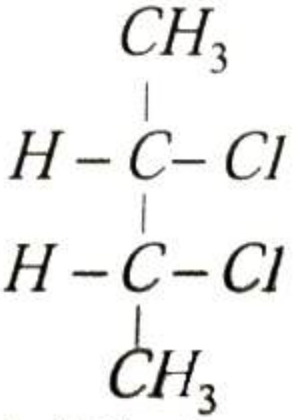
2-bromobutane



$$H_3C-\overset{\displaystyle Br}{\overset{|}{CH}}-CH_2-CH_3$$

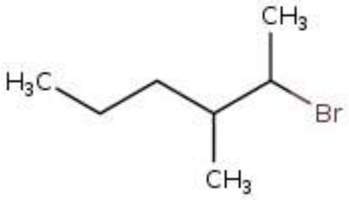
2-Iodobutane





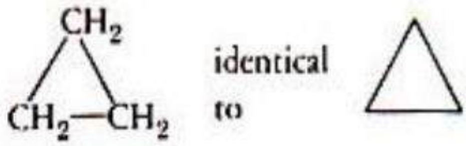
2, 3-dichlorobutane

2-Bromo-3-methylhexane

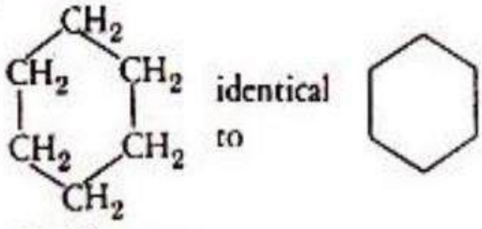


- Saturated hydrocarbons can also exist as rings. Cyclic compounds of carbon containing only single bonds are called Cycloalkanes.If The compounds contain only one ring, they have the general formula C_nH_{2n}

Cycloalkanes are named by adding the prefix cyclo- to the name of the straight – chain hydrocarbon containing the same number of carbon atoms. For example



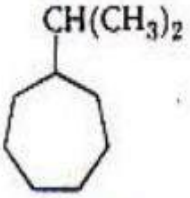
Cyclopropane



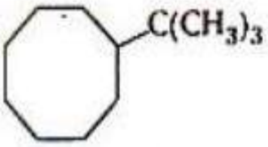
Cyclohexane

All the carbon atoms of a cycloalkane are equivalent. Therefore, no number prefix is needed for monosubstituted cycloalkanes. For example:

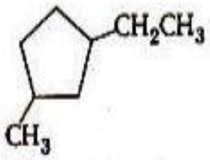
Methylcyclopropane



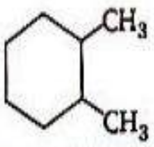
Isopropylcycloheptane



t-Butylcyclooctane

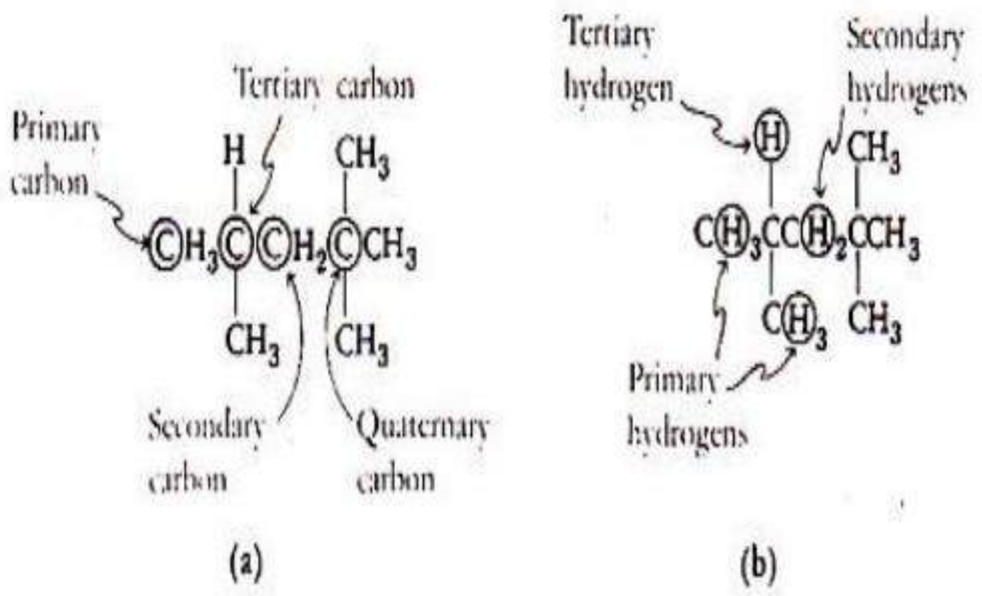


1-Ethyl-3-methylcyclopentane



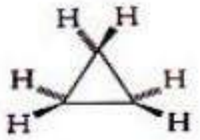
1,2-Dimethylcyclohexane

A carbon atom is designated: primary,secondary,or tertiary according to the number of carbon atoms bonded to it.



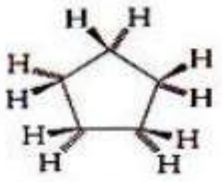
Geometric Isomers

Molecules that differ in the three – dimensional arrangements of their atoms in space.

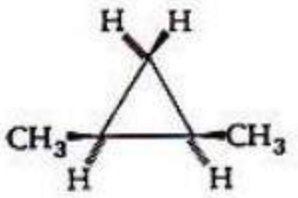


Cyclopropane

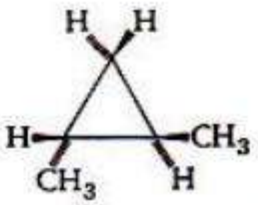
Cyclobutane



Cyclopentane



cis-1,2-Dimethylcyclopropane



trans-1,2-Dimethylcyclopropane

Physical Properties

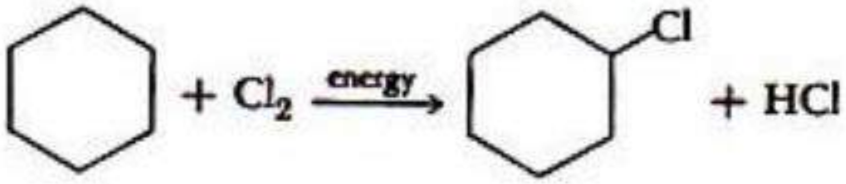
The alkanes can exist as gases, liquids, or solids at room temperature. The unbranched alkanes methane, ethane, propane, and butane are gases. Branched alkanes normally exhibit lower boiling points than unbranched alkanes of the same carbon content. This occurs because of the greater van der Waals forces that exist between molecules of the unbranched alkanes. The unbranched alkanes have greater van der Waals forces of attraction because of their greater surface areas. alkanes are almost completely insoluble in water. Alkanes are **non-polar solvents**. Since only C and H atoms are present, alkanes are nonpolar. Alkanes are immiscible in water but freely miscible in other non-polar solvents. Alkanes consisting of weak dipole dipole bonds can not break the strong hydrogen bond between water molecules hence it is not miscible in water.

Chemical Reactions

- Chlorination

$$RH + Cl_2 \xrightarrow[\text{or } \Delta]{\text{energy as light}} RCl + HCl$$

$$CH_4 + Cl_2 \xrightarrow{\text{energy}} CH_3Cl + HCl$$



Oxidation:

In the presence of excess oxygen,alkanes burn to form carbon dioxide,water and energy

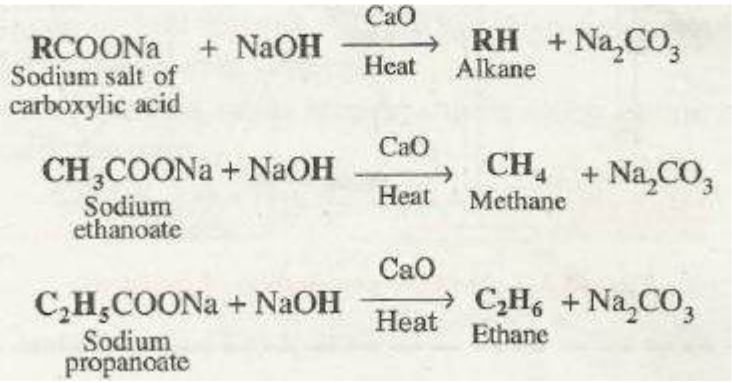
$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O + \Delta$$

If insufficient oxygen ,alkanes form carbon monoxide or carbon

$$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$$

$$CH_4 + O_2 \longrightarrow C + 2H_2O$$

Preparing alkane



$$\underset{\text{Sodium salt of carboxylic acid}}{RCOONa} + NaOH \xrightarrow[\text{Heat}]{CaO} \underset{\text{Alkane}}{RH} + Na_2CO_3$$

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + NaOH \xrightarrow[\text{Heat}]{CaO} \underset{\text{Methane}}{CH_4} + Na_2CO_3$$

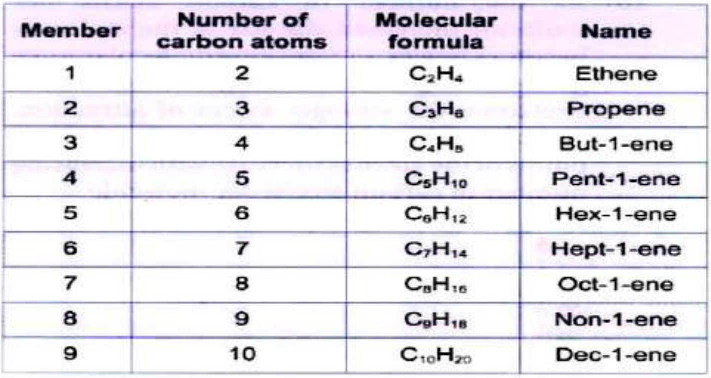
$$\underset{\text{Sodium propanoate}}{C_2H_5COONa} + NaOH \xrightarrow[\text{Heat}]{CaO} \underset{\text{Ethane}}{C_2H_6} + Na_2CO_3$$

Alkenes

Alkenes

Alkenes are alphatic (branched or unbranched) hydrocarbons having one carbon-to-carbon double bond (C=C) and the general molecular formula C_nH_{2n} . Because alkenes contain less than the maximum possible number of hydrogen atoms per carbon atom, they are said to be unsaturated. An older is olefins.

Table *Names and molecular formulae of the first nine straight-chain alkenes*



Member	Number of carbon atoms	Molecular formula	Name
1	2	C_2H_4	Ethene
2	3	C_3H_6	Propene
3	4	C_4H_8	But-1-ene
4	5	C_5H_{10}	Pent-1-ene
5	6	C_6H_{12}	Hex-1-ene
6	7	C_7H_{14}	Hept-1-ene
7	8	C_8H_{16}	Oct-1-ene
8	9	C_9H_{18}	Non-1-ene
9	10	$C_{10}H_{20}$	Dec-1-ene

Naming of alkene

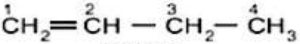
1-The longest chain selected as the parent hydride must include the double bond.

2-The suffix *-ane* in the corresponding alkane parent name is replaced with the suffix *-ene* if the compound contains only one double bond, *-adiene* for two double bonds, *-atriene* for three double bonds, etc.

3-Carbons in the parent chain are numbered beginning with the chain end nearest a double bond.

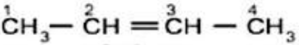
4-The stem name (e.g., pentene or hexene) is affixed with a numerical locant identifying the lowest carbon number associated with the double bond (e.g., pent-2-ene for $CH_3CH=CHCH_2CH_3$).

1-butene , 2-butene and 2-methyl-1-butene



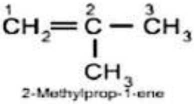
$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2-\overset{4}{C}H_3$

But-1-ene



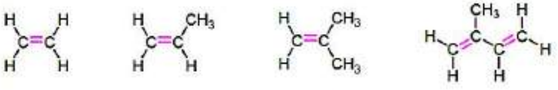
$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_3$

But-2-ene



$\overset{1}{C}H_2=\underset{\underset{CH_3}{|}}{\overset{2}{C}}-\overset{3}{C}H_3$

2-Methylprop-1-ene



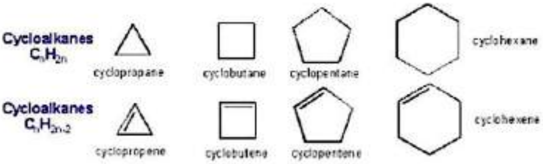
Common Name:	**Ethylene**	**Propylene**	**Isobutylene**	**Isoprene**
IUPAC Name:	**Ethene**	**Propene**	**2-Methylpropene**	**2-Methyl-1,3-butadiene**

1,3-pentadiene

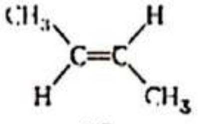
1,4-pentadiene

Cycloalkene

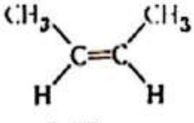
A cycloalkene or cycloolefin is a type of alkene hydrocarbon which contains a closed ring of carbon atoms,. Some cycloalkenes, such as cyclobutene and cyclopentene



Alkenes can form geometric isomers. The trans isomer has the two methyl groups across from each other, and the cis isomer has the groups adjacent to each other(other example trans-2-hexene,cis-2-hexene)



trans-2-Butene



cis-2-Butene

Addition Reactions OF Alkenes

Alkenes and alkanes undergo different types of reactions. Alkanes react by substitution, whereas addition to the double bond is the reaction of alkenes.

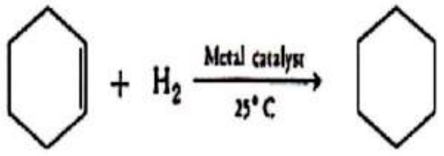
$$CH_3CH_3 + Cl_2 \xrightarrow{\text{Light}} ClCH_2CH_3 + HCl \quad \text{Substitution}$$

$$CH_2{=}CH_2 + Cl_2 \longrightarrow ClCH_2CH_2Cl \quad \text{Addition}$$

1- Addition of Hydrogen:

Reduction of the carbon – carbon double bond The addition of H_2 to alkenes in the presence of a metal catalyst converts them to alkanes.

Some specific examples:



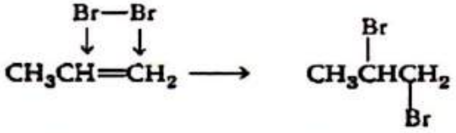
Cyclohexene Cyclohexane

$$CH_2{=}CHCH{=}CHCH_3 + 2\,H_2 \xrightarrow[25^{\circ}C]{\text{Metal catalyst}} CH_3(CH_2)_3CH_3$$

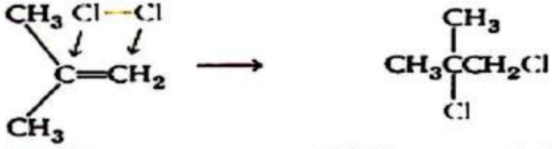
1,3-Pentadiene Pentane

2- Addition of Halogens

The addition of bromine and chlorine to alkenes occurs readily. Examples

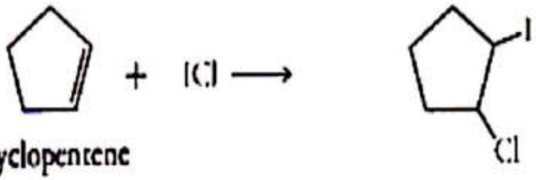


Propene 1,2-Dibromopropane



Methylpropene 1,2-Dichloro-2-methylpropane

Iodine usually does not react with alkenes but the interhalogens iodine monochloride (ICl) and iodine mono bromide (IBr) are added readily.

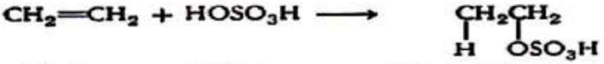


Cyclopentene

1-Chloro-2-iodocyclopentane

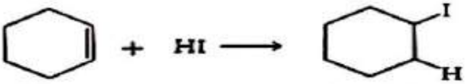
3- Addition of Acides

Acids such as sulfuric acid and the hydrogen halides are readily added to alkenes. Examples

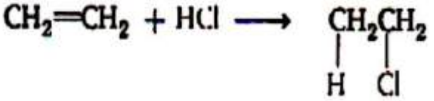


$$CH_2{=}CH_2 + HOSO_3H \longrightarrow \underset{H}{\underset{|}{CH_2}}\underset{OSO_3H}{\underset{|}{CH_2}}$$

Ethylene Sulfuric acid Ethyl hydrogen sulfate



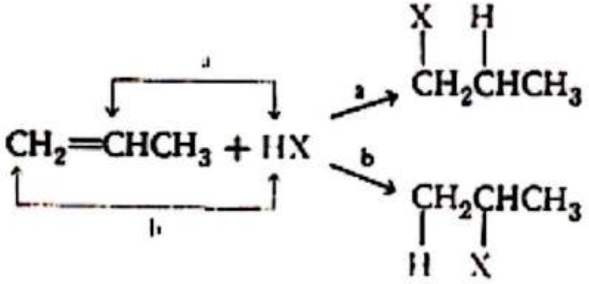
Cyclohexene Iodocyclohexane



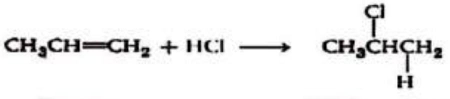
$$CH_2{=}CH_2 + HCl \longrightarrow \underset{H}{\underset{|}{CH_2}}\underset{Cl}{\underset{|}{CH_2}}$$

Ethylene Chloroethane

The addition of an unsymmetrical reagent such as HX to an unsymmetrical alkene can form two isometric products:

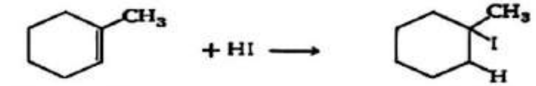


Actually, only one product is obtained, the one formed when the hydrogen of the acid is added to the carbon of the double bond containing the greatest number of hydrogens.This rule is called the Markownikoff rule. Examples

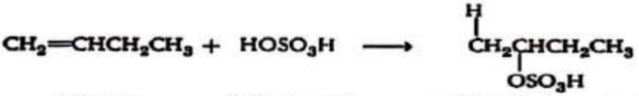


$$CH_3CH{=}CH_2 + HCl \longrightarrow CH_3\overset{Cl}{C}H\underset{H}{C}H_2$$

Propene **2-Chloropropane**



1-Methylcyclohexene **1-Iodo-1-methylcyclohexane**

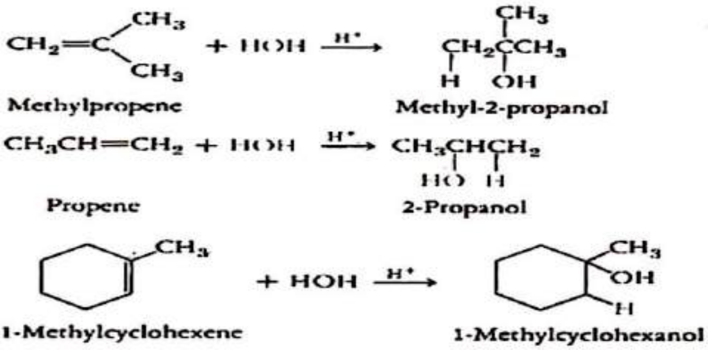


$$CH_2{=}CHCH_2CH_3 + HOSO_3H \longrightarrow \overset{H}{C}H_2\underset{OSO_3H}{C}HCH_2CH_3$$

1-Butene **Sulfuric acid** **sec-Butyl hydrogen sulfate**

4- Addition of Water

The addition of water to alkenes, called Hydration,riquires the presence of a strong acid catalyst such as sulfuric or phosphoric acid.



Methylpropene → Methyl-2-propanol

Propene → 2-Propanol

1-Methylcyclohexene → 1-Methylcyclohexanol

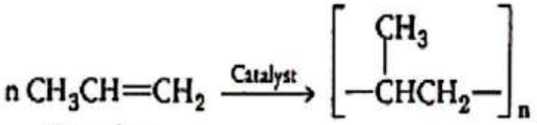
Polymerization: One alkene adding to another Polymer: A huge molecule with a high molecular weight formed by combining a large number of monomers(monomer:one molecule of an alkene),for example, ethylene polymerizes to form polyethylene with the a catalyst.

$$n\,CH_2{=}CH_2 \xrightarrow{\text{Catalyst}} \left[-CH_2CH_2-\right]_n$$

Ethylene (a monomer)

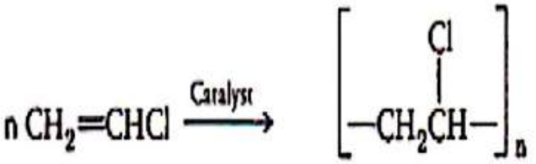
Polyethylene (a polymer)

n is a whole number that varies from several hundred to several thousand



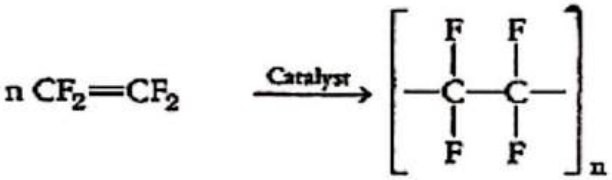
$$n\,CH_3CH{=}CH_2 \xrightarrow{\text{Catalyst}} \left[-\overset{\overset{\displaystyle CH_3}{|}}{C}HCH_2-\right]_n$$

Propylene   Polypropylene



$$n\,CH_2{=}CHCl \xrightarrow{\text{Catalyst}} \left[-CH_2\overset{\overset{\displaystyle Cl}{|}}{C}H-\right]_n$$

Vinyl chloride   Polyvinyl chloride (PVC)



$$n\,CF_2{=}CF_2 \xrightarrow{\text{Catalyst}} \left[-\underset{\underset{\displaystyle F}{|}}{\overset{\overset{\displaystyle F}{|}}{C}}-\underset{\underset{\displaystyle F}{|}}{\overset{\overset{\displaystyle F}{|}}{C}}-\right]_n$$

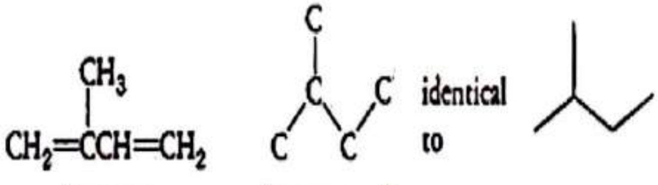
Tetrafluoroethylene   Teflon

$$n\,CH_2{=}CHCH{=}CH_2 \xrightarrow{\text{Catalyst}} \left[-CH_2CH{=}CHCH_2-\right]_n$$

1,3-Butadiene   Polybutadiene

Polymers Formed By Living Systems

Polymerization also occurs in living systems. A large number of compounds called terpenes are found in living systems. These compounds are all polymers made of a repeating five-carbon unit that is structurally related to isoprene

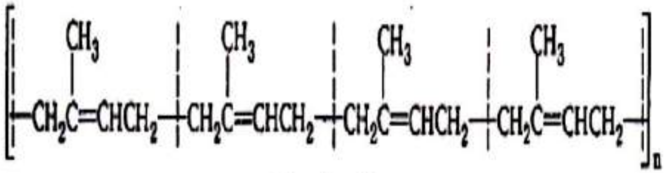


$CH_2{=}C(CH_3)CH{=}CH_2$

Isoprene

Isoprene unit

Natural rubber is an example of a polymer made by combining thousands of isoprene unit.

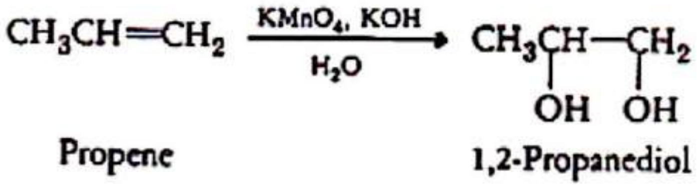


$$\left[-CH_2C(CH_3){=}CHCH_2-CH_2C(CH_3){=}CHCH_2-CH_2C(CH_3){=}CHCH_2-CH_2C(CH_3){=}CHCH_2- \right]_n$$

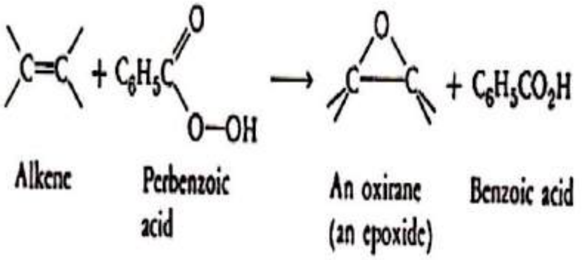
Natural rubber

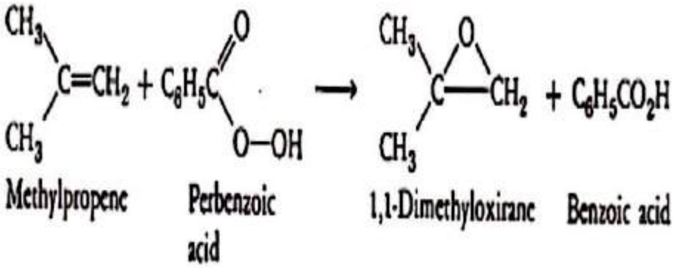
Oxidation of carbon-carbon Double Bonds

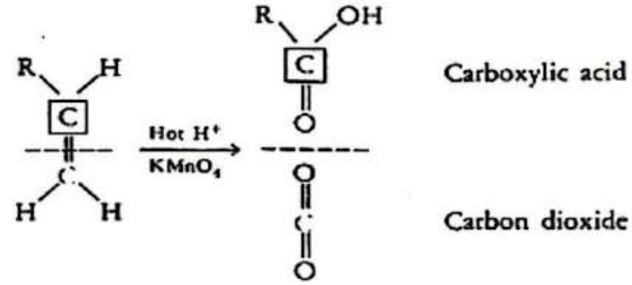
The carbon-carbon double bond of an alkene reacts readily with a number of oxidizing reagents such as potassium permanganate, peracids and ozone. The product of the reaction depends on the reagent and the experimental conditions

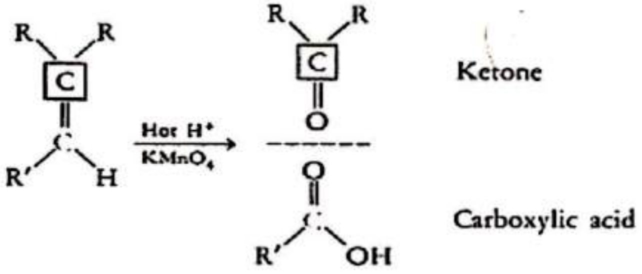


$$\mathrm{CH_3CH{=}CH_2} \xrightarrow[\mathrm{H_2O}]{\mathrm{KMnO_4,\ KOH}} \mathrm{CH_3}\underset{\mathrm{OH}}{\mathrm{CH}}-\underset{\mathrm{OH}}{\mathrm{CH_2}}$$

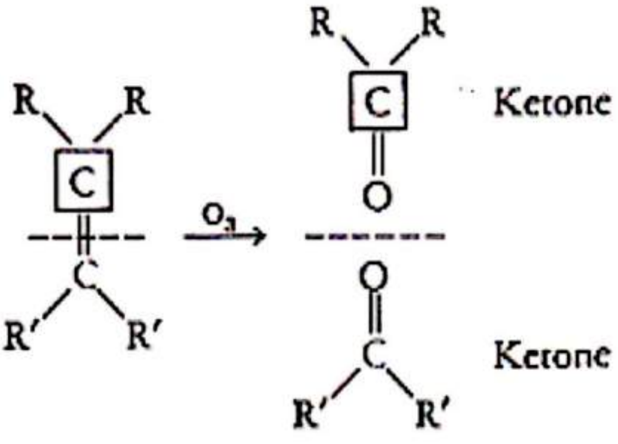








The reaction with O3 called ozonolysis,also breaks the double bond.



Alkynes

Any of a group of unsaturated hydrocarbons that have carbon atoms in chains linked by one or more triple bonds and that have the general formula C_nH_{2n-2} Alkynes can be solid, liquid, or gaseous and include acetylene. The group of alkynes as a whole is called the **alkyne series** or the acetylene series. The first five members of the alkyne series are acetylene (or ethyne), propyne, butyne, pentyne, and hexyne.$H-C\equiv C-H$,$R-C\equiv C-H$ and $R-C\equiv C-R$.

$CH_3-C\equiv C-H$ methyl acetylene , $CH_3-CH_2-C\equiv C-H$ ethylacetylene

$CH_3-C\equiv C-CH_3$ dimethyl acetylene $CH_3-CH_2-C\equiv C-H$ CH_3 methyl ethyl acetylene

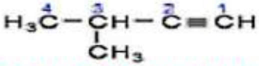
Naming of Alkynes

1- The -yne suffix (ending) indicates an alkyne.

2- The longest chain chosen for the root name must include both carbon atoms of the triple bond.

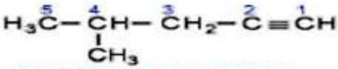
3- The root chain must be numbered from the end nearest a triple bond carbon atom. If the triple bond is in the center of the chain, the nearest substituent rule is used to determine the end where numbering starts.

4- The smaller of the two numbers designating the carbon atoms of the triple bond is used as the triple bond locator.



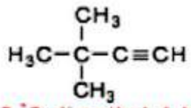
$$H_3\overset{4}{C}-\underset{CH_3}{\overset{3}{C}}H-\overset{2}{C}\equiv\overset{1}{C}H$$

3-methyl-1-butyne



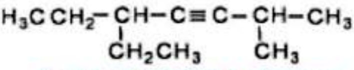
$$H_3\overset{5}{C}-\underset{CH_3}{\overset{4}{C}}H-\overset{3}{C}H_2-\overset{2}{C}\equiv\overset{1}{C}H$$

4-methyl-1-pentyne



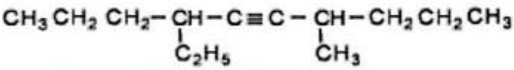
$H_3C-\overset{CH_3}{\underset{CH_3}{C}}-C\equiv CH$

3, 3-dimethyl-1-butyne



$H_3CCH_2-\underset{CH_2CH_3}{CH}-C\equiv C-\underset{CH_3}{CH}-CH_3$

5-ethyl-2-methyl-3-heptyne



$CH_3CH_2CH_2-\underset{C_2H_5}{CH}-C\equiv C-\underset{CH_3}{CH}-CH_2CH_2CH_3$

4-ethyl-7-methyl-5-decyne

Physical Properties of Alkynes

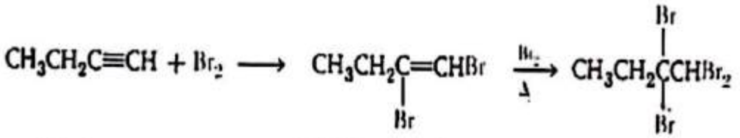
The properties of alkynes pretty much follow the same pattern of those of alkanes and alkenes.Alkynes are unsaturated carbon that shares a triple bond at **the** carbon site.All alkynes are odourless and colourless with the exception of ethylene which has a slight distinctive odour.

The first three alkynes are gases, and the next eight are liquids. All alkynes higher than these eleven are solids .Alkynes are slightly polar in nature

The boiling point and melting point of alkynes increases as their molecular structure grows bigger. The boiling point increases with increase in their molecular mass

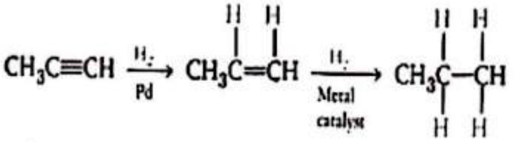
Also, the boiling points of alkynes are slightly higher than those of their corresponding alkenes, due to the one extra bond at the carbon site.

The reactions of alkynes are similar to those of alkenes.



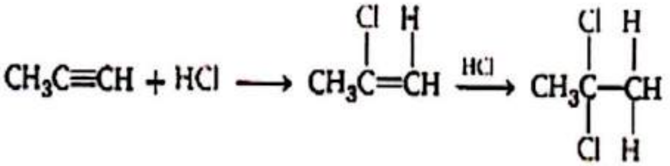
$$CH_3CH_2C\equiv CH + Br_2 \longrightarrow CH_3CH_2\underset{Br}{\underset{|}{C}}=CHBr \xrightarrow[\Delta]{Br_2} CH_3CH_2\overset{Br}{\overset{|}{\underset{Br}{\underset{|}{C}}}}CHBr_2$$

1-Butyne 1,2-Dibromo-1-butene 1,1,2,2-Tetrabromobutane



$$CH_3C\equiv CH \xrightarrow[Pd]{H_2} CH_3\overset{H}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}H \xrightarrow[\text{Metal catalyst}]{H_2} CH_3\overset{H}{\overset{|}{\underset{H}{\underset{|}{C}}}}-\overset{H}{\overset{|}{\underset{H}{\underset{|}{C}}}}H$$

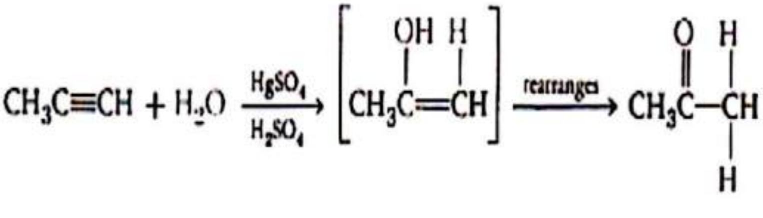
Propyne Propene Propane



$$CH_3C\equiv CH + HCl \longrightarrow CH_3\overset{Cl}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}H \xrightarrow{HCl} CH_3\overset{Cl}{\overset{|}{\underset{Cl}{\underset{|}{C}}}}-\overset{H}{\overset{|}{\underset{H}{\underset{|}{C}}}}H$$

$$2\,HC\equiv CH \xrightarrow{\text{Catalyst}} HC\equiv CCH=CH_2$$

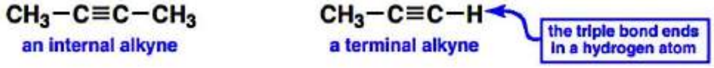
Acetylene **Butenyne (vinylacetylene)**

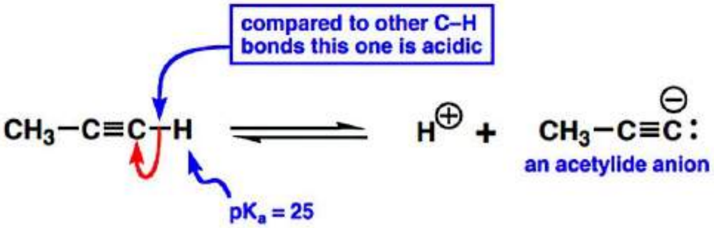


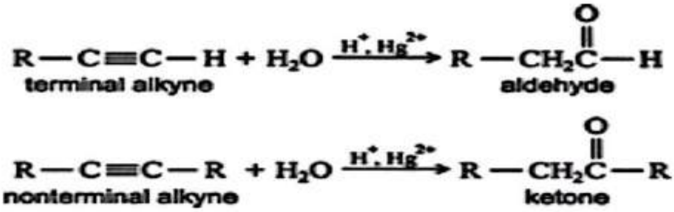
$$CH_3C\equiv CH + H_2O \xrightarrow[H_2SO_4]{HgSO_4} \left[CH_3\overset{OH}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}H\right] \xrightarrow{\text{rearranges}} CH_3\overset{O}{\overset{\parallel}{C}}-\overset{H}{\overset{|}{\underset{H}{\underset{|}{C}}}}H$$

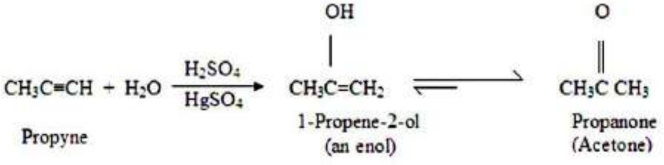
Alkyne has two functional groups (carbon triple bond) and(acidic hydrogen atom). are referred to as **terminal alkynes.** These types of alkynes are weakly acidic. Exposure to a strong base, such as sodium amide, produces an acid-base reaction

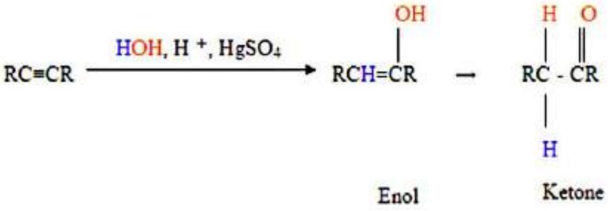
The **acidity** of a terminal **alkyne** is due to the high level of s character in the sp hybrid orbital, which bonds with the s orbital of the **hydrogen atom** to form a single covalent bond. ... This slight positive charge makes the **hydrogen atom** a weak **proton**, which can be removed by a strong base











$$RC{\equiv}CR \xrightarrow{HOH,\ H^{+},\ HgSO_4} RCH{=}\overset{OH}{\overset{|}{C}}R \rightarrow R\underset{H}{\underset{|}{\overset{H}{\overset{|}{C}}}}-\overset{O}{\overset{\|}{C}}R$$

Preparing of alkynes

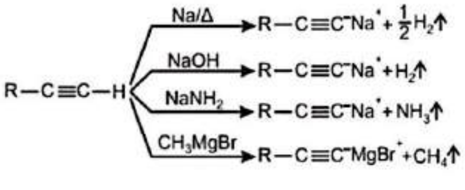
1-Methan converts into acetylene

$$2CH_4 \xrightarrow[0.01-0.1\ sec.]{1500^{\circ}C} HC \equiv CH + 3\,H_2$$

2-Calcium carbide (CaC_2) reacts with water to produce acetylene (C_2H_2):

$CaC_2 + 2\ H_2O \rightarrow Ca(OH)_2 + HC{\equiv}CH$

3-Substitution of acidic hydrogen by sodium atom



All the salts can react with alkylhalide (R-X) to lengthen alkyne chain.

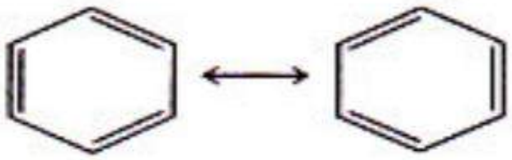
$H\text{-}C{\equiv}C\text{-}H + Na \rightarrow H\text{-}C{\equiv}CNa + 1/2\ H_2$

$H\text{-}C{\equiv}CNa + CH_3Cl \rightarrow H\text{-}C{\equiv}C\text{-}CH_3 + NaCl$

$H\text{-}C{\equiv}C\text{-}CH_3 + Na \rightarrow Na\text{-}\ C{\equiv}C\text{-}CH_3 + 1/2\ H_2$

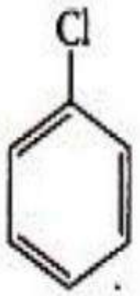
Aromatic Compounds

Benzene has a high degree of unsaturation but is unreactive.It does not undergo the usual addition reactions of alkenes and alkynes. It does react under more vigorous conditions(heat or catalysts) to form products of substitution. This difference in chemical reactivity is due to the structure of benzene.

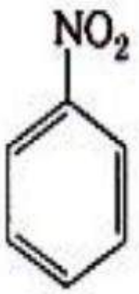


Naming Aromatic Compounds

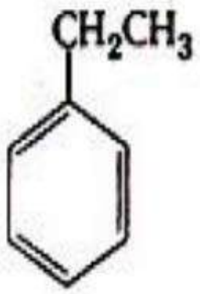
When one group is attached to benzene, the compound is named by placing the name of the group as prefix to the benzene.



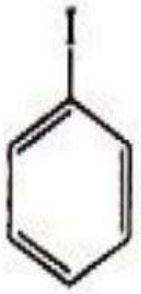
Chlorobenzene



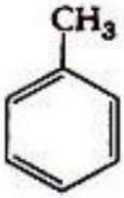
Nitrobenzene



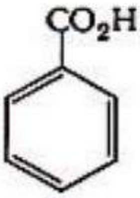
Ethylbenzene



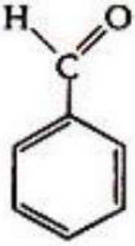
Iodobenzene



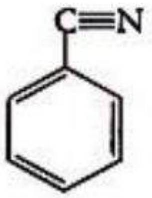
Toluene



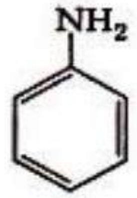
Benzoic acid



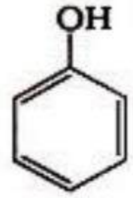
Benzaldehyde



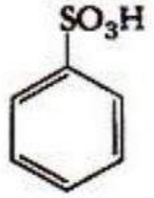
Benzonitrile



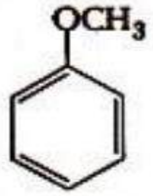
Aniline



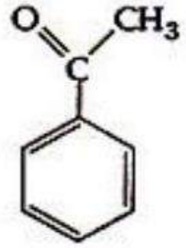
Phenol



Benzenesulfonic acid

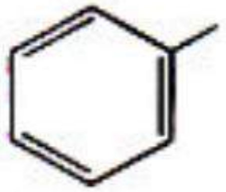


Anisole

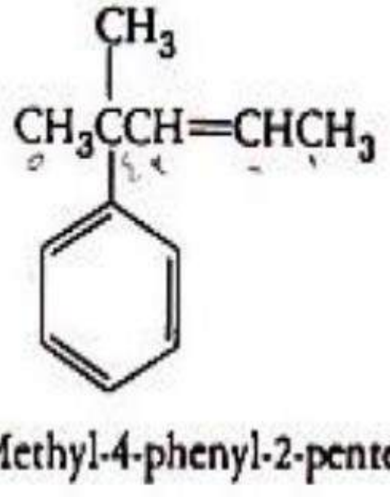


Acetophenone

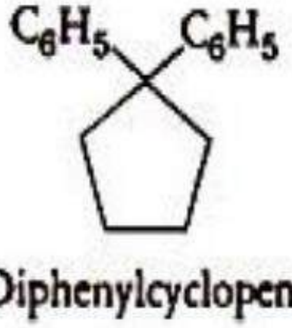
C_6H_5— or



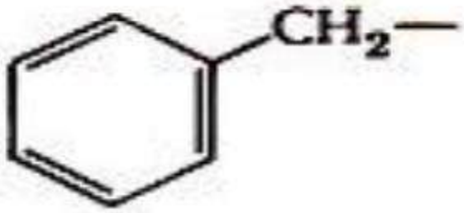
Phenyl group



4-Methyl-4-phenyl-2-pentene

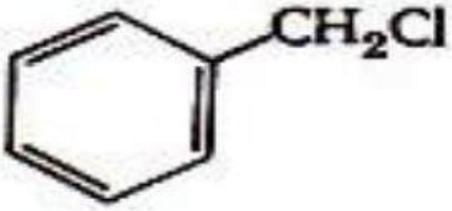


1,1-Diphenylcyclopentane

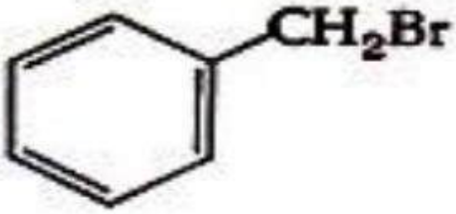


Benzyl group

For example:

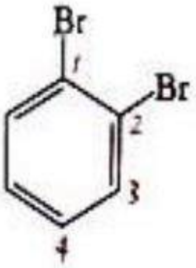


Benzyl chloride

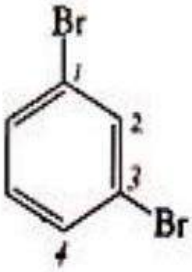


Benzyl bromide

If two groups are attached to the benzene ring, the name must not only tell what groups are present, but also where they are located. We can differentiate the three possible isomers of a disubstituted benzene in two ways.



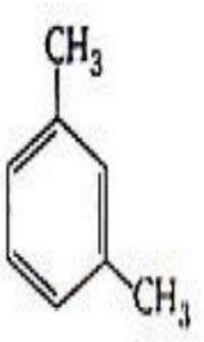
o-Dibromobenzene
1,2-Dibromobenzene



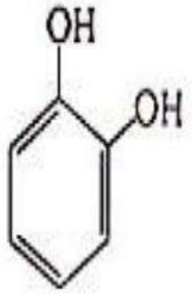
m-Dibromobenzene
1,3-Dibromobenzene

p-Dibromobenzene
1,4-Dibromobenzene

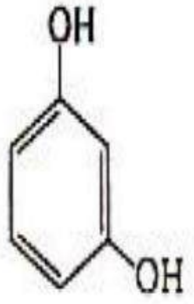
Several disubstituted benzenes have been given names that, give no indication of the kind of groups attached to the ring.



m-Xylene



Catechol



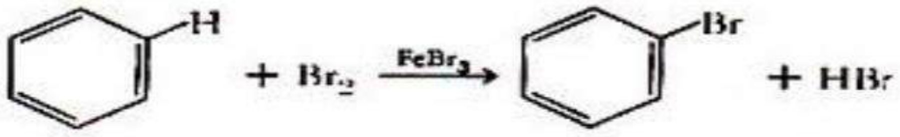
Resorcinol

Hydroquinone

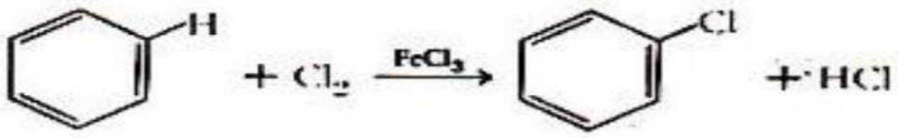
p-Cresol

Substitution Reactions Of Aromatic Compounds

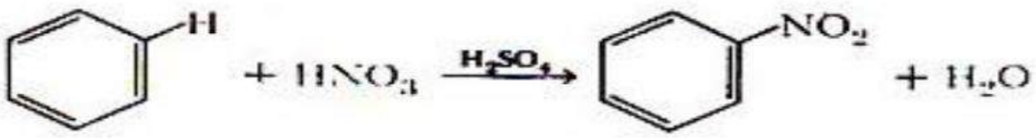
Bromination

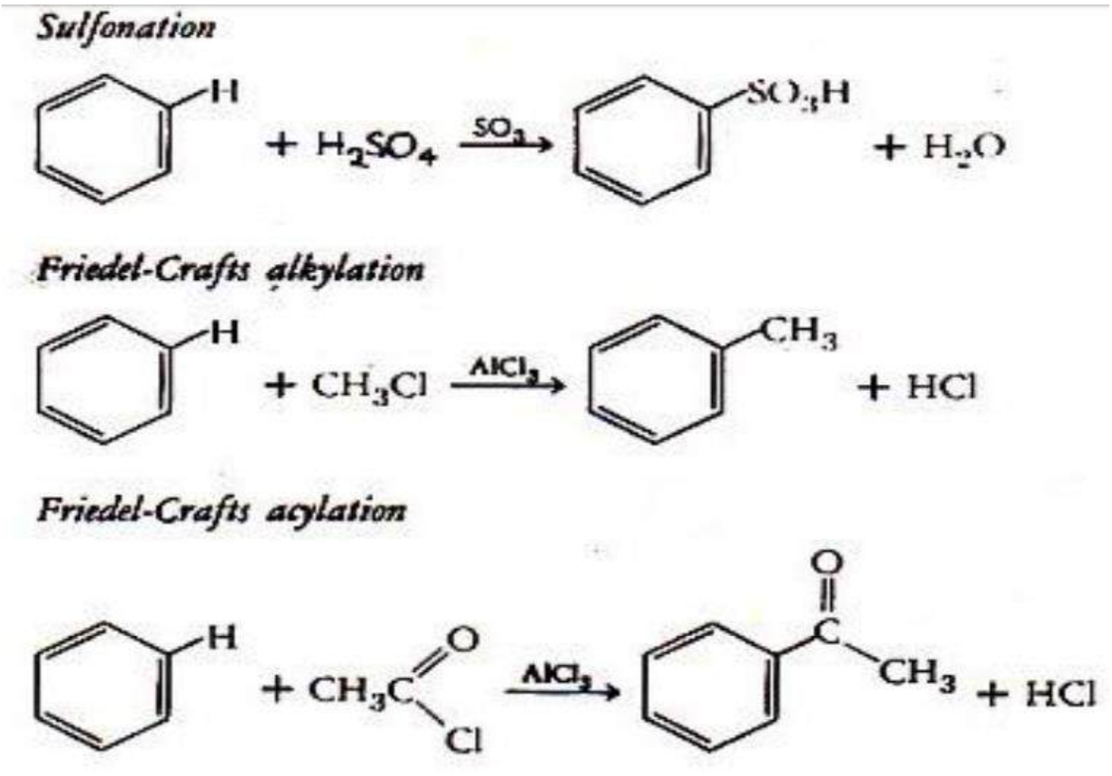


Chlorination



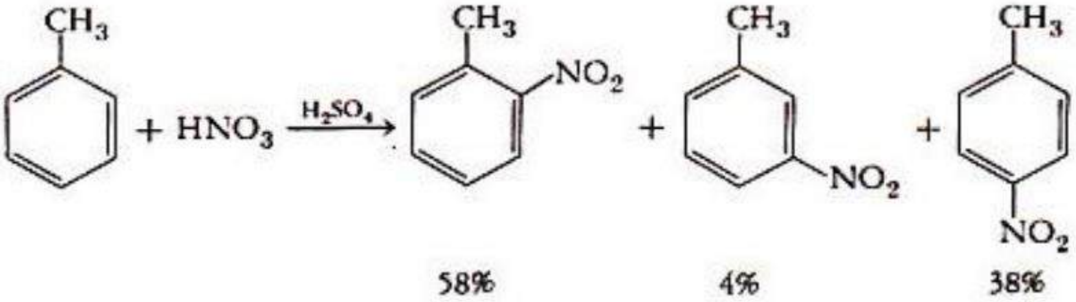
Nitration





Toluene,nitrobenzene,chlorobenzene and many other aromatic compounds also undergo substitution reactions. These compounds differ from benzene in that they already have a substituent on the benzene ring. The remaining five hydrogens are not equivalent. When these hydrogens undergo substitution reactions, isomers can be formed depending on which hydrogen is replaced.

Examples:



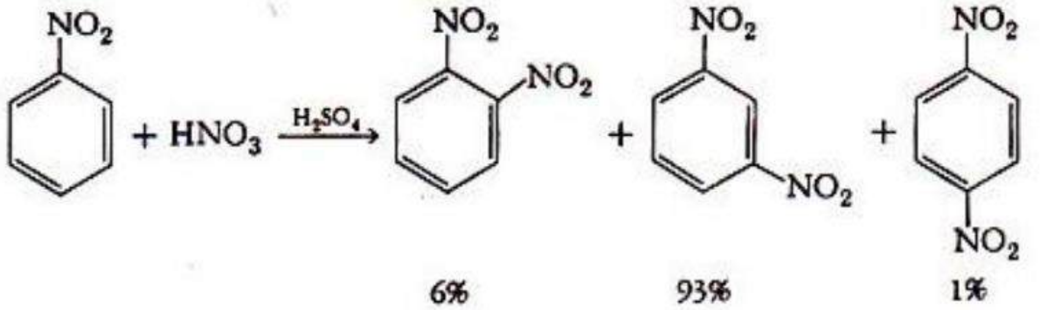
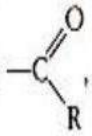
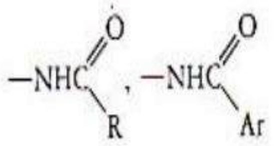


Table 13-1. Directing Effect of Substituents[a]

Predominant Directing	
o, p	*m*
$-NH_2$, $-NHR$, $-NR_2$	$-NO_2$
$-NH_2$, $-NHAr$, $-N(Ar)_2$	$-CN$
$-OH$, $-OR$, $-OAr$	$-CO_2H$, $-CHO$,  $-C(=O)R$, $-CO_2R$, $-CO_2Ar$
 $-NHC(=O)R$, $-NHC(=O)Ar$	$-SO_3H$
Alkyl groups	$-\overset{+}{N}H_3$, $-\overset{+}{N}H_2R$, $-\overset{+}{N}HR_2$, $-\overset{+}{N}R_3$
Halogens	$-\overset{+}{N}H_3$, $-\overset{+}{N}H_2Ar$, $-\overset{+}{N}H(Ar)_2$, $-\overset{+}{N}(Ar)_3$

[a] R = alkyl groups; Ar = aryl groups.

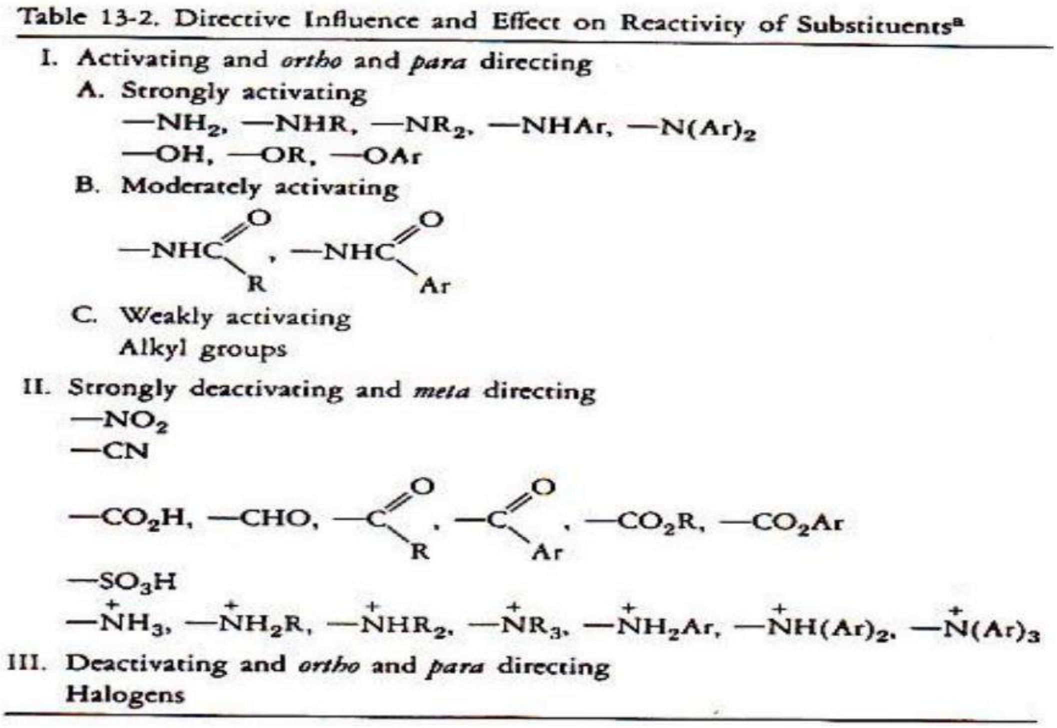


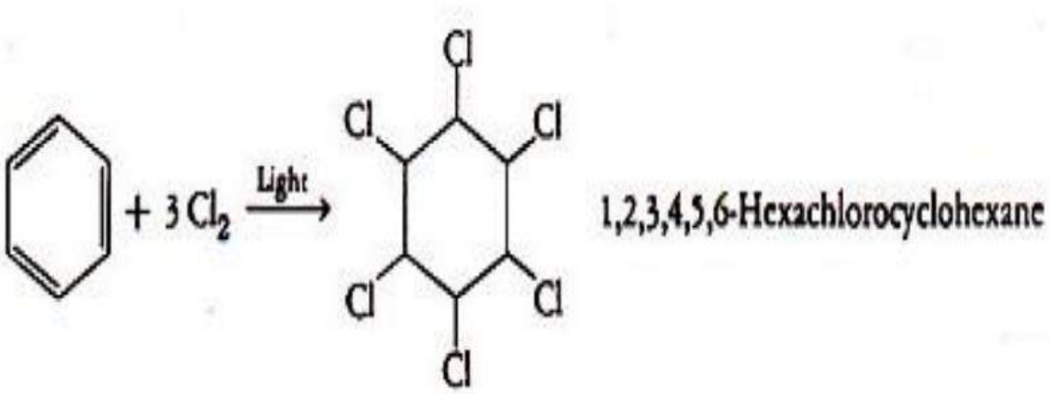
Table 13-2. Directive Influence and Effect on Reactivity of Substituents[a]

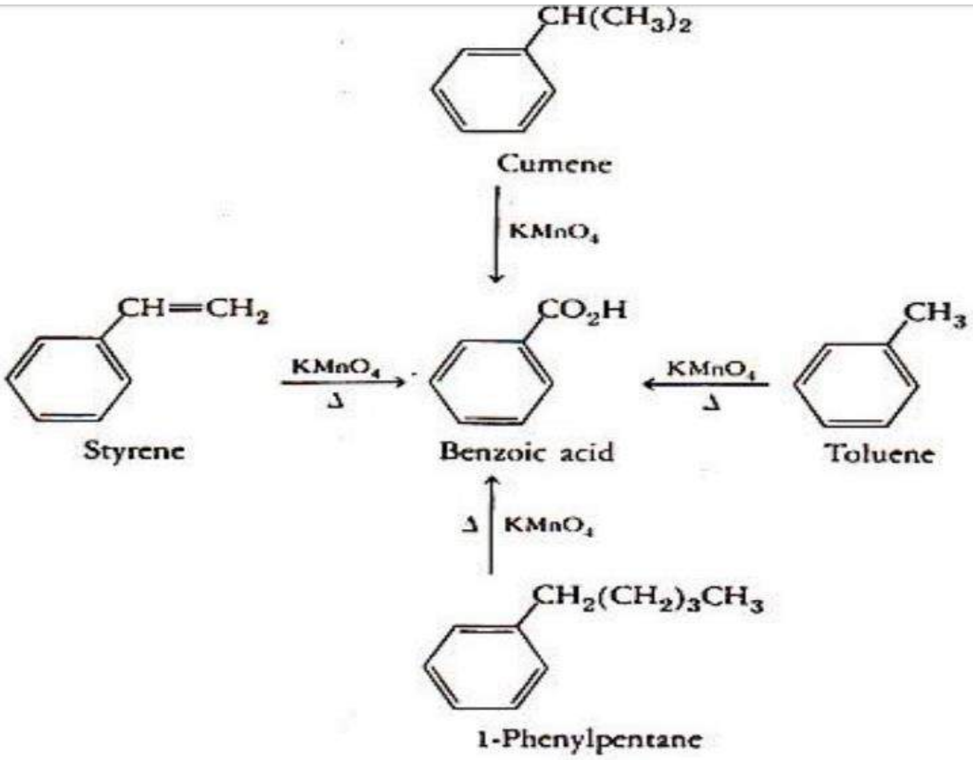
I. Activating and *ortho* and *para* directing
  A. Strongly activating
    $-NH_2$, $-NHR$, $-NR_2$, $-NHAr$, $-N(Ar)_2$
    $-OH$, $-OR$, $-OAr$
  B. Moderately activating
    $-NHC(=O)R$, $-NHC(=O)Ar$
  C. Weakly activating
    Alkyl groups

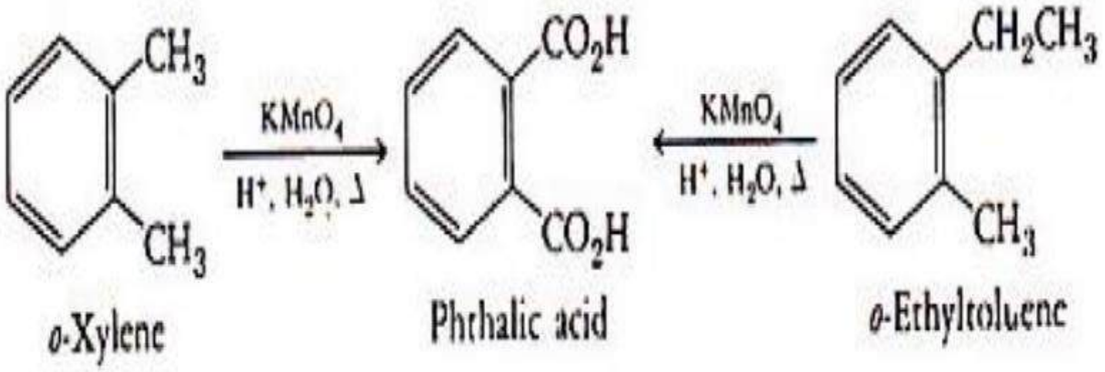
II. Strongly deactivating and *meta* directing
  $-NO_2$
  $-CN$
  $-CO_2H$, $-CHO$, $-C(=O)R$, $-C(=O)Ar$, $-CO_2R$, $-CO_2Ar$
  $-SO_3H$
  $-\overset{+}{N}H_3$, $-\overset{+}{N}H_2R$, $-\overset{+}{N}HR_2$, $-\overset{+}{N}R_3$, $-\overset{+}{N}H_2Ar$, $-\overset{+}{N}H(Ar)_2$, $-\overset{+}{N}(Ar)_3$

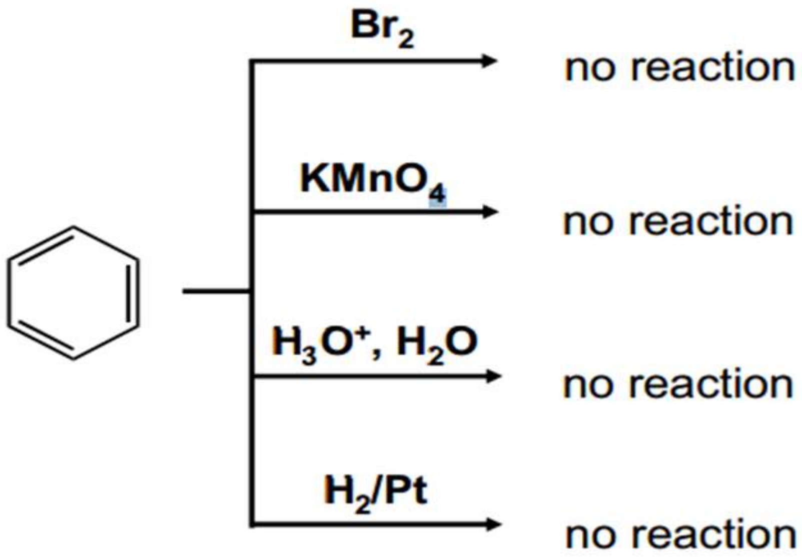
III. Deactivating and *ortho* and *para* directing
  Halogens

Other Reactions Of Aromatic Compounds

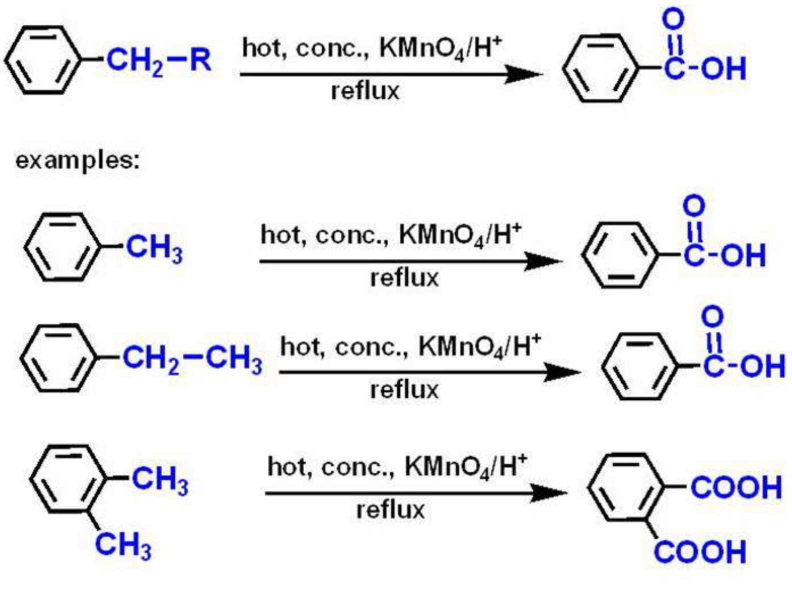



CH(CH3)2
Cumene
KMnO4
CH=CH2
Styrene
KMnO4
Δ
CO2H
Benzoic acid
KMnO4
Δ
CH3
Toluene
Δ
KMnO4
CH2(CH2)3CH3
1-Phenylpentane


CH3
CH3
o-Xylene
KMnO4
H+, H2O, Δ
CO2H
CO2H
Phthalic acid
KMnO4
H+, H2O, Δ
CH2CH3
CH3
o-Ethyltoluene



OXIDATION REACTION OF ALKYLBENZENE



Complete the following reactions

1-Benzonitrile + Br_2 / $FeBr_3$

2-Acetophenone + HNO_3 /H_2SO_4

3-Anisole + CH_3Cl /$AlCl_3$

4-Phenol + H_2SO_4/ SO_3

Aromatic compounds in natural

1-benzen is toxic compound

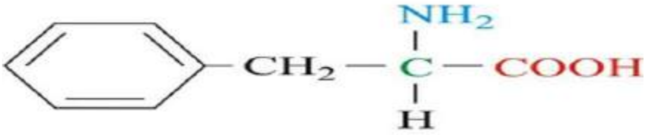
2-It cause severe liver damage.

3-It is possible carcinogen(cause cancer).

4-It is not found in natural .

Many compounds that have a benzene ring in their basic structure such compound are called derivatives of benzene

1-Phenylalanine(essential amino acid) a compound essential for life contains a benzene a ring and is derivative of benzene



This compound cannot be made in the human body and must be obtained from food we eat .However ,plants can make phenylalanine (**called essential amino acids**).Phenylalanine can be used to prepare other important compounds such as hormones epinephrine and Dopa.

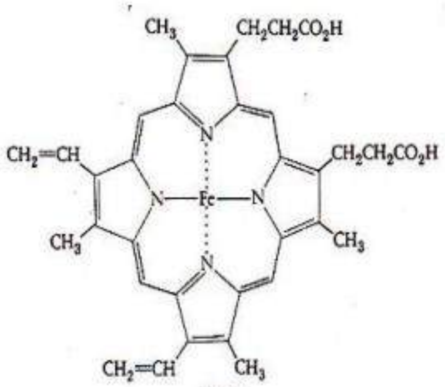
Phenylalanine is transformation into tyrosine(isnot essential amino acid)

Aromatic Heterocyclic compounds

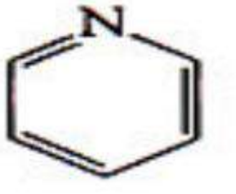
Resemble benzene in they are highly unsaturated yet undergo electrophilic substitution ,They contain at least one element other than carbon or hydrogen usually nitrogen.They contain 6 electrons in ring and heteroatom.

1-Four pyrrole rings joined together by CH bridge to form porphyrins that their ability to bind metal ions in space between the four nitrogen atoms

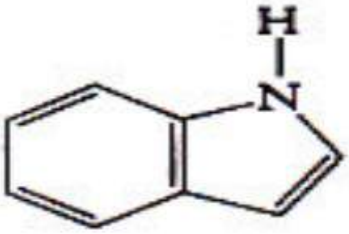
Hemoglobin is composed of two parts .One parts protein portion called globin.The other part is porphyrin part called heme .Heme contains an iron atom in ferrous oxidation state in space between the nitrogen atoms.



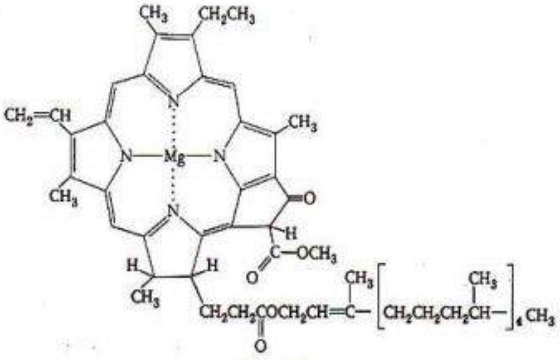
Heme



Pyridine



Indole



Chlorophyll a

2-pyridine

Pyridine can be regarded as benzene in which one carbon has been replaced by a nitrogen atom .

Some exampleNicotinamide ,Nicotine ,Nicotinic acid and pyridoxine (vitamin B_6)

3-Indole

Indole is an aromatic heterocyclic compound containing a pyrrole ring and benzene ring with one side in common .The single most important derivative of indole in living system is the amino acid tryptophane it is essential amino acid for mammals must get it from foods.Many important compounds are prepared from tryptophane in living systems .One of them is serotonin,an important hormone that affects blood pressure and is a factor in the functioning of brain.

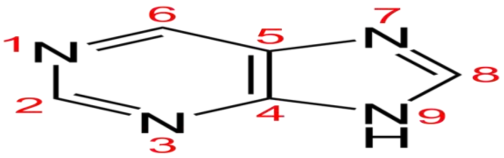
4-Imidazole is a compound that contains tow nitrogen atoms in five membrane ring

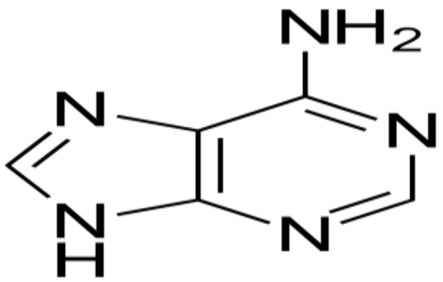
The most important derivative of imidazole is the amino acid histidine .

In living systems enzyme transform histidine to the pharmacologically active histamine

Histamine which causes dilation of capillaries and stimulation of muscle

5-Purine is a compound that contains two heteroaromatic rings that have one side in common .A derivative of purine with an $-NH_3$ (amine)substitutuent in the 6 position is called adenine .It is part of adenine triphosphate (ATP).





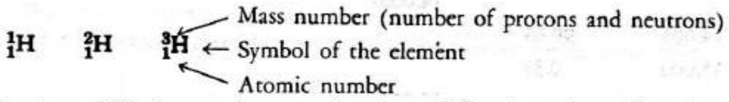
Fluid and electrolyte

Atomic number

The atomic number of an element is equal to the number of protons in its nucleus.

Isotopes

Atoms whose nuclei have the same number of protons but different numbers of neutrons are called *isotopes*. A specific isotopes of an element is designated by writing the symbol of the element with the atomic mass number placed as a superscript to the left and atomic number is also added as a subscript to the left .



Isotopes differ in mass because they have different numbers of neutrons in its nuclei.

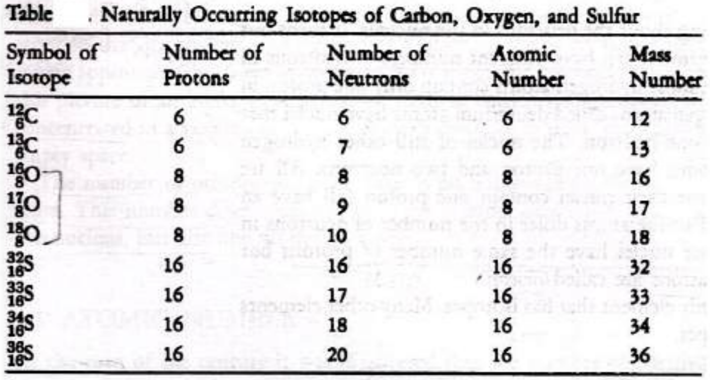


Table . Naturally Occurring Isotopes of Carbon, Oxygen, and Sulfur

Symbol of Isotope	Number of Protons	Number of Neutrons	Atomic Number	Mass Number
$^{12}_{6}C$	6	6	6	12
$^{13}_{6}C$	6	7	6	13
$^{16}_{8}O$	8	8	8	16
$^{17}_{8}O$	8	9	8	17
$^{18}_{8}O$	8	10	8	18
$^{32}_{16}S$	16	16	16	32
$^{33}_{16}S$	16	17	16	33
$^{34}_{16}S$	16	18	16	34
$^{36}_{16}S$	16	20	16	36

Mass number

Mass number of an atom is the sum of the number of protons and number of neutrons in its nucleus. The number of protons within the atom's nucleus is called atomic number and is equal to the number of electrons in the neutral (non-ionized) atom.

Electron arrangement

Electrons are located in shells in the space around the nucleus

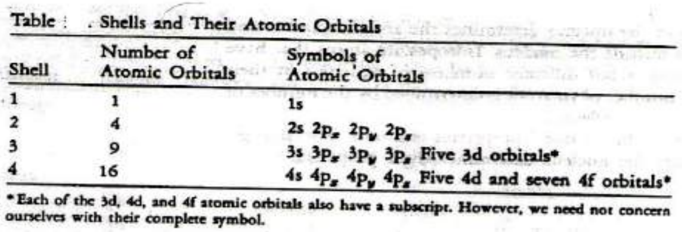


Table : . Shells and Their Atomic Orbitals

Shell	Number of Atomic Orbitals	Symbols of Atomic Orbitals
1	1	1s
2	4	2s $2p_x$ $2p_y$ $2p_z$
3	9	3s $3p_x$ $3p_y$ $3p_z$ Five 3d orbitals*
4	16	4s $4p_x$ $4p_y$ $4p_z$ Five 4d and seven 4f orbitals*

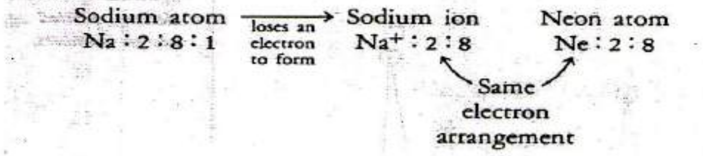
*Each of the 3d, 4d, and 4f atomic orbitals also have a subscript. However, we need not concern ourselves with their complete symbol.

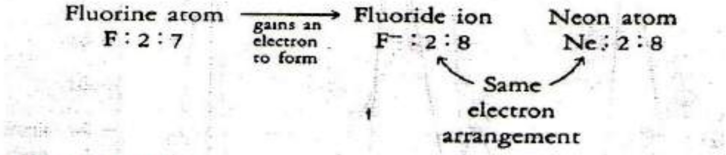
$_8O$: $1s^2\ 2s^2\ 2p^4$ **or** $_8O: 2:6$

$_{17}Cl$: $1s^2 2s^2 2p^6 3s^2 3p^5$ or $_{17}Cl:2:8:7$

$_{53}I$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^5$ or $_{53}I:2:8:18:18:7$

$_{53}I$: $_{36}[Kr]5s^2 4d^{10} 5p^5$



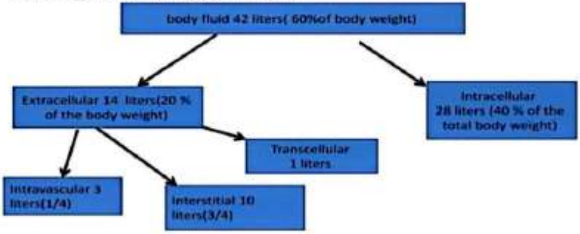


The body fluids

A body fluid refers to any fluid produced by a living organism. In humans,The major component of the human body is water, which accounts for 63% of an adult male. and in female increased body fat content is associated with ageing , obesity, Consequently, the percentage of water in women falls to 52%, Dissolved within this water are carbon dioxide (CO_2) nutrients, proteins and charged particles (ions). the body fluid can be classified into two major types according to location

Body Fluid Compartments

average 70-kilogram man



(1) intracellular fluid (ICF): the fluid inside the cells. It makes up about 67% of the total body water composition in humans. The body fluid within the cell composed mainly of water dissolved ions, and other molecules.

(2) extracellular fluid (ECF): The extracellular fluid is the body fluid located outside the cell(s). It makes up about 26% of the total body water composition in humans.

All fluids outside cells, its divide to:-1 - interstitial fluid (ISF): exists in the spaces between cells and lie outside the vascular system. The interstitial fluid, the fluid filling up the spaces between cells, is the major constituent whereas the transcellular. The fluid found in the intercellular spaces composed of water, amino acids, sugars, fatty acids, coenzymes, hormones, neurotransmitters, salts, and cellular products. It bathes and surrounds the cells of the body, and provides a means of delivering materials to the cells, intercellular communication, and removal of metabolic waste.

2- intravascular fluid (IVF): exists as blood plasma in blood vessels. intravascular fluid and plasma are in a state of continual exchange via pores in the highly permeable capillary membrane. The two fluids therefore have a similar composition, with the exception of large proteins, which are trapped within the capillaries in the vascular system. Intravascular fluid (blood plasma), interstitial fluid, lymph and trans cellular fluid make up the extracellular fluid. The transcellular fluid is the smallest component of the extracellular fluid.

3 -Transcellular fluid (i.e): the fluid filling up the spaces of chambers formed from the linings of the epithelial cells, is the least. Blood plays a major role in the body's defense against infection by carrying blood waste away from our cells and flushing them out of the body in urine, feces, and sweat.

Examples of body fluids are as follows: (1)- amniotic fluid (2)- bile (3)- blood plasma (4)- breast milk(5)- cerebrospinal fluid(6)- gastric juice(7)- lymph(8)- mucus(9)- saliva (10)- serous fluid(11)- semen (12) -sweat(13)- tears(14) – urine.

The Significance of body fluids:

1- helps to protect the cushion joints and organs.

2- Fluid helps to prevent dehydration.

3- Fluid helps your kidneys work to produce urine and remove waste from the body, and keeping the urinary tract healthy.

4- Rapid Specific Method for Determination of Aldosaccharides in body

5- helps to control body temperature.

6- helps to carry nutrients around the body, and prevent constipation by keeping stools soft and regular.

Electrolytes:

Are minerals in the body that have an electric charge. They are in blood, urine and body fluids. Maintaining the right balance of electrolytes helps your body's blood chemistry, muscle action and other processes.

Electrolytes : An element or compound that, when melted or dissolved in water or another solvent, dissociates into ions and is able to conduct an electric current. Levels of electrolytes in our bodies can become too low or too high. That can happen when the amount of water in your body changes, causing dehydration or over-hydration. Causes include some medicines, vomiting, diarrhea, sweating or kidney problems.

Fluid balance : The amount of water gained each day equals the amount lost.

Electrolyte balance: The ion gain each day equals the ion loss.

Acid-base balance: H^+ gain is offset by their loss.

These electrolytes are involved in metabolic activities and are essential to the normal function of all cells.

COMPOSITION OF BODY FLUIDS

The fluids circulating throughout the body in extracellular and intracellular fluid spaces contain

1.Electrolytes
2.Minerals
3.Cells

Intracellular Fluid Composition:

The cytosol or intracellular fluid consists mostly of water, dissolved ions mainly cations and anions, small and large molecules, water-soluble molecules (such as proteins), metabolic blood gasses, hormones, and glucose. This mixture of small molecules is extraordinarily complex, as the variety of enzymes that are involved in cellular metabolism is immense. 5 These enzymes are involved in the biochemical processes that sustain cells and activate or deactivate toxins. Most of the cytosol is water, which makes up about 70% of the total volume of a typical cell.

The pH of the intracellular fluid is 7.4 . The cell membrane separates cytosol from extracellular fluid, but can pass through the membrane via specialized channels and pumps during passive and active transport. The concentrations of the other ions in cytosol or intracellular fluid are quite different from those in extracellular fluid. The cytosol also contains much higher amounts of charged macromolecules, such as proteins and nucleic acids, than the outside of the cell. In contrast to extracellular fluid, cytosol has a high concentration of potassium ions and a low concentration of sodium ions. The reason for these specific sodium and potassium ion concentrations are Na+/K ATPase pumps that facilitate the active transport of these ions. These pumps transport ions against their concentration gradients to maintain the cytosol fluid composition of ions.

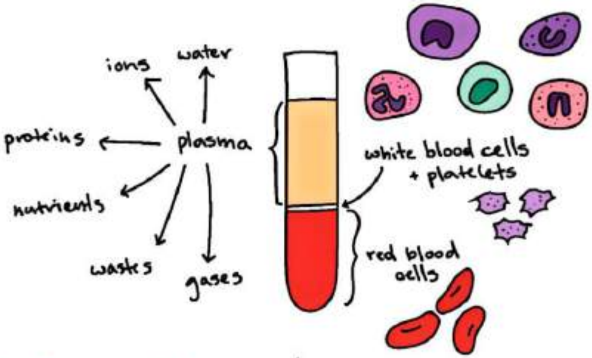
Extracellular fluid Composition

The extracellular fluid is mainly cations and anions. The cations include: sodium (Na^+ = 136-145 mEq/L), potassium (K^+ = 3.5-5.5 mEq/L) and calcium ($Ca2^+$ = 8.4-10.5 mEq/L). Anions include: chloride (mEq/L) and hydrogen carbonate (HCO3- 22-26 mM). These ions are important for water transport throughout the body.

Plasma is mostly water (93% by volume) and contains dissolved proteins (the major proteins are fibrinogens, globulins, and albumins), glucose, clotting factors, mineral ions (Na^+, Ca^{++}, Mg++, $HCO3^-$ Cl- etc.), hormones and carbon dioxide (plasma being the main medium for excretory product transportation). These dissolved substances are involved in many varied physiological processes, such as gas exchange, immune system function, and drug distribution throughout the body. Because of its composition, therefore, serves as a delivery medium for nutrients and waste products. It is also a crucial site for various homeostatic mechanisms. For example , in humans, the normal glucose concentration of extracellular fluid that is regulated by homeostasis is approximately 5 mM. The pH of extracellular fluid is tightly regulated by buffers around 7.4. The volume of extracellular fluid is typically 15 L (i.e. 12 L is interstitial fluid and 3 L is plasma).

Blood Plasma Composition

Plasma contains about 90 percent water, with 10 percent being made up of ions, proteins, dissolved gases, nutrient molecules, and wastes. Plasma proteins are the most abundant substances in the plasma and are present in three major types, namely, albumin, globulins, and fibrinogen. They play specialized roles as follows: Plasma that separates from blood in coagulation.The water substance in which all blood cells are suspended in, until movement by the heart pushes them along the bloodstream.

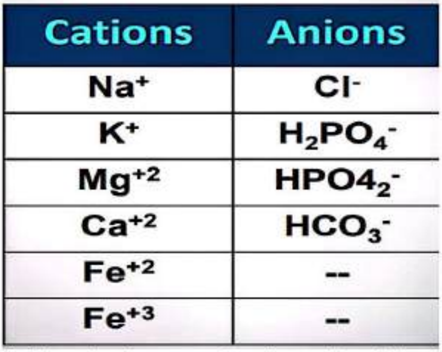


Lymph composition

Lymph is fluid which flows through the lymphatic system that composed of lymph nodes and lymph vessels or channels, yellowish to almost colourless, slightly alkaline, It is very much similar to blood plasma, water (96%), inorganic and organic substances (4%), but has lesser number of calcium, proteins, phosphoeous, and high amount of glucose concentration. however lymph contains mainly of white blood cells, and (chlorides , bicarbonates) more than plasma.

Anions and Cations

Negatively charged ions are called **anions**, and positively charged ions are called **cations** that is carrying out by forming chemical bond. Most common cations and anions in the living system are:



Cations	Anions
Na^+	Cl^-
K^+	$H_2PO_4^-$
Mg^{+2}	$HPO4_2^-$
Ca^{+2}	HCO_3^-
Fe^{+2}	--
Fe^{+3}	--

Calcium is the most abundant mineral in the body. Calcium salts are structural components of bones and teeth. Ca^{+2} which are primarily extracellular cations, function in blood clotting, neurotransmitter release, and contraction of muscle. Ca^{+2} level is controlled by parathyroid and calcitrol. • In general, imbalances in calcium concentrations affect the bones, kidney and gastrointestinal tract. Calcium also influences the permeability of cell membranes and thereby regulates neuromuscular activity.oxalate reacts with calcium ions to form complex and by this way absorption of calcium decreases in intestines.

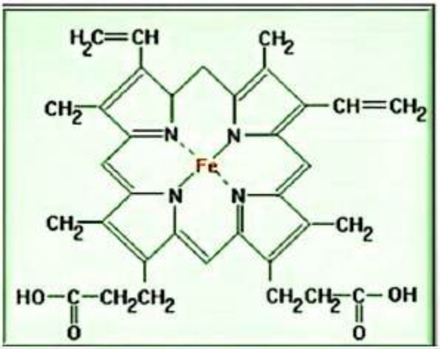
${}_{20}$Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ or ${}_{20}$Ca:${}_{18}$[Ar] $4s^2$
Ca^{+2}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0$ or Ca^{+2}:${}_{18}$[Ar] $4s^0$

Sodium affects the osmolality of blood and therefore influences blood volume and pressure and the retention or loss of interstitial fluid.

Potassium affects muscular activities, notably those of the heart, intestines and respiratory tract, and also affects neural stimulation of the skeletal muscles. • Mg^{+2} ions -intracelluar cations that act as cofactors for enzymes.Phosphate ions are principally intracellular anions and their salts are structural components of bones and teeth, also required for the synthesis of nucleic acids and ATP and participate in buffer reactions. Level is controlled by PTH and calcitrol.

A traces of certain metallic cations are needed to maintain life, like presence of ferrous ion Fe^{+2} in hemoglobin which play important role in transport of oxygen and carbon dioxide:

Fe^{+2}↔Fe^{+3}



Pb^{+2} have toxic effect to kidney and also cause nerve damage, while Hg^{+2} cause damage to brain and nerve system.

Q- Each question below contains four suggested answers of which one or more is correct.Choose the answer.

A- if only 1,2,and 3 are correct
B- if only 1 and 3 are correct
C- if only 2 and 4 are correct

D- if only 4 is correct

E- if only 1,2,3,and,4 are correct

1- Sodium affects the osmolality of blood and therefore influences

(…..) 1- blood volume and pressure

2- the permeability of cell membranes

3- the retention or loss of interstitial fluid

4- muscular activities

2- Plasma proteins are the most abundant substances in the plasma and are present in three major types, namely

(……) 1- albumin.

2- fibrinogen

3- globulins.

4-Keratin.

3- The cations include

(…..) 1- Na^+

2 K^+

3- Ca_2^+

4- Mg^{+2}

CARBOHYDRATES

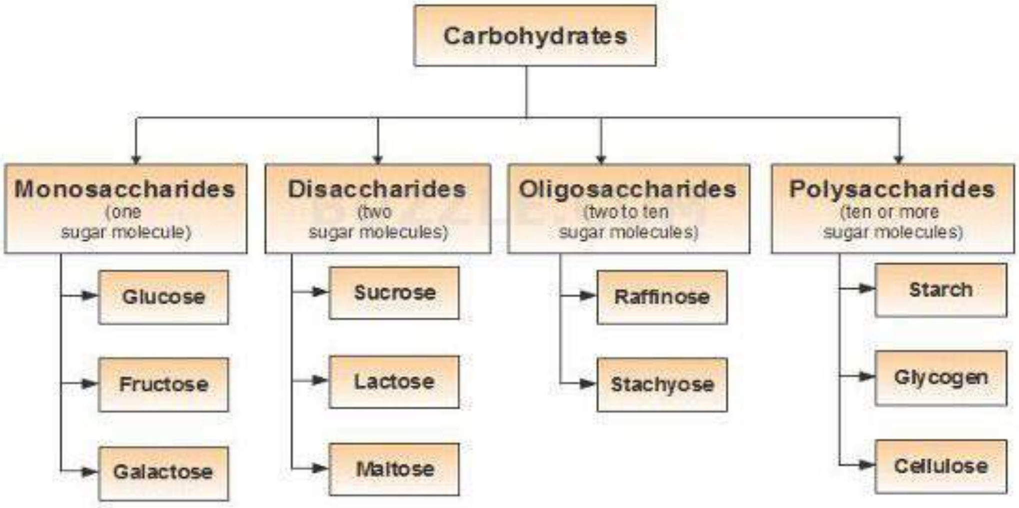
Carbohydrates are the most abundant biomolecules on earth. Oxidation of carbohydrates is the central energy-yielding pathway in most non-photosynthetic cells.

Definition: Carbohydrates are polyhydroxy aldehydes or ketones, or substances that yield such compounds on hydrolysis. carbohydrates have the formula $(CH2O)n$.

Biological Importance of carbohydrates

- Carbohydrates act as energy reserves and metabolic intermediates.
- Ribose and deoxyribose sugars forms the structural frame of the genetic material, RNA and DNA.
- Polysaccharides like cellulose are the structural elements in the cell walls of bacteria and plants.
- Carbohydrates are linked to proteins and lipids that play important roles in cell interactions.
- Carbohydrates are intermediates in biosynthesis of fats and proteins.
- In animals they are important constituent of connective tissues.
- They participate in biological transport, cell-cell communication and activation of growth factors.
- Carbohydrates that are rich in fiber content help to prevent constipation.

There are four major classes of carbohydrates:

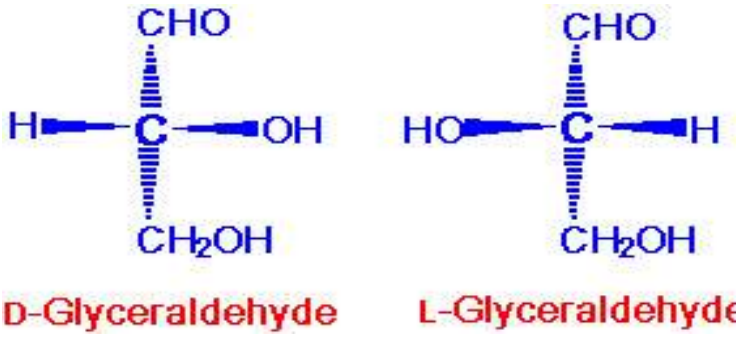


1. Monosaccharides

Monosaccharides, or simple sugars, consist of a single polyhydroxy aldehyde or ketone unit. The most monosaccharide in nature is the six-carbon sugar D- glucose, sometimes referred to as dextrose. The word “Monosaccharides” derived from the Greek word “Mono” means Single and “saccharide” means sugar. They contain 3 to 7 carbon atoms, 2 or more hydroxyl (OH) groups and one aldehyde (CHO) or one ketone (CO) group.

Physical Properties of monosaccharides

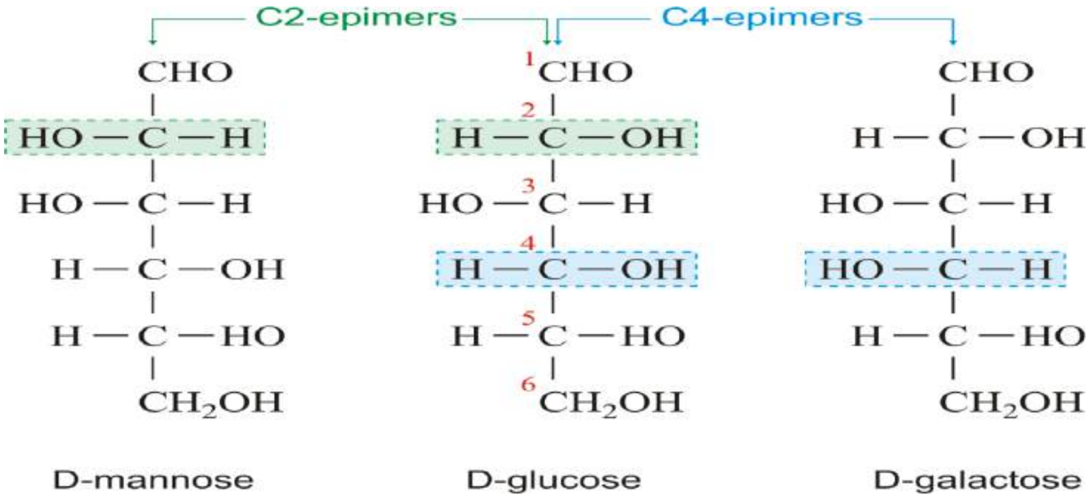
They are colorless, crystalline compounds, readily soluble in water. Their solutions are optically active. Carbohydrates spontaneously change between the α and β configuration.



When the - OH group around the carbon atom adjacent to the terminal primary alcohol carbon is on the right, the sugar is a member of the D-series, when it is on the left, it is a member of the L-series. These D and L configuration.

Optical Activity - The presence of asymmetric carbon atom causes optical activity. When a beam of plane polarized light is passed through a solution of carbohydrate it will rotate the light either to right or to left. Depending on the rotation, molecules are called dextrorotatory (+) (d) or levorotatory (-) (l).

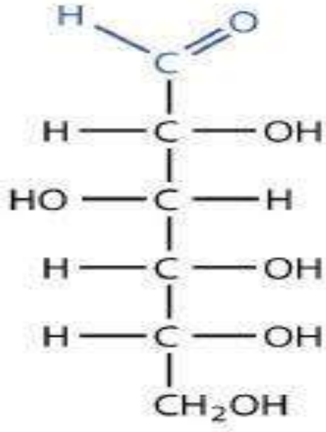
Epimers- When sugars are different from one another, only in a single carbon atom (around one carbon atom) they are called **epimers** of each other. For example glucose and mannose are epimers. They differ only in configuration around C2. Mannose and Galactose are epimers of Glucose.



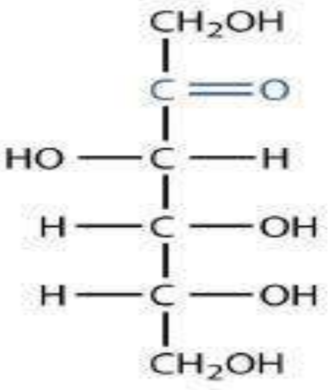
Classification of Monosaccharides

Monosaccharides are classified in two ways. (a) First of all, based on the number of carbon atoms present in them and (b) secondly based on the presence of carbonyl group.

The naturally occurring monosaccharides contain three to seven carbon atoms per molecule. For example, the terms *triose*, *tetrose*, *pentose*, and *hexose* signify monosaccharides with, respectively, three, four, five, and six carbon atoms. Monosaccharides are also classified as aldoses or ketoses. Those monosaccharides that contain an aldehyde functional group are called aldoses; those containing a ketone functional group on the second carbon atom are ketoses.

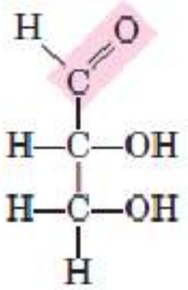


Glucose
(an aldohexose)

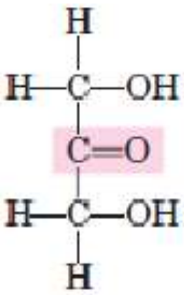


Fructose
(a ketohexose)

Name	Formula	Aldose	Ketose
Triose	$C_3H_6O_3$	Glycerose	Dihydroxy acetone
Tetrose	$C_4H_8O_4$	Erythrose	Erythrulose
Pentose	$C_5H_{10}O_5$	Ribose	Ribulose
Hexose	$C_6H_{12}O_6$	Glucose	Fructose
Heptose	$C_7H_{14}O_7$	Glucoheptose	Sedo heptulose



Glyceraldehyde, an aldotriose



Dihydroxyacetone, a ketotriose

Hexoses

Hexoses are "Monosaccharides" containing 6 carbon atoms. The molecular formula of Hexose is C6H12O6

Characteristics

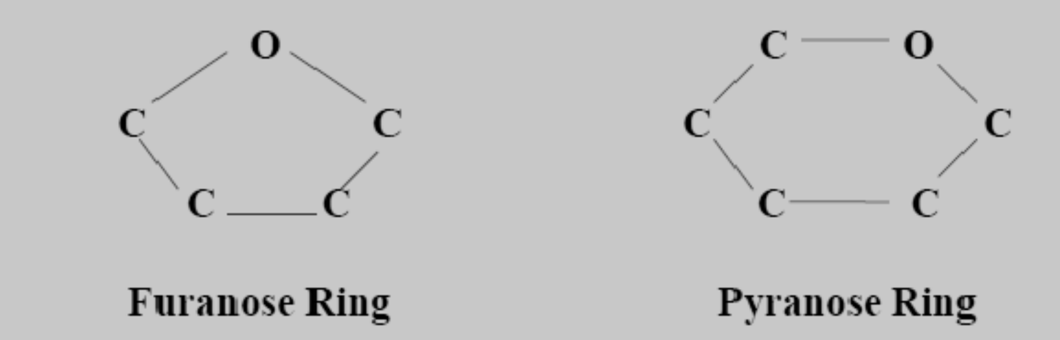
- Hexoses are simple sugars
- Hexoses are soluble in water
- They are sweet in taste .
- They are *crystalline* forms.
- The pentoses may contain an aldehyde group (aldohexose) or a ketone group (ketohexose).

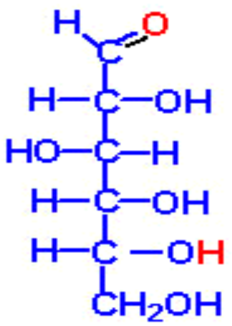
Structure of Monosaccharides

1. **Straight or Open Chain Structure**: Here 6 carbon atoms of glucose are arranged in a straight line. It is also called open chain structure because the two ends remain separate and they are not linked.

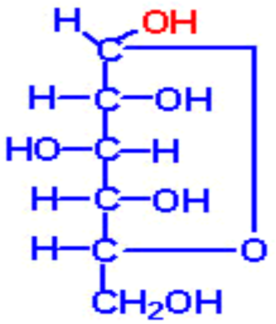
2. **Cyclic or Ring Structure:** Here the atoms are arranged in the form of a ring. Haworth (1929) proposed this formula and hence the name Haworth's Projection Formula. The sugar molecules exist in two type of rings which are as follows – (a) Furanose Ring – 5 membered ring

(b) Pyranose Ring- 6 membered ring

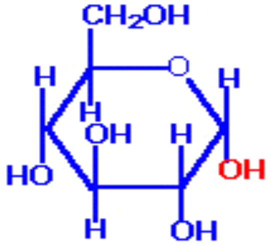




Open chain D-glucose



α-D –glucose
(Fisher formula)



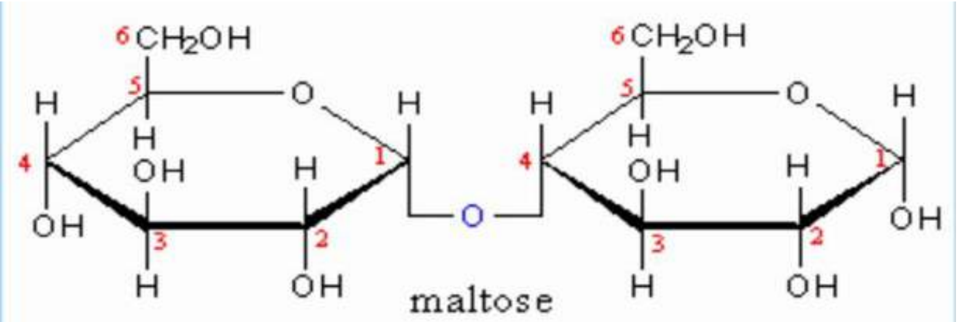
α-D –glucose
(Haworth formula)

2- Disaccharides

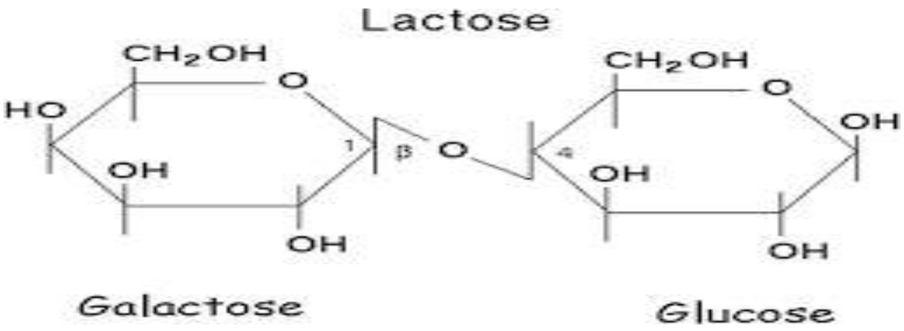
Disaccharides consist of two sugars joined by an glycosidic bond, like sucrose, lactose and maltose.

The disaccharides can be classified into:

1. Homodisaccharides



2. Heterodisaccharides: are formed of 2 different monosaccharide units like sucrose composed of glucose and fructose , lactose composed of glucose and galactose.



3- Oligosaccharides

Oligosaccharides consist of short chains of monosaccharide units (3-9), or residues, joined by characteristic linkages called glycosidic bonds. Common oligosaccharides include raffinose, and stachyose. These oligosaccharides can be found in relatively abundant levels in legumes, whole grains, some cruciferous vegetables, and some fruits.

4- Polysaccharides

Polysaccharides contain hundreds or thousands of carbohydrate units. The anomeric carbons are connected through glycosidic linkages.

Polysaccharides are of two types based on their function and composition.

A. Storage polysaccharide - starch.
B. Structural polysaccharide - cellulose.

Homopolysaccharide: a polysaccharide is made up of **one type** of monosaccharide unit.

Starch

- Starch is a polymer consisting of D-glucose units.
  Starches (and other glucose polymers) are usually insoluble in water because of the high molecular weight, but they can form thick colloidal suspensions with water.
- Starch is a **storage** compound in plants, and made of glucose units
- It is a homopolysaccharide made up of two components: **amylose** and **amylopectin**.
- Most starch is 10-30% amylose and 70-90% amylopectin.
- **Amylose** – a straight chain structure formed by **1,4 glycosidic bonds** between **α-D-glucose** molecules.

Glycogen

- Glycogen is the main storage polysaccharide of animal cells (Animal starch).
- - It is present in liver and in skeletal muscle.
- - Like amylopectin glycogen is a branched polysaccharide of D-glucose units in α - (1, 4) linkages, but it is highly branched.

- - The branches are formed by α -(1,6) glycosidic linkage that occurs after every 8 - 12 residues. Therefore liver cell can store glycogen within a small space. Multiple terminals of branch points release many glucose units in short time.

- Like amylopectin, glycogen gives a red-violet color with iodine.

Cellulose

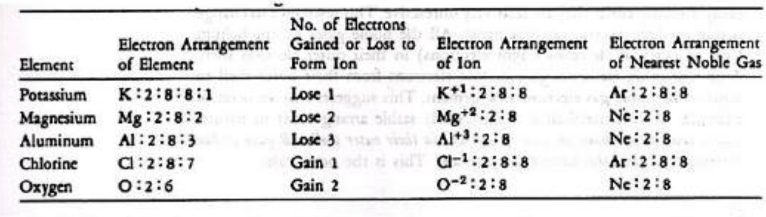
- Cellulose is the most abundant structural polysaccharide in plants. It is fibrous, tough, water insoluble. Cellulose is a linear unbranched homopolysaccharide of 10,000 or more D- glucose units connected by β-(1, 4) glycosidic bonds. Humans cannot use cellulose because they lack of enzyme (cellulase) to hydrolyze the β-(1-4) linkages.
- Cellulose is an important structural polysaccharide, and is the single most abundant organic compound on earth. It is the material in plant cell walls that provides strength and rigidity; wood is 50% cellulose.
- Cellulose is also important industrially, from its presence in wood, paper, cotton, nitrocellulose, photographic films (cellulose acetate), etc.

Chemical Bond

Molecules are made up of atoms joined together .The links that join these atom are called chemical bonds.The properties of a molecule are determined by its chemical bonds.

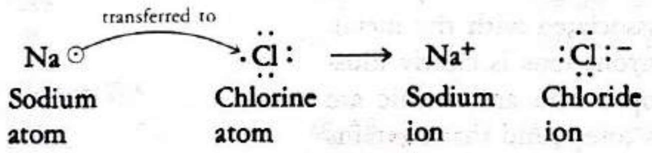
Types of Chemical Bonds

1-Ionic bonding is a chemical bond that involves the electrostatic attraction between oppositely charged ions, and is the primary interaction occurring in ionic compounds. The ions are atoms that have gained one or more electrons (known as anions, which are negatively charged) and atoms that have lost one or more electrons (known as cations, which are positively charged). In the simplest case, the cation is a metal atom and the anion is a nonmetal atom.



Element	Electron Arrangement of Element	No. of Electrons Gained or Lost to Form Ion	Electron Arrangement of Ion	Electron Arrangement of Nearest Noble Gas
Potassium	K:2:8:8:1	Lose 1	K^{+1}:2:8:8	Ar:2:8:8
Magnesium	Mg:2:8:2	Lose 2	Mg^{+2}:2:8	Ne:2:8
Aluminum	Al:2:8:3	Lose 3	Al^{+3}:2:8	Ne:2:8
Chlorine	Cl:2:8:7	Gain 1	Cl^{-1}:2:8:8	Ar:2:8:8
Oxygen	O:2:6	Gain 2	O^{-2}:2:8	Ne:2:8

An ionic bond is the transfer of electrons from a metal to a non-metal in order to obtain a full valence shell for both atoms.



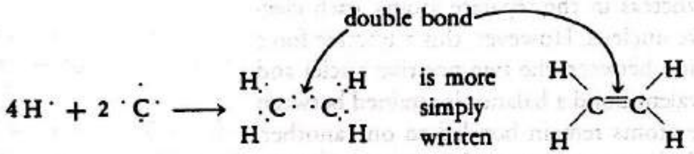
2- covalent bond(molecular bond) is a chemical bond that involves the sharing of electron pairs between atoms. These electron pairs are known as ***shared pairs*** or ***bonding pairs,*** and the stable balance of attractive forces between atoms, when they share electrons, is known as covalent bonding for many molecules, the sharing of electrons allows each atom to attain the equivalent of a full outer shell, corresponding to a stable electronic configuration(to achieve noble gas electron arrangement for each atom).

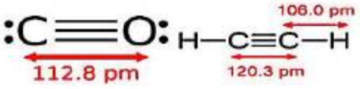
For getting stability, hydrogen atom shares its valence electron with other hydrogen atom to form single covalent bond results the formation of hydrogen molecule(H:H or H-H). So each bonded hydrogen atom gets two electrons and stabilized in hydrogen molecule.

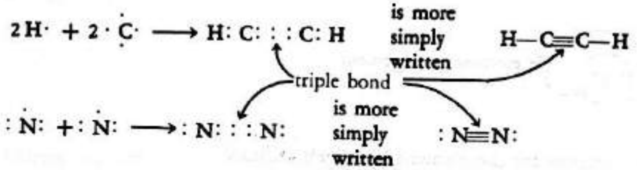
For getting stability, hydrogen atom shares its valence electron with other hydrogen atom to form single covalent bond results the formation of hydrogen molecule. So each bonded hydrogen atom gets two electrons and stabilized in hydrogen molecule.

Another example of covalent bonding is carbon dioxide molecule in which center carbon atom is bonded with two oxygen atoms through double covalent bonds($O=C=O$ or O::C::O). The center atom contains four valence electrons and to get the octet configuration, it tends to form four covalent bonds with same or different atoms. Similarly oxygen atom contains 6 valence electrons and needs two electrons to get octet configuration therefore it can form two covalent bonds. Therefore four covalent bonds by carbon atoms and two covalent bonds by oxygen atoms form carbon dioxide

A single line indicates a single bond between two atoms (i.e., involving one electron pair), double lines (=) indicate a double bond between two atoms (i.e., involving two electron pairs), and triple lines (≡) represent a triple bond, as found, for example, in carbon monoxide ($C\equiv O$). Single bonds consist of one sigma (σ) bond, double bonds have one σ and one pi (π) bond, and triple bonds have one σ and two π bonds.



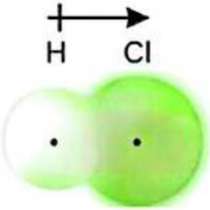




Covalent Polar bonds

A bond between 2 nonmetal atoms that have different electronegativities and therefore have unequal sharing of the bonding electron pair

Example: In H-Cl, the electronegativity of the Cl atom is 3.0, while that of the H atom is 2.1



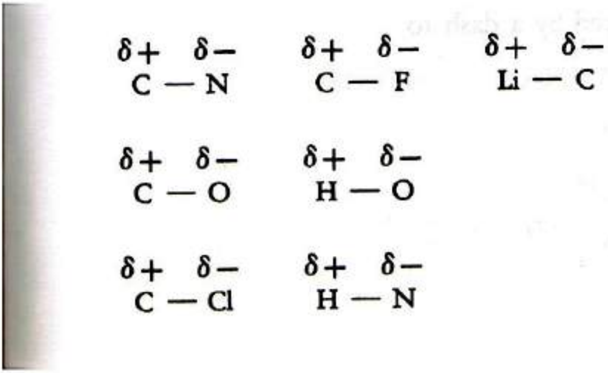
$\delta+\ \delta-$

H—Cl

The result is a bond where the electron pair is displaced toward the more electronegative atom. This atom then obtains a partial-negative charge while the less electronegative atom has a partial-positive charge.This separation of charge or bond dipole can be illustrated using an arrow with the arrowhead directed toward the more electronegative atom. Within a molecule each polar bond has a bond dipole.A polar molecule always contains polar bonds, but some molecules with polar bonds are nonpolar.

Polar Molecule

A molecule in which the bond dipoles present do not cancel each other out and thus results in a molecular dipole.Cancellation depends on the shape of the molecule or Stereochemistry and the orientation of the polar bonds.



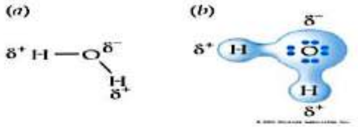
$$\overset{\delta+}{\mathrm{C}}-\overset{\delta-}{\mathrm{N}} \qquad \overset{\delta+}{\mathrm{C}}-\overset{\delta-}{\mathrm{F}} \qquad \overset{\delta+}{\mathrm{Li}}-\overset{\delta-}{\mathrm{C}}$$

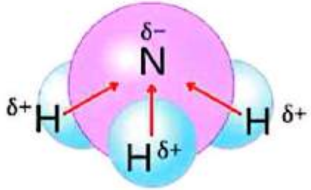
$$\overset{\delta+}{\mathrm{C}}-\overset{\delta-}{\mathrm{O}} \qquad \overset{\delta+}{\mathrm{H}}-\overset{\delta-}{\mathrm{O}}$$

$$\overset{\delta+}{\mathrm{C}}-\overset{\delta-}{\mathrm{Cl}} \qquad \overset{\delta+}{\mathrm{H}}-\overset{\delta-}{\mathrm{N}}$$

Molecular Dipole
A result of the bond dipoles in a molecule.
Bond dipoles may or may not cancel out thereby producing either molecules that are nonpolar, if they cancel, or polar, if they do not cancel

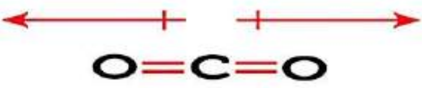
Examples:H_2O is polar molecule its shape(V) molecule with 2 bond dipoles that are equal and same direction therefore the bond polarities not cancel and the molecule is polar.





CO_2 is a linear molecule with 2 bond dipoles that are equal and oppositely directed therefore the bond polarities cancel and the molecule is nonpolar.

Carbon Dioxide (CO_2)



Carbon dioxide is a nonpolar compound. Both ends of the molecule are slightly negative in charge.

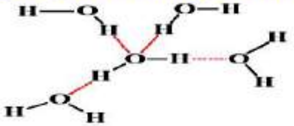
HCN is a linear molecule with 2 bond dipoles that are in the same direction and are not equal therefore the bond polarities do not cancel and the molecule is polar

3-Hydrogen bond

A hydrogen bond is an electrostatic attraction between two polar groups that occurs when a hydrogen (H) atom, covalently bound to a highly electronegative atom such as nitrogen (N), oxygen (O), or fluorine (F), experiences the electrostatic field of another highly electronegative atom nearby.

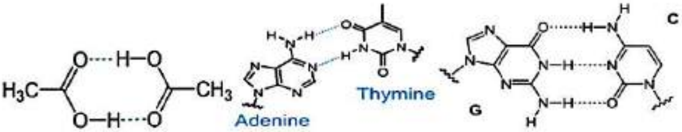
Hydrogen bonds can occur between molecules (intermolecular) or within different parts of a single molecule (intramolecular). Depending on the nature of the donor and acceptor atoms which constitute the bond. Hydrogen bonding is important in many chemical processes.

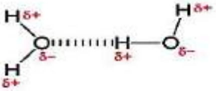
Hydrogen Bonding in Water



Hydrogen bonding is responsible for water's unique solvent capabilities. Hydrogen bonds hold complementary strands of DNA together(Guanine with Cytosine G≡C,and Thymine with Adenine T=A) and they are responsible for determining the three-dimensional structure of folded proteins including enzymes and antibodies.when the numbers of hydrogen bond had increased hydroge

Bond power.

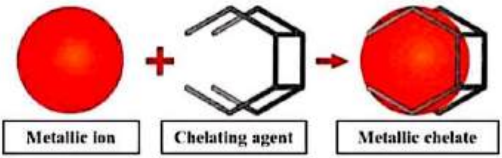




Chelation

Chelation is a type of bonding of ions and molecules to metal ions. It involves the formation or presence of two or more separate coordinate bonds between a polydentate ligand and a single central metal atom.

These ligands are called chelants, chelators or chelating agents.

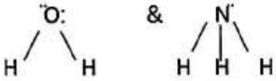


1- The case of zinc and its use as a maintenance therapy to prevent the absorption of copper in people with Wilson's disease.

2-

ligand

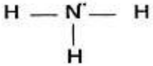
A ligand is an ion or molecule, which donates a pair of electrons to the central metal atom or ion to form a coordination complex



The atom in a ligand that is bound directly to the metal atom is known as the "donor atom". Depending on the number of donor atoms, ligands are classified as:

Monodentate, bidentate, or polydentate.

H_2O, NH_3,

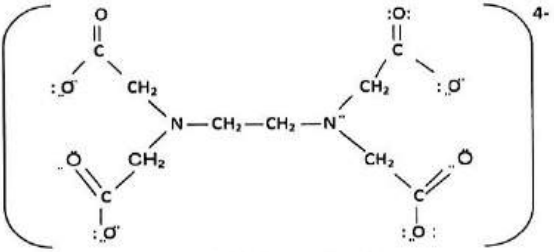


$H-\ddot{N}(H)-H$

$H_2\dot{N}-CH_2-CH_2-NH_2$

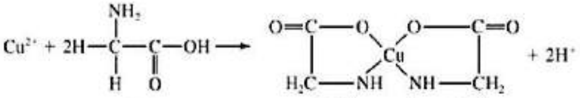
Monodentate

Bidentate ligand (Ethtlenediamine)



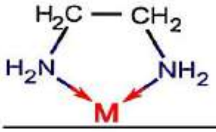
EDTA (Polydentate ligand)

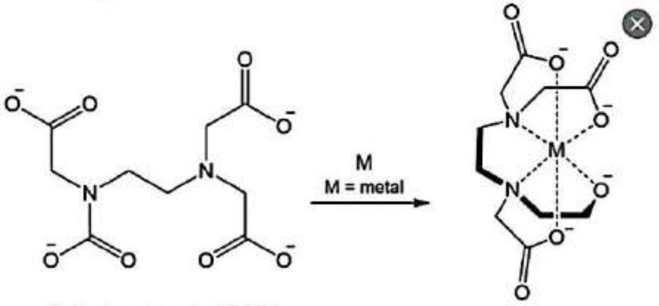
Glycine is amino acid consider bidentate ligand



Glycine

Cu^{2+} complex with glycine.





Fully deprotonated EDTA

"Metal-EDTA complex"

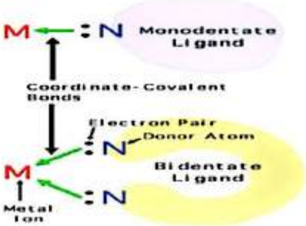
While individual hydrogen bonds are not very strong, a series of hydrogen bonds is very secure. When one molecule hydrogen bonds through two or more sites with another molecule, a ring structure known as a chelate is formed. Chelating compounds are useful for removing or mobilizing molecules and atoms such as metals. **chelation therapy to remove toxic metals from the body,EDTA (ethylenediaminetetra aceticacid) is injected into the bloodstream to remove heavy metals and/or minerals from the body. Chelation means "to grab" or "to bind." When EDTA is injected into the veins, it "grabs" heavy metals and minerals such as lead, mercury, copper, iron, arsenic, aluminum, and calcium and removes them from the body.**

4-coordinate bond

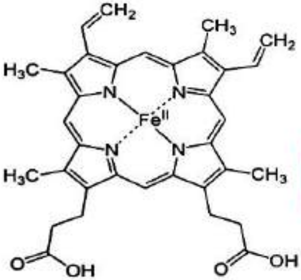
A covalent chemical bond between two atoms that is produced when one atom shares a pair of electrons with another atom lacking such a pair. A type of covalent bond in which both the shared electrons are contributed by one of the two atoms(first atom with pair of electron and the another atom with empty orbital)

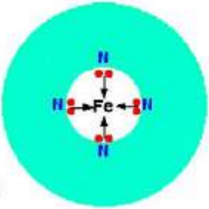
$_5$B $1s^2\,2s^2\,2p^1$ $_7$N $1s^2\,2s^2\,2p^4$

A compound that donates one electron pair is monodentate ligand while any compound donates two electron pairs is didentateligand.this compounds donate the electron pairs for empty orbital to hold coordinate bonds.



Hemoglobin (***Hb)*** (contains 4 subunits protein), each subunit contains a heme group. Each heme group contains an iron atom that is able to bind to one oxygen (O_2) molecule. Therefore, each hemoglobin protein can bind four oxygen molecules. One of the most important classes of chelating agents in nature are the porphyrins. A porphyrin molecule can coordinate to a metal using the four nitrogen atoms as electron-pair donors, and hence is a polydentate ligand . Heme is a porphyrin that is coordinated with Fe(II).In the body, the iron in the heme is coordinated to the four nitrogen atoms of the porphyrin of the hemoglobin protein .Hemoglobin is the protein that transports oxygen (O_2) in human blood from the lungs to the tissues of the body and transports carondioxide (CO_2) in human blood from the tissues of the body to the lungs.



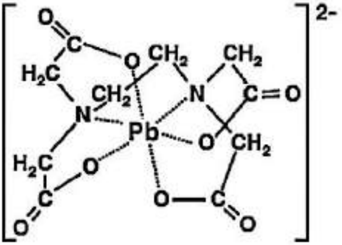


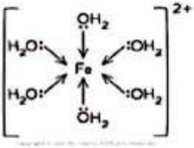
Example:Binding of EDTA with Pb^{+2}

$_{82}$Pb $[Xe]\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^2$

Pb^{+2} $[Xe]\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^0$

Pb^{+4} $[Xe]\ 6s^0\ 4f^{14}\ 5d^{10}\ 6p^0$

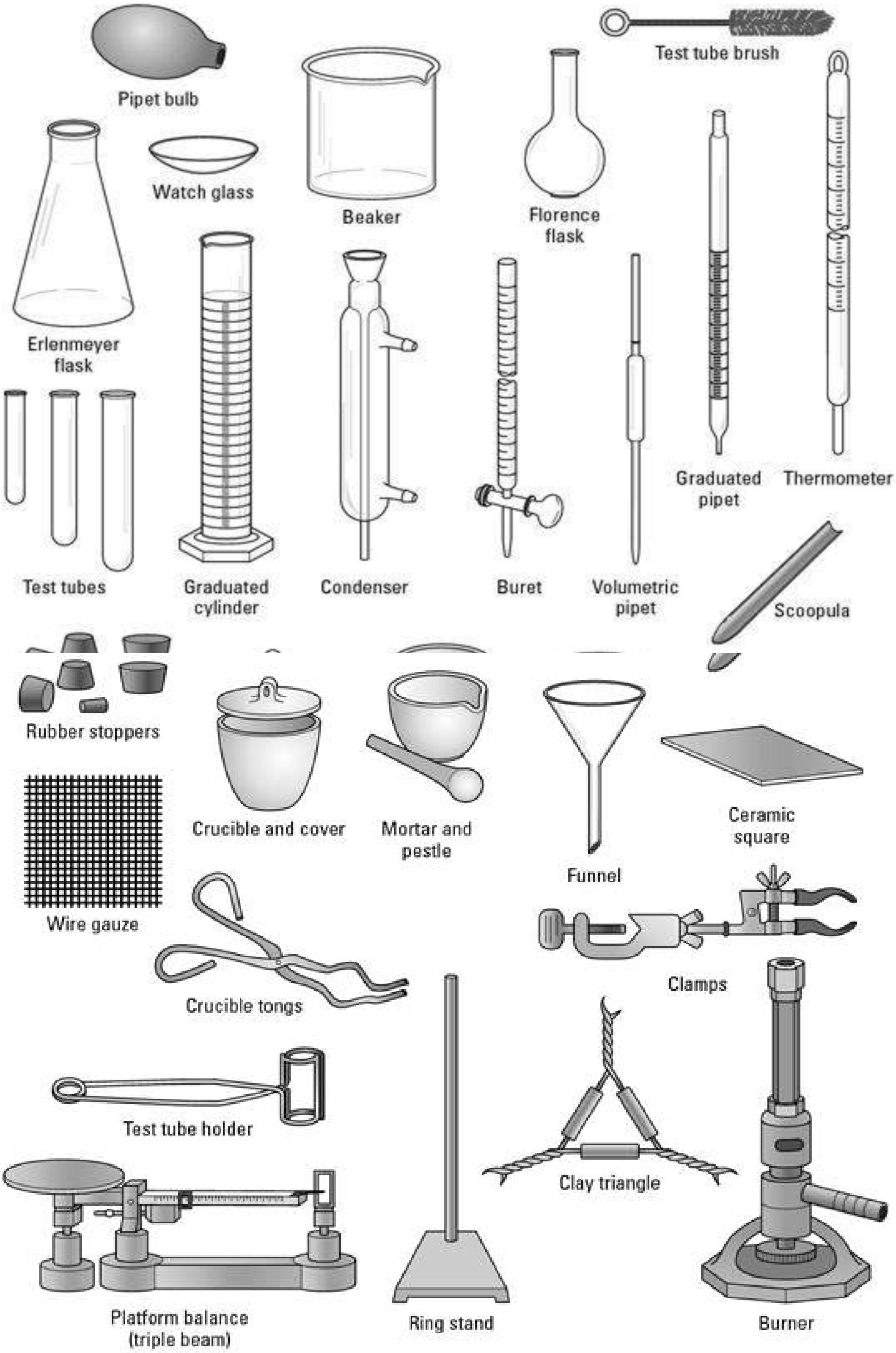



OH2
H2O:
:OH2
Fe
H2O:
:OH2
ÖH2
2+

Tikrit University **College of Dentistry**

Chemistry lab:1 **First stage**

Lab Equipments



Lab Equipments

- **Balance:** Used for obtaining the masses of solid and liquid substances.
- **Beaker:** A flat-bottomed, cylindrical piece of glassware used for mixing and heating compounds.
- **Bunsen burner:** Attached to a gas line and lit to provide heat for your experiments.
- **Burette:** An extremely accurate device with a stopcock at the bottom used to measure volumes of reagents.
- **Ceramic Square:** Used to avoid burning the surface of your lab bench.
- **Clamps:** Used to hold a variety of things in place, especially test tubes.
- **Test tube:** Cylindrical open-topped piece of glassware that comes in varying sizes. Used to hold and mix small samples. Stirred by tapping the bottom with two fingers. Fit into both a centrifuge and test tube rack. **Graduated cylinder:** Used to precisely measure volumes.
- **Graduated cylinder:** Used to precisely measure volumes. They are available in various sizes.
- **Metal spatula:** Used to measure out solid substances.
- **Mortar and pestle:** Used to grind solid chemical compounds for chemistry experiments.

- **Pipette bulb:** Used to transfer accurately measured amounts of liquid from one container to another.
- **Rubber stoppers:** Used to close flasks or test tubes to prevent evaporation of liquids or escape of gases.
- **Crucible:** A cup-shaped container capable of sustaining high temperatures. It is used to heat chemical compounds.
- **Crucible tongs:** Used to handle the hot crucible.
- **Clay triangle:** Used to hold a crucible while it's being heated.
- **Condenser:** Used to collect vapors by condensing them into liquids as they contact the liquid-cooled inner surface of the condenser.
- **Erlenmeyer flask (Conical Flask):** Used to hold liquids. The small upper opening slows evaporation, so for some volatile liquids, a flask is a better choice than a beaker. The shape also makes it suitable for mixing and swirling liquids during a titration.
- **Florence flask (Volumetric Flask):** A type of flask, generally round-bottomed, usually suspended and heated from below. Its shape makes it easy to swirl and mix liquids inside of it.
- **Funnel:** Used together with filter paper to filter precipitates out of solutions.
- **Watch glass:** A piece of glassware in the shape of a large contact lens used for evaporating liquids.
- **Wire gauze:** Generally used as a surface for a beaker or flask to rest when being heated by a Bunsen burner.

- **Graduated Pipet**: Can be used to any of the given markings along its side.
- **Volumetric Pipet**: Extremely accurate, but only used for one volume.
- **Test Tube Brush:** An instrument used to clean the equipments by using water and purifier.
- **Test Tube Holder:** Used to hold a test tube while it's being heated.
- **Ring Stand**: Used in conjunction with clamps to hold equipment that cannot stand up on its own.
- **Scoopula:** Another instrument used to transfer solids from one place to another.
- **Thermometer:** Used to measure temperatures. Thermometer generally contain liquid mercury (Hg).

Chemistry lab:2 First stage

REACTIONS OF ACID RADICALS OR – ANIONS

We are studying some acid radicals such as:-

1- Chloride Cl^{-}

2- Iodide I^{-}

3- Phosphate PO_4^{-2}

4- Sulphate SO_4^{-2}

5- Thiocyanate SCN^{-}

6- Oxalate $C_2O_4^{-2}$

The reactions of these anions depend upon precipitation reaction, and their solubility's, or upon oxidation – reduction reaction as in a certain organic acid such as oxalate.

1-STUDY THE REACTIONS OF CHLORIDE ION Cl^{-}

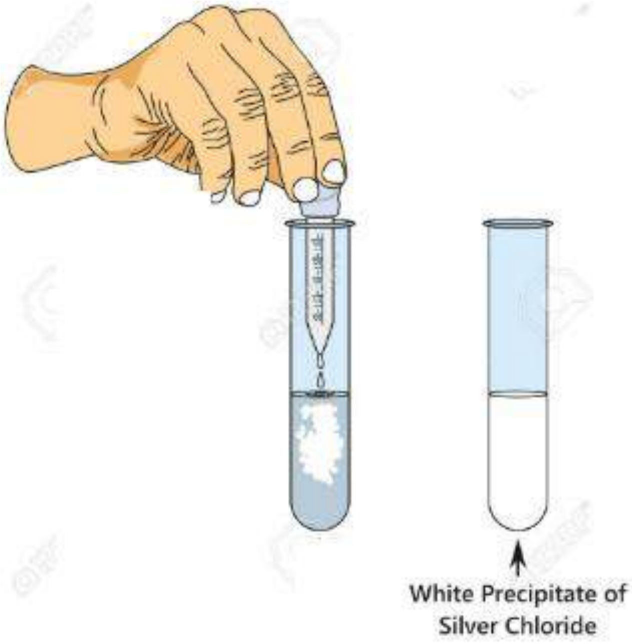
(USE NaCl SOLUTION 5%)

Chloride is constituent of hydrochloric acid (HCl) produced by parietal cells of stomach. It is more in extracellular fluid than intracellular fluid. It is required for proper erythrocyte (RBC) function by chloride shift. It is involved in maintenance of plasma volume. It is activator of some enzymes like amylase, angiotensin converting enzyme etc.

REACTION -1

-With $AgNO_3$ solution 5%

When an aqueous solution of silver nitrate ($AgNO_3$) is (10 drops) added to the aqueous solution of (10 drops) sodium chloride (NaCl), a white precipitate of silver chloride (AgCl) is formed that is indicated by the following chemical reaction.



$$\underset{\substack{\downarrow \\ \text{wt. ppt.}}}{} \mathrm{NaCl} + \mathrm{AgNO_3} \longrightarrow \underset{\substack{\downarrow \\ \text{wt. ppt.}}}{\mathrm{AgCl}} + \mathrm{NaNO_3}$$

REACTION -2

-Confirm by:

1- Try the solubility of AgCl in HNO_3 (insoluble).

2- Try the solubility of AgCl in dil NH_4OH (soluble).

In order to confirm that this precipitate is AgCl, 20 drops of NH_4OH is added to the same test tube. The white precipitate dissolves because AgCl salt forms a complex with NH_3.

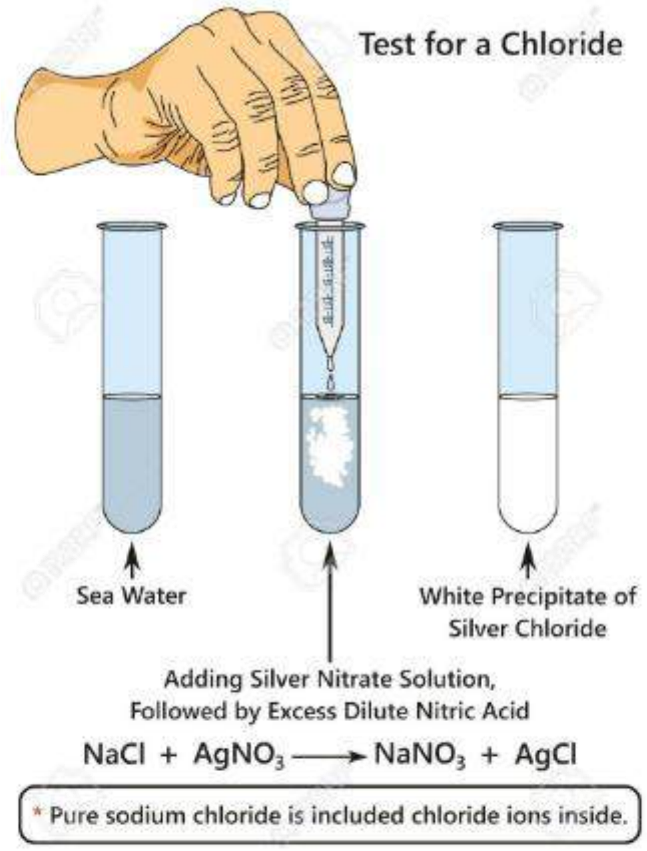
$$AgCl_{(s)} + 2NH_3 \rightarrow [Ag(NH_3)_2]^+ + Cl^-$$

$$AgCl + 2NH_4OH \longrightarrow \underset{\text{soluble complex}}{Ag(NH_3)_2Cl} + 2H_2O$$

Added 15 drops of HNO_3 into the solvated complex and a white precipitate is re-constituted. Because with the addition of HNO_3, the silver diamine complex $[Ag(NH_3)_2\,]^+$ decomposes and re-precipitates as AgCl.

$$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \rightarrow 2NH_4^+ + 2NO_3^- + AgCl_{(s)}$$

Note:-Sea water and tap water Contains (Cl^-)



2-STUDY THE REACTIONS OF IODIDE ION I^-

(USE KI SOLUTION 5%)

Iodine is constituent of thyroid hormones. Thyroxine (T_4) and triiodothyronine (T_3) synthesis involves iodine utilization. Thyroid hormones are essential for mental development as well as physical development.

REACTION -1

-With $AgNO_3$ solution 5%

Add (10 drops) of $AgNO_3$ solution to (10 drops) of KI solution then you will see yellow precipitate of AgI in the tube which will be insoluble in NH_4OH and HNO_3.

$$\mathrm{KI} + \mathrm{AgNO_3} \longrightarrow \underset{\downarrow}{\mathrm{AgI}} + \mathrm{KNO_3}$$

yell. ppt.
Insoluble in
NH_4OH and HNO_3

REACTION -2

-Confirm by starch test:

Iodides are readily oxides in acid solution to free iodine by a number of oxidizing agents, free iodine identified by the deep blue coloration produced with starch solution.

Add (5 drops) of KI solution to (5 drops) of HNO_3 solution then you will see brown solution of free iodine.

$$\mathrm{KI} + \mathrm{HNO_3} \longrightarrow \mathrm{HI} + \mathrm{KNO_3}$$

3-STUDY THE REACTIONS OF PHOSPHATE ION PO_4^{-2}

(USE Na_2HPO_4 SOLUTION 15%)

Phosphate is present in humans to an extant of about 500-700gm. More of it is present in bone and teeth. In the body phosphate is present in two forms. An inorganic form found in bone and teeth which is complexes with calcium and magnesium. Another is organic form. It is present as organic compounds in the cells and cell membranes. In the bone and teeth it is present as hydroxyl apatite. Phosphate is component of blood buffers.

REACTION -1

-With $AgNO_3$ solution 5%

Add (10 drops) of $AgNO_3$ solution to (10 drops) of Na_2HPO_4 solution then you will see yellow precipitate of Ag_3PO_4 in the tube which will be sparingly soluble in HNO_3.

$$Na_2HPO_4 + 3AgNO_3 \longrightarrow \underset{\text{yell. ppt.}}{\underset{\downarrow}{Ag_3PO_4}} + 2NaNO_3 + HNO_3$$

Try the solubility of the yellow ppt. Ag_3PO_4 in

1- In dilute NH_4OH (soluble).

2- In dilute HNO_3 (soluble).

REACTION -2

-Confirm by $FeCl_3$ test:

Pale buff $FePO_4$, soluble in excess of $FeCl_3$ and in HCl, but insoluble in acetic acid (CH_3COOH).

Add (2drops) of $FeCl_3$ solution to (10 drops) of Na_2HPO_4 solution then you will see pale Buff ppt. $FePO_4$ in the tube.

$$Na_2HPO_4 + FeCl_3 \longrightarrow \underset{\text{pale Buff. ppt.}}{FePO_4} + 2NaCl + HCL$$

4-STUDY THE REACTIONS OF SULPHATE ION $SO_4^{=}$

(USE Na_2SO_4 SOLUTION 10%)

Reaction -1

Add (10 drops) of $AgNO_3$ solution to (10 drops) of Na_2SO_4 solution then you will see white precipitate of Ag_2SO_4 in the tube which will be sparingly soluble in HNO_3.

$$2AgNO_3 + Na_2SO_4 \rightarrow \underset{\text{wt. ppt.}}{\underset{\downarrow}{Ag_2SO_4}} + 2NaNO_3$$

Reaction -2

-Confirm by reaction with $BaCl_2$ solution

Add (10 drops) of $BaCl_2$ solution to (10 drops) of Na_2SO_4 solution then you will see white precipitate of $BaSO_4$ which be insoluble in dil HCl.

$$Na_2SO_4 + BaCl_2 \rightarrow \underset{\text{wt. ppt.}}{\underset{\downarrow}{BaSO_4}} + 2NaCl$$

To 0.5 mL of sample in a test tube, add 7 drops of HNO_3 and 1 drop of $BaCl_2$, respectively. The white precipitate is $BaSO_4$ and the formation of this precipitate indicates the presence of SO_4^{2-} ion in the sample.

Sulphate ions SO_4^{2-}

Add acidified barium chloride

Barium chloride + potassium sulfate →
Barium sulfate + potassium chloride

$BaCl_2 + K_2SO_4 \rightarrow BaSO_4 + 2KCl$

$Ba^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow BaSO_{4\,(s)}$

White precipitate

5-STUDY THE REACTIONS OF THIOCYANATE ION SCN^- (USE KSCN SOLUTION 5%)

Reaction -1

Add (10 drops) of $AgNO_3$ solution to (10 drops) of KSCN solution then you will see white precipitate of AgSCN in the tube which will be soluble in NH_4OH but insoluble in dil HNO_3.

$$KSCN + AgNO_3 \longrightarrow \underset{\substack{\downarrow \\ \text{wt. ppt.}}}{AgSCN} + KNO_3$$

Reaction -2

-Confirm by $FeCl_3$ test:

Add (5 drops) of $FeCl_3$ solution to (5 drops) of KSCN solution the product solution will be red blood solution of $Fe(SCN)_3$

$$FeCl_3 + 3KSCN \rightarrow Fe(SCN)_3 + 3KCl$$

red blood colour solution

6-STUDY THE REACTIONS OF OXALATE ION $C_2O_2^{=}$ (USE $K_2C_2O_4$ SOLUTION 5%)

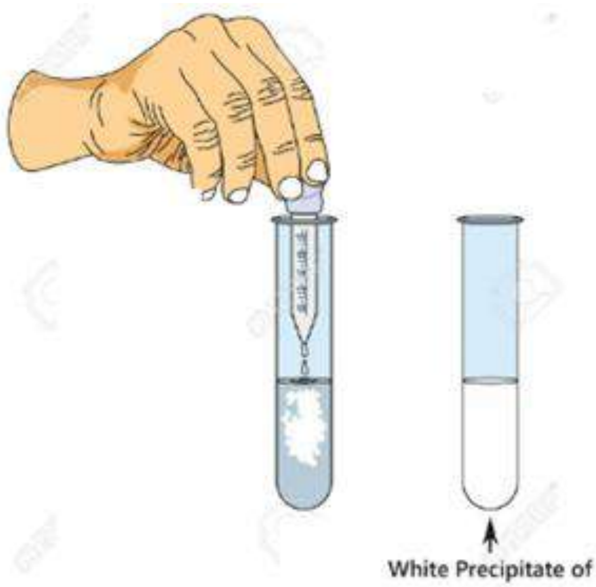
Many metal ions form insoluble precipitates with oxalate, a prominent example being calcium oxalate, the primary constituent of the most common kind of kidney stones.

Reaction -1

-With $AgNO_3$ solution (5%)

When an aqueous solution of silver nitrate (AgNO3) is (10 drops) added to the aqueous solution of (10 drops) potassium oxalate ($K_2C_2O_4$), a white precipitate of silver oxalate ($Ag_2C_2O_4$) is formed that is indicated by the following chemical reaction.

$$K_2C_2O_4 + 2AgNO_3 \rightarrow \underset{\text{Wt.PPt}}{\underset{\downarrow}{Ag_2C_2O_4}} + 2KNO_3$$



1- Try the solubility of Ag $_2C_2O_4$ in HNO_3 (soluble).
2- Try the solubility of Ag $_2C_2O_4$ in dil NH_4OH (soluble).

Reaction - 2

-Confirm by $KMnO_4$ test:

Decolourized the purpul colour of Permanganate (2 drops) when warmed in acid solution (2 drops) with oxalate (10 drops) in (60-70C)

$$K_2C_2O_4 + H_2SO_4 \rightarrow H_2C_2O_4 + K_2SO_4$$

$$2 KMnO_4 + H_2C_2O_4 + 3 H_2SO_4 \rightarrow 2MnSO_4 + 10CO_3 + 8H_2O + K_2SO_4$$

This reaction depended upon oxidation reduction reaction.

Tikrit University **College of Dentistry**

Chemistry lab:3 **First stage**

REACTIONS OF (METAL IONS) OR – CATIONS:

The compounds of these metals are characterized by their precipitation as chlorides by diluted hydrochloric acid (HCl) or by soluble chloride.

These metals or cations are:

1- Silver – Ag^+.
2- Lead – Pb^{+2}.
3- Mercury – Hg_2^{+2}.

1.Silver – Ag^+

Silver is a white mutable and ductile metal, it is insoluble in (H_2SO_4 and dil.HCl) but dissolves in nitric acid HNO_3 (2:1) and in boiling conc.H_2SO_4.

$$Ag^+ + 2HNO_3 \longrightarrow AgNO_3 + NO_2^- + H_2O$$

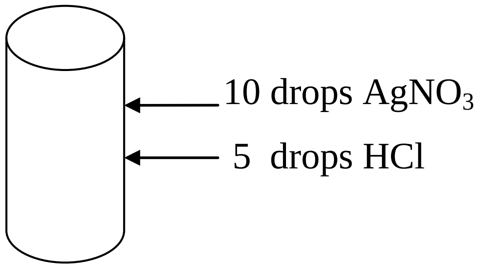
$$2Ag^+ + 2H_2SO_4 \longrightarrow Ag_2SO_4 + SO_4^{-2} + 2H_2O$$

1- REACTIONS OF SILVER ION Ag^+

(Use a solution of silver nitrate ($AgNO_3$ 5%)

REACTION -1

-With diluted hydrochloric acid (HCl)



white .ppt of AgCl

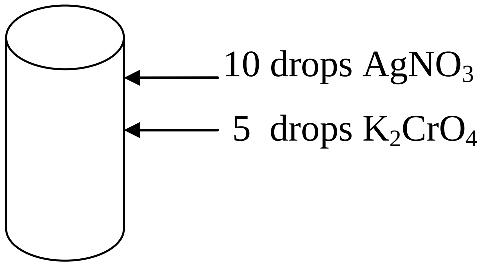
$$HCl + AgNO_3 \longrightarrow \underset{\substack{\downarrow \\ \text{wt. ppt.}}}{AgCl} + HNO_3$$

1- The white precipitate of AgCl is insoluble in water (H_2O) and acid (including nitric acid HNO_3).
2- The white precipitate of AgCl is soluble in dilute NH_4OH to formation the complex soluble salt $Ag(NH_3)_2Cl$.

$$AgCl + 2NH_4OH \longrightarrow \underset{\text{Complex soluble salt}}{Ag(NH_3)_2Cl} + 2H_2O$$

REACTION -2

-With potassium chromate K_2CrO_4



red ppt. of Ag_2CrO_4

$$2AgNO_3 + K_2CrO_4 \longrightarrow \underset{\substack{\downarrow \\ \text{red ppt.}}}{Ag_2CrO_4} + 2KNO_3$$

1- The red precipitate of silver chromate Ag_2CrO_4 is insoluble in dilute acetic acid (CH_3COOH).
2- The red precipitate of silver chromate Ag_2CrO_4 is soluble in NH_4OH and in dilute HNO_3.

2.Lead - Pb^{+2}

Lead is a bluish – grey metal, it is readily dissolved by dilute nitric acid (HNO_3).

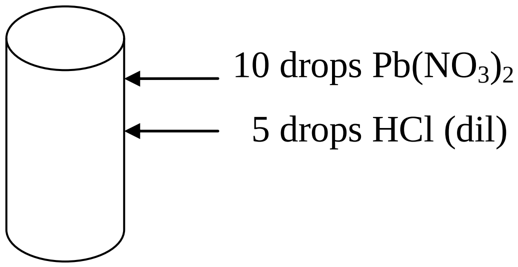
$$3Pb^{+2} + 8HNO_3 \longrightarrow 3Pb(NO_3)_2 + 2NO + 4H_2O$$

2- REACTIONS OF LEAD ION - Pb^{+2}

(Use a solution of lead nitrate $Pb(NO_3)_2$ 5%)

REACTION -1

-With diluted hydrochloric acid (HCl)



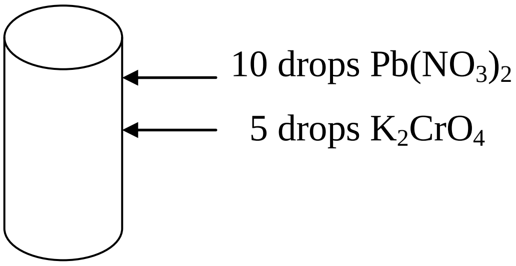
white ppt. of $PbCl_2$

$$2HCl + Pb(NO_3)_2 \longrightarrow \underset{\substack{\downarrow \\ \text{wt. ppt.}}}{PbCl_2} + 2HNO_3$$

1- The white precipitate of $PbCl_2$ is soluble in hot water.
2- The white precipitate of $PbCl_2$ is separate in the solution cooled.

REACTION -2

-With potassium chromate K_2CrO_4



yell. ppt. of $PbCrO_4$

$$Pb(NO_3)_2 + K_2CrO_4 \longrightarrow \underset{\text{yell. ppt.}}{PbCrO_4 \downarrow} + 2KNO_3$$

1- The yellow precipitate of $PbCrO_4$ is insoluble in NH_4OH.
2- The yellow precipitate of $PbCrO_4$ is soluble in alkali hydroxide (NaOH).

$$PbCrO_4 + 4NaOH \longrightarrow \underset{\text{Complex soluble salt}}{Na_2(PbO_2)} + Na_2CrO_4 + 2H_2O$$

3.Mercury - Hg_2^{+2}

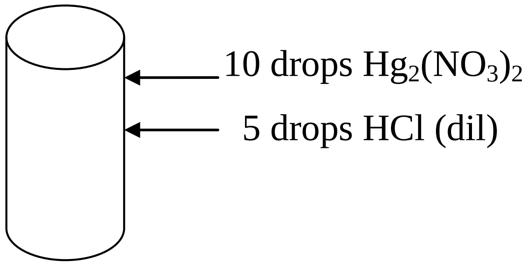
Mercury is a silvery – white, liquid metal at the ordinary temperature, it is unaffected by treatment with dilute HCL or dilute H_2SO_4 but react readily with nitric acid HNO_3. Cold dil. of nitric acid and excess of mercury yield mercurous nitrate $Hg_2(NO_3)_2$.

3- REACTIONS OF MERCUROUS ION – Hg_2^{+2}

(Use a solution of mercurous nitrate $Hg_2(NO_3)_2$ 5%)

REACTION -1

-With diluted hydrochloric acid (HCl)



white .ppt of Hg_2Cl_2

$$2HCl + Hg_2(NO_3)_2 \longrightarrow \underset{\text{wt. ppt.}}{\underset{\downarrow}{Hg_2Cl_2}} + 2HNO_3$$

The white precipitate of Hg_2Cl_2 is insoluble in hot water.

REACTION -2

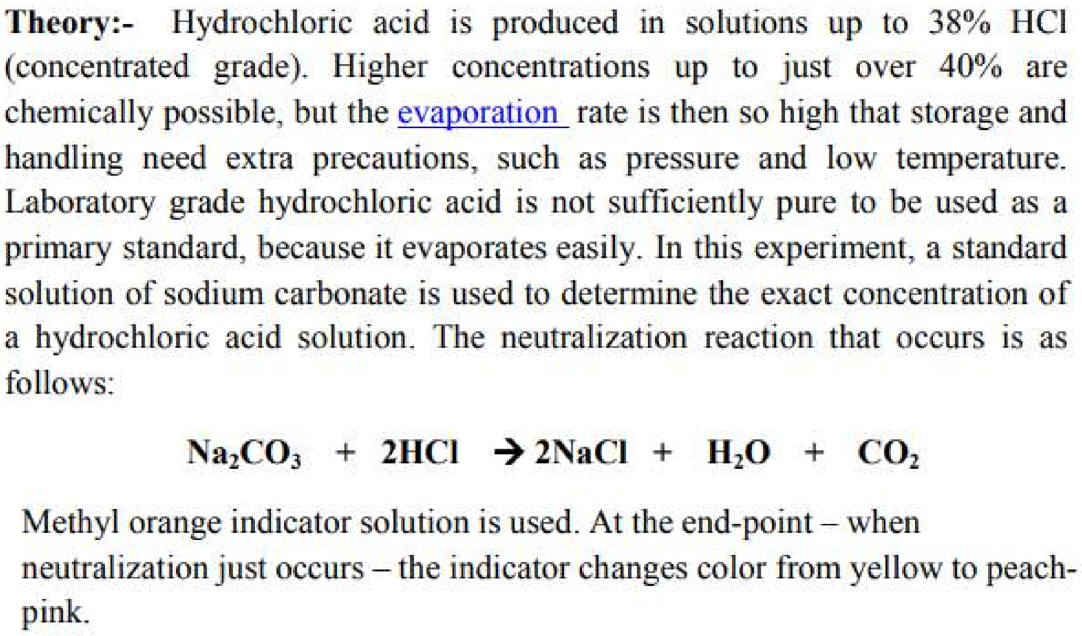
-With NH_3 solution:

The white precipitate of Hg_2Cl_2 react with NH_4OH to formation black precipitate $Hg(NH_2)Cl$.

$$Hg_2Cl_2 + 2NH_4OH \longrightarrow \underset{\text{black. ppt.}}{\underset{\downarrow}{Hg(NH_2)Cl}} + Hg + NH_4Cl + 2H_2O$$

Preparation and standardization of 0.1 M(HCl) hydrochloric acid solution

Hydrochloric acid is present in the digestive juices of the human stomach. Excessive secretion of the acid causes gastric ulcer, while a marked deficiency of it impairs the digestive process and is sometimes the primary cause of deficiency anemia. Concentrated hydrochloric acid causes burns and inflammation of the skin.



Theory:- Hydrochloric acid is produced in solutions up to 38% HCl (concentrated grade). Higher concentrations up to just over 40% are chemically possible, but the evaporation rate is then so high that storage and handling need extra precautions, such as pressure and low temperature. Laboratory grade hydrochloric acid is not sufficiently pure to be used as a primary standard, because it evaporates easily. In this experiment, a standard solution of sodium carbonate is used to determine the exact concentration of a hydrochloric acid solution. The neutralization reaction that occurs is as follows:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

Methyl orange indicator solution is used. At the end-point – when neutralization just occurs – the indicator changes color from yellow to peach-pink.

Procedure:-

1. **Preparing (50 ml) 0.1 M HCl Solution**:38 % HCL shows density 1.19 g/mL and we can find M by next : -

$$M = \frac{sp.gr * \% * 1000}{M.wt}$$

Calculate the volume of HCl (conc.):- We must dilute it to preparing 0.1 M HCl in 50 ml from next: $(M^* V)_{conc.} = (M * V)$ dilute

$$M * V_{ml} = 0.1 * 50_{ml}$$

Transfer V ml by cylinder to clean and dry beaker containing 30 ml D.W, transfer the solution to volumetric flask capacity 50 ml, and complete the volume to the mark by D.W.

2. **Preparing (50 ml) 0.1 M Na_2CO_3 Solution**:-calculate amount from sodium carbonate for prepare 0.1 M in 50 ml -

$$M = \frac{Wt.(gm)}{M.Wt.} * \frac{1000}{V(ml)}$$

$$0.1 = \frac{Wt.(gm)}{106} * \frac{1000}{50}$$

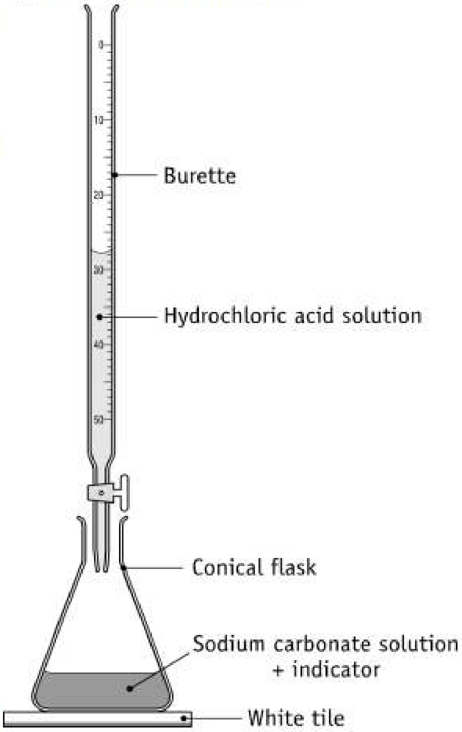
$$Wt. = 0.53 \text{ gm}$$

Weigh 0.53 gm. from Na_2CO_3 in clean and dry beaker and dilute in 30 ml D.W, transfer solution to volumetric flask capacity 50 ml and complete the volume to the mark by D.W.

3. Transfer known volume of 5 ml the sodium carbonate solution, with a pipette, to a conical flask then add one or two drops of methyl orange to this solution.

4. Add the acid unknown solution from the burette gradually with continuous swirling of the solution in the conical flask and near the end point, the acid is added drop by drop. Continue the addition of the acid until the color of the solution passes from yellow to faint red.

5. Repeat the experiment three times and tabulate your results then take the mean of the three readings.



Calculations: Calculate the molarity of HCl:-

$$\text{m mol HCl} = \text{m mol } Na_2CO_3$$

$$(M * V)\,HCl = (M * V)\,Na_2CO_3 * \frac{1}{2}$$

$$(M * V_{\text{burette}}) = (0.1 * 5) * \frac{1}{2}$$

Discussion:-

1. What the difference between primary and secondary standard substances?

2. Calculate the volume of conc. HCl required for preparing 250 ml 0.1 M?

Chemistry lab:5 **First stage**

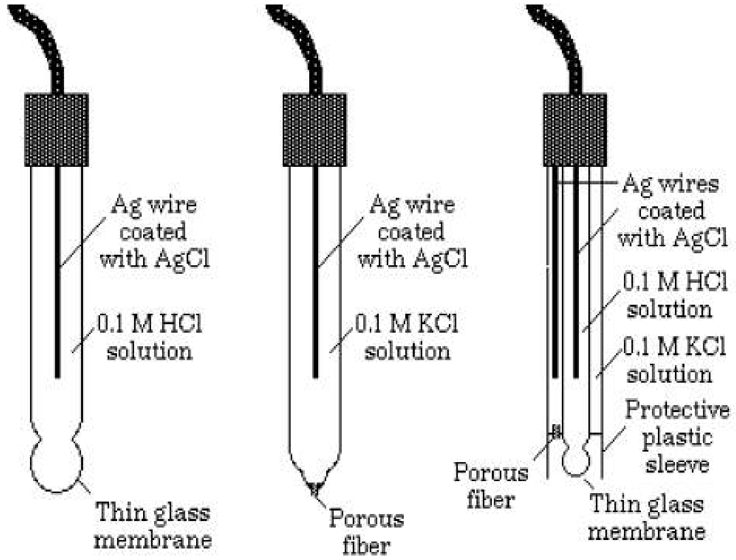
pH METER

Principles of operation of a pH meter:

A pH meter is essentially a voltmeter with high input impedance which measures the voltage of an electrode sensitive to the hydrogen ion concentration, relative to another electrode which exhibits a constant voltage. The key feature of the pH-sensitive electrode is a thin glass membrane that's outside surface contacts the solution to be tested. The inside surface of the glass membrane is exposed to a constant concentration of hydrogen ions (0.1 M HCl).

Inside the **glass electrode** assembly, a silver wire, coated with silver chloride and immersed in the HCl solution, is called an Ag/AgCl electrode. This electrode carries current through the half-cell reaction. The potential between the electrode and the solution depends on the chloride ion concentration, but, since this is constant (0.1 M), the electrode potential is also constant.

A **reference electrode** is needed to complete the electrical circuit. A common choice is to use another Ag/AgCl electrode as the reference. The Ag/AgCl electrode is immersed in a 0.1 M KCl solution which makes contact with the test solution through a porous fiber which allows a small flow of ions back and forth to conduct the current. The potential created at this junction between the KCl solution and the test solution is nearly zero and nearly unaffected by anything in the solution, including hydrogen ions.



Glass electrode Reference electrode Combined electrode

Using the pH Meter:

Allow the meter a few minutes to stabilize after you plug it in. When you are not using the meter, keep the electrode immersed in pH 7.0 buffer to a depth of about one inch. The meter must be calibrated by using standards of known pH before an unknown is measured. Since the unknowns are acidic, the pH 4.00 and pH 7.00 standards should be used.

An accurate pH reading depends on standardization, the degree of static charge, and the temperature of the solution.

1. The pH meter should be standardized each time it is used with a buffer of known pH, preferably one closest to the desired final pH. To calibrate the pH meter, expose the hole in the electrode, rinse the electrode with deionized water, and place the electrode in a standard solution, e.g., pH 7.
2. Make sure the solution you are measuring is at room temperature since the pH can change with a change in temperature.

3. The pH-sensitive glass membrane is very thin and very easily broken. Therefore do not touch the membrane with anything harder and do that very gently; do not put the electrode down on the desk. Do not drop the electrode or bump it on the bottom of the beaker when immersing it in a solution.
4. The glass membrane must be thoroughly hydrated to work properly. Do not allow the electrode to remain out of water any longer than necessary. When the electrode is not in use, keep it immersed in the pH 7.00 buffer.

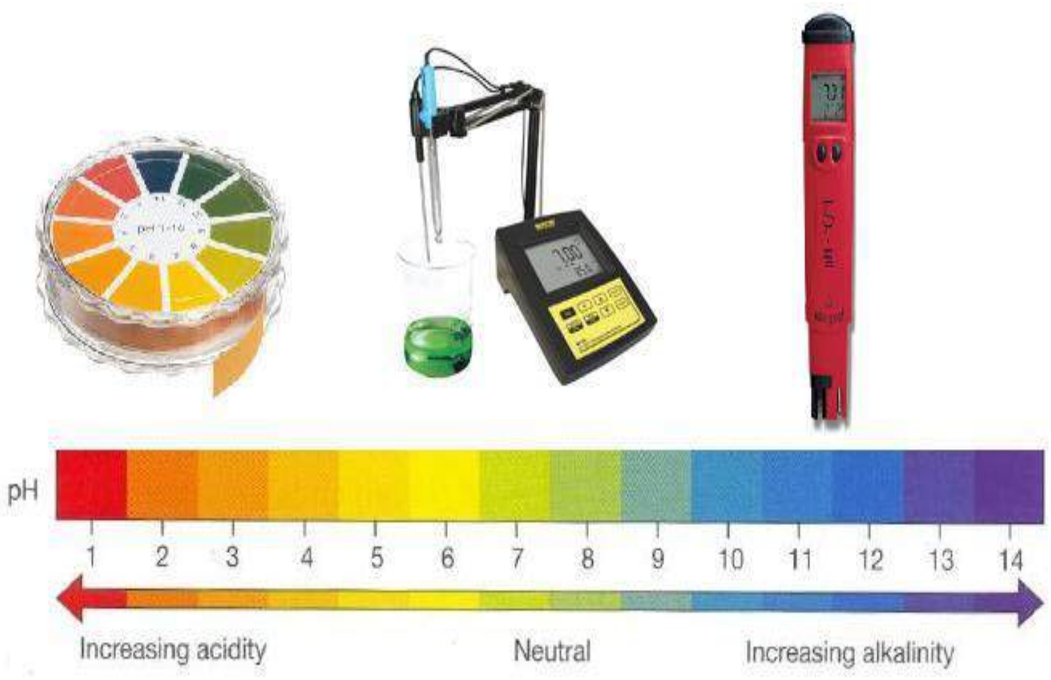
The importance of pH and pH control:

Solution pH and pH control play a major role in many facets of our lives. Consider a few examples:

- Agriculture: Crops grow best in a soil of proper pH. Proper fertilization involves the maintenance of a suitable pH.
- Physiology: If the pH of our blood were to shift by one unit, we would die. Many biochemical reactions in living organisms are extremely pH dependent.
- Industry: From manufacture of processed foods to the manufacture of automobiles, industrial processes often require rigorous pH control.
- Municipal services: Purification of drinking water and treatment of sewage must be carried out at their optimum pH.

pH meter

Litmus Paper



Chemistry lab:6 **First stage**

Action strong acid and base on Indicators

Indicators:

There are many substances that show one colour in an acidic medium and another colour in a basic medium. Such substances are called **acid-base indicators**.

An acid/base indicator is a weak organic acid or a weak organic base whose un dissociated form differs in color from its conjugate base or its conjugate acid form.

Litmus is a natural dye found in certain lichens. It was the earliest indicator to be used. It shows red colour in acidic solutions and blue colour in basic solutions. Phenolphthalein and methyl orange are some other indicators.

Procedure:

1- Take about 2 mL solution of acid or base in a test tube.

2- Add a drops of indicator to it and observe the colour. **What to observe?**

3- Tabulate your observations in Table.

Sample solution	**red litmus**	**blue litmus**	**phenolphthalein**	**methyl red**	**methyl orange**

Chemistry lab:7 First stage

"Experiment for preparing of methane gas in the laboratory"

Chemical properties of alkanes:

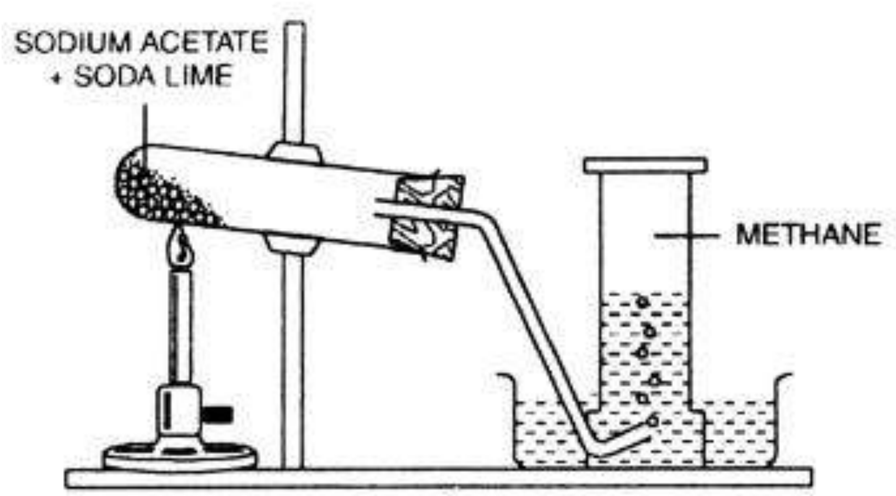
1. Alkanes have a formula C_nH_{2n+2}, n=1,2,3 …etc.
2. Alkane doesn't have functional group because it's formed from saturated hydrocarbon (C-C and C-H).
3. Alkane structure (R-R or R-H) R=alkyl group.
4. Alkane is unaffected by many common chemical reagents but reacts with chlorine or fluorine in the presence of light.
5. The alkanes can exist as gases, liquids, or solids at room temperature. The unbranched alkanes (methane CH_4, ethane C_2H_6, propane C_3H_8, and butane C_4H_{10}) are gases; while from (pentane C_5H_{12} to hexadecane $C_{17}H_{36}$) are liquids; and the larger than hexadecane are solid.

Procedure:

Methane can be prepared in the laboratory by heating a mixture of sodium acetate with sodium hydroxide according to the equation:

$$CH_3COONa + NaOH \xrightarrow{\Delta} CH_4 + Na_2CO_3$$

1- Firstly measure out 5 gm of sodium acetate or (sodium ethanoate).
2- Then add 2.5 gm of pulverized sodium hydroxide (or soda lime) and mix these two compounds well.
3- Transfer the mixture into a hard glass test tube / boiling tube and heat strongly.
4- (Sodium hydroxide NaOH and calcium oxide CaO) are called **soda lime**.
5- Methane can be collected by tube of the gas will replace the water.



After prepare methane we can study physical properties of methane or (alkanes):

1- Combustion: in combustion of methane gas is produce carbon dioxide, water vapor and heat.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Heat\ \Delta$$

$$Alkane + O_2 \rightarrow CO_2 + H_2O + Heat\ \Delta$$

2- It is a colorless and odorless gas.

3- It is lighter than water and insoluble in water but soluble in non-polar solvents (organic solvents) like; alcohol (R-OH), carbon tetrachloride (CCl_4) … etc.

NOW:

1. Can you prepare hexane, butane and ethane?
2. Define sodium lime?
3. Write chemical equation for combustion of propane?
4. Ethane can be solved in ………. and ……… but not in …………..

Chemistry lab: 8 First stage

"Experiment for preparing of ethene(ethylene) gas in the laboratory"

Alkenes:

1-Alkenes are unsaturated hydrocarbons have (C=C) that consider the functional group.

2-Alkenes formula C_nH_{2n} where n= 2, 3, 4 ………

3-Alkene reacts with brom water (Br_2), when the red brom water is adding into alkene solution its color will disappear.

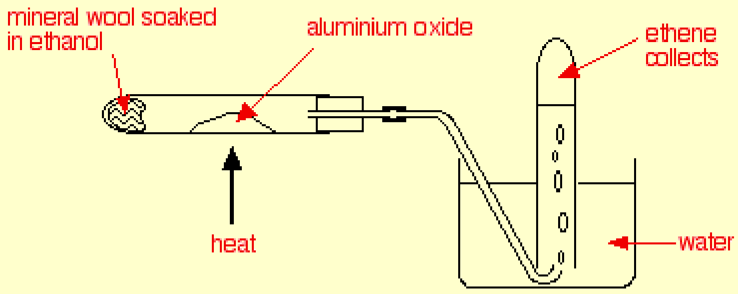
Procedure:

The dehydration of ethanol to give ethene (ethylene):

1-This is a simple way of making gaseous alkenes like ethene. If ethanol vapor is passed over heated aluminium oxide powder, the ethanol is essentially broken to give ethene and water vapor.

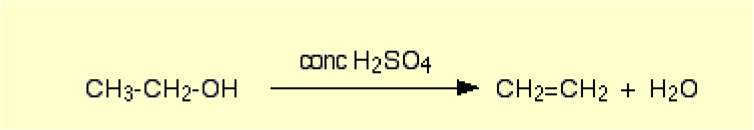
$$CH_3\text{-}CH_2\text{-}OH \xrightarrow{Al_2O_3} CH_2\text{=}CH_2 + H_2O$$

To make a few test tubes of ethene, you can use this apparatus:



It wouldn't be too difficult to imagine scaling this up by boiling some ethanol in a flask and passing the vapor over aluminium oxide heated in a long tube.

2-Ethanol is heated with an excess of concentrated sulphuric acid at a temperature of 170°C. The gases produced are passed through sodium hydroxide solution to remove the carbon dioxide and sulphur dioxide produced from side reactions.



$$CH_3\text{-}CH_2\text{-}OH \xrightarrow{\text{conc } H_2SO_4} CH_2{=}CH_2 + H_2O$$

Do the following

1-Distinguish between ethane and ethene.

2-By the same way prepare propene.

3-see the diagram then explain why alkane has red color.

4- Dehydration reagents are ………. and ………. .

5- See the equation then complete

$CH_3\text{-}CH{=}CH\text{-}CH_3 + Br_2 \rightarrow$

$CH_3\text{-}CH_2 \text{–} CH_2\text{-}CH_3 + Br_2 \rightarrow$

Chemistry lab:9 First stage

"Experiment for preparing of ethyne (acetylene) gas in the laboratory"

Chemical properties of alkynes or (acetylenes):

1. Acetylenes are unsaturated hydrocarbons that have carbon atoms in chains linked by one or more triple bond (C≡C).
2. Acetylenes have a formula C_nH_{2n-2}; R-C≡C-H and R-C≡C-R where R=alkyl group, acetylene formula C_2H_2 (H-C≡C-H).
3. Acetylenes have two functional groups (C≡C) and acidic hydrogen atom (R-C≡C-H).

Experiment:

Ethyne gas or (acetylene) is prepared by the reaction of water with calcium carbide (CaC_2). Acetylene is a colorless gas.

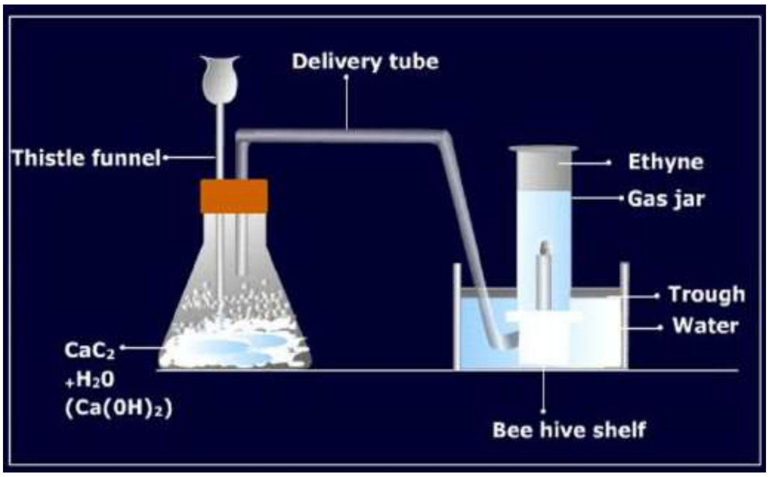
$$CaC_2 + 2H_2O \rightarrow H\text{-}C\equiv C\text{-}H + Ca(OH)_2$$

Main Chemicals required:

1. Calcium Carbide (CaC_2) [also known as calcium dicarbide] is a white/gray solid.
2. Water H_2O.

Procedure

1. Set up the apparatus as shown in the diagram.
2. Place few pieces of calcium carbide in a Büchner flash.
3. Add water from the dropping funnel, few drops at a time.
4. Collect the gas produced in the test tube.
5. Discard the first test tube as it a mixture of air and ethyne.



After preparing ethyne now we study some physical properties of ethyne

1-Combustion:

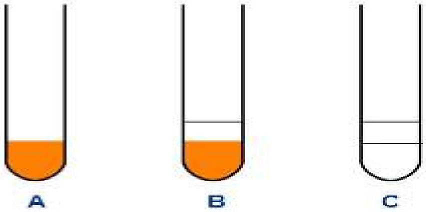
The ethyne gas burns with a **luminous smoky flame** as a result of unburned carbons.

$$2C_2H_2+5O_2 \longrightarrow 4CO_2+2H_2O$$

2-Addition of bromine test:

Addition of bromine water is presence of a triple bond C≡C (unsaturated compound), turns the color from ***yellow/red color*** to ***colorless***. The decolorisation of bromine is the standard test for **unsaturated** in a compound.

A. Place bromine water in the test tube.
B. Add the hydrocarbon to the test tube and shake
C. If the bromine color disappears then the hydrocarbon is unsaturated.



$$H\text{-}C{\equiv}C\text{-}H \quad + \quad 2Br_2 \longrightarrow CHBr_2\text{-}CHBr_2$$

Yellow –red ***Colorless***

3-Addition of acidified potassium permanganate ($KMnO_4$) test:

This is also used to test for presence of a triple bond C≡C (unsaturated compound), the color turn from purple to colorless.

A. Place the hydrocarbon to the test tube.

B. Add $KMnO_4$ solution in the test tube and shake.
C. If the $KMnO_4$ color disappears then the hydrocarbon is unsaturated.

$$R\text{-}C\equiv CH \xrightarrow[H_3O^+]{KMnO4} R\text{-}COOH + CO_2$$

$$R\text{-}C\equiv CR' \xrightarrow[H_3O^+]{KMnO4} R\text{-}COOH + R'\text{-}COOH$$

4-Addition of tollen reagent [$Ag(NH_3)_2OH$] test:

The tollen reagent $Ag(NH_3)_2OH$ turns from **colorless** to **white precipitate.**

A. Place the alkyne to the test tube.
B. Add some drops of $Ag(NH_3)_2OH$ solution to the test tube and shake .
C. If the solution colorless turns to white precipitate then the alkyne has acidic hydrogen atom (***terminal Hydrogen atom***)

$$H\text{-}C\equiv C\text{-}H + Ag(NH_3)_2OH \rightarrow H\text{-}C\equiv C\text{-}Ag + 2NH_3 + H_2$$

(Terminal Hydrogen atom)

$$R\text{-}C\equiv C\text{-}R + Ag(NH_3)_2OH \rightarrow N.R$$

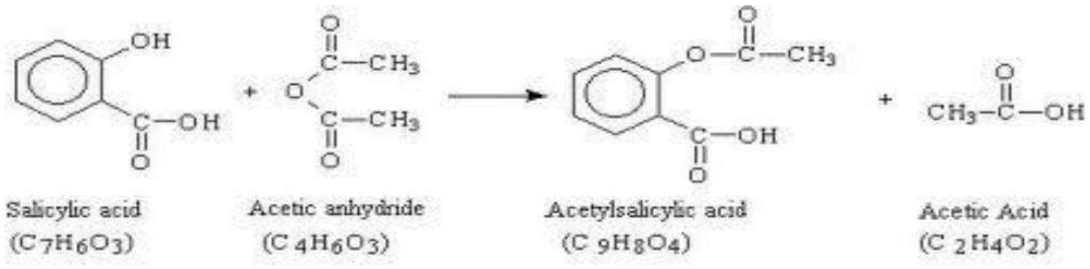
(No terminal Hydrogen atom)

Chemistry lab:10 **First stage**

Aspirin synthesis

Principle

Aspirin is formed by reaction of salicylic acid with acetic anhydride in the presence of sulfuric acid and heat according to the equation:



Acetic anhydride serves as both a reactant and a solvent.

Reagents:

Salicylic acid, acetic anhydride, sulfuric acid.

Procedures:

1-Weight 2 gm of salicylic acid (2- hydroxyl benzoic acid). Place the solid in a test tube and take it to the hood.

2-Carefully add 3 ml of acetic anhydride and then 5 drops of sulfuric acid to the solid, and shake well for 5 minutes. (sometimes product forms at this stage).

3-Place the test tube in a water bath (60 C) and heat, with intermetten shaking, for 10 minutes.

4-Place the tube in an ice water bath. Add 5 ml for distilled water and stir for 5 minutes (keep the tube in the bath while stirring)

6- Leave the crystals to dry overnight

7-Determine the weight of the crystals.

pH of solutions

The pH of solution is defined as following

$\mathrm{pH} = -\log_{10}[\mathrm{H}^+]$ $[\mathrm{H}^+] = 10^{-\mathrm{pH}}$ (in mol/L)

$\mathrm{pOH} = -\log_{10}[\mathrm{OH}^-]$ $[\mathrm{OH}^-] = 10^{-\mathrm{pOH}}$ (in mol/L)

$\mathrm{pH} + \mathrm{pOH} = 14$ $[\mathrm{H}^+] \times [\mathrm{OH}^-] = 10^{-14}$ (in mol²/L²)

$K_w = [\mathrm{H}^+] \times [\mathrm{OH}^-]$ At 25°C, $K_w = 10^{-14}\ \mathrm{mol}^2/\mathrm{L}^2$

The pH of some common Body Fluids

The various body fluids differ both in their,acidity and in their range of acidities.Stomach acid is the most acid is the most aciditic ,and it has a narrow pH rang(1 to 3).Blood plasma is slightly basic,and it has a very narrow pH range .If the pH of blood changes to a value outside this range,the ability of the blood to transport oxygen is reduced.Therefore,maintaining the pH of blood plasma within a narrow range is important to human life .Urine has a wide pH range .It can be acidic ,basic or neutral.This wide range of the pH of urine is due to many acidic and basic substances are removed from the body through the urine to help maintain the pH of blood plasma.A list of the pH values of body fluids given in the following table.

Fluid	pH range
Blood	7.35-7.45
Gastric juices	1.6-1.8
Bile	7.8-8.6
Urine	5.5-7.0
Saliva	6.2-7.4

Buffer solution

A buffer solution is an mixture of either a weak acid plus a salt of this weak acid or weak base plus a salt of this weak base .Such a mixture reacts with both acids or strong base cause little change in its pH.For example: acetic acid and sodium acetate dissolved in water is an example of solution. Weak acid molecules ($C_2 H_3 O_2 H$) and conjugate base of the the acetic ion of sodium acetate ($C_2H_3O_2^-$).Now if small amount of strong acid added to the buffer solution it will react with the conjugate base as follows:

$$H_3O^+ + C_2H_3O_2^- \;\rule{3cm}{0.4pt}\; C_2H_3O_2H + H_2O$$

If hydroxide ions added to the buffer solution they will react with molecules of acetic acid to form acetate ions and water as following :

$$\longrightarrow \mathbf{OH^- + C_2H_3O_2H \quad C_2H_3O_2^- + H_2O}$$

The pH of a buffer solution is determined by the pKa of weak acid and log of the ratio of the concentration of the conjucate base to the concentration of the acid

Henderson-Hasselblach equation

$$PH = PKa + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

A small change in the concentration of either acetate or acetic acid will hardly change the PH.

A buffer solution has a limited ability to react with acids and bases without changing its PH.

A solution act as a buffer because its contains both members of a conjucate acid-base pair. Remove one of these two by either a chemical or physical process destroy the buffer action of the solution.

Biological Buffer Significance

1- Ability to prevent large change in pH is an important property of most intact biological organism.

2- Blood plasma is highly effective buffer solution and designed to keep the range of pH of blood within (0.2) pH unit from (7.35-7.45) outside this range are compatable with life.

3- Many of metabolites constantly produced and utilized in the cell are weak acids.

BLOOB BUFFER:

The blood retains its fairly constant pH because of the presence of buffer .These buffer present both in blood plasma and in red blood cells
In plasma are sodium buffer,in red blood cells potassium buffers
The blood buffer consist the following:

1- *BicarbonateBuffers*

The bicarbonate buffer system in the red blood cell consists of carbonic acid (H_2CO_3),and potassium bicarbonate ($KHCO_3$).The bicarbonate buffer system in the blood plasma consists of carbonic acid and sodium bicarbonate ($NaHCO_3$).If we assume that a strong acid (such as HCl) is added to a sample of blood,it will react with the salt part of the buffer and undergo the following reactions

$HCl + KHCO_3 \xrightarrow{\qquad} H_2CO_3 + KCl$ (in blood cells)

$HCl + NaHCO_3 \xrightarrow{\qquad} H_2CO_3 + NaCl$ (in blood plasm

The carbonic acid produced (H_2CO_3) is part of the original buffer .Note that the strong acid (HCl).has been replaced by very weak one (H_2CO_3).The other products (KCl and NaCl) are neutral salts and will not affect the pH of systems:

$\longrightarrow KOH + H_2CO_3 \quad KHCO_3 + H_2O$ (in the blood cells)
$\longrightarrow \quad NaOH + H_2CO_3 \quad NaHCO_3 + H_2O$ (in the blood plasma)

The salts ($KHCO_3$ and $NaHCO_3$) are part of the original buffer system and the water produced is neutral. So that the pH again is unaffected in both cases (reaction with a strong acid or a strong base) more of the buffer is produced plus a neutral compound.

The bicarbonate buffers and the blood protein buffers play a major part in the control of the pH; the phosphate buffers have an important role inside the cell and in the urine.

2- Phosphate Buffers

The phosphate buffers consist of mixtures of K_2HPO_4 and KH_2PO_4 (also Na_2HPO_4 and NaH_2PO_4). Which function similarly to the bicarbonate buffers in neutralizing excess acid and base.

$$HCl + K_2HPO_4 \longrightarrow KH_2PO_4 + KCl$$

$$KOH + KH_2PO_4 \longrightarrow K_2HPO_4 + H_2O$$

3- Hemoglobin Buffers

The hemoglobin buffers account for more than one half of the total buffering action in the blood. There are hemoglobin buffers and oxyhemoglobin buffers.

Hemoglobin Buffer	**Oxyhemoglobin Buffer**
HHb	$HHbO_2$
KHb	$KHbO_2$

Acid-Base balance in blood

Carbonic acid-bicarbonate ion (conjugate acid-base pair) acts as a buffer in the control of blood .

Carbonic acid is formed by dissolving carbon dioxide in aqueous body fluids.It a weak acid that ionizes to bicarbonate ion.The equation for these two equilibrium reactions is as follows:

$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow HCO_3^- + H^+$$

Normally, in body fluids such as blood ,there is 24 m Eq / L of bicarbonate ion to 1.2 m Eq / L of carbonic acid .

$$\frac{[HCO_3^-]}{[H_2CO_3]} = \frac{24\ \text{mEq/L}}{1.2\ \text{mEq/L}} = 20$$

1-The pH of blood is within normal its normal range of 7.35-7.45 when this ratio, 20 parts carbonate ion to 1 part carbonic acid.

2-The pH of blood becomes more acidic when the ratio $[HCO_3^-]$ / $[H_2CO_3]$ become less than 20 /1 or 12 /1.Say 16/1 or 12/1 condition of blood signified by a pH less than 7.35 is called acidemia

3-The pH of blood becomes more basic when the ratio $[HCO_3^-]/[H_2CO_3]$ become more than 20/1.say 25/1 or 30/1.

The alkaline condition of the blood signified by a pH greater than 7.45 is called alkalemia.

amount of carbon dioxide (CO_2),deeper and faster breathing called hyperventilation occurs.

This causes a decrease in the acidity of the blood because the carbon dioxide formed is lost through the lungs.The kidneys can help by releasing more bicarbonate ion into the blood and removing hydrogen ions .In these ways ,the body returns the $[HCO_3^-]/[H_2CO_3]$ ratio to its normal value of 20 and maintain the acid-base balance in the blood.

Death occure if the pH of blood is more acidic than 6.8 or more basic than 7.8.

Buffers in the body differ in one important respect from those in the laboratory.The body can supply components of the buffer solution as they are used up or can remove from the body any excess component.To explain this,let us consider how the body uses the carbonic acid-bicarbonate ion buffer system to overcome the increase in either the acid or the base concentration in the blood.

Acidosis

Consider a patient who has an illness that causes an increase in the concentration of acidic products in the blood.The physiologic processes causing academia are call acidosis.The acidic products react with bicarbonate ions to produce carbonic acid.

$$H_3O^+ + HCO_3^- \xrightarrow{\qquad} H_2CO_3 + H_2O$$

This causes a dcrease in the ratio $[HCO^-_3]$ /$[H_2CO_3]$,so acidosis will occur.One of the functions of both the lungs and the kidneys is to maintain the pH of the blood by supplying the buffer components that are used up or removing any excess components from the body.

The circulation of air into and out of the lungs,called ventilation .An increase in the amount of carbonic acid in the blood cause increase in the

Blood causes increase in amount of carbon dioxide formed from decomposition of carbonic acid .To loss this excess of carbon dioxide ,deeper and faster breathing ,called hyperventilation occurs.This causes a decrease in the acidityof the blood because the carbon dioxide formed is lost through the lungs.The kidneys can help by releasing more bicarbonate ion into blood and removing hydrogen ion .in this way ,the body retains the $[HCO_3^-]/[H_2CO_3]$ ratio to its normal value of 20 and maintain the acid-base balance in the blood

•

Alkalosis

Consider another patient who has an illness causing an increase in concentration of basic products in the blood.The physiologic process causing alkalemia.

The lungs and the kidneys will both involved in this case. These basic products react with carbonic acid to form bicarbonate ions.This time the ratio $[HCO_3^-]/[H_2CO_3]$ increases.

$$\underset{\text{Basic product}}{OH^-} + H_2CO_3 \underline{\qquad\qquad} HCO^-_3 + H_2O$$

The simplest way to prevent this ratio from increasing is to keep the carbon dioxide in the blood and use it to produce carbonic acid .To do this loss of carbon dioxide through the lungs is minimized by slower and shallow breathing ,called hypoventilation.

As before,the kidneys can help by removing bicarbonate ions and adding hydrogen ions to the blood.Thus ,the lungs and kidneys can function to maintain the pH of the blood within its normal range of 7.35to 7.45

Measuring pH

The pH of a solution can be calculated if the concentration of either H_3O^+ or OH^- is known. Alternatively, measurement of pH allows the calculation of H_3O^+ or OH^- concentration. The pH of aqueous solutions may be approximated by using indicating paper (pH paper) that develops a color related to the solution pH. Alternatively, a pH meter can give us a much more exact pH measurement. A sensor measures an electrical property of a solution that is proportional to pH.

Calculating pH

One of our objectives in this chapter is to calculate the pH of a solution when the hydronium or hydroxide ion concentration is known, and to calculate $[H_3O^+]$ or $[OH^-]$ from the pH. We will develop this skill using two different approaches, one requiring a working knowledge of logarithms, the other using decimal logic.

The pH of a solution is defined as the negative logarithm of the molar concentration of the hydronium ion:

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

Example 1

Calculate the pH of a $1.0 \times 10^{-3}\,M$ solution of HCl.

Solution

HCl is a strong acid. If 1 mol HCl dissolves and dissociates in 1L of aqueous solution, it produces 1 mol H_3O^+ (a 1 M solution of H_3O^+). Therefore a $1.0 \times 10^{-3}\,M$ HCl solution has $[H_3O^+] = 1.0 \times 10^{-3}\,M$, and

$$\begin{aligned} pH &= -\log [H_3O^+] \\ &= -\log [1.0 \times 10^{-3}] \end{aligned}$$

Consider the concentration term as composed of two parts, 1.0 and 10^{-3}. The logarithm of $1.0 = 0$, and the logarithm of 10^{-3} is simply the exponent, -3. Therefore

$$\begin{aligned} pH &= -[\log 1.0 + \log 10^{-3}] \\ &= -[0 - 3.00] \\ &= -[-3.00] = 3.00 \end{aligned}$$

Example 2

Calculate the $[H_3O^+]$ and $[OH^-]$ of a sodium hydroxide solution with a pH = 10.00.

Solution

First, calculate $[H_3O^+]$:

$$\begin{aligned} pH &= -\log[H_3O^+] \\ 10.00 &= -\log[H_3O^+] \\ -10.00 &= \log[H_3O^+] \\ \text{antilog } -10 &= [H_3O^+] \\ 1.0\times10^{-10}\,M &= [H_3O^+] \end{aligned}$$

To calculate the $[OH^-]$, we need to solve for $[OH^-]$ by using the following expression:

$$[H_3O^+][OH^-] = 1.0\times10^{-14}$$

$$[OH^-] = \frac{1.0\times10^{-14}}{[H_3O^+]}$$

Substituting the $[H_3O^+]$ from the first part, we have

$$[OH^-] = \frac{1.0\times10^{-14}}{[1.0\times10^{-10}]}$$

$$= 1.0\times10^{-4}\,M$$

POLLUTION

Pollution

The addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form.

Effect of pollution

The effect of pollution may conclude human being, animals and plants, so it is important to know the sources of pollution and their effect.

Types of pollution

I-Air pollution:- mainly the products of oxidation from combustion of fuels. And the air pollutant are CO, colloids, SO_2, hydrocarbons, No_2 (from Gasoline, diesel, natural gas, coal,.....)

Aerosols

Any suspension of colloidal or near colloidal particles in a gas is called "*Aerosol*". The particles may be:

1- Liquid as in mist, fog, clouds, or haze.
2- Solid as fumes, dust, fly ashes.
3- Gases as mix with the air, are dissolved in liquid droplets

4-Smoke

Smoke is an aerosol produced by incomplete combustion. It varies in composition and properties with the fuel and oxidation condition. Smoke from fire is different from smoke of a mechanically fired industrial plant.

Cigarette smoke is largely a suspension of liquid droplets, aqueous solutions, oil, and tars.

Soft coal and heavy oils, when burned with insufficient oxygen, produce the dirtiest and most corrosive type of smoke.

- The complex aerosol know as smoke may contain toxic gases, CO, H_2S under poor oxidizing conditions, and So_2, So_3, NO, No_2 and CO_2 in normal combustion as well as unsaturated hydrocarbon vapors and droplets, aldehydes, peroxides, tars, organic acids, soot, dust, fly – ash and other solid.
- The aerosol formed by the reaction of some of the components of smoke with fog or water vapor has been dubbed smog. It reduces visibility and cuts of the UV radiation. It causes eye and throat irritation.

The primary cause of this harmful cloud was SO_2. Today, we are more familiar with "Photochemical smog", which is formed by the reactions of automobile exhaust in the presence of sunlight.

Automobile exhaust consists mainly of No, CO, and various unburned hydrocarbons. These gases are called "*Primary pollutants*" because they set in motion a series of photochemical reactions that produce "*Secondary Pollutants*". It is the secondary pollutants – chiefly No_2 and O_3 – that are responsible for the buildup of smog.

$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$

NO when release into the atmosphere

$2NO_{(g)} + O_2 \rightarrow 2NO_{2(g)}$ oxidation

$$NO_{2(g)} + h\nu \xrightarrow{\lambda < 400\ \text{nm}} NO_{(g)} + \underset{\text{reactive}}{O_{(g)}}$$

$$O_{(g)} + O_{2(g)} + M \rightarrow \underset{\text{Ozone}}{O_{3(g)}} + M$$ M is the inert substance such as N_2

Ozone can be formed also by a series of very complex reactions involving unburned hydrocarbons, nitrogen oxides, and oxygen.

There is a typical variation with time of primary and secondary pollutants.

$NO + O_2 \rightarrow NO_2$ {when solar radiation penetrates the atmosphere}

Ozone concentration also rise rapidly. The actual amounts depend on the location, traffic and weather conditions, but their presence is always accomplished by haze.

- The oxidation of hydrocarbons produces droplets of alcohols, and carboxylic acids. The dispersion of these droplets in air cause scatter of sunlight and reduce visibility and make the air look hazy. Major efforts have been made to reduce the buildup of primary pollutants:-

$$\underset{\text{\& unburned hydrocarbons}}{\overset{\text{oxidation}}{Co}} \rightarrow CO_2 + H_2O$$

$$\underset{\&NO_2}{NO} \xrightarrow{\text{reduction}} N_2 + O_2$$

More efficient automobile engine and better public transportation system would help to decrease air pollution in Urban areas.

$$O_{3(g)} + CO_{(g)} \xrightarrow{Pt} O_{2(g)} + CO_{2(g)}$$

Prevention and Cure of air pollution

By proper combustion methods (proportion of air and vaporized fuel must be regulated and four factors which must be controlled : temperature, time, turbulence, treatment of the issuing gases.)

Cure

1- Low temperature catalytic returners are used.

2- Control of fuel composition.

3- Addition of smoke-reducing additives (ethyl nitrite and ethyl nitrate).
4- Use Pt catalyst to convert O_3 and CO to O_2 and CO_2.

Indoor air pollution

The common indoor pollutants and radon, carbon monoxide, and carbon dioxide, and formaldehyde.

1- *Radon (Rn)*

Rn is a member of group 8A (noble gases), it's an intermediate product of the radioactive decay of Uranium – 238.

All isotopes of radon are radioactive, but radon – 222 is the most hazardous because it has the longest $t_{1/2}$ = 3.8 days. Radon is generated mostly from the phosphate minerals of Uranium.

$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$

Radon is found in higher concentrations with Uranium, this is not surprising, since radium is formed as a part of the stepwise decay of uranium.

Radon is radioactive but its radiation is not the major problem. Since it is a gas and chemically inert, it is rapidly exhaled after breathing. Radon decays to Polonium:

$^{222}_{86}Rn \rightarrow {}^{218}_{84}PO + {}^{4}_{2}He$

Polonium isotope is radioactive with long half-life, and is a nonvolatile heavy metal that can attach itself to bronchial or lung tissue and remain for a long time, emitting hazardous radiation.

2- *Carbon dioxide and carbon monoxide*

Both CO_2 & CO are products of combustion. CO_2 is formed in abundant of oxygen. CO & CO_2 is formed in a limited supply of oxygen.

- Carbon dioxide is not a toxic gas, but it does have an asphyxiating effect. In air tight buildings, the concentration of CO_2 can reach as high as 2000 ppm by volume (3ppm outdoor).

  Workers exposed to high $[CO_2]$ become fatigued more easily and have difficulty concentrating. Adequate ventilation is the solution to CO_2pollution.
- Co is a colorless and odorless gas and is highly poisonous. The toxicity of CO lies in its unusual ability to bind very strongly to hemoglobin. Both O_2 and CO bind to the Fe II ion in hemoglobin but the affinity of hemoglobin for CO is about 200 in times greater than that for O_2. Carboxyhemoglobin cannot carry the oxygen needed for metabolic processes. CO can cause drowsiness and headache, death may result when half the hemoglobin molecules are complexed with CO. the best first aid response to CO poisoning is to remove the victim immediately to an area with a plentiful oxygen supply or to give mouth – mouth resuscitation.

3- *Formaldehyde (CH_2O)*

Is a disagreeable – smelling liquid used as a preservative for laboratory specimens. Formaldehyde resins are used as a bonding agent in building and furniture materials. In addition Urea – formaldehyde insulation foams are used to fill wall cavities.

Free formaldehyde is released under acid and humid conditions.

Low concentrations of formaldehyde in the air can cause drowsiness nausea, headache, breathing high concentrations of formaldehyde can induce cancers in animals, but whether it has a similar effect in humans in unclear. The safe standard of formaldehyde in indoor air has been set at 0.1 ppm by volume.

oxidant such as Al_2O_3/KM_nO_4,which converts formaldehyde to less volatile formic acid (HCOOH).

2-Water pollution

1. Presence of organic substances degridated by microorganisms (food),so it consume O_2 which reduce O_2 in water that cause a death of many animals living in water.

   Microorganism + O_2 $\longrightarrow$ H_2S (odour)
   From nitrate
   In water

2. Factories and industrial plants product and houses.
3. Presence of Hg in water lead to poisonous of fish human.some microorganism change Hg^+ to CH_3Hg^+ soluble.
4. Suspense particles.
5. Radioactive isotopes from reactors which contaminate water and underground water.

3-Agriculture Pollution

1. Animals products reduces the O_2 in water.

2. Presence of antiseptic and fertilizer.

3. Some chemicals taken by animals and concentrate in fats more than in meat.

4. Rain water bring NO_3^- and PO_4^{2-} to the water and soil.

4-Radiation pollution

Factories $\xrightarrow[\text{As coolant}]{\text{used } H_2O}$ hot water $\longrightarrow$ growth of some weeds
as blue – green weeds

Consumption $\longleftarrow$ (40^0c)

O_2

Radioactive waste , ionizing radiation from nuclear reactors and nuclear reactions produce radiation such as α ,β ,γ,neutron,this may lead to many reactions that produce free radicals,electrons ,positive species.These are all active and cause to form new species either in air ,solution ,water and soil.

5-Volcanoes

Active volcane emits gases ,liquids,and solids.The gases include primerly N_2,CO_2,HCl,HF,H_2S and another vapors.The volcanes are the source of two-third of the sulfure in the air.

At high temperature, the hydrogen sulfide gas given off by a volcan is oxidized by air.

$$2\,H_2S(g) + 3O_2(g) \xrightarrow{\hspace{3em}} 2SO_2(g) + 2\,H_2O(g)$$

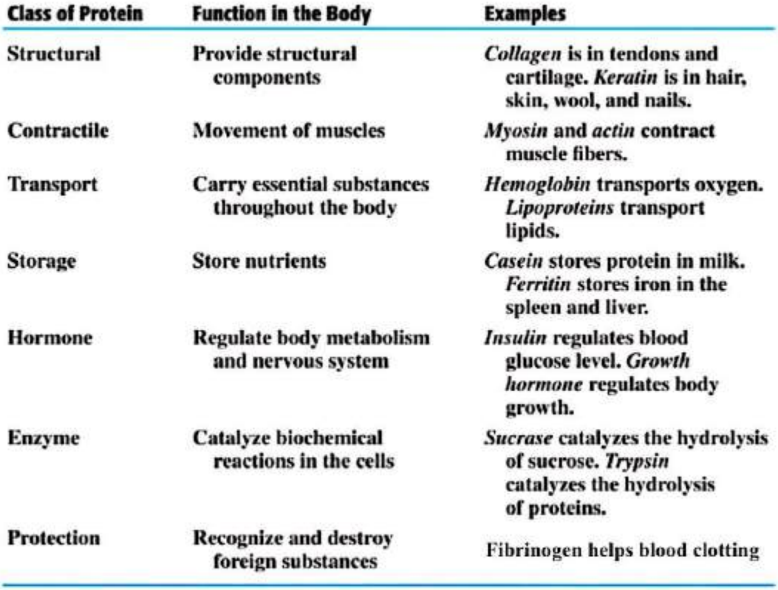
Some SO_2 is reduced by more H_2S

$$2H_2S(g) + SO_2(g) \xrightarrow{\hspace{3em}} 3S(s) + 2\,H_2O(g)$$

$$SO_2 + H_2O \xrightarrow{\hspace{3em}} \text{acid rain}$$

Proteins

Function of proteins



Class of Protein	Function in the Body	Examples
Structural	Provide structural components	*Collagen* is in tendons and cartilage. *Keratin* is in hair, skin, wool, and nails.
Contractile	Movement of muscles	*Myosin* and *actin* contract muscle fibers.
Transport	Carry essential substances throughout the body	*Hemoglobin* transports oxygen. *Lipoproteins* transport lipids.
Storage	Store nutrients	*Casein* stores protein in milk. *Ferritin* stores iron in the spleen and liver.
Hormone	Regulate body metabolism and nervous system	*Insulin* regulates blood glucose level. *Growth hormone* regulates body growth.
Enzyme	Catalyze biochemical reactions in the cells	*Sucrase* catalyzes the hydrolysis of sucrose. *Trypsin* catalyzes the hydrolysis of proteins.
Protection	Recognize and destroy foreign substances	Fibrinogen helps blood clotting

Proteins

- Proteins account for 50% of the dry weight of the human body.

- Unlike lipids and carbohydrates, proteins are not stored, so they must be consumed daily.

- Current recommended daily intake for adults is 0.8 grams of protein per kg of body weight (more is needed for children).

- Dietary protein comes from eating meat and milk.

Proteins

100,000 different proteins in human body

Fibrous proteins:

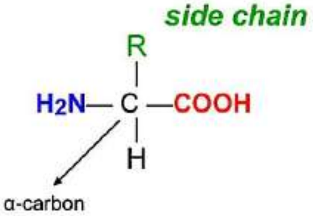
Insoluble in water – used for structural purposes (Keratin & Collagen).

Globular proteins:

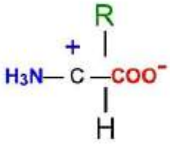
More or less soluble in water – used for nonstructural purposes.

Amino acids

- Are the building blocks of proteins.
- Contain carboxylic acid and amino groups.
- Are ionized in solution (soluble in water).
- They are ionic compounds (solids-high melting points).
- Contain a different side group (R) for each.



$H_2N-C(R)(H)-COOH$



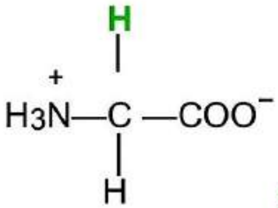
$H_3\overset{+}{N}-C(R)(H)-COO^-$

Zwitterion

Ionized form (Salt)

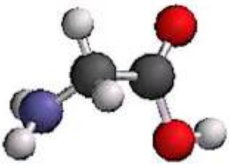
Amino acids

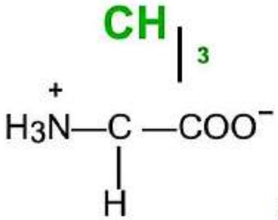
Only difference: containing a different side chain (R) for each.



$H_3\overset{+}{N}-C(H)(H)-COO^-$

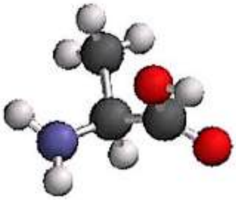
glycine





$H_3\overset{+}{N}-C(CH_3)(H)-COO^-$

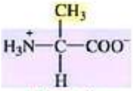
alanine



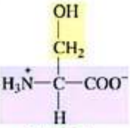
Amino acids

Amino acids are classified as:

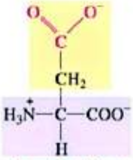
- Nonpolar (Neutral) amino acids (hydrophobic) with hydrocarbon (alkyl or aromatic) sides chains.
- Polar (Neutral) amino acids (hydrophilic) with polar or ionic side chains.
- Acidic amino acids (hydrophilic) with acidic side chains (-COOH).
- Basic amino acids (hydrophilic) with –NH_2 side chains.



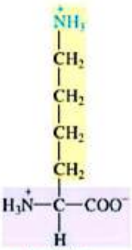
Alanine (Ala)



Serine (Ser)



Aspartic acid (Asp)



Lysine (Lys)

Amino acids

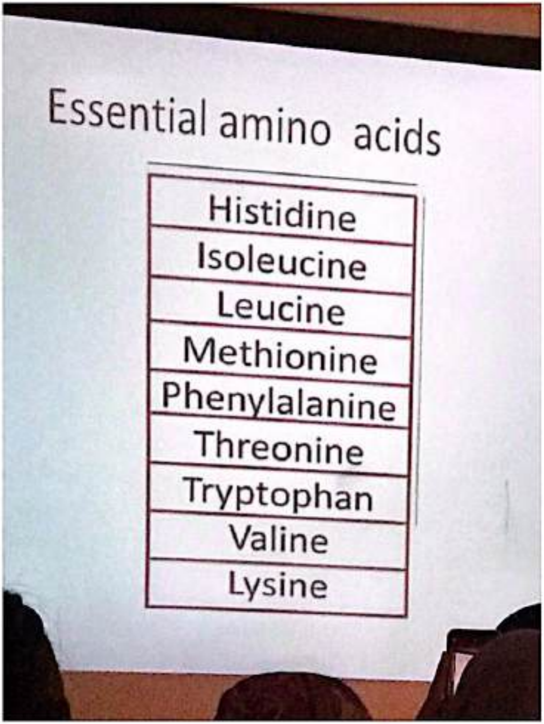
There are many amino acids.

There are only 20 different amino acids in the proteins in humans.

They are called α amino acids.

- Humans cannot synthesize 10 of these 20 amino acids. (Essential Amino Acids)

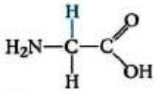
- They must be obtained from the diet (almost daily basis).

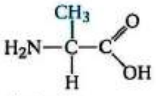


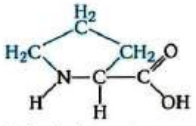
Essential amino acids

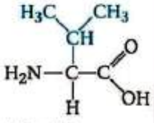
Histidine
Isoleucine
Leucine
Methionine
Phenylalanine
Threonine
Tryptophan
Valine
Lysine

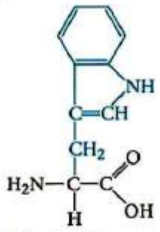
Nonpolar R Groups (hydrophobic)

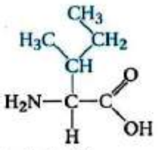

Glycine (gly)

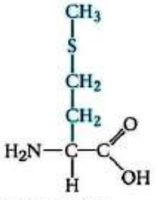

Alanine (ala)

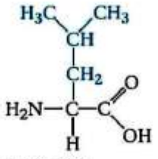

Proline (pro)

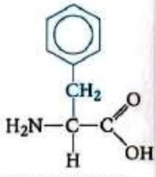

Valine (val)


Tryptophan (trp)

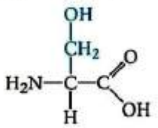

Isoleucine (ile)

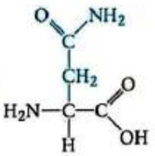

Methionine (met)

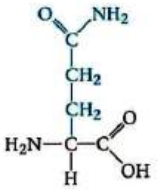

Leucine (leu)

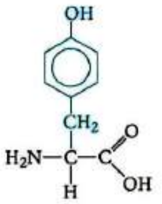

Phenylalanine (phe)

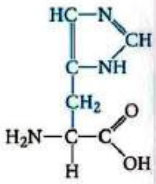
Polar R Groups (hydrophilic)

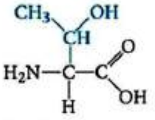

Serine (ser)

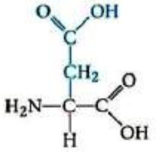

Asparagine (asn)

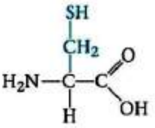

Glutamine (gln)

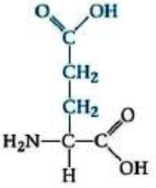

Tyrosine (tyr)

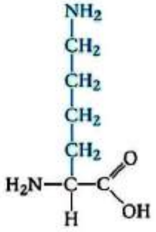

Histidine (his)

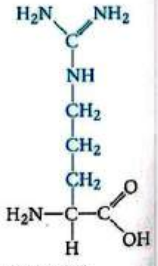

Threonine (thr)


Aspartic acid (asp)


Cysteine (cys)


Glutamic acid (glu)

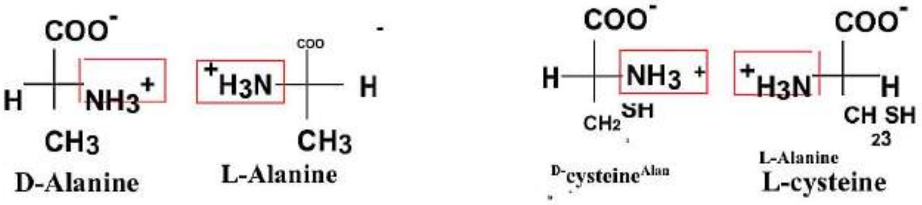

Lysine (lys)


Arginine (arg)

All of the α-amino acids are chiral (except glycine)

↓

Four different groups are attached to central carbon (α-carbon).

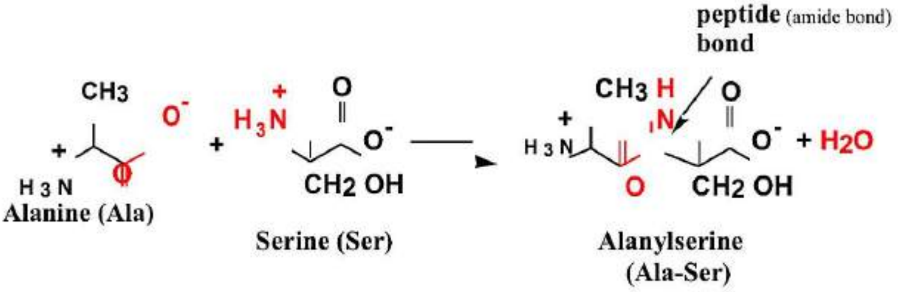


L isomers is found in the body proteins and in nature.

Peptide

A dipeptide forms:

- When an amide links two amino acids (Peptide bond).
- Between the COO^- of one amino acid and the NH_3^+ of the next amino acid.



Peptide

- **Dipeptide:** A molecule containing two amino acids joined by a peptide bond.

- **Tripeptide:** A molecule containing three amino acids joined by peptide bonds.

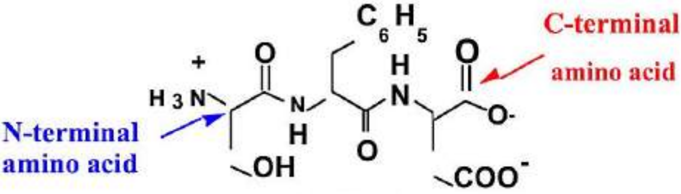
- **Polypeptide:** A macromolecule containing many amino acids joined by peptide bonds.

- **Protein:** A biological macromolecule containing at least 40 amino acids joined by peptide bonds.

Naming of peptides

C-terminal amino acid: the amino acid at the end of the chain having the free $-COO^-$ group (always written at the left).

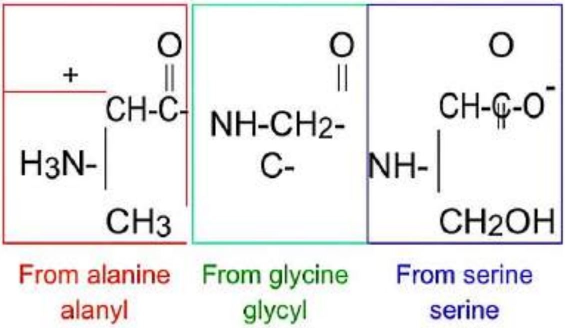
N-terminal amino acid: the amino acid at the end of the chain having the free $-NH_3^+$ (always written at the right). group



Ser-Phe-Asp

Naming of peptides

- Begin from the N terminal.
- Drop "-ine" or "-ic acid" and it is replaced by "-yl".
- Give the full name of amino acid at the C terminal.



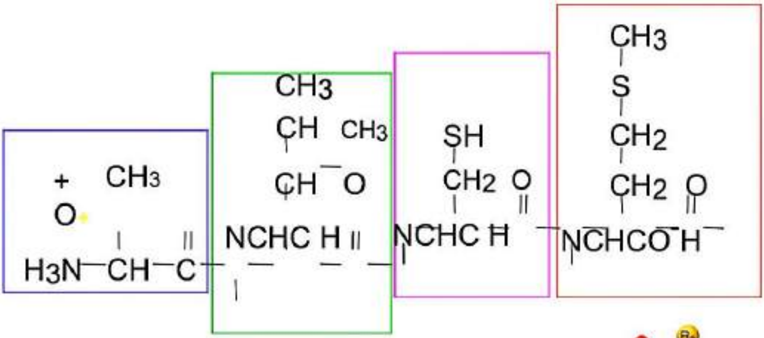
Alanylglycylserine
(Ala-Gly-Ser)

Structure of proteins

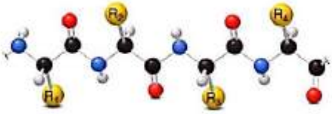
1. Primary structure
2. Secondary structure
3. Tertiary structure
4. Quaternary structure

Primary Structure of proteins

- The order of amino acids held together by peptide bonds.
- Each protein in our body has a unique sequence of amino acids.
- The backbone of a protein.
- All bond angles are 120°, giving the protein a zigzag arrangement.

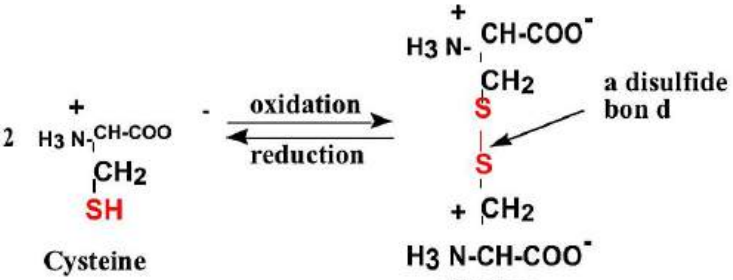


Ala–Leu–Cys–Met



Cysteine

The -SH (sulfhydryl) group of cysteine is easily oxidized to an -S-S- (disulfide).



Cysteine

Cystine

Primary Structure of proteins

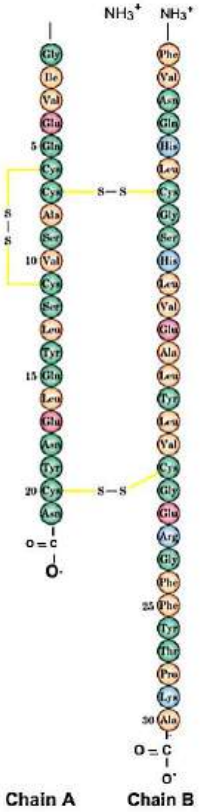
The primary structure of insulin:

- Is a hormone that regulates the glucose level in the blood.

- Was the first amino acid order determined.

- Contains of two polypeptide chains linked by disulfide bonds (formed by side chains (R)).

- Chain A has 21 amino acids and chain B has 30 amino acids.



Secondary Structure of proteins

Describes the way the amino acids next to or near to each other along the polypeptide are arranged in space.

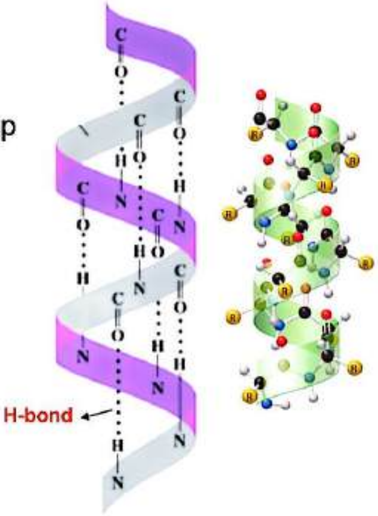
1. Alpha helix (α helix)

2. Beta-pleated sheet (-pleated sheet)

3. Triple helix (found in Collagen)

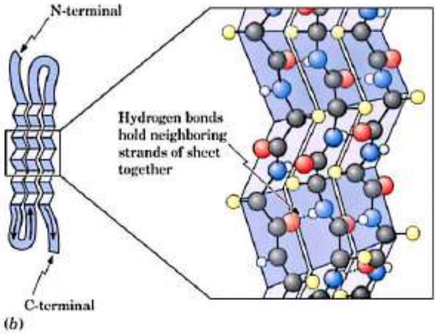
Secondary Structure - α-helix

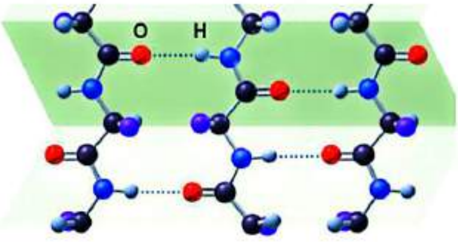
- A section of polypeptide chain coils into a rigid spiral.
- Held by H bonds between the H of N-H group and the O of C=O of the fourth amino acid down the chain (next turn).
- looks like a coiled
- All R- groups point outward from the helix.
- Myosin in muscle and α-Keratin in hair have this arrangement.



Secondary Structure - -pleated sheet

- Consists of polypeptide chains (strands) arranged side by side.
- Has hydrogen bonds between the peptide chains.
- Has R groups above and below the sheet (vertical).
- Is typical of fibrous proteins such as silk.





Secondary Structure – Triple helix (Superhelix)

- Collagen is the most abundant protein.

- Three polypeptide chains (three α-helix) woven together.

- It is found in connective tissues: bone, teeth, blood vessels, tendons, and cartilage.

Tertiary Structure

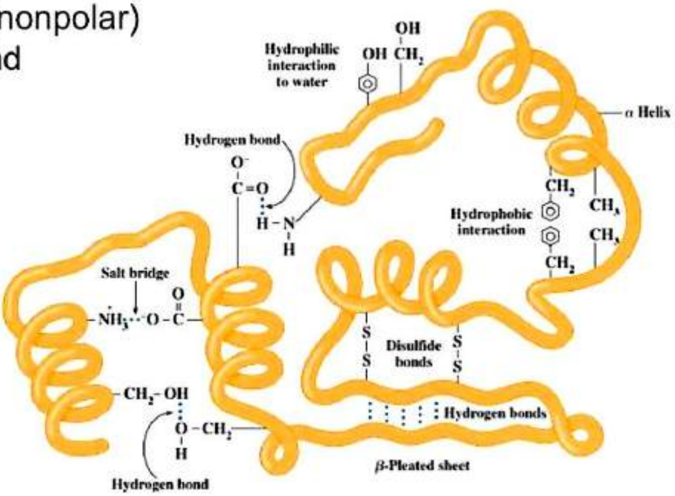
The tertiary structure is determined by attractions and repulsions between the side chains (R) of the amino acids in a polypeptide chain.

Interactions between side chains of the amino acids fold a protein into a specific three-dimensional shape.

	Nature of Bonding
Hydrophobic interactions	**Attractions between nonpolar groups**
Hydrophilic interactions	**Attractions between polar groups and water**
Salt bridges	**Ionic interactions between acidic and basic amino acids**
Hydrogen bonds	**Occur between H and O or N**
Disulfide bonds -S-S-	**Strong covalent links between sulfur atoms of two cysteine amino acids**

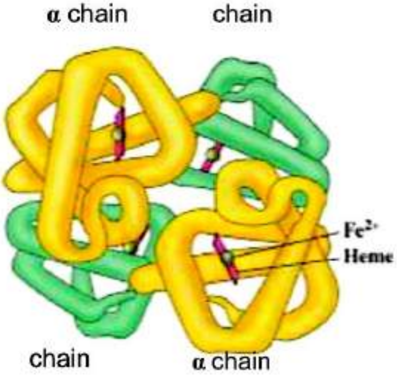
Tertiary Structure

(1) Disulfide (-S-S-)
(2) salt bridge (acid-base)
(3) Hydrophilic (polar)
(4) hydrophobic (nonpolar)
(5) Hydrogen bond



Quaternary Structure

- Occurs when two or more protein units (polypeptide subunits) combine.
- Is stabilized by the same interactions found in tertiary structures (between side chains).
- Hemoglobin consists of four polypeptide chains as subunits.
- Is a globular protein and transports oxygen in blood (four molecules of O_2).



Hemoglobin

Radiation

Invisible energy waves or particles

The radioactivity is the property of some atoms to spontaneously give off energy as particles or rays. The atoms that make up the radioactive materials are the source of radiation.

Isotopes are variants of atoms of a particular chemical element, which have differing numbers of neutrons.

Radioactivity it is the emission of particles and energy by isotope.

Radioactive decay is the process by which an atomic nucleus of an unstable atom loses energy by emitting ionizing particles (ionizing radiation).

The radiation emitted can be one of three types, called alpha, beta, or gamma radiation

1. α (alpha) radiation- is a stream of particles moving at about 1/10 the speed of light that attrached toward the negative electrostatic field.The emission of an alpha particle (which contains 2 protons and 2 neutrons) from an atomic nucleus. When this occurs, the atom's atomic mass will decrease by 4 units and atomic No. will decrease by 2 particles.

Alpha Particles

- ➢ Two neutrons and two protons
- ➢ Charge of +2
- ➢ Emitted from nucleus of radioactive atoms

- Transfer energy in very short distances (10 cm in air)
- Shielded by paper or layer of skin

Alpha emitters can accumulate in tissue (bone, kidney, liver, lung, spleen) causing local damage

Alpha Radiation α has the same constitution as a helium nucleus. Alpha particles may be written as:

$$^{4}_{2}\mathrm{He} \text{ or } ^{4}_{2}\alpha$$

They have a double positive charge and a mass of 4 u

2. β (beta) radiation- Beta particles $^{0}_{-1}\beta$:- are stream of electrons that attached toward the positive electrostatic field.,which indicates that they consist of negatively charged particles. The electrons are produced within the nucleus by the transformation(transmutation)of a neutron into a proton and an electron $^{1}_{0}n \rightarrow {}^{1}_{1}P + {}^{0}_{-1}\beta$

After this happens, the electron is emitted from the nucleus into the electron cloud.

Beta Particles

Small electrically charged particles

- Similar to electrons
- Charge of -1
- Ejected from nuclei of radioactive atoms
- Shielded by wood, body penetration 0.2 to 1.3 cm depending on energy
- Can cause skin burns

Beta-minus Radiation Beta-minus particles are electrons

Beta-minus Radiation

β^- produced when a neutron decays Beta-minus particles may be written as

$${}^{0}_{-1}\beta^{-} \text{ or } {}^{0}_{-1}e^{-}$$

They have a negative charge and a mass of 1 /1800 u

Beta-minus Radiation

β^{--} produced when a neutron decays

3. ɣ (gama)radiation-it consists of photons with a frequency of greater than 1019 Hz. It is much like X-rays, and can pass completely through the human body. Thus gamma rays emitted from outside of the body may cause ionization, and possible health effects, in any organ in the body.

Gamma - Rays

➢ Electromagnetic photons or radiation (identical to x-rays)

➢ Emitted from nucleus of radioactive atoms – spontaneous emission

➢ Highly penetrating – extensive shielding required

➢ Serious external radiation hazard

Gamma Radiation

Gamma rays are a form of electro-magnetic radiation

ɣ release is often associated with α or β decay. Gamma rays remove energy from an unstable nucleus

Positron the same electron mass but opposite charge (+). Because positron is consider to β+ some references used negatron for β- and positron for β+ .

Beta-plus Radiation b + particles are positrons

Beta-plus Radiation

β+ is produced when a proton decays

X-rays have smaller wavelengths and energy higher than ultraviolet waves. Xray light tends to act more like a particle than a wave. X-rays have a wavelength in the range of 0.01 to 10 nanometer, and energies in the range 120 eV to 120 keV.

X-ray can form ions in matter by knocking electrons off the atoms and molecules in its path creating ions, that's why it is called ionization radiation.

X-ray cannot pass through bones and teeth as easily as through the tissues so dental X-rays show the presence of cavities and advanced bone destruction.

The Electromagnetic Spectrum

X-rays

- Overlap with gamma-rays
- Electromagnetic photons or radiation
- Produced from orbiting electrons or free electrons – usually machine produced
- Emitted with various energies & wavelengths
- Highly penetrating – extensive shielding required
- External radiation hazard

There are two less common but important types of nuclear radiation are Neutron and positron

Type of radiation	Composition	Symbol	Electric charge	Approximate penetration of skin (cm)
Alpha	Helium nucleus	α, $^{4}_{2}He$	+2	0.01
Beta	Electron	β, $^{0}_{-1}e$	-1	1
Gamma	Energy	ɣ	0	100
Neutron	Neutron	n, $^{1}_{0}n$	0	10
Positron	Positron	B^{+}, $^{0}_{1}e$	+1	1

•

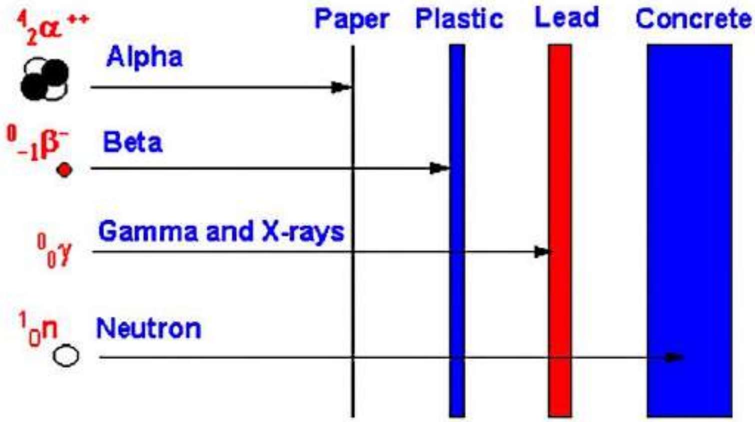
Penetrating power

α has a high mass, It is stopped by a few centimetres of air

β has a small mass, It is stopped by a few millimetres of aluminium

ɣ has zero mass, It is stopped by thick lead or concrete

Penetrating power



Ionization

Ionizing radiation is produced by unstable atoms, because they have an excess of energy or mass or both. Unstable atoms are said to be radioactive. In order to reach stability, these atoms give off, or emit, the excess energy or mass. These emissions are called radiation.

Ionizing and Non-ionizing radiation?

Radiation carries a range of energy forming an electromagnetic spectrum.

Radiation that does not have enough energy to break chemical bonds but can vibrate atom is referred to as "Non-ionizing Radiations" e.g. radiowaves, microwaves, infrared, visible light etc.

Radiation that has enough energy to break chemical bonds is referred to as 'ionizing radiation, e.g. alpha particles, beta particles, gamma rays etc.

Detection ionizing radiation.

1- Scintillation counters are instruments that contain a surface coated with a special substance that gives off flashes of light when hit by ionizing radiation .The invisible ionizing radiation stricks the surface and some of its energy is transformed into light.Electronic devices magnify and record theses flashes.

2- Geiger-Muller counter the detecting part of the instrument is a metal tube.contains windows is made of a thin material to allow alpha and beta particles to enter .A large potential difference is maintained between tha metal walls of the tube and the center wire .when ionizing radiation enters the tube ,it forms ions that causes a pulse is counted by an electric device that produce either a meter reading or an audible click sound..

3- Film badges:X-ray technicians and other who work around radiation usually are required to wear film badge .These badges indicate the accumulated amount of radiation to which they have been exposed .They contain a piece of photographic film whose darkening is directly proportional to the amount of radiation received.

Nuclear reactions

Some radioisotopes contain nuclei which are highly unstable and decay spontaneously by splitting into 2 smaller nuclei. Such spontaneous decays are accompanied by the release of neutrons.

Nuclear reaction can be induced by bombarding atoms with neutrons. The nuclei of the atoms then split into 2 parts. Induced fission decays are also accompanied by the release of neutrons.

In nuclear reaction, two nuclei with low mass numbers combine to produce a single nucleus with a higher mass number

The followings rules must be observed when writing nuclear reactions

1-The sum of the atomic numbers on both sides of the equation must be the same.

2- The sum of the mass numbers on both sides of the equation must be the same.

${}^{40}_{19}\mathrm{K} \rightarrow {}^{40}_{20}\mathrm{Ca} + {}^{0}_{-1}\beta$

${}^{212}_{84}\mathrm{Po} \rightarrow {}^{208}_{82}\mathrm{Pb} + {}^{4}_{2}\alpha$

${}^{197}_{79}\mathrm{Au} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{198}_{79}\mathrm{Au}$

${}^{14}_{7}\mathrm{N} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{14}_{6}\mathrm{C} + {}^{1}_{1}\mathrm{H}$ $({}^{1}_{1}\mathrm{H} = p)$

${}^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}{}^{\mathrm{Th}} + {}^{4}_{2}\mathrm{He}$ α – decay

${}^{16}_{7}\mathrm{N} \rightarrow {}^{16}_{8}\mathrm{O} + {}^{0}_{-1}\mathrm{e}$ β – decay

${}^{99m}_{43}\mathrm{Tc} \rightarrow {}^{99}_{43}\mathrm{Tc} + 8$ metastable isotop

${}^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\beta + {}^{0}_{0}8$

${}^{238}_{92}\mathrm{U} \rightarrow {}^{0}_{0}8 + {}^{238}_{92}\mathrm{U}^{*}$ (*) indicates slightly lower energy

Radioisotope (radisotope)

The isotopes produced artificially by bombardment with one of the various particles are called radisotopes.Radisotopes have the same chemical properties as non-radioactive isotopes of the same element because chemical properties are based upon electrons only. radisotopes have medical uses.

Half life

It is the time needed for one-half of the original nuclei of an isotope to decay to other substances and represent by the symbol $t_{1/2}$ which indicate half life. The importance of half life, it tell us how long a sample of isotope will exist. For medical work ,a radioisope must have a half-life such that it will remian in the body long enough to supply the radiation needed and yet will decrease in radioactivity within a reasonable period of time so that the body doesnot receive excess radiation . Radioistopes of long half-life are very dangerous to the body for example radium has a half-life of 1590years ,therefore ,if it is taken into the body it continues to give off its radiation with no change in amount during the life of that person.Some radioactive elements have a half-life measured in terms of billions of years ,whereas others are measured in fractions of a second.

ionization radiation has been known to cause:

- Skin cancer.
- Bone cancer. And damage to bone cells.
- Leukaemia.
- Other types of cancer.
- Damage to brain cells.
- Eye cells.
- Damage to other organ cells and tissues.
- Genetic risk (which is more difficult to determine because it may appear after several generations). This type of risk causes damage to genes of the cell nuclei).

X-ray is also harmful; person must take precaution to avoid exposure. The effect of being exposure to high level of radiation kill the cells (this fact is used to treat cancer), so normally cancer cells is exposed to high energy radiation (X-Ray, ɣ radiation...) to destroy these cells.

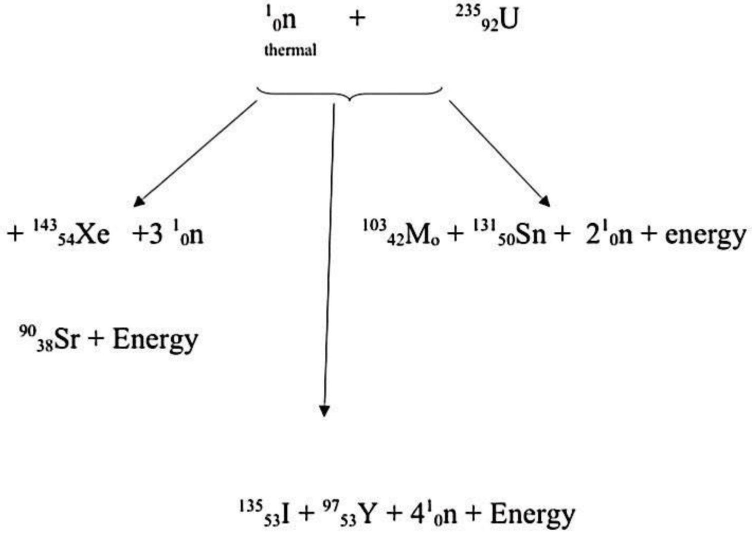
Energy and Nuclear reactions

1- Fission reaction: the nuclear reaction that causes an atom to split into several smaller parts is called fission reaction. This splitting process is accompanied by the release of large amount of energy.

A nuclear power uses a fissionable material (one that is capable of undergoing fission) such as U – 125, as fuel.

- U – 235 is the only naturally occurring isotope that undergoes this reaction.

- Two other isotopes formed by nuclear bombardment, PU – 239 and U – 233 also undergo fission reactions.



$^{1}_{0}n \quad + \quad ^{235}_{92}U$

thermal

$+ \; ^{143}_{54}Xe \;\; +3\,^{1}_{0}n$

$^{90}_{38}Sr + \text{Energy}$

$^{103}_{42}M_o + {}^{131}_{50}Sn + 2\,^{1}_{0}n + \text{energy}$

$^{135}_{53}I + {}^{97}_{53}Y + 4\,^{1}_{0}n + \text{Energy}$

Each neutrons released react with other nuclei this is called chain reaction. The amount of material needed for a chain reaction to continue is called the "*Critical Mass*".

Nuclear fusion

Results from combination of two small nuclei to form a large nucleus with the release of large amount of energy.

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + \text{energy}$$

Such fusion reaction occur in two places in the world:-

1- In the sun.
2- In the hydrogen bomb.

The high temperature needed to carry out the fusion reaction is furnished by the explosion of an atomic bomb. The atomic bomb is set off first and provides the energy to trigger the hydrogen bomb.

The Effects of Radiation on the Cell at the Molecular Level

When radiation interacts with target atoms, resulting in ionization or excitation.

The absorption of energy produces damage to molecules by direct and indirect actions.

For direct action, damage occurs to atoms on key molecules in the biologic system for example radiation can strick molecule of water in the cells and may knock an electron from a water molecule or it is may remove a hydrogen ion from water molecule

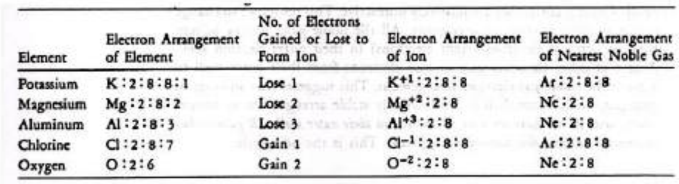
$H_2O \rightarrow e - H_2O^+$

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

Indirect action involves the production of free radicals whose toxic damage on the key molecule results in a biologic effect.

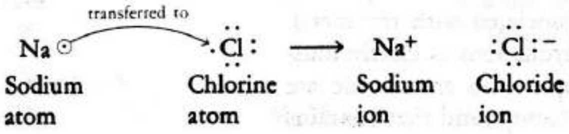
Salts

Salt is substance produced by the reaction of an acid with a base. A salt consists of the positive ion (cation) of a base and the negative ion (anion) of an acid. The reaction between an acid and a base is called a neutralization reaction. When in solution or the molten state, most salts are completely dissociated into negatively and positively charged ions and are good electrolytes (conductors of electricity).Salt is ionic compound that is formed by electrostatic attraction between oppositely charged ions and this electrostatic attraction is called ionic bond.



Element	Electron Arrangement of Element	No. of Electrons Gained or Lost to Form Ion	Electron Arrangement of Ion	Electron Arrangement of Nearest Noble Gas
Potassium	K:2:8:8:1	Lose 1	K^{+1}:2:8:8	Ar:2:8:8
Magnesium	Mg:2:8:2	Lose 2	Mg^{+2}:2:8	Ne:2:8
Aluminum	Al:2:8:3	Lose 3	Al^{+3}:2:8	Ne:2:8
Chlorine	Cl:2:8:7	Gain 1	Cl^{-1}:2:8:8	Ar:2:8:8
Oxygen	O:2:6	Gain 2	O^{-2}:2:8	Ne:2:8

An ionic bond is the transfer of electrons from a metal to a non-metal in order to obtain a full valence shell for both atoms.



Types of salts

Salts are ionic compounds usually obtained by neutralization reactions. They are generally neutral compounds but some of them are acidic and basic in their solution form. This concept was explained by Bronsted-Lowry. It states that ions can act either as an acid or a base. So, the acidity or basicity of salts depends upon the type of cations and anions produced in the solution..The common types of salts are acid, basic, neutral, double, and complex salts.

1-Acidic salts

Acidic salt is chemical compound formed When a strong acid reacts with a weak base such as (NH_4Cl) that formed when Hydrochloric acid(HCl) reacts with (NH_4OH), The aqueous solution for this salt is acid solution its pH less than 7

$[H^+] = (c \times Kw/K_b)^{1/2}$ C is molar concentration

Ammonium chloride (NH_4Cl) is the salt of a strong (HCl), and a weak base (NH_4OH), so an aqueous solution of ammonium chloride is acidic in nature.

When ammonium chloride is dissolved in water, it gets hydrolyzed to some extent to form ammonium hydroxide and hydrochloric acid :

$$NH_4Cl\ (s) + H_2O\ (l) \rightarrow NH_4OH(aq) + HCl\ (aq)$$

Hydrochloric acid is a strong acid that is completely ionized and gives a large quantum of hydrogen ions ($H_{(aq)}$). On the other hand, ammonium hydroxide is a weak base that is only slightly ionized and gives a small quantum of hydroxide ions ($OH^-_{(aq)}$). Since ammonium chloride result contains additional hydrogen ions than hydroxide ions, it's acidic in nature.Another illustration of a salt that gives an acidic solution is ammonium sulphate $(NH_4)_2SO_4$. It is formed from a strong acid sulphuric acid (H_2SO_4) and a weak base ammonium hydroxide (NH_4OH)

Ammonium chloride solution is acidic in nature because of the acidic nature of ammonium (NH_4+) ions.

$$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$$

Here ammonium ions act as an acid and donate a proton to H_2O resulting in H_3O^+.

2-Basic salts

Basic salt is chemical compound formed When a strong base reacts with a weak acid such as (CH_3COONa) that formed when CH_3COOH reacts with (NaOH) ,The aqueous solution for this salt is basic solution its pH more than 7

$[H^+]=[(Kw \times K_a)/c]^{1/2}$ C is molar concentration

Sodium carbonate (Na_2CO_3) is the salt of weak acid carbonic acid (H_2CO_3) and a strong base sodium hydroxide (NaOH), so an aqueous solution of sodium carbonate will be elementary in nature (or alkaline in nature). When sodium carbonate is dematerialized in water, it gets hydrolyzed to some extent and forms sodium hydroxide and carbonic acid

$$Na_2CO_{3(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_2CO_{3(aq)}$$

where, (NaOH) is a Strong base and (H_2CO_3) is a weak acid. (NaOH) is a strong base that is completely ionized and gives a large quantum of (OH^- (aq)). On the other hand, (H_2CO_3) is a weak acid that is exclusively hardly ionized and hence gives a fragile quantum of hydrogen ions (H^+(aq)). Since the sodium carbonate solution contains further d hydroxide ions than hydrogen ions, it's basic in nature (or alkaline in nature). Sodium cyanide is a basic salt. Upon its addition to water, it hydrolyzes into its ions.

$$NaCN \rightarrow Na^{+} + CN^{-}$$

$$CN^{-} + H2O \rightarrow HCN + OH^{-}$$

Sodium ions are not reactive while CN^- ions react with H_2O to form OH^- ions. By the Lowry-Bronsted concept, cyanide ion is a base as it accepts a proton. This is why NaCN is a basic salt.

3- Neutral salts

Neutral salt is chemical compound formed When a strong acid reacts with a strong base such as (NaCl and ,KBr) The aqueous solution for this salt is neutral solution its pH equal to than 7 .NaCl is an example of neutral salt.When Hydrochloric acid(HCl) reacts with

Sodium hydroxide(NaOH) , the formation of neutral salt that is Sodium chloride NaCl .

Some salts produce ions on hydrolysis which do not react with water to produce hydronium ions or hydroxyl ions. For example, NaCl is soluble in water. It gives Na^+ and Cl^- ions. Both these ions are unreactive to species present inside water.

$$Cl^- + H_2O \rightarrow \text{no reaction}$$

$$Na^+ + H_2O \rightarrow \text{no reaction}$$

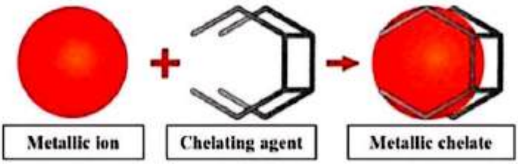
4- Complex salts

__The coordination compounds are sometimes referred to as complex salts. This is because they contain transition metal atoms as cations. The "complex" word describes the varying valencies of the transition metals. In such complexes, cations are in the center surrounded by anions and ligands to form complexes.

Chelation and Ligands forming coordinate bonds in Complex salts

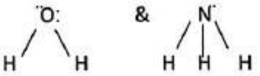
Chelation is a type of bonding of ions and molecules to metal ions. It involves the formation or presence of two or more separate coordinate bonds between a polydentate ligand and a single central metal atom.

These ligands are called chelants, chelators or chelating agents.



ligand

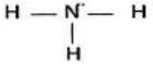
A ligand is an ion or molecule, which donates a pair of electrons to the central metal atom or ion to form a coordination complex



The atom in a ligand that is bound directly to the metal atom is known as the "donor atom". Depending on the number of donor atoms, ligands are classified as:

Monodentate, bidentate, or polydentate.

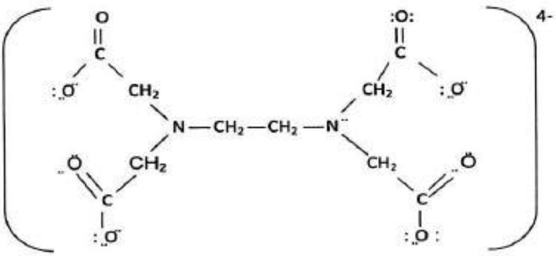
H_2O, NH_3,



$$\begin{array}{c} H - \ddot{N} - H \\ | \\ H \end{array}$$

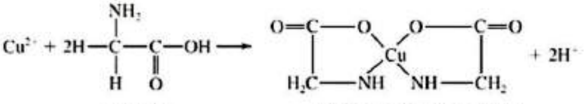
$H_2\dot{N} — CH_2 — CH_2 — \ddot{N}H_2$

Monodentate **Bidentate ligand (Ethtlenediamine)**



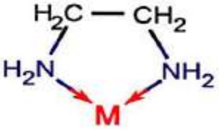
EDTA (Polydentate ligand)

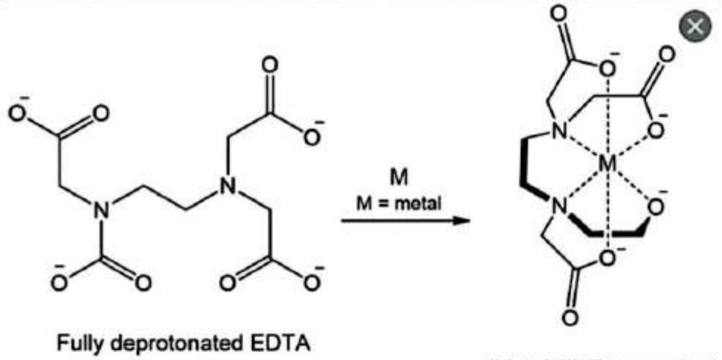
Glycine is amino acid consider bidentate ligand



Glycine

Cu^{2+} complex with glycine.





Fully deprotonated EDTA

"Metal-EDTA complex"

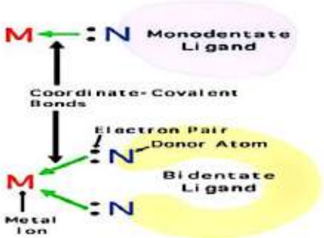
While individual hydrogen bonds are not very strong, a series of hydrogen bonds is very secure. When one molecule hydrogen bonds through two or more sites with another molecule, a ring structure known as a chelate is formed. Chelating compounds are useful for removing or mobilizing molecules and atoms such as metals. chelation therapy to remove toxic metals from the body,EDTA (ethylenediaminetetra aceticacid) is injected into the bloodstream to remove heavy metals and/or minerals from the body. Chelation means "to grab" or "to bind." When EDTA is injected into the veins, it "grabs" heavy metals and minerals such as lead, mercury, copper, iron, arsenic, aluminum, and calcium and removes them from the body.

coordinate bond

A covalent chemical bond between two atoms that is produced when one atom shares a pair of electrons with another atom lacking such a pair. A type of covalent bond in which both the shared electrons are contributed by one of the two atoms(first atom with pair of electron and the another atom with empty orbital)

$_5$B $1s^2\,2s^2\,2p^1$ $_7$N $1s^2\,2s^2\,2p^4$

A compound that donates one electron pair is monodentate ligand while any compound donates two electron pairs is didentateligand.this compounds donate the electron pairs for empty orbital to hold coordinate bonds.



Properties of Salt

1- Colour: Solid salts tend to be transparent, while the polycrystalline aggregates seem to be like white powders.

2-Odour: Salts of both strong acids and strong bases are non-volatile and often odourless, whereas the salts of either weak acids or weak bases can smell as the conjugate acid or the conjugate base of the component ions.

3-Taste: sweet (lead diacetate, which causes lead poisoning when ingested), salty (sodium chloride), bitter (magnesium sulfate), sour (potassium bitartrate), and savoury (monosodium glutamate) .

4- Conductivity: salt solutions conduct electricity. Due to this reason, liquified (molten) salts and the solutions consisting of dissolved salts (for example, sodium chloride in water) are referred to as electrolytes.

5- Melting Point: salts contain high melting points.

Preparation of salts

Most acids when reacting with metals, hydroxides, carbonates, and bicarbonates produce salts.

1. Reaction of Metals with acids

$$\text{Metal} + \text{Acid} \rightarrow \text{Salt} + H_{2(g)}$$

Examples:

$$HCl + Mg \rightarrow MgCl_2 + H_2$$

$$H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$$

$$CH_3COOH + Na \rightarrow CH_3COONa + H_{2(g)}$$

2. By the reaction of acid and base

when an acid reacts with a base, salt is formed. The reaction is called the neutralization reaction. The salt produced in this reaction has cation from the base and anion from the acid reagent.

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + H_2O$$

Examples:

$$2HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$$

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

3. By the reaction of acids with Carbonates/ Bicarbonates

When acids are treated with carbonates and bicarbonates, salts are formed. The salts are in an aqueous medium, and thus, can be separated by physical techniques.

$$\text{Acid} + \text{Carbonates or Bicarbonates} \rightarrow \text{Salt} + CO_2 + H_2O$$

Examples:

$$2HCl + MgCO_3 \rightarrow MgCl_2 + CO_2 + H_2O$$

$$HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$$

Salts according to solubility

Salt compounds can be divided into two types depending on their water solubility. They are soluble and insoluble salts. The key difference between soluble and insoluble salts is that soluble salts can dissolve in water at room temperature, whereas insoluble salts cannot dissolve in water at room temperature. Moreover, soluble salts are polar; that's why they can dissolve in water, which is a polar solvent. In contrast, insoluble salts are nonpolar. Soluble salts such as NaCl, NH_4SO_4 and CH_3COONa

Sparingly soluble salts are insoluble salts those salts whose solubility is very low. **When a sparingly soluble salt is placed in water, a very small amount of the salt dissolves in the water and a solution is formed. The solubility product, K_{sp}, determines the equilibrium that exists between the sparingly soluble salt and the ions that are dissolved in water.**such as AgCl ,$Ca_3(PO_4)_2$,$PbSO_4$,$BaSO_4$,$Mg(OH)_2$,and CaF

$$Ca_3(PO_4)_{2(s)} \rightleftharpoons 3Ca^{2+}_{(aq)} + 2PO^{3-}_{4(aq)}$$

$$K = \frac{[\mathrm{Ca}^{2+}]^3[\mathrm{PO}_4^{3-}]^2}{[\mathrm{Ca}_3(\mathrm{PO}_4)_2]}$$

$$[\mathrm{Ca}_3(\mathrm{PO}_4)_2]K = K_{\mathrm{sp}} = [\mathrm{Ca}^{2+}]^3[\mathrm{PO}_4^{3-}]^2$$

Significance of salts

Low sodium levels can result if there is too much fluid in the body, for example, because of fluid retention. Diuretics are given in this case, to reduce fluid retention.

The body uses sodium to maintain fluid levels. A balance of fluid and sodium is necessary for the health of the heart, liver, and kidneys. It regulates blood fluids and prevents low blood pressure.

1- If sodium levels fall in the blood, this affects brain activity. The person may feel sluggish and lethargic. They may experience muscle twitches, followed by seizures, a loss of consciousness, coma, and death. If sodium levels fall quickly, this may happen very fast.

2-Excess sodium intake has been linked to health problems, such as kidney disease, and hypertension, or high blood pressure, which can lead to cardiovascular disease ..

Q- Each question below contains four suggested answers of which one or more is correct.Choose the answer.

A- if only	1,2,and 3	are correct
B- if only	1 and 3	are correct
C- if only	2 and 4	are correct
D- if only	4	is correct
E- if only	1,2,3,and,4	are correct

1-The acidic salt is producted by the reaction

1-NaOH + HCl

2-NH_4OH + HF

3-NH_4OH +CH_3COOH

4- NH_4OH +H_2SO_4

2-Monodentate compound is

1-NH_3

2-Glycine

3-H_2O

4-EDTA

Colloids and colloidal dispersions

Solubility:

Is an ability of a substance to dissolve. In the process of dissolving

Factors Affecting Solubility

1- Pressure:

The solubility of gases increases with an increase in the pressure of a gas above the solution.

2-Tempreture, for most solids increase the solubility will increase the solubility except $Ca(OH)_2$, $CaCr_2O_7$, $CaSo_4$, the solubility decrease with increase the temperature and gas in liquid the solubility decrease with increase the temperature.

3-Intermolecular Forces

Some substances, like water and alcohol, can be mixed together and create a homogenous phase in any proportion. A solubility measure cannot be applied to such two substances. Such substances are called miscible. On the other hand if two substances cannot be mixed together (like water and oil), they are called immiscible.

General Rule: "Like dissolves Like"

•Polar solvents tend to dissolve polar or ionic solutes.

•Non-polar solvents tend to dissolve non-polar solutes.

4-pH: Salt solubility is pH sensitive when one of the constituent ions is a weak acid or base.

Acidic salts are more soluble in basic solutions (pH > 7), and less soluble in acidic solutions.

Basic salts are more soluble in acidic solutions (pH < 7), and less soluble in basic solutions.

The solubility of neutral salts is unaffected by a change in pH.

*Heterogeneous: mixture are those which are not homogeneous.

*Homogenous Homogeneous mixtures are those in which the smallest samples are everywhere identical in composition and properties.

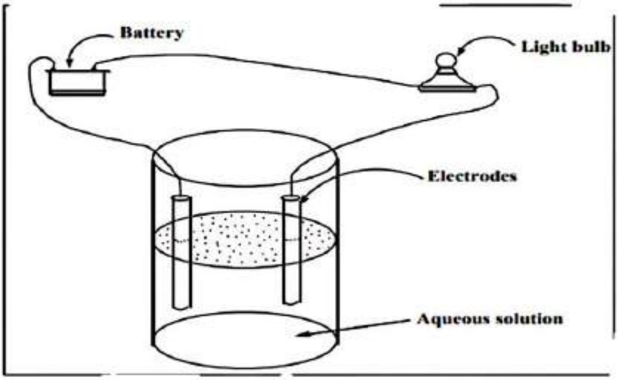
Dissolution is a physical change—you can get back the original solute by evaporating the solvent. If you can't, the substance didn't dissolve, it reacted.

There are five main types of solution as shown in the table below

State of Solution	Original State of Solute	State of	
		Solvent	Examples
Gas	Gas	Gas	Air, natural gas;
Liquid	Liquid	Liquid	alcoholic beverages, antifreeze
Liquid	Solid	Liquid	seawater, sugar solution, etc.
	Gas	Liquid	carbonated (soda) water
Solid	Solid	Solid	metal alloy, e.g., steel, brass,
bronze, etc;			

Electrolytes and nonelectrolytes

Electricity is the flow of electrons in circuit from a battery or electrical generator along a wire back to the source. The electricity passing through the circuit can do work, such as running a motor or providing heat and light. The flow of electricity stop if the circuit is broken. An electrical circuit can also contain aqueous solution as shown in following figure



The circuit contain (battery, aqueous solution, light bulb of two wires called electrodes)

-The two electrode are oppositely charged.

-For electricity to flow through this circuit after the connection have been made.

-The solution must be able to conduct electricity. Glowing light bulb indicates

that electricity is flow through circuit. Aqueous solutions either conduct electricity or they do not. One that undergo either a physical or a chemical change in solution to yield ions that can conduct electricity are called electrolytes. If a substance yields ions in solution, that is, if the compound undergoes 100% dissociation, then the substance is a strong electrolyteconducts electricity is called an electrolytic solution : one that dose not is called a nonelectrolytic solution(A non electrolyte Substances that do not yield ions when dissolved in water. that does not conduct electricity when dissolved in water. For example: sugar molecular ($C_6H_{12}O_6$).)

Electrolyte: A solute that forms an aqueous electrolytic solution.

Nonelectrolyte: A solute that forms an aqueous nonelectrolyte solution.

Hydration: is a close association of water molecule with an ion, we say that ion is hydrated. Thus according to Arrhenius theory, one mole of sodium chloride forms one mole of sodium ions and 1 mole of chloride ion when dissolved in water.Aqueous solution of electrolytes are really solutions of hydrated ions. The total number of ions formed per mole of electrolyte depends on

Electrolytes and Nonelectrolytes

Electrolytes		Nonelectrolytes	
NaCl	sodium chloride	$C_{12}H_{22}O_{11}$	sucrose
KI	potassium iodide	C_2H_5OH	Ethyl alcohol
LiBr	Lithium bromide	C_3H_6O	Acetone
Na_2SO_4	sodium sulfate	CH_4	Methane
KNO_3	potassium nitrate	N_2	Nitrogen
$CaCl_2$	Calcium chloride	O_2	Oxygen
LiF	Lithium floride	CO	Carbon monoxide

The total number of ions formed per mole of electrolyte depends on the chemical formula of the electrolyte as shown in following Table.

Ex: 1 mole of calcium chloride dissolved in water forms 1 mole of hydrated calcium ions and 2 moles of hydrated chloride ions.

Number of ions formed per mole of electrolyte

chemical formula	ions formed in aqueous solution	Number of ions in 1 mol of electrolyte
NaCl	Na^+ Cl^-	$2 \times 6.02 \times 10^{23}$
LiBr	Li^+ Br^-	$2 \times 6.02 \times 10^{23}$
KNO_3	K^+ NO_3^-	$2 \times 6.02 \times 10^{23}$
$CaCl_2$	Ca^+ Cl^- Cl^-	$3 \times 6.02 \times 10^{23}$
Na_2SO_4	Na^+ Na^+ SO_4^{-2}	$3 \times 6.02 \times 10^{23}$
Na_3PO_4	Na^+ Na^+ Na^+ PO_4^{-3}	$4 \times 6.02 \times 10^{23}$

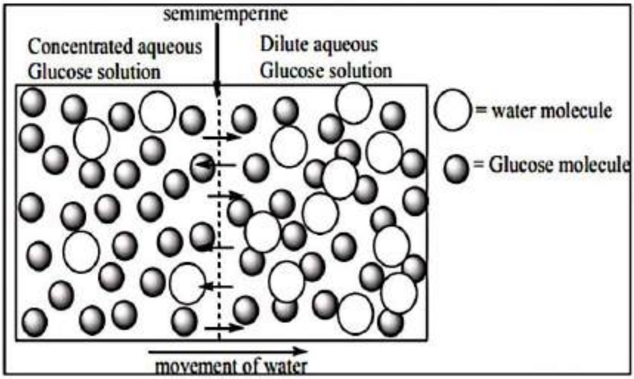
The sugar molecules surrounded by water molecules, are neutral when a pair of electrodes is placed in this solution. The sugar molecules are not attracted by their electrode. Consequently no electric current flows through the solution.

OSMOSIS AND OSMOTIC PRESSURE

Cells have limiting boundary membranes that are called plasma membranes. These membranes not only keep the cell intact but also allow the exchange of materials back and forth between the interior of the cell and its exterior surroundings. Dialysis and Osmosis are two ways that such an exchange of materials occurs.

Osmosis: is the movement of water through an osmotic membrane from an aqueous solution that is less concentrated to one that is more concentrated. This phenomenon that occur whenever an osmotic membrane separated two solution of different concentration. Osmotic membrane = semipermeable membrane= plasma membrane.

Osmotic pressure: The pressure needed to prevent osmosis is called the osmosis pressure. Notice that a high solute concentration means high osmotic pressure. Water moves from dilute to more concentrated solutions. The purpose of this movement of water is to make the concentrations of the solution equal. In the following figure, the water moves to the solution that has the greater number of dissolved particle (Glucose).



Colligative property: Any property of a solution that depends on the number of dissolved particles in the solvent. We can easily that osmotic pressure is a colligative property. For example, if we measure the osmotic pressure of a 1M aqueous sodium chloride solution, we find that it is exactly twice that of a 1M aqueous glucose solution. The reason for this difference in osmotic pressure is that sodium chloride is an electrolyte, whereas glucose is a nonelectrolyte. An aqueous solution containing 1mole of sodium chloride actually contains 1 mole of sodium ions and 1 mole of chloride ions.

The relative osmotic pressures of two solutions are extremely important in living systems.

Types of Solutions according to tonicity:

Isotonic Solutions:

The normal concentration of NaCl in blood is 0.9% and this usually called normal saline solution. No effect on the red blood cell (RBC). The cell membrane behaves as semipermeable membrane, and since the concentration of NaCl inside and outside the RBC is the same then no flow of water will occur.

(*The two solutions that have the same osmotic pressure,for example, 1M glucose solution and a 1M urea (nonelectrolyte)*).

2-Hypertonic solutions:

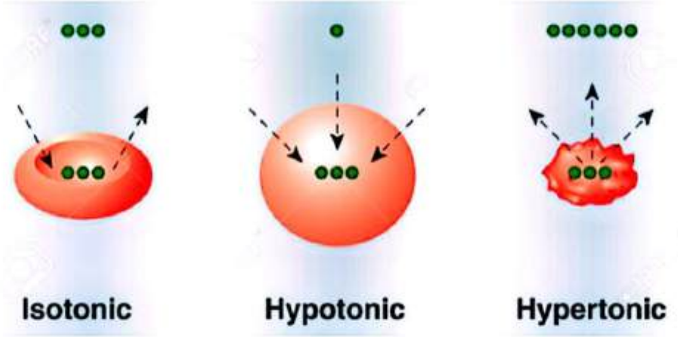
That solutions with contain more than 0.9% of NaCl. If RBC put in this solution, then it will shrink since water will flow from the inside to outside the cell.

(One of the two solutions has a higher osmatic pressure, for example, 1M NaCl solution has a higher osmotic pressure than a 1M glucose solution).

3-Hypotonic solutions:

That solutions with contain less than 0.9% of NaCl. If RBC put in this solution, then it will swell or burst, since water will flow from the outside to inside the cell.

(One of the two solutions that has the lower osmotic pressure than the other, for example, 1M NaCl solution has a lower osmotic pressure than a 2M LiBr solution).



The plasma membranes of red blood cells behave as osmotic membranes. The cells contain an aqueous fluid made up of dissolved compounds. This fluid has an osmotic pressure determined by the concentration of dissolved molecules and ions in the fluid. Osmotic occurs when a red blood cell is placed in water.

*The solution inside the cell is hypertonic compared to pure water, so water enters the cell.

Hemolysis: The rupture of red blood cells when much water enter cell, the cells are called (Hemolyzed).

Osmosis also occurs when red blood cell is placed in solution of concentrated saline (sodium chloride). But the solution inside cell is hypotonic and water leave cell.

-Crenation: The process of leaving water and passes into solution and causes R. B. C to shrivel and shrink.

Degree of saturation

-A-Saturated solution

1-Solvent holds as much solute as is possible at that temperature.

2-Undissolved solid remains in flask.

3-Dissolved solute is in dynamic equilibrium with solid solute particles.

B-Unsaturated Solution

1-Less than the maximum amount of solute for that temperature is dissolved in the solvent.

2-No solid remains in flask

C-Supersaturateds

1-Solvent holds more solute than is normally possible at that temperature.

2-These solutions are unstable; crystallization can often be stimulated by adding a "seed crystal" or scratching the side of the flask.

Suspension:

is a heterogeneous mixture of two or more substances. In a suspension, very small pieces of solid are spread through a liquid but do not dissolve. If left, the solid pieces will separate from the liquid and either fall to the bottom or rise to the top. Sand in water is a suspension. Suspensions may separate quickly or stay suspended for a long time, depending on what they contain.

When some powdered clay is placed in water and strongly shaken, a suspension of clay in water will be produced. This suspension will not be clear opaque upon standing, the clay will slowly settle.

When the suspension is poured into a funnel containing a piece of filter paper, only water passes through the filter paper, the clay doesn't of same medications, such as milk of magnesia, are administered as a suspension. Many bottles of medications state on the label shake before using. A mist is a suspension of liquid in a gas, water droplets suspension in air are one example of a mist.

Colloids and colloidal dispersions

The particles in a solution are the size of atoms and molecules (0.05-0.25 nm). Sometimes intermolecular attractions between molecules cause several hundred or thousand of them to cluster together. The size of these clusters range from 1-100 nm. Matter containing particles of this size is called a "Colloid".A uniform dispersion of a colloid in water is called a "Colloidal-dispersion". A colloidal dispersion usually appears cloudy. The colloid in a colloidal dispersion is called the dispersed substance.

Proteins form colloidal dispersion in water being colloidal so they can pass through a filter paper but no in membrane. Proteins present in blood stream cannot pass through the cell membranes and should remain in blood stream. Since the present of protein in the urine indicates damage to the membranes in the kidneys.

Colloid: Mater contain particle it is size range from (1-100 nm)

-Colloidal dispersion: A uniform dispersion of a colloid in water.

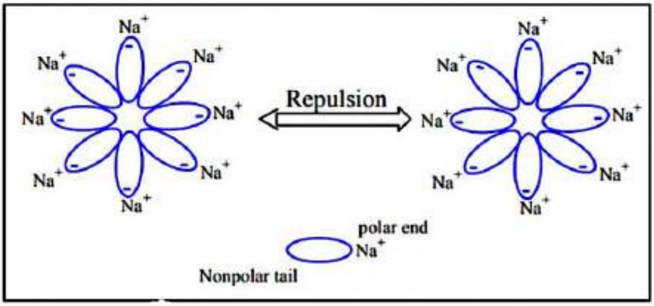
-Dispersion substance: the colloid in a colloidal dispersion

-Dispersing substance: The continuous matter in which the colloid is dispersed.

The dispersed and dispersing substance can be liquids, solids or gases. They can combine in nine different ways to form colloidal dispersion containing two components. but only eight of these nine possible combinations. Mixture of two gases can not be colloid dispersion because the particle of gas are individual molecules. The eight types of colloidal dispersion are given in the following Table.

Dispersed substance	Dispersing substance	Example
Liquid	Gas	Fog, clouds
Solid	Gas	Smoke
Gas	Liquid	Foams, whipped cream
Liquid	Liquid	Milk, butter
Solid	Liquid	Paints, glue
Gas	Solid	Foam, rubber, pumice
Liquid	Solid	Jellies, cheese
Solid	Solid	Colored glass, gems

If the colloids are clusters of molecules, why don't the clusters increase in size unit they get large enough to settle out? The reason is that particle in the most stable colloid dispersions all have the same electrical charge can be caused by adsorption of ions to the surface of the particle, or the large particle themselves can be charged. As result the particle repel each other and can not form particle large enough to settle out as shown:



Colloids formed by attractions between complex molecules

Emulsifying agent:

A Compound or substance that stabilized a colloidal dispersion for example (Soap) in mixture of oil and water. Water is immiscible with oil, if we add soap to mixture the oil is emulsified by the soap.

*Dailyzing membrane: membrane that allow small molecules and ions to pass while holding back large molecules and colloidal particle.

Dailysis: The selective passage of small molecules and ions in either direction by dialyzing membrane. Dialysis differ from osmosis in that osmotic membrane allow only solvent molecules to pass.

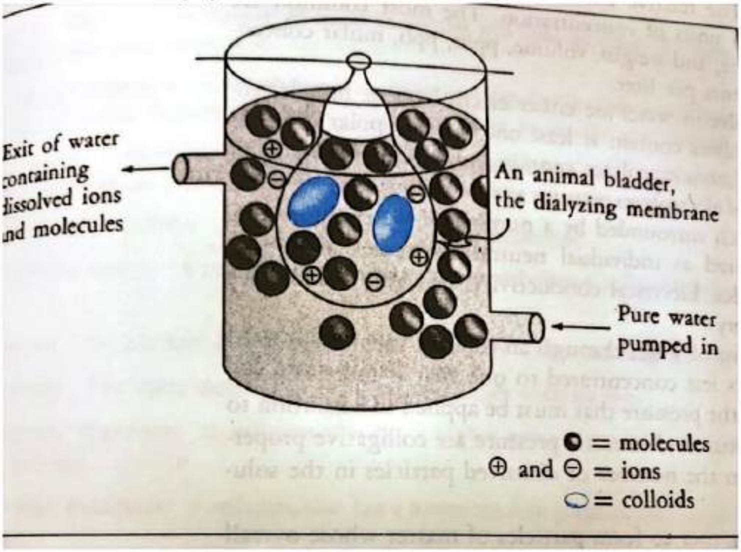
*The kidneys are an example of organs in the body that use dialysis to maintain the solute and electrolyte balance of the blood.

The main purpose of the kidneys are to clean the blood by removing the waste products of metabolism and control the concentration of electrolyte.

*The efficient kidneys purified 180L of blood in a 68kg (150 Ib(adult.

Bag made of dialyzing membrane such as animal bladder .The bag contains mixture of colloidals and dissolved molecules and ions.The bag is placed in container of pure water and the water continually passed through the membrane .The water carries the ions and molecules through the membrane leave the colloidals behind.The ability of dialyzing membranes to allow the passage of only selected substances is extremely important to living system

a mixture



Concentration ,Preparation of solution.

solution

solution is a special type of homogeneous mixture composed of two or more substances. In such a mixture, a solute (smaller amount) is a substance dissolved in another substance, known as a solvent (larger amount).

Solutions that contain liquids as solvents are the types of solutions most familiar to use.

Solvent = dissolving medium (often liquid frequently water, gas in air and other gas solutions, rarely a solid)

Solute(s) = dissolved material(s)(solids, liquids, and/or gases, often more than one solute)

They have the following properties:

1- Consist of a soluble material (the solute) dissolved in a liquid (the solvent)

2- homogeneous mixture of two or more substances.

3- Stable and will not precipitate(don't settle)

4-The solute from a solution cannot be separated by filtration (or mechanically).

5-clear

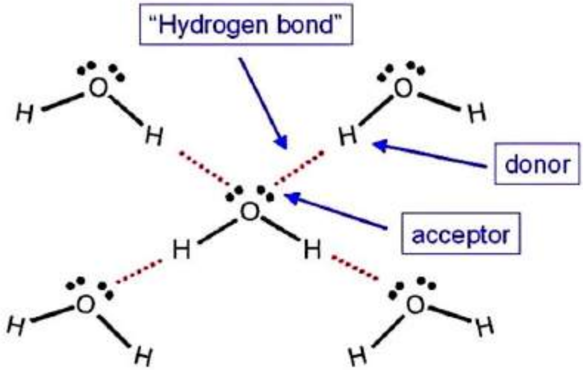
6-It is composed of only one phase

May be separated by physical means.

Water as Solvent (-Form aqueous solutions, -One of best solvents for dissolving ionic substances)

Water

A water molecule has two partial positive hydrogen atoms and two lone pairs of electrons located on the oxygen atom. For that each water molecule can potentially have both its hydrogen atoms and both its lone pairs involved in hydrogen bonding. Water is one of best solvents for ionic material(electrolytes) Water's polar molecular structure interacts strongly with charged ions



***Hydrogen bond** is an intermolecular force that forms a special type of dipole-dipole attraction when a hydrogen atom bonded to a strongly electronegative atom (such as O,N and F) exists in the vicinity of another electronegative atom with a lone pair of electrons. Intermolecular forces occur between molecules. Hydrogen bond weaker than true covalent and ionic bonds.*

Polar solvents

Polar solvents are the solvents that contain partial positive and partial negative charge or they must have a dipole moment.The dipole moment occurs during charge separation.Polar solvents generally dissolve other polar substances as polar solvents generally carry a positive and negative charge and when we add a polar substance negative charge of the polar substance goes to the positive charge of the solvent and the positive charge of the polar substance goes to the negative charge of polar solvents. So that Polar substances can dissolve in polar solvents.
Example of polar solvents is Water, Acetone Methanol , etc

Nonpolar solvents

Nonpolar solvents are solvents that do not have dipole moment or do not contain any partial positive and partial negative charge.In nonpolar solvents, atoms come by forming a bond, and the atoms have less difference in electronegativities. Nonpolar solvents do not dissolve in polar solvents as they do not carry any charge Nonpolar solvents are dissolved in nonpolar compounds like alkanes and aromatic compounds.
Examples of nonpolar solvents are Benzene, Toluene and hexane etc

Solution Concentrations

1-Weight/Weight percent (W/W %)

To specify the concentration of a solute in a solution.

$$W/W\ \% = \frac{\text{Weight of solute (g)}}{\text{weight of solute (g)} + \text{weight of solvent (g)}} \times 100$$

2-Volume/Volume percent (V/V %)

A convenient way of expressing the concentration of a liquid solute dissolved in a liquid.

$$V/V\ \% = \frac{\text{Volume of solute (ml)}}{\text{Total volume of solution (ml)}} \times 100$$

3-Weight/Volume percent (W/V)

Widely used method to expressing concentration is a combination of weight and volume.

$$W/V\ \% = \frac{\text{Weight of solute (g)}}{\text{Total volume of solution (ml)}} \times 100$$

4- ‰ Concentration has multiplier of 1000 to place ratio on "parts per 1000 total" basis:

$$‰ = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 1000$$

6- ppm concentration has multiplier of 10^6 to place ratio on "parts per million total" basis:

$$\text{ppm} = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 10^6$$

Parts per million(ppm) and Parts per billion(ppb)
ppm=μg solute/ ml solution = mg solute / L solution
ppb=ng solute/ ml solution = μg solute / L solution
1L=1000ml =10dl , dl=100ml , μl=10^{-6} L

7-Mole Fraction(X)

s = solute ; A = solvent; V = Tot. Vol. of solution.

$$\chi_s = \frac{n_s}{n_s + n_A}$$

8-Molarity (Molar concentration) (mole/L):number of moles of solute per liter of solution.

$$M = \frac{\text{Number of moles of solute}}{\text{Number of liter of solution}}$$

$$M = \frac{\text{Mole}}{\text{L}} \quad , \quad \text{mole} = \frac{\text{weight}}{\text{molecular weight}} = \frac{\text{wt.}}{\text{M. Wt.}}$$

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

*Number of mole = (solute weight) / (Molecular weight) .

molecular weight = molecular mass =(number of atoms)(atomic weight)
molecular weight = (number of H atoms)(H atomic weight)=2 x 1=2 g\mole.
molecular weight for H_2O (atomic weight H=1 and O=16)
Molecular (mass) weight(H_2O)=1x2 + 16 x1 = 2+16=18 g/mole
molecular weight = molecular mass =(number of atoms)(atomic weight)

9-Normality(N) (Eq/L)

$$\text{normality} = N = \frac{\text{number of equivalents of solute}}{\text{1 liter of solution}} = \frac{\text{equivalents}}{\text{liter}}$$

where

$$\text{number of equivalents of solute} = \frac{\text{grams of solute}}{\text{equivalent weight of solute}}$$

then

$$N = \frac{\text{grams of solute}}{\text{eq wt solute} \times \text{L solution}} = \frac{\text{grams}}{\text{eq wt} \times \text{L}}$$

$$\text{Equivalent weight} = \frac{\text{Molecular weight}}{\text{Valence}}$$

$$N = \frac{\text{Wt.}}{\text{Eq. Wt.}} \times \frac{1000}{\text{V (ml)}}$$

Valance (n) =(number of hydrogen ions in acid)or(number of hydroxide ions in base) or (number of electrons transport in reaction).

$HCl \rightarrow H^+ + Cl^-$ n=H^+=1
$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$ n=2H+=2
$Ca(OH)_2 \rightarrow 2OH^- + Ca^{+2}$ n=$2OH^-$=2
$MgSO_4 \rightarrow Mg^{+2} + SO_4^{-2}$ n=+2e=-2e=2

N = n M

10-Molality concentration (m): The number of solvent moles per kilogram

$$Molality\,(M) = \frac{Number\ of\ moles\ of\ solute}{Mass\ of\ solvent\ in\ kgs}$$

$$Molality\,(M) = \frac{g \times 1000}{W \times m}$$

11-Milliequivalent per litter(mEq/L)

mEq/L=(number of milliequivalent of ion) / (volume of solution in L)

Dilution

When a solution is diluted, solvent is added to lower its concentration.

The amount of solute remains constant before and after the dilution:

moles BEFORE = moles AFTER

$C_1\ V_1 = C_2\ V_2$

Q4-1:Determine the concentration of each ion,in mEq/L in each of the following solutions:

(a) 0.001M LiBr (b) 0.05 M Na_2CO_3

Q4-2:How many grams are needed to make the following solutions?

(a)1L of a 0.1M of NaCl (b)0.05M Na_2CO_3

Q4-3: Each question below contains four suggested answers of which one or more is correct.Choose the answer .

A- if only 1,2,and 3 are correct
B- if only 1 and 3 are correct
C- if only 2 and 4 are correct
D- if only 4 is correct
E- if only 1,2,3,and,4 are correct

1-The polar covalent bond is formed between (H)atom and ….

1- Cl atom
2- Br atom
3- F atom
4- I atom

2-The NH_3 compound is polar because it is

1- the bond dipoles present do not cancel each other .
2- Containing polar bonds.
3- shape(V) molecule with 2 bond
4- all the above.