

# ALCOHOLS

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# The objective of the lecture



- Define of alcohols
- Types of alcohols
- Physical properties of alcohols
- Uses of alcohols
- Identification of alcohols

# What is alcohols?

**Alcohols** are a **homologous series** of organic compounds with the general formula  $C_nH_{2n+1}OH$  and names ending *-ol*.

The functional group in alcohols is the **hydroxyl group**:  $-OH$ .

No. of carbon atoms	Molecular formula	Name
1	$CH_3OH$	methanol
2	$C_2H_5OH$	ethanol
3	$C_3H_7OH$	propanol
4	$C_4H_9OH$	butanol
5	$C_5H_{11}OH$	pentanol
6	$C_6H_{13}OH$	hexanol

# Types of alcohols

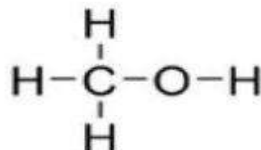
- Alcohol is any compound in which a hydroxyl functional group (-OH) is bound to a carbon atom.
- There are three classes (types) of alcohols:
  - ✓ primary
  - ✓ secondary
  - ✓ and tertiary

## Primary Alcohol:

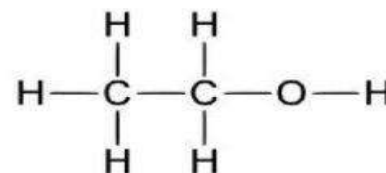
- In a primary ( $1^\circ$ ) alcohol, the carbon which carries the -OH group is only attached to one alkyl group.

General formula: **R**CH<sub>2</sub>OH

## Primary Alcohol examples



Methanol

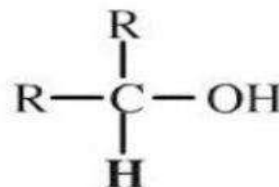


Ethanol

## Secondary Alcohol:

In a secondary (2°) alcohol, the carbon with the -OH group attached is joined directly to two alkyl groups.

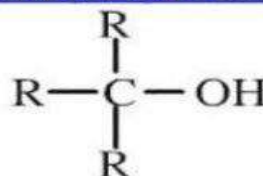
General formula: **R<sub>2</sub>CHOH**



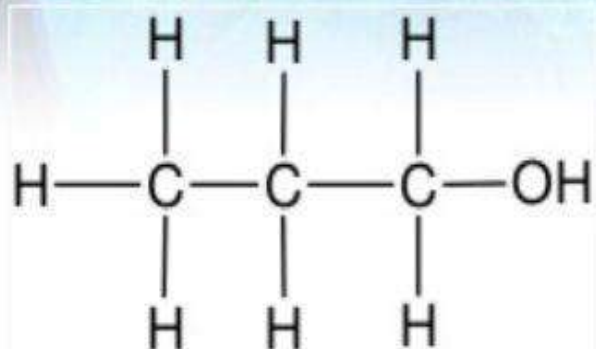
## Tertiary Alcohol:

In a tertiary (3°) alcohol, the carbon atom holding the -OH group is attached directly to three alkyl groups.

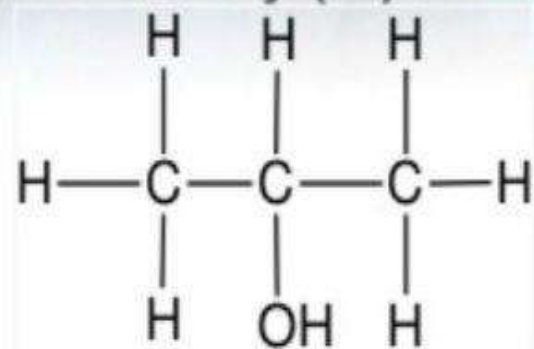
General formula: **R<sub>3</sub>COH**



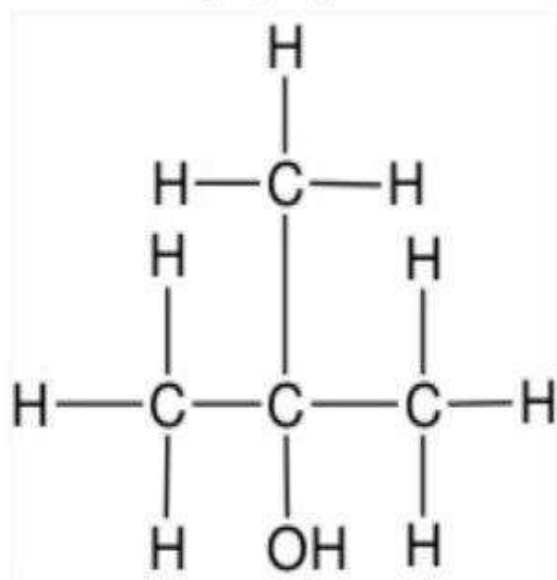
### Primary (1°) Alcohol



### Secondary (2°) Alcohol



### Tertiary (3°) Alcohol



- **PHYSICAL STATES OF ALCOHOLS**

- simple aliphatic alcohols and lower aromatic alcohols (such as phenylmethanol,  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ )  $\rightarrow$  liquids at room temperature.

- highly branched alcohols and alcohols with twelve or more carbon atoms  $\rightarrow$  solids.

## .solubility

i) Alcohols with short carbon chains (such as methanol, ethanol, and propanol) dissolve in water.

- when alcohols dissolve in water, hydrogen bonds are formed between the -OH group of the alcohol molecule and the -OH group of the water molecule.

ii) The **solubility** of alcohols in water **decreases** sharply with the **increasing length of the carbon chain**. Higher alcohols are insoluble in water.

- alcohol contains a polar end (-OH group) called '*hydrophilic*' and a non-polar end (the alkyl group) called '*hydrophobic*'.
- the water solubility decreases as the alkyl group becomes larger.

## ▪ Boiling point:

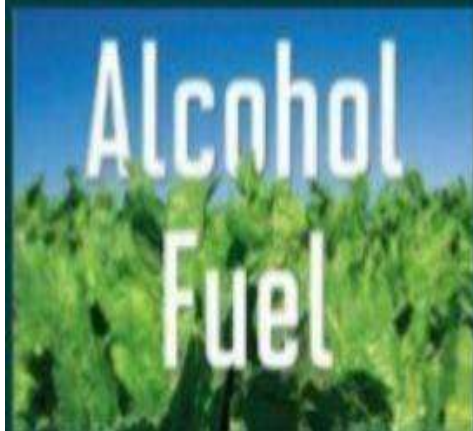
- ✓ the boiling point of an alcohol is always much higher than that of the alkane with the same number of carbon atoms.
- ✓ alcohols with two or more –OH groups have higher boiling point.

# Physical Properties of Alcohol

## Methanol, Ethanol and Glycerol:

<b>Color</b>	colorless
<b>Odor</b>	they have faint odor (alcoholic odor) <b><u>except</u></b> glycerol which is odorless.
<b>Solubility</b>	completely miscible with water.
<b>Flammability</b>	flammable with blue, non smoky flame.
<b>State</b>	liquid except glycerol which is viscous liquid.
<b>Acid-base properties</b>	neutral

## Uses of alcohols



### ➤ As fuel

- Some alcohol, mainly ethanol and methanol, can be used as an alcohol fuel.
- A mixture of petrol with 10 - 20% ethanol (gasohol)
- Methanol (as a fuel for racing cars)

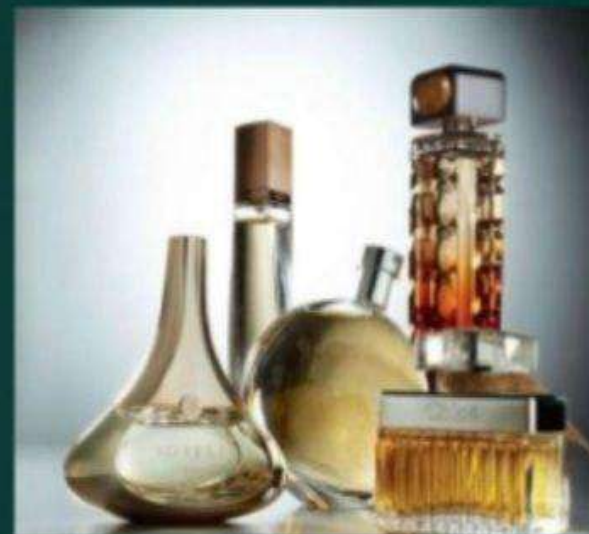


## ➤ As antiseptic

- Ethanol can be used as an antiseptic to disinfect the skin before injection are given, often along with iodine.

## ➤ As solvent

- Ethanol can be used as solvent in perfumes, cosmetics thinners for lacquers, vernishers and vegetable essences such as vanilla.



## ➤ As source of medical products

- Ethanol as a solvent in the preparation of cough syrups
- Propan-2-ol as a rubbing alcohol (bring down high fever)



## ➤ As source of chemicals

- As a raw materials in the manufacture of polymers, fibers, explosives and plastics
- Ethanol  $\rightarrow$  ethanoic acid (vinegar)

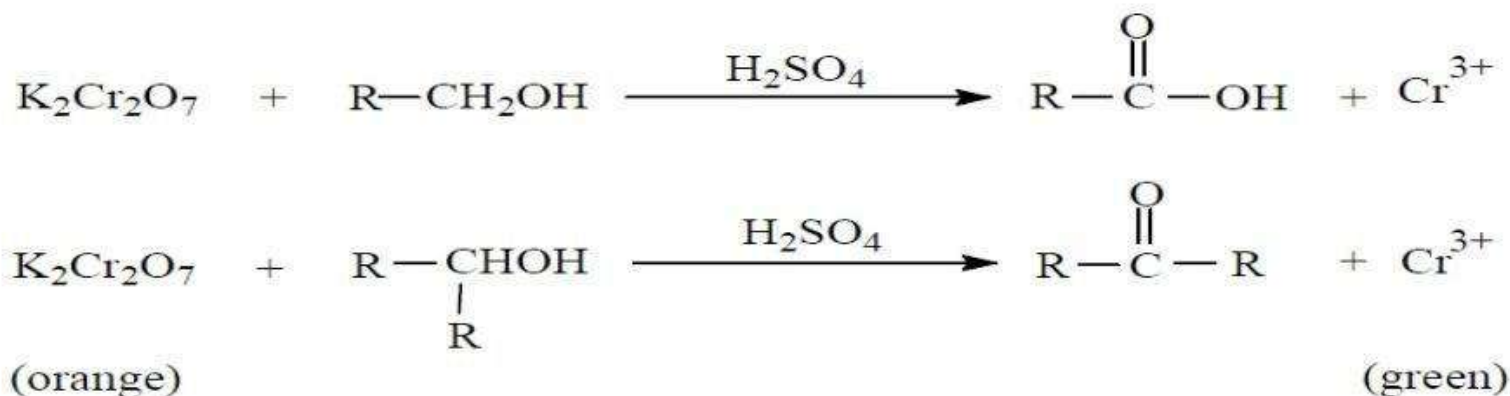
# Identification of alcohols [R –OH]

## 1. Chromic Acid Oxidation of Alcohols

**Procedure :** Place 5 ml of 1% potassium dicromate solution and 2 drops of concentrated sulfuric acid in each of two test tubes .

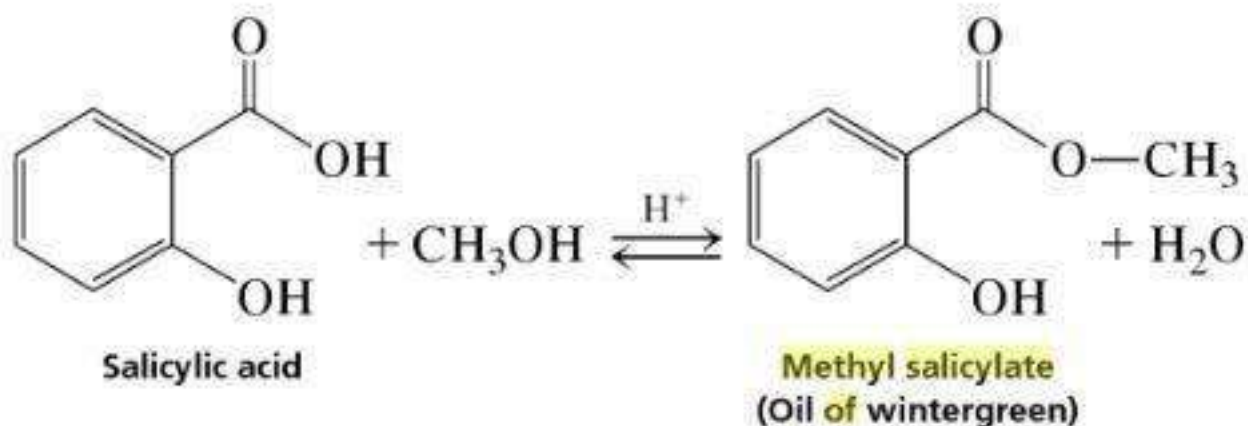
Mix thoroughly And add 2 drops of one of the following alcohols : Methanol , Isopropanol. Shake tubes and observe any change in color

**Note : (Tertiary alcohol =No reaction)**



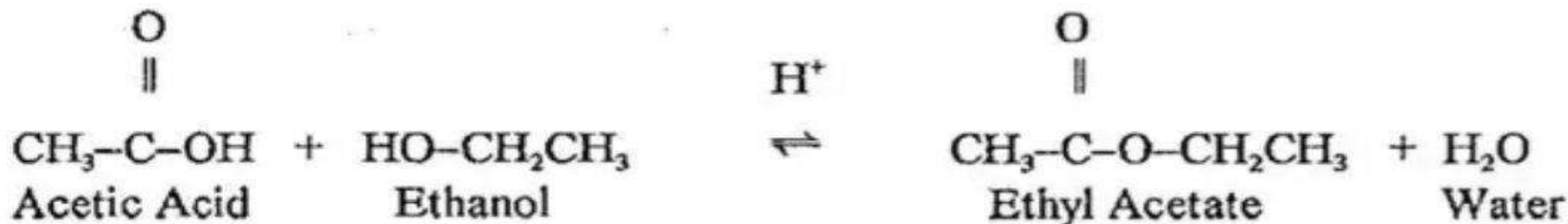
## 2-Methyl salicylate test (Special test for methanol )

Heat 1ml of methanol with 0.5gm of sodium salicylate (or salicylic acid) and a few drops of conc.H<sub>2</sub>SO<sub>4</sub> gently for 1 mint. Cool , pour into a few ml of cold water and shake detect the odour of methylsalicylate ester (oil of wintergreen).



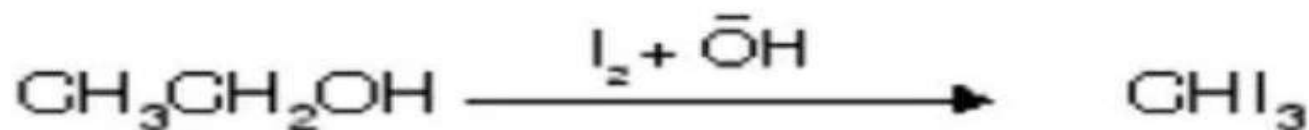
### *3-Ethyl acetate test (Special Test for ethanol)*

Heat 1ml of ethanol with 0.5gm of sodium acetate and few drops of conc.H<sub>2</sub>SO<sub>4</sub> gently for about 1minute . Cool and pour into a few ml of water . Note fruity odour of the ethylacetate .



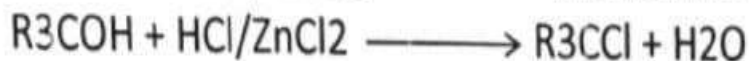
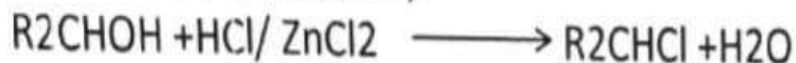
## 4-Iodoform reaction

To 0.5ml of ethanol add 2ml of  $I_2$  in 10%KI solution and 2 drops of 20%NaOH solution. Warm gently in water bath , fine yellow crystals of iodoform ( $CHI_3$ ) separate .



## 6-Lucas test ( $\text{ZnCl}_2/\text{HCl}$ )

### - Lucas test ( $\text{ZnCl}_2/\text{HCl}$ )



1. add 2 drops (0.2g) of UN

2. add 2 ml of Lucas reagent

3. stopper the tube and shake well, allow to stand and record the formation of a turbid solu.

3  $\longrightarrow$  1-2 min.

2  $\longrightarrow$  5-6 min.

1  $\longrightarrow$  negligibly slowly or  
not at all



1. Why are short-chain alcohols so soluble in water?
2. The  $C_6H_5$ - group has a special name. What is it?
3. What are alcohols used for in chemistry?
4. What are the 3 types of alcohol?
5. How do you identify alcohol?
6. What is the formula for ethanol?
7. What is an aliphatic alcohol?
8. Which is a secondary alcohol?

# Laboratory instruments & glass ware



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# Beaker



Are useful as a reaction container or to hold liquid or solid samples

(but not very accurately)

May be heated

Used to titrations, filtrats and mix chemicals



# Erlenmeyer Flask

Erlenmeyer flasks hold solids or liquids that may release gases during a reaction .

Measures liquids (but not accurately)

- May be heated
- Used for mixing
- Used in titrations



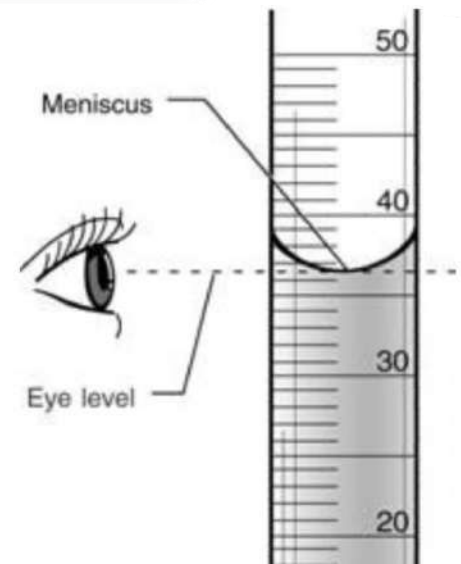
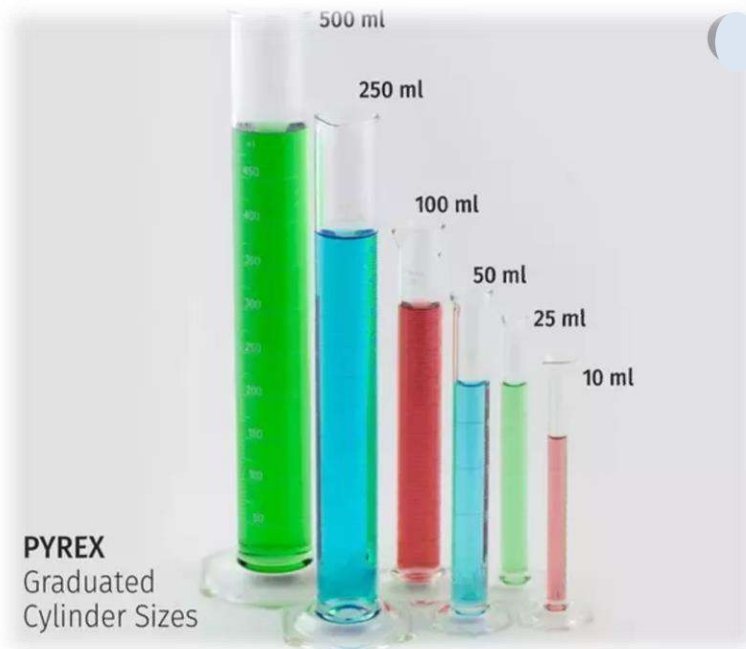
# Florence Flask

Rarely used in first year chemistry, it is used for the mixing of chemicals. Narrow neck prevents splash exposure.



# Graduated Cylinder

An item of glass laboratory equipment consisting of a tall, narrow cylinder with a scale which is used to measure liquids fairly accurately but not precisely



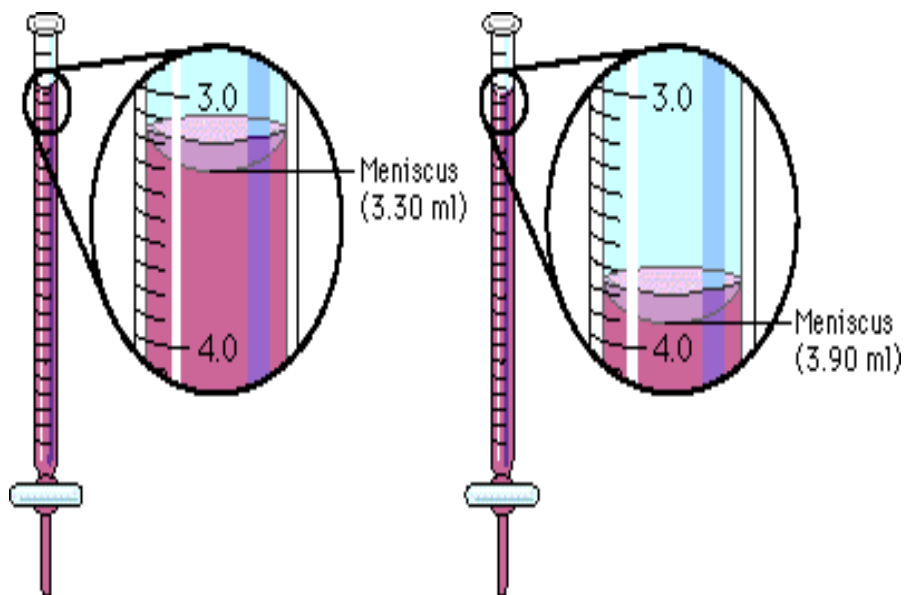
# Spatulas

Used to transfer solids from one container to another

**Note :** Chemicals should never be transferred with your bare hands.



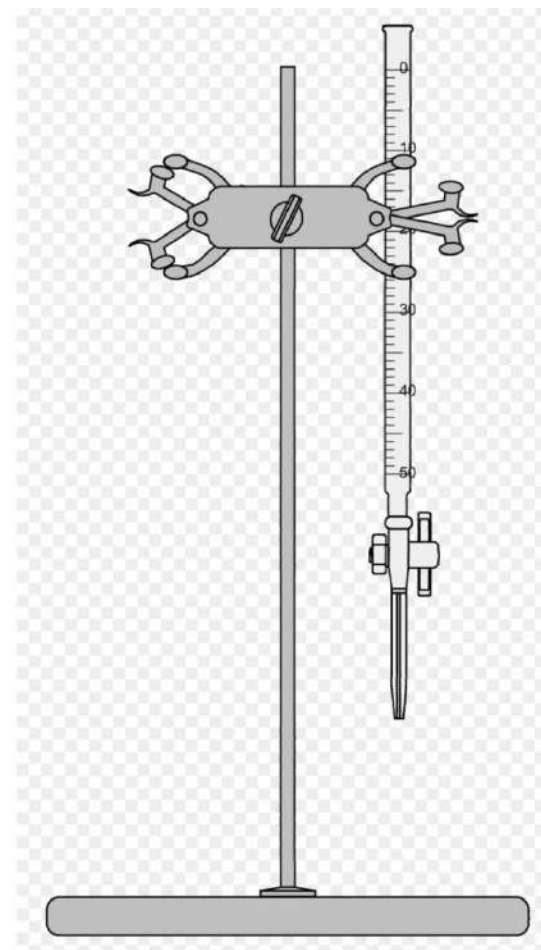
# Buret



# Buret & Buret Clamp



A glass tube with fine gradations and a stopcock at the bottom, used in laboratory procedures for accurate fluid dispensing and titration



# Clamps



Utility clamps are used to secure test tubes, distillation columns, and burets to the ringstand.



# Ringstands and their Components



Ringstands are a safe and convenient way to perform reactions that require heating using a Bunsen burner.

Multi-purpose, mostly used as a support to heat chemicals and hold burets.



## Forceps

Forceps (or tweezers) are used to pick up small objects.



## Funnel

.Holds filter paper for filtering solutions.

.Transferring liquids to smaller narrow necked containers.

# Funnel(glasses)

A funnel is used to aid in the transfer of liquid from one vessel to another.



# Reagent Bottle

Used to store, transport, or view reagents such as acids or bases. it's made of glass or plastic .

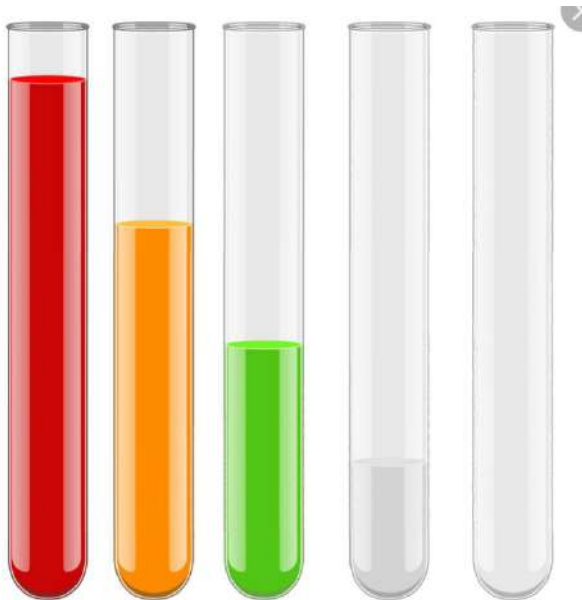


# Parafilm

Flexible, thermoplastic covering culture tube or flask mouths and sealing petri dish edges.



# Test Tubes



- May be heated
- Mix chemicals
- Holding small amounts of chemicals

## Stirring Rod

Glass rod used for stirring  
BE CAREFUL! They break easily

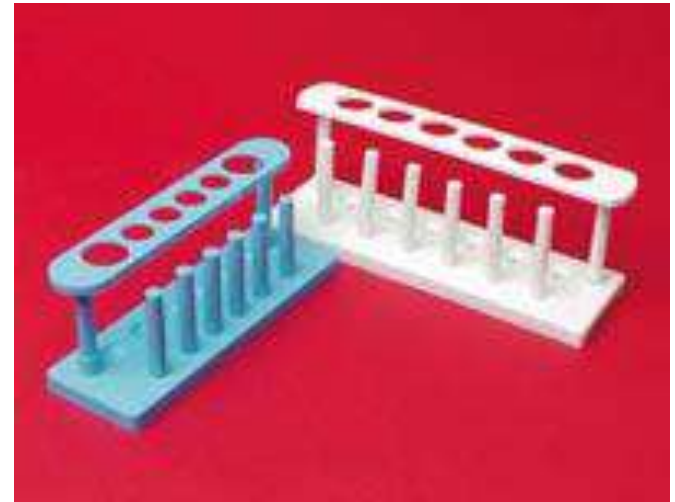


# Glass Stir Rod

Small ,solid glass rod .This is used to stir and mix chemicals during a reaction .Glass will not react most chemicals ,so this is the best choice for stirring



# Test Tube Racks



- Holds test tubes in a vertical position.
- Allows for clear sight.
- Drying rack

# Test Tube Brushes

Test tube brushes are used to clean test tubes and graduated cylinders.

Forcing a large brush into a small test tube will often break the tube.



# Test Tube Holder



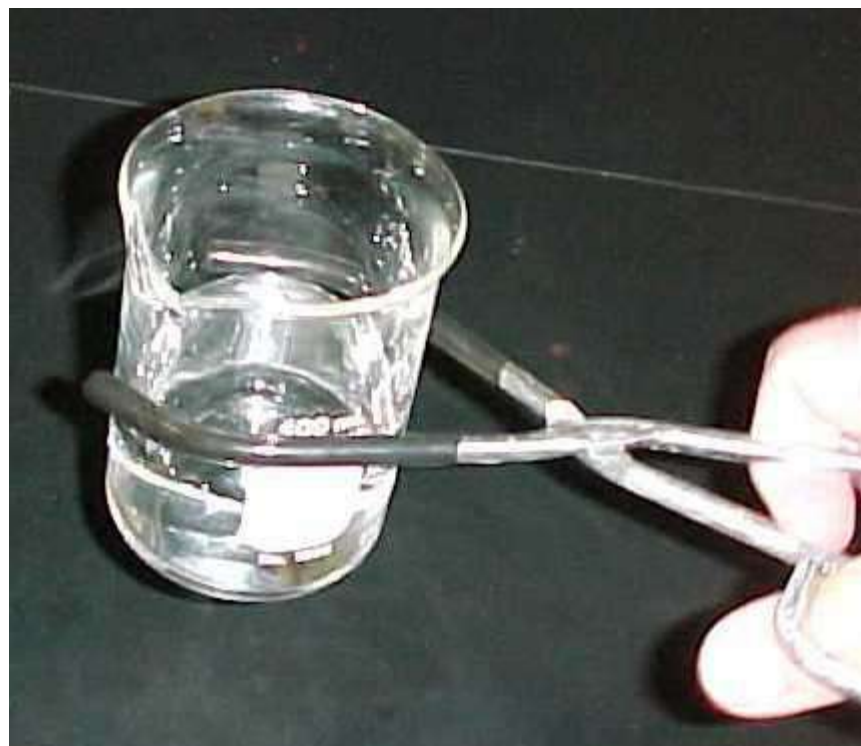
A test tube holder is useful for holding a test tube which is too hot to handle.



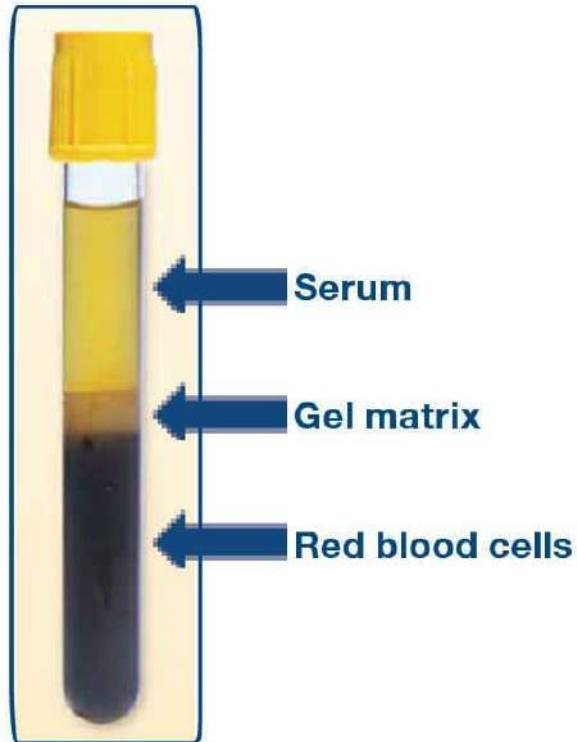
# Beaker Tongs



Used to handle hot beakers  
Do not work well for very small  
beakers or very large beakers



# Jel tube

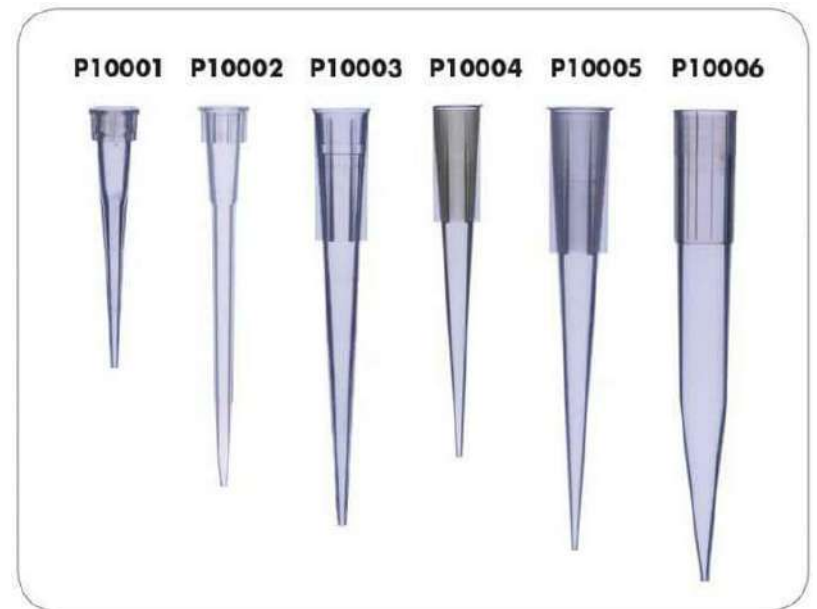


# Micropipette

A pipette for measurement of minute volumes

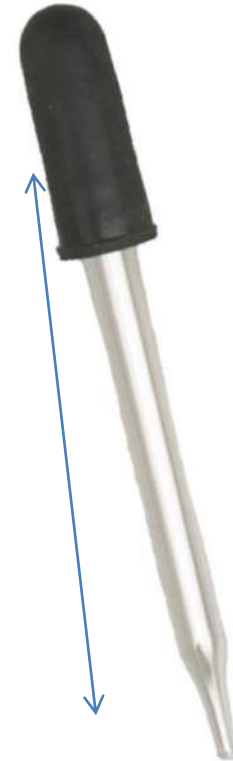


# tips



# Medicine Dropper

A medicine dropper is used to addition of liquid drop by drop (less than one mL).



On top of each medicine dropper is a “rubber bulb”

# Wash Bottle

Are used for dispensing small quantities of distilled water

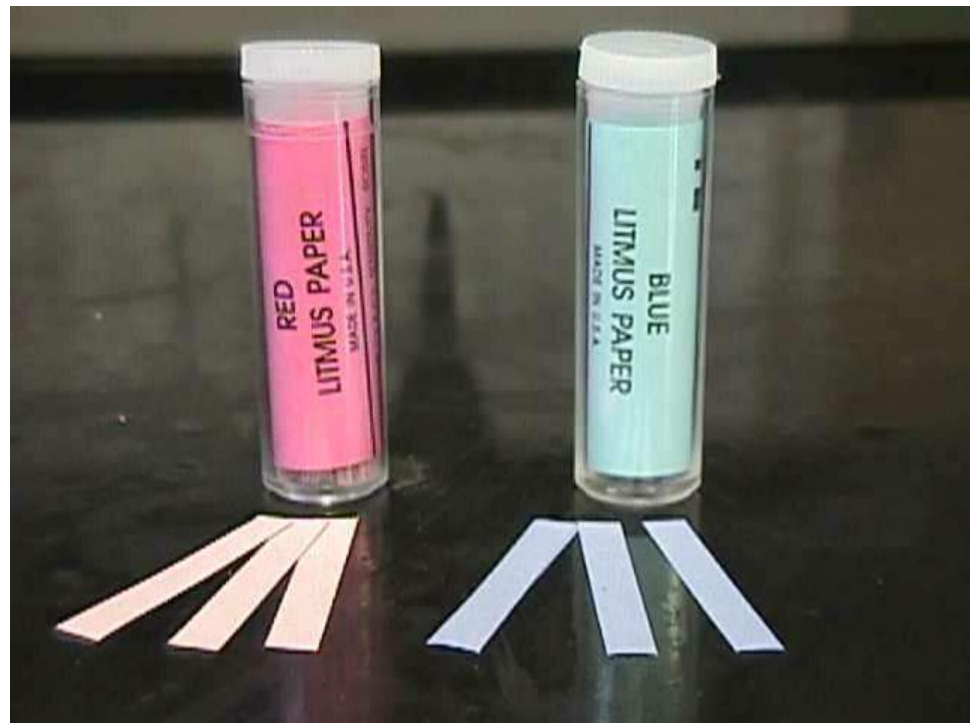
Distilled water is the only liquid that should be used in a wash bottle.



# Litmus Paper

Red litmus paper is used to identify acids.

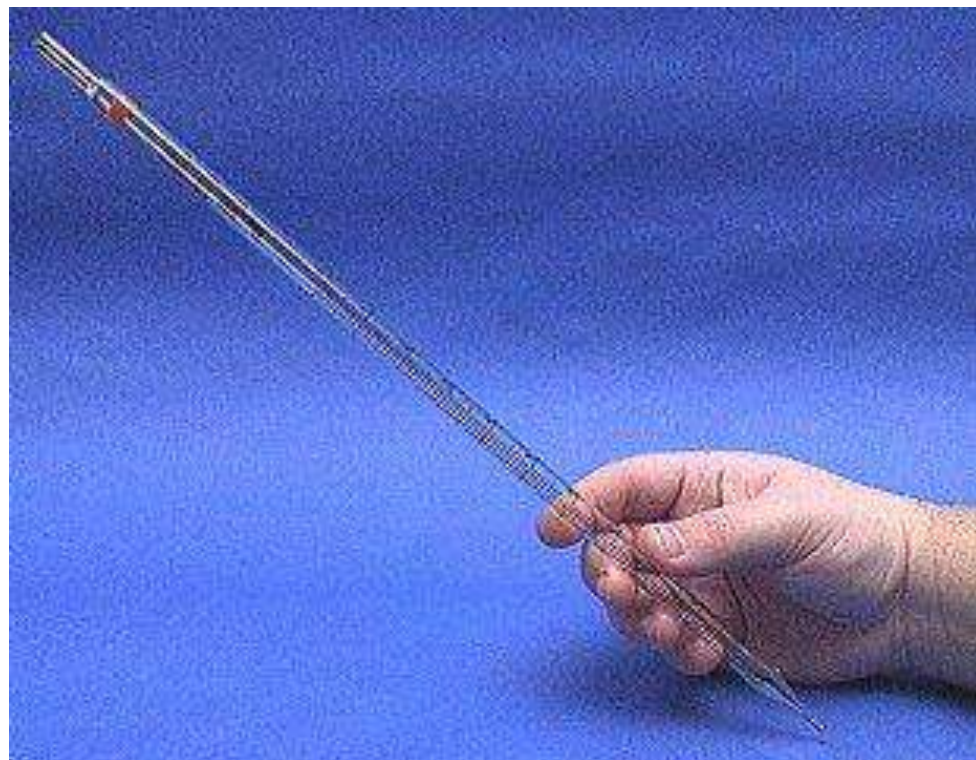
Blue litmus paper is used to identify bases.



# Mohr Pipet



A Mohr pipet measures and delivers exact volumes of liquids.



# Water bath



## Electronic Balance

Usually used to weigh solids



## Hot Plate

Usually used to heating .when an open flame is not desirable



# Centrifuge

Used to separate  
suspensions (solids from  
liquids)

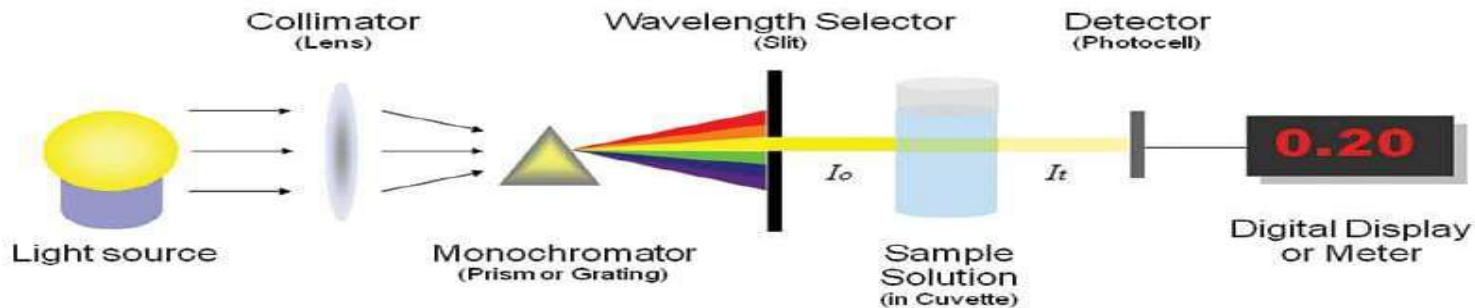


**Spectrophotometer:** is an analytical instrument used to quantitatively measure



# Spectrophotometer

Principle, Instrumentation, Applications





## Melting Points

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# The objective of the lecture



- Define of melting point and purpose of measuring melting point
- Comparison of ancient and modern methods of measuring melting point

## Definition

The melting point of a compound is the temperature at which it changes from a solid to a liquid (temperature at which solid is in equilibrium with its liquid )

Pure compound usually melt over a narrow temperature range of 1-2 °C

## Purpose :

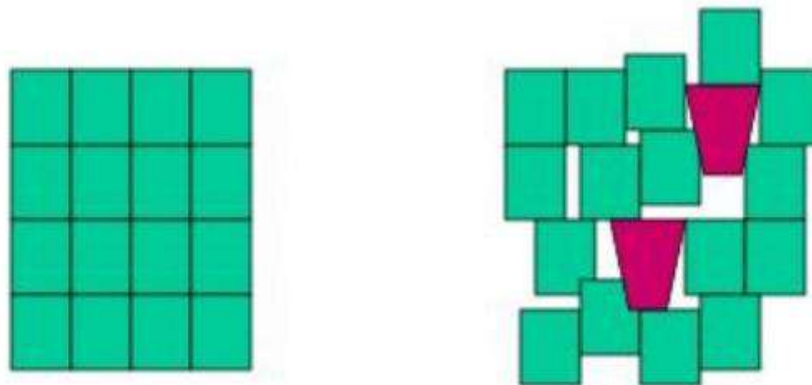
This is a physical property often used to identify compounds or to check the purity of the compound

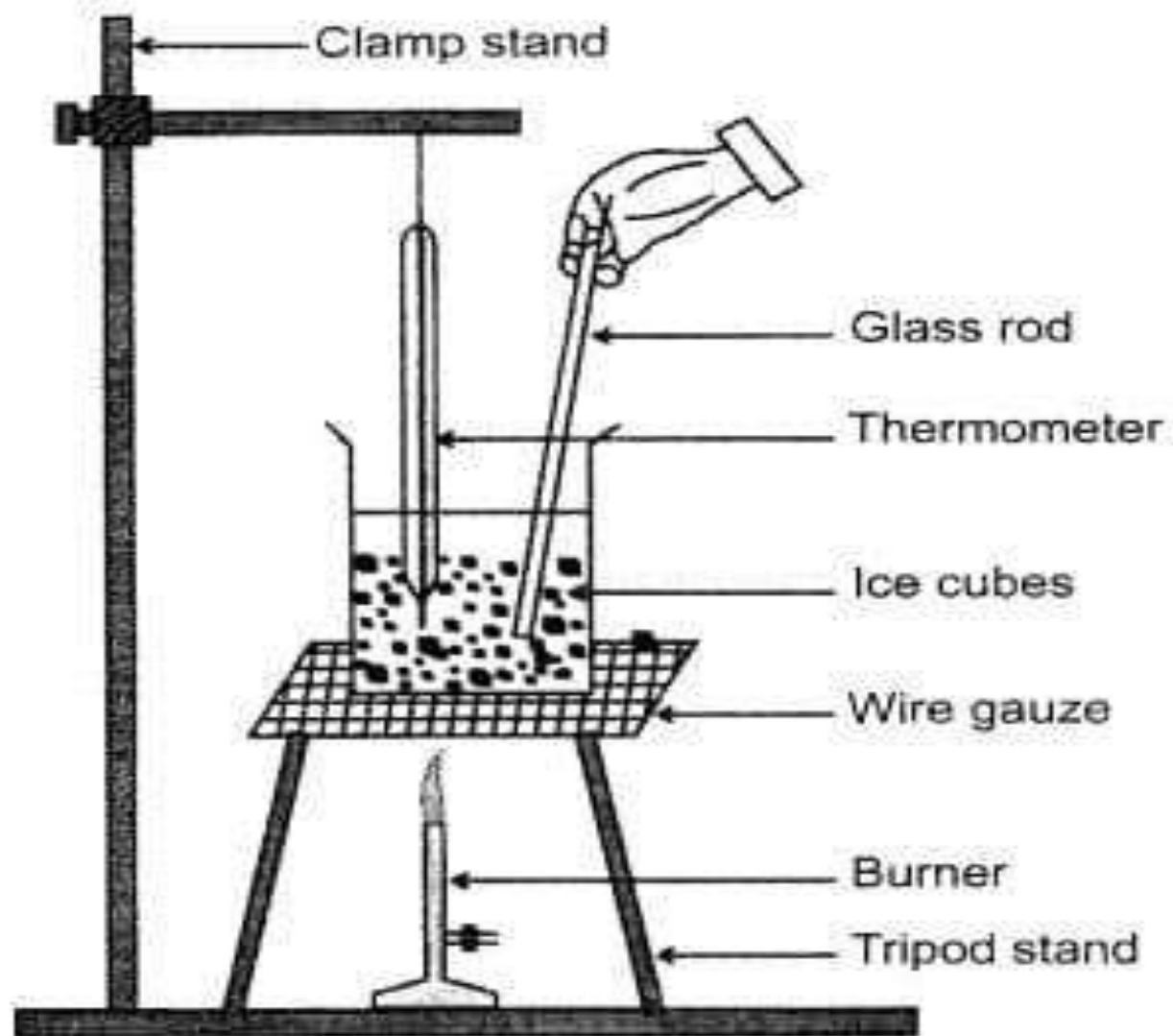
**Pure solids possess a narrow melting point**

**Because all the component atoms molecules or ions  
are the same distance from the same number**

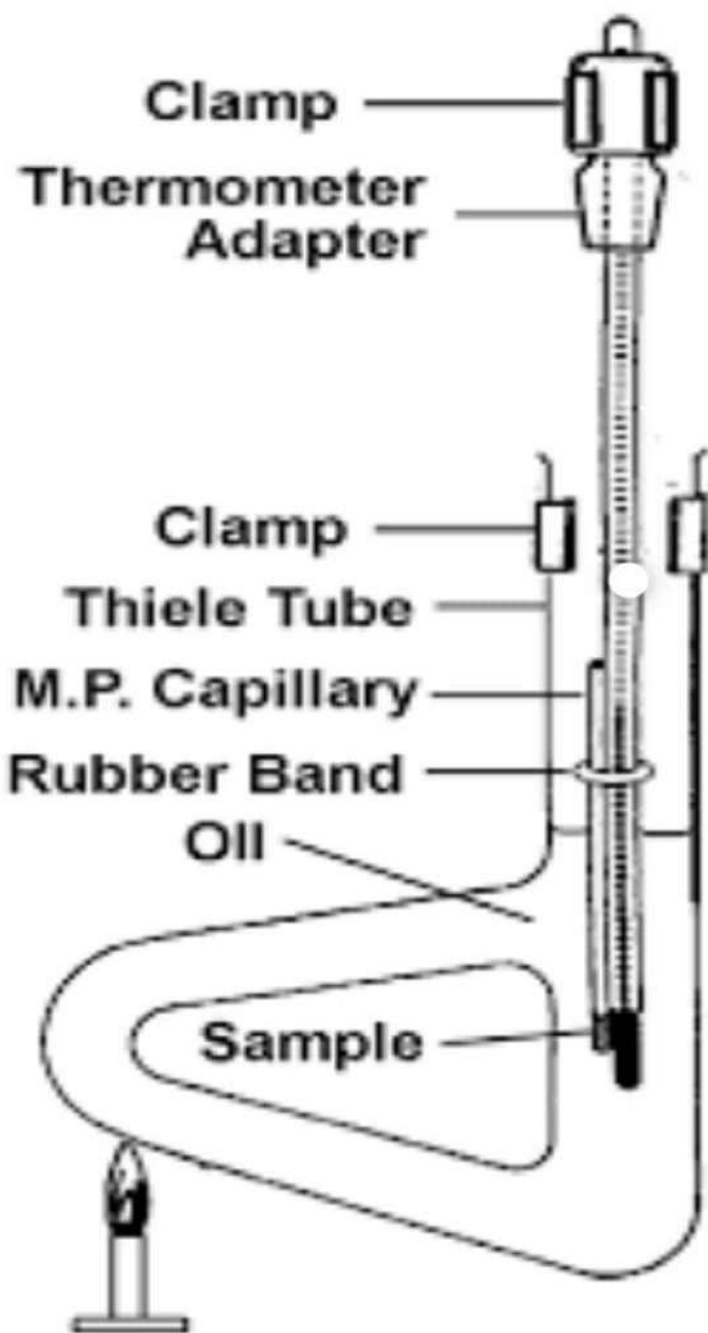
**That is the regularity of the crystalline lattice  
creates local environments that are the same**

- Impurities lower melting point:
  - takes less energy to disrupt crystal lattice when impurities are present
  - melting point will be lower
  - melting point will be broader





Determination of melting point of ice



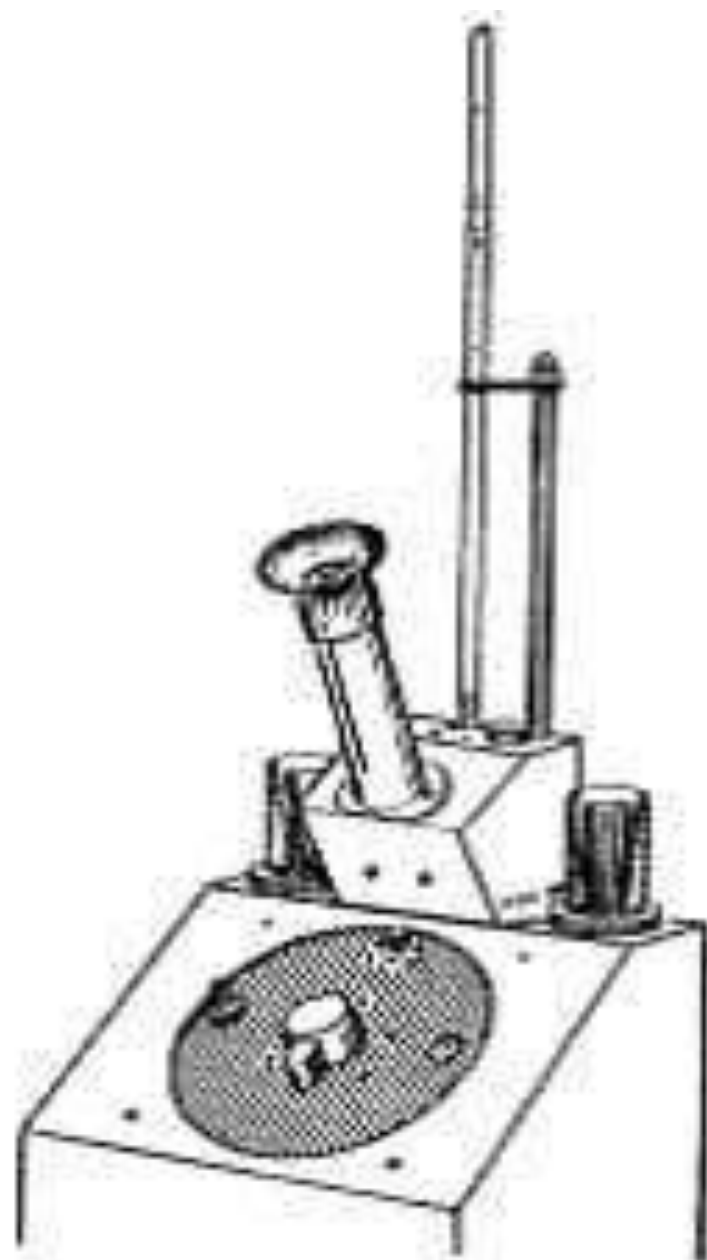


Fig. 11, 11, 2.



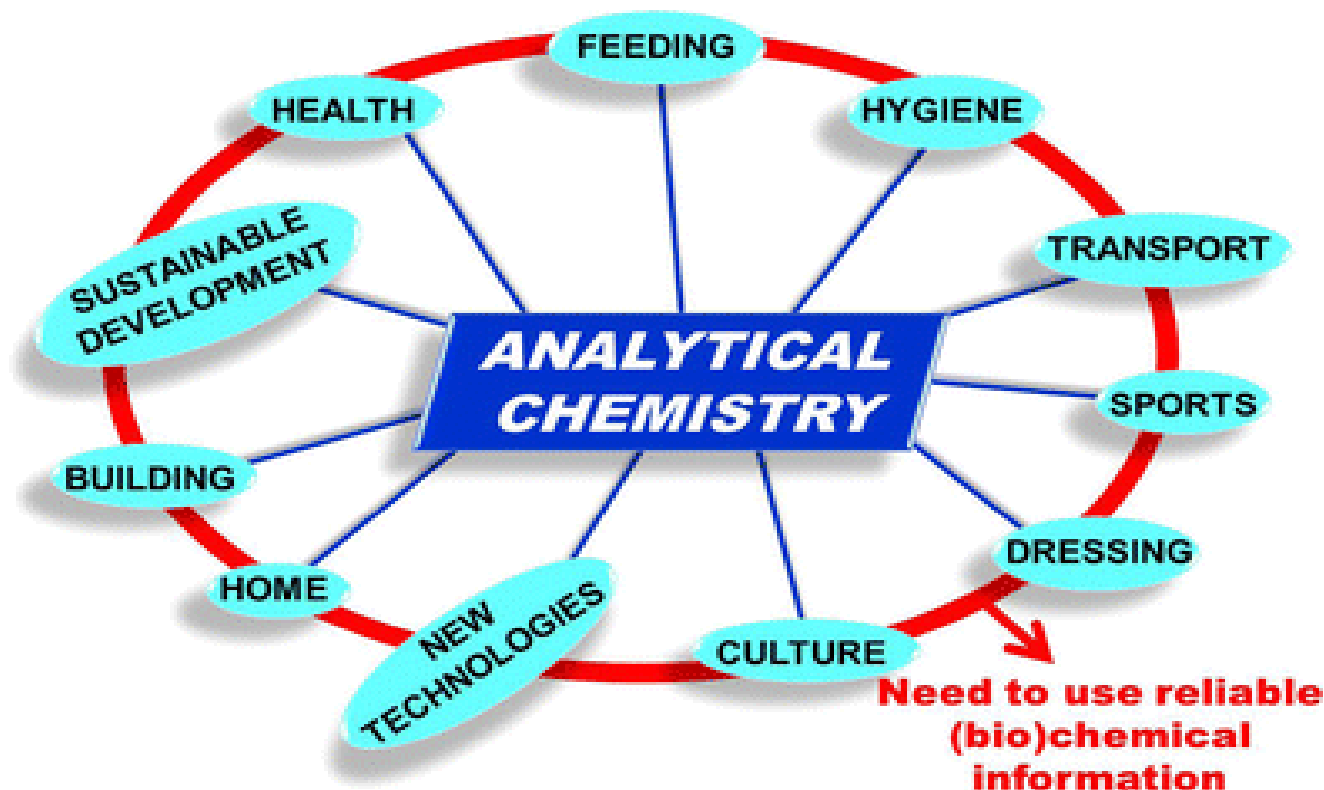
# Procedure :

## **Procedure:**

1. Obtain a capillary melting point tube and a known compound.
2. Place a small amount of the compound on a clean surface. Push the open end of the tube into the compound. Some of the sample will now be in the top of the tube.
3. Hold the closed end of the capillary tube over a dropping tube; the dropping tube should be held perpendicular to the table and a couple of inches above the table surface. Drop the capillary tube into the dropping tube; the capillary tube will bounce on the table, packing the powder into the bottom.
4. Place the capillary melting point tube in the Mel-temp apparatus chamber. Start with a setting of two to two and a half; the temperature should slowly rise. The sample should be observed continuously, so that the melting point of the sample is not missed. Heat slowly to acquire the most accurate results. Record the melting range, which begins when the sample first starts to melt and ends when the sample is completely melted.
5. Obtain an unknown sample and determine its melting range. Identify the unknown by comparing the data on the knowns the class has obtained.

# Questions :

1. Why can you not re-use a sample in a capillary tube  
? for melting point analysis
2. What the difference between a narrow melting point and broad melting point ?



# Analytical chemistry

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# The objective of the lecture



- ☐ .learn what is analytical chemistry
- ☐ .what are the types of analytical chemistry
- ☐ . How to calculate percentage

# Analatical chemistry

**Qualitative analysis**  
separate and identify  
species in a sample

**Quantitative analysis**  
determine the amount of one  
or more of species in a sample

**Instrumental methods**  
use apparatus to measure physical quantities  
of analyte such as: conductivity,  
fluorescence light absorption.

**Classical methods**

**Volumetric**

**Gravimetric**

# There are two main branches for analytical chemistry:-

## A. Qualitative analysis

Provides information about the identity of species or functional groups in the sample

## B. Quantitative analysis

Provides numerical information of analyte (quantitate the exact amount or concentration)

**b1.** Micro- quantitative analysis “works on micro quantities of compounds ( $\mu\text{g}$  or  $\mu\text{l}$ )”

**b2.** Macro- quantitative analysis “works on macro quantities of compounds (mg )

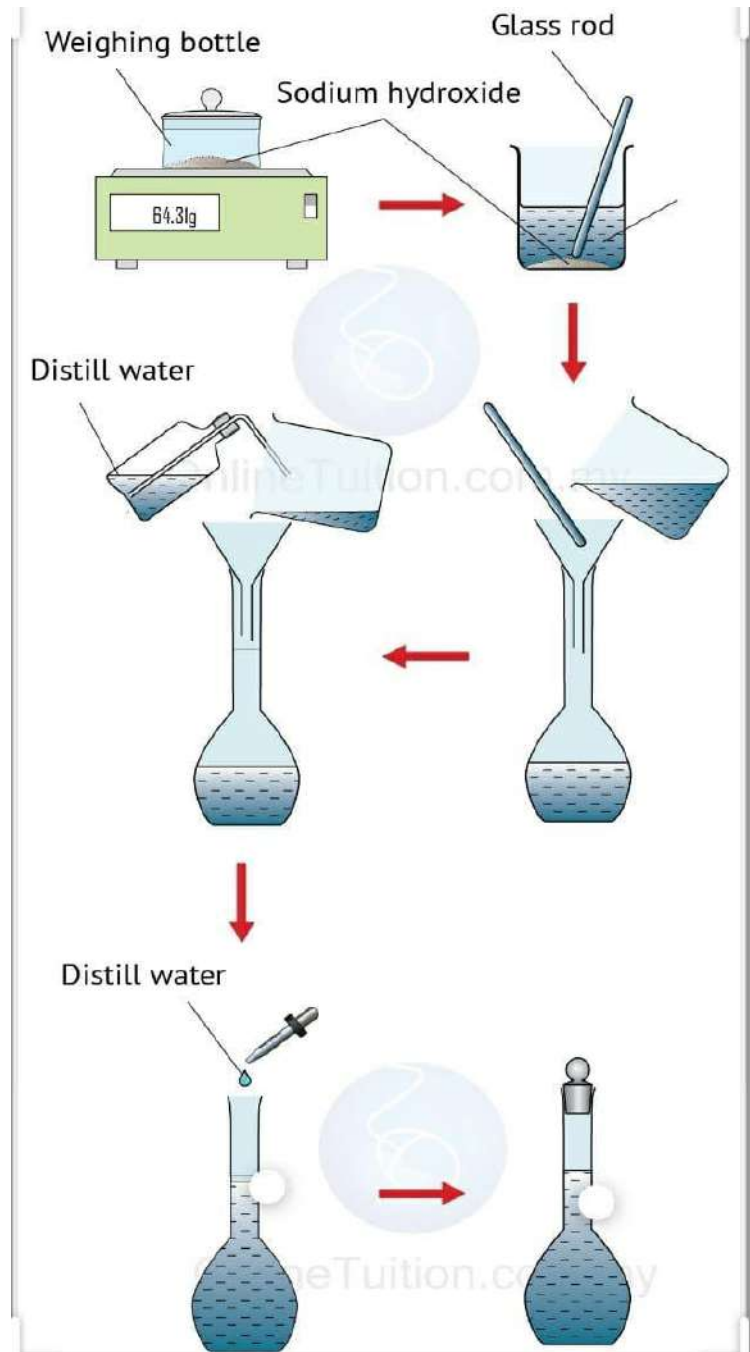
# standard solution

Is a solution for which the concentration is accurately known

We can use these solution to determine the concentration of other unknown solutions

a. **Primary standard**

b. **Secondary standard**



# Standard solution

- A standard is a solution of precisely known concentration
- It must be available in a highly pure state
- It must be stable in air
- It must dissolve easily in water
- It should have a fairly high relative molecular wt
- It should under go a complete and rapid reaction

# Primary Standard

## Definition:

A primary standard is a substance which can be obtained in a stable, pure and soluble solid form so that it can be weighed out and dissolved in water to give a solution of accurately known concentration

**Primary Standard Solution = Pure 100% Soluble Stable once made up**

## Examples of Primary Standards:

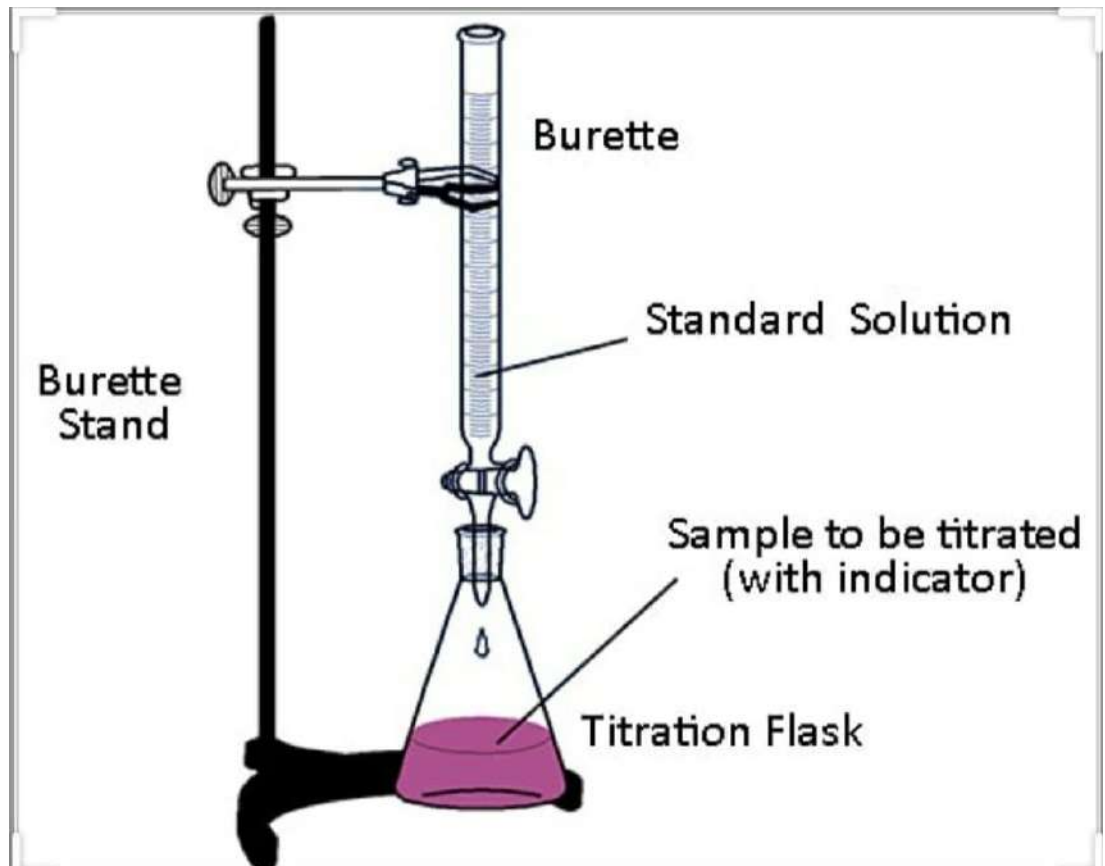
- Anhydrous sodium carbonate  $\text{Na}_2\text{CO}_3$
- Sodium Chloride  $\text{NaCl}$
- Potassium Dichromate  $\text{K}_2\text{Cr}_2\text{O}_7$

## Secondary Standards

A secondary standard is a standard that is prepared in the laboratory for a specific analysis. It is usually standardized against a primary standard.

**Some secondary standards for titration of acids**

**Sodium hydroxide**  
**Potassium hydroxide**



# % Concentration

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

Mass and volume units must match.

(g & mL)      or      (Kg & L)

**EX/ What is the concentration in %w/v of a solution containing 39.2 g of potassium nitrate in 177 mL of solution?**

$$\% \text{ (w/v)} = \frac{\text{mass solute}}{\text{volume solution}} \times 100 = \frac{39.2g}{177mL} \times 100 = 22.1 \% \text{ w/v}$$

EX/ What is the concentration in %v/v of a solution containing 3.2 L of ethanol in 6.5 L of solution?

$$\% \text{ (v/v)} = \frac{\text{volume solute}}{\text{volume solution}} \times 100 = \frac{3.2L}{6.5L} \times 100 = 49 \% \text{ v/v}$$

Concentration could also be expressed as parts of solute per million parts of solution.

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

ppm used for very dilute solutions

---

## 1- Prepare 50 ml of 1% ethanol solution.

### Procedure:

Transfer (X) ml of ethanol to volumetric flask, •  
then complete the volume to 50 ml.

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

---

## 2- Prepare 50 ml of 1% NaCl solution.

### Procedure:

Dissolve (X) gm from NaCl in D.W and then complete the volume to 50 ml.

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



# H.W



**1. IS the level of contamination in a sample determined to be quantitative or qualitative analysis? And why?**

**2. Prepare 5% ethanol in 50 ml**

**3. Prepare 6% NaCl solution in 50 ml**



# Normality and molarity

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# The objective of the lecture



1. .how to calculate the molecular weight and equivalent weight
2. How to calculate molarity
3. How to calculate normality
4. Relation between N and M
5. Relation between ppm and N,M

# **Molecular weight**

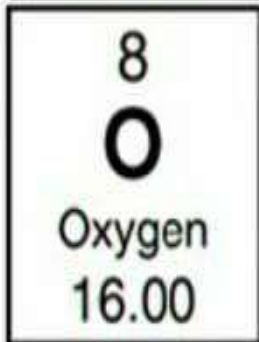
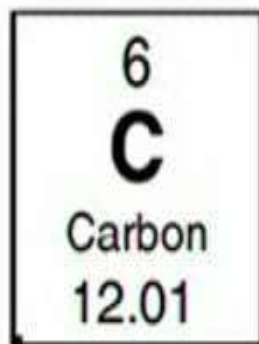
**Molecular weight is a measure of the sum of the atomic weight values of the atomic in molecule (M.wt)**

**Molecluar weigh=**

**$\Sigma$ (atomic mass of element\*No. of atoms of that element)**



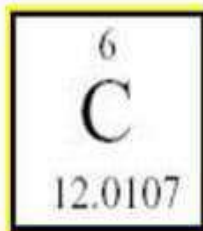
Molecular Weight



$$\begin{array}{r} 12.01 \text{ g/mol} \\ + 16.00 \text{ g/mol} \times 2 \\ \hline 44.011 \text{ u} \end{array}$$

## Calculating Molar Mass

Calculate molar mass of  
magnesium carbonate,  $\text{MgCO}_3$ .



$$24.3 \text{ g} + 12.0 \text{ g} + 3 \times (16.00 \text{ g}) = 84.3 \text{ g}$$

So,  $84.3 \text{ g}$  = molar mass for  $\text{MgCO}_3$

# Calculate the molar mass

- HCl (think H<sub>1</sub>Cl<sub>1</sub>)  
 $1 * 1.0 + 1 * 35 = 36 \text{ g/mol}$
- Al<sub>2</sub>O<sub>3</sub>  
 $2 * 27.0 + 3 * 16.0 = 102 \text{ g/mol}$
- C<sub>25</sub>H<sub>52</sub>  
 $25 * 12.0 + 52 * 1.0 = 352 \text{ g/mol}$
- C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>  
 $6 * 12.0 + 12 * 1.0 + 6 * 16.0 = 180 \text{ g/mol}$
- Mg(ClO<sub>3</sub>)<sub>2</sub>  
 $1 * 24 + 2 * 35 + 6 * 16 = 190 \text{ g/mol}$

- **Equivalent weight** defined as the quantity of an element will react with a fixed amount of another

- $$eq. wt = \frac{M.wt}{\eta}$$

- For example

- $K_2O$  it is salt

- (  $K=39$   $O=16$ )  $M.wt = 94$

- $Eq.wt = 94/2 = 47$

Calculate Eq.wt for  $\text{CH}_3\text{COOH}$  (  
 $\text{C}=12, \text{H}=1, \text{O}=16$ )

$\text{CH}_3\text{COOH}$  is acid

Calculate  $\text{M.wt} = (12 \times 2) + (2 \times 16) + (4 \times 1) = 60$

No. of acidity H atom = 1

$\text{Eq.wt} = 60/1 = 60$

Calculate Eq.wt of  $\text{Mg(OH)}_2$  Mg=24 ,O=16 ,H=1

$\text{Mg(OH)}_2$  is base

M.Wt of  $\text{Mg(OH)}_2 = 24 + (16 \times 2) + (1 \times 2) = 58$

NO. of basic OH = 2

Eq.wt =  $58 / 2 = 29$

# Normality

$$N = \frac{Wt * 1000}{eq. wt * V}$$

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

N=normality

wt=weight of solid

V=volume of solution

eq.wt=equivalent weight

M.wt=Molecular weight

$\eta$ =equivalence force

---

$$N = \frac{d * \% w * 1000}{eq. wt}$$

d=density

$$N_1 V_1 = N_2 V_2$$

# Molarity

$$M = \frac{wt * 1000}{M.wt * v}$$

---

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

$$M_1 V_1 = M_2 V_2$$

Equivalent weight of acid = Molecular weight/ No. of replaceable H ions

Table 6.1 Name, formula, molecular weight and equivalent weight of commonly used chemicals			
Name	Formula	Mol. wt. (g/mol)	Eq. wt. (g/mol)
Hydrochloric acid	HCl	36.5	36.5
Nitric acid	HNO <sub>3</sub>	63	63
Potassium hydroxide	KOH	56	56
Calcium hydroxide	Ca(OH) <sub>2</sub>	74	37
Potassium dichromate	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	294	49
Sodium thiosulphate	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> .5H <sub>2</sub> O	248	248
Sodium chloride	NaCl	58.5	58.5
Potassium chloride	KCl	74.5	74.5
Iodine	I <sub>2</sub>	254	127

## Converting from Molarity to Normality

you can convert from molarity (M) to normality (N) using the following equation:

$$N = M * n$$

where n is the number of equivalents, note that for some chemical species N and M are the same (n is 1)

## Relation between M,N and ppm

$$\text{ppm} = M \times M.Wt \times 10^3$$

$$\text{ppm} = N \times Eq.Wt \times 10^3$$

1- prepare 0.2N of NaCl in 250 ml D.W.

Procedure: Dissolve (X)gm from NaCl in D.W and then complete the volume to 250 ml.

---

**2-prepare 0.3N of HCl from concentration (36%) HCl in 250 ml D.W.(d=1.18).**

**Procedure:**

- 

Calculate the N of HCl (conc)

$$N(\text{for liquid}) = \frac{d * \% w * 1000}{eq. wt}$$

then, take (X) volume from HCl conc.and complete volume to 250ml distilled water.

no.of moles of concentrated=no.of moles of diluted

$$N_1 V_1 = N_2 V_2$$

## H.W

1. Prepare 100 ml of 1 N of HCl from concentration (12 N) of HCl .
2. Prepare 0.8 N of  $Na_2CO_3$  in 250 ml D.W and dilute it with 250 ml of D.W to 0.5N  
( given Na =23 , C=12 , O=16)
3. If the N = 10 calculate M if you know  $\eta=2$
4. Calculate ppm if you know M = 10 and the M.wt = 50



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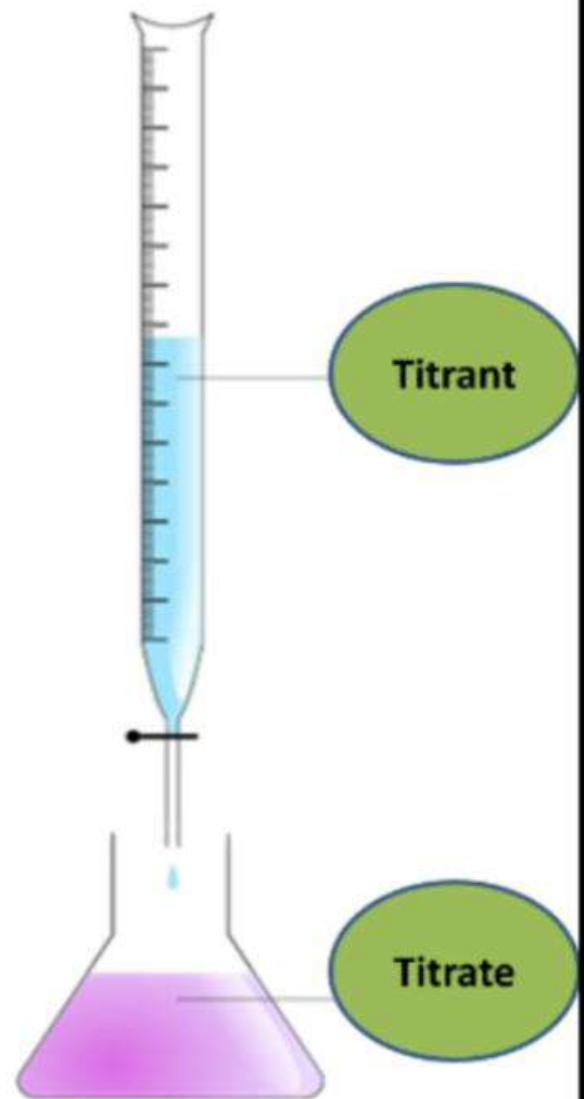
# The objective of the lecture



- ☐ Definition of titration  
,types of titration
- ☐ How to use acid –base  
titration to determining  
unknown concentration

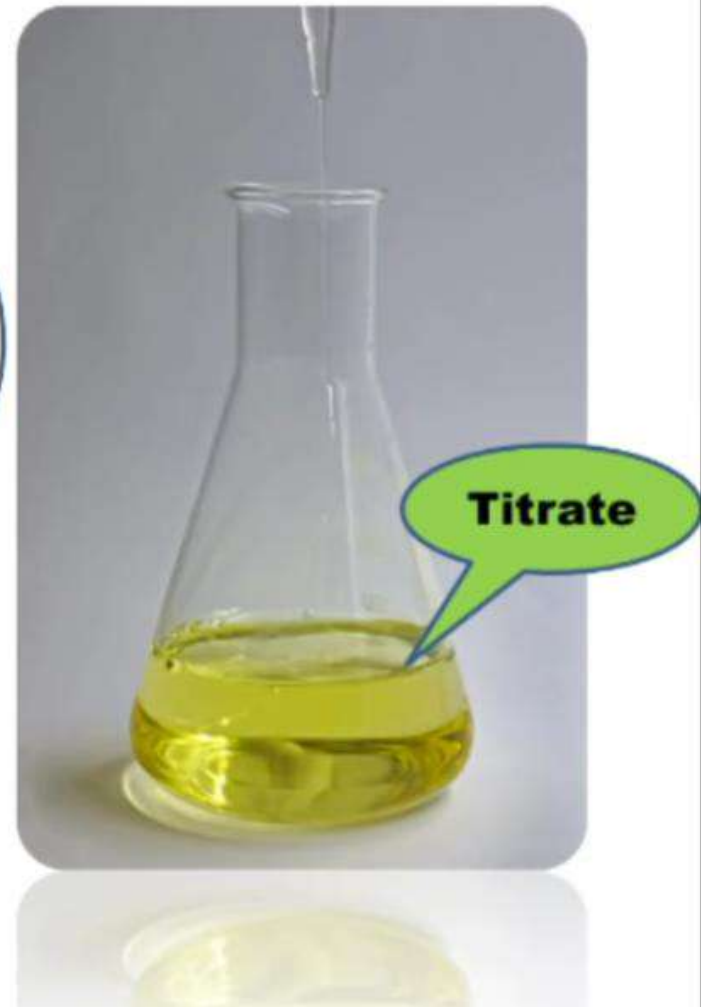
# TITRATION

The process of addition of standard solution from burette into the solution of unknown concentration taken in the conical flask is known as titration



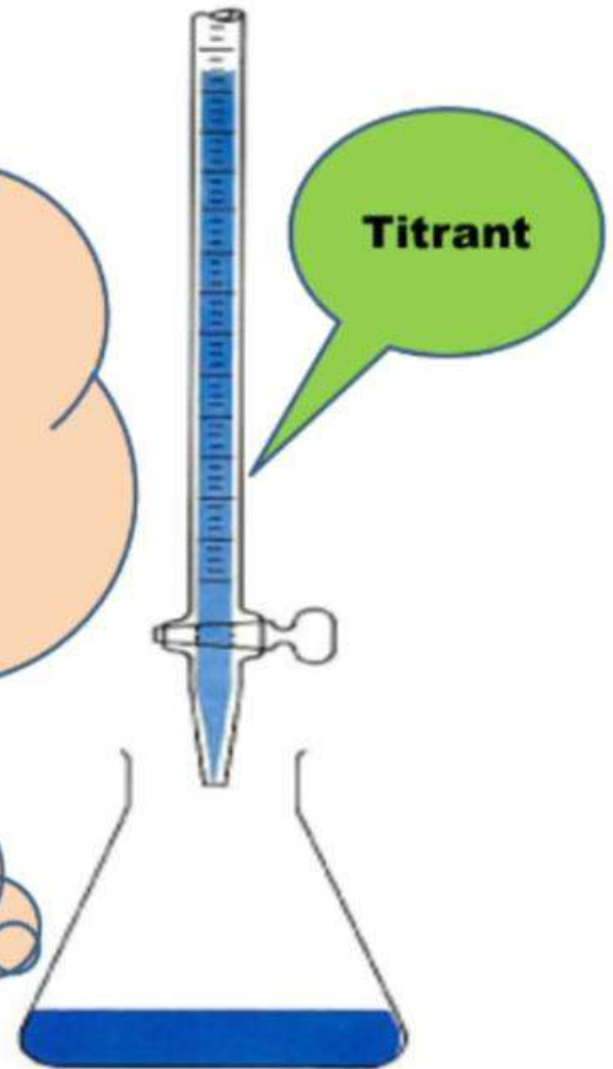
# TITRATE

The substance  
being  
titrated (taken in  
conical flask)  
is known as titrate



# TITRANT

The solution of known concentration used in titration (added from burette) are known as titrant



# END OR EQUIVALANCE POINT

- The point at which reaction between titrate and titrant is just complete. Indicated by change in the color of indicator.



Color change on  
reaction completion

# INDICATOR

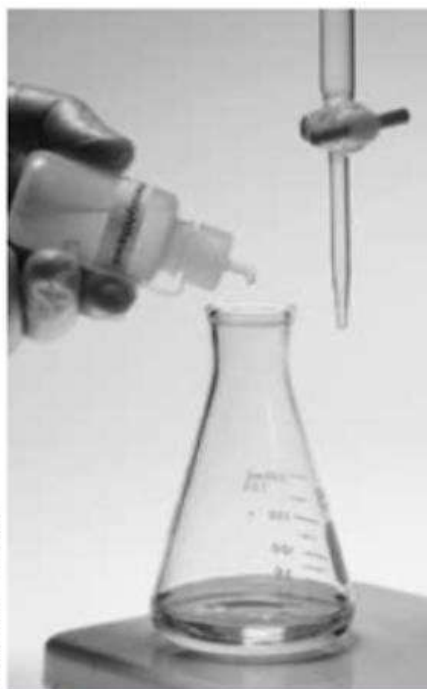
- It is a complex organic compound which shows clear visual change after the reaction between titrant and titrate is just complete e.g.
- Phenolphthalein
- Methyl orange
- Thymol blue
- Methyl red



Charles D. Winters



Charles D. Winters



Charles D. Winters



# CLASSIFICATION OF VOLUMETRIC ANALYSIS

- Acid-Base titration
- Redox titration
- Complexometric titration
- Precipitation titration

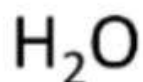
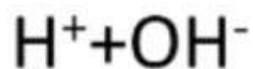
# WHAT IS ACID-BASE TITRATION?

Acid-base titration is a technique to determine the concentration of an acid or base solutions by neutralizing the unknown concentration of a solution (acid/base) with the known concentration of base/acid.

The **neutralization** reaction is determined by using an indicator where the indicator will change its colour at the end point of the titration. This method allows the quantitative analysis for the unknown acid/alkali concentration.

# ACID-BASE TITRATION

- It involves the acid-base neutralization reactions in presence of water as solvent. These reactions involves combination of hydrogen and hydroxide ion to form water e.g.



# Neutralisation reaction



**Acid + Alkali  $\longrightarrow$  Salt + Water**

**Acid**

**Base**



# Uses of Neutralization

1. To treat wasp stings
2. To treat acidity or gastric patients
3. To treat acidic or basic soils
4. To treat tooth decay or cavities
5. To prevent coagulation of latex

## Methyl Orange

shows in pink color in acidic medium and yellow color in basic medium ( PH greater than 4.4 ) it is usually used in titration for acids .it has sharp end point

## Phenolphthalein

An acid –base indicator used to test the PH of a solution ,turns pink due to the presence of a weak base

The solution remains colorless in the presence of an acid .if the PH of the solution 8.2 or above causing the solution to turn **PINK**

## Procedure

### A. Standardization of prepared of 0.1 N HCl solution:

1. Fill the burette with the prepared HCl solution
2. Transfer 10 ml of exactly 0.1 N Na<sub>2</sub>CO<sub>3</sub>
3. Add 2 drops of methyl orange as an indicator yellow color to pink
4. Titrate with HCl solution drop by drop from the burette into the conical flask until a faint orange color is change to red color
5. The exact normality of HCl can be calculated form the following



$$N_1V_1 \text{ of Na}_2\text{CO}_3 = N_2V_2 \text{ of HCl}$$

## B. Determination of the Normality of NaOH solution :

1. Transfer 10 ml NaOH solution to a conical flask
2. Add 1-2 drops of phenolphthalein (ph.ph) as an indicator
3. Fill the burette with standard HCl solution
4. Add HCl drop by drop into conical flask until the color of the solution change from pink to colorless
5. The exact Normality of NaOH is obtained from



$$N_1V_1 (\text{NaOH}) = N_2V_2 (\text{HCl})$$

No.of reading	Burette Reading			Concurrent volume (ml)
	Initial reading (initial volume from burette)	Final reading (final volume from burette)	Difference	
1				
2				
3				



1. we titration HCl with  $\text{Na}_2\text{CO}_3$  ?
2. Why we use M.O when we titrate HCl with  $\text{Na}_2\text{CO}_3$  ?
3. Why we use ph.ph when we titrate HCl with NaOH ?

# ***FLAME PHOTOMETER***

م.م ايمن رمزي محمد / قسم التخدير  
المرحلة الاولى

# The objective of the lecture:



- **Define flame photometer**
- **Factors on which the flame photometer measurement depends**
- **Flame photometer applications**

# Flame photometer

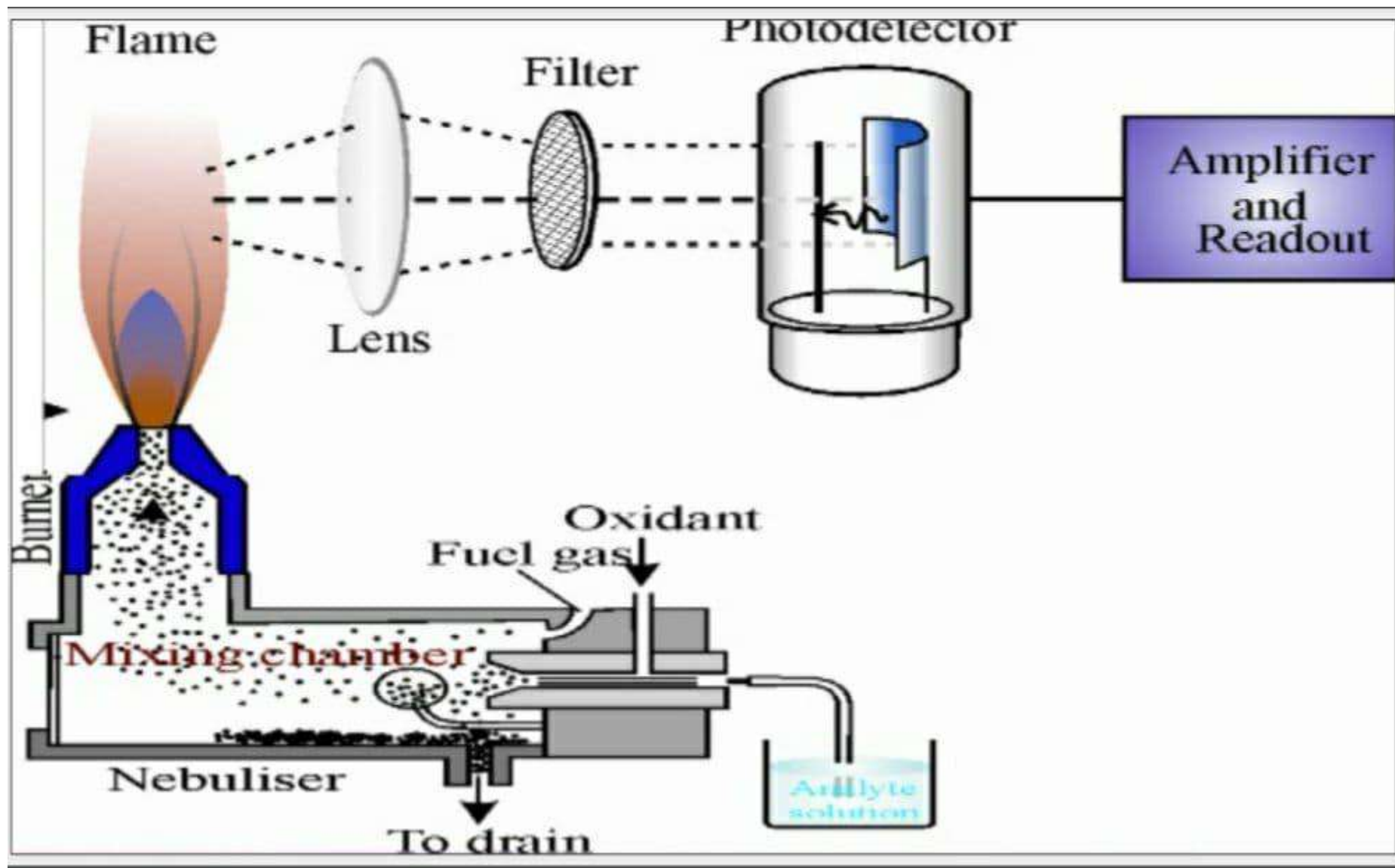
\_an instrument used in inorganic chemical analysis to determine the concentration of certain ions among them sodium Na , potassium K ,calcium Ca ,lithium Li

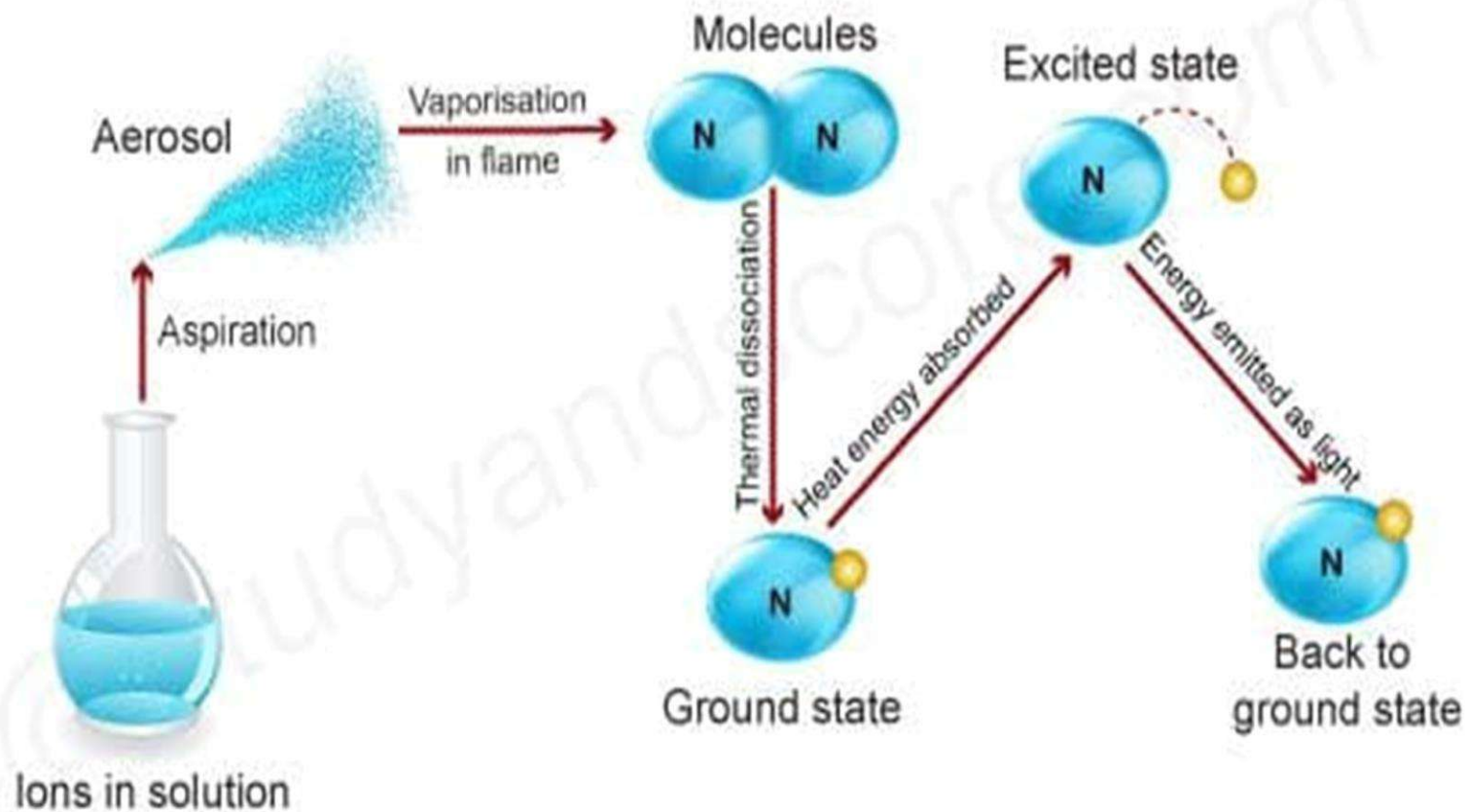
# The measurement of flame photometry depends on:

1. flame photometry is based on measurement of intensity of the light emitted when a metal is introduced into flame
2. the wavelength of color tells us what the element is ( qualitative)
3. the color's intensity tell us how much of the element present ( quantitative )

# Parts of a flame photometer:

- **source of flame** : a burner that provides flame and can be maintained in a constant and at a constant temperature
- **Nebulizer and mixing chamber** : help to transport the homogeneous solution of the substance into the flame at a steady rate
- **Optical system**: contain three parts:
  - a. Convex mirror   b. lens   c. filter
- **Photo Detector** : detect the emitted light and measure the intensity of radiation emitted by the flame

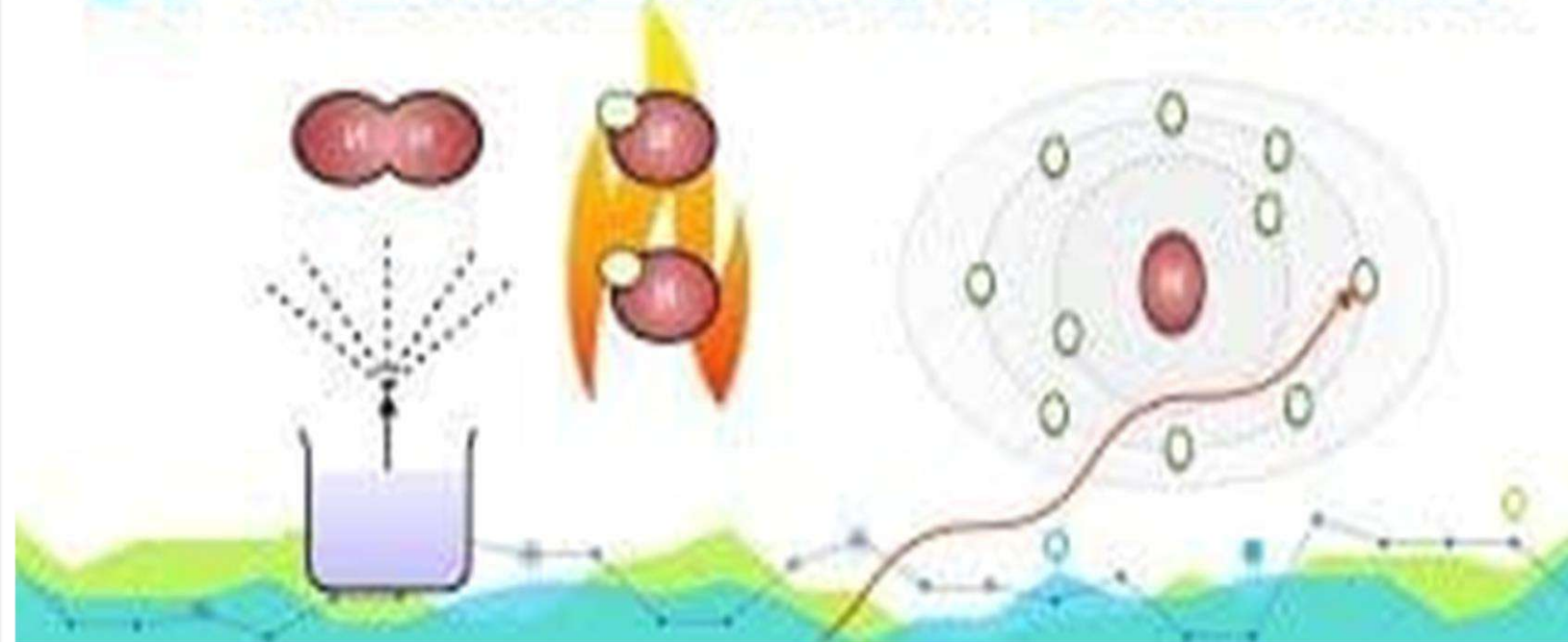




## OVERVIEW OF FLAME PHOTOMETRY






*Spectroscopy*

# EXPLAIN THE PRINCIPLE OF FLAME PHOTOMETRY.



# Applications:

- Flame photometer has both quantitative and qualitative applications.
- Flame photometer with mono-chromators emits radiations of characteristic wavelengths which help to detect the presence of a particular metal in the sample.
- To estimate sodium, potassium, calcium, lithium etc. level in sample of serum, urine, CSF and other body fluids.
- $\text{Na}^+$  and  $\text{K}^+$  ions in, muscles and heart can be determined by diluting the blood serum and aspiration into the flame.

Name of the element	Emitted wavelength range (nm)	Observed color of the flame
Potassium (K)	766	Violet 
Lithium (Li)	670	Red 
Calcium (Ca)	622	Orange 
Sodium (Na)	589	Yellow 
Barium (Ba)	554	Lime green 

# Advantages:

- Simple quantitative analytical test based on the flame analysis.
- Inexpensive.
- The determination of elements such as alkali and alkaline earth metals is performed easily with most reliable and convenient methods.
- Quite quick, convenient, and selective and sensitive to even parts per million (ppm) to parts per billion (ppb) range.

## Disadvantage:

- The concentration of the metal in the solution cannot be measured accurately
- The elements such as carbon (C) ,Hydrogen (H) , and Halides (x) cannot be detected due to its non radiating





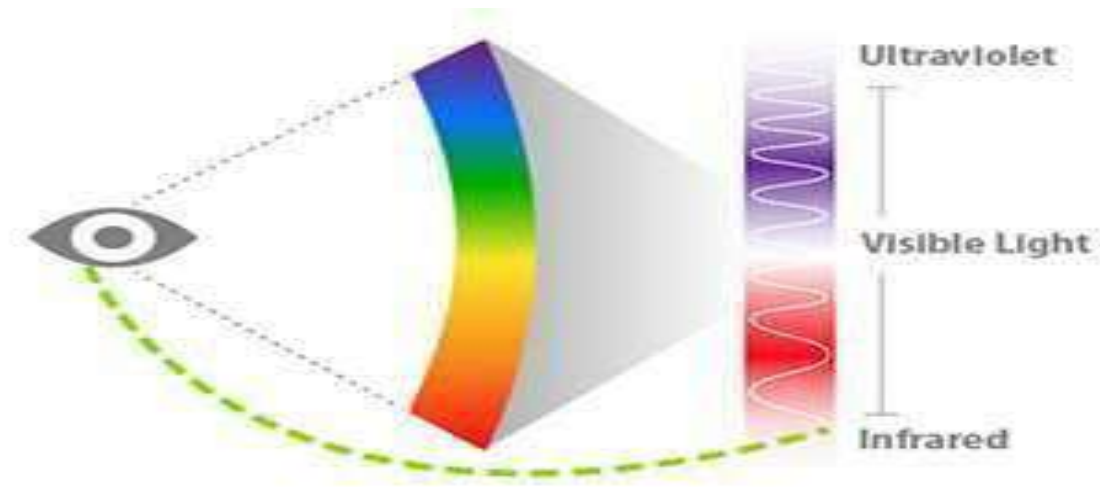
# Procedure:

- 1. The standard stock solution and sample solution are prepared in fresh distilled water
- 2. Now the instrument is switched **ON** and the lids of the chamber are opened to insert appropriate color filter
- The reading of the galvanometer is adjusted to zero by spraying **D.W** into the flame
- Reading of the **standard stock solution** into the flame, galvanometer is recorded
- Finally **sample solution** is sprayed into the flame and the reading of galvanometer is recorded

## H.W

- 1. How can you detect presence of metal in the sample
- 2.can't determine carbon by flame photometer

# SPECTROPHOTOMETRY



م.م ایمان رمزي محمد / قسم التخدير المرحلة الاولى

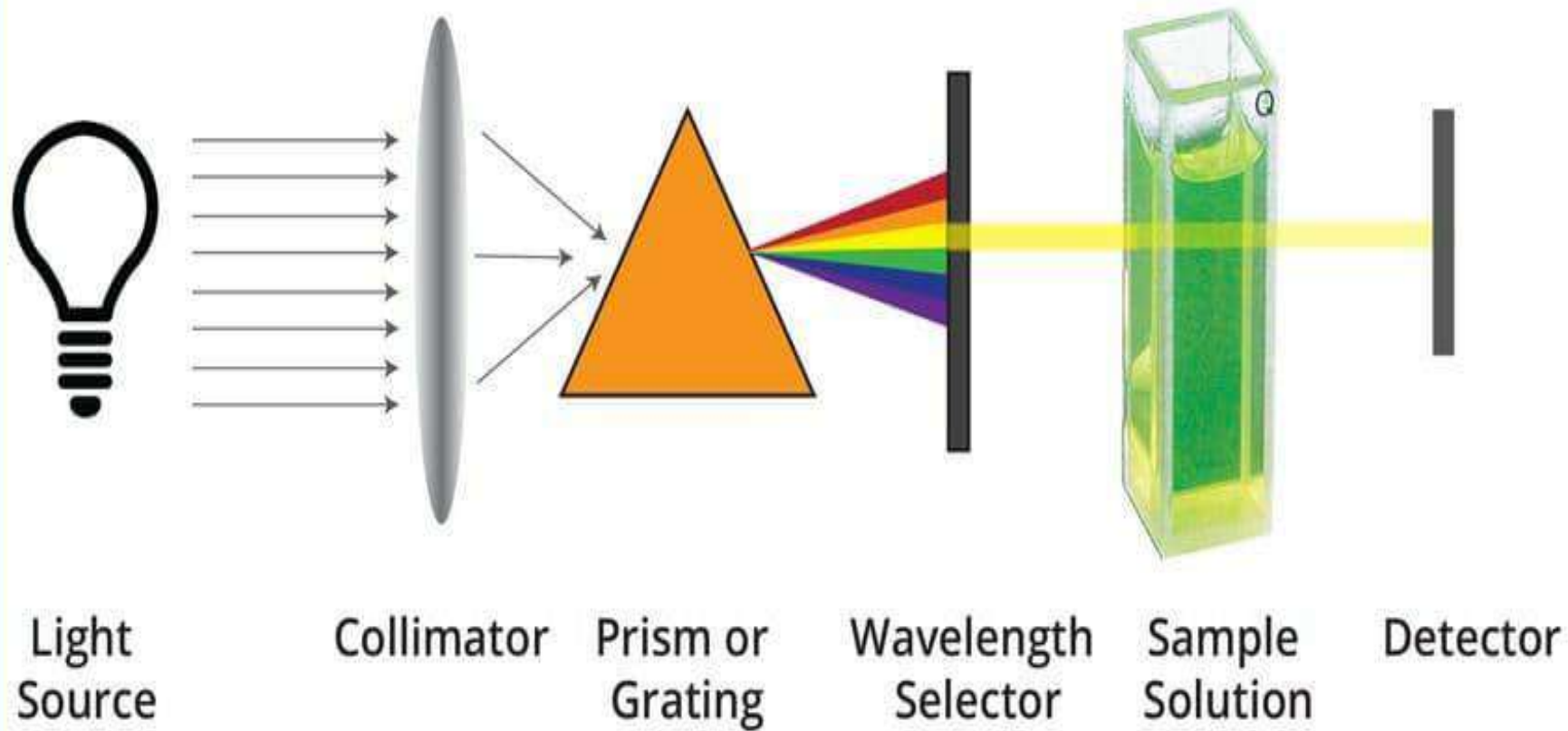
# SPECTROPHOTOMETER

*A spectrophotometer is a machine which measures the intensity of light at selective wavelength.*

- *In clinical chemistry laboratory, we use spectrophotometer to detect the concentration of a compound of interest in a solution with the help of Beer-Lambert law by absorption spectrophotometry.*

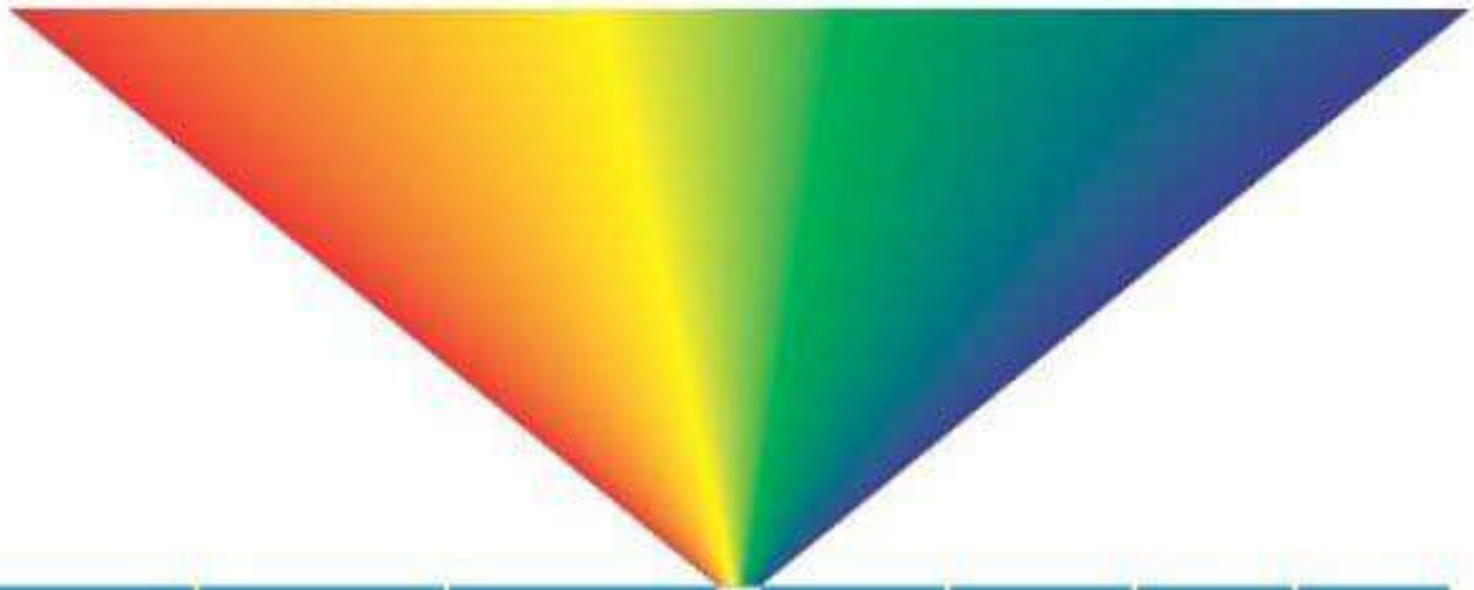
## The spectrophotometer consist of the following parts

- **.light source** :it produce a desired range of wavelength of light
  - **. Collimator** :transmits a straight beam of light
  - **.Monochromator** : split the light into its component wavelength
  - **.Wavelength selector** : transmits only the desired wavelength
- The photometer detects the light absorbed by the sample as the light from the slit is passed through the solution .And then it sends signal to the galvanometer or digital display



Visible spectrum (wavelength)

750 nm 700 nm 650 nm 600 nm 550 nm 500 nm 450 nm 380 nm



Decreasing wavelength

Increasing energy



Infra red

400

500

600

700

Wavelength [nm]



UV

Bee Vision

300

400

500

600

Wavelength [nm]



Color	Wavelength (nm)
Violet	380-450
Blue	450-475
Cyan	476-495
Green	495-570
Yellow	570-590
Orange	590-620
Red	620-750

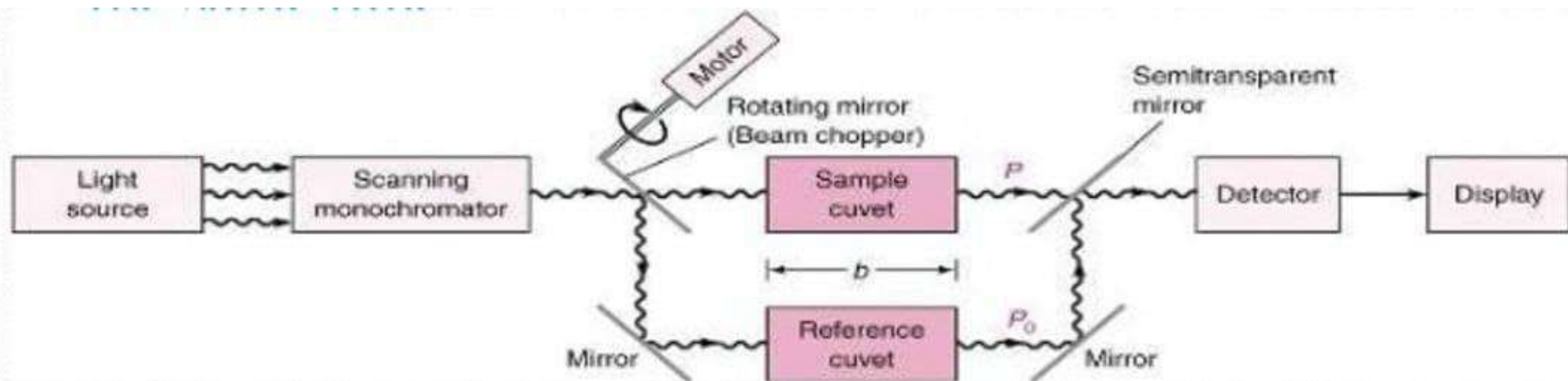
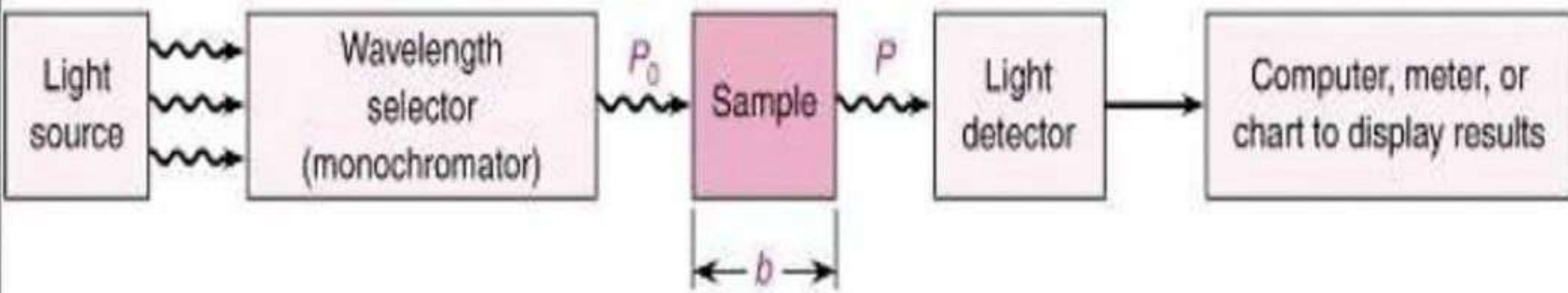


with  
internal cuvette storage  
to protect samples

# Classes of Spectrophotometers

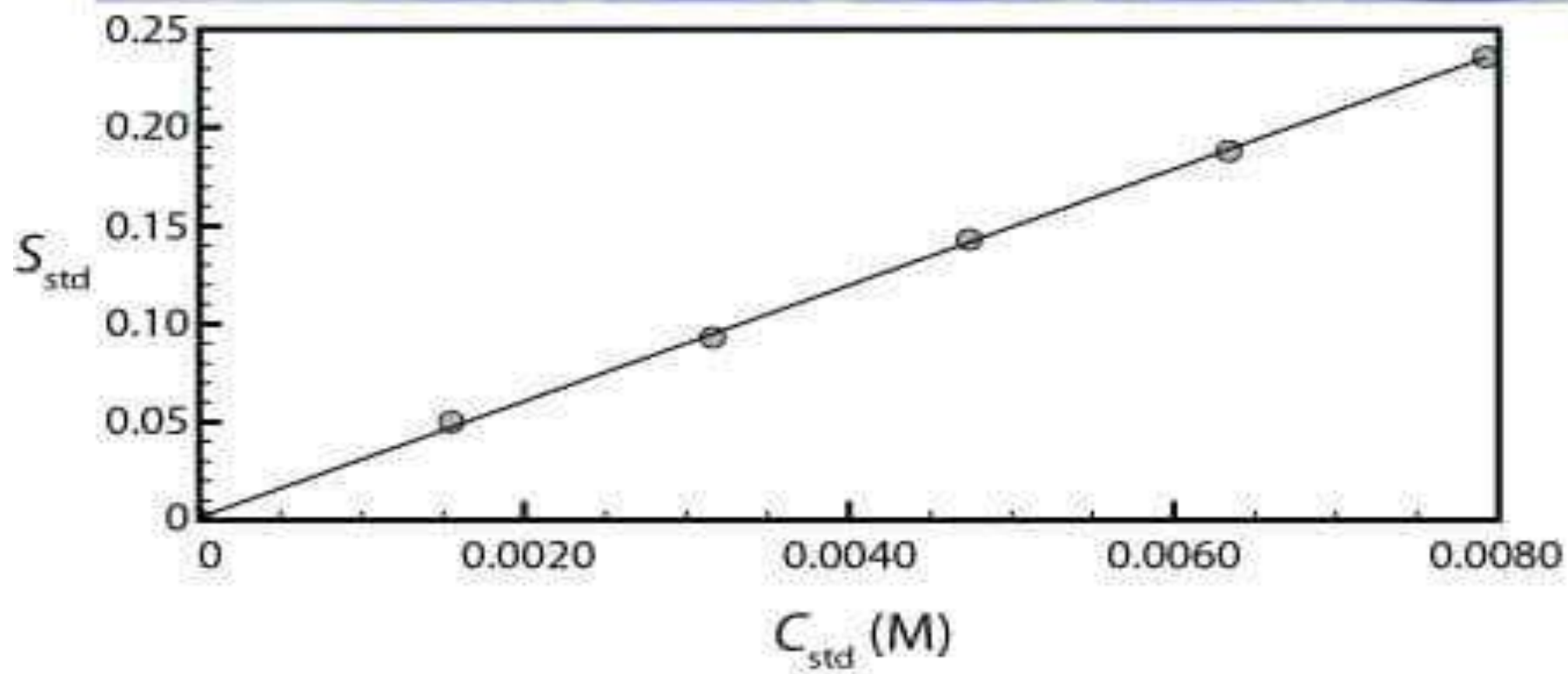
**Single beam** and **double beam** are the two major classes of spectrophotometer.

- **Single Beam:** In this type, all the light passes through the sample. To measure the intensity of the incident light the sample must be removed so that all the light can pass through. This type of spectrometer is usually less expensive and less complicated.
- **Double Beam:** In this type, before reaching the sample the light source is split into two separate beams. From these one passes through the sample and the second one is used for reference. This gives the advantage because at the same time the reference reading and sample reading can take place.

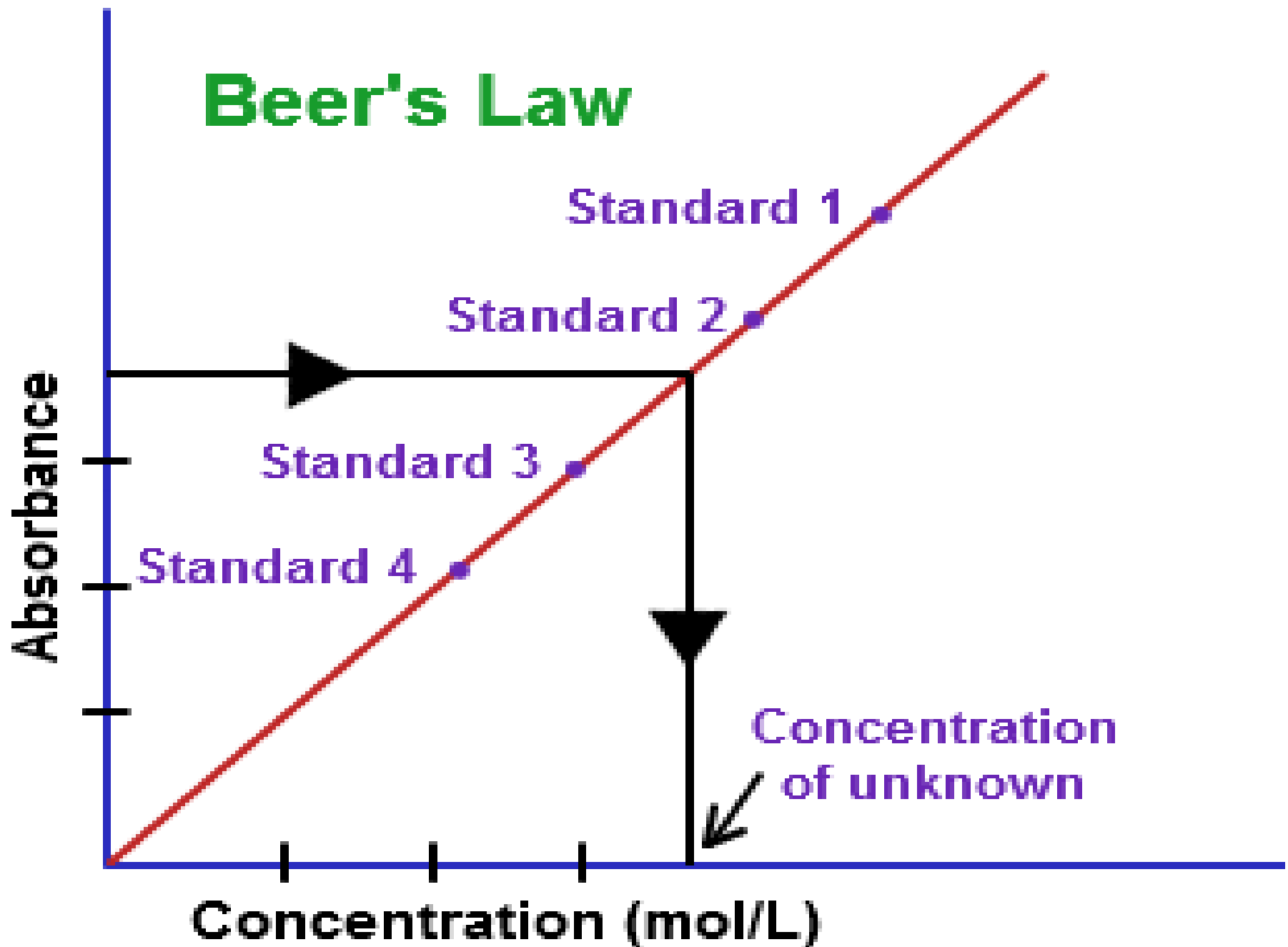


# Calibration Curve

Also known as a **standard curve**.is a general method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration



# Beer's Law



# Absorbance

**Beer-Lambert Law (a.k.a. Beer's law)** - the linear relationship between absorbance and concentration of an absorbing species.

$$A = abc$$

**A** is the **absorbance**

**“a”** is **molar absorptivity** in  $\text{L}/[(\text{mole})(\text{cm})]$

Also called “**extinction coefficient**” or “ **$\epsilon$** ”;  
it is dependent on the material being studied.

**“b”** is the **path length** in **cm**

The **diameter of the cuvette** or sample holder which is the distance the light travels through the absorbing sample. “b” is a **constant** when the **same size cuvette** is used for all samples.

**“c”** is the **concentration** of the sample in **(mol/L)**

**Main use of Beer's Law** is to **determine the concentration**  
of various solutions.

# Beer's Law

$$A = \epsilon cl$$

$A$

Absorbance

$\epsilon$

Molar absorption coefficient

$\text{M}^{-1}\text{cm}^{-1}$

$c$

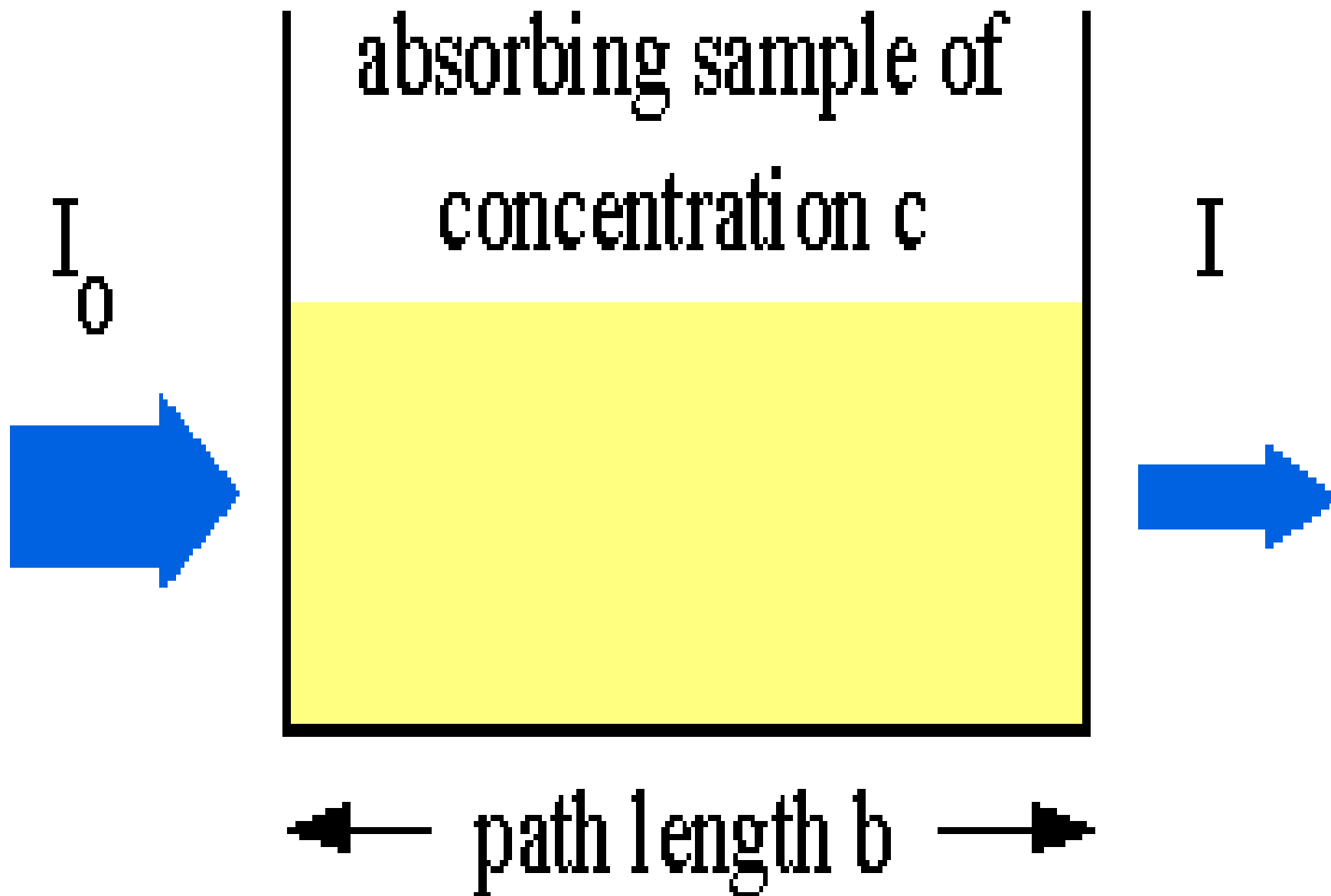
Molar concentration

$\text{M}$

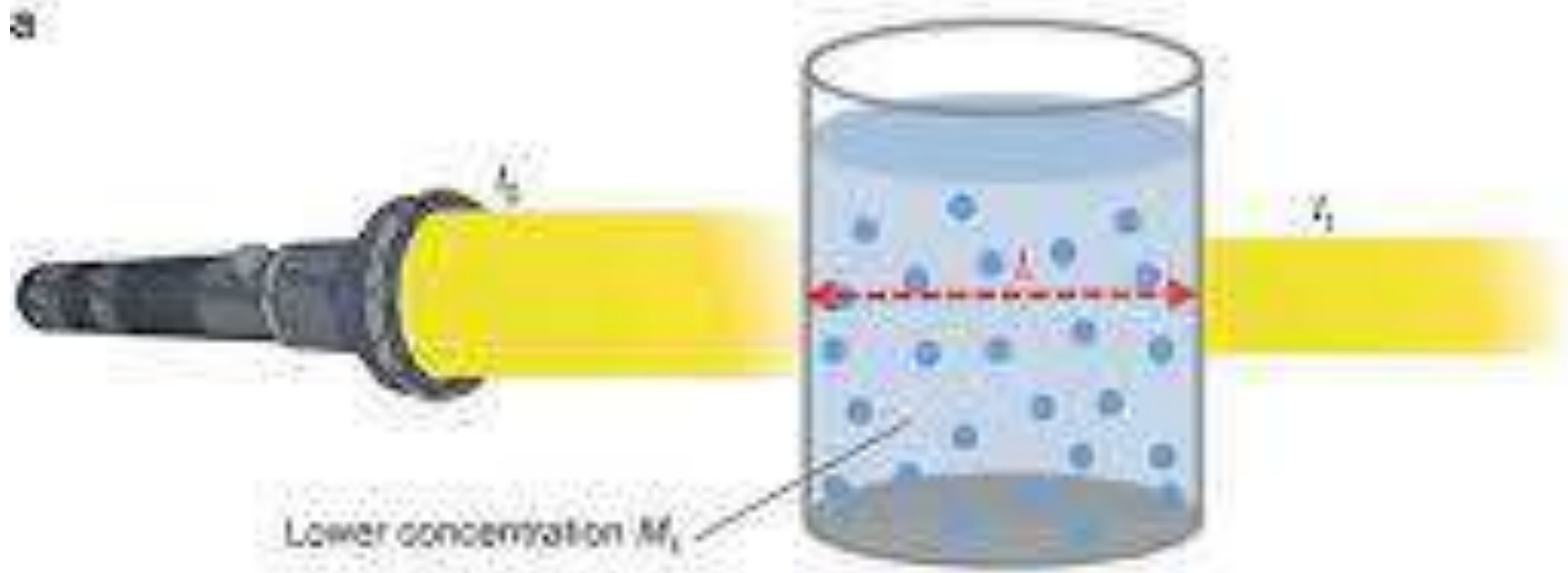
$l$

optical path length

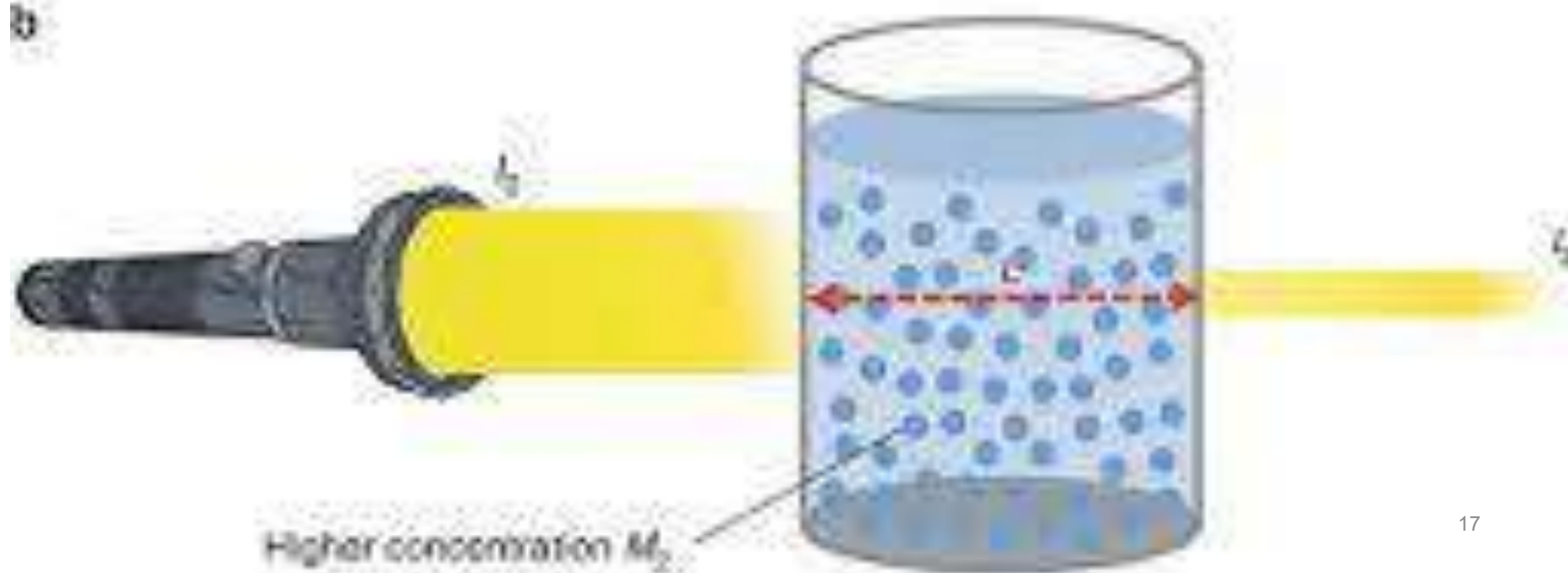
$\text{cm}$



a



b

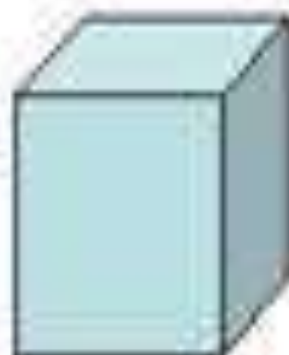


light  
source



$I_0$

sample



$I$



"Incident"  
light

"Transmitted"  
light

"Transmittance"  $T = I / I_0$

$$0 \leq T \leq 1$$

$$T = \frac{I}{I_0}$$

$$T(\%) = 100 \frac{I}{I_0}$$

# Procedure :

- 1- dissolve 10 gm of copper sulphate in 500 ml distilled water .( M.wt=159)
- 2- pull 5 ml from concentrated solution and put it in volumetric flask 25 ml , 50 ml, 100 ml.
- 3- complete the volume with distilled water.
- 4- measure the absorbance for each solution (at 550 nm)
- 5- Draw calibration curve.
- 6- measure the absorbance for unknown concentration



## **Questions**

**What is spectrophotometry?**

**What is the function of spectrophotometry?**

**Why do we use it?**

**How does it work?**

- A solution has a maximum absorbance of 275 nm  
 $\epsilon_{275} = 8400 \text{ M}^{-1} \text{ cm}^{-1}$  and the path length is 1 cm  
using a spectrophotometer to find that the  $A_{275} = 0.7$   
what is the concentration of solution?



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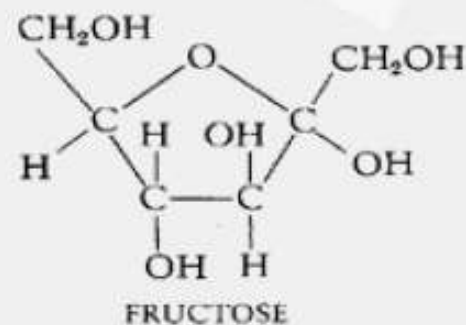
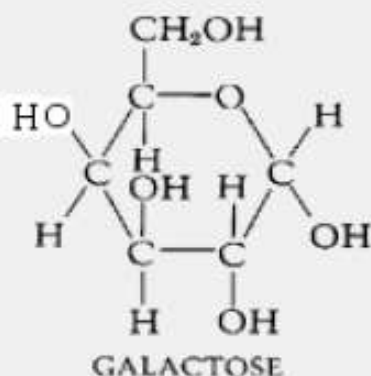
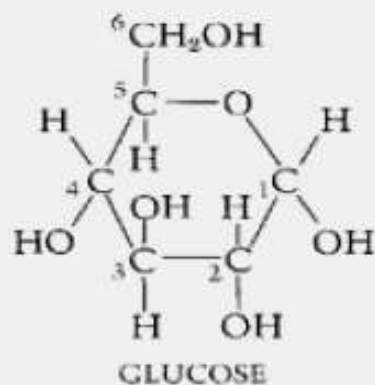
# The objective of the lecture



- **Define of carbohydrates**
- **Types of carbohydrates**
- **Function of carbohydrates**
- **Detection of carbohydrates**

# Carbohydrates

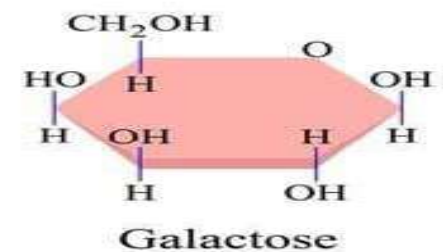
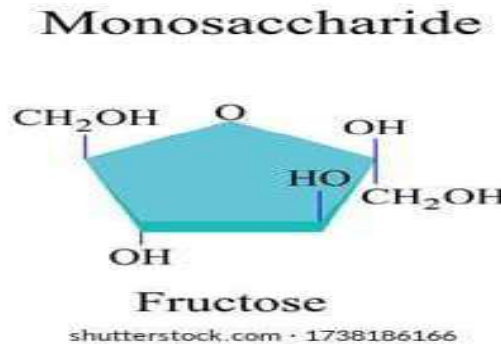
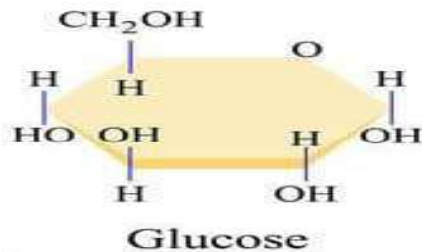
are one of a major type of big biomolecules, are also a class of organic compounds, it is about (15%) organic compounds of cell structure. The general formula of carbohydrate is  $(C_n(H_2O)_n)$  where  $(n \geq 3)$  carbohydrates are now defined as aldehydes or ketones of polyhydroxy alcohol.



# Classification of carbohydrates

## 1-Monosaccharides (Simple sugar):

contain **one** monosaccharide units, they can not broken to smaller carbohydrates. (glucose, galactose , fructose)



# Monosaccharide

(Basic building blocks of carbohydrates)

They can be classified by the number of carbon atoms ■

trioses (C-3) ■

tetroses (C-4) ■

pentoses (C-5) ■

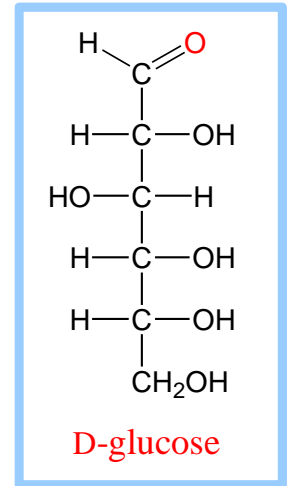
hexoses (C-6) ■

heptoses (C-7) ■

also be classified as ketoses or aldoses. •

**A ketose** contains a carbonyl group attached to •  
two R groups having one or more hydroxyl groups.

**An aldose** contains terminal aldehyde group in addition to •  
R group containing -OH.



aldose

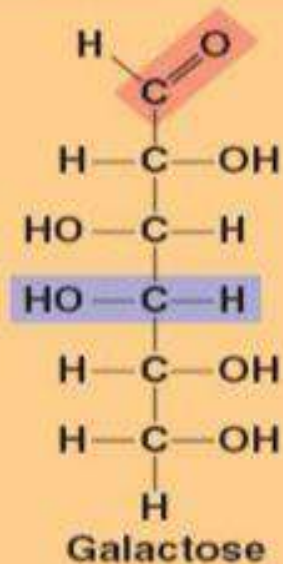
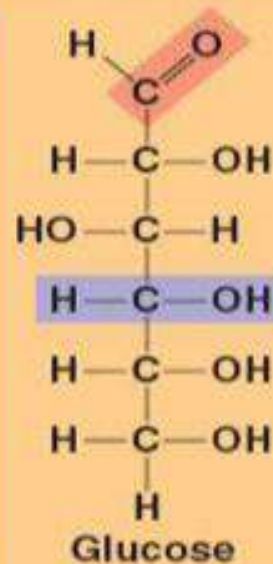
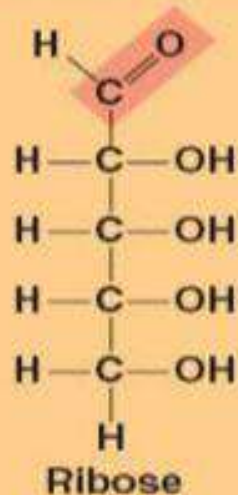
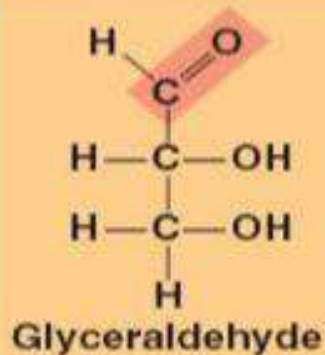


Triose sugars  
( $C_3H_6O_3$ )

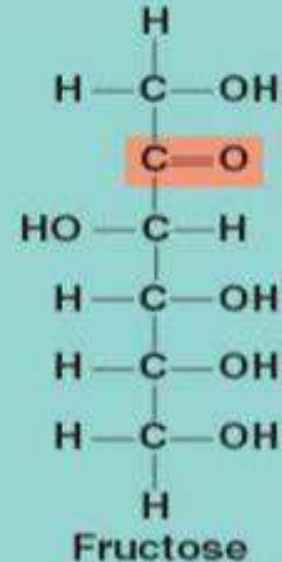
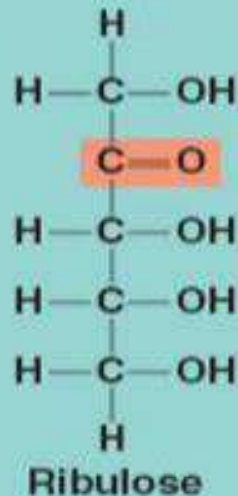
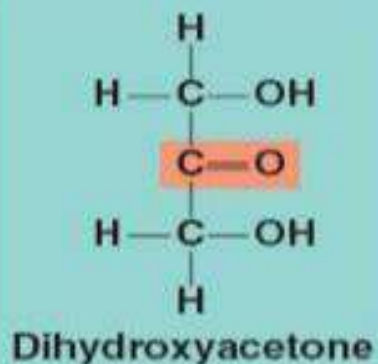
Pentose sugars  
( $C_5H_{10}O_5$ )

Hexose sugars  
( $C_6H_{12}O_6$ )

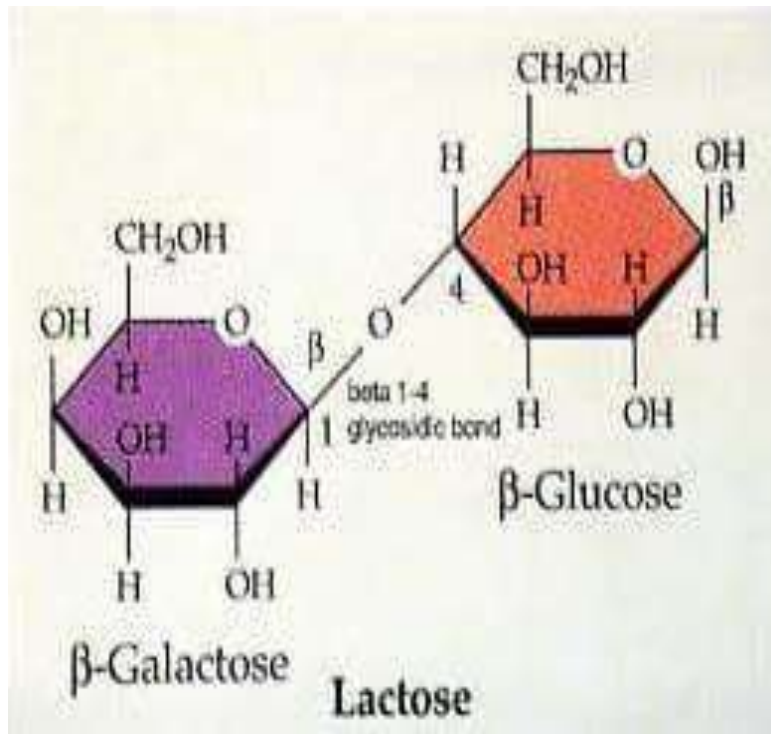
Aldoses



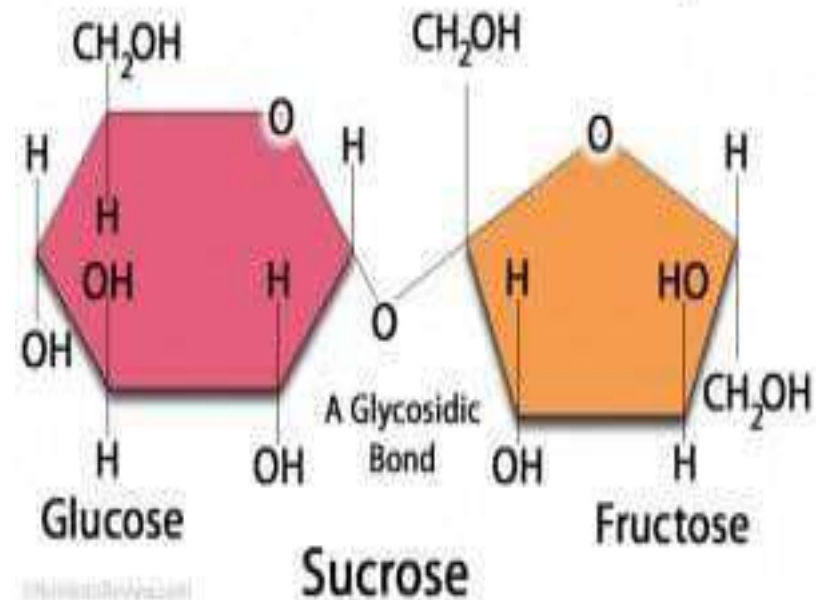
Ketoses



**2-Disaccharides:** contain **two** monosaccharide units (sucrose, maltose, lactose).



## A Disaccharide Example



# Disaccharides

- Composed of 2 monosaccharides
- cells can make disaccharides by joining two monosaccharides by biosynthesis.

## Glucose + fructose = sucrose

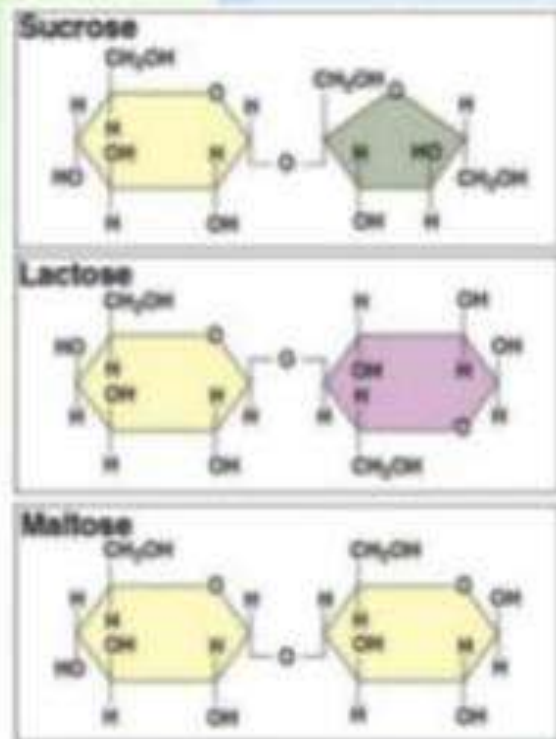
- Table sugar
- Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

## Glucose + galactose = lactose

- The primary sugar in milk and milk products.
- Many people have problems digesting large amounts of lactose (lactose intolerance)

## Glucose + glucose = Maltose

- Produced when starch breaks down.
- Used naturally in fermentation reactions of alcohol and beer manufacturing.



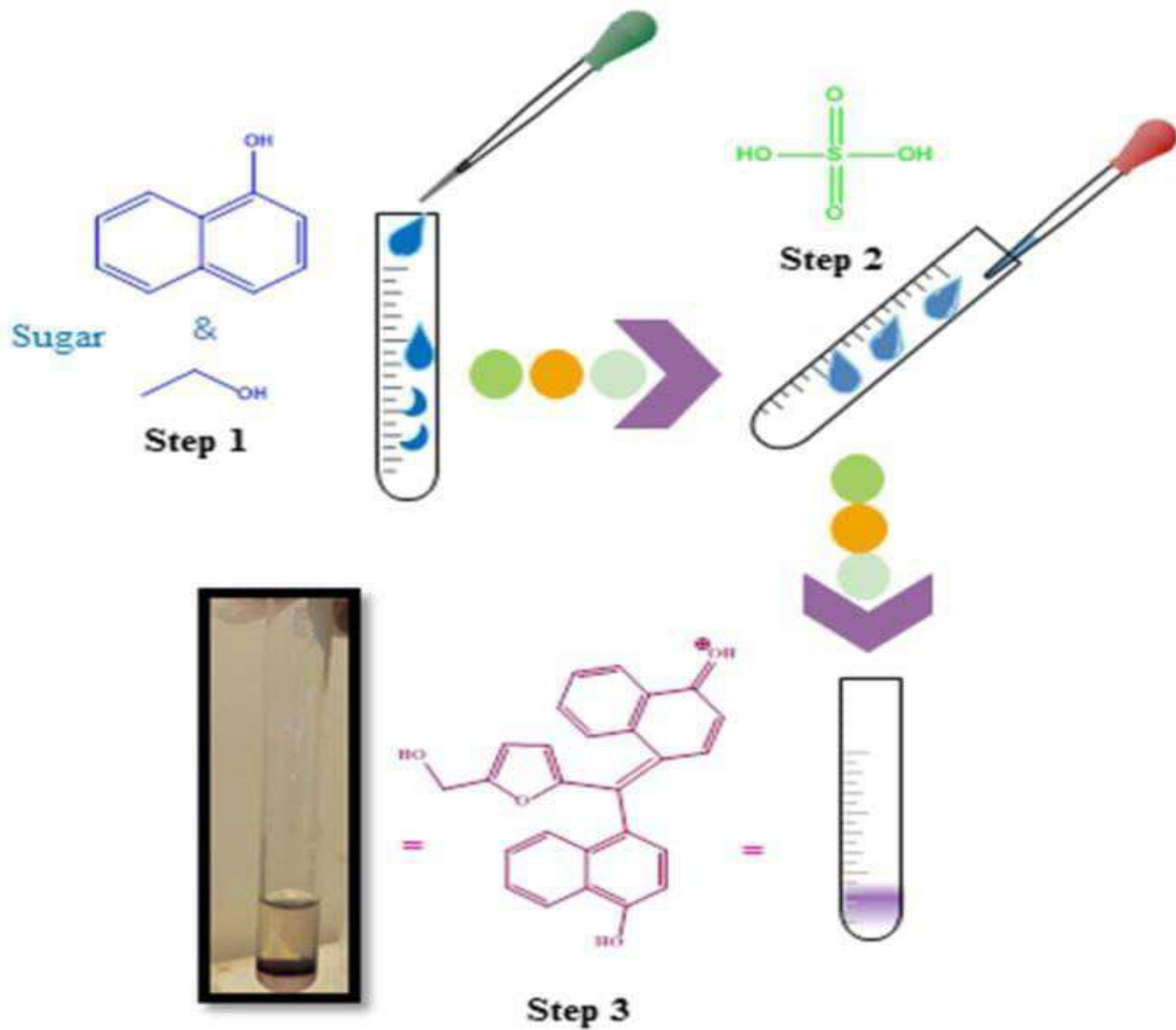
# How detection of carbohydrates

## 1. Molisch's test

This is a very sensitive general test for all carbohydrates because they all give furfural or hydroxy methyl furfural upon heating with a strong hot acidic solutions.

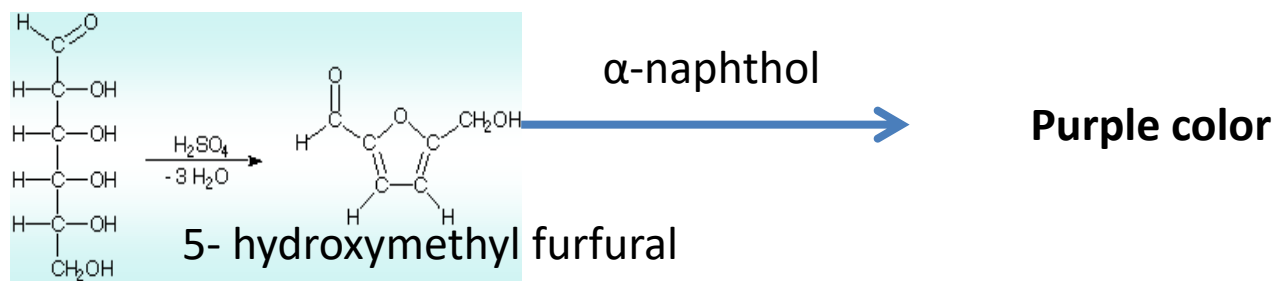
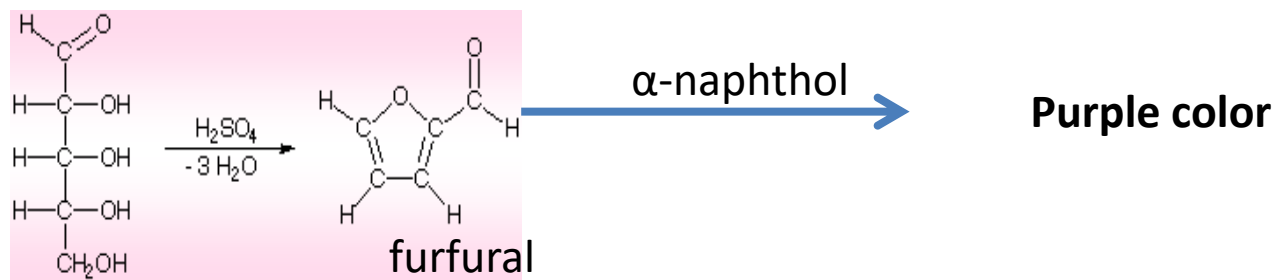
Monosaccharide gives a **rapid** positive test,  
Disaccharides and polysaccharides react **slower**.

**Objective:** To identify the carbohydrate from other macromolecules lipids and proteins.



**Principle:** The test reagent(**H<sub>2</sub>SO<sub>4</sub>**) dehydrates pentose to form furfural and dehydrates hexoses to form 5- hydroxy methyl furfural.

The furfural and 5- hydroxy methyl furfural further react with  $\alpha$ -naphthol present in the test reagent to produce a purple product.

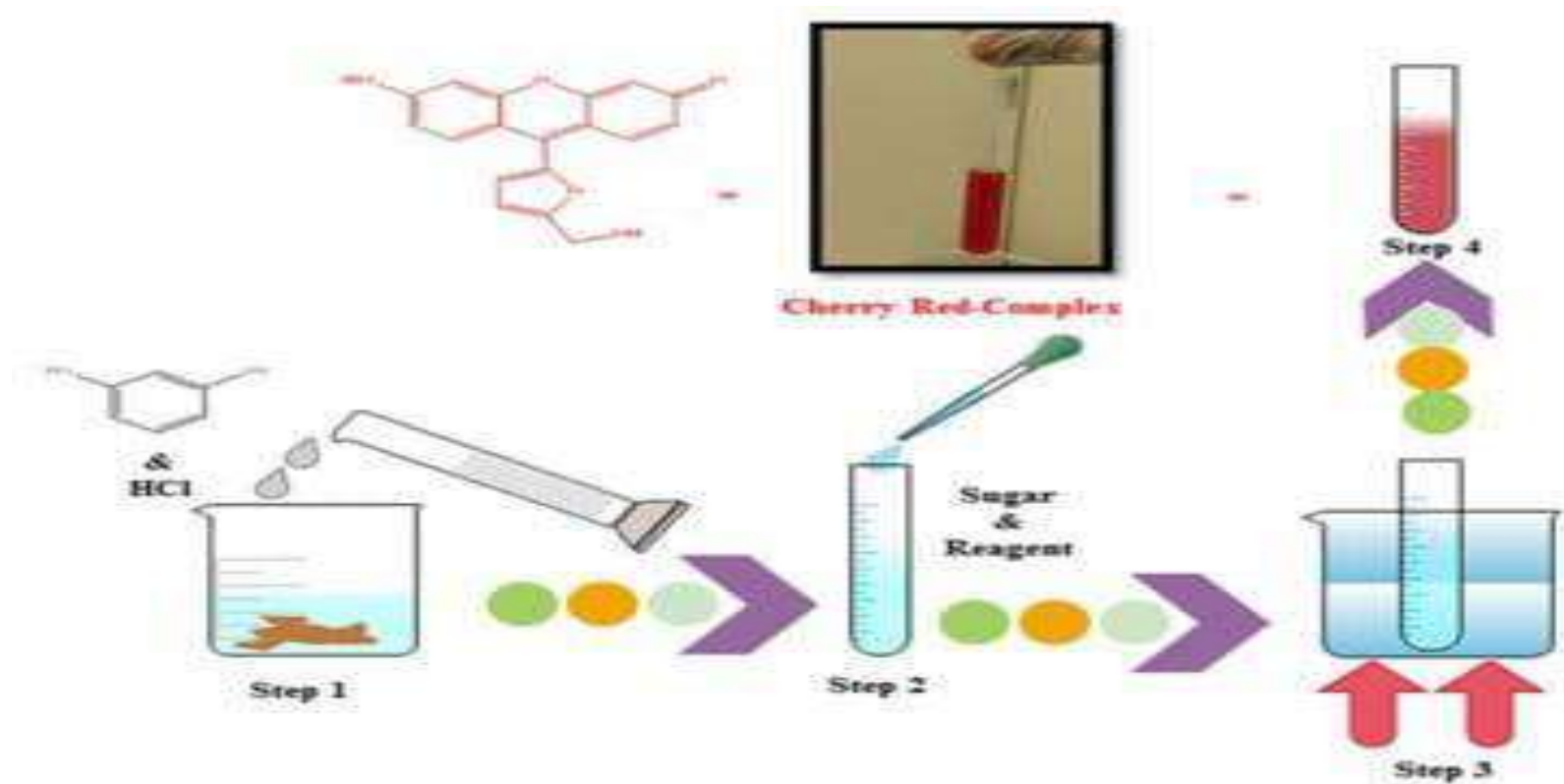


## Procedure :-

- 1-In a clean and dry test tube take 0.5ml of sugar.
- 2- Add (3-4) drops of Molish's reagent and mix well by shaking.
- 3- Carefully add about 0.5 ml of conc. Sulphuric acid by the side of the tube without mixing so that two layers will be formed , the upper layer for carbohydrate solution and the lower for conc.sulphuric acid.

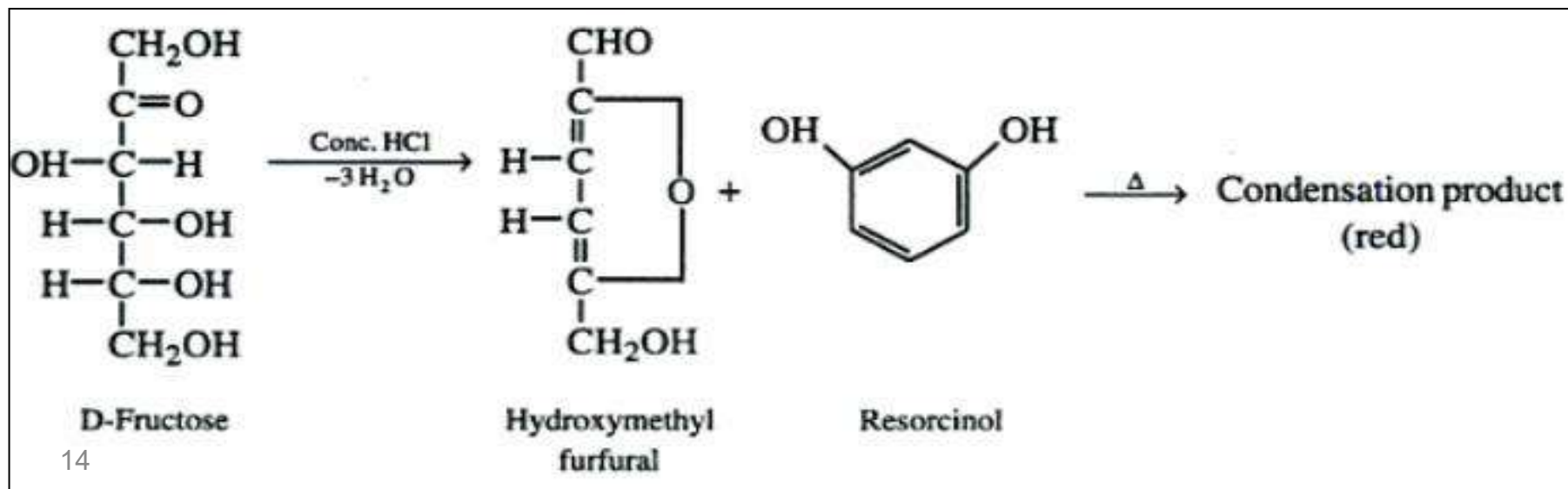
## 2. Seliwanoff's Test

This test is used to distinguish between aldoses (like glucose) and ketoses (like fructose).



**Principle** : Seliwanoff's Test uses dil. HCl as •  
dehydrating agent and resorcinol as condensation  
reagent. The test reagent dehydrates ketohexoses to  
form 5-hydroxy methyl furfural.

5-hydroxymethylfurfural further condenses with •  
resorcinol present in the test reagent to produce a  
cherry red product within two minutes.



## **Procedure:**

1- Place 1 ml of Selwanoff's reagent in a test tube.

2- Add 3 drops of carbohydrate solution, mix.

3- Place in boiling water bath for (2) minutes exactly, then cool the solution.

4- An appearance of cherry red color indicates the presence of fructose.

# 3.Bial's Test

This test is used to distinguish between pentose and hexose monosaccharides

## *Result*

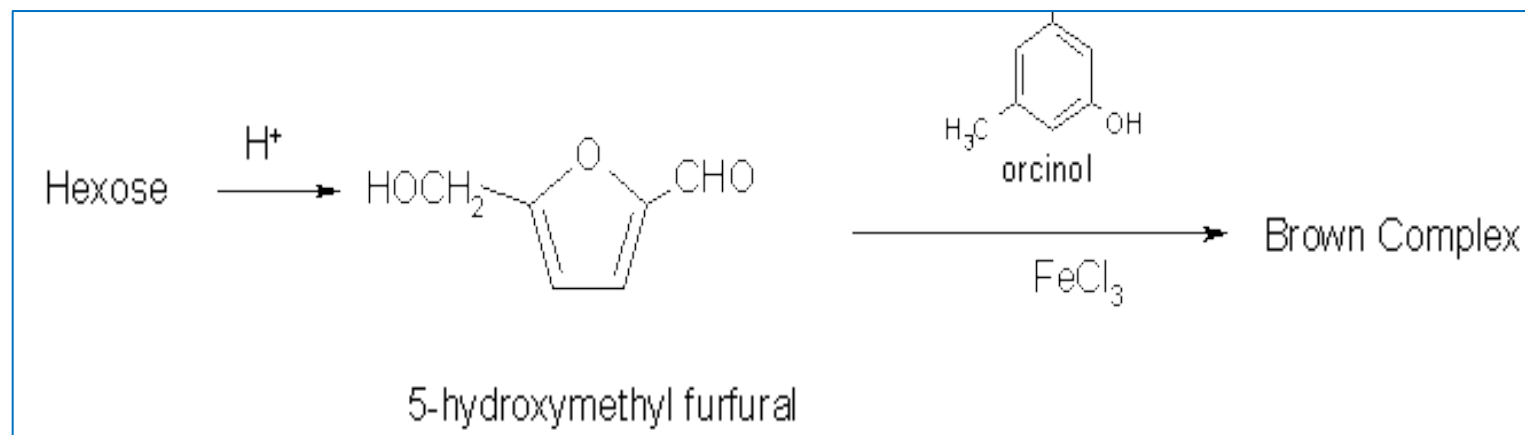
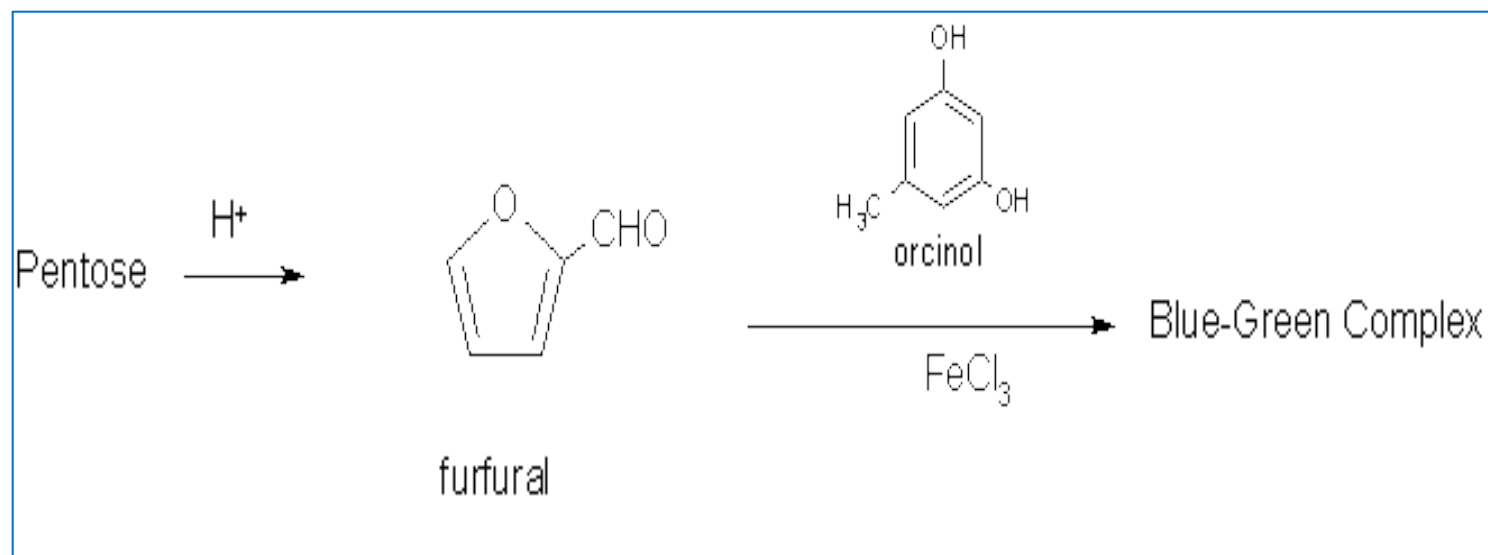
- A bluish color indicates a positive result.
- Prolonged heating of some hexoses yields hydroxymethyl furfural which also reacts with orcinol to give colored complexes.



Two negative tests (left, middle) and a positive test (right)

## Principle:

uses concentrated HCl as a dehydrating acid and orcinol + traces of ferric chloride as condensation reagent. The test reagent dehydrates pentoses to form furfural. Furfural further reacts with orcinol and the iron ion present in the test reagent to produce a bluish - green product, while hexoses yield muddy-brown to grey condensation product.



## **Procedure**

1- To 1 ml of Bial's reagent add 5 drops of pentose solution , mix.

2- Heat in a boiling water bath for (3) minutes to get a blue – green indicate a positive result.



- 1- If a black ring formed in Molisch's test, on what indicates.
- 2- On what indicates the formation of purple ring in Molisch's test
3. Fructose or glucose gives a positive result in Selvanoff's test
4. We must avoid over heating of glucose in selvanoff's test.

# CARBOHYDRATES



ايمان رمزي محمد/قسم التخدير  
المرحلة الاولى

# The objective of the lecture

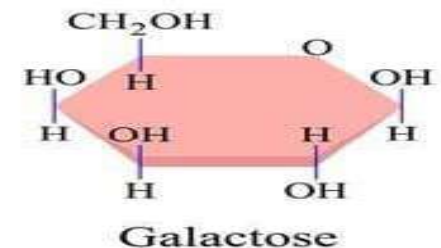
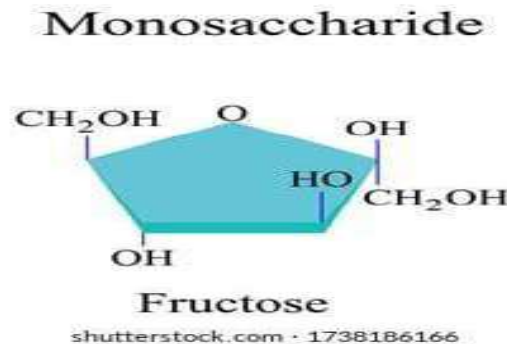
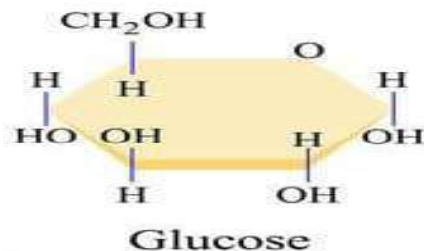


- **Define of carbohydrates**
- **Types of carbohydrates**
- **Function of carbohydrates**
- **Detection of carbohydrates**

# Classification of carbohydrates

## 1-Monosaccharides (Simple sugar):

contain **one** monosaccharide units, they can not broken to smaller carbohydrates. (glucose, galactose , fructose)



# Monosaccharide

(Basic building blocks of carbohydrates)

They can be classified by the number of carbon atoms ■

trioses (C-3) ■

tetroses (C-4) ■

pentoses (C-5) ■

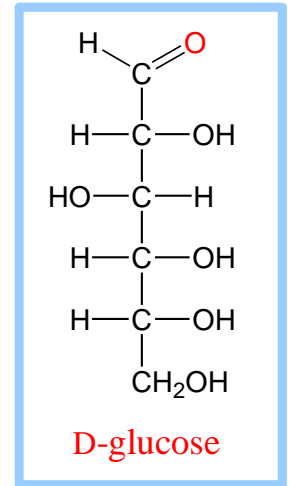
hexoses (C-6) ■

heptoses (C-7) ■

also be classified as ketoses or aldoses. •

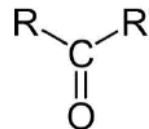
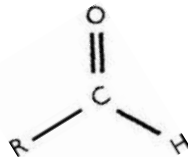
A **ketose** contains a carbonyl group attached to •  
two R groups having one or more hydroxyl groups.

An **aldose** contains terminal aldehyde group in addition to •  
R group containing -OH.



D-glucose

aldose

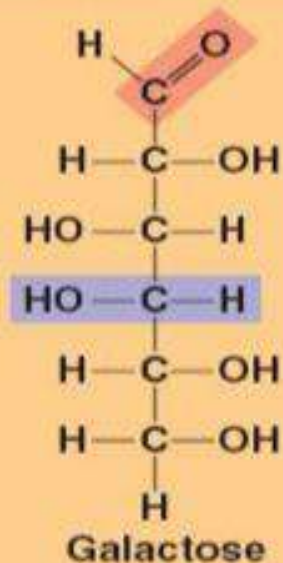
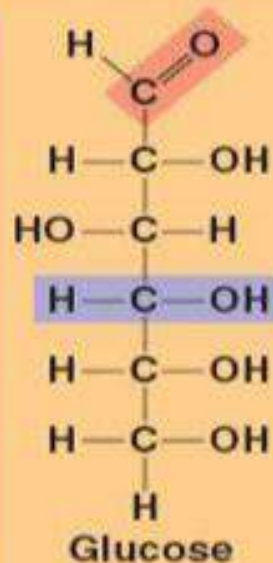
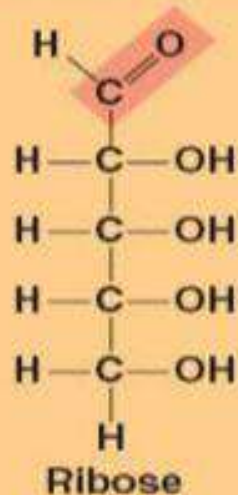
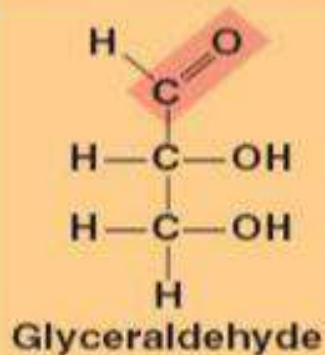


Triose sugars  
( $C_3H_6O_3$ )

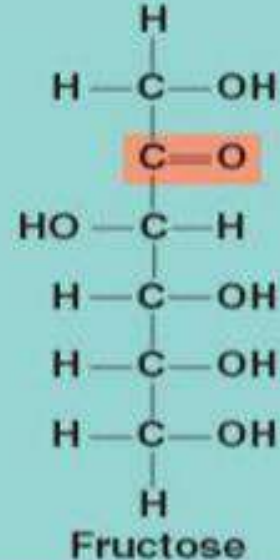
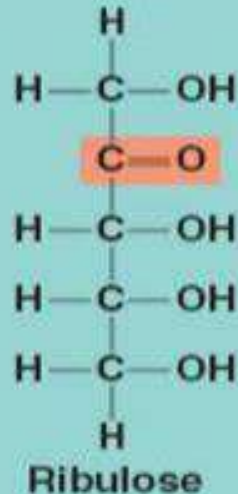
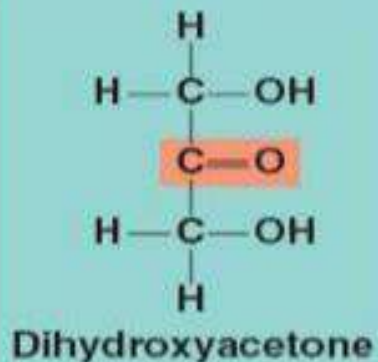
Pentose sugars  
( $C_5H_{10}O_5$ )

Hexose sugars  
( $C_6H_{12}O_6$ )

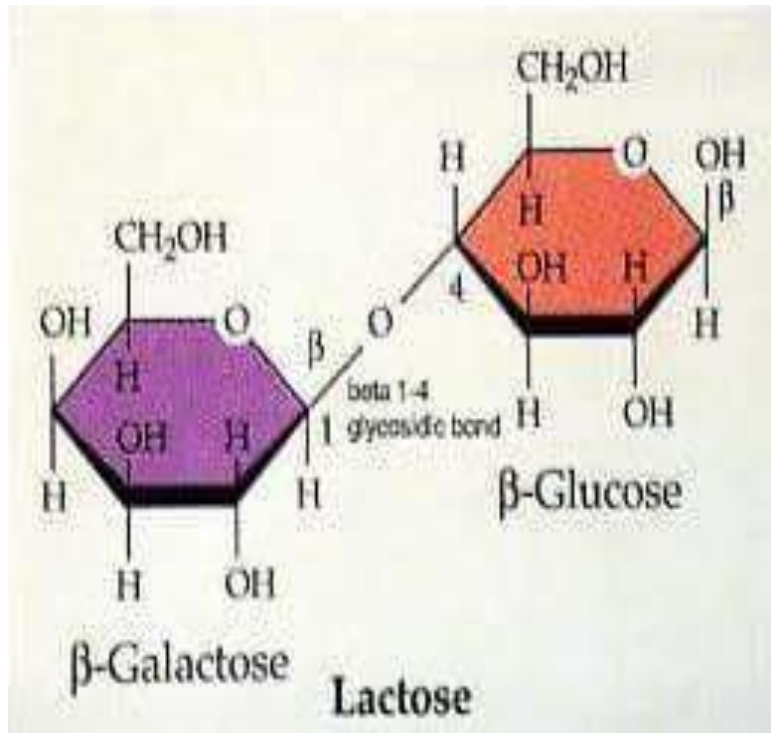
Aldoses



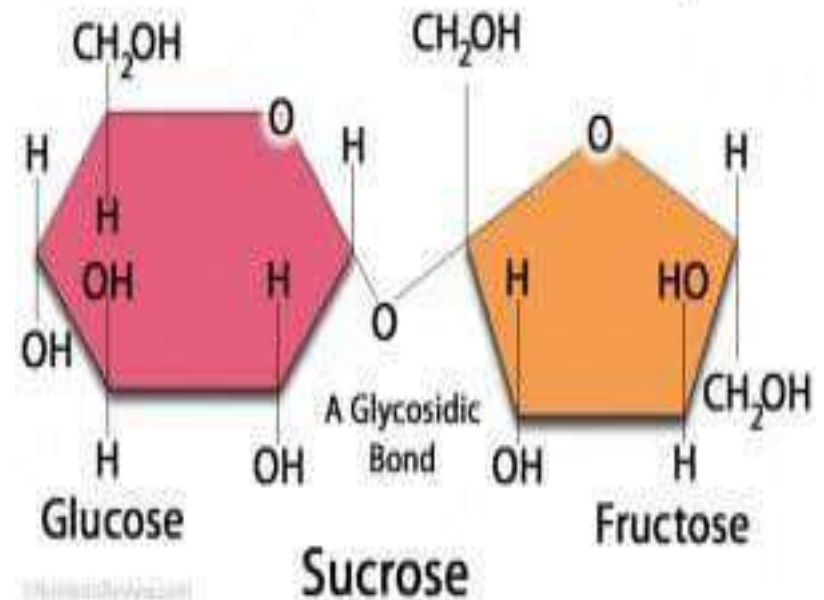
Ketoses



**2-Disaccharides:** contain **two** monosaccharide units (sucrose, maltose, lactose).



## A Disaccharide Example



# Disaccharides

- Composed of 2 monosaccharides
- cells can make disaccharides by joining two monosaccharides by biosynthesis.

## Glucose + fructose = sucrose

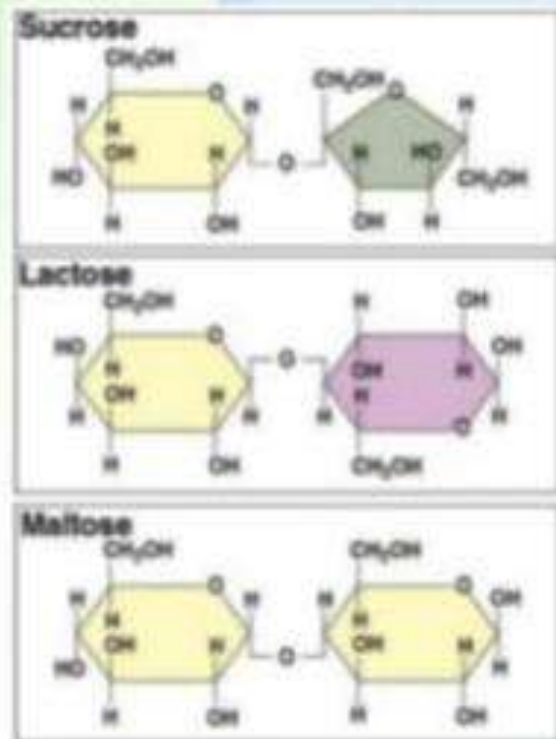
- Table sugar
- Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

## Glucose + galactose = lactose

- The primary sugar in milk and milk products.
- Many people have problems digesting large amounts of lactose (lactose intolerance)

## Glucose + glucose = Maltose

- Produced when starch breaks down.
- Used naturally in fermentation reactions of alcohol and beer manufacturing.

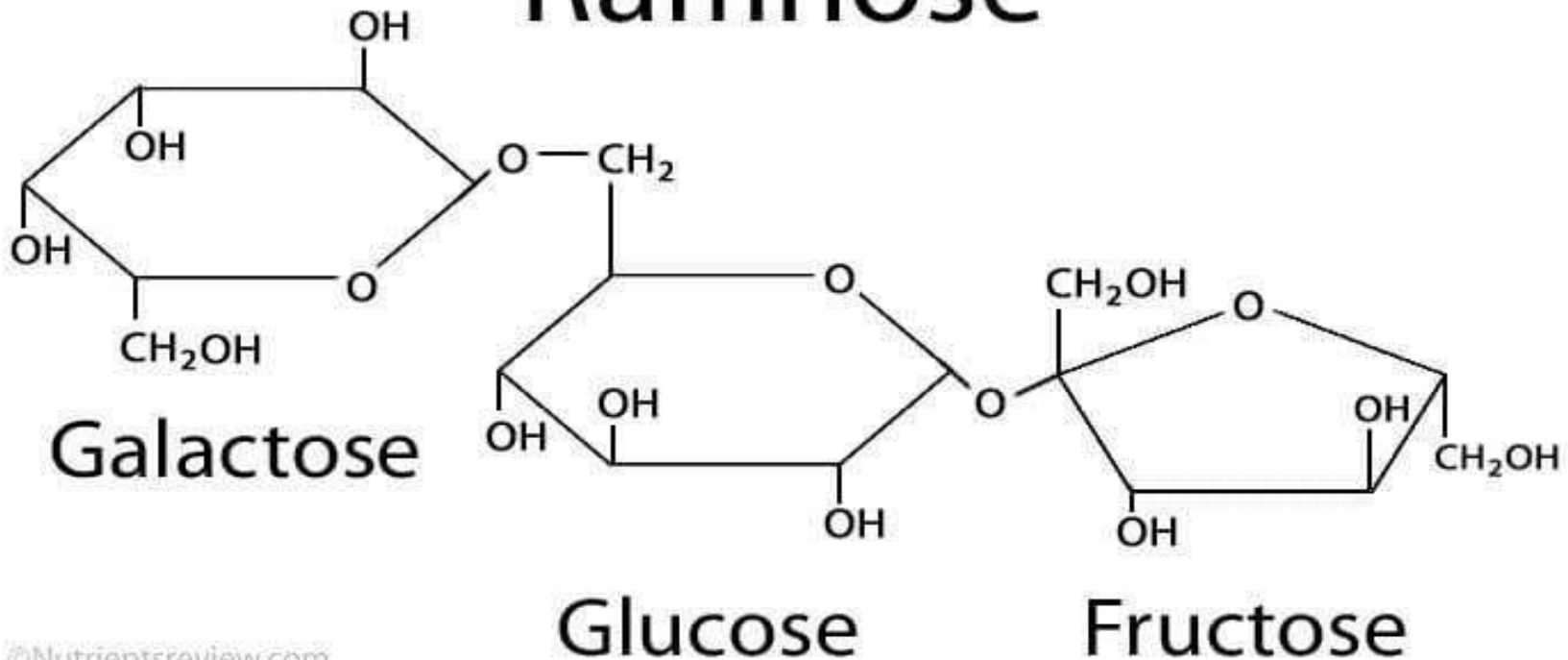


## 3-Oligosaccharides:

contain **3-10** monosaccharide units.(raffinose)

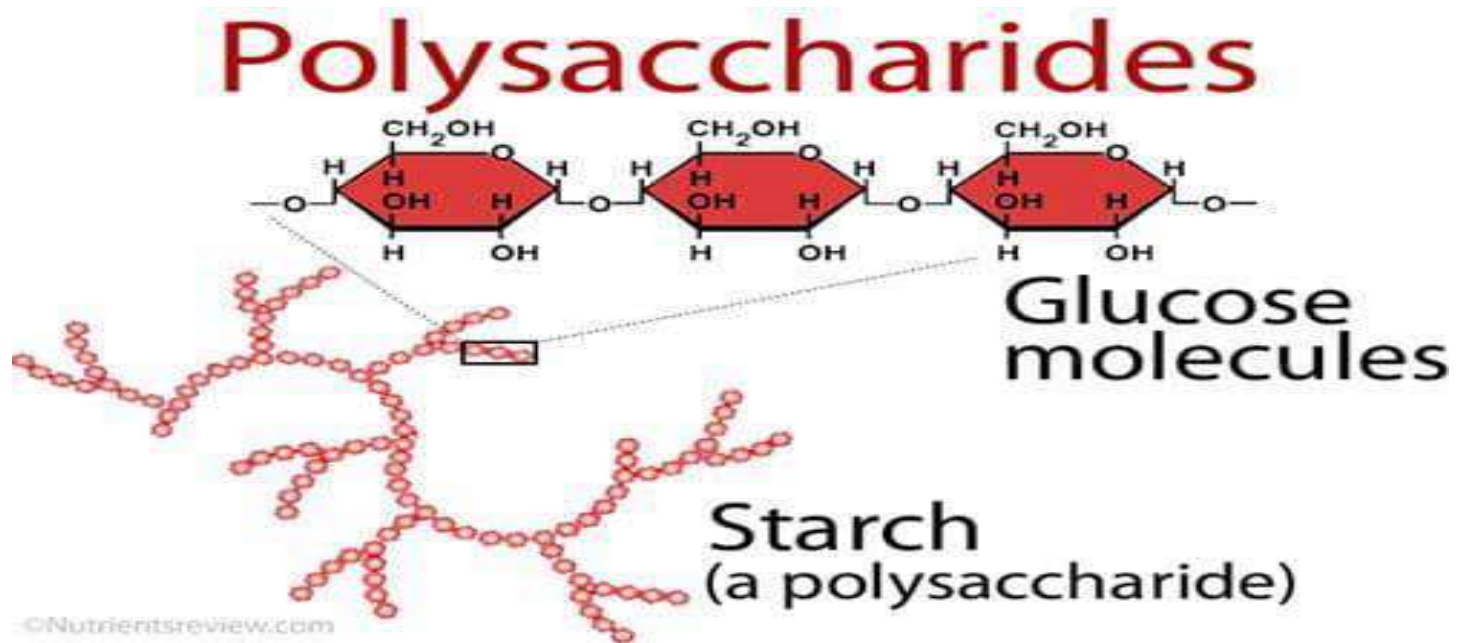
# Oligosaccharides

## Raffinose



## 4-Polysaccharides:

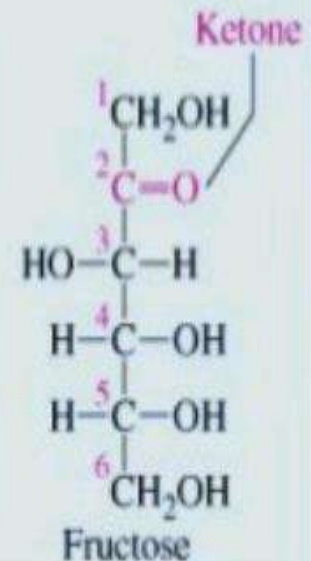
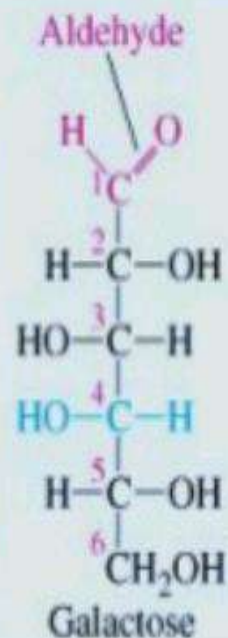
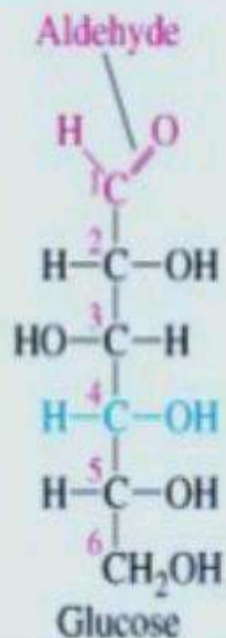
contain more than **10** monosaccharide units.(starch , glycogen).



(Disaccharides , Oligosaccharides ,Polysaccharides) can be broken down into smaller sugar units through a process known as **hydrolysis**

# Function of Carbohydrates in Cells

- ✓ Major source of energy for the cell
- ✓ Major structural component of plant cell
- ✓ Immediate energy in the form of GLUCOSE
- ✓ Reserve or stored energy in the form of GLYCOGEN



# Solubility

Monosaccharide and disaccharide can be dissolved freely in water because water is a polar substance, while polysaccharide cannot be dissolved easily in water, because, it has high molecular weight, which give colloidal solutions in water soluble.



# Reducing and non reducing sugars

**Reducing sugars:** They contain free aldehyde or ketone groups that are capable of acting as reducing agent.

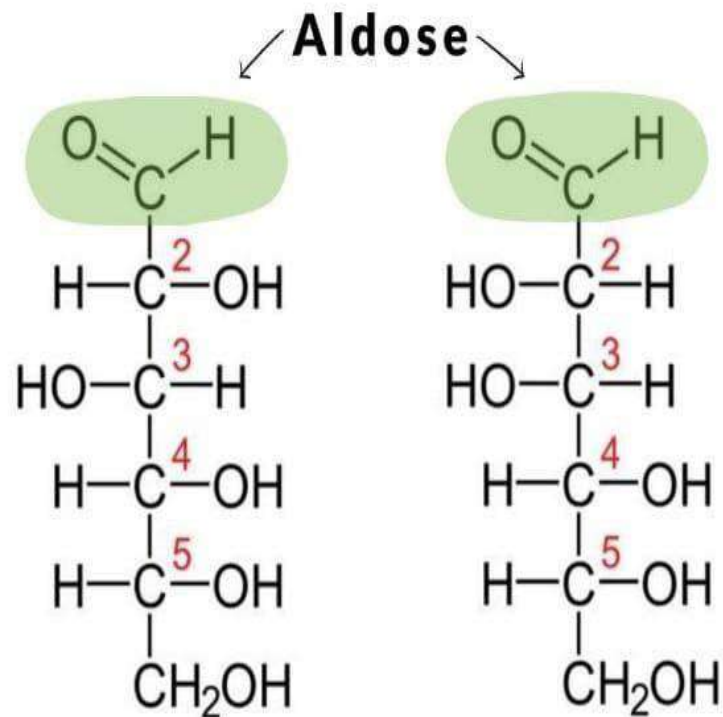
**Non reducing sugars:** They lack the free aldehyde or ketone groups.

-All mono saccharides are reducing sugars.

-Maltose and lactose are reducing sugars in disaccharides, but sucrose is non reducing sugar.

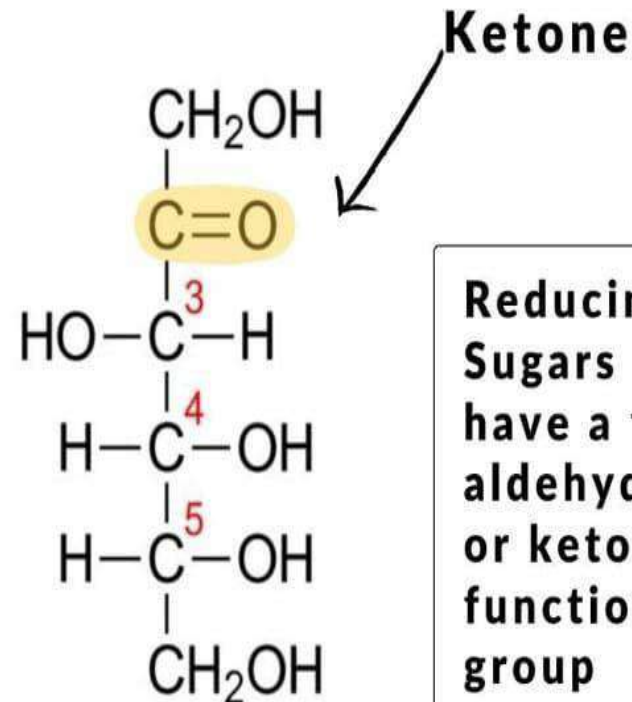
-All polysaccharides are non reducing sugars.

# Reducing Sugar



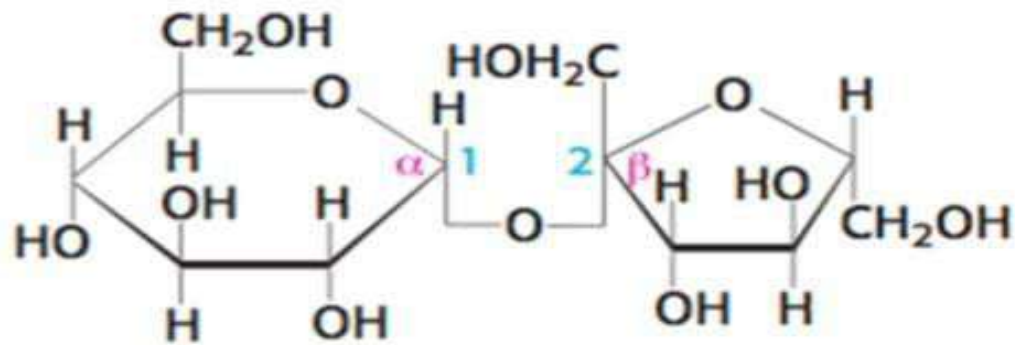
D-Glucose

D-Mannose

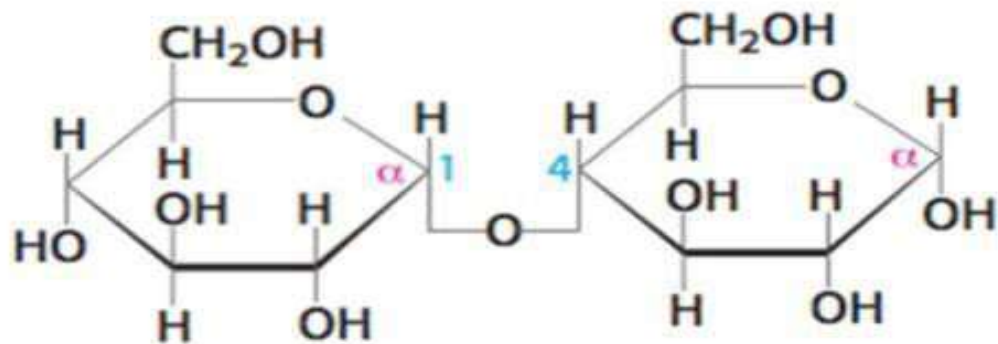


D-Fructose

**Reducing  
Sugars  
have a free  
aldehyde  
or ketone  
functional  
group**



**Sucrose**  
 **$\alpha$ -D-Glucopyranosyl- $\beta$ -D-fructofuranose**



**Maltose**  
 **$\alpha$ -D-Glucopyranosyl-(1  $\rightarrow$  4)- $\alpha$ -D-glucopyranose**

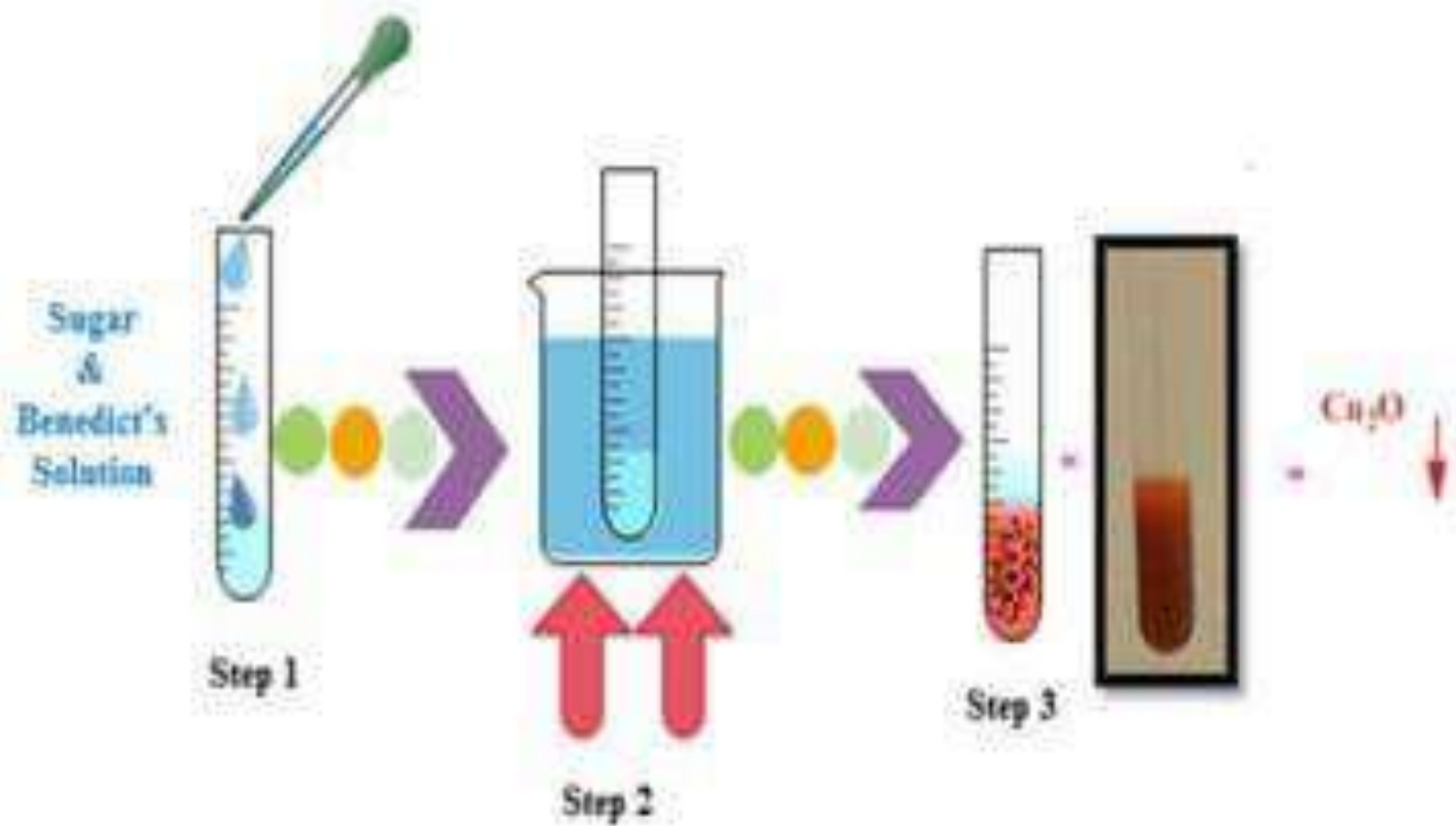
## 4. Benedict's test

Is a test used to distinguish between reducing sugar from non-reducing sugars.

**All monosaccharides are reducing sugars**, they all have a free reactive carbonyl group.

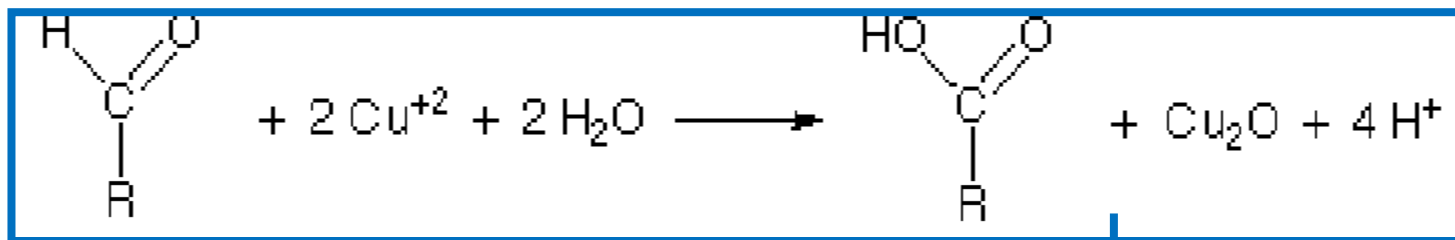
**Some disaccharides have exposed carbonyl groups and are also reducing sugars.** Other disaccharides such as **sucrose are non-reducing sugars** and will not react with Benedict's solution.

Large polymers of glucose, such as starch, are not reducing sugars



**Principle:** The copper sulfate ( $\text{CuSO}_4$ ) present in Benedict's solution reacts with electrons from the aldehyde or ketone group of the reducing sugar in **alkaline medium**.

Reducing sugars are oxidized by the copper ion in solution to form a carboxylic acid and a reddish precipitate of copper oxide.



reddish precipitate of copper

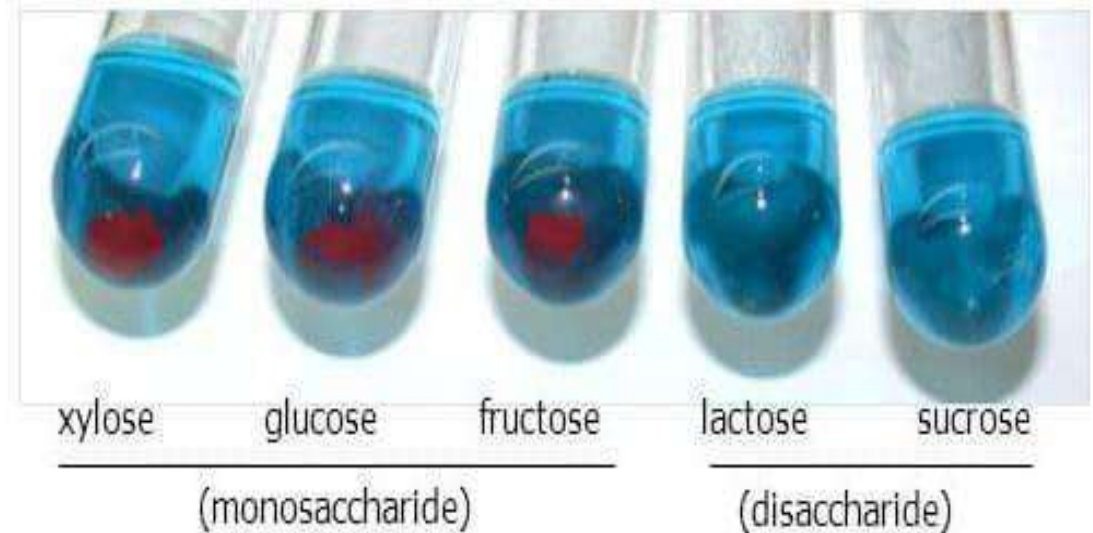
## Procedure

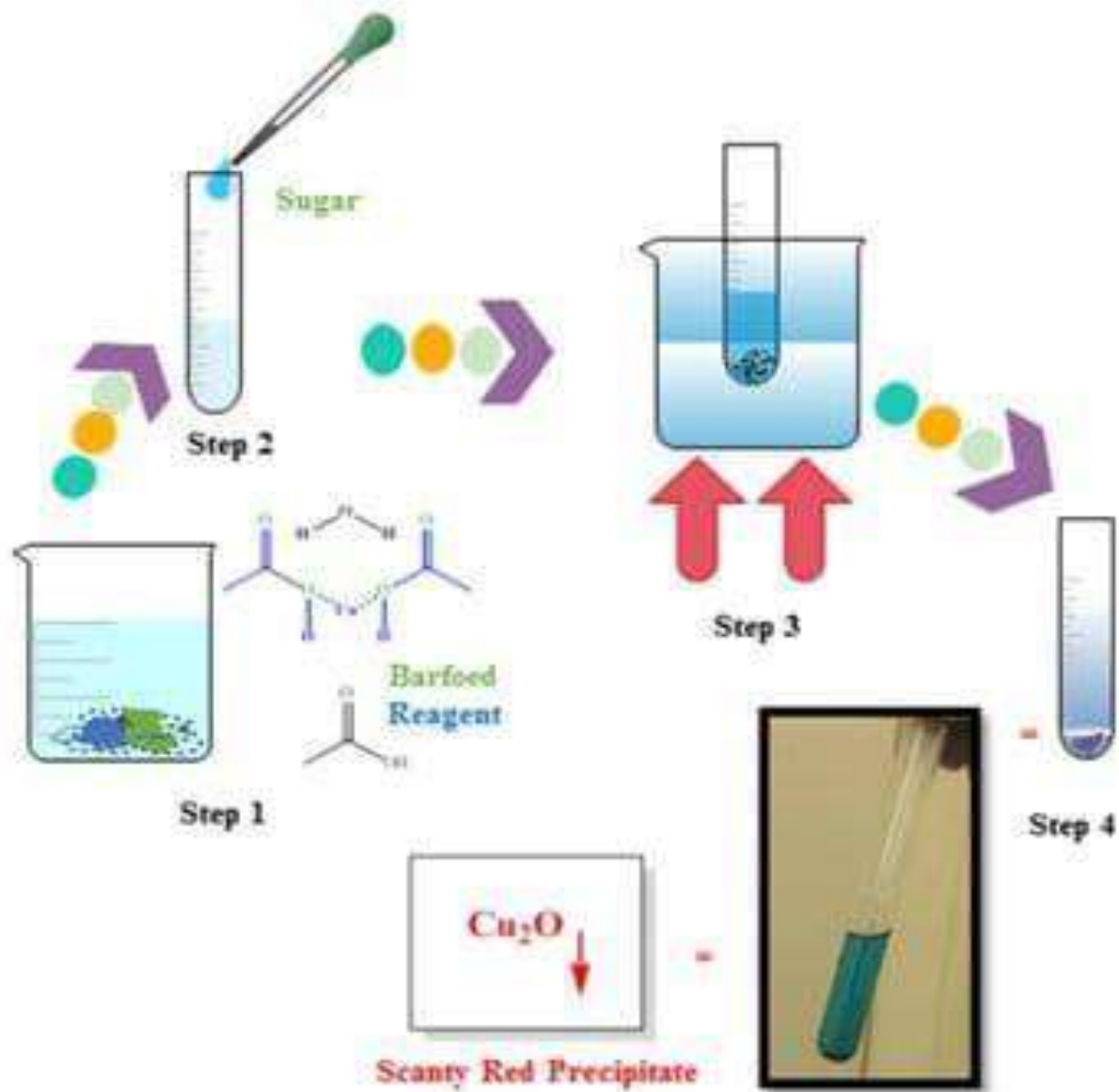
- 1- Add 1 ml of Benedict's reagent in the test tube and then add 4 drops of the test solution, mix well.
- 2- Put the reaction test tube in boiling water bath for (2-5) minutes, and then let it cool.
- 3- A positive test is indicated by: The formation of a reddish precipitate.

# 5.Barfoed's Test

This test is performed to distinguish between reducing monosaccharides, reducing disaccharides

Barfoed's test  
(test for  
monosaccharides)

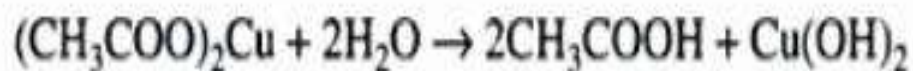




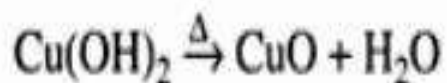
**Principle:** Barfoed's test used copper (II) ions in a **slightly acidic medium**.

Reducing monosaccharides are oxidized by the copper ion in solution to form a carboxylic acid and a reddish precipitate of copper (I) oxide within three minutes. Whereas Reducing disaccharides give negative result (solution remain blue) unless they present in high concentration or hydrolyzed to their main constituents of monosaccharides due to the prolonged heating of the reaction mixture

Barfoed's reagent, cupric acetate in acetic acid, so in acidic medium, disaccharide is a weaker reducing agent than monosaccharide, so monosaccharide will reduce the copper in less time.



Cupric hydroxide



Cuprous oxide  
(Red ppt.)



## **Procedure:**

1- To 1 ml of Barfoed's reagent add 5 drops of test solution, mix.

2- Place the test tube in boiling water bath for exactly 3 minutes.

3- Then remove the test tube and allow cooling gradually a red precipitate of cuprous oxide is formed in case of presence of monosaccharides.

## 6- Iodine test:-

A test to distinguish between simple sugars and polysaccharides.

Iodine can form an adsorption complex with the helical structure (coil-like) of the polysaccharides.

So it give a **blue** color with **starch**,

**red** with **dextrin**

**brown-red** with **glycogen**

depending on coil size and molecular weight. The test solution should be either neutral or slightly acidic but never alkaline, since alkaline medium react with iodine molecule and dissociate it.

Brown / Yellow



**Negative Test** (starch absent)

Blue / Purple



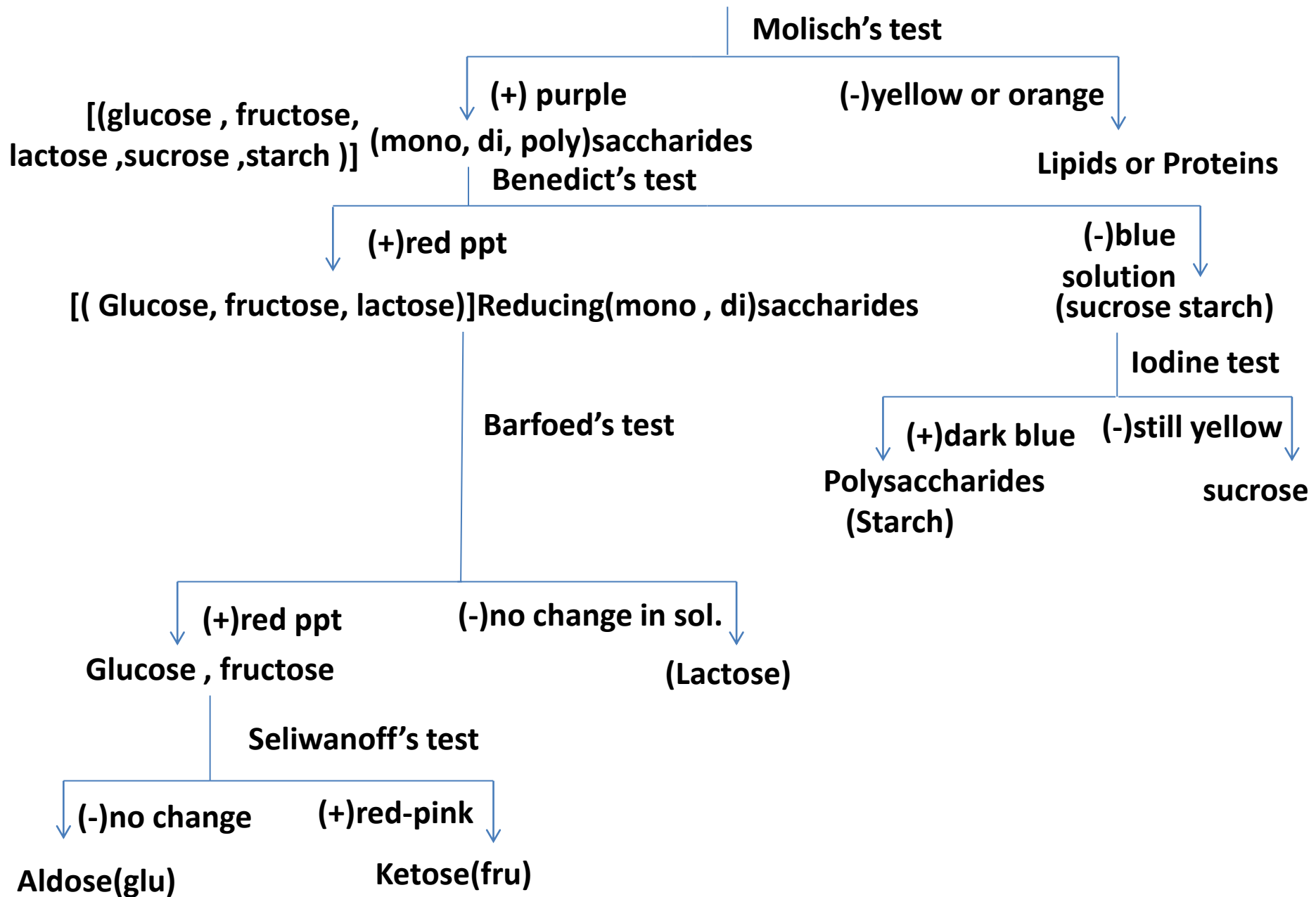
**Positive Test** (starch present)

## procedure

- 1- Place 1 ml of test solution in dry test tube
- 2- Add (1-2) drops of iodine.

Test	objective
<b>Molisch's test</b>	(general test for carbohydrates) To identify the carbohydrate from other macromolecules lipids and proteins
<b>Benedict's test</b>	Benedict's reagent is used as a test for the presence of reducing sugars.
<b>Barfoed's Test</b>	to distinguish between reducing monosaccharides, reducing disaccharides
<b>Bial's Test</b>	To distinguish between pentose monosaccharide and hexose monosaccharide
<b>Seliwanoff's Test</b>	To distinguish between aldose and ketose sugars
<b>Iodine test</b>	To distinguish polysaccharides from other carbohydrates

# Scheme identification for unknown carbohydrates



# H.W

- 1- Why polysaccharides can not be dissolved in water.
- 2- How a sucrose gives a positive result in Benedict's test.
- 3- How a reducing disaccharides give a positive result in Barfoed's test.
- 4- Why we use a slightly acidic medium in Iodine test.

## CHAPTER TWO: Inorganic Chemistry

### What are inorganic chemistry examples?

**Examples** of **inorganic** compounds include: Sodium chloride ( $\text{NaCl}$ ): used as table salt. Silicon dioxide ( $\text{SiO}_2$ ): used in computer chips and solar cells. Sapphire ( $\text{Al}_2\text{O}_3$ ): a well-known gemstone. Sulfuric acid ( $\text{H}_2\text{SO}_4$ ): a **chemical** widely used in the production of fertilizers and some household products such as drain cleaners.

### What is inorganic chemistry simple?

The branch of **chemistry** concerned with the elements and all their compounds except those containing carbon. Some **simple** carbon compounds, such as oxides, carbonates, etc., are treated as **inorganic**. Compare organic **chemistry**.

### What does inorganic chemistry include?

**Inorganic chemistry** is concerned with the properties and behavior of **inorganic** compounds, which **include** metals, minerals, and organometallic compounds.

### What is difference between organic and inorganic chemistry?

**Organic compounds** always contain carbon while **inorganic compounds** contain metal and other elements. Carbon-Hydrogen bonds are the characteristic of **organic compounds** while these are not found in **inorganic compounds**. **Inorganic compounds** contain metal atoms while they are never found in **organic compounds**.

### Is Inorganic Chemistry hard?

**Inorganic** is moderately **tough** but as not as physical **chemistry**. Organic **chemistry** is easy as it contains basic concepts.

### What are the 4 inorganic molecules?

Inorganic compounds are important in the body and responsible for many simple functions. The major inorganic compounds are **water** ( $\text{H}_2\text{O}$ ), bimolecular **oxygen** ( $\text{O}_2$ ), carbon dioxide ( $\text{CO}_2$ ), and some acids, bases, and salts.

### Is water inorganic?

The most general classification of chemical compounds is that of **inorganic** and organic substances. **Inorganic** substances generally do not contain a carbon atom, whereas organic substances contain several. ... **Water** is definitely an **inorganic** compound (di-hydrogen oxide) and methyl alcohol is definitely an organic compound.

### Is inorganic chemistry harder than organic?

**Organic Chemistry** is **harder than Inorganic Chemistry** and therefore you would need extra efforts and more investment of time to learn the concepts and gain expertise. Understanding the concept is the key to master **Organic Chemistry** and you should invest more time in learning the foundations.

### What are the branches of inorganic chemistry?

Subdivisions of inorganic chemistry are **organometallic chemistry**, **cluster chemistry** and **bioinorganic chemistry**.

### Why is $\text{CaCO}_3$ inorganic?

**Calcium carbonate**  $\text{CaCO}_3$  is considered as **inorganic** compound because it is not carbon - hydrogen base. ... **Inorganic** compound - contains any element even carbon and hydrogen, like **calcium carbonate**

### What are the main types of inorganic compounds?

In general, there are four groups of inorganic compound types. They are divided into bases, acids, salts, and **water**. Note that these are the broadest categories of inorganic compounds

### What is inorganic reaction?

A combination **reaction**, also known as a synthesis **reaction**, is a **reaction** in which two or more substances combine to form a single new substance.

Combination **reactions** can also be called synthesis **reactions**. The general form of a combination **reaction** is:  $A+B \rightarrow AB$

### Is human body organic or inorganic?

An organic **compound** is a substance that contains both **carbon** and hydrogen. **Organic compounds** are synthesized via covalent bonds within living organisms, including the human body.

### **Are proteins inorganic?**

**Carbohydrates, lipids, proteins** and **vitamins** have carbon in their structure, making them organic. Water and minerals do not, so they are **inorganic**.

### **What makes something inorganic?**

**Inorganic** molecules do **not** contain **carbon-hydrogen** bonds. While carbon can still appear in **inorganic** molecules, such as in carbon dioxide, it lacks the additional hydrogen's that **make** it organic. ... However, they can still have covalent bonds, such as in water molecules or oxygen gas.

### **Why do we need to study inorganic chemistry?**

**Inorganic chemistry** is used to **study** and develop catalysts, coatings, fuels, surfactants, materials, superconductors, and drugs. Important **chemical** reactions in **inorganic chemistry** include double displacement reactions, acid-base reactions, and redox reactions.

### **Is Sugar an inorganic?**

Yes **sugars** are organic compounds, as organic compounds are defined as Carbon containing compounds with hydrogen attached most of the time. These organic compounds can be synthesized in living beings. They are even used by living being as a source of energy.

### **Is plastic inorganic?**

**Plastics** are made out of a wide variety of organic and **inorganic** compounds. They are mostly synthetic and often made out of petrochemicals, although many **plastics** are partially natural. "Bio plastics" are made from renewable biomass resources including vegetable fats and oils, corn starch, or even bacteria.

**What are the 4 types of compounds?**

**There are four types of compounds, depending on how the constituent atoms are held together:**

- Molecules held together by covalent bonds.
- Ionic **compounds** held together by ionic bonds.
- Intermetallic **compounds** held together by metallic bonds.
- Certain complexes held together by coordinate covalent bonds.

**How many inorganic compounds are there?**

While organic chemistry has identified about 19 million **known carbon compounds**, **inorganic** chemistry comprises only about 500,000 **known compounds**

**What are the topics in inorganic chemistry?**

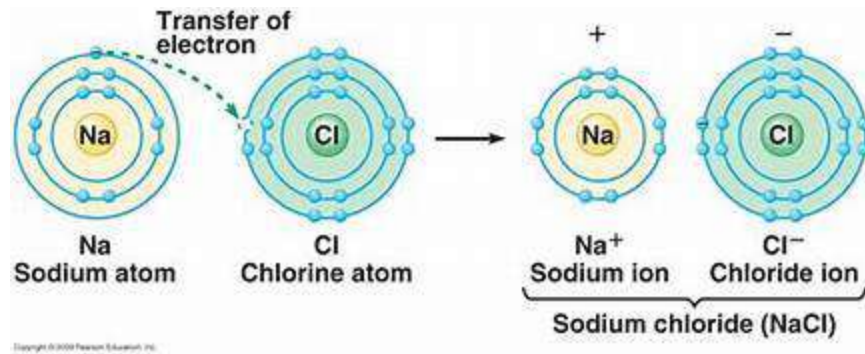
**Book: Introduction to Inorganic Chemistry**

- Front Matter.
- 1: Review of **Chemical** Bonding.
- 2: Molecular Orbital Theory.
- 3: Acid-Base **Chemistry**.
- 4: Redox Stability and Redox Reactions.
- 5: Coordination **Chemistry** and Crystal Field Theory.
- 6: Metals and Alloys- Structure, Bonding, Electronic and Magnetic Properties.
- 7: Metals and Alloys - Mechanical Properties.

## Chemical Bonds

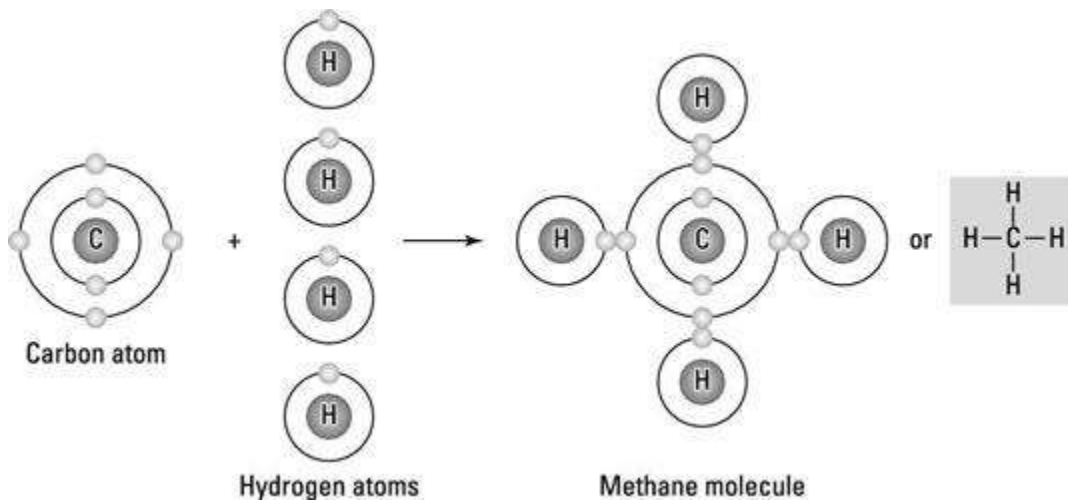
### **1** Ionic bond

**Ionic bond** involves a transfer of an electron, so one atom gains an electron while one atom loses an electron. One of the resulting ions carries a negative charge (anion), and the other ion carries a positive charge (cation). Because opposite charges attract, the atoms bond together to form a molecule.



## 2 Covalent bond

The most common bond in organic molecules, a [covalent bond](#) involves the sharing of electrons between two atoms. The pair of shared electrons forms a new orbit that extends around the nuclei of both atoms, producing a molecule. There are two secondary types of covalent bonds that are relevant to biology — polar bonds and hydrogen bonds.

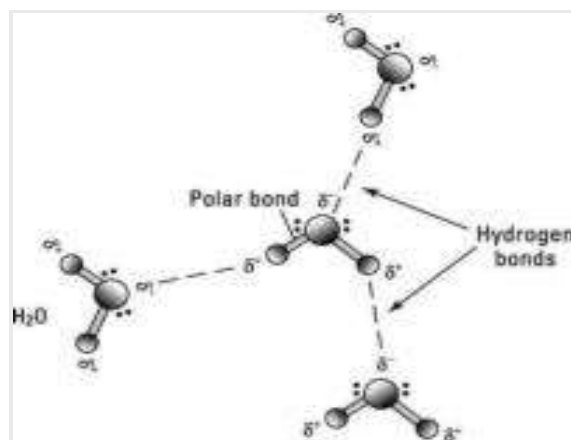


## 3 Polar bond

Two atoms connected by a covalent bond may exert different attractions for the electrons in the bond, producing an unevenly distributed charge. The result is known as a *polar bond*, an intermediate case between ionic and covalent bonding,

with one end of the molecule slightly negatively charged and the other end slightly positively charged.

These slight imbalances in charge distribution are indicated in the figure by lowercase delta symbols with a charge superscript (+ or -). Although the resulting molecule is neutral, at close distances the uneven charge distribution can be important. Water is an example of a polar molecule; the oxygen end has a slight positive charge whereas the hydrogen ends are slightly negative. Polarity explains why some substances dissolve readily in water and others do not.



#### 4Hydrogen bond

Because they're polarized, two adjacent H<sub>2</sub>O (water) molecules can form a linkage known as a *hydrogen bond*, where the (electronegative) hydrogen atom of one H<sub>2</sub>O molecule is electrostatically attracted to the (electropositive) oxygen atom of an adjacent water molecule.

Consequently, two molecule of water join together transiently in a hydrogen-bonded lattice. [Hydrogen bonds](#) have only about 1/20 the strength of a covalent bond, yet even this force is sufficient to affect the structure of water, producing many of its unique properties, such as high surface tension, specific heat, and heat of vaporization. Hydrogen bonds are important in many life processes, such as in replication and defining the shape of DNA molecules.

## Acids, bases and Salts

In **acid – base** chemistry, **salts** are ionic compounds that result from the neutralization reaction of an **acid** and a **base**. Basic **salts** contain the conjugate **base** of a weak **acid**, so when they dissolve in water, they react with water to yield a solution with pH greater than 7.0.

### What is the difference between acids, bases and salts?

An **acid** is defined as a substance whose water solution tastes sour, turns blue litmus red and neutralizes **bases**. A substance is called **base** if its aqueous solution tastes bitter, turns red litmus blue or neutralizes **acids**. **Salt** is a neutral substance whose aqueous solution does not affect litmus.

### Do acids react with bases to form salts?

When an **acid** and a **base** are placed together, they **react** to neutralize the **acid** and **base** properties, producing a **salt**. The  $H^{(+)}$  cation of the **acid** combines with the  $OH^{(-)}$  anion of the **base to form** water. The compound formed by the cation of the **base** and the anion of the **acid** is called a **salt**.

## What are 5 examples of bases?

### Examples of Bases and Alkalis

1. Sodium hydroxide (NaOH) or caustic soda.
2. Calcium hydroxide  $Ca(OH)_2$  or limewater.
3. Ammonium hydroxide ( $NH_4OH$ ) or ammonia water.
4. Magnesium hydroxide ( $Mg(OH)_2$ ) or milk of magnesia.
5. Many bleaches, soaps, toothpastes and cleaning agents.

### Is Salt a basic or acidic?

Salt substance produced by the reaction of an acid with a base. A salt consists of the positive ion (cat ion) of a base and the negative ion (anion) of an acid. The reaction between an acid and a base is called a **neutralization reaction**.

## What are the uses of acid, bases and salt?

### Uses of Acids and Bases

1. Uses of Acids. Vinegar, a diluted solution of acetic acid, has various household applications. It is primarily used as a food preservative. ...
2. Uses of Bases. The manufacturing of soap and paper involves the use of sodium hydroxide. NaOH is also used in the manufacture of **rayon**.

### Can a strong acid neutralize a weak base?

**Strong acids** will **neutralize strong bases** of equal concentrations in equal amounts. More volume of a **weak acid** is needed to **neutralize a strong base** if the concentrations are equal and vice versa for **weak bases** and **strong acids**. ... A **buffer** is a solution that contains a **weak acid** and salt with the same anion as the **acid**.

### Is $\text{NH}_4\text{Cl}$ a basic salt?

**Salts** can be acidic, neutral, or **basic**. **Salts** that form from a strong acid and a weak **base** are acid **salts**, like **ammonium chloride** ( $\text{NH}_4\text{Cl}$ ). **Salts** that form from a weak acid and a strong **base** are **basic salts**, like sodium bicarbonate ( $\text{NaHCO}_3$ ).

### Is $\text{Na}_2\text{CO}_3$ a basic salt?

Sodium carbonate is a **basic salt** because it is a **salt** of  $\text{NaOH}$ .

### What are 3 common household bases?

Common household chemical bases include ammonia, baking soda and lye.

- **Baking Soda.** Baking soda or sodium bicarbonate ( $\text{NaHCO}_3$ ) has a pH of 8.3, higher than distilled water's pH of 7.0. ...
- **Borax:** Cleaning and Pest Control. ...
- Milk of Magnesia (**Magnesium Hydroxide**) ...
- **Ammonia**, Enemy of Dirt. ...
- Lye: Clog Buster.

### What is the pH of a salt?

7.2

Here  $\text{NaCl}$  is a Neutral base, and hence the **PH** is equal to 7.2

Can a base be a salt?

A **salt can** be made of either, a weak acid and strong **base**, strong acid and weak **base**, a strong acid and strong **base**, or a weak acid and weak **base**.

What happens when acid and salt?

Often when an **acid** and base reacts a **salt** and water will be formed. ... A **salt** (to chemists) is a product of an **acid-base reaction** and is made up of the cat ion from the base and the anion from the **acid**. Hydrochloric **acid reacts** with sodium hydroxide to form sodium chloride (a **salt**) and water.

### What are 5 uses of acids?

Other uses of acids include: benzoic acid (salt used to preserve food), carbonic acid (used to make carbonated drinks), **ethanoic acid** (used to clean metals before electroplating/processing leather/household cleaning/ maintenance of swimming pools), nitric acid (used in the production of fertilizers, explosives, dissolution ...

### What is acid base and salt with example?

Common **examples** include hydrochloric **acid**, sulfuric **acid**, citric **acid** and ethanoic **acid** (vinegar/acetic **acid**). **Bases** are a group of substances that neutralize **acids**. Soluble **bases** are called alkalis. ... **Salts** are odorless and have a salty taste, and many are soluble in water.

### What are three uses of bases?

#### Uses of bases

- **Sodium hydroxide** is used in the manufacture of soap, paper, and the synthetic fiber rayon.
- **Calcium hydroxide** (slaked lime) is used in the manufacture of bleaching powder.
- **Calcium hydroxide** is also used to clean the sulfur dioxide, which is caused by the exhaust, which is found in power plants and factories.

### Can you neutralize acid with baking soda?

When **you** mix **baking soda**, a mild base, with **acids**, a chemical reaction turns the **acids** into harmless byproducts, such as salt and carbon dioxide. Knowing **how** to use **baking soda** is simple. With the right supplies and directions, **you** can safely **neutralize** hydrochloric **acid**.

How do you neutralize a weak base?

To **neutralize** acids, a **weak base** is used. **Bases** have a bitter or astringent taste and a pH greater than 7. Common **bases** are sodium hydroxide, potassium hydroxide and ammonium hydroxide. **Bases** are **neutralized** by using a **weak acid**.

How much base is needed to neutralize an acid?

#### Titration

When hydrochloric **acid** is reacted with sodium hydroxide, an **acid/base** mole ratio of 1:1 is required for full **neutralization**.

### What are three types of salt?

These include table salt, **Himalayan pink salt**, **kosher salt**, **sea salt** and **Celtic salt**, just to name a few. Not only do they differ in taste and texture, but also in mineral and **sodium** content. This article explores the most popular salt types and compares their nutritional properties.

### Is $\text{NH}_4\text{Cl}$ weak or strong?

As mentioned in the other answer,  **$\text{NH}_4\text{Cl}$**  is an “acidic” salt, formed by the neutralization of a **strong** acid ( $\text{HCl}$ ) with a **weak** base ( $\text{NH}_3$ ). Therefore, when the salt is completely dissociated in an aqueous solution, it forms  $\text{NH}_4^+$  and  $\text{Cl}^-$  ions.

### Is $\text{NH}_4\text{Cl}$ acid or base?

**Ammonium** chloride, also known as Sal ammoniac, is a compound of **ammonia** ( $\text{NH}_3$ ) and chlorine ( $\text{Cl}$ ). It is denoted by the symbol  $\text{NH}_4\text{Cl}$  and is in solid crystalline form in nature. This compound is a water-soluble **salt** of **ammonia**, and aqueous **ammonium** chloride is slightly acidic.

### How can you tell if a salt is basic?

A pH less than 7 indicates an acidic solution, a pH greater than 7 indicates a **basic** solution, and a pH of 7 indicates a neutral solution. Determining whether a **salt** exhibits acidic or **basic** character, then, requires dissolving the **salt** in water and measuring the pH of the resulting solution.

### What are the five types of salt in chemistry?

Table salt, for example, is called sodium chloride ( $\text{NaCl}$ ).

- **Sodium Chloride.** •• **Sodium chloride** ( $\text{NaCl}$ ) is the most common type of salt in our lives. ...
- Potassium Dichromate. •• ...
- Calcium Chloride. •• ...
- Sodium Bisulfate. •• ...
- Copper Sulfate. ••

How are basic salts formed?

**Salts** come in three different forms: **basic salts**, neutral **salts** and acid **salts**. When a strong base reacts with a strong acid, a neutral **salt** is **formed**. When a strong base reacts with a weak acid, a **basic salt** is **formed**. When a strong acid reacts with a weak base, an acidic **salt** is **formed**.

What are common household bases?

## Examples of Everyday Bases

- Drain cleaner.
- Laundry detergent.
- Lubricating grease.
- Alkaline batteries.
- Soaps and bath products.
- Sugar.
- Baking soda.

### Is vinegar, an acid or a base?

Vinegar is acidic. Vinegar's pH level varies based upon the type of vinegar it is. White distilled vinegar, the kind best suited for household cleaning, typically has a pH of around 2.5. Vinegar, which means “sour wine” in French, can be made from anything containing **sugar**, such as fruit.

### Is coffee an acid or base?

While our bodies have a pH value of 7.4 (around neutral), tap water 6.5-8.5, **coffee** is typically around pH 4.3-5, which is mildly **acidic**. Typically any food or beverage more **acidic** than our own body chemistry can trigger digestive discomfort, inflammation and "burning" side-effects like **acid** reflux or heartburn.<sup>13</sup>

### What is the most basic substance?

Basic substances include things like **baking soda**, **soap**, and **bleach**.

Distilled **water** is a neutral substance. The pH scale, which measures from 0 to 14, provides an indication of just how acidic or basic a substance is.

### Is milk an acid or base?

**Milk** — pasteurized, canned, or dry — is an **acid**-forming food. Its pH level is below neutral at about 6.7 to 6.9. This is because it contains lactic **acid**.

Remember, though, that the exact pH level is less important than whether it's **acid**-forming or **alkaline**-forming.

### Which has highest pH value?

If a solution **contains** more hydroxide ion than hydrogen ion, it is said to be basic, and its **pH** is **higher** than 7.

Increasing pH (Decreasing Acidity)	Substances
0 (most acidic)	Hydrochloric acid (HCl)
1	Stomach acid
2	Lemon juice
3	Cola, beer, vinegar

### What liquid is a base?

Almost all liquids are either **acids** or bases to some degree. Whether a liquid is an **acid** or **base** depends on the type of ions in it. If it has a lot of hydrogen ions, then it is an **acid**. If it has a lot of **hydroxide ions**, then it is a base.

What makes a good base?

A **good base** is usually a **good** nucleophile. So, **strong bases** — substances with negatively charged O, N, and C atoms — are **strong** nucleophiles. Examples are:  $\text{RO}^-$ ,  $\text{OH}^-$ ,  $\text{RLi}$ ,  $\text{RC}\equiv\text{C}^-$ , and  $\text{NH}_2^-$ . Some **strong bases** are poor nucleophiles because of steric hindrance.

What pH is  $\text{NH}_4\text{Cl}$ ?

4.6 to 6.0



A 5% by weight solution of **ammonium chloride** in water has a **pH** in the range 4.6 to 6.0. Some of **ammonium chloride's** reactions with other chemicals are endothermic like its reaction with barium hydroxide and its dissolving in water.

What is the pH of pepper?

8.5

With a **pH** level of 8.5, **cayenne peppers** are one of the most alkalizing foods. They're also full of antibacterial properties, are a good source of vitamin A, and work to fight off free radicals that trigger stress and illness.

### How do you tell if it's an acid or base?

To **determine whether** a substance is an **acid** or a **base**, count the hydrogen's on each substance before and after the reaction. **If** the number of hydrogen's has

decreased that substance is the **acid** (donates hydrogen ions). **If** the number of hydrogen's has increased that substance is the **base** (accepts hydrogen ions).

### What type of salt is called acidic salt?

**Acidic Salt:** A normal **salt** which is formed by the neutralization of a strong **acid** and weak base is **called acidic salt** because its aqueous solution turns blue litmus red. Examples: The compounds like  $\text{FeCl}_3$ ,  $\text{ZnCl}_2$ ,  $\text{HgCl}_2$ ,  $\text{Fe}_2(\text{SO}_4)_3$ ,  $\text{HgSO}_4$  etc. are **acidic salt**.

### Which salt is not acidic?

Sodium carbonate  $\text{Na}_2\text{CO}_3$  is not an acidic salt. It is a **basic salt**. It is a salt of the strong base **NaOH** with weak acid  $\text{H}_2\text{CO}_3$ .

### Is $\text{NaHSO}_4$ an acid salt?

$\text{NaHSO}_4$  is a sodium **salt** of the bisulfate anion with chemical name Sodium bisulfate. It is also called Sodium **acid** sulfate or Bisulfate of soda or Sodium hydrosulfate. In its anhydrous form, it is hygroscopic. The solutions are **acidic** with a pH value of 1 for every 1M solution.

### What are the ten uses of acid?

Acid	Uses
Sulphuric acid	In storage batteries In the manufacture of fertilizers, paints and pigments, detergents and artificial fiber, In the manufacture of hydrochloric acid and alum
Phosphoric acid	In <b>fertilizer</b> and detergent industries

What are the five common acids?

Five of the most commonly used acids are **sulfuric acid**, **nitric acid**, **hydrochloric acid**, **citric acid**, and **acetic acid**.

### Daily uses of acids and bases in life. ?

1. Hydrochloric **acid** **used** in the production of glucose from corn starch.
2. Carbonic **acid** ( $\text{H}_2\text{CO}_3$ ) is **used** in aerated drinks.
3. Sulphuric **acid** is **used** in the manufacture of fertilizers, paints, dyes, chemicals, plastics and synthetic fibers.
4. Sulphuric **acid** is also **used** in car batteries.

Acids and **bases** are **important** in living things because most enzymes can do their job only at a certain level of acidity. Cells secrete **acids** and **bases** to maintain the proper pH for enzymes to work.

## How is chemistry applied in medicine?

### Chemistry in Medicine

Major Contributions to health care has been made by **chemistry**. The development of new drugs involves **chemical** analysis and synthesis of new compounds. ... The **chemistry** of the disease must be studied, as well as how the drug affects the human body. A drug may work well in animals, but not in humans.

الفيديوهات يمكن مشاهدتها على الاتي

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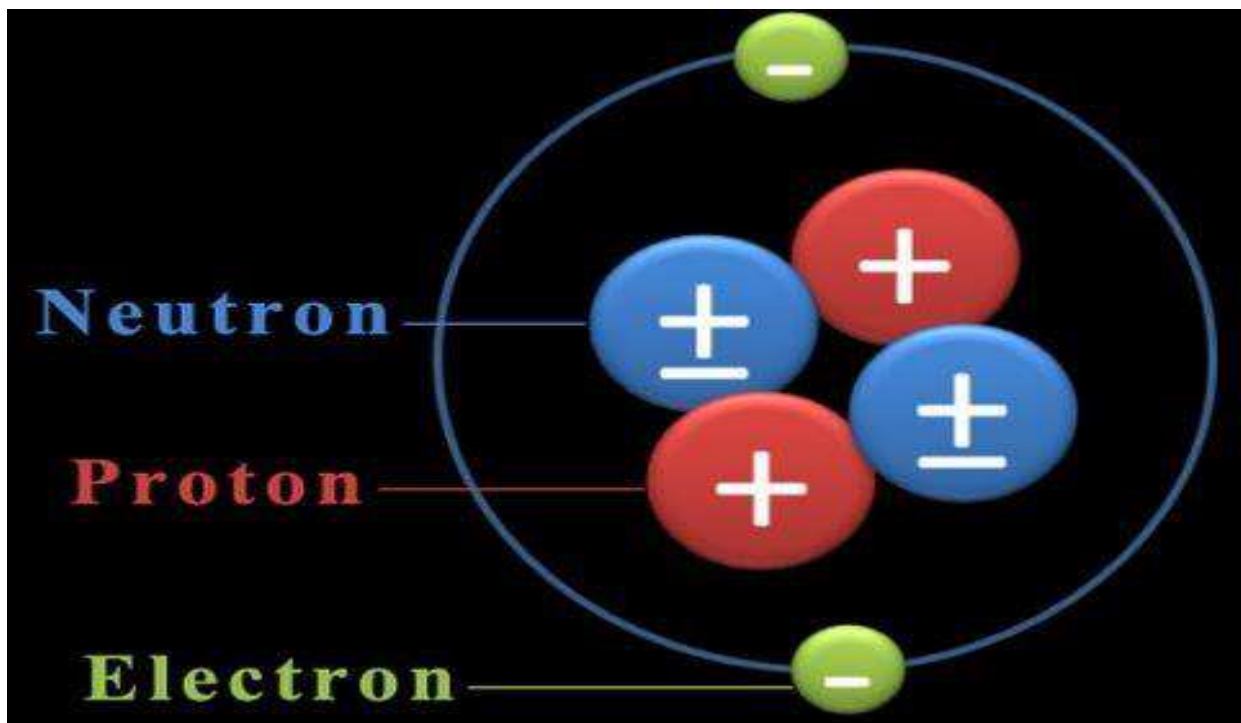
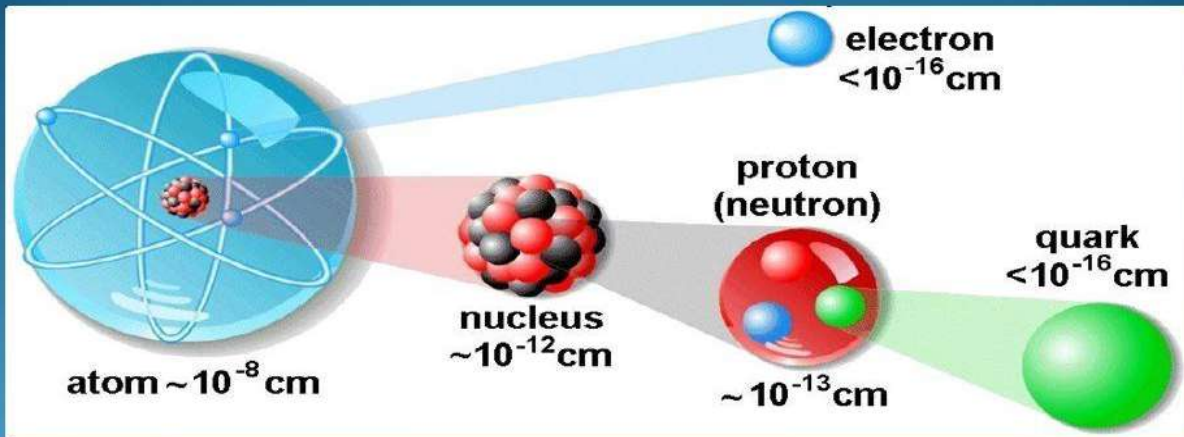
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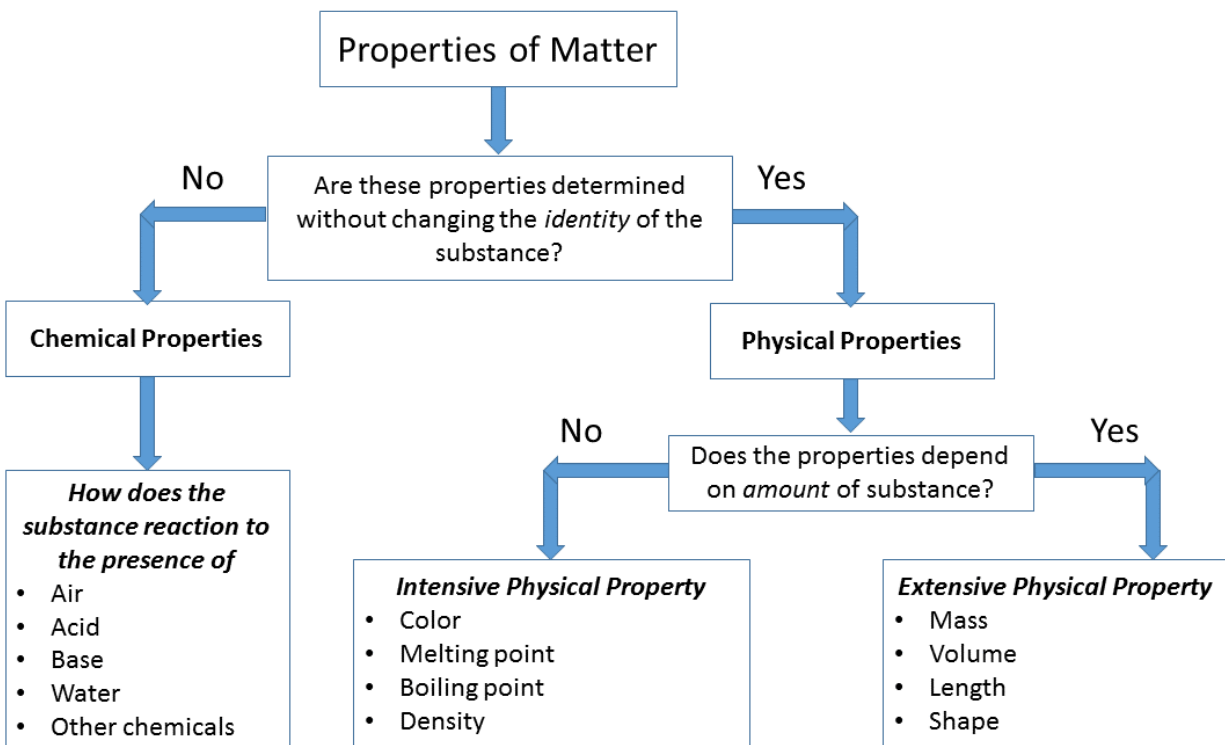
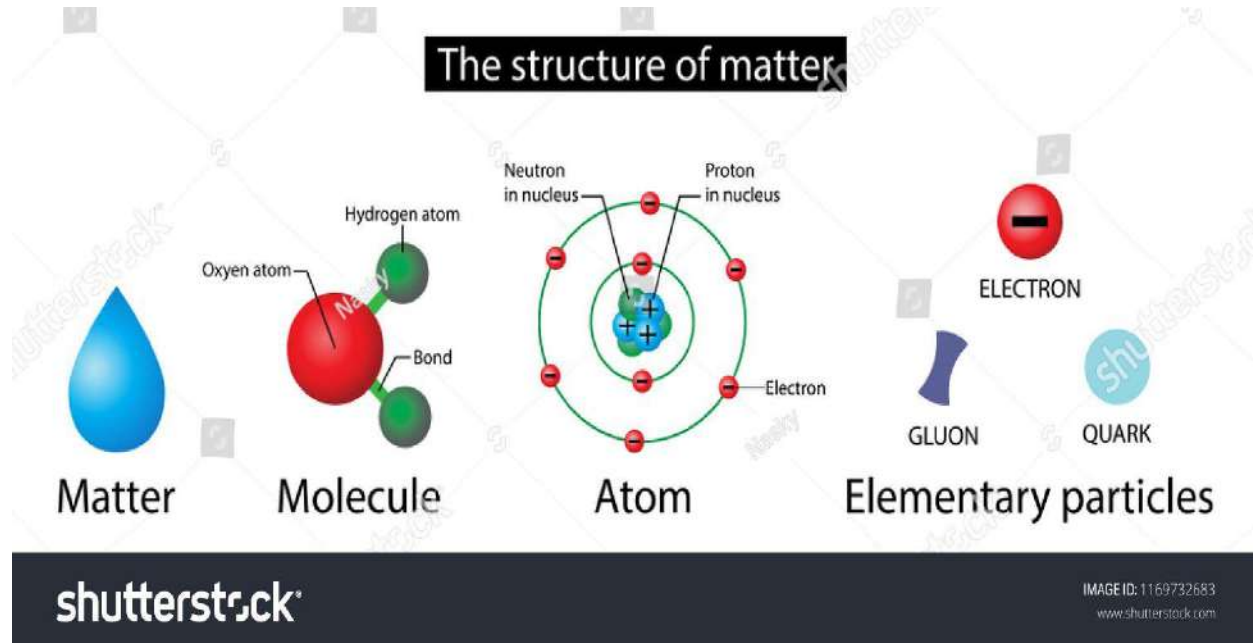
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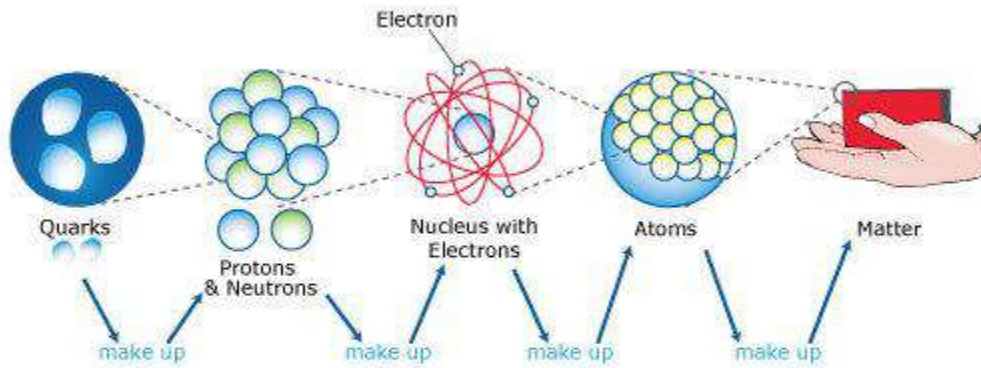


## Chapter Six

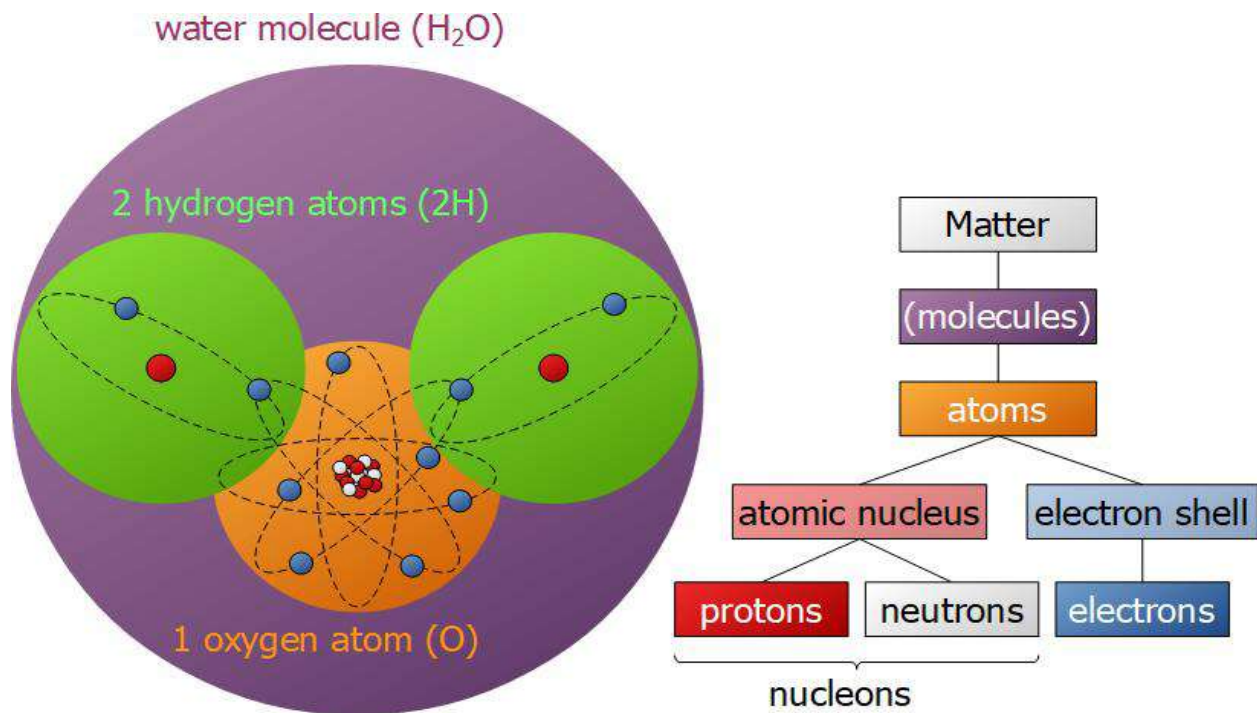
# The Structure of Matter







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WHO Studies structure of matter?

Chemistry is also the study of **matter's** composition, **structure**, and properties. **Matter** is essentially anything in the world that takes up space and has mass. Chemistry is sometimes called “the central science,” because it bridges physics with other natural sciences, such as geology and biology.

What are the 4 types of atoms?

### **Different Kinds of Atoms**

- Description. Atoms are made of tiny particles called protons, neutrons and electrons. ...
- Stable. Most atoms are stable. ...
- Isotopes. Every atom is a chemical element, like **hydrogen**, iron or chlorine. ...
- Radioactive. Some atoms have too many neutrons in the nucleus, which makes them unstable. ...
- Ions. ...
- Antimatter.

What are 10 examples matter?

### Examples of Matter

An apple.

A person.

A table.

Air.

Water.

A computer.

Paper.

Iron.

What is structure and properties of matter?

**Matter** exists as different substances that have observable different **properties**. ...

The fact that **matter** is composed of atoms and molecules can be used to explain the **properties** of substances, diversity of materials, states of **matter**, phase changes, and conservation of **matter**.

What is the smallest unit of matter?

atom

The atom is the **smallest** and most fundamental **unit of matter**. It consists of a nucleus surrounded by electrons.052020/06/

How many elements are there?

118 elements

Click on any elements name for further chemical properties, environmental data or health effects. This list contains the **118 elements** of chemistry.

Are humans made of atoms?

About 99 percent of your body is **made** up of **atoms** of hydrogen, carbon, nitrogen and oxygen. You also contain much smaller amounts of the other elements that are essential for life. ... The hydrogen **atoms** in you were produced in the big bang, and the carbon, nitrogen and oxygen **atoms** were **made** in burning stars.032015/11/

Can an atom be created?

**Atoms** cannot be **created** nor destroyed, and they are indestructible; they cannot be broken into smaller parts. This was based on the Law of Conservation of Mass. It was later learned that **atoms can** break into smaller parts. Chemical reactions involve a separation, combination, or rearrangement of **atoms**.

?

Is water made of matter?

Reference Article: Facts about the states of **matter**. A glass holds H<sub>2</sub>O in three states of **matter**: ice (solid), **water** (liquid) and vapor (gas). **Matter** is the "stuff" that makes up the universe — everything that takes up space and has mass is **matter**

What items is not matter?

### 10 Examples of Things That Are Not Matter

- Vacuum: By definition, a vacuum is a region that does not contain any matter. ...

- Energy: **Light**, heat, kinetic and potential energy, and sound are **non-matter** because they are massless. ...
- Time: Time can be measured, but it has no mass and occupies no volume.
- Rainbow: A rainbow is an optical phenomenon.

What are the properties of matter?

The properties of matter include any traits that can be measured, such as an object's **density**, **color**, **mass**, **volume**, length, malleability, melting point, hardness, **odor**, temperature, and more.

What are 4 properties of matter?

**Some examples of physical properties are:**

- color (intensive)
- **density** (intensive)
- **volume** (extensive)
- **mass** (extensive)
- Boiling point (intensive): the temperature at which a substance boils.
- Melting point (intensive): the temperature at which a substance melts.
- - What are the 5 properties of matter?
  - Extensive properties vary with the **amount of the substance** and include mass, weight, and **volume**. Intensive properties, in contrast, do not depend on the **amount of the substance**; they include **color**, melting point, boiling point, electrical conductivity, and **physical state** at a given temperature.052020/09/
- - What is basic unit of matter?
  - Different elements are different kinds of **matter** distinguished by different physical and chemical properties. In turn, the atom is the **fundamental unit of matter**..., that is, of an element. The number of positively charged protons and neutral neutrons in an atomic nucleus account for most of the mass of an atom.142020/08/
- - What's the smallest particle?
  - Quarks

- **Quarks**, the smallest particles in the universe, are far smaller and operate at much higher energy levels than the **protons** and **neutrons** in which they are found.042019/03/

What's smaller than an atom?

In the physical sciences, subatomic particles are smaller than atoms. They can be composite particles, such as the **neutron** and **proton**; or elementary particles, which according to the standard model are not made of other particles. Particle physics and nuclear physics study these particles and how they interact.

- 
- What is the largest unit of matter?
- What is the largest unit of matter? There is only one. **Natural unit** of matter and its size is impossible to measure, but it is the smallest amount of matter that can exist.
- What are 10 physical properties of matter?
- Physical properties include: appearance, texture, color, odor, **melting point**, **boiling point**, **density**, solubility, polarity, and many others.

What are physical properties of matter and examples?

**Some examples of physical properties are:**

- **color** (intensive)
- **density** (intensive)
- volume (extensive)
- mass (extensive)
- **Boiling point** (intensive): the temperature at which a substance boils.
- **Melting point** (intensive): the temperature at which a substance melts.

Which state of matter is most important?

Overall, **plasmas** are the most common state of matter – they make up 99% of the visible universe.122010/04/

What is a solid object?

**Objects** that occupy space are called **solid** shapes. Their surfaces are called faces. Faces meet at edges and edges meet at vertices. Some examples of **solid** shapes: Cone, Cuboid, Sphere, Cylinder, Cube. ... Sphere has neither any edges nor vertices.312015/08/

What are the 5 properties of matter?

Extensive properties vary with the **amount of the substance** and include mass, weight, and **volume**. Intensive properties, in contrast, do not depend on the **amount of the substance**; they include **color**, melting point, boiling point, electrical conductivity, and **physical state** at a given temperature.052020/09/

What are chemical properties of matter?

Chemical properties of matter, on the other hand, are characteristics that can only be measured and observed when the substance has a change in chemical composition. Corrosiveness, **flammability**, toxicity, acidity, or chemical **reactivity** are all examples of chemical properties of matter.

What are the properties of matter 2nd grade?

Materials (and matter) have different properties. **Objects** can be sorted and classified by properties. Observable properties include color, flexibility, **hardness**, texture, and absorbency. Properties of small **objects** do not change when the pieces are used to build larger **objects**.

What are the properties of matter 2nd grade?

Materials (and matter) have different properties. **Objects** can be sorted and classified by properties. Observable properties include color, flexibility, **hardness**, texture, and absorbency. Properties of small **objects** do not change when the pieces are used to build larger **objects**.

Is DNA made of atoms?

**DNA**, which stands for deoxyribonucleic acid, resembles a long, spiraling ladder. It consists of just a few kinds of **atoms**: carbon, hydrogen, oxygen, nitrogen, and phosphorus. ... Nucleotides are the units which, when linked sugar to phosphate, make up one side of a **DNA** ladder.

What is the chemical formula for fire?

The heat of the flame will keep remaining fuel at ignition temperature. The flame ignites gases being emitted, and the **fire** spreads. As long as there is enough fuel and oxygen, the **fire** keeps burning. Fuel + oxygen (from the air) = combustion products (mainly  $\text{CO}_2 + \text{H}_2\text{O}$ ) + heat energy.192009/11/

Why is fire plasma?

The bottom line is that a **flame** only becomes plasma if it gets hot enough. Flames at lower temperatures do not contain enough ionization to become plasma. On the other hand, a higher-temperature **flame** does indeed contain enough freed electrons and ions to act as a **plasma**.282014/05/

What is fire chemically?

**Fire** is the rapid oxidation of a material in the exothermic **chemical** process of combustion, releasing heat, light, and various reaction products. ... The **flame** is the visible portion of the **fire**. Flames consist primarily of carbon dioxide, water vapor, oxygen and nitrogen.

What are two classification of matter?

### **Classifying Matter**

**Matter** can be **classified** into several categories. **Two** broad categories are mixtures and pure substances. ... Pure substances may be divided into **two** classes: elements and compounds. Pure substances that cannot be broken down into simpler substances by chemical changes are called elements.142019/02/

What are the two main types of matter?

We can classify matter into several categories. Two broad categories are mixtures and **pure substances**. A **pure substance** has a constant composition. All specimens of a **pure substance** have exactly the same makeup and properties.

What are the 5 classification of matter?

Phases of **matter**: There are four natural states of **matter**: Solids, liquids, gases and plasma. The fifth state is the man-made Bose-Einstein condensates. In a solid, particles are packed tightly together so they don't move much.212019/08/

Does matter exist?

**Matter exists** in various states (also known as phases). These include classical everyday phases such as solid, liquid, and gas – for example water **exists** as ice, liquid water, and gaseous steam – but other states are possible, including plasma, Bose–Einstein condensates, fermionic condensates, and quark–gluon plasma.

# Introduction to Analytical Chemistry



# Lesson 1 Objectives

## Students should be able to:

1. Define and differentiate the following terms: Qualitative analysis, Quantitative analysis & Analytes.
2. Define the role of analytical chemistry.
3. Define quantitative analytical methods.
4. Define the following terms: Heterogeneous materials, an assay, Replicate samples, Interference, Specific and Selective techniques and reactions, sample matrices and calibration.
5. Discuss the process of quantitative analysis.

# The Analytical Chemistry Laboratory



# What is Analytical Chemistry?

- **Analytical Chemistry** provides the methods and tools needed for insight into our material world...for **answering four basic questions** about a material sample:
  - What?
  - Where?
  - How much?
  - What arrangement, structure or form?

# Areas of Chemical Analysis and Questions They Answer

- Detection:
  - Does the sample **contain** substance X?
- Separation:
  - How can the **species of interest be separated** from the sample matrix for better quantitation and identification?
- Quantitation:
  - **How much** of substance X is in the sample?
- Identification:
  - **What** is the identity of the substance in the sample?

# What is the Role of Analytical Chemistry?

- Analytical chemistry is applied throughout **industry**, **medicine**, and **all the sciences**.

- Examples:

1. To determine the **concentration of oxygen and carbon dioxide** in **blood samples** to **diagnose and treat** illnesses.

1. Determination of **nitrogen in foods** establishes their **protein content** and thus their **nutritional value**.

Home Work: What are three (3) other examples?

# Definitions

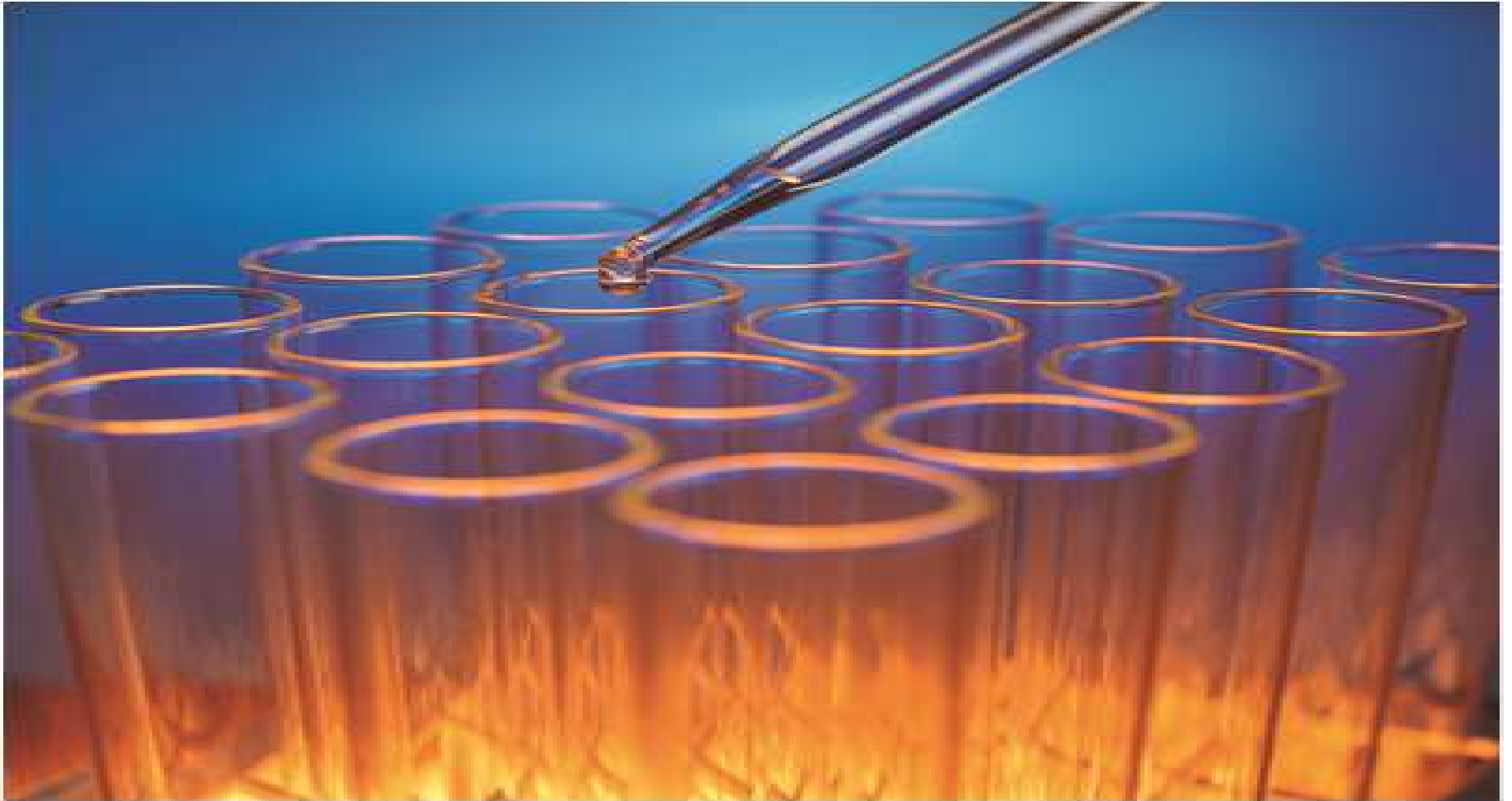


# Heterogeneous Materials



- A **heterogeneous mixture** is a mixture where the **components** of the mixture are **not uniform** or have **localized regions** with **different properties**.

# Assay



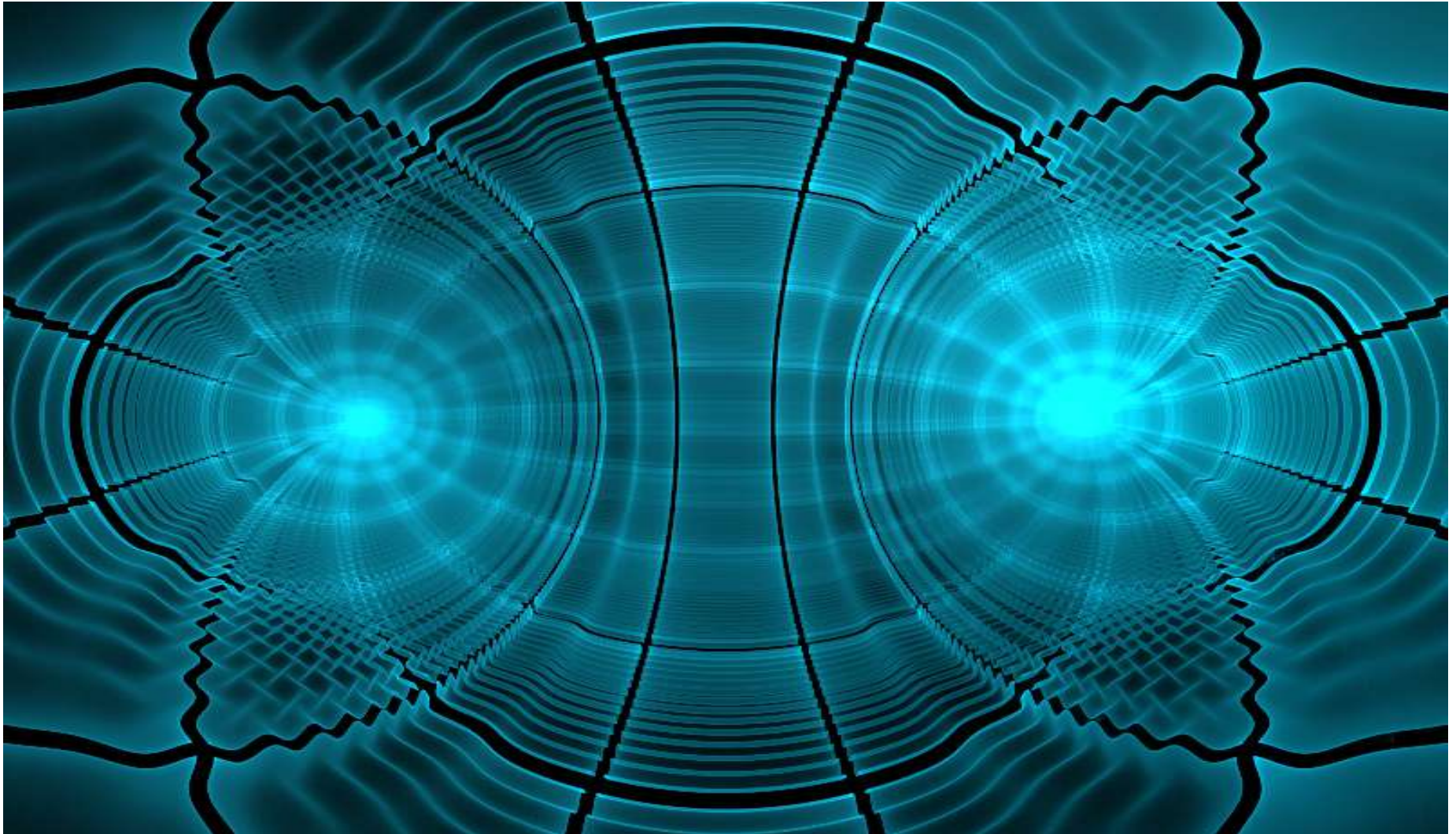
- The process of determining how much of a given sample is the material indicated by its name.

# Replicate Samples



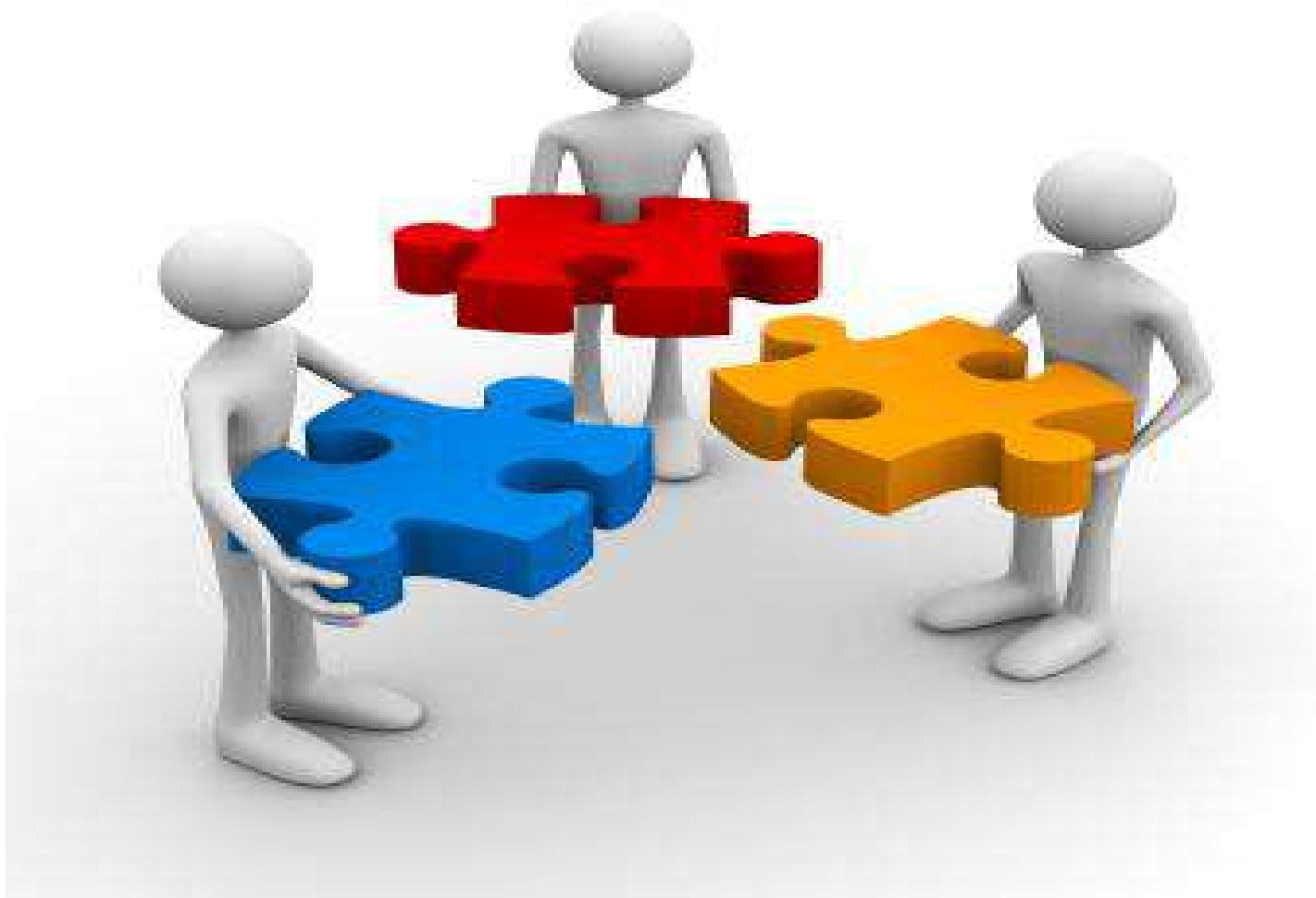
- Portions of a material, of approximately the same size, that are carried through an analysis at the same time and in the same way.

# Interferences



- Species that affect the signal on which an analysis is based.

# Specificity



- Refers to methods or reagents that respond or react with one and only one analyte.

# Selectivity



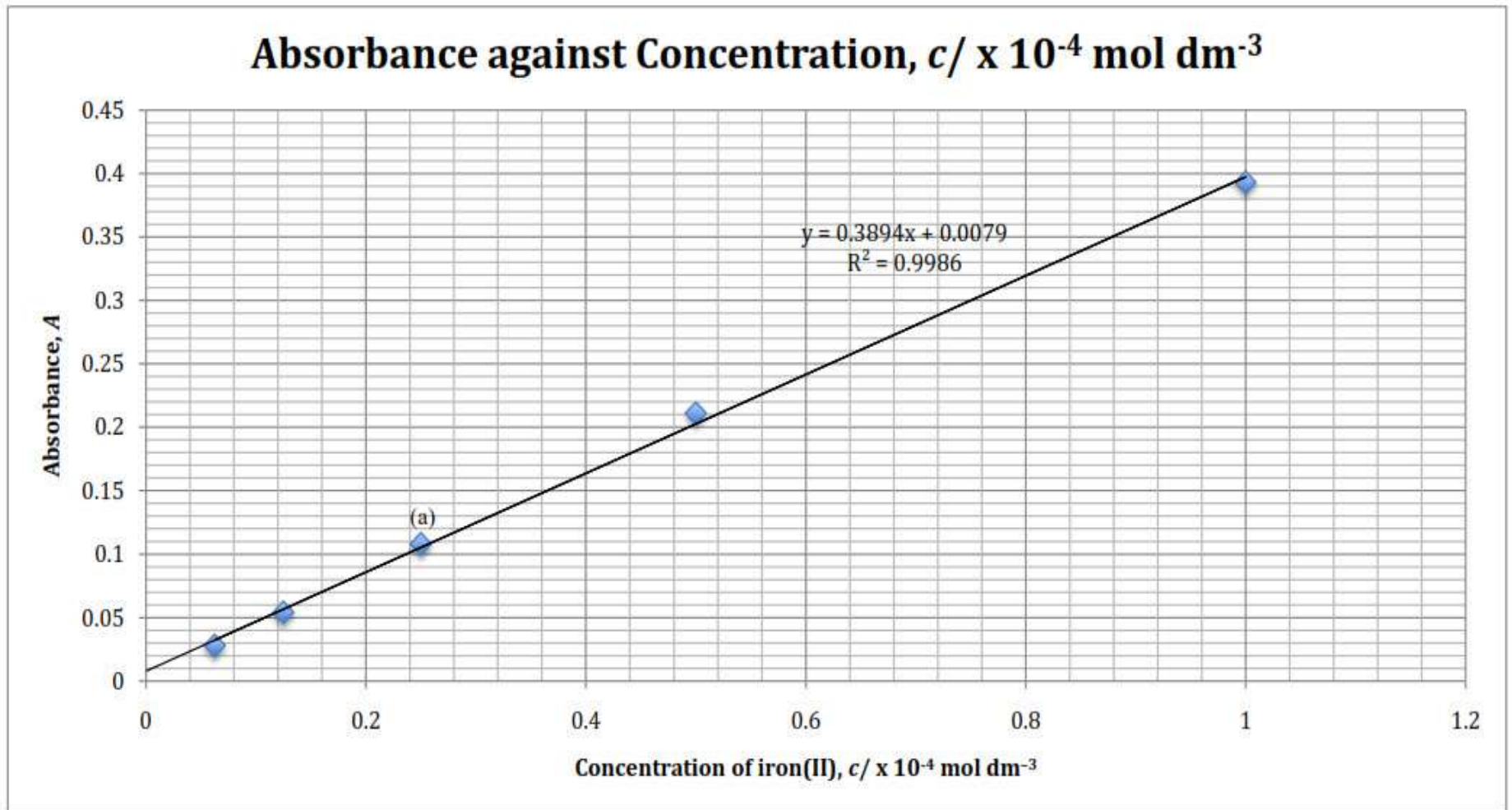
- The tendency for a reagent or an instrumental method to react with or respond similarly to only a few species.

# Sample Matrix



- The medium that contains an analyte.

# Calibration



- The empirical determination of the relationship between a measured quantity and a known reference or standard value.

# Analyte



- The analyte is the sample being analysed.

# What is the difference between qualitative and quantitative analysis?

- Two main types of chemical analysis:
  - **Qualitative**: branch of chemistry that deals with the **identification** of elements or grouping of elements present in a sample
  - **Quantitative**: branch of chemistry that deals with the determination of the **amount or percentage** of one or more constituents of a sample.



Qualitative analysis is what.

Quantitative analysis is how much.

# Types of qualitative and quantitative analysis

- Qualitative Analysis
  - qualitative inorganic analysis
  - qualitative organic analysis
- Quantitative Analysis
  - Chemical
  - Physical

# Qualitative Inorganic Analysis



- A solution is treated with **various reagents** to test for **reactions characteristic of certain ions**, which may cause **color change**, **solid forming** and other **obviously visible changes**.

# Qualitative Organic Analysis



Organic compounds are analysed using all or some of the following methods:

- (1) Analysis of **physical properties**
- (2) Classification by **solubility**
- (3) **Spectroscopic analysis**
- (4) Classification **tests for functional groups**
- (5) Synthesis of **solid derivatives**

# Quantitative Chemical Analysis

## Main methods:

- Gravimetric: includes all methods of analysis in which the final stage of the analysis involves weighing.
- Titrimetric: volumetrically measures the amount of reagent, often called a titrant, required to complete a chemical reaction with the analyte.
- Electroanalytical: involves the measurement of electrical properties in relation to the concentration of analyte in the sample.
- Spectroscopic: based on measurement of the interaction between electromagnetic radiation and the analyte.

# The Process of Quantitative Analysis

- The analytical process begins with a question such as "Is this water safe to drink?"
- A scientist translates such questions into the need for particular measurements.
- An analytical chemist then must choose or invent a procedure to carry out those measurements.
- The analyst must translate the results of the completed analysis into terms that can be understood preferably by the general public.
- A most important feature of any results is its limitations- which reflect the reliability of the results.
- The results and their limitations are used to draw conclusions and reach decisions.

# The Process of Chemical Analysis



- Let us look at this [process](#) in a bit more detail...

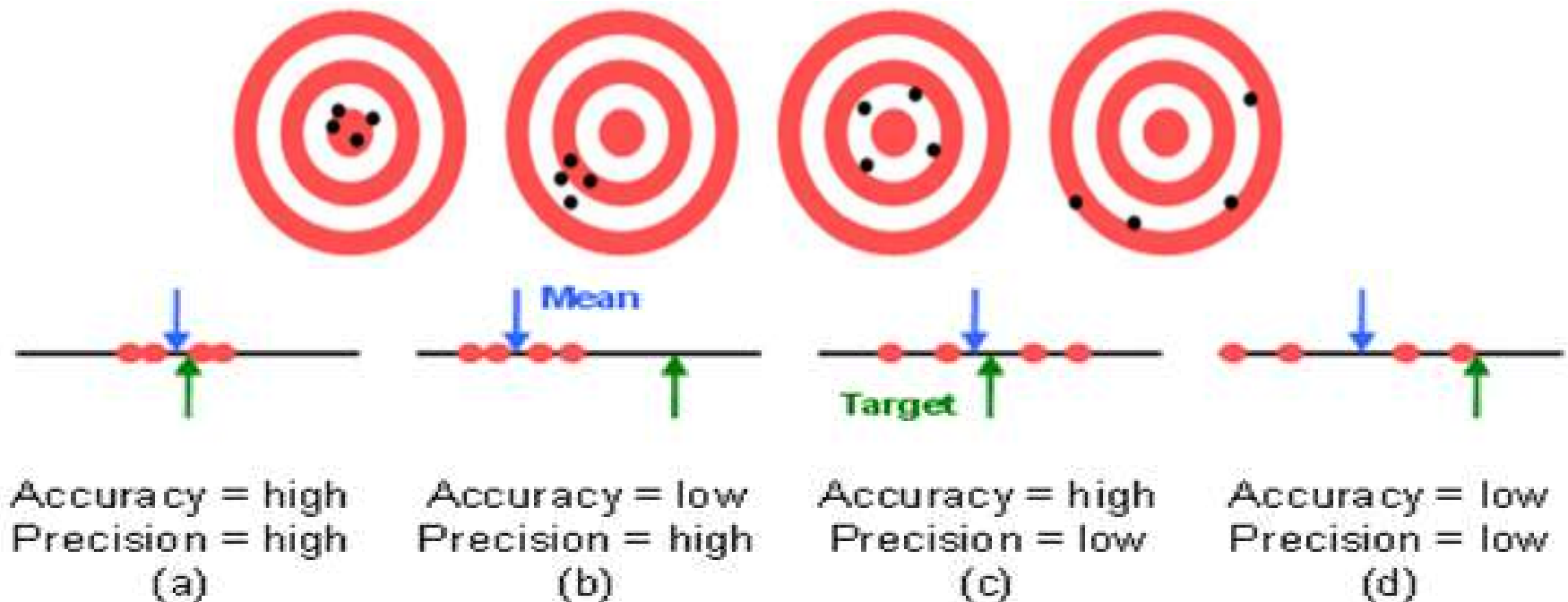
# Data Analysis

- Since **analytical chemistry** is the science of making **quantitative measurements**, understanding the difference between **accuracy** and **precision** is vital.
- Also, it is important that **raw data** is **manipulated** and **reported correctly** to give a **realistic estimate** of the uncertainty in a result.
- **Presentation** of data in the form of **graphs** is **extremely useful**.



# Accuracy and precision

- Accuracy is **how close** a measured value is to the **actual (true) value**.
- Precision is **how close** the measured values are **to each other**.
- Study the diagrams below. The target is the centre. Which diagram(s) show high accuracy? Which show high precision?



# Bias

## Bias (don't let precision fool you!)

- So, if you measure something several times and **all values are close**, they **may still all be wrong** if there is a "**Bias**"
- **Bias** is a **systematic (built in) error** which makes **all measurements wrong by a certain amount**.

## Examples of Bias

- The scales read "1 kg" when there is no weight on them
- You always measure your height wearing shoes with thick soles.
- A stopwatch that takes half a second to stop when clicked

# The Laboratory Notebook

- Your **Critical Record**
- Why must **all data be recorded in ink when they are collected?**
- **Saving Time:**
  - don't have to reorganize and rewrite data
  - more organized and prepared to carry out the analysis
- **Immediate record:**
  - detect possible errors in measurements and calculations
  - data will not be lost or transferred incorrectly

# A Typical Quantitative Analysis



## **Group Discussion & Presentation.**

Construct a flow diagram to show the steps involved in a typical quantitative analysis. Include considerations for each step.

# Sampling



**Individual Activity: Read Chapter 8 & the article on Environmental Sampling and make short notes on the following questions.**

1. Describe the steps in a well-designed sampling plan.
2. What is the importance of a good sample?
3. What factors must be considered when obtaining a sample?
4. What factors must be considered when storing and transporting a sample?

# Assignment



## READ:

### Fundamentals of Analytical Chemistry (8th Edition)

- **Chapter 1:** The Nature of Analytical Chemistry, pages 2 – 16,
- **Chapter 2:** Chemicals, Apparatus, and Unit Operations in Analytical Chemistry, pages 20 – 53
- **Chapter 4:** Calculations Used in Analytical Chemistry, pages 71 – 89
- **Chapter 8:** Sampling, Standardization and Calibration, pages 175 – 191

# References

## **1. Fundamentals of Analytical Chemistry (8th Edition)**

Douglas A. Skoog

Donald M. West

F. James Holler

Stanley R. Crouch

## Expression of Strengths Percent Concentration:

The term "Per cent" or more usually the symbol "%" is used with one of four different meanings in the expression of concentrations according to circumstances. In order that the meaning to be attached to the expression in each instance is clear, the following notation is used...

a) Percent w/w (%w/w) - (Percentage weight in weight) expresses the number of grams of solute in 100 gm. of product. The concentrations of strong acids, as available commercially, are expressed in this way. E.g.,  $\text{H}_2\text{SO}_4$  98.0% w/w;  $\text{CH}_3\text{COOH}$  33% w/w etc. 4 Also expressing the percentage purity of the solid dosage forms such as tablets, capsules etc. as Percent weight/weight (%w/w).

b) Percent w/v (%w/v) - (Percentage weight in volume) It expresses the number of grams of solute in 100 ml of product. (i.e. 100 ml of solution). This is a common way of specifying solution composition of mixtures of miscible liquids, or solids in liquids. e.g.  $\text{H}_2\text{O}_2$  solution 5-7% w/v;  $\text{BaCl}_2$  solution 10% w/v etc.

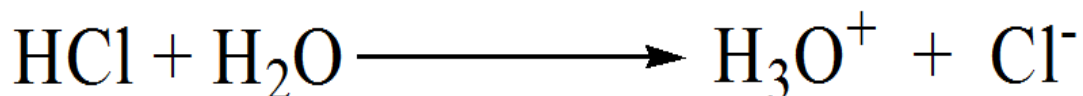
c) Percent v/v (%v/v) - (Percentage volume in volume) It expresses the number of milliliters of solute in 100 ml of product. e.g. Alcohol 95% v/v.

d) Percent v/w (%v/w) - (Percentage volume in weight) It expresses the number of milliliters of solute in 100 gm. of product. Usually the strength of solutions of solids in liquids are expressed as percentage weight in volume, of liquids as percentage volume in volume and of gases in liquids as percentage weight in weight.

e) Parts per million (ppm) - When the concentration of a solution is expressed as parts per million (ppm), it means weight in weight, unless otherwise specified. ppm- the number of grams of solute contained in 106 gm. of solution. e.g. In the limit test of chloride 25 ppm of cl.

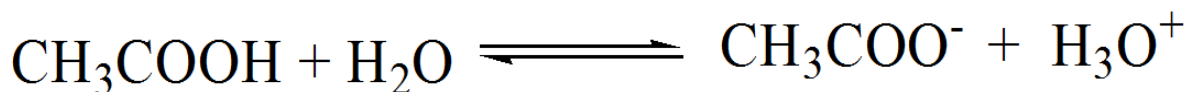
## Acid-base titration curves

Before we start discussing about titration and titration curves, we should quickly refresh the concept of a weak/strong acid and weak/strong base. A strong acid dissociates (or ionizes) completely in aqueous solution to form hydronium ions.



### Diagram of strong acid ionizing to form hydronium ions

A weak acid does not dissociate completely in aqueous solution to form hydronium ions.



A strong base dissociates completely in aqueous solution to form hydroxide ions.



A weak base does not dissociate completely in aqueous solution to form hydroxide ions.



Examples of weak/strong acids and bases

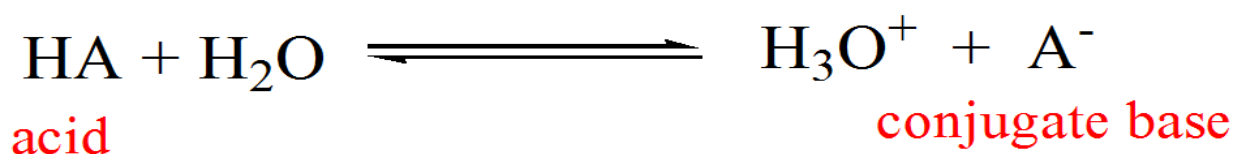
Type	Examples
<b>Strong Acids</b>	Hydrochloric acid (HCl), sulfuric acid (H <sub>2</sub> SO <sub>4</sub> ), nitric acid (HNO <sub>3</sub> )
<b>Weak Acids</b>	acetic acid (CH <sub>3</sub> COOH), hydrofluoric acid (HF), oxalic acid (HOOC-COOH)

Type	Examples
<b>Strong Bases</b>	sodium hydroxide (NaOH), potassium hydroxide (KOH), lithium hydroxide (LiOH)

**Weak**

**Bases** ammonium hydroxide (NH<sub>4</sub>OH), ammonia (NH<sub>3</sub>)

Weak acids and weak bases always exist as *conjugate acid-base pairs* in an aqueous solution as represented below



Here, HA is the acid and A<sup>-</sup> is termed as the conjugate base of HA.



In the above reaction, A<sup>-</sup> superscript is a base and HA is the conjugate acid of A<sup>-</sup>.

Rule of thumb is: *Weak acids have strong conjugate bases, while weak bases have strong conjugate acids. As shown in the above two reactions, if HA is a weak acid, then its conjugate base A<sup>-</sup> superscript will be a strong base.*

*Similarly, if A<sup>-</sup> is a weak base, then its conjugate acid HA will be a strong acid.*

## How do we define ‘titration’?

Illustration of titration setup with burette and conical flask

Titration is a technique *to determine the concentration of an unknown solution*. As illustrated in the titration setup above, a solution of known

concentration (*titrant*) is used to determine the concentration of an unknown solution (*titrand or analyte*).

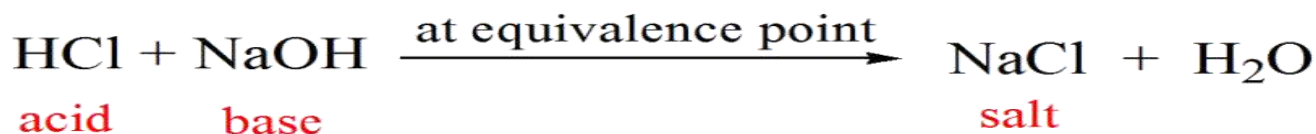
Typically, the titrant (the solution of known concentration) is added through a burette to a known volume of the analyte (the solution of unknown concentration) until the reaction is complete. Knowing the volume of titrant added allows us to determine the concentration of the unknown analyte.

Often, an *indicator* is used to signal the end of the reaction, the *endpoint*.

Titrand and analyte is a pair of acid and base. *Acid-base titrations are monitored by the change of pH as titration progresses.*

Let us be clear about some terminologies before we get into the discussion of titration curves.

- **Titrand:** solution of a known concentration, which is added to another solution whose concentration, has to be determined.
- **Titrand or analyte:** the solution whose concentration has to be determined.
- **Equivalence point:** point in titration at which the amount of titrant added is just enough to completely neutralize the analyte solution. *At the equivalence point in an acid-base titration, moles of base = moles of acid and the solution only contains salt and water.*



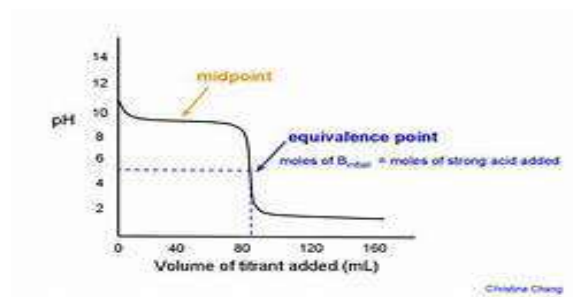
Acid-base titrations are monitored by the change of pH as titration progresses

Indicator: For the purposes of this tutorial, it's good enough to know that an indicator is a weak acid or base that is added to the analyte solution, and it changes color when the equivalence point is reached i.e. the point at which the amount of titrant added is just enough to completely neutralize the analyte

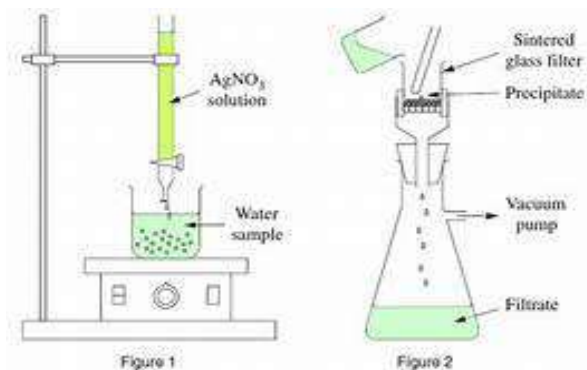
solution. The point at which the indicator changes color is called the endpoint. So the addition of an indicator to the analyte solution helps us to visually spot the equivalence point in an acid-base titration.

Endpoint: refers to the point at which the indicator changes color in an acid-base titration.

**What is a titration curve?** A titration curve is the plot of the pH of the analyte solution versus the volume of the titrant added as the titration progresses.



**Titration curve chart**



**Gravimetric example**

# Chemistry of buffers and buffers in our blood

Let's go to a chemistry lab and conduct a simple experiment. As shown below, we have

1. two solutions - 50 mL of **A** and 50 mL of **B** respectively
2. a solution of 0.2M hydrochloric acid (HCl)
3. a solution of 0.2M sodium hydroxide (NaOH)
4. pH meter to measure pH of the solution

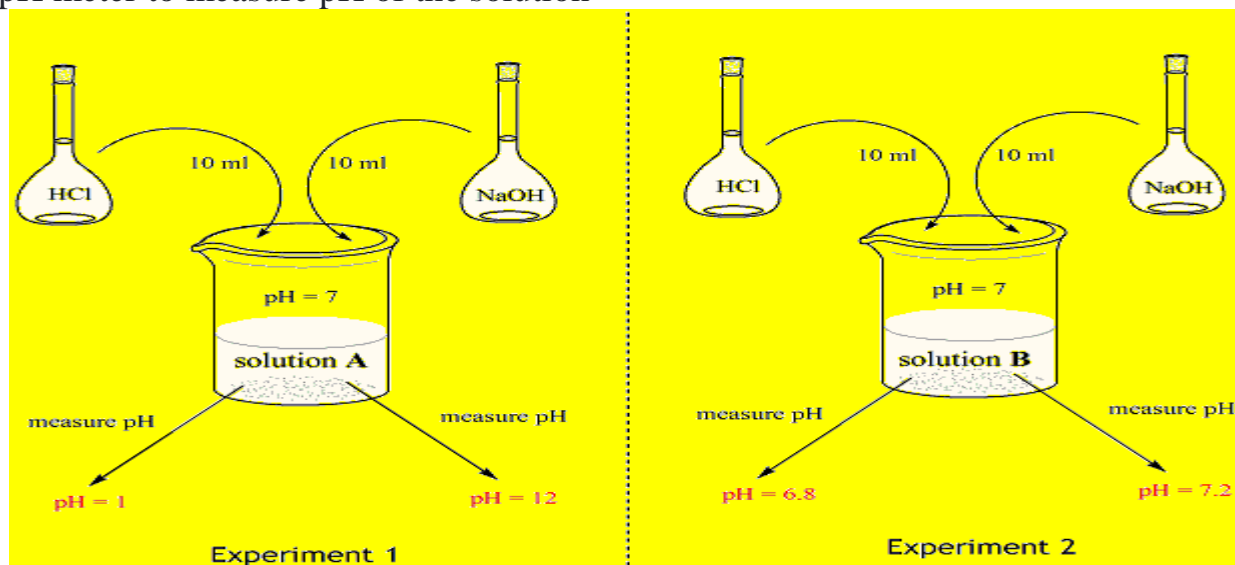


Illustration of experiment 1 and experiment 2

**Experiment 1:** The pH of solution **A** is 7.0 i.e. it's neutral. When we add 10 mL of 0.2M HCl to it, the pH decreases to 1.5. On the other hand, when we add 10 mL of 0.2M NaOH to solution **A** the pH shoots up to 12.5. In both these cases we see a drastic change in pH due to either the increase or decrease of proton  $[H^+]$ .

Remember, *pH of a solution is dependent on the concentration of hydronium ions.*

**Experiment 2:** Let's see what happens when we repeat the same experiment with solution **B**, whose pH is also maintained at 7.0. When we add 10 mL of 0.2M HCl to it, the pH decreases by only 0.2 units to 6.8. Next, when we add 10 mL of

NaOH to solution B, the pH just slightly rises to 7.2 from 7.0. In both these cases we do not see a drastic change in pH, as we observed with solution A.

*So, our observation from this experiment is that solution A underwent drastic changes in pH upon addition of a strong acid or a strong base, while solution B resisted a change in pH.*

Can you guess what the difference might be between solutions A and B?

*Solution A is pure 'water', while solution B is a 'buffer'.*

## How do we define a buffer?

*"A buffer is an aqueous solution that resists changes in pH upon the addition of an acid or a base".* Also, adding water to a buffer or allowing water to evaporate from the buffer does not change the pH of a buffer significantly.

Buffers basically constitute a pair of a weak acid and its conjugate base, or a pair of a weak base and its conjugate acid.

### Example:

Acetic acid ( $\text{CH}_3\text{COOH}$ ) + Sodium acetate ( $\text{CH}_3\text{COONa}$ ).

### Principles of Buffers:



Where, HAC=Acetic acid; NaAC = Sodium acetate.

If alkali (NaOH) is added to this system, it will form salt and no free  $\text{H}^+$  or  $\text{OH}^-$  will be available.



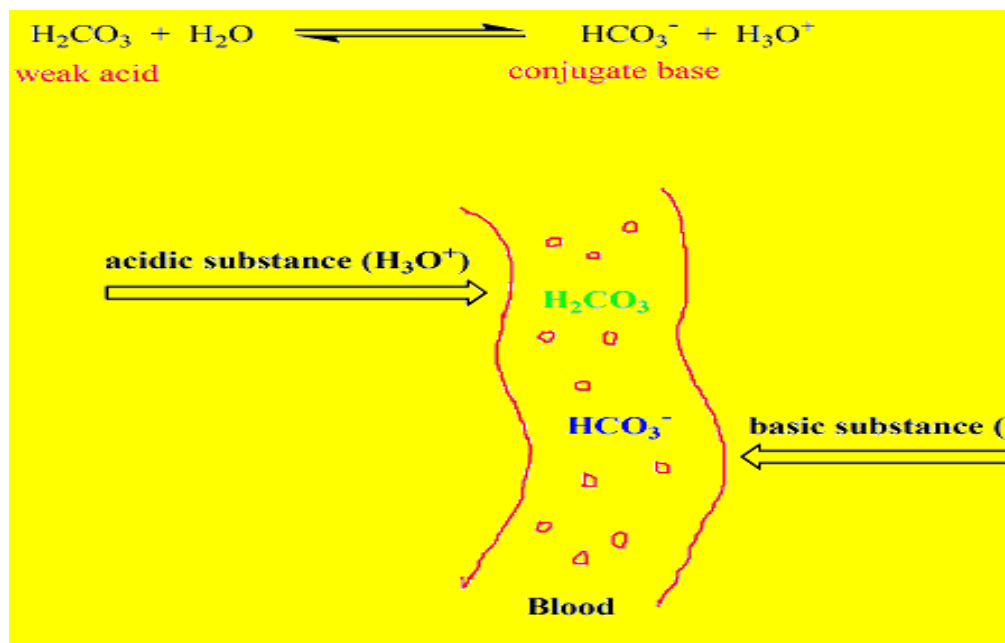
If acid (HCl) is added to this system, it will also form salt and no free  $\text{H}^+$  or  $\text{OH}^-$  will be available.



In either cases there is no change in hydrogen ion concentration. The buffer acts almost as if it were “absorbing” the added free hydrogen or hydroxyl ions.

## Buffering system of blood

Maintaining a constant blood pH is critical for the proper functioning of our body. The buffer that maintains the pH of human blood involves



### Diagram carbonic acid - bicarbonate ion system in human blood

When any acidic substance enters the bloodstream, the bicarbonate ions neutralize the hydronium ions forming carbonic acid and water. Carbonic acid is already a component of the buffering system of blood. Thus hydronium ions are removed, preventing the pH of blood from becoming acidic.



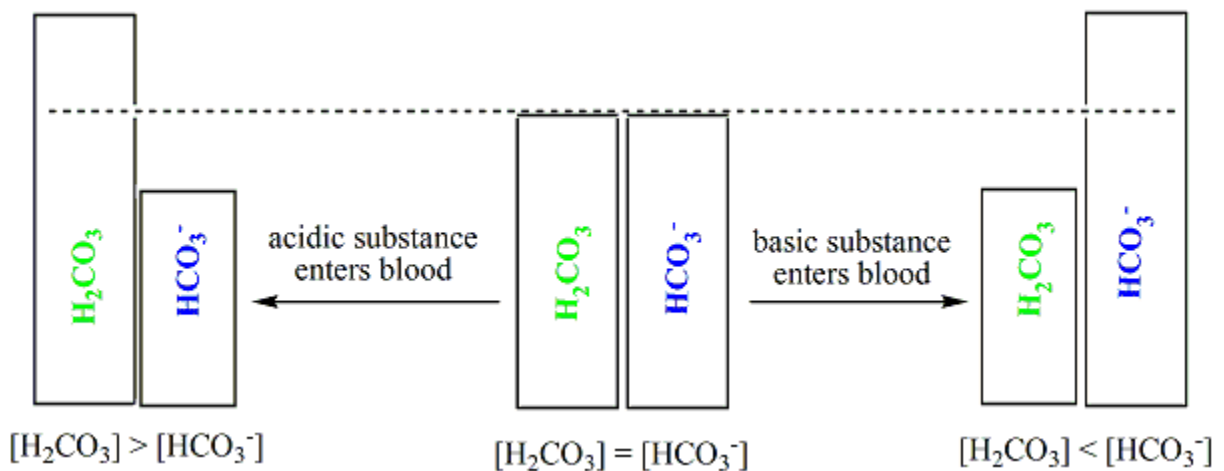
Chemical reaction diagram of bicarbonate ions neutralizing hydronium ions forming carbonic acid and water

On the other hand, when a basic substance enters the bloodstream, carbonic acid reacts with the hydroxide ions producing bicarbonate ions and water. Bicarbonate ions are already a component of the buffer. In this manner, the hydroxide ions are removed from blood, preventing the pH of blood from becoming basic.



Chemical diagram of carbonic acid reacting with hydroxide ions producing bicarbonate ions and water

The critical thing is that this buffering mechanism prevents the blood from becoming acidic or basic, which can be detrimental.



**Diagram of blood pH maintained at approx. 7.4 by the carbonic acid – bicarbonate ion buffering system**

*The pH of blood is maintained at ~ 7.4 by the carbonic acid – bicarbonate ion buffering system.*

## What does redox reaction stand for?

# Oxidation-Reduction Reactions

- Electrons can be neither created out of nothing nor destroyed
- In any redox reaction there is an element being reduced and an element being oxidized
- The total increase in the oxidation numbers must equal the total decrease in the oxidation numbers

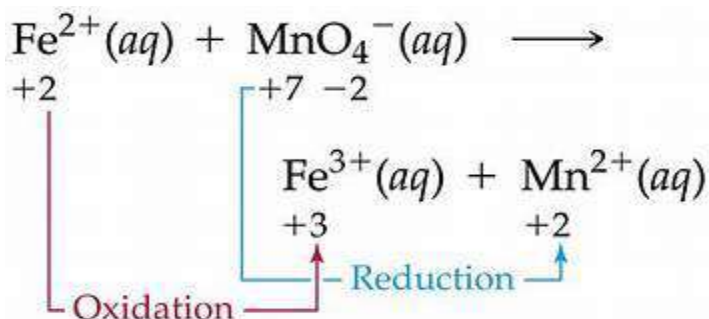
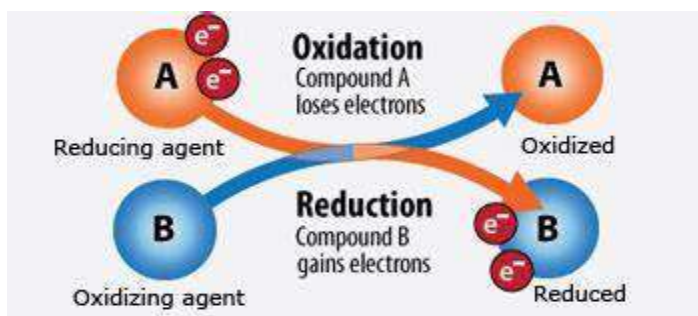
If an element is reduced

- It gains electrons
- Oxidation number decreases
- The substance is classified as an oxidizing agent

If an element is oxidized

- It loses electrons
- Oxidation number increases
- The substance is classified as a reducing agent

1





# Introduction to organic chemistry

## What is the introduction to organic chemistry?

- A brief introduction to organic chemistry Carbon can form covalent bonds with itself and other elements to create a mind-boggling array of structures. In organic chemistry, we will learn about the reactions chemists use to synthesize crazy carbon based structures, as well as the analytical methods to characterize them.

## What is the relationship between organic chemistry and biochemistry?

- The majority of chemical compounds occurring in biological organisms are in fact carbon compounds, so the association between organic chemistry and biochemistry is so close that biochemistry might be regarded as in essence a branch of organic chemistry.
  - **Organic chemistry** is the branch of chemistry that deals with organic molecules. An **organic molecule** is one that contains carbon.
  - All **living organisms** contain carbon. Plants use sunlight to convert carbon dioxide in the air into organic compounds through the process of **photosynthesis**. Animals and other organisms then feed on plants to obtain their own organic compounds. **Fossil fuels** are another important source of carbon.
  - It is the **unique properties of the carbon atom** that give organic compounds certain properties.
  - The carbon atom has **four valence electrons**, so it can bond with many other atoms, often resulting in long chain structures. It also forms mostly **covalent bonds** with the atoms that it bonds to.
  - An organic compound can be represented in different ways, using its **molecular formula, structural formula, semi-structural formula** or **condensed structural formula**.
  - A **functional group** is a particular group of atoms within a molecule, which give it certain reaction characteristics. Organic compounds can be grouped according to their functional group.

- The **hydrocarbons** are organic compounds that contain only carbon and hydrogen. They can be further divided into the alkanes, alkenes and alkynes, based on the type of bonds between the carbon atoms.
- The **alkanes** have only **single bonds** between their carbon atoms and are unreactive. The **alkenes** have at least one **double bond** between two of their carbon atoms and the **alkynes** have at least one **triple bond** between two of their carbon atoms. They are both more reactive than the alkanes.
- An **alcohol** is an organic compound that contains a **hydroxyl group**  $\text{(-OH)}$ .
- The alcohols have a number of different uses including their use as a solvent, for medicinal purposes and in alcoholic drinks.
- The alcohols share a number of **properties** because of the hydroxyl group. The hydroxyl group affects the **solubility** of the alcohols (in water). Those with shorter carbon chains are generally more soluble, and those with longer chains are less soluble. The strong hydrogen bond between the hydrogen and oxygen atoms in the hydroxyl group gives alcohols a higher melting point and boiling point than the hydrocarbons.
- A **carbonyl group** consists of an oxygen atom that is double-bonded to a carbon atom. In a **ketone** the carbonyl group is in the middle of the carbon chain. In an **aldehyde** the carbonyl group is at the end of the chain.
- The **carboxylic acids** are organic acids that contain a **carboxyl group** with the formula  $\text{(-COOH)}$ . In a carboxyl group a carbon atom is double-bonded to an oxygen atom, and it is also bonded to a hydroxyl group.
- The carboxylic acids have weak **acidic properties** because the hydrogen atom is able to dissociate from the carboxyl group.
- An **ester** is formed when an alcohol reacts with a carboxylic acid. Esters contain a carbonyl functional group as well as an oxygen atom bonded to the carbonyl carbon atom and another carbon atom.

- A molecule is said to be **saturated** if it contains the maximum possible number of hydrogen (or other) atoms for that molecule. The alkanes are all saturated compounds.
- A molecule is **unsaturated** if it does not contain the maximum number of hydrogen atoms for that molecule. The alkenes and alkynes are examples of unsaturated molecules. If a double or triple bond is broken, more hydrogen (or other) atoms can be added to the molecule.
- If two compounds are **isomers**, it means that they have the same molecular formulae but different structural formulae.
- Organic compounds are **named** according to their functional group and its position in the molecule, the number of carbon atoms in the molecule and the position of any double and triple bonds. The IUPAC rules for nomenclature are used in the naming of organic molecules.
- Many of the **properties** of the hydrocarbons are determined by their **molecular structure**, the **bonds** between atoms and molecules, and their **surface area**.
- The **melting points** and **boiling points** of the hydrocarbons increase as their number of carbon atoms increases.
- The **molecular mass** of the hydrocarbons determines whether they will be in the gaseous, liquid or solid phase at specific temperatures.
- Three types of reactions that occur are **addition**, **elimination** and **substitution**. The alkenes undergo **addition** reactions because they are unsaturated.

## Hydrocarbons

The simplest class of organic compounds is the hydrocarbons, which consist entirely of carbon and hydrogen.

1. The four major classes of hydrocarbons are the following: the alkanes, which contain only carbon–hydrogen and carbon–carbon single bonds;
2. The alkenes, which contain at least one carbon–carbon double bond;
3. The alkynes, which contain at least one carbon–carbon triple bond;
4. The aromatic hydrocarbons, which usually contain rings of six carbon atoms that can be drawn with alternating single and double bonds. Alkanes are also called *saturated* hydrocarbons, whereas hydrocarbons that contain multiple bonds (alkenes, alkynes, and aromatics) are *unsaturated*.

## Alkanes

The following table lists the IUPAC names assigned to simple continuous-chain alkanes from C-1 to C-10. A common “**ane**” suffix identifies these compounds as alkanes. Longer chain alkanes are well known, and their names may be found in many reference and text books.

The names **methane** through **decane** should be memorized, since they constitute the root of many IUPAC names. Fortunately, common numerical prefixes are used in naming chains of five or more carbon atoms.

Name	Molecular Formula	Structural Formula	Isomers	Name	Molecular Formula	Structural Formula	Isomers
methane	CH <sub>4</sub>	CH <sub>4</sub>	1	hexane	C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	5
ethane	C <sub>2</sub> H <sub>6</sub>	CH <sub>3</sub> CH <sub>3</sub>	1	heptane	C <sub>7</sub> H <sub>16</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>	9
propane	C <sub>3</sub> H <sub>8</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	1	octane	C <sub>8</sub> H <sub>18</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	18
butane	C <sub>4</sub> H <sub>10</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	2	nonane	C <sub>9</sub> H <sub>20</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	35
pentane	C <sub>5</sub> H <sub>12</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	3	decane	C <sub>10</sub> H <sub>22</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>	75

Table 1: Simple Unbranched Alkanes

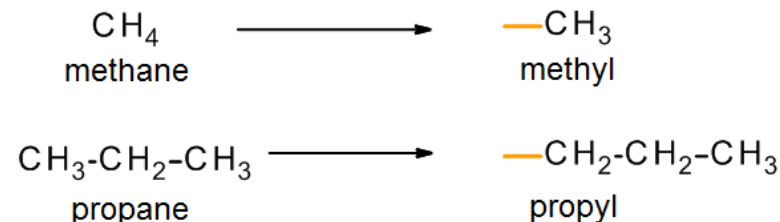
## SOME IMPORTANT BEHAVIOR TRENDS AND TERMINOLOGIES

1. The formulas and structures of these alkanes increase uniformly by a  $\text{CH}_2$  increment.
2. A uniform variation of this kind in a series of compounds is called **homologous**.
3. These formulas all fit the  $\text{C}_n\text{H}_{2n+2}$  rule (for acyclic aka non-cyclic) alkanes. This is also the highest possible H/C ratio for a stable hydrocarbon.
4. Since the H/C ratio in these compounds is at a maximum, we call them **saturated** (with hydrogen).

### Alkyl groups

Acyclic **alkanes** can be described by the general formula  $\text{C}_n\text{H}_{2n+2}$ . An alkyl group is formed by removing one hydrogen from the alkane chain and is described by the formula  $\text{C}_n\text{H}_{2n+1}$ . The removal of this hydrogen results in a stem change from **-ane** to **yl**.

Take a look at the following examples.



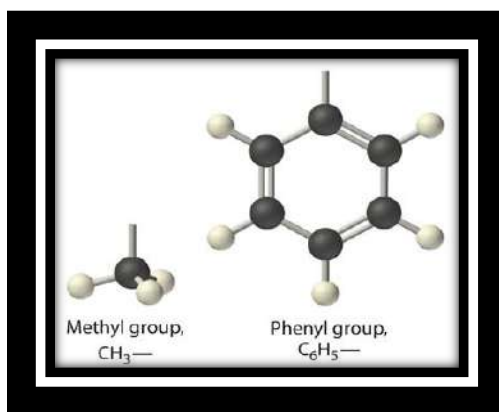
*The orange "bond" shows the point of attachment*

The same concept can be applied to any of the straight chain alkane names provided in the table above. Examples of some common **alkyl groups** are given in the following table. Note that the “ane” suffix is replaced by “yl” in naming groups. The symbol **R** is used to designate a generic (unspecified) alkyl group.

$\text{CH}_3\text{—}$	$\text{C}_2\text{H}_5\text{—}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{—}$	$(\text{CH}_3)_2\text{CH—}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{—}$	$(\text{CH}_3)_2\text{CHCH}_2\text{—}$	$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{—}$	$(\text{CH}_3)_3\text{C—}$
Methyl	Ethyl	Propyl	Isopropyl	Butyl	Isobutyl	sec-Butyl	tert-Butyl

### Alkyl Groups Names

Similarly, groups of atoms derived from aromatic hydrocarbons are *aryl groups*, which sometimes have unexpected names. For example, the  $\text{-C}_6\text{H}_5$  fragment is derived from benzene, but it is called a *phenyl* group. In general formulas and structures, alkyl and aryl groups are often abbreviated as R.



### IUPAC Rules for Alkane Nomenclature

1. Find and name the longest continuous carbon chain.
2. Identify and name groups attached to this chain.
3. Number the chain consecutively, starting at the end nearest a substituent group.
4. Designate the location of each substituent group by an appropriate number and name.
5. Assemble the name, listing groups in alphabetical order.
6. The prefixes di, tri, tetra etc., used to designate several groups of the same kind, are not considered when alphabetizing.

For the above isomers of hexane the IUPAC names are: B 2-methylpentane C 3-methylpentane D 2,2-dimethylbutane E 2,3-dimethylbutane.

## Naming complex alkanes

Beginning with butane ( $C_4H_{10}$ ), and becoming more numerous with larger alkanes, we note the existence of alkane isomers. For example, there are five  $C_6H_{14}$  isomers, shown below as abbreviated line formulas (A through E):



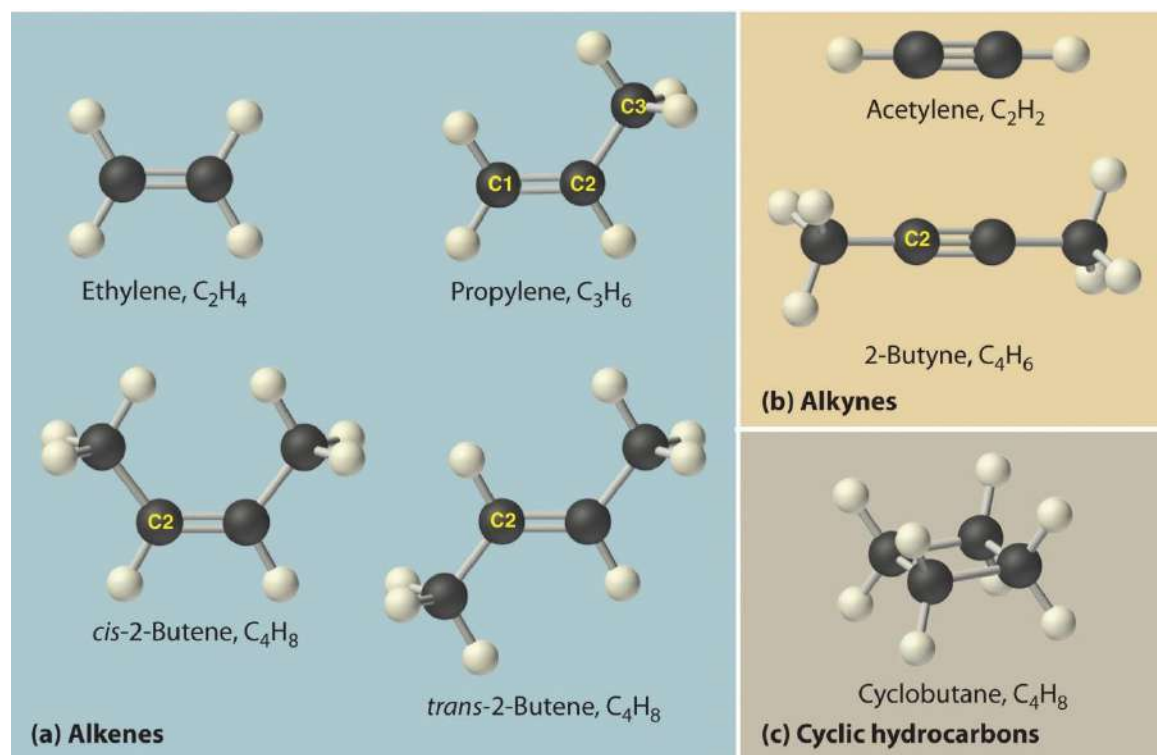
Although these distinct compounds all have the same molecular formula, only one (A) can be called hexane. How then are we to name the others? (Answers below.)

The **IUPAC** system requires first that we have names for simple un branched chains, as noted above, and second that we have names for simple alkyl groups that may be attached to the chains. Examples of some common **alkyl groups** are given in the following table. Note that the “ane” suffix is replaced by “yl” in naming groups. The symbol **R** is used to designate a generic (unspecified) alkyl group.

## Alkenes

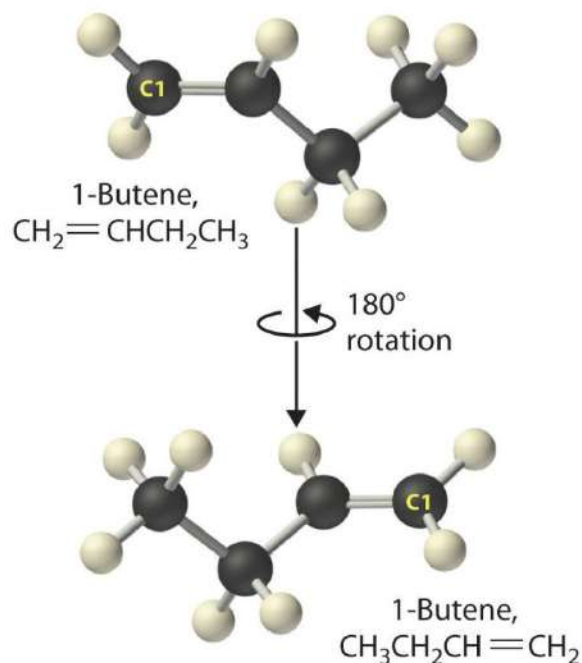
The simplest alkenes are *ethene* (traditionally called *ethylene*),  $C_2H_4$  or  $CH_2=CH_2$ , and *propene* (or *propylene*),  $C_3H_6$  or  $CH_3CH=CH_2$  (part (a) in the figure below). The names of alkenes that have more than three carbon atoms use the same stems as the names of the alkanes (see table above, “The First 10 Straight-Chain Alkanes”) but end in *–ene* instead of *–ane*.

As with alkanes, more than one structure is possible for alkenes with four or more carbon atoms. For example, an alkene with four carbon atoms has three possible structures. One is  $CH_2=CHCH_2CH_3$  (but-1-ene, formerly called 1-butene), which has the double bond between the first and second carbon atoms in the chain. The other two structures have the double bond between the second and third carbon atoms and are forms of  $CH_3CH=CHCH_3$  ((but-2-ene, formerly called 2-butene). All four carbon atoms in but-2-ene lie in the same plane, so there are two possible structures (part (a) in Figure 3.7.2). If the two methyl groups are on the same side of the double bond, the compound is *cis*-but-2-ene (=cis-2-butene) (from the Latin *cis*, meaning “on the same side”). If the two methyl groups are on opposite sides of the double bond, the compound is *trans*-but-2-ene (=trans-2-butene) (from the Latin *trans*, meaning “across”). (NB: We will learn more complete naming for such isomers in [section 4.3.](#)) These are distinctly different molecules: *cis*-but-2-ene melts at  $-138.9^\circ C$ , whereas *trans*-but-2-ene melts at  $-105.5^\circ C$ .



*Some Simple (a) Alkenes, (b) Alkynes, and (c) Cyclic Hydrocarbons. The positions of the carbon atoms in the chain are indicated by  $C_1$  or  $C_2$ . Some names here are traditional names rather than modern IUPAC names.*

Just as a number indicates the positions of branches in an alkane, the number in the name of an alkene specifies the position of the *first* carbon atom of the double bond. The name is based on the lowest possible number starting from *either end* of the carbon chain, so  $CH_3CH_2CH=CH_2$  is called but-1-ene (formerly 1-butene), *not* but-3-ene. Note that  $CH_2=CHCH_2CH_3$  and  $CH_3CH_2CH=CH_2$  are different ways of writing the *same molecule* (but-1-ene) in two different orientations.



**The name of a compound does *not* depend on its orientation.** As illustrated for 1-butene, both condensed structural formulas and molecular models show different orientations of the same molecule. It is important to be able to recognize the same structure no matter what its orientation.

## NOTE

The positions of groups or multiple bonds are always indicated by the lowest number possible.

## Alkynes

The simplest alkyne is *ethyne*, traditionally called *acetylene*,  $\text{C}_2\text{H}_2$  or  $\text{HC}\equiv\text{CH}$  (part (b) in the figure above). Because a mixture of acetylene and oxygen burns with a flame that is hot enough ( $>3000^\circ\text{C}$ ) to cut metals such as hardened steel, acetylene is widely used in cutting and welding torches. The names of other alkynes are similar to those of the corresponding alkanes but end in *-yne*. For example,

$\text{HC}\equiv\text{CCH}_3$  is *propyne*, and  $\text{CH}_3\text{C}\equiv\text{CCH}_3$  is *but-2-yne* because the multiple bond begins on the second carbon atom.

### NOTE

The number of bonds between carbon atoms in a hydrocarbon is indicated in the suffix:

- *alkane*: only carbon–carbon single bonds
- *alkene*: at least one carbon–carbon double bond
- *alkyne*: at least one carbon–carbon triple bond

### Aromatic hydrocarbons

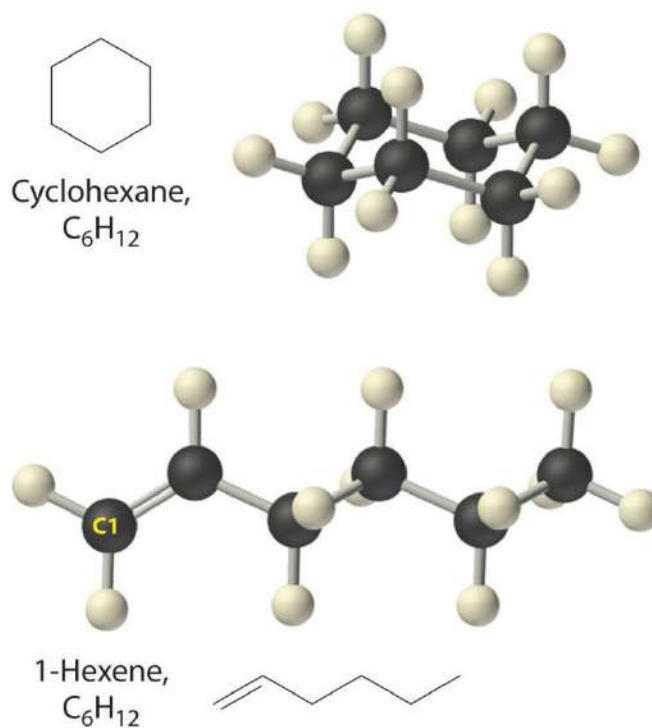
Alkanes, alkenes, alkynes, and cyclic hydrocarbons are generally called aliphatic hydrocarbons. The name comes from the Greek *aleiphar*, meaning “oil,” because the first examples were extracted from animal fats. In contrast, the first examples of **aromatic hydrocarbons**, also called *arenes*, were obtained by the distillation and degradation of highly scented (thus *aromatic*) resins from tropical trees.

The simplest aromatic hydrocarbon is *benzene* ( $\text{C}_6\text{H}_6$ ), which was first obtained from a coal distillate. The word *aromatic* now refers to benzene and structurally similar compounds. As shown in part (a) in Figure 3.7.4, it is possible to draw the structure of benzene in two different but equivalent ways, depending on which carbon atoms are connected by double bonds or single bonds. *Toluene* is similar to benzene, except that one hydrogen atom is replaced by a  $-\text{CH}_3$  group; it has the formula  $\text{C}_7\text{H}_8$  (part (b) in Figure 3.7.4). The chemical behavior of aromatic compounds differs from the behavior of aliphatic compounds. Benzene and toluene are found in gasoline, and benzene is the starting material for preparing substances as diverse as aspirin and nylon.



**Figure 3.7.4:** Two Aromatic Hydrocarbons: (a) Benzene and (b) Toluene

Figure 3.7.5 illustrates two of the molecular structures possible for hydrocarbons that have six carbon atoms. As shown, compounds with the same molecular formula can have very different structures.



### EXERCISE

Write the condensed structural formula for each hydrocarbon.

1. n-octane
2. hex-2-ene (- 2-hexene)

3. hept-1-yne (= 1-heptyne)
4. Cyclopentane (give the skeletal formula)

### 3.3. Properties of alkanes

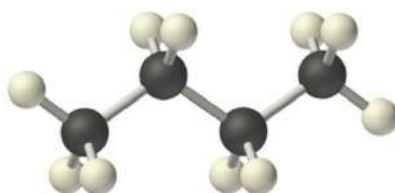
Alkanes are organic compounds that consist entirely of single-bonded carbon and hydrogen atoms and lack any other functional groups. Alkanes have the general formula  $C_nH_{2n+2}$  and can be subdivided into the following three groups: the **linear straight-chain alkanes**, **branched alkanes**, and **cycloalkanes**. Alkanes are also *saturated hydrocarbons*. Alkanes are the simplest and least reactive hydrocarbon species containing only carbons and hydrogens. They are commercially very important, being the principal constituent of gasoline and lubricating oils and are extensively employed in organic chemistry; though the role of pure alkanes (such as hexanes) is relegated mostly to serving as solvents. The distinguishing feature of an alkane, making it distinct from other compounds that also exclusively contain carbon and hydrogen, is its lack of unsaturation. That is to say, it contains no double or triple bonds, which are highly reactive in organic chemistry. Though not totally devoid of reactivity, their lack of reactivity under most laboratory conditions makes them a relatively uninteresting, though very important component of organic chemistry. As you will learn about later, the energy confined within the carbon-carbon bond and the carbon-hydrogen bond is quite high and their rapid oxidation produces a large amount of heat, typically in the form of fire.

#### More on properties of alkanes

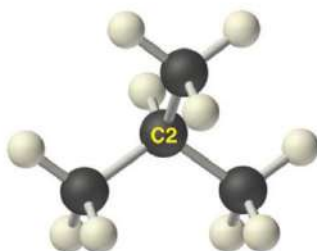
##### Isomerism

Alkanes with four or more carbon atoms can have more than one arrangement of atoms, so they can form structural isomers. The carbon atoms can form a single un

branched chain, or the primary chain of carbon atoms can have one or more shorter chains that form branches. For example, butane ( $C_4H_{10}$ ) has two possible structures. *Normal* butane (usually called *n*-butane or simply *butane*) is  $CH_3CH_2CH_2CH_3$ , in which the carbon atoms form a single unbranched chain. In contrast, the condensed structural formula for the isomer 2-*methylpropane* (sometimes called *isobutane*) is  $(CH_3)_2CHCH_3$ , in which the primary chain of three carbon atoms has a one-carbon chain branching at the central carbon. Three-dimensional representations of both structures are as follows:

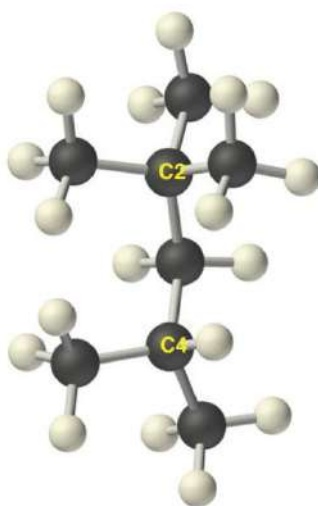


*n*-Butane,  $C_4H_{10}$



Isobutane (2-methylpropane),  $C_4H_{10}$

One of the major components of gasoline is commonly called isooctane; its



structure is as follows: Isooctane (2,2,4-trimethylpentane)

The compound has a chain of five carbon atoms, so it is a derivative of pentane. There are two methyl group branches at one carbon atom and one methyl group at another. Using the lowest possible numbers for the branches gives 2,2,4-trimethylpentane for the systematic name of this compound.

### Uses for alkanes

The simplest alkane is methane ( $\text{CH}_4$ ), a colorless, odorless gas that is the major component of natural gas. Other simple alkanes are used as fuels and solvents.

Name	Number of Carbon Atoms	Molecular Formula	Condensed Structural Formula	Boiling Point ( $^{\circ}\text{C}$ )
methane	1	$\text{CH}_4$	$\text{CH}_4$	-162
ethane	2	$\text{C}_2\text{H}_6$	$\text{CH}_3\text{CH}_3$	-89
propane	3	$\text{C}_3\text{H}_8$	$\text{CH}_3\text{CH}_2\text{CH}_3$	-42
butane	4	$\text{C}_4\text{H}_{10}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ or $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$	0
pentane	5	$\text{C}_5\text{H}_{12}$	$\text{CH}_3(\text{CH}_2)_3\text{CH}_3$	36
hexane	6	$\text{C}_6\text{H}_{14}$	$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$	69
heptane	7	$\text{C}_7\text{H}_{16}$	$\text{CH}_3(\text{CH}_2)_5\text{CH}_3$	98

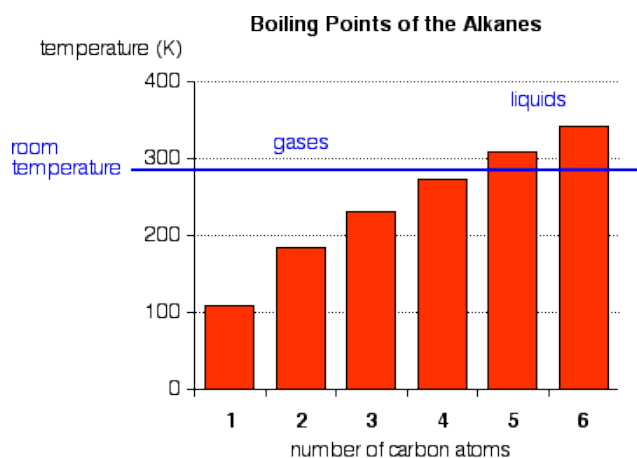
Name	Number of Carbon Atoms	Molecular Formula	Condensed Structural Formula	Boiling Point (°C)
octane	8	C <sub>8</sub> H <sub>18</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	126
nonane	9	C <sub>9</sub> H <sub>20</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	151
decane	10	C <sub>10</sub> H <sub>22</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>	174

*Table: The First 10 Straight-Chain Alkanes*

## Physical properties

### Boiling points

The boiling points shown are for the “straight chain” isomers in which there are more than one (Figure 1). Notice that the first four alkanes are gases at room temperature, and solids do not start to appear until about C<sub>17</sub>H<sub>36</sub>.



*Figure 1: Normal boiling points of first four alkanes*

The temperatures cannot be more precise than those given in this chart because each isomer has a different melting and boiling point. By the time you get 17 carbons into an alkane, there are unbelievable numbers of isomers! Cycloalkanes have boiling points that are approximately 10 – 20 °C higher than the corresponding straight chain alkane.

will be very small for a molecule like methane but will increase as the size of the molecules increase. Therefore, the boiling There electronegativity difference between carbon and hydrogen (2.1 vs. 1.9) is small; therefore, there is only a slight bond polarity, meaning that the only attractions between one molecule and its neighbors will be Van der Waals dispersion forces. These forces points of the alkanes increase with the molecular size.

Regarding isomers, the more branched the chain, the lower the boiling point tends to be. Van der Waals dispersion forces are smaller for shorter molecules and only operate over very short distances between one molecule and its neighbors. It is more difficult for short, bulky molecules (with substantial amounts of branching) to lie close together (compact) compared with long, thin molecules.

### EXAMPLE

The boiling points of the three isomers of  $C_5H_{12}$  are as follows:

- pentane (309.2 K)
- 2-methylbutane (301.0 K)
- 2,2-dimethylpropane (282.6 K)

Note that as the surface area of the alkane becomes smaller (because of branching), the boiling point is slightly reduced.

### Solubility

Alkanes (both normal and cycloalkanes) are virtually insoluble in water but dissolve in organic solvents. The liquid alkanes are good solvents for many other covalent compounds. When a molecular substance dissolves in water, the following must occur:

### Solubility in organic solvents

In most organic solvents, the primary forces of attraction between the solvent molecules are the Van der Waals forces composed of either dispersion forces or

dipole-dipole attractions. Therefore, when an alkane dissolves in an organic solvent, the Van der Waals forces are broken and are replaced by new Van der Waals forces. The two processes more or less cancel each other out energetically; thus, there is no barrier to solubility.

## Chemical reactivity

Alkanes contain strong carbon-carbon single bonds and strong carbon-hydrogen bonds. The carbon-hydrogen bonds are only very slightly polar. Therefore, there is no portion of the molecule that carries any significant amount of positive or negative charge, which is required for other molecules to be attracted to it. For example, many organic reactions start because an ion or a polar molecule is attracted to a portion of an organic molecule, which carries some positive or negative charge. This attraction does not occur with alkanes because alkane molecules do not have this separation of charge. The net effect is that alkanes have a fairly restricted set of reactions, including the following:

- burn them – destroying the entire molecule;
- react them with some of the halogens, breaking the carbon-hydrogen bonds;
- crack them, breaking carbon-carbon bonds.

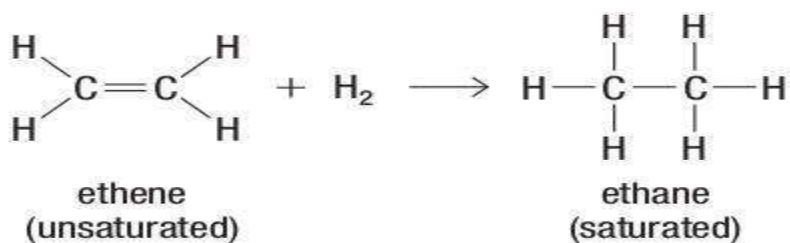
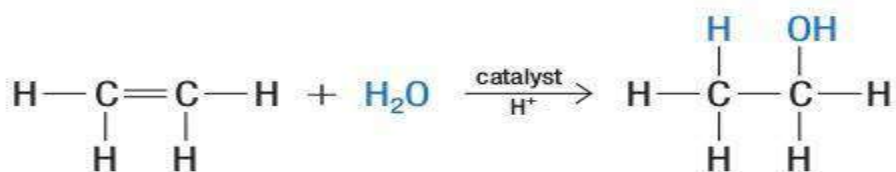
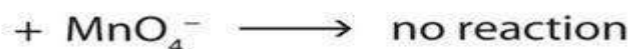
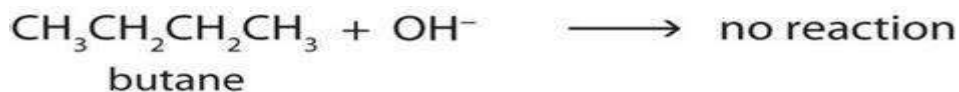
Cycloalkanes are very similar to the alkanes in reactivity, except for the very small cycloalkanes, especially cyclopropane. Cyclopropane is much more reactive than what is expected because of the bond angles in the ring. Normally, when carbon forms four single bonds, the bond angles are approximately  $109.5^\circ$ .

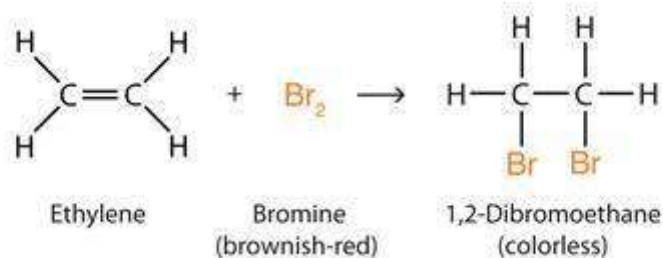
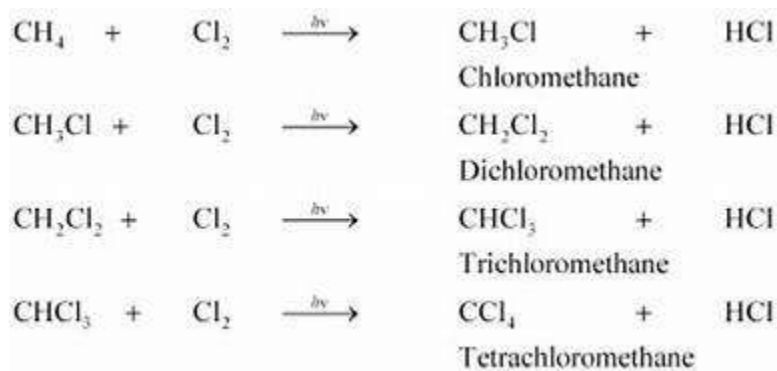
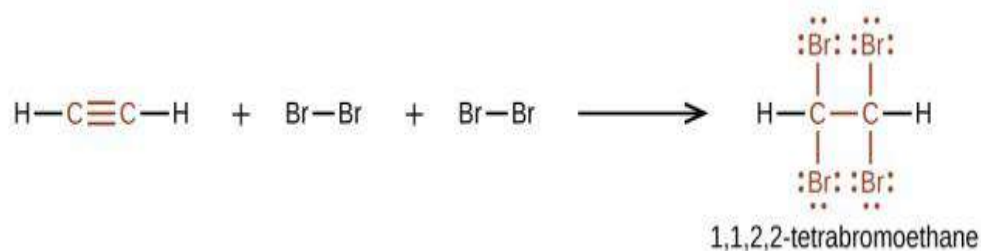
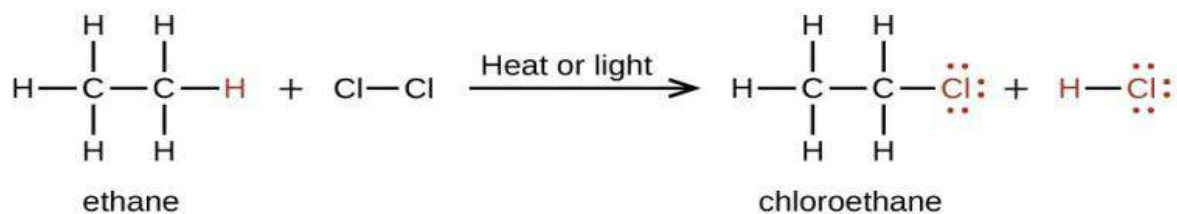
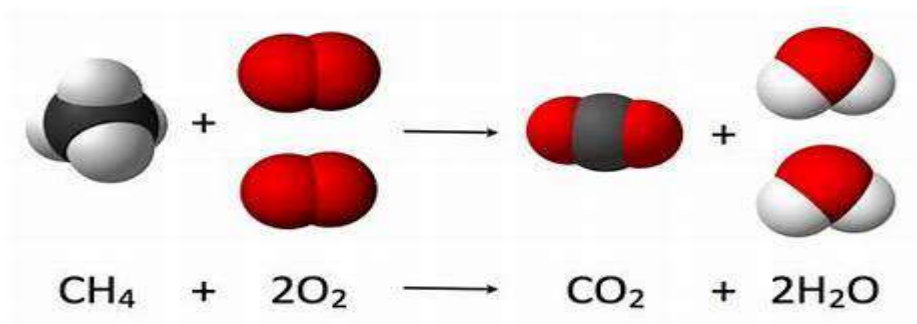
## Reaction of hydrocarbons

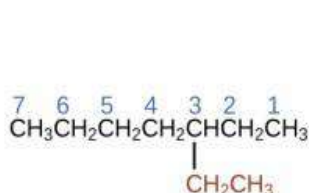
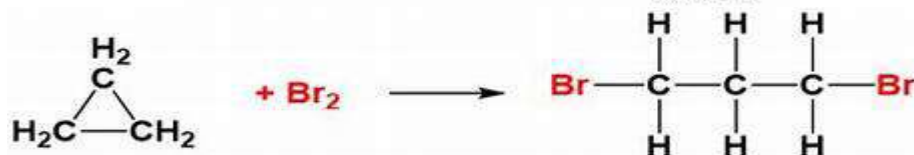
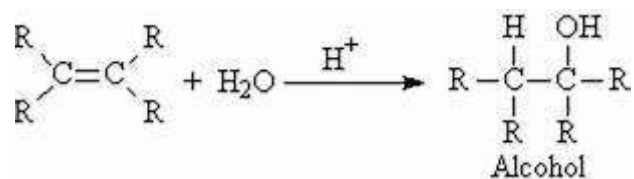


### Hydrocarbons

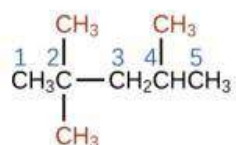
- The simplest organic compounds are the **hydrocarbons**:
  - organic compounds that contain only carbon and hydrogen
  - four general types:
    - **alkanes**
    - **alkenes**
    - **alkynes**
    - **aromatic hydrocarbons**



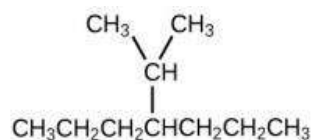




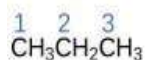
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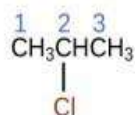
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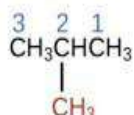
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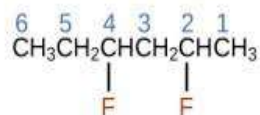
propane



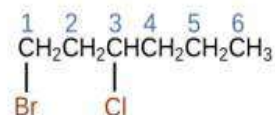
2-chloropropane



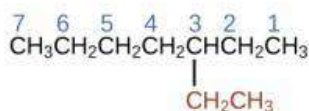
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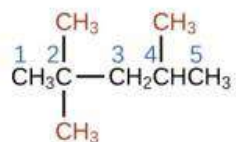
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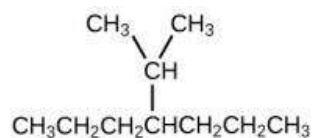
1-bromo-3-chlorohexane



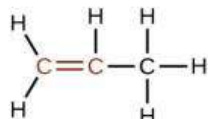
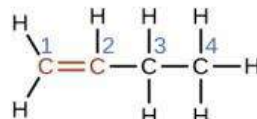
3-ethylheptane



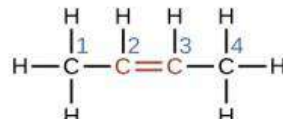
2,2,4-trimethylpentane



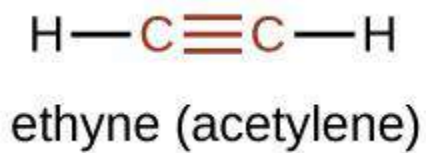
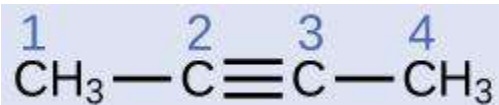
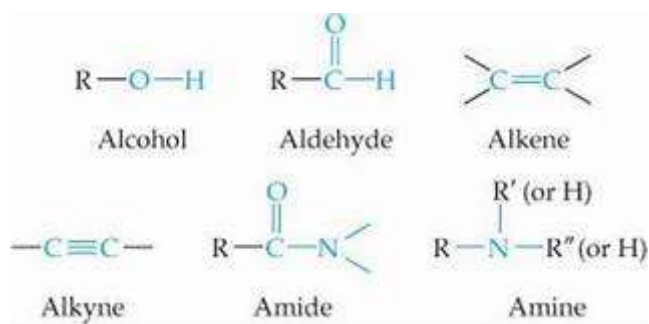
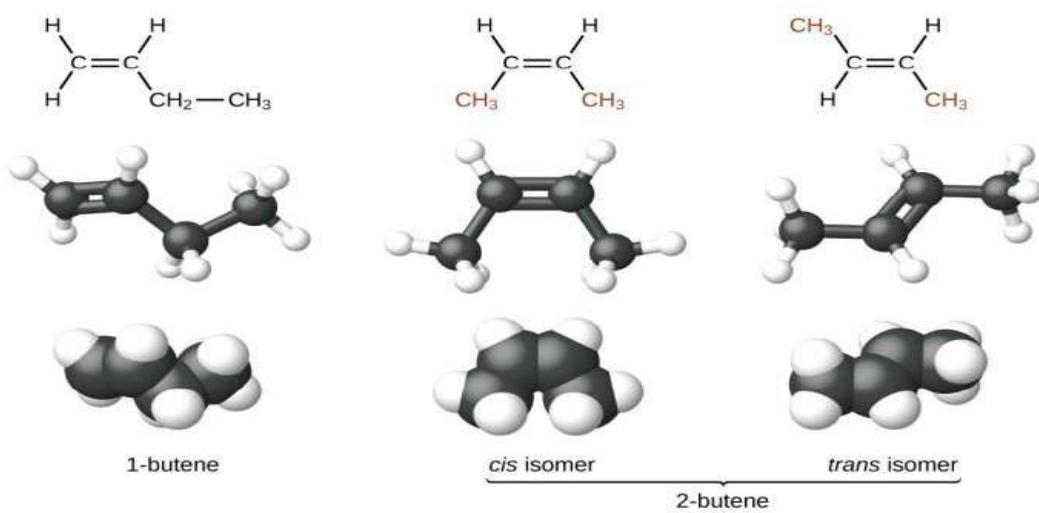
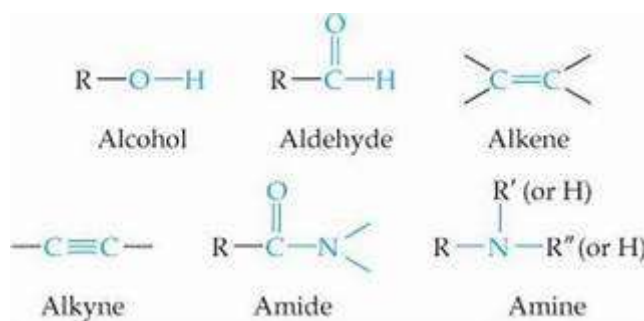
4-isopropylheptane

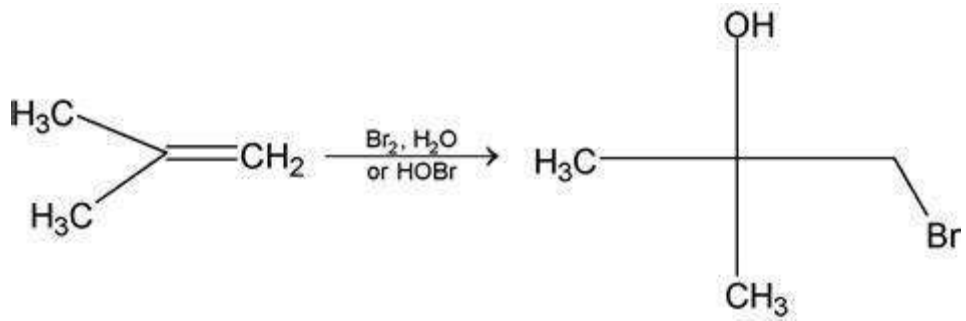
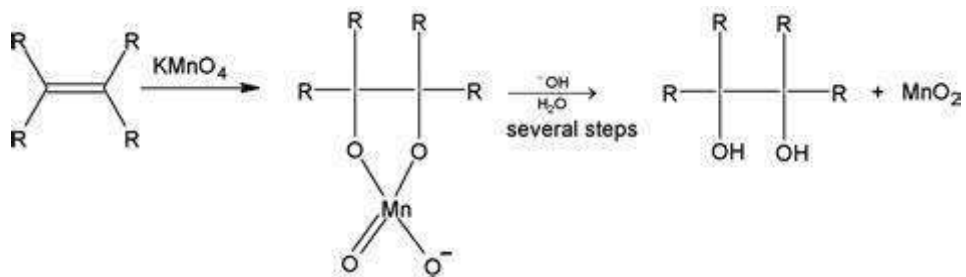
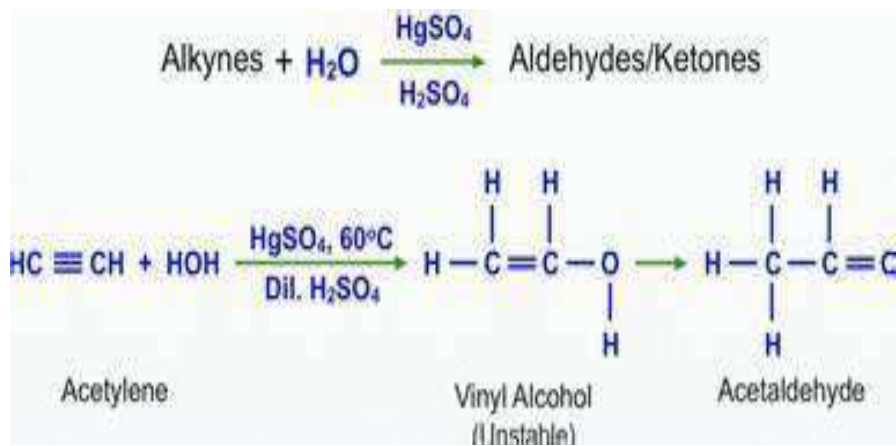
ethene  
(ethylene)propene  
(propylene)

1-butene



2-butene





## Introduction to Aromatic Compounds

**Aromatic compounds** are a class of hydrocarbons that possess much greater stability than their conjugated unsaturated system suggests. Benzene is the simplest example of this class of compounds.

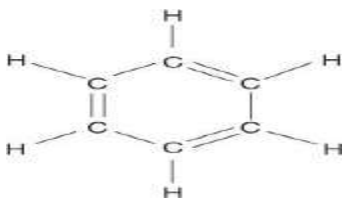
### Benzene

#### Structure of the benzene molecule

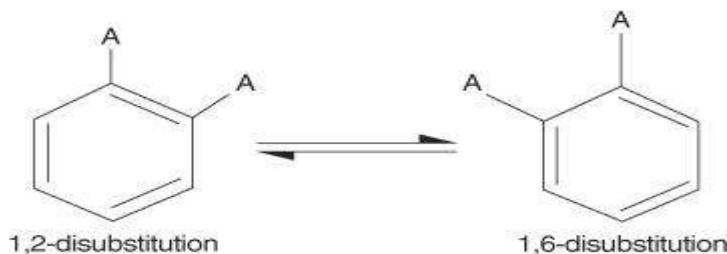
In 1866, August Kekulé used the principles of structural theory to postulate a structure for the benzene molecule. Kekulé based his postulation on the following premises:

- The molecular formula for benzene is  $C_6H_6$ .
- All the carbons have four bonds as predicted by structural theory.
- All the hydrogen's are equivalent, meaning they are indistinguishable from each other.

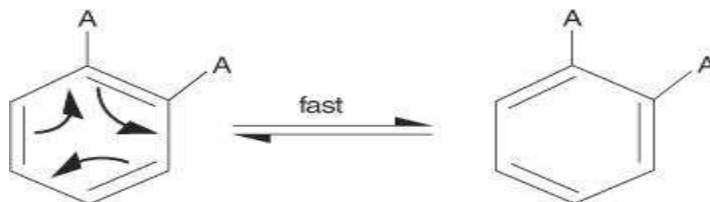
Based on these assumptions, Kekulé postulated a structure that had six carbons forming a ring structure. The remaining three modes of unsaturation were the result of three double bonds alternating with three single bonds. This arrangement allowed all the carbon atoms to have four bonds as required by structural theory.



Scientists soon realized that if Kekulé's structure were correct, substituting substituent groups for hydrogen's on the 1,2 positions would lead to a different compound than substitution on the 1,6 positions.



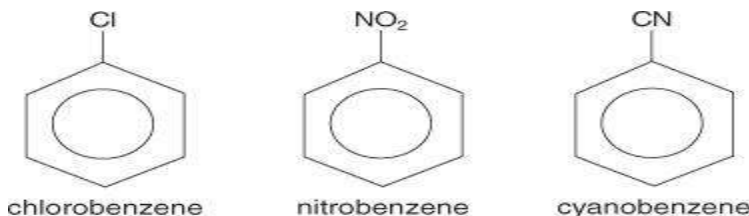
Because no such isomers could be produced experimentally, Kekulé was forced to modify his proposed structure. Kekulé theorized that two structures existed that differed only in the location of the double bonds. These two structures rapidly interconverted to each other by bond movement.



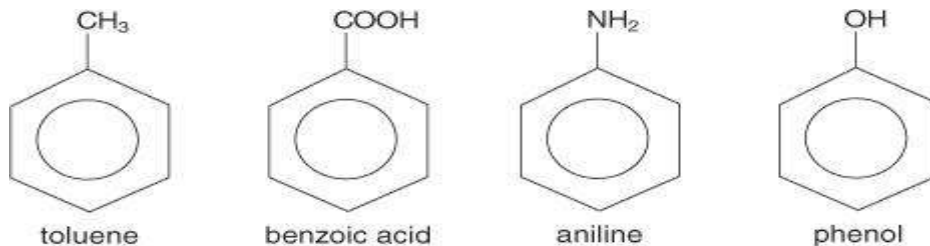
Although Kekulé's structure accounted for the modes of unsaturation in benzene, it did not account for benzene's reactivity.

## Nomenclature

In IUPAC nomenclature, benzene is designated as a parent name. Other compounds that contain the benzene molecule may be considered as substituted benzenes. In the case of **mono-substitution** (the replacement of a single hydrogen), the prefix of the substituent is added to the name benzene.

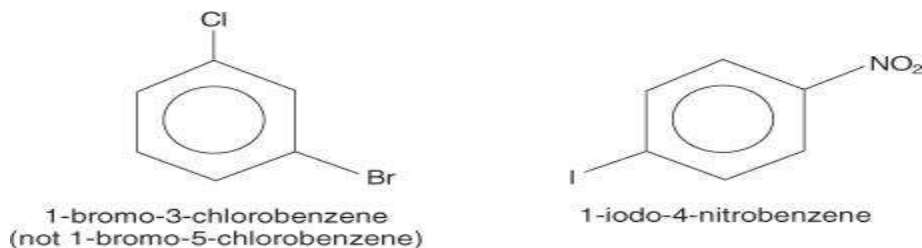


In other cases, the substituent, along with the benzene ring, forms a new parent system.



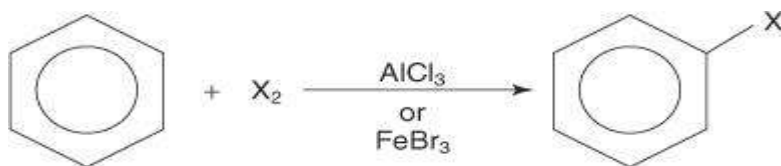
When a benzene molecule is **di-substituted** (replaced two hydrogen), two nomenclature methods exist. Either a number system or name system indicates the relative position of one substituent to the other. In the number system, one

substituent is given the number one position and the second substituent is assigned the lower possible second number. The number position is given to the atom or group that has the higher priority as determined by the Cahn-Ingold-Prelog nomenclature system rules.

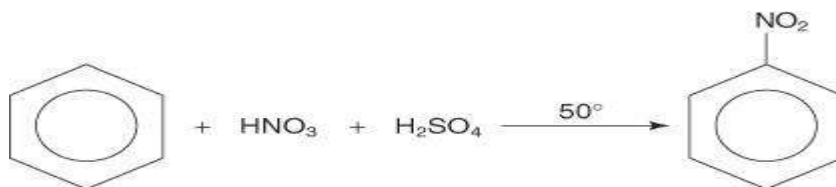


### Reactions: Aromatic Compounds

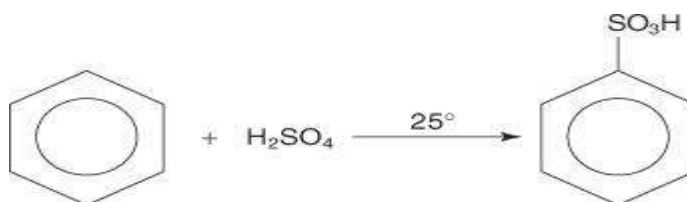
#### Halogenation



#### Nitration



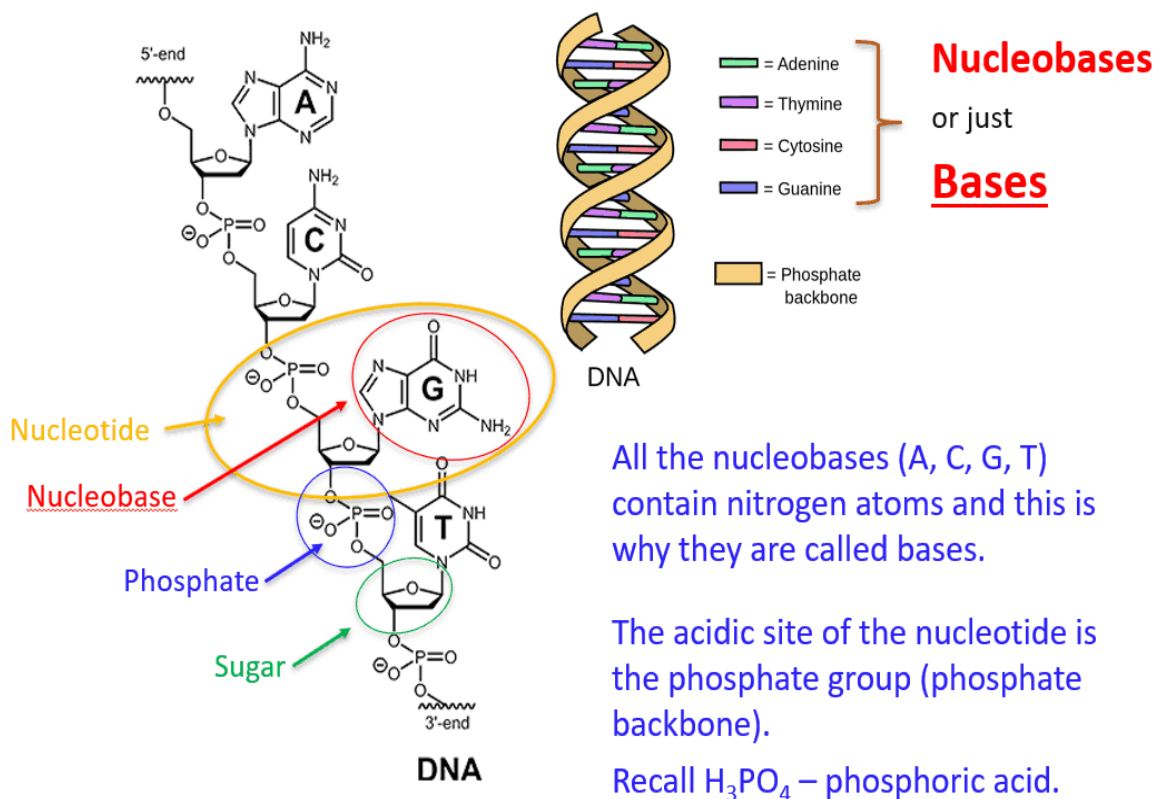
#### Sulfonation



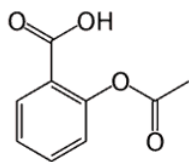
### Importance of Aromatic Compounds

The unusual stability makes aromatic compounds very common in natural systems such as for example the DNA which contains nucleobase responsible for the genetic information. Adenine, Guanine, Thymine and Cytosine are all aromatic compounds:

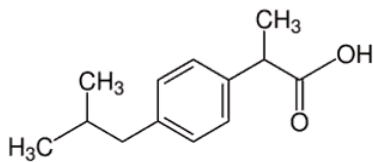
## DNA - ? Deoxyribonucleic acid



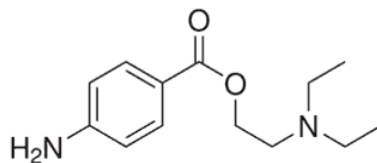
What are the key patterns to recognize here when comparing to benzene? First, remember that it is cyclic (all the aromatic compounds are **cyclic**), and it has a **double bond on every second carbon**. It goes interchangeably single-double. Here are also some important molecules that are not natural and prepared through organic synthesis:



**Aspirin**



**Ibuprofen**



**Novocain**



# Nomenclature of Alcohols

## Introduction

### Alcohols

Alcohols are an important class of compounds containing the hydroxyl functional group. There are three classes of alcohols; primary, secondary, and tertiary.

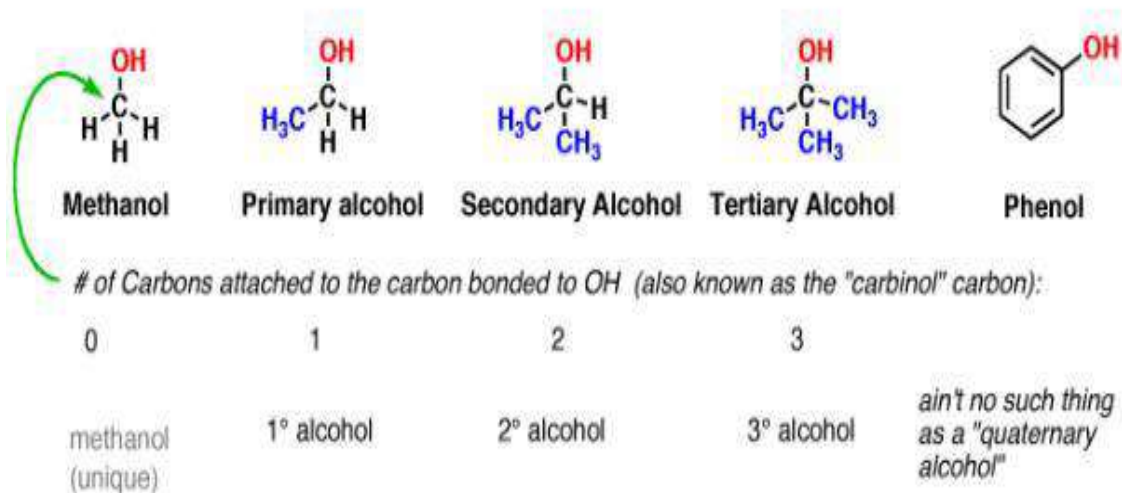
The following is list of some common primary alcohols based on the IUPAC naming system.

Name	Molecular Formula
Methanol (methyl alcohol)	CH <sub>3</sub> OH
Ethanol (ethyl alcohol)	C <sub>2</sub> H <sub>5</sub> OH
Propanol	C <sub>3</sub> H <sub>7</sub> OH
Butanol	C <sub>4</sub> H <sub>9</sub> OH
Pentanol	C <sub>5</sub> H <sub>11</sub> OH
Hexanol	C <sub>6</sub> H <sub>13</sub> OH
Heptanol	C <sub>7</sub> H <sub>15</sub> OH
Octanol	C <sub>8</sub> H <sub>17</sub> OH

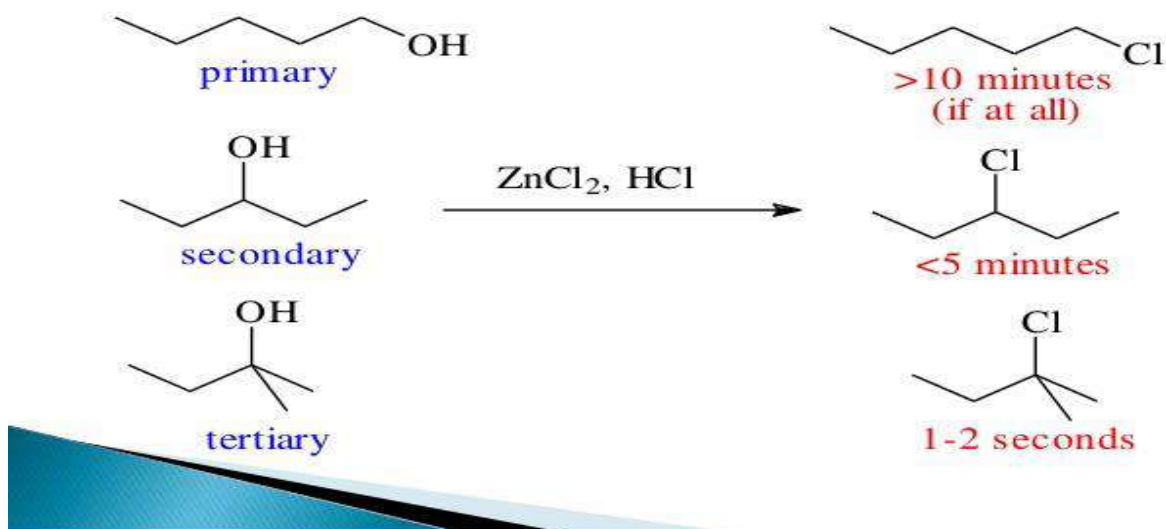
## Rules for naming the alcohols

1. Find the longest chain containing the hydroxyl group (OH). If there is a chain with more carbons than the one containing the OH group it will be named as a substituent.
2. Place the OH on the lowest possible number for the chain. With the exception of **carbonyl** groups such as ketones and aldehydes, the alcohol or hydroxyl groups have first priority for naming.
3. When naming a cyclic structure, the -OH is assumed to be on the first carbon unless the carbonyl group is present, in which case the later will get priority at the first carbon.
4. When multiple -OH groups are on the cyclic structure, number the carbons on which the -OH groups reside.
5. Remove the final **e** from the parent **alkane** chain and add **-ol**. When multiple alcohols are present use **di**, **tri**, et.c before the **ol**, after the parent name.

Primary, secondary, tertiary alcohol - what does it mean?



## Lucas test

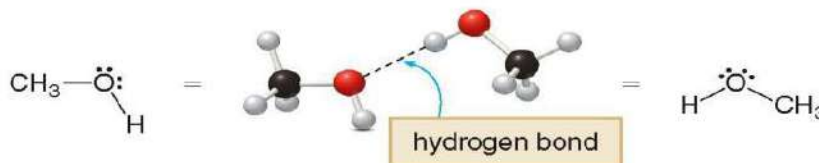


## Properties of Alcohols

- Solubility decreases as the size of the alkyl group increases.
  - 1-hexanol is less soluble than ethanol
- Solubility increases as the alkyl group becomes more compact/spherical.
  - t-butyl alcohol is more soluble than 1-butanol.
- Solubility increases with increasing number of OH groups.

## Structure and Properties of Alcohols

- Alcohols have an H atom bonded to an O atom, making them capable of **intermolecular hydrogen bonding**.



- All of these properties give alcohols much **stronger intermolecular forces** than alkanes and alkenes.

## Properties of Alcohols

- BP increases as the amount of hydrogen bonding increases:

- 1-propanol

BP = 97°C

- 1,2-propanediol  
(propylene glycol)

BP = 188°C

- 1,2,3-propanetriol  
(Glycerol)

BP = 290°C

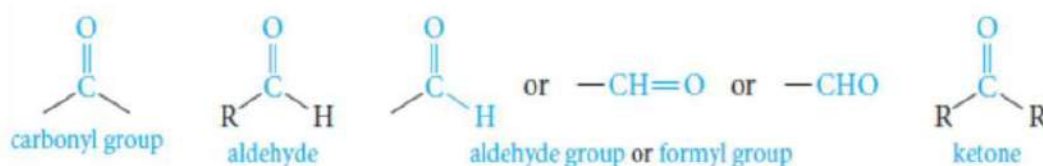
LC9512

### Alcohols: Chemical Properties

<p>1. Oxidation : Alcohol is oxidized with alkaline <math>K_2Cr_2O_7</math> at room temperature.</p> $CH_3OH \xrightarrow[K_2Cr_2O_7]{[O]} HCHO + H_2O \xrightarrow[K_2Cr_2O_7]{[O]} HCOOH$	<p>2. Combustion of ethanol : Ethanol burns with a sooty flame.</p> $C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{Heat}$
<p>3. Reaction with acetic acid (esterification) : alcohol + carboxylic acid <math>\longrightarrow</math> ester + water</p> $CH_3OH + CH_3COOH \longrightarrow CH_3COOCH_3 + H_2O$ <p style="text-align: center;">Methyl Acetate</p>	<p>4. Dehydration with conc. Sulphuric acid : Alcohol + <math>H_2SO_4 \longrightarrow</math> alkene + <math>H_2O</math></p> $C_2H_5OH \xrightarrow[\text{Heat}]{H_2SO_4} CH_2=CH_2 + H_2O$
<p>5. Halogenation (haloalkanes are produced):</p> $3CH_3OH + PCl_3 \longrightarrow 3CH_3Cl + H_3PO_3$ <p style="text-align: center;">Chloromethane</p>	<p>6. Reaction with Halogen Acids (haloalkanes are produced): Alcohol + Haloacid <math>\longrightarrow</math> Haloalkane + water</p> $CH_3OH + HCl \longrightarrow CH_3Cl + H_2O$
<p>7. Reduction :</p> $\text{Alcohol} + 2HI \longrightarrow \text{Alkane} + \text{water} + I_2$ $CH_3OH + HI \longrightarrow CH_4 + H_2O + I_2$	<p>8. Reaction with Sodium :</p> $\text{Alcohol} + \text{Sodium} \longrightarrow \text{Sodium alkoxide} + H_2$ $2CH_3OH + 2Na \longrightarrow 2CH_3ONa + H_2$
<p>9. Reaction of Sodalime :</p> $\text{Alcohol} + \text{Sodalime} \longrightarrow \text{Sodium Ethanoate} + \text{Hydrogen}$ $C_2H_5OH + NaOH \longrightarrow CH_3COONa + 2H_2$	<p>Dehydrogenation : Alcohol <math>\xrightarrow[Cu, 300^\circ C]{-H_2}</math> Aldehyde</p> $C_2H_5OH \xrightarrow[Cu, 300^\circ C]{-H_2} CH_3CHO$

## Introduction

- Aldehydes and ketones are characterized by the presence of the **carbonyl group**, perhaps the most important functional group in organic chemistry.
- Aldehydes** have at least **one hydrogen** atom attached to the carbonyl carbon atom. The remaining group may be another hydrogen atom or any aliphatic or aromatic organic group.
- The **–CH=O** group characteristic of aldehydes is often called a **formyl group**.
- In ketones**, the carbonyl carbon atom is connected to **two other carbon atoms**.



### 34.3 Physical Properties of Carbonyl Compounds (SB p.5)

Carbonyl compound	Formula	Boiling point (°C)	Melting point (°C)	Density at 20°C (g cm <sup>-3</sup> )
<b>Ketones:</b>				
Propanone	CH <sub>3</sub> COCH <sub>3</sub>	56.2	–95.4	0.791
Butanone	CH <sub>3</sub> COCH <sub>2</sub> CH <sub>3</sub>	79.6	–86.9	0.806
Pentan-3-one	CH <sub>3</sub> CH <sub>2</sub> COCH <sub>2</sub> CH <sub>3</sub>	102	–39.9	0.814
Pentan-2-one	CH <sub>3</sub> CO(CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>	102	–77.8	0.811
3-Methylbutan-2-one	CH <sub>3</sub> COCH(CH <sub>3</sub> ) <sub>2</sub>	95	–92	0.803
Hexan-2-one	CH <sub>3</sub> CO(CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	127	–56.9	0.812
Phenylethanone	C <sub>6</sub> H <sub>5</sub> COCH <sub>3</sub>	202	19.6	1.028



### 34.3 Physical Properties of Carbonyl Compounds (SB p.5)

- Simple aldehydes and ketones are gases or liquids at room temperature
- Aliphatic aldehydes have unpleasant and pungent smell**
- Ketones and benzaldehyde have a pleasant and sweet odour**

Carbonyl compound	Formula	Boiling point (°C)	Melting point (°C)	Density at 20°C (g cm <sup>-3</sup> )
<b>Aldehydes:</b>				
Methanal	HCHO	-21	-92	—
Ethanal	CH <sub>3</sub> CHO	20.8	-124	0.783
Propanal	CH <sub>3</sub> CH <sub>2</sub> CHO	48.8	-81	0.807
Butanal	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CHO	75.7	-99	0.817
Methylpropanal	(CH <sub>3</sub> ) <sub>2</sub> CHCHO	64.2	-65.9	0.790
Benzaldehyde	C <sub>6</sub> H <sub>5</sub> CHO	179	-26	1.046

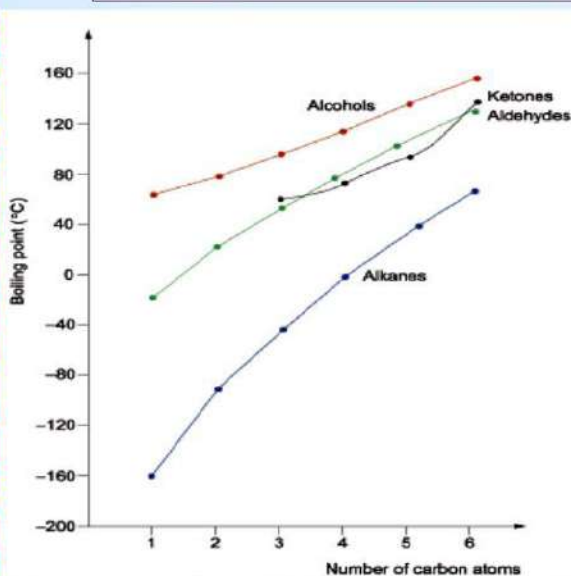
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### 34.3 Physical Properties of Carbonyl Compounds (SB p.5)

#### Boiling Point and Melting Point



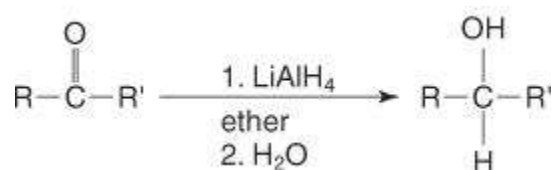
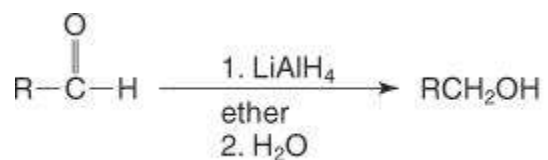
- Carbonyl compounds have higher b.p. and m.p. than hydrocarbons of similar relative molecular masses**  
∴ the presence of **dipole-dipole interactions**
- Carbonyl compounds have lower b.p. and m.p. than the corresponding alcohols**  
∴ **dipole-dipole interactions are weaker than intermolecular hydrogen bonds**

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## Reduction reaction

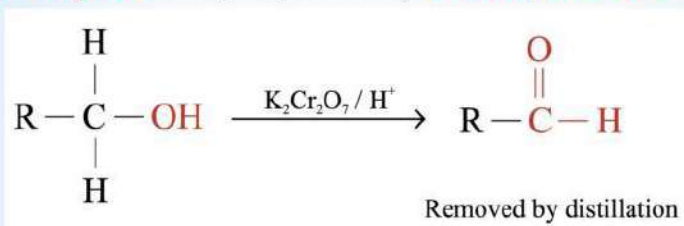


### 34.4 Preparation of Carbonyl Compounds (SB p.8)

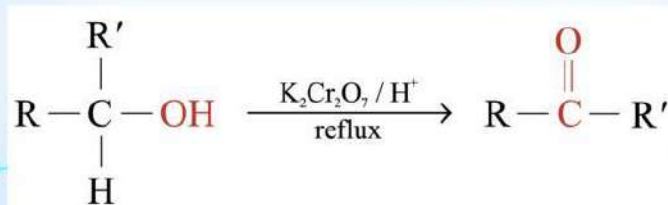
#### *Oxidation of Alcohols*

Example of oxidizing agents: **acidified K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>**

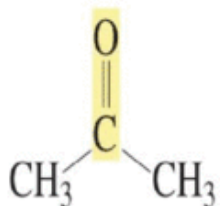
- Aldehydes** are prepared by **oxidation of 1° alcohols**



- Ketones** are prepared by **oxidation of 2° alcohols**



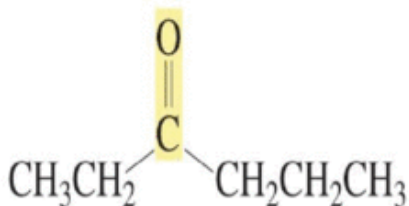
## Nomenclature of Ketones



e: **propanone**

**acetone**

dimethyl ketone



**3-hexanone**

ethyl propyl ketone



**6-methyl-2-heptanone**

isohexyl methyl ketone

**p/s: Give the ketone the smaller number.**

# cholesterol

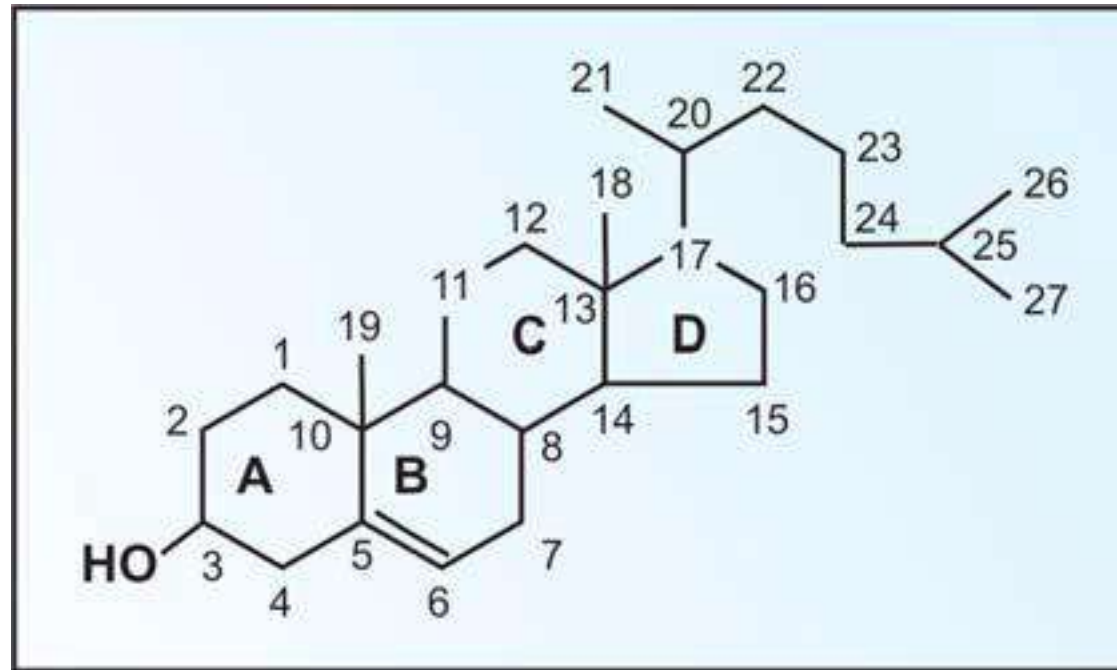
الكيمياء العملي  
المرحلة الاولى  
قسم تقنيات التخدير

**Cholesterol** is a waxy, fat-like substance (steroid) found in the walls of cells in all parts of the body.

**Cholesterol** is a compound containing 27 carbon with four rings labeled (A, B, C, and D).

**Source:** more than 90% synthesized in body (liver), less than 10% from food (animal source as meat, eggs and dairy products).

# Structure of cholesterol



# The importance of cholesterol in the body

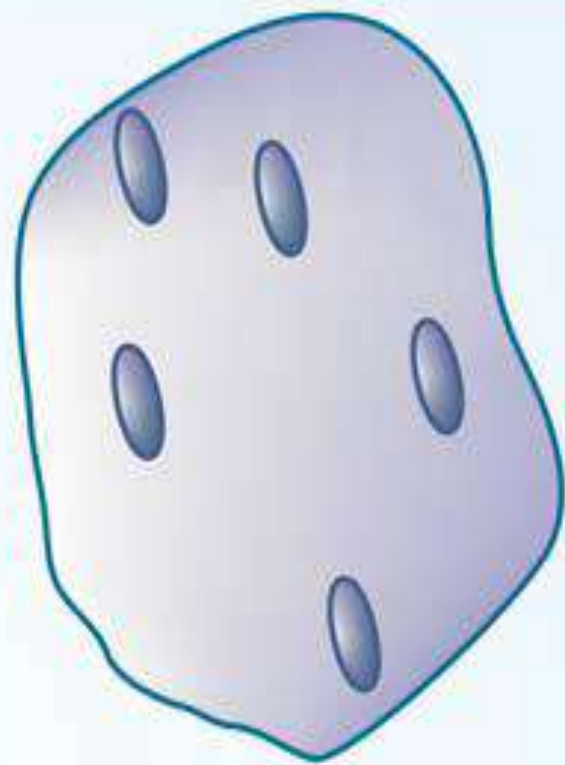
- For the synthesis of bile salts that are important in lipid digestion and absorption.
- For the synthesis of steroid hormones that are biologically important like the sex hormones estrogen and progesterone.
- For the synthesis of vitamin D3
- As a structural material in cell membranes and brain tissue.

# Blood lipoproteins

the blood lipoproteins serve to transport of water-insoluble triglyceride and cholesterol from one tissue to another.

## Classification of lipoproteins:

- 1- chylomicron
- 2- very low density lipoprotein (vLDL)
- 3- intermediate density lipoprotein (IDL)
- 4-low density lipoprotein (LDL)
- 5- high density lipoprotein (HDL)



Chylomicron



VLDL



IDL



LDL

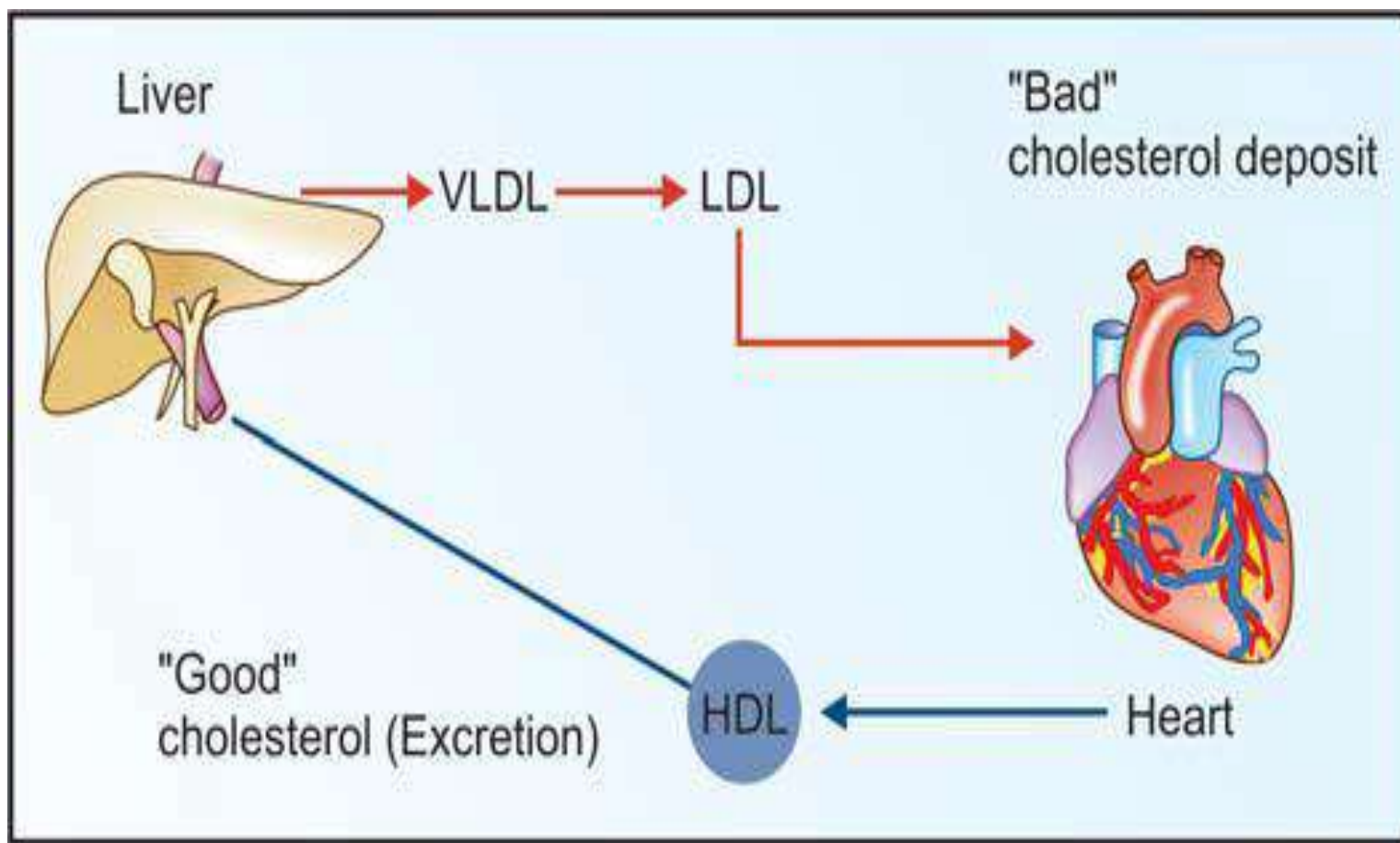


HDL

# Two main types of lipoproteins carry cholesterol in the blood:

1- Low density lipoprotein (LDL), which also is called the “bad” cholesterol because it carries cholesterol from liver to tissues and Blood vessels

2- High density lipoprotein (HDL), which also is called the “good” cholesterol because it takes cholesterol from tissues to the liver, which removes it from the body .



# Serum cholesterol level:

In normal persons, cholesterol level varies from 150 to 200 mg/dl. It should be preferably below 180 mg/dl.

Values around 220 mg/dl will have moderate risk and values above 240 mg/dl will need active treatment.

## Notes:

- Measuring blood cholesterol level not need fasting.
- high level of cholesterol in blood in a long time lead to the development of cardiovascular diseases, atherosclerosis and myocardial infarction.

# Causes of hypercholesterolemia (high cholesterol concentration in the blood):

- 1- overt hypothyroidism.
- 2- nephritic syndrome or chronic renal failure.
- 3- uncontrolled diabetes mellitus.
- 4- medication ( some drugs).
- 5- Familial hypercholesterolemia.

## Principle

Cholesterol esterase hydrolyses esterified cholesterols to free cholesterol. The free cholesterol is oxidised to form hydrogen peroxide which further reacts with phenol and 4-aminoantipyrine by the catalytic action of peroxidase to form a red coloured quinoneimine dye complex. Intensity of the colour formed is directly proportional to the amount of cholesterol present in the sample.

### *Cholesterol Esterase*



### *Cholesterol Oxidase*



### *Peroxidase*



## Procedure

	Blank	Standard	Test (assay)
Reagent	1 ml	1 ml	1 ml
D.W	10 µL		
Standard		10 µL	
Specimen (serum )			10 µL

Mix. let Stand for (5 minutes) at (37 C) or (10 minutes) at room temperature . record absorbance at (500 nm ) against reagent blank.

### Calculation

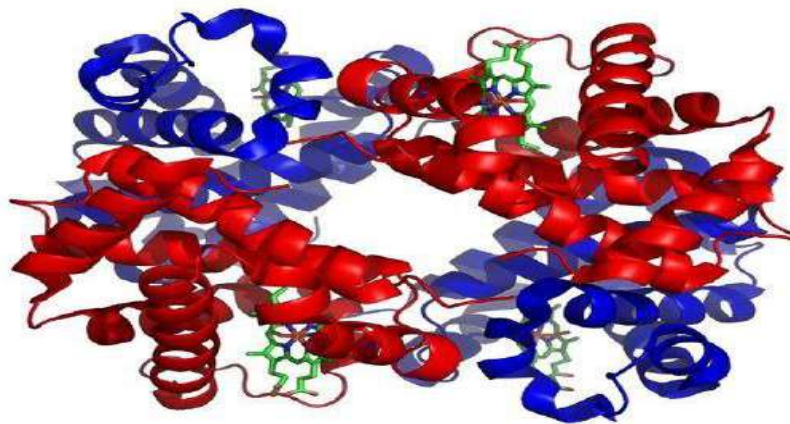
$$\text{Cholesterol Conc.} = \frac{\text{Abs. test}}{\text{Abs.St}} \times \text{Standard Con. (200).} \quad \text{mg/dl}$$

# Homework

- 1- Measuring blood cholesterol level not need fasting?**
- 2- explain the importance of cholesterol in the body?**



# Protein structure and function



م.م ايمن رمزي محمد  
المرحلة الاولى / قسم التخدير

# The objective of the lecture



- Define proteins
- Types and functions of proteins
- Amino - acids : define and structure
- How do we detect proteins and amino acids

# Proteins

Proteins are organic compounds containing **carbon**, **hydrogen**, **oxygen** and **nitrogen** it main contain sulphur and phosphorous also

**Amino - acid** is the simplest unit of protein

The quality of protein depends upon the amino acid they contain  
There are about **20** amino acids which are essential for human growth and development

Human body cannot synthesis these amino acids, there for these amino acid must be present in the proteins we eat

ESENCIALES	NO ESENCIALES
Isoleucina (Ile)	Alanina (Ala)
Leucina (Leu)	Tirosina (Tyr)
Lisina (Lys)	Aspartato (Asp)
Metionina (Met)	Cisteína (Cys)
Fenilalanina (Phe)	Glutamato (Glu)
Treonina (Thr)	Glutamina (Gln)
Triptófano (Trp)	Glicina (Gly)
Valina (Val)	Prolina (Pro)
Histidina (His)	Serina (Ser)
	Asparagina (Asn)
	Arginina (Arg)

# Types of Proteins:

**1.simple protein** :as albumin, globuline, gelatin and prolamin

**2.conjugated proteins:** compounds proteins which are bonded with non proteinous compound as lipoprotein glycoprotein and nucleoprotein

**3. Derivative proteins** : this type result of some nature and chemical factors so can changes the nature structure but still keep the speceific characters as pepton

# Classification of Proteins



**Based on Conformation    Based on Composition**

<b>Fibrous Insoluble in H<sub>2</sub>O</b>	<b>Globular Soluble in H<sub>2</sub>O</b>	<b>Simple</b>	<b>Conjugated</b>	<b>Derived</b>
<ul style="list-style-type: none"> <li>•α-Keratin</li> <li>•β-Keratin</li> <li>•Collagen</li> </ul>	<ul style="list-style-type: none"> <li>•Myoglobin</li> <li>•Hemoglobin</li> <li>•Lysozyme</li> <li>•Ribonuclease</li> <li>•Chymotrypsin</li> <li>•Cytochrome-c</li> <li>•Lactate dehydrogenase</li> <li>•subtilisin</li> </ul>	<ul style="list-style-type: none"> <li>•Albumin</li> <li>•Globulin</li> <li>•Glutalins</li> <li>•Prolamins</li> <li>•Protamines</li> <li>•Histones</li> <li>•Scleroproteins</li> </ul>	<ul style="list-style-type: none"> <li>•Nucleoprotein</li> <li>•Lipoprotein</li> <li>•Phosphoprotein</li> <li>•Metalloprotein</li> <li>•Glycoprotein</li> <li>•Flavoprotein</li> <li>•Hemoprotein</li> <li>•chromoproteins</li> </ul>	<ul style="list-style-type: none"> <li>•Protiose</li> <li>•Peptones</li> <li>•Small peptides</li> <li>•Fibrin</li> <li>•Metaproteins</li> <li>•Coagulated proteins</li> </ul>

**Based on Nature of**

<b>Acidic</b>	<b>Basic</b>
<ul style="list-style-type: none"> <li>•Blood proteins</li> </ul>	<ul style="list-style-type: none"> <li>•Histones</li> </ul>

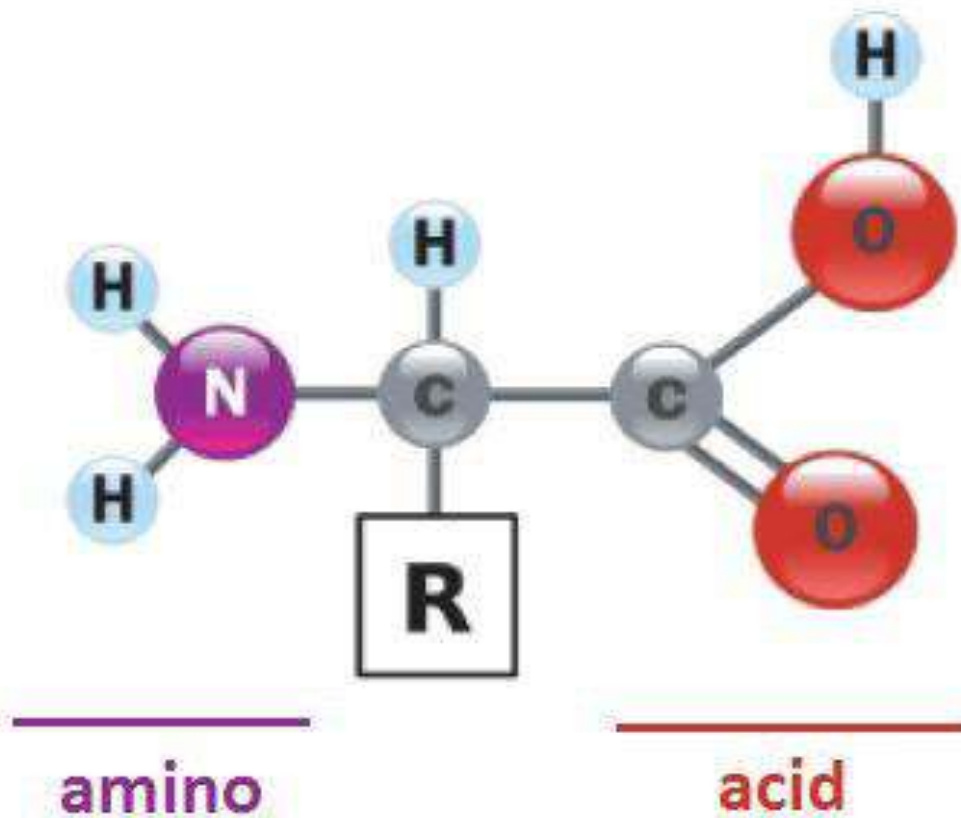
# Functions of proteins

- ❑ Proteins is needed to grow ,repair and maintain al cells and organs
- ❑ Proteins is the **major source of energy**
- ❑ Proteins is involved in the creation of some **hormones**
- ❑ Proteins produce **enzymes** that increase the rate of chemical reactions in the body
- ❑ Proteins transports other molecules through the blood in/out of cell ( **like hemoglobin**) is called **transport protein**

- ❑ Proteins called **antibodies** help rid the body of the foreign protein
- ❑ Proteins **help store other substance** in the organism ( **iron** is stored in the liver in a complex with the protein **ferritin** )

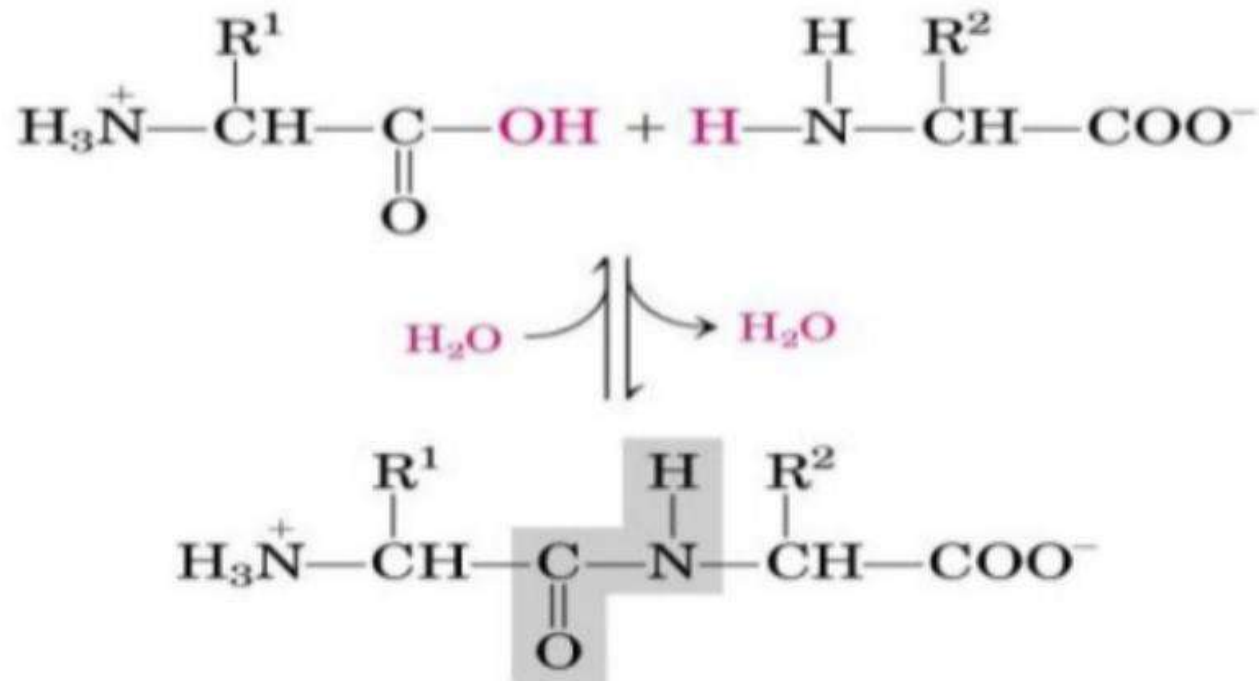
# Amino Acids: Definition and Structure

- **Amino acids** are organic compounds containing both a carboxyl ( $\text{—COOH}$ ) and an amino ( $\text{—NH}_2$ ).
- All amino acids found in proteins have a basic structure.
- The human body needs high levels of protein and peptides to function.
- And for the body to be able build these proteins and **peptides** naturally, it requires amino acids.



KEY: H = hydrogen , N = nitrogen , C = carbon , R = variable side chain

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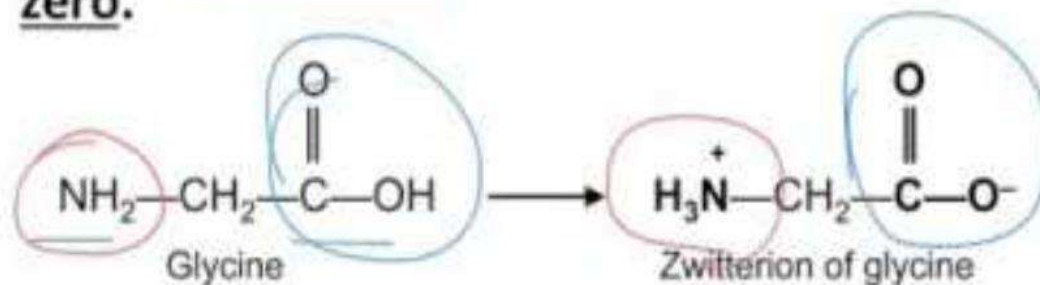
## Characteristics of Peptide Bonds

- Peptide bonds are **strong** with partial double bond character:
  - They are **not broken by usual denaturing agents** like **heating** or **high salt concentration**.
  - They can be **broken by**:
    - Prolonged exposure to **strong acid or base** at **elevated temperatures**.
    - Specific **enzymes** such as digestive enzymes.
- Peptide bonds are **rigid and planner resisting free rotation**, therefore they stabilize protein structure

- **Peptides** and **proteins** are polymers of twenty amino acids connected to each other by peptide bonds.
- **Oligopeptide** is formed of (2 –10) amino acids:
  - 2 amino acids → dipeptide,
  - 3 amino acids → tripeptide,
  - 4 amino acids → tetrapeptide ....etc.
- **Polypeptide** is formed of more than **10 amino acids**.

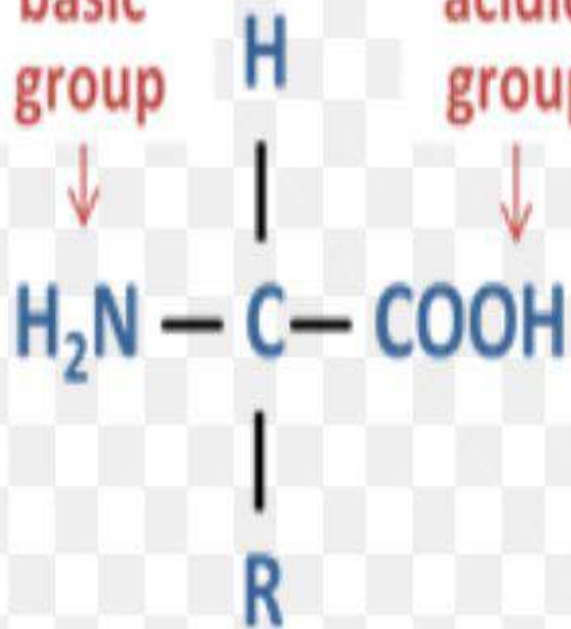
# ZWITTERION

- At pH of 7, amino group is protonated ( $\text{-NH}_3^+$ ) and carboxyl group is ionized ( $\text{COO}^-$ ). The amino acid is called a zwitterion.
- At the pH of most bodily fluids, the carboxyl group will lose  $\text{H}^+$  and the amino group accepts an  $\text{H}^+$
- This is a dipolar (DIPOLE ION) form of the amino acid
- This makes a dipolar form of the amino acid called a zwitterion. It has a net charge of zero.

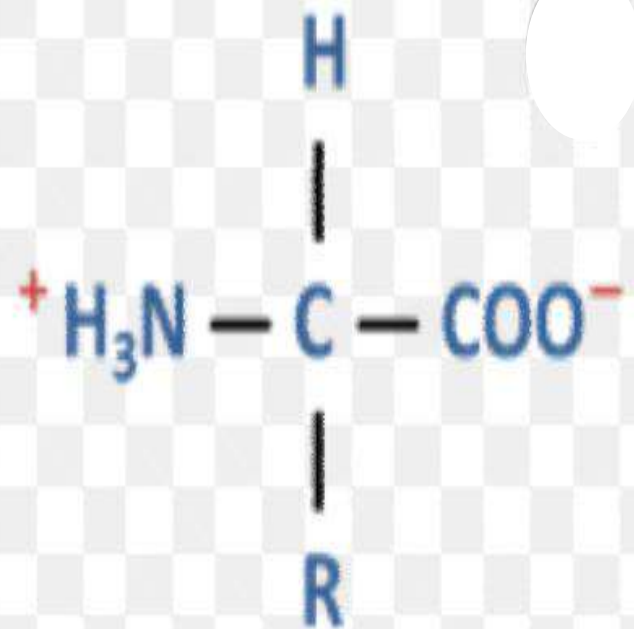


basic  
group

acidic  
group

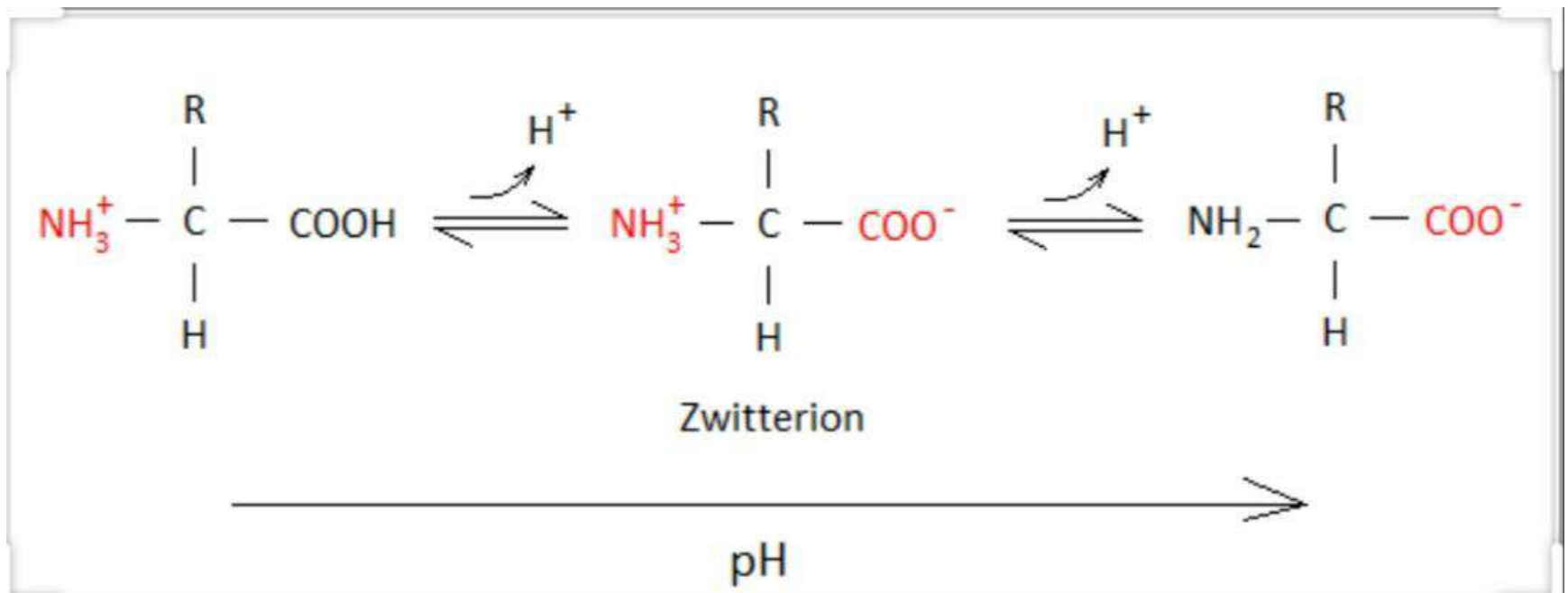


amino acid



zwitterion

## The form of the amino acid in the acidic ,basic and neutral medium



# ISOELECTRIC POINT

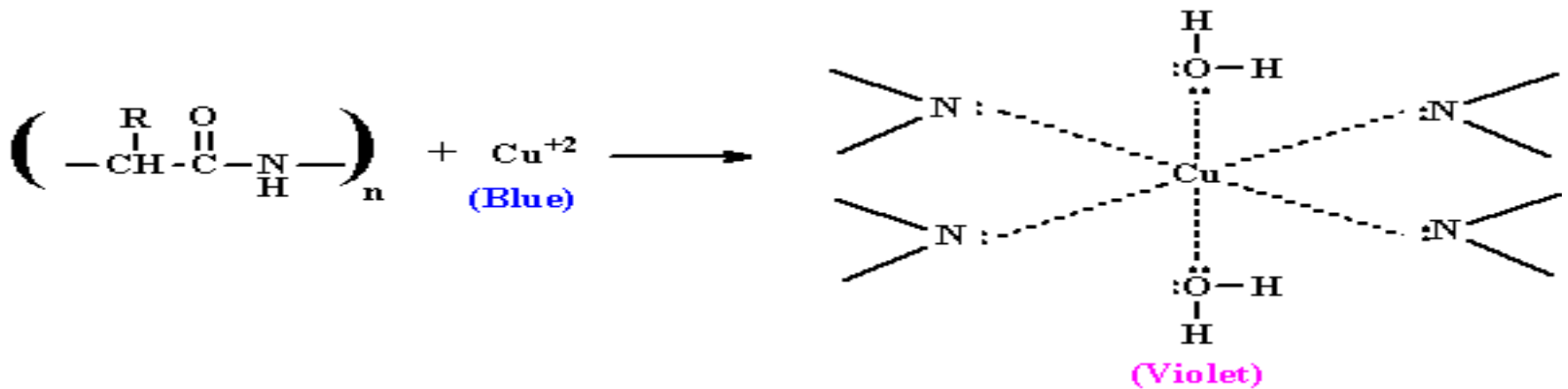
- Solid amino acids have a very high melting points because the zwitterion has the properties of a salt. The ionic charges of the amino acids make them more soluble in water, but not in organic solvents

# Some color tests for amino acids and proteins

## 1. Biuret test

Biuret test is given by all compounds that contains three or more peptide bonds. Since proteins are polypeptide, it is a general test for proteins.

All proteins contain large number of peptide bond when a protein solution is treated with cupric ion in a moderately alkaline medium (Biuret solution) a colored coordinate complex is formed between the copper ions and the peptide bond present in the protein. A positive test indicated by the formation of a violet color.

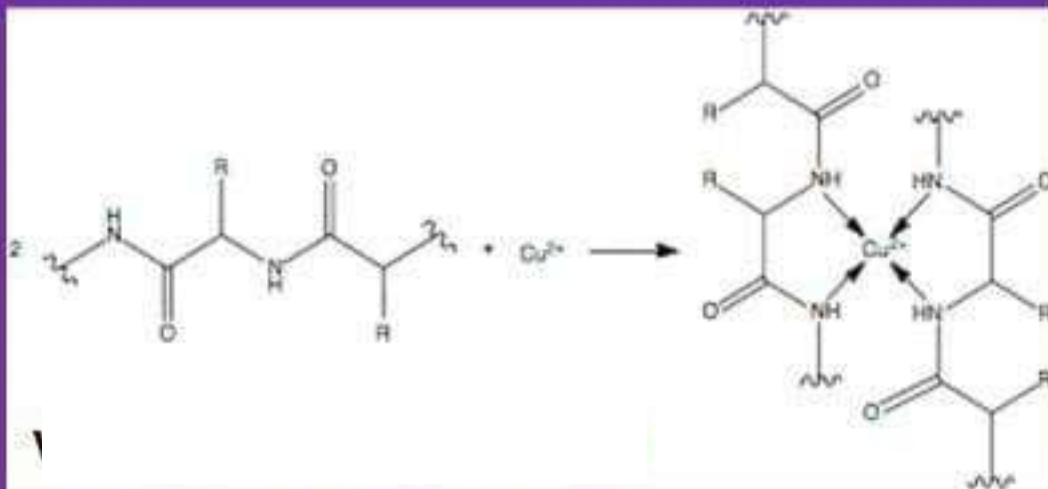


## Procedure

- 1- Prepare and label four test tubes.
- 2- Place 1 ml of test solution in each test tube
- 3- Add 1 ml of 10% NaOH, mix.
- 4- Add drop by drop of 0.5% CuSO<sub>4</sub>, mix.
- 5- Note the colors produced.

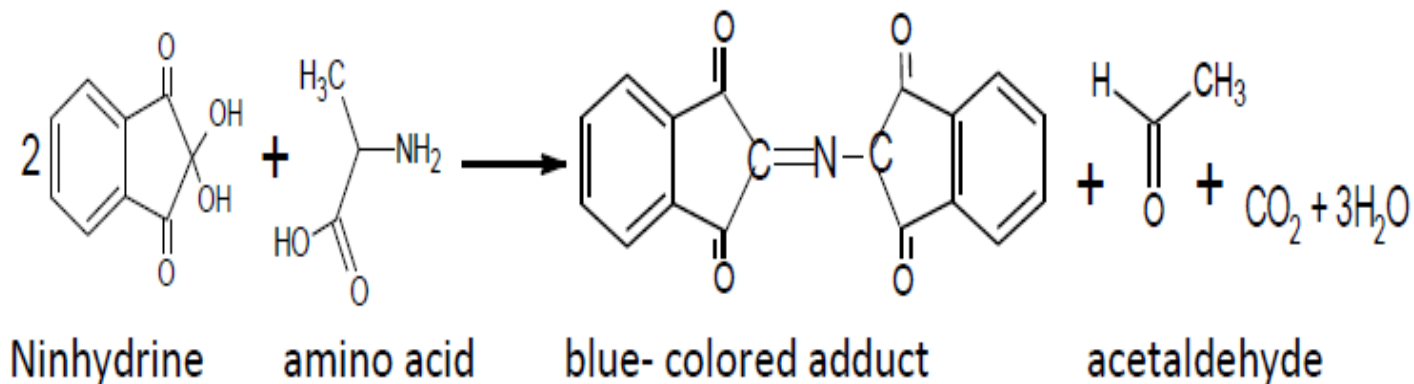
# Biuret test

(Detection of peptide bond)



## 2- Ninhydrin test

Ninhydrine reacts with  $\alpha$ - amino acids to yield a characteristic blue violet products [ decarboxylation ]. The overall reaction is shown below, for the sequence of steps involved:



Most amino acids give almost the same color, except proline makes a pale- yellow

**This test is used to distinguish between amino acids and nonprotein compounds.**

## **Procedure**

**1- Prepare and label four test tubes.**

**a- 1 ml protein solution.**

**b- 1 ml amino acid solution.**

**c- 1 ml proline.**

**d- 1 ml distilled water.**

**2- Add 2-5 drops of freshly prepared 0.2% ninhydrin solution.**

**3- Heat in boiling water bath about 2-5 minutes.**

**4- Allow to cool, a blue color is produced**

## Ninhydrin Test- Definition, Principle, Procedure, Result, Uses



**Negative  
Ninhydrin Test**

**Amino acid  
Absent**



**Positive  
Ninhydrin Test**

**Amino acid Present**

**Purple-colored  
complex present**



**Proline present**

### 3. Xanthoprotic test:

Amino acid containing an aromatic nucleus form a yellow nitro derivative on heating with conc. nitric acid. The salt of these derivatives are orange.

#### Procedure

1- Prepare and label three test tubes:

a- 1 ml of alanine.

b- 1 ml of tyrosine.

c- 0.5 ml of egg albumin.

2- Add 10 drops of conc. nitric acid

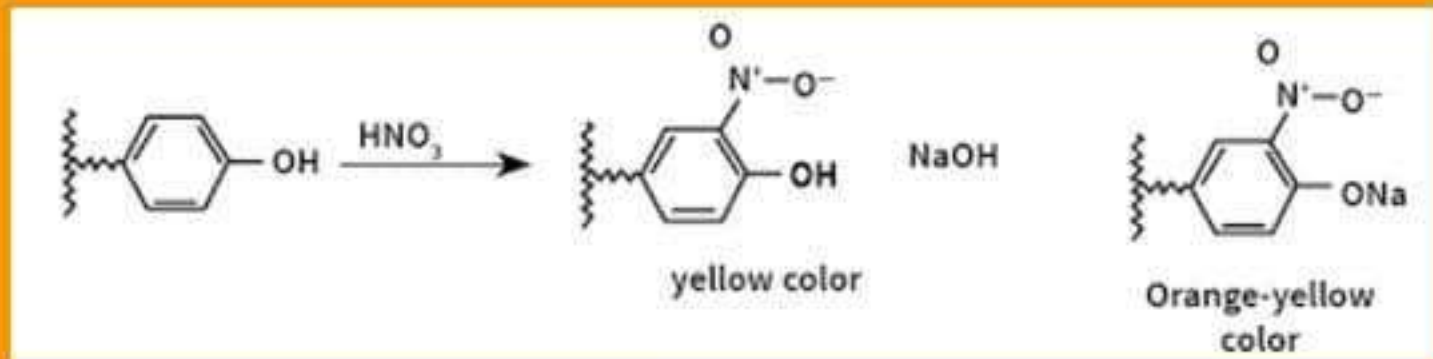
3- Heat the test tubes 3-5 minutes in boiling water bath and observe the color change.

4- Add NaOH to make the solution strongly alkaline.

5- A yellow color in acid solution turn to bright orange with alkaline because a nitrogen added to aromatic ring.

# Xanthoproteic test

(Detection of aromatic amino acids)



[www.biocheminfo.com](http://www.biocheminfo.com)

## **Xanthoproteic Test- Definition, Principle, Procedure, Result, Uses**



**Xanthoproteic  
Test Negative**

**Absence of aromatic  
amino acids (tyrosine  
and tryptophan)**

**Absence of the dark  
yellow or orange color**



**Xanthoproteic  
Test Positive**

**Presence of aromatic  
amino acids (tyrosine  
and tryptophan)**

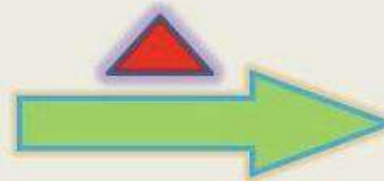
**Presense of the dark  
yellow or orange color**

## 4. Cystine, cysteine test

This test is done to detect the presence of sulfur containing amino acids such as cysteine and cystine.

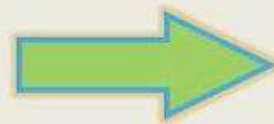
By boiling the sample with 40% NaOH the organically combined sulfur in the amino acid or protein molecule (which contain cysteine or cystine ) is converted to sodium sulfide. Brown or black precipitate (PbS) is formed by the addition of lead acetate solution.

Cysteine – SH + 40% NaOH



$\text{Na}_2\text{S}$

$\text{Na}_2\text{S} + \text{pd} (\text{CH}_3\text{COO})_2$



$\text{PdS} + \text{CH}_3\text{COONa}$



**Black ppt.**

## Procedure

**1- Prepare and label three test tubes:**

**a- 1 ml of amino acid containing sulfhydryl group SH solution.**

**b- 1 ml of glycine solution.**

**c- 1 ml D.W.**

**2- Add 5 drops of 40% NaOH for all tubes.**

**3- Boil for 3 minutes then cool.**

**4- Add 1 ml of lead acetate solution.**

**5- Report your observation.**



## **Lead Sulfide Test- Definition, Principle, Procedure, Result, Uses**



**Lead Sulfide  
Negative Test**

**Black precipitate  
absent**

**Sulfur-containing  
amino acids absent  
(cysteine or cystine)**



**Lead Sulfide  
Positive Test**

**Black precipitate  
present**

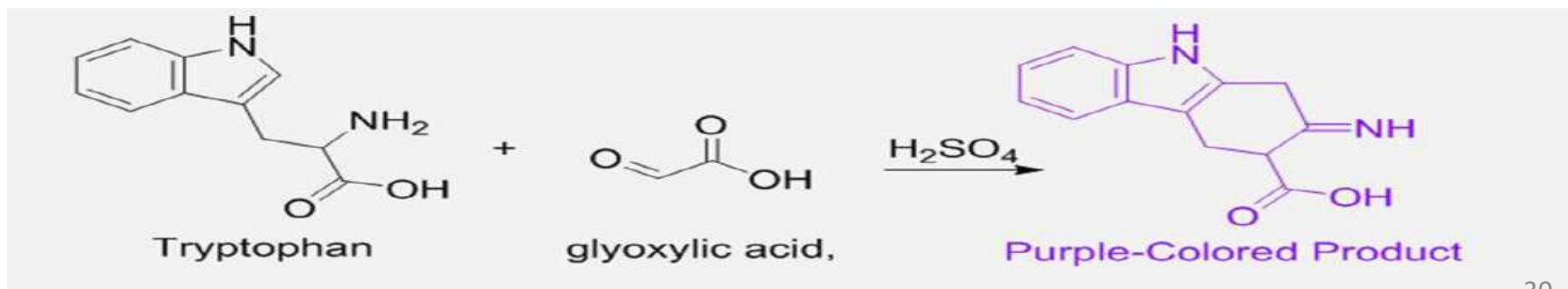
**Sulfur-containing  
amino acids present  
(cysteine or cystine)**

## 5. Hopkin cole test:

This test is used to detect the presence of tryptophane which contains an indole ring, which it reacts with glyoxylic acid in the presence of conc.sulfuric acid to give a purple ring.

### Procedure

- 1- Add 1 ml of test solution on test tube.
- 2- Add 1 ml of glacial acetic acid.
- 3- Add drop by drop of conc.sulfuric acid carefully down the sides of a sloping test tube without mix.
- 4- A purple ring formed at the junction between layers of fluid, on shaking the whole solution may become red.



## **Hopkin's Cole Test- Definition, Principle, Procedure, Result, Uses**



**Hopkin's Cole  
Negative Test**

**Purple ring  
absent**

**Tryptophan Absent**



**Hopkin's Cole  
Positive Test**

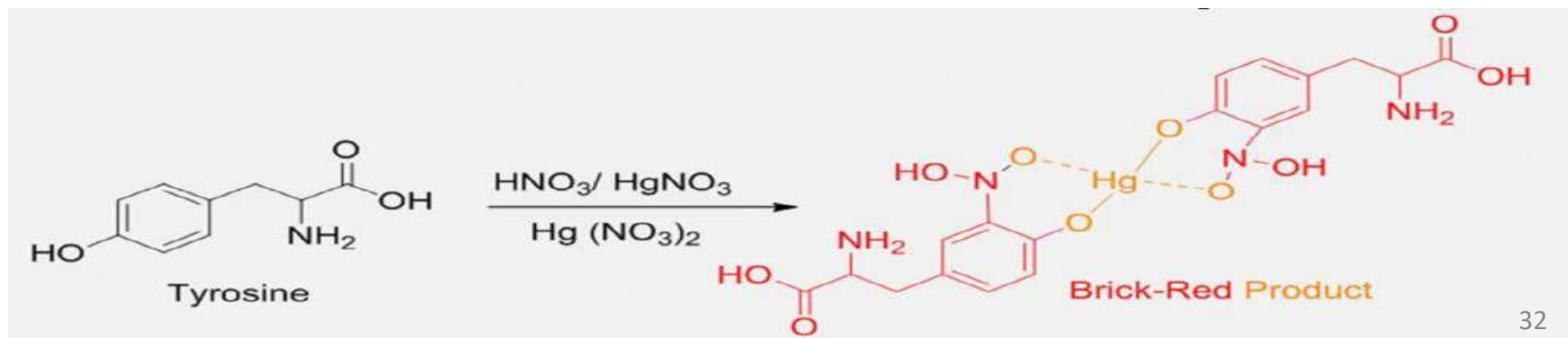
**Purple ring  
present**

**Tryptophan Present**

## 6. Millon's test:

This test is specific for tyrosine and is an indication of the presence of tyrosine in the protein because tyrosine is the only amino acid containing hydroxy phenyl group.

Millon's reagent contains Hg ion which forms red color complex with tyrosine. If the unknown is protein solution, a red precipitate will be formed because heavy metal (Hg) are precipitating agents, while if the unknown is tyrosine a red color solution will be formed.



## **Procedure**

**1- Prepare and label four test tubes:**

**a- 1 ml tyrosine.**

**b- 1 ml alanine.**

**c- 1 ml albumin.**

**d- 1 ml D.W.**

**2- Add (3-5) drops of millon's reagent to each test tube, mix well.**

**3- Heat gently in boiling water bath for 5 minutes.**

**4- Record your observation.**

## Millon's Test- Definition, Principle, Procedure, Result, Uses



### Millon's Negative Test

Absence of tyrosine  
or phenol-containing  
compounds

Red or pink colored  
precipitate absent

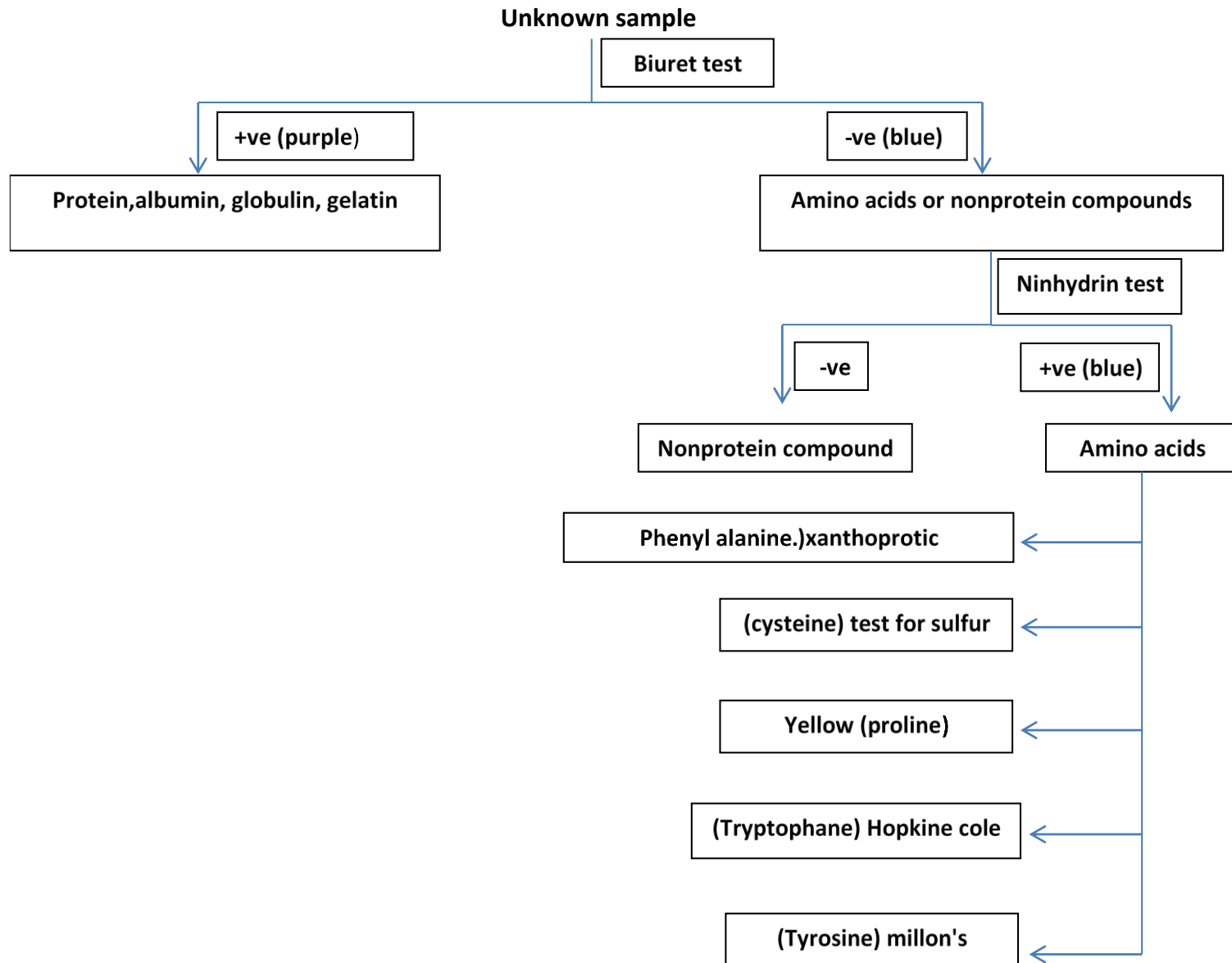


### Millon's Positive Test

Presence of tyrosine  
or phenol-containing  
compounds

Red or pink colored  
precipitate present

## General scheme for identification for unknown amino acids and proteins





- 1. why is proteins important to eat?**
- 2. Define amino-acid and peptide bond**
- 3. write down the tests you made in the laboratory and the function of each test**
- 4. Draw the structure of the zwitterion**
- 5. Mention the characteristics of solid amino acid**

# CARBOHYDRATES



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المرحلة الاولى

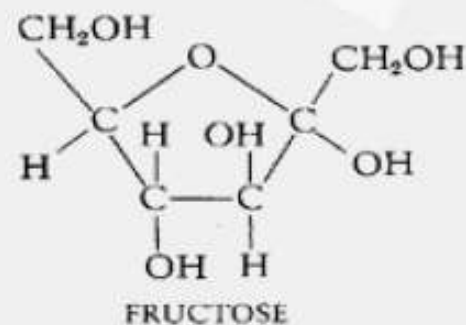
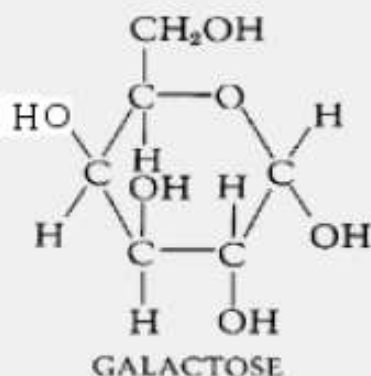
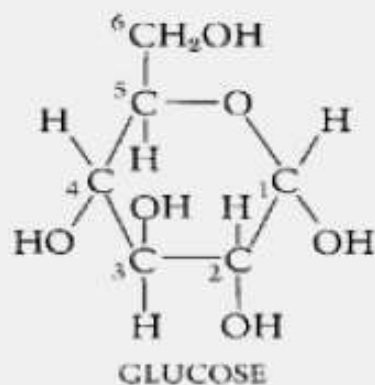
# The objective of the lecture



- **Define of carbohydrates**
- **Types of carbohydrates**
- **Function of carbohydrates**
- **Detection of carbohydrates**

# Carbohydrates

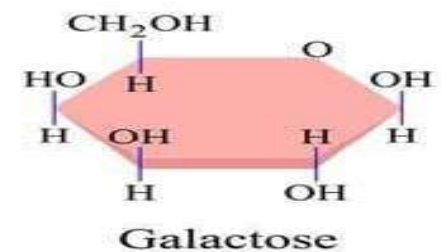
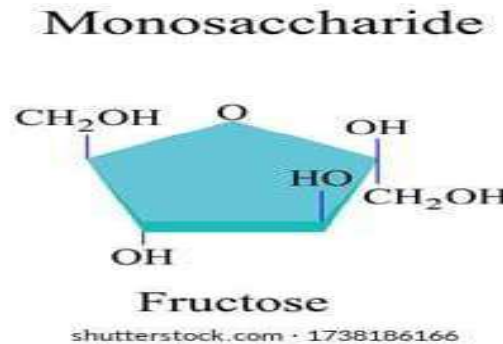
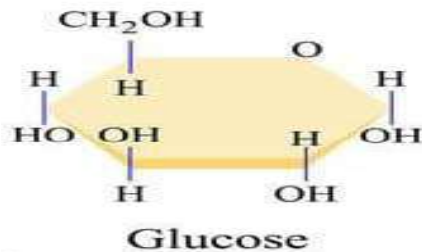
are one of a major type of big biomolecules, are also a class of organic compounds, it is about (15%) organic compounds of cell structure. The general formula of carbohydrate is  $(C_n(H_2O)_n)$  where  $(n \geq 3)$  carbohydrates are now defined as aldehydes or ketones of polyhydroxy alcohol.



# Classification of carbohydrates

## 1-Monosaccharides (Simple sugar):

contain **one** monosaccharide units, they can not broken to smaller carbohydrates. (glucose, galactose , fructose)



# Monosaccharide

(Basic building blocks of carbohydrates)

They can be classified by the number of carbon atoms ■

trioses (C-3) ■

tetroses (C-4) ■

pentoses (C-5) ■

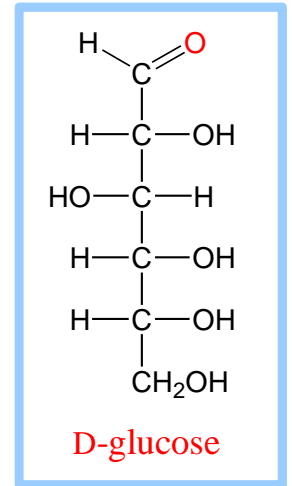
hexoses (C-6) ■

heptoses (C-7) ■

also be classified as ketoses or aldoses. •

**A ketose** contains a carbonyl group attached to •  
two R groups having one or more hydroxyl groups.

**An aldose** contains terminal aldehyde group in addition to •  
R group containing -OH.



D-glucose

aldose

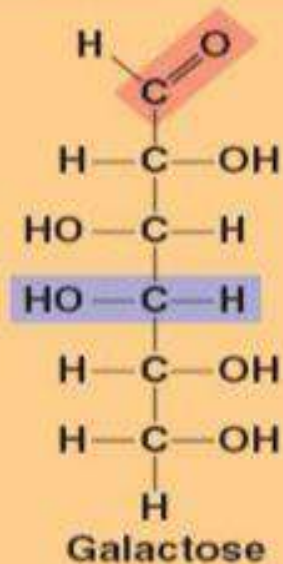
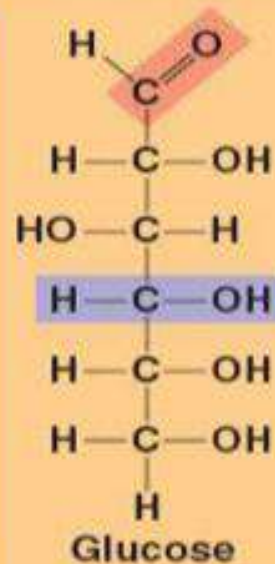
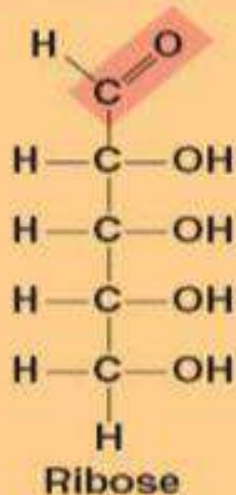
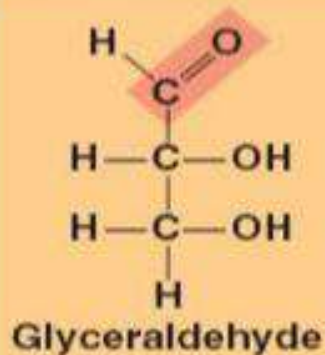


Triose sugars  
( $C_3H_6O_3$ )

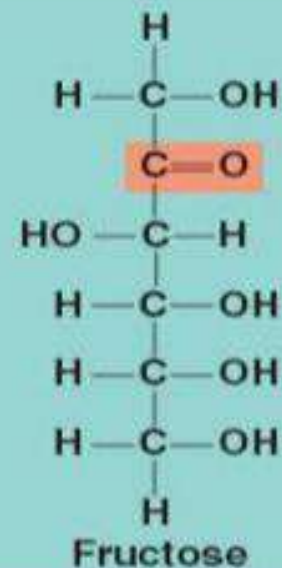
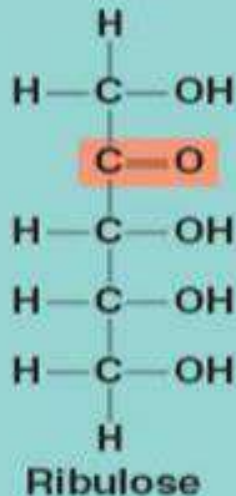
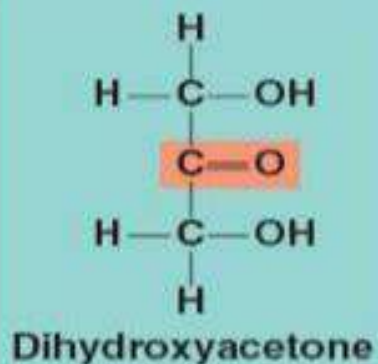
Pentose sugars  
( $C_5H_{10}O_5$ )

Hexose sugars  
( $C_6H_{12}O_6$ )

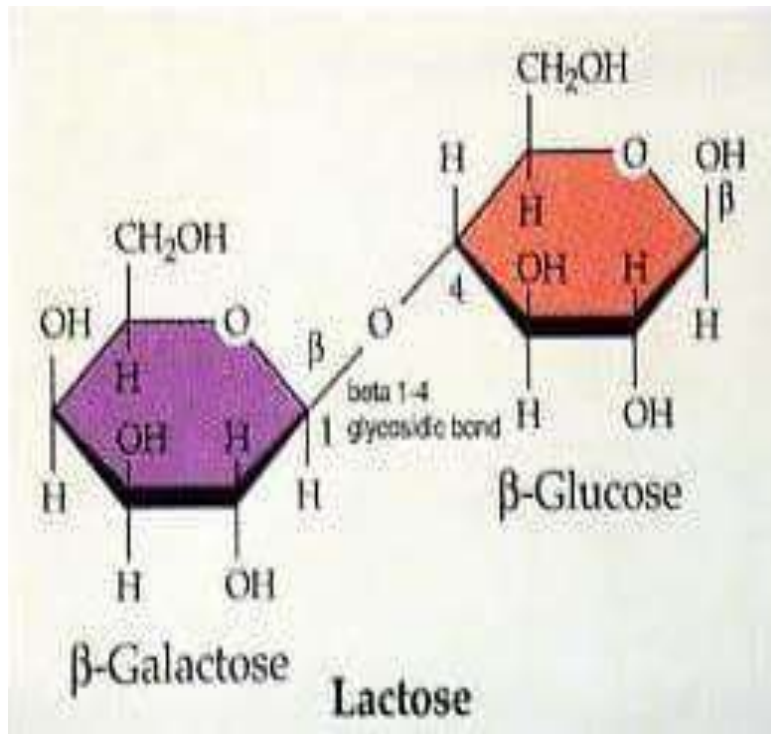
Aldoses



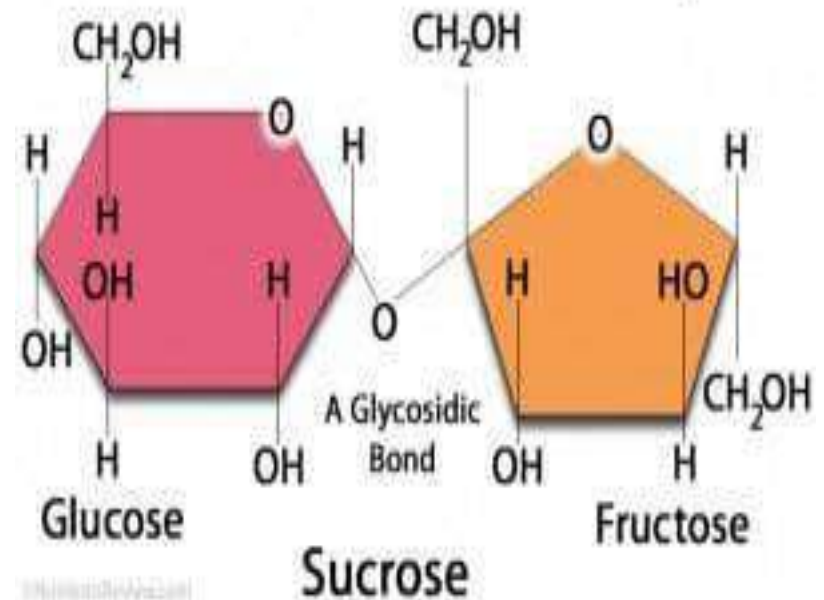
Ketoses



**2-Disaccharides:** contain **two** monosaccharide units (sucrose, maltose, lactose).



## A Disaccharide Example



# Disaccharides

- Composed of 2 monosaccharides
- cells can make disaccharides by joining two monosaccharides by biosynthesis.

## Glucose + fructose = sucrose

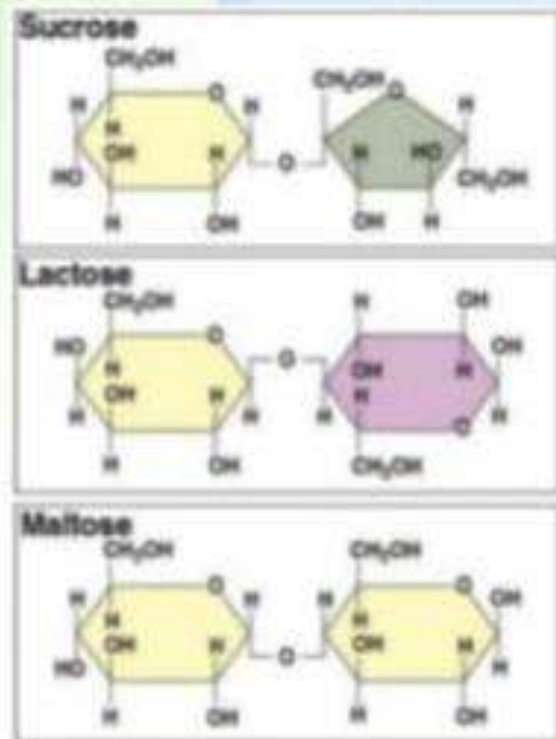
- Table sugar
- Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

## Glucose + galactose = lactose

- The primary sugar in milk and milk products.
- Many people have problems digesting large amounts of lactose (lactose intolerance)

## Glucose + glucose = Maltose

- Produced when starch breaks down.
- Used naturally in fermentation reactions of alcohol and beer manufacturing.



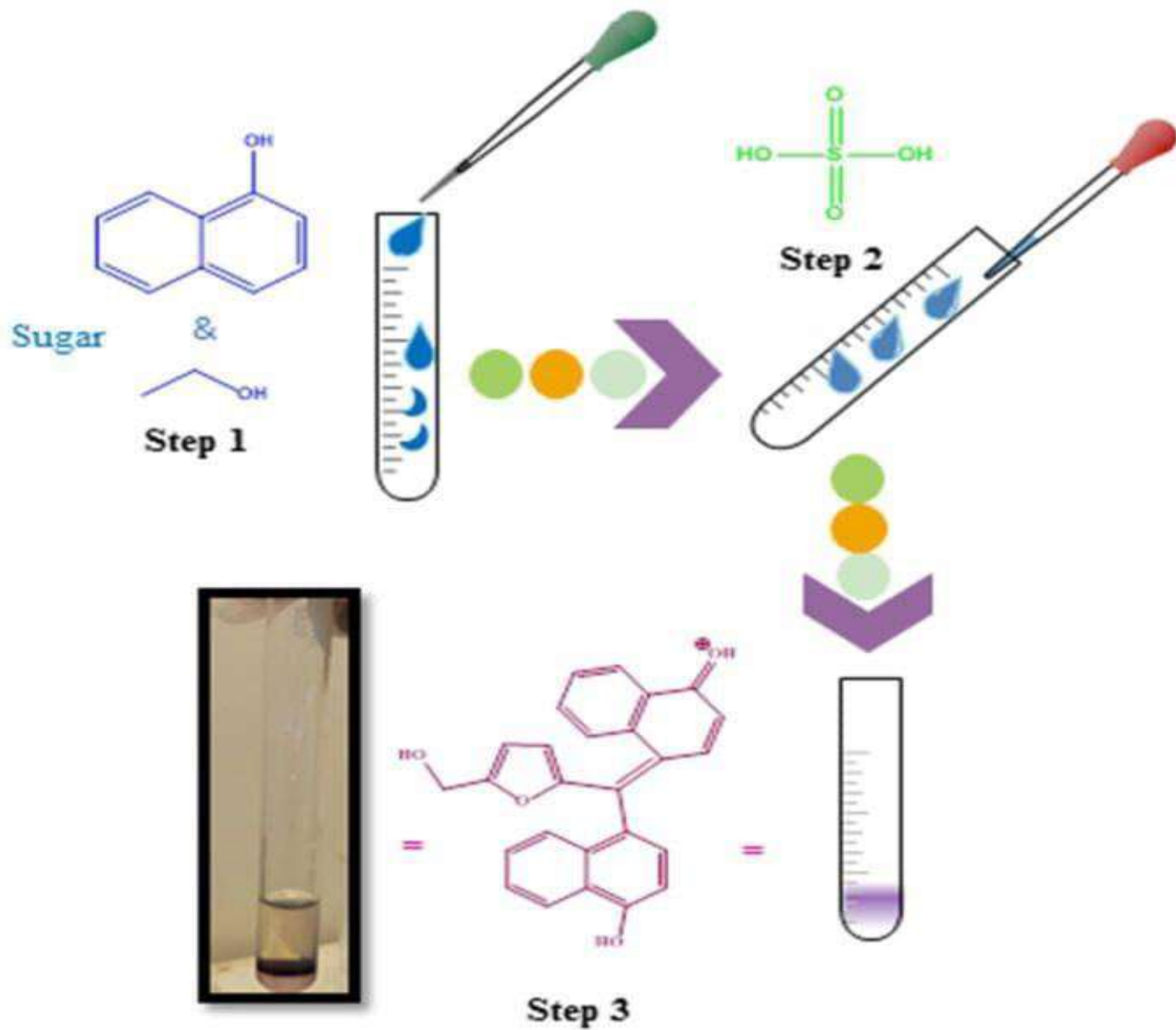
# How detection of carbohydrates

## 1. Molisch's test

This is a very sensitive general test for all carbohydrates because they all give furfural or hydroxy methyl furfural upon heating with a strong hot acidic solutions.

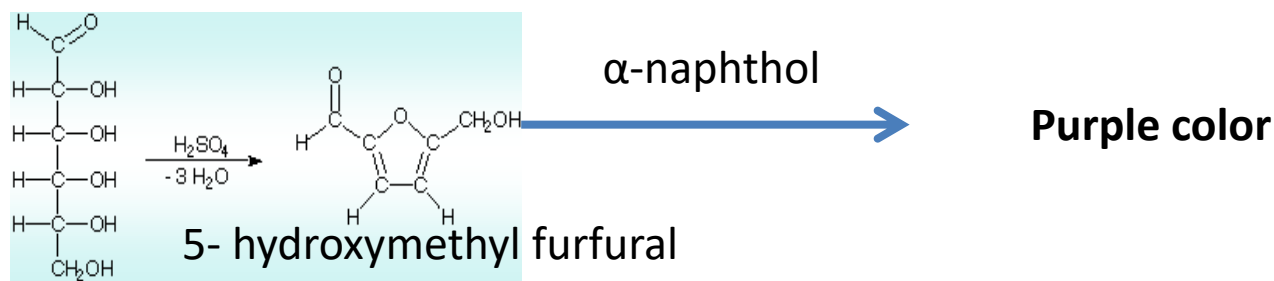
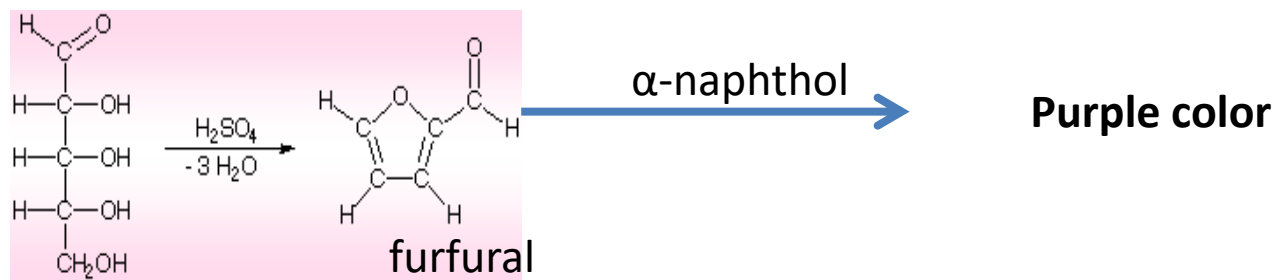
Monosaccharide gives a **rapid** positive test,  
Disaccharides and polysaccharides react **slower**.

**Objective:** To identify the carbohydrate from other macromolecules lipids and proteins.



**Principle:** The test reagent(**H<sub>2</sub>SO<sub>4</sub>**) dehydrates pentose to form furfural and dehydrates hexoses to form 5- hydroxy methyl furfural.

The furfural and 5- hydroxy methyl furfural further react with  $\alpha$ -naphthol present in the test reagent to produce a purple product.

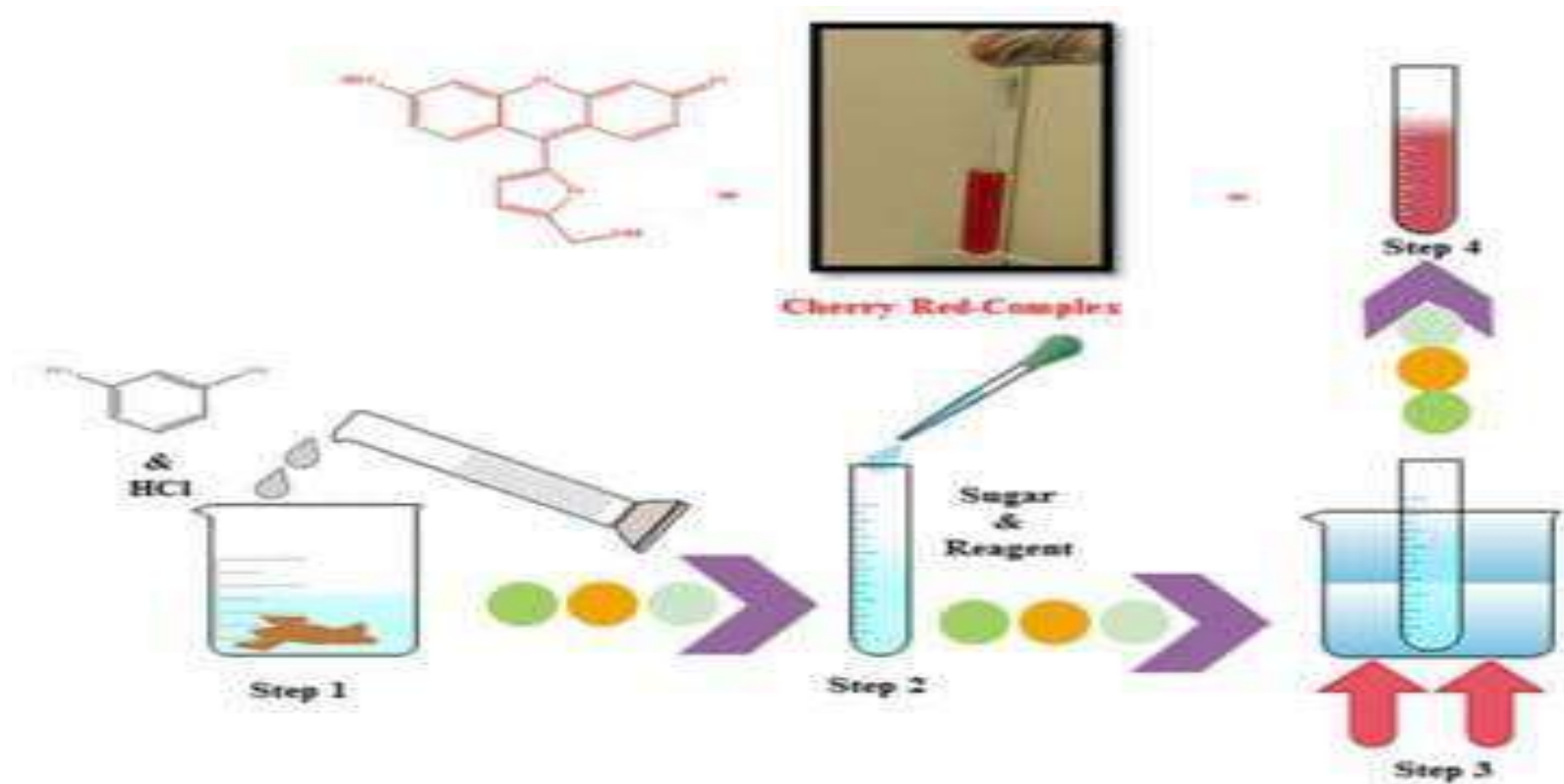


## Procedure :-

- 1-In a clean and dry test tube take 0.5ml of sugar.
- 2- Add (3-4) drops of Molish's reagent and mix well by shaking.
- 3- Carefully add about 0.5 ml of conc. Sulphuric acid by the side of the tube without mixing so that two layers will be formed , the upper layer for carbohydrate solution and the lower for conc.sulphuric acid.

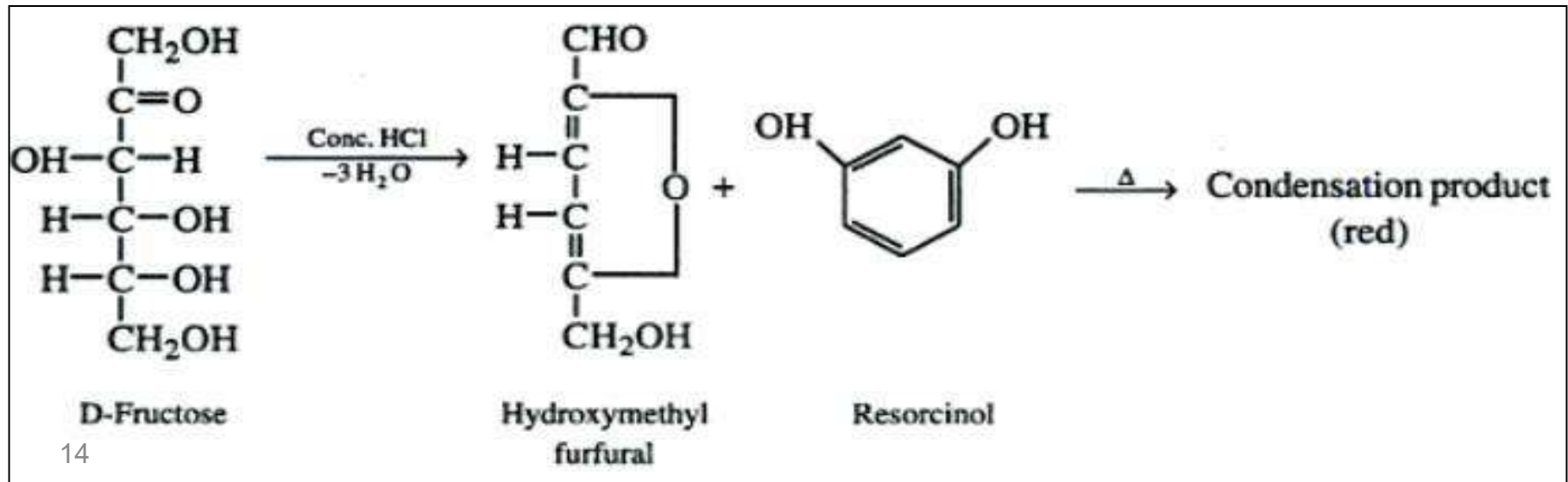
## 2. Seliwanoff's Test

This test is used to distinguish between aldoses (like glucose) and ketoses (like fructose).



**Principle** : Seliwanoff's Test uses dil. HCl as •  
dehydrating agent and resorcinol as condensation  
reagent. The test reagent dehydrates ketohexoses to  
form 5-hydroxy methyl furfural.

5-hydroxymethylfurfural further condenses with •  
resorcinol present in the test reagent to produce a  
cherry red product within two minutes.



## **Procedure:**

1- Place 1 ml of Selwanoff's reagent in a test tube.

2- Add 3 drops of carbohydrate solution, mix.

3- Place in boiling water bath for (2) minutes exactly, then cool the solution.

4- An appearance of cherry red color indicates the presence of fructose.

# 3.Bial's Test

This test is used to distinguish between pentose and hexose monosaccharides

## *Result*

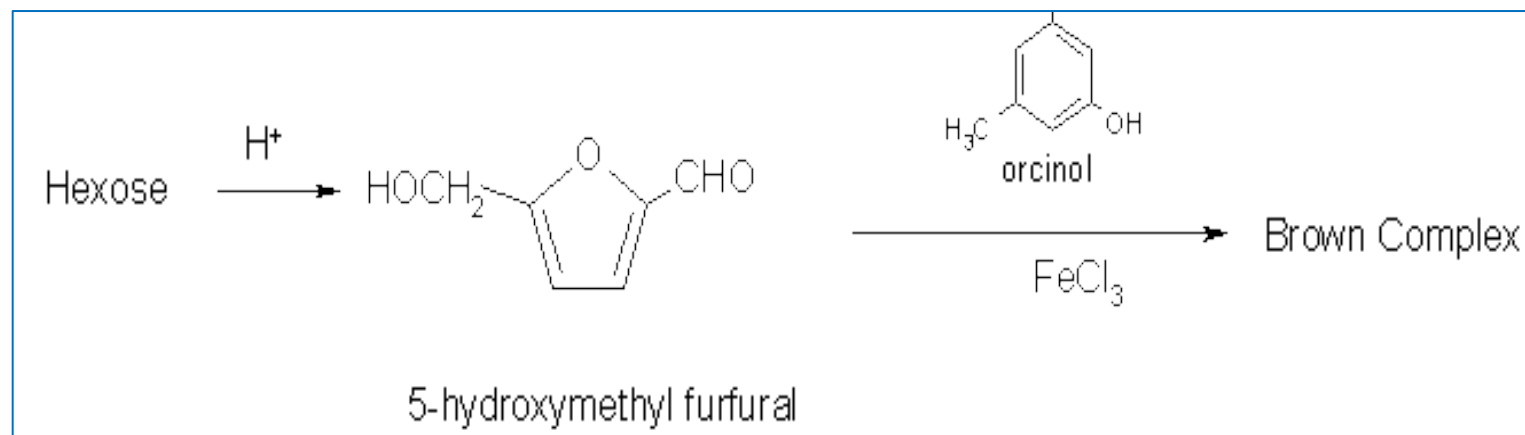
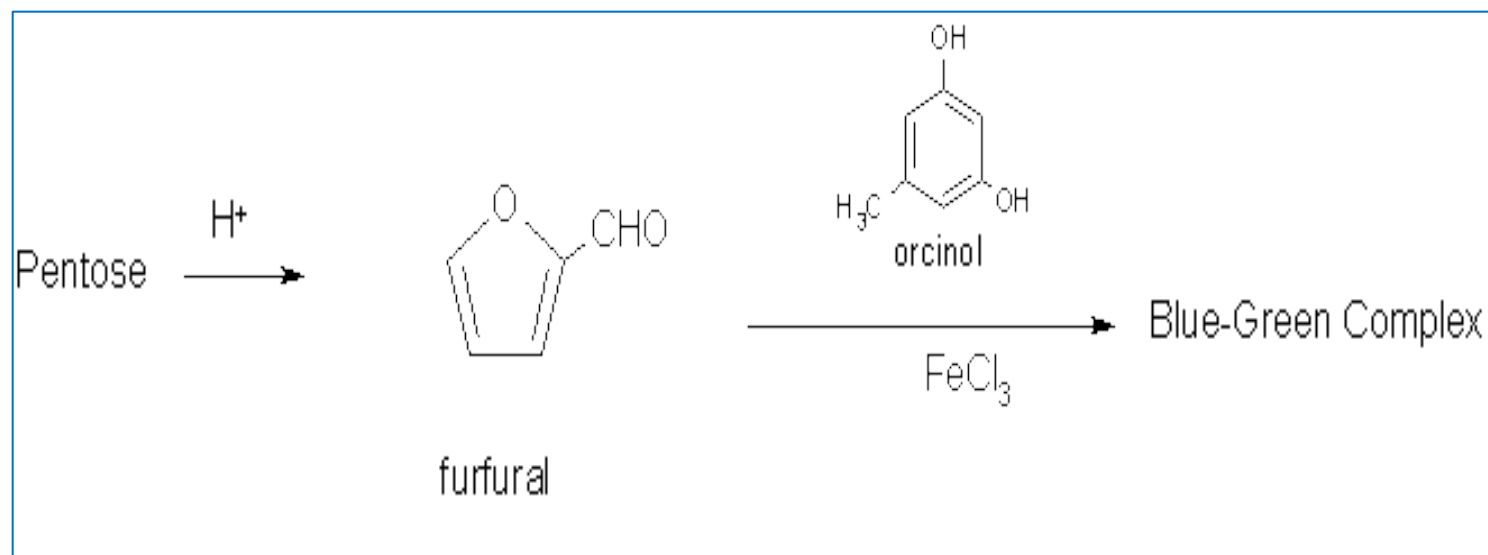
- A bluish color indicates a positive result.
- Prolonged heating of some hexoses yields hydroxymethyl furfural which also reacts with orcinol to give colored complexes.



Two negative tests (left, middle) and a positive test (right)

## Principle:

uses concentrated HCl as a dehydrating acid and orcinol + traces of ferric chloride as condensation reagent. The test reagent dehydrates pentoses to form furfural. Furfural further reacts with orcinol and the iron ion present in the test reagent to produce a bluish - green product, while hexoses yield muddy-brown to grey condensation product.



## **Procedure**

1- To 1 ml of Bial's reagent add 5 drops of pentose solution , mix.

2- Heat in a boiling water bath for (3) minutes to get a blue – green indicate a positive result.



- 1- If a black ring formed in Molisch's test, on what indicates.
- 2- On what indicates the formation of purple ring in Molisch's test
3. Fructose or glucose gives a positive result in Selvanoff's test
4. We must avoid over heating of glucose in selvanoff's test.

# CARBOHYDRATES



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# The objective of the lecture

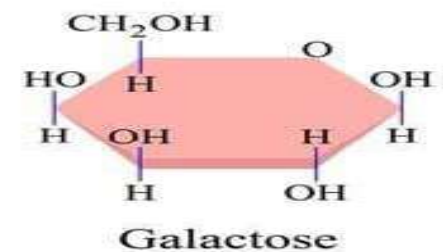
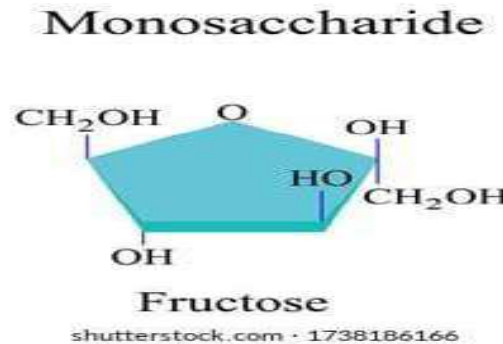
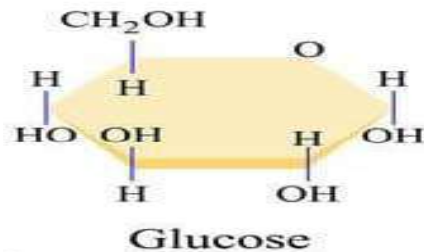


- **Define of carbohydrates**
- **Types of carbohydrates**
- **Function of carbohydrates**
- **Detection of carbohydrates**

# Classification of carbohydrates

## 1-Monosaccharides (Simple sugar):

contain **one** monosaccharide units, they can not broken to smaller carbohydrates. (glucose, galactose , fructose)



# Monosaccharide

(Basic building blocks of carbohydrates)

They can be classified by the number of carbon atoms ■

trioses (C-3) ■

tetroses (C-4) ■

pentoses (C-5) ■

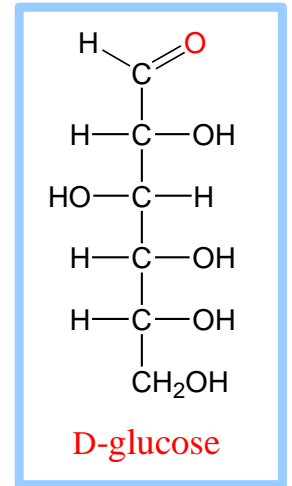
hexoses (C-6) ■

heptoses (C-7) ■

also be classified as ketoses or aldoses. •

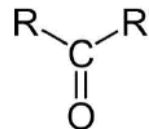
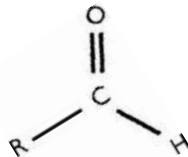
A **ketose** contains a carbonyl group attached to •  
two R groups having one or more hydroxyl groups.

An **aldose** contains terminal aldehyde group in addition to •  
R group containing -OH.



D-glucose

aldose

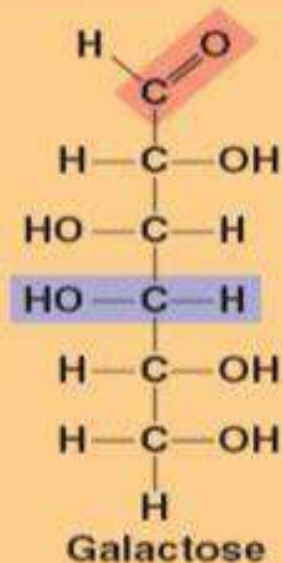
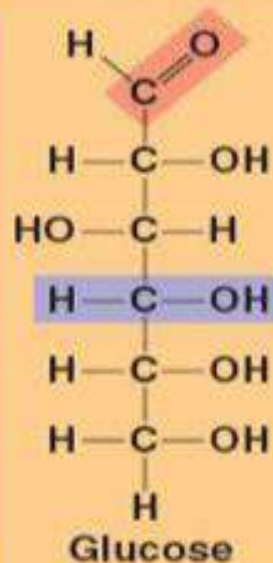
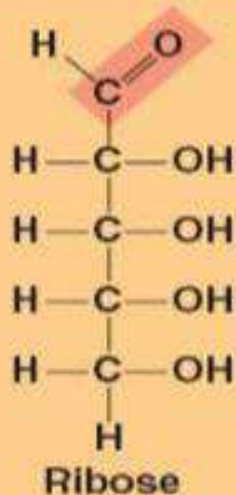
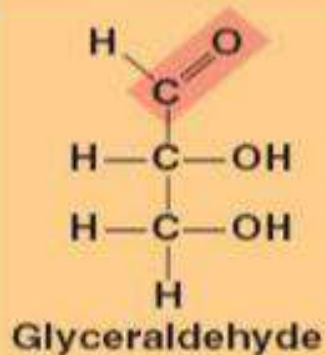


Triose sugars  
( $C_3H_6O_3$ )

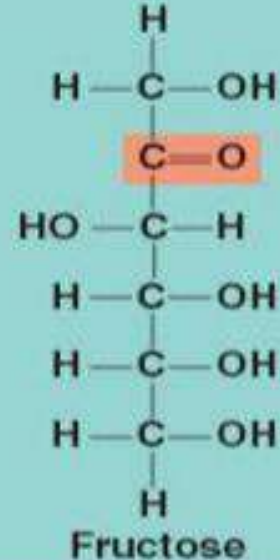
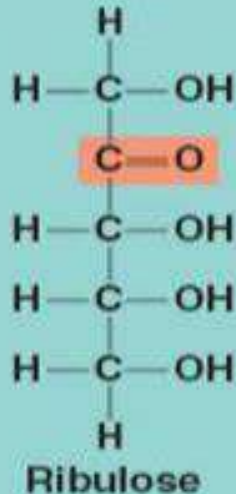
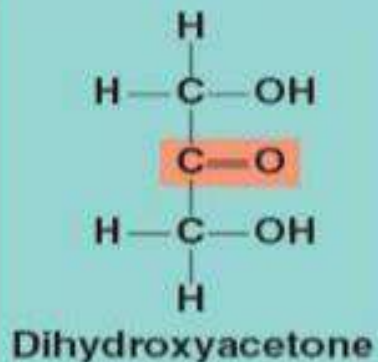
Pentose sugars  
( $C_5H_{10}O_5$ )

Hexose sugars  
( $C_6H_{12}O_6$ )

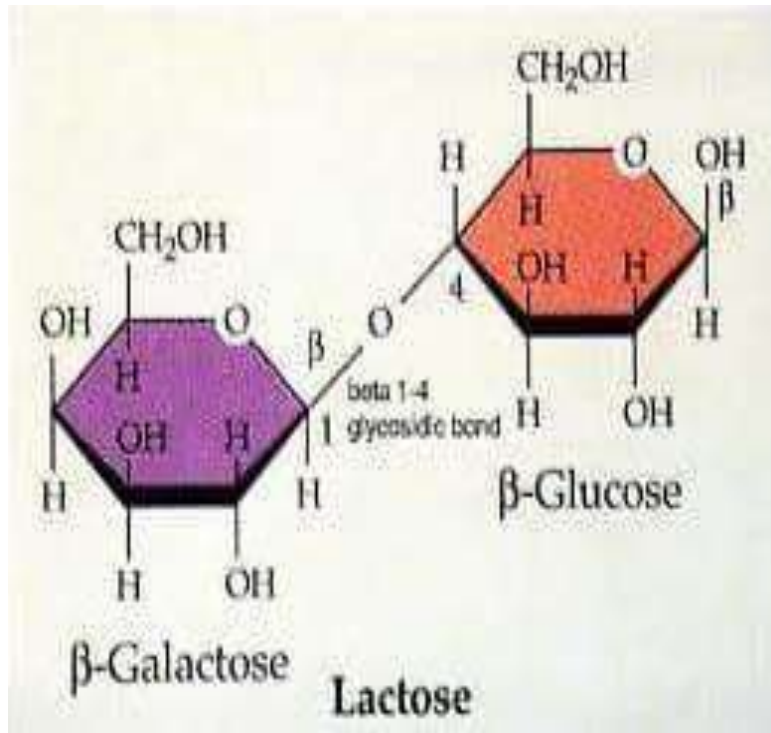
Aldoses



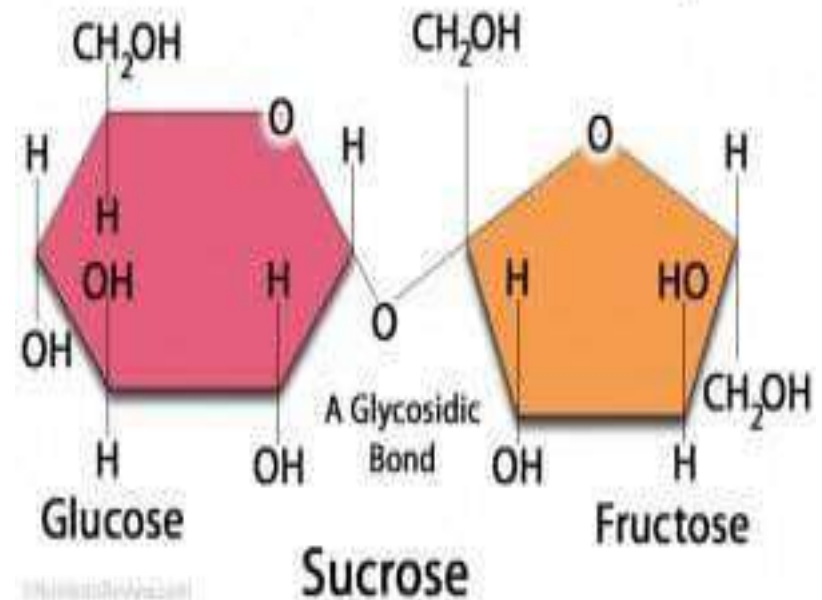
Ketoses



**2-Disaccharides:** contain **two** monosaccharide units (sucrose, maltose, lactose).



## A Disaccharide Example



# Disaccharides

- Composed of 2 monosaccharides
- cells can make disaccharides by joining two monosaccharides by biosynthesis.

## Glucose + fructose = sucrose

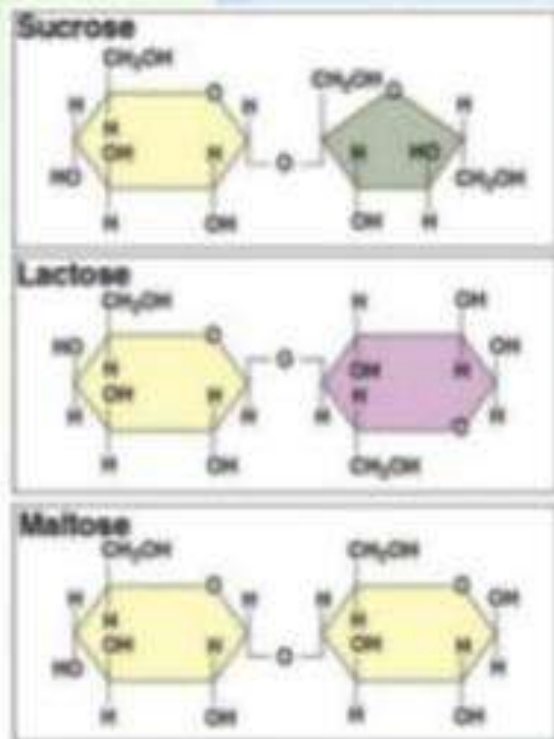
- Table sugar
- Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

## Glucose + galactose = lactose

- The primary sugar in milk and milk products.
- Many people have problems digesting large amounts of lactose (lactose intolerance)

## Glucose + glucose = Maltose

- Produced when starch breaks down.
- Used naturally in fermentation reactions of alcohol and beer manufacturing.

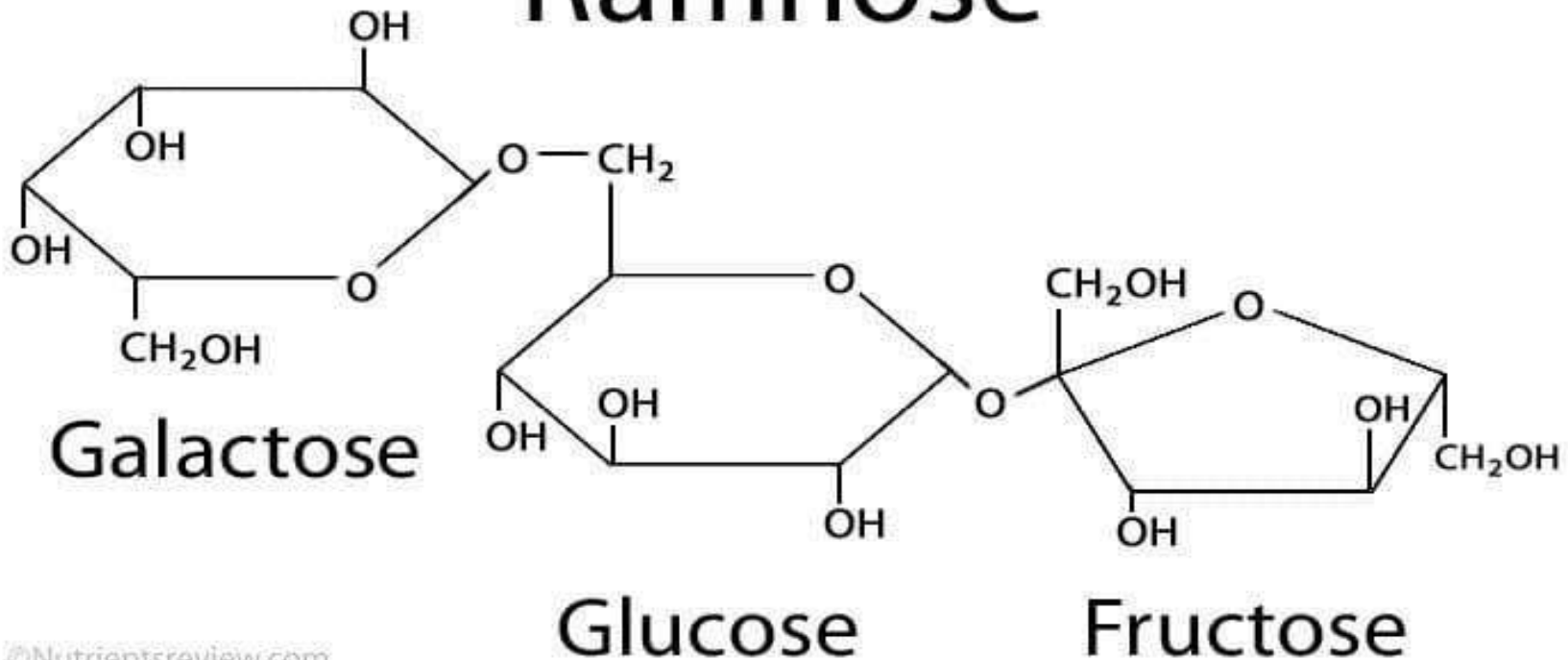


## 3-Oligosaccharides:

contain **3-10** monosaccharide units.(raffinose)

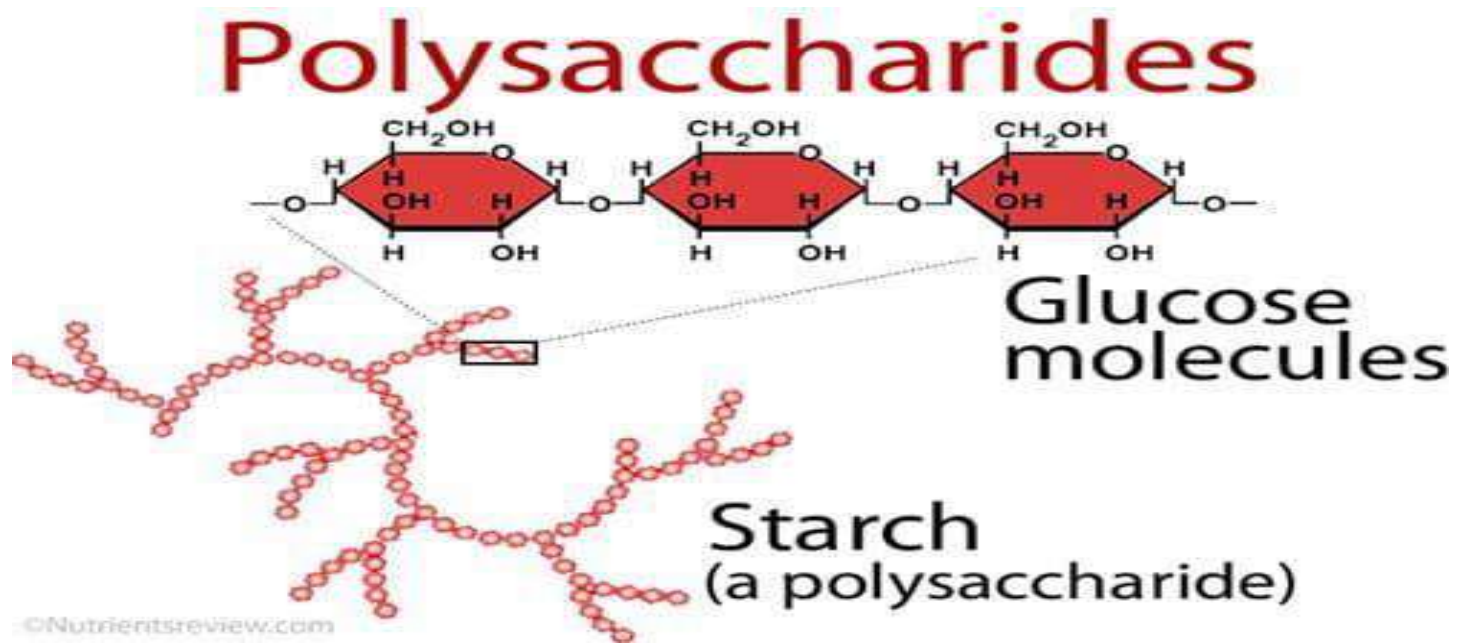
# Oligosaccharides

## Raffinose



## 4-Polysaccharides:

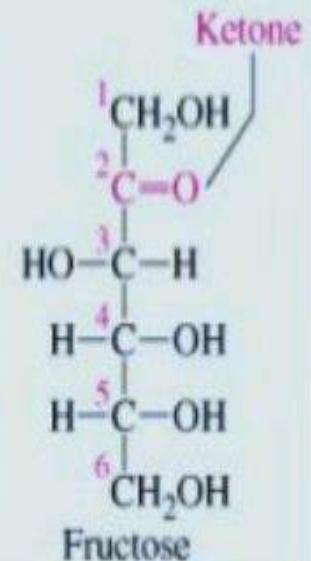
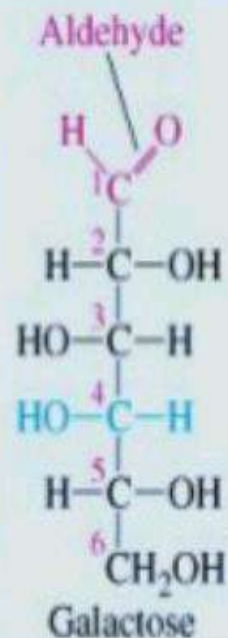
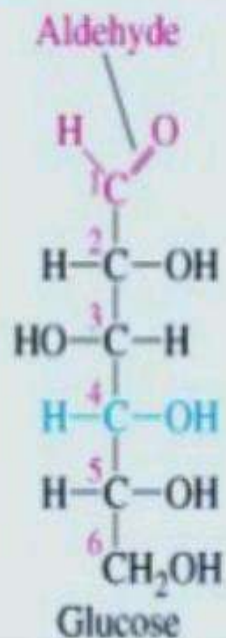
contain more than **10** monosaccharide units.(starch , glycogen).



(Disaccharides , Oligosaccharides ,Polysaccharides) can be broken down into smaller sugar units through a process known as **hydrolysis**

# Function of Carbohydrates in Cells

- ✓ Major source of energy for the cell
- ✓ Major structural component of plant cell
- ✓ Immediate energy in the form of GLUCOSE
- ✓ Reserve or stored energy in the form of GLYCOGEN



# Solubility

Monosaccharide and disaccharide can be dissolved freely in water because water is a polar substance, while polysaccharide cannot be dissolved easily in water, because, it has high molecular weight, which give colloidal solutions in water soluble.



# Reducing and non reducing sugars

**Reducing sugars:** They contain free aldehyde or ketone groups that are capable of acting as reducing agent.

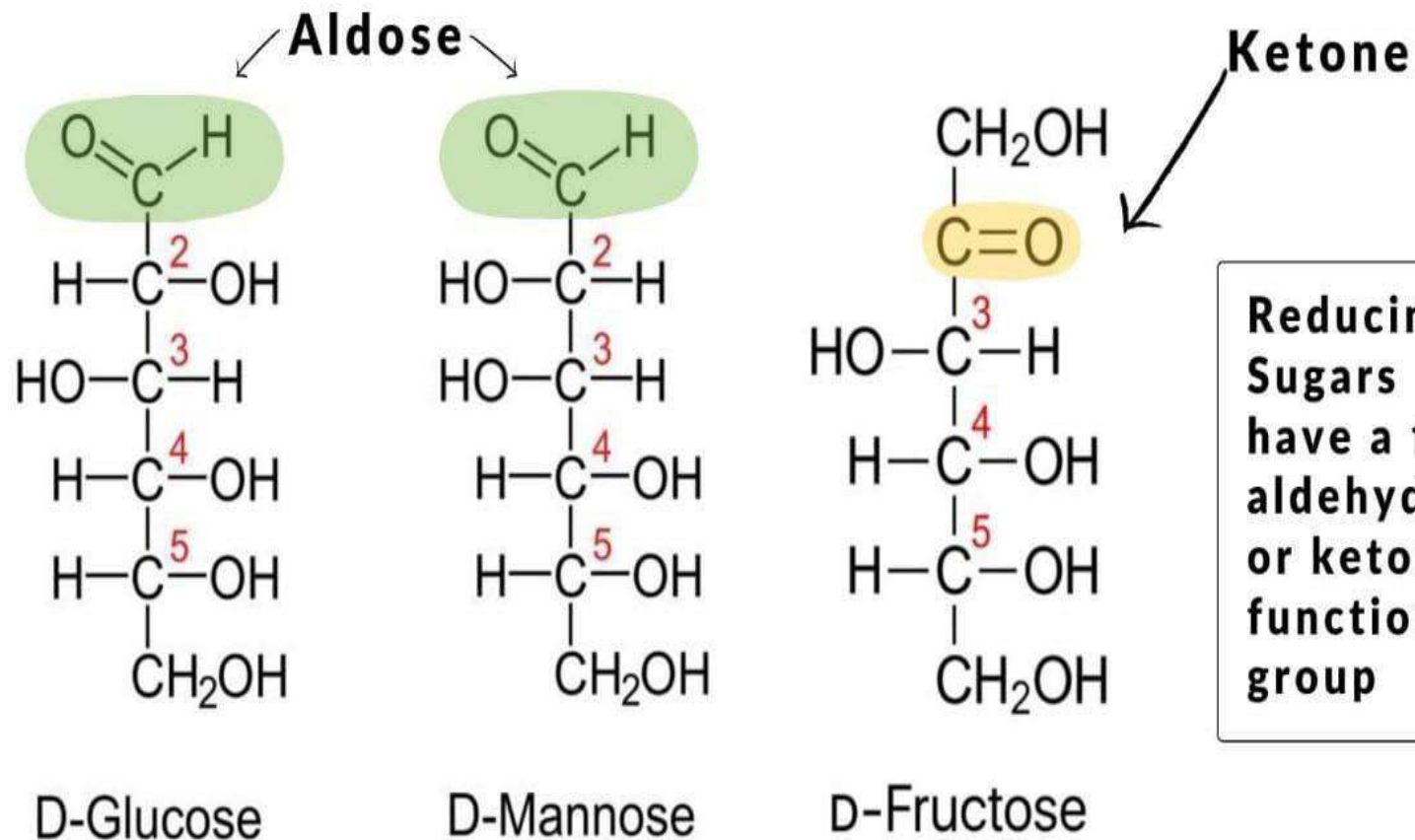
**Non reducing sugars:** They lack the free aldehyde or ketone groups.

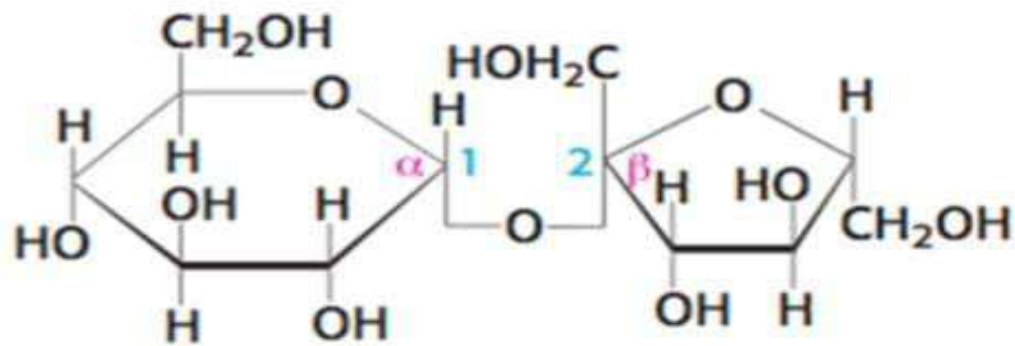
-All mono saccharides are reducing sugars.

-Maltose and lactose are reducing sugars in disaccharides, but sucrose is non reducing sugar.

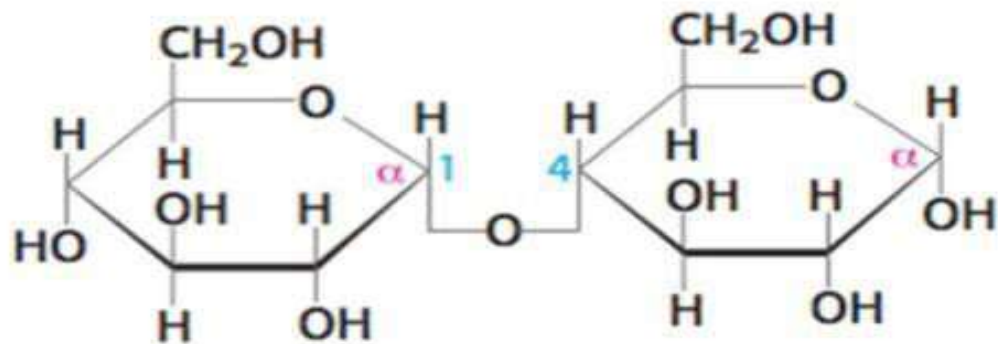
-All polysaccharides are non reducing sugars.

# Reducing Sugar





**Sucrose**  
 **$\alpha$ -D-Glucopyranosyl- $\beta$ -D-fructofuranose**



**Maltose**  
 **$\alpha$ -D-Glucopyranosyl-(1  $\rightarrow$  4)- $\alpha$ -D-glucopyranose**

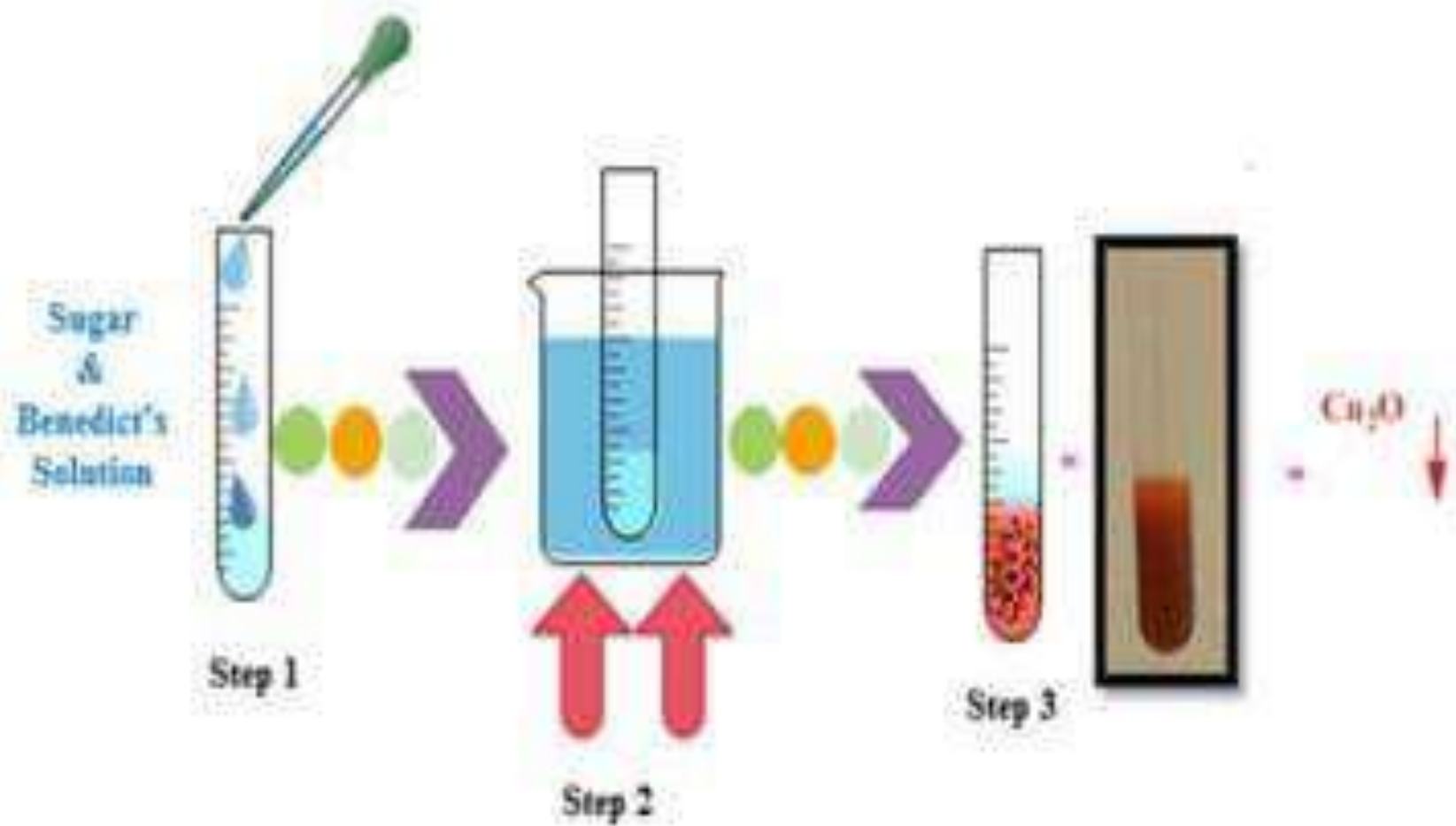
## 4. Benedict's test

Is a test used to distinguish between reducing sugar from non-reducing sugars.

**All monosaccharides are reducing sugars**, they all have a free reactive carbonyl group.

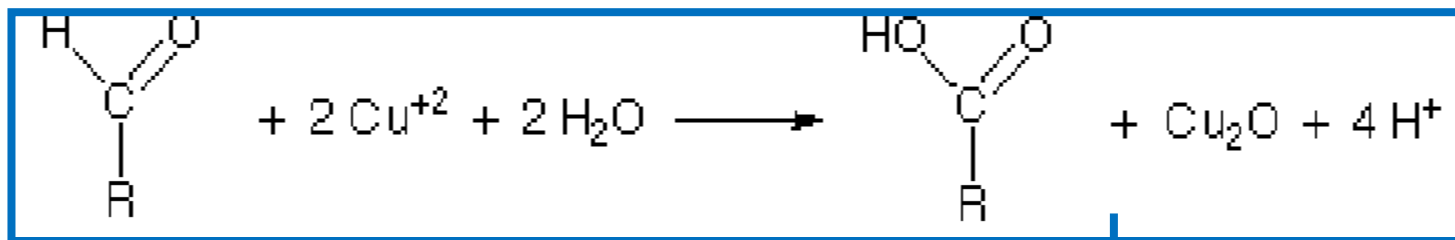
**Some disaccharides have exposed carbonyl groups and are also reducing sugars.** Other disaccharides such as **sucrose are non-reducing sugars** and will not react with Benedict's solution.

Large polymers of glucose, such as starch, are not reducing sugars



**Principle:** The copper sulfate ( $\text{CuSO}_4$ ) present in Benedict's solution reacts with electrons from the aldehyde or ketone group of the reducing sugar in **alkaline medium**.

Reducing sugars are oxidized by the copper ion in solution to form a carboxylic acid and a reddish precipitate of copper oxide.



reddish precipitate of copper

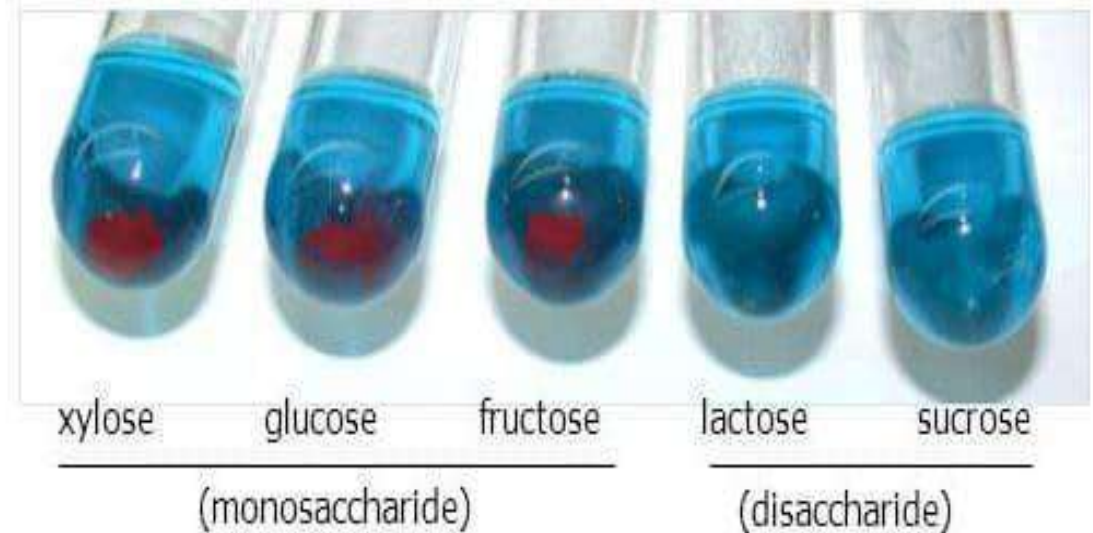
## Procedure

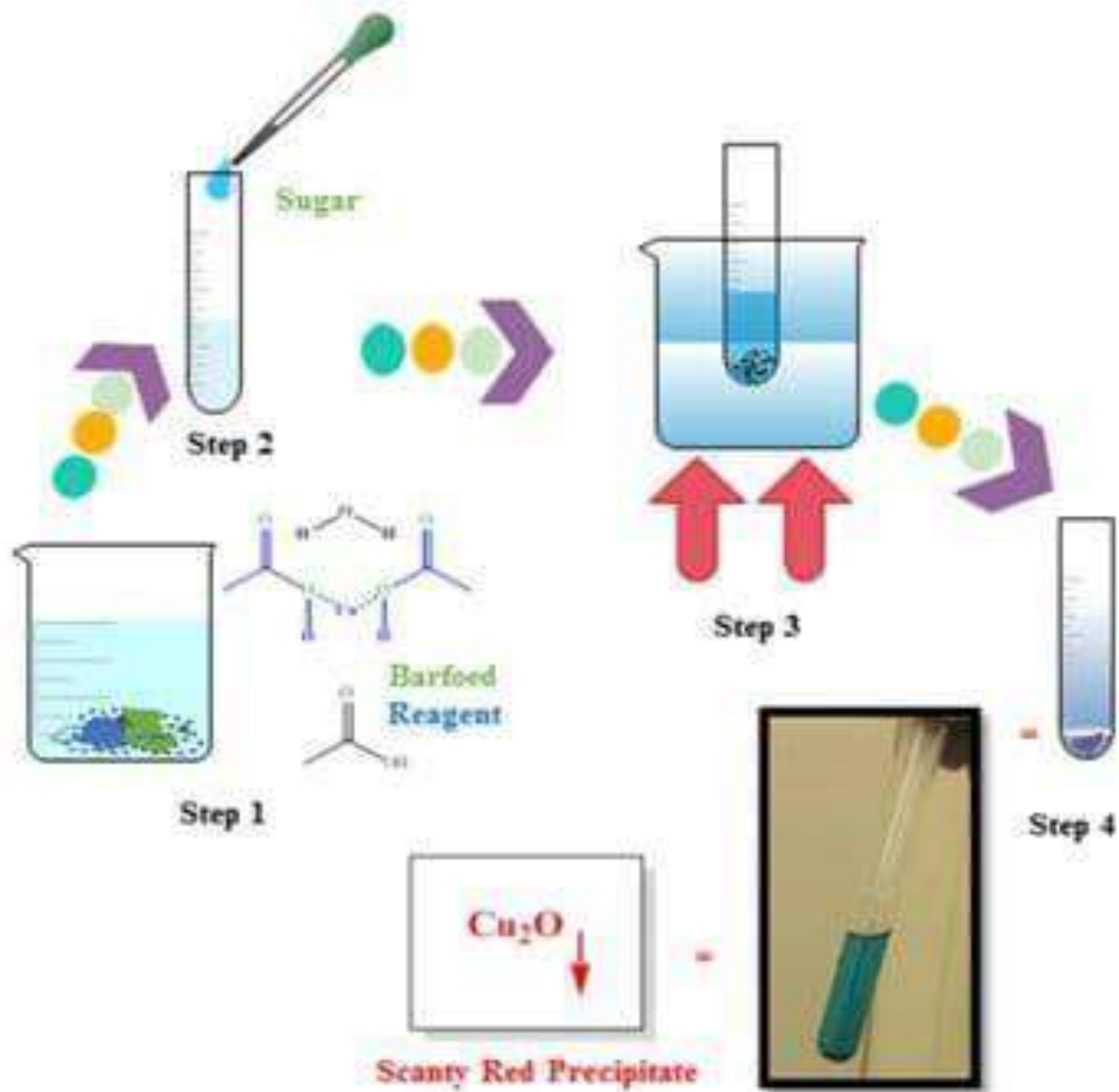
- 1- Add 1 ml of Benedict's reagent in the test tube and then add 4 drops of the test solution, mix well.
- 2- Put the reaction test tube in boiling water bath for (2-5) minutes, and then let it cool.
- 3- A positive test is indicated by: The formation of a reddish precipitate.

# 5.Barfoed's Test

This test is performed to distinguish between reducing monosaccharides, reducing disaccharides

Barfoed's test  
(test for  
monosaccharides)

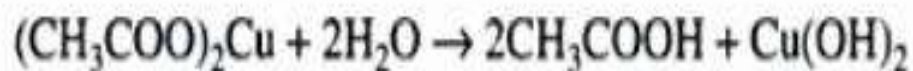




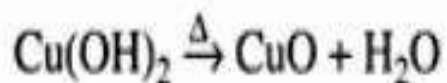
**Principle:** Barfoed's test used copper (II) ions in a **slightly acidic medium**.

Reducing monosaccharides are oxidized by the copper ion in solution to form a carboxylic acid and a reddish precipitate of copper (I) oxide within three minutes. Whereas Reducing disaccharides give negative result (solution remain blue) unless they present in high concentration or hydrolyzed to their main constituents of monosaccharides due to the prolonged heating of the reaction mixture

Barfoed's reagent, cupric acetate in acetic acid, so in acidic medium, disaccharide is a weaker reducing agent than monosaccharide, so monosaccharide will reduce the copper in less time.



Cupric hydroxide



Cuprous oxide  
(Red ppt.)



## **Procedure:**

1- To 1 ml of Barfoed's reagent add 5 drops of test solution, mix.

2- Place the test tube in boiling water bath for exactly 3 minutes.

3- Then remove the test tube and allow cooling gradually a red precipitate of cuprous oxide is formed in case of presence of monosaccharides.

## 6- Iodine test:-

A test to distinguish between simple sugars and polysaccharides.

Iodine can form an adsorption complex with the helical structure (coil-like) of the polysaccharides.

So it give a **blue** color with **starch**,

**red** with **dextrin**

**brown-red** with **glycogen**

depending on coil size and molecular weight. The test solution should be either neutral or slightly acidic but never alkaline, since alkaline medium react with iodine molecule and dissociate it.

Brown / Yellow



**Negative Test** (starch absent)

Blue / Purple



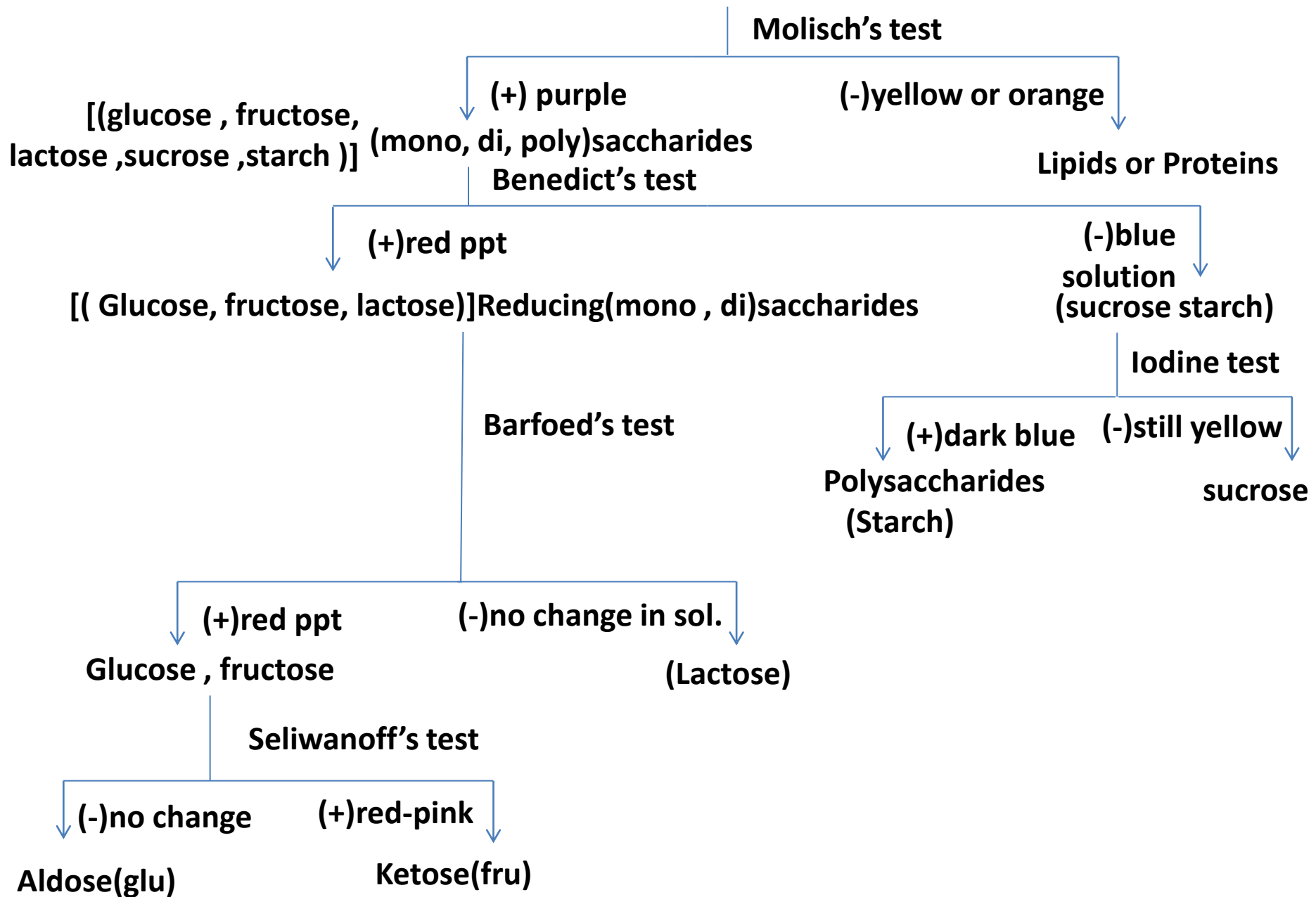
**Positive Test** (starch present)

## procedure

- 1- Place 1 ml of test solution in dry test tube
- 2- Add (1-2) drops of iodine.

Test	objective
<b>Molisch's test</b>	(general test for carbohydrates) To identify the carbohydrate from other macromolecules lipids and proteins
<b>Benedict's test</b>	Benedict's reagent is used as a test for the presence of reducing sugars.
<b>Barfoed's Test</b>	to distinguish between reducing monosaccharides, reducing disaccharides
<b>Bial's Test</b>	To distinguish between pentose monosaccharide and hexose monosaccharide
<b>Seliwanoff's Test</b>	To distinguish between aldose and ketose sugars
<b>Iodine test</b>	To distinguish polysaccharides from other carbohydrates

# Scheme identification for unknown carbohydrates



# H.W

- 1- Why polysaccharides can not be dissolved in water.
- 2- How a sucrose gives a positive result in Benedict's test.
- 3- How a reducing disaccharides give a positive result in Barfoed's test.
- 4- Why we use a slightly acidic medium in Iodine test.

# Glucose in blood

م.م ايمن رمزي محمد  
قسم التخدير / المرحلة الاولى

# Introduction to biochemistry

- **Biochemistry is the study of molecules and their reactions in living organisms**
- **The pharmaceutical industry designs molecules that mimic or alter the action of biomolecules**
- **The goal of biochemistry is to understand the structures of biomolecules and the relationship between their structures and functions**

## 2. Plasma vs. serum

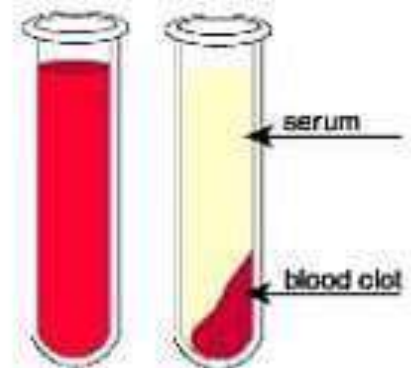
• **Plasma** is the liquid, cell-free part of blood, that has been **treated with anti-coagulants**.

Anticoagulated



**Serum** is the liquid part of blood **AFTER coagulation**, therefore devoid of clotting factors as fibrinogen.

Clotted



• serum = plasma - fibrinogen

# The objective of the lecture



- ✓ Introduction about blood glucose
- ✓ Types of glucose test
- ✓ Main types of diabetes
- ✓ methods of measuring blood glucose level

# **Blood glucose**

**A blood glucose test measure the a mount of a type of sugar called glucose in your blood**

**Glucose come from carbohydrate , protein ,and lipid .it is the main source of energy used by the body**

**Insulin is a hormone that help your body's cells use the glucose insulin is produced in the pancreas and released into the blood when the amount of glucose in to the blood rises**

# There are several different types of blood glucose tests:

- ☐ **Fasting blood sugar (FBS)**: measure blood glucose after you have not eaten for at 8 hours
- ☐ **2- hour postprandial blood sugar** : measure blood glucose exactly 2 hours after you start eating ,this test is used to see if someone with diabetes is taking a right amount of insulin with meals
- ☐ **random blood sugar ( RBS)** : measure blood glucose regardless of when you last ate ,random testing is useful because glucose level in healthy people not very widely ,blood glucose level that very widely may mean a problem
- ☐ **glucose tolerance test ( GTT)**: is used to diagnose prediabetes and diabetes
- ☐ **Hemoglobin A1C (HbA1C)**: measure how much glucose is stuck red blood cell ,It is also shows how well your diabetes has been controlled in the past 2 to 3 months

# Carbohydrates: Clinical applications

---

Carbohydrate metabolism disorders include:

- **Hyperglycemia**: increased blood glucose
- **Hypoglycemia**: decreased blood glucose
- **Inborn errors of metabolism**



**VERY HIGH**  
**Blood Sugar Levels**

**250-400 (mg/dL)**  
**13.9-22.2 (mmol/L)**

**MODERATE DIABETES**

Blood glucose level rises.

In response to glycogen, the liver breaks down glycogen and releases glucose into the blood.

The pancreas releases insulin.

The pancreas releases glucagon.

In response to insulin, target cells take up glucose and the liver converts glucose to glycogen.

Blood glucose level falls.



# Main types of **DIABETES**



## **TYPE 1 DIABETES**

Body does not produce enough insulin



## **TYPE 2 DIABETES**

Body produces insulin but can't use it well



## **GESTATIONAL DIABETES**

A temporary condition in pregnancy

# Two methods of measuring blood glucose level:

1. Reduction method, which is based on the ability of glucose to **reduce**  $\text{Cu}^{++}$  to  $\text{Cu}^{+}$  → less sensitive, → substances that could reduce  $\text{Cu}^{++}$  : fructose, galactose, vitamin C, creatinin, uric acid, glutathion, etc.
2. Enzymatic method (more specific and precise result) : Glucose is **oxidized** by glucose oxidase → gluconic acid +  $\text{H}_2\text{O}_2$  → **red dye**.

# Specimen collection

- Serum, plasma is suitable for samples.
- Whole blood and hemolysis are not recommended for use as a sample.
- Freshly drawn serum is the preferred specimen.
- Stability: serum , heparin or EDTA plasma (with addition of glycolytic inhibitor):
  - ❖ 2 days at 20-25°C
  - ❖ 7 days at 2-8° C

# PROCEDURE

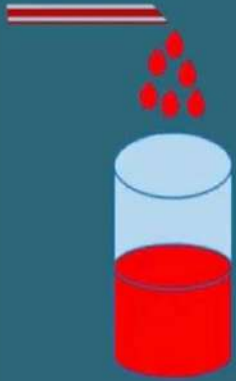
	Blank	Standard	Test
Reagent	1 ml	1 ml	1 ml
D.W	10 µL		
Standard		10µL	
Serum			10µL

Mix & keep it for incubation at 37° C for 10 min or at room temperature for 20 min. Measure the intensity of color at (500 nm)

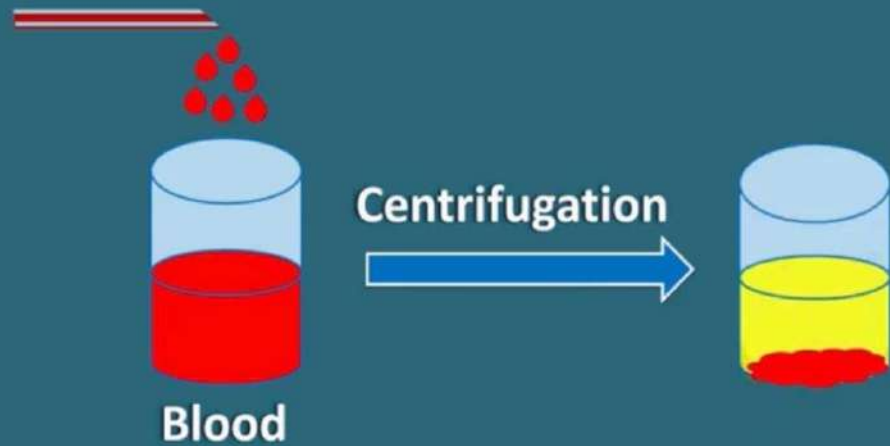
## Calculation :

$$\text{glu. Conc.} = \frac{\text{Abs. Assay}}{\text{Abs. Standard}} \times \text{Standard Conc. (100) mg / dl}$$

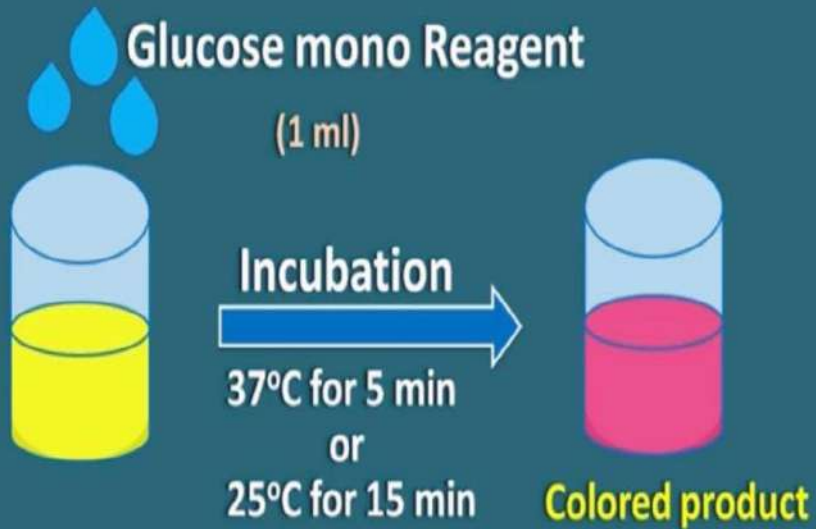
How it is estimated?



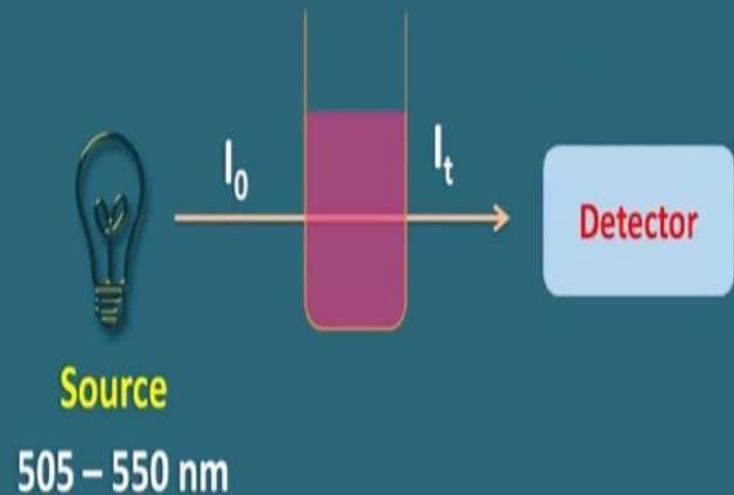
How it is estimated?



How it is estimated?



How it is estimated?



# Principle of blood glucose test

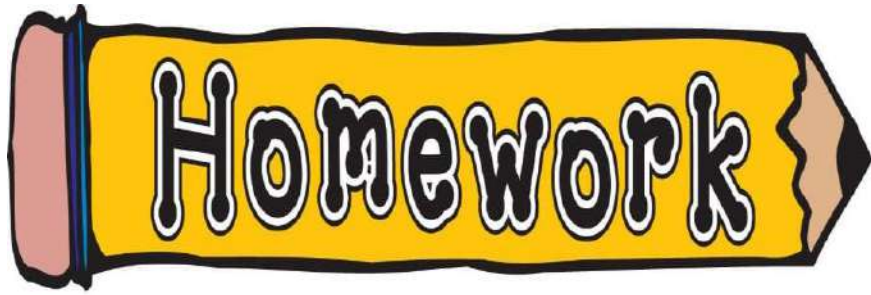
- Colorimetric, enzymatic method with glucose oxidase
- Glucose oxidase (GOD) catalyses the oxidation of glucose to gluconic acid and hydrogen peroxide.
- The formed hydrogen peroxide ( $H_2O_2$ ), react with phenol and aminophenazone in the presence of peroxidase (POD) to form a color complex quinone.
- The absorbance of coloured complex proportional to the concentration of glucose in the sample

# Principle



# Blood Sugar Levels Chart

	Normal	Prediabetic	Type 2 Diabetic
<b>Fasting</b>	70-100mg/dL (3.8-5.6 mmol/L)	100-125 mg/dL (5.6-6.9 mmol/L)	126mg/dl or greater (7mmol/L or greater)
<b>2 hours after eating</b>	<140 mg/dL (<7.8 mmol/L)	140-199 mg/dL (7.8-11 mmol/L)	200 mg/dL or more (>11 mmol/L)
<b>A1C</b>	6% or less	6% to 6.4%	6.5% or greater



- 1. What affects glucose test ? •**
- 2. When is blood sugar the highest ?**
- 3. Who is responsible helping your body's cells use the glucose?**

# Estimation of Urea

الكيمياء

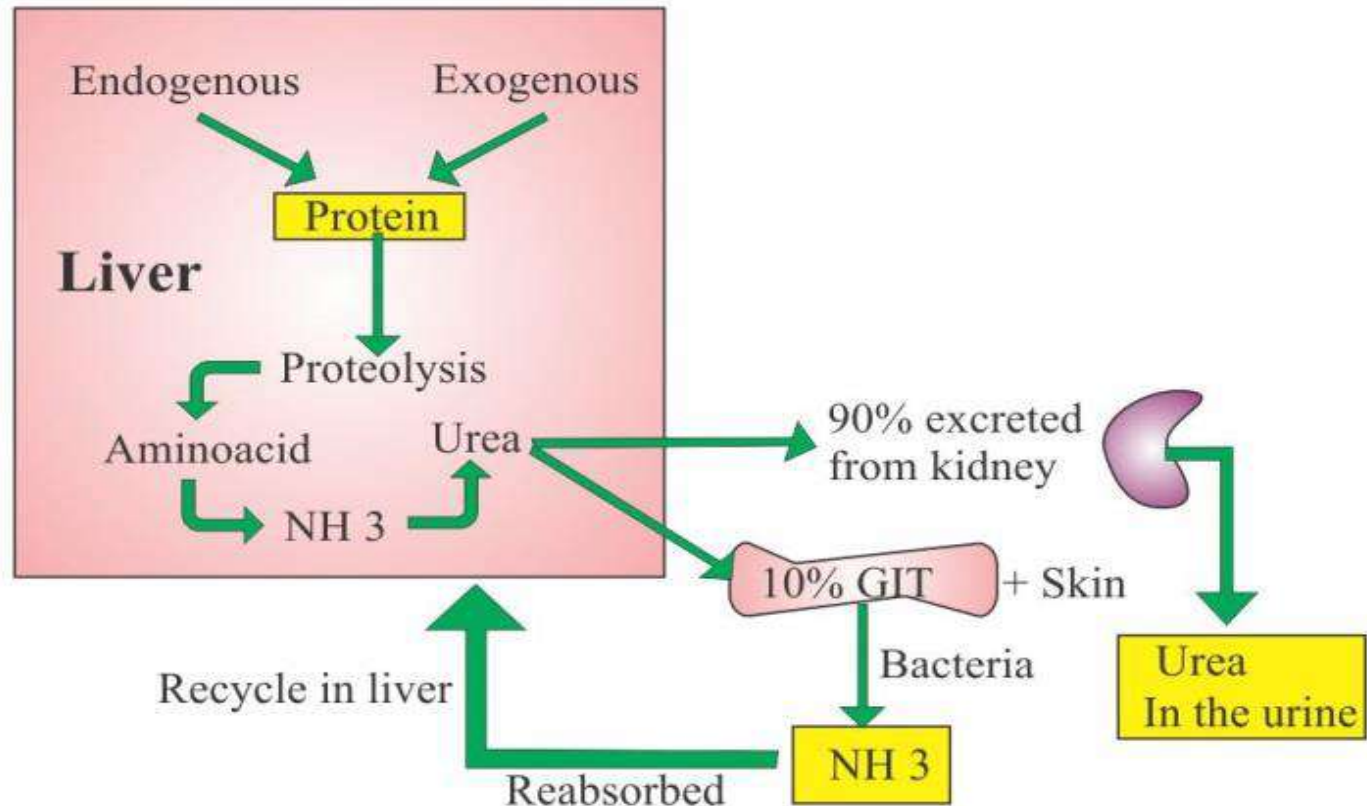
قسم تقنيات التخدير

المرحلة الاولى

# urea

**Urea** is the major excretory product of protein metabolism. Urea synthesis occurs in the liver. Proteins are broken down to amino acids, which are then deaminated to form ammonia. **Ammonia** is readily converted to urea avoiding toxicity. The **kidney** is the only significant route of excretion for urea.

## Urea excretion cycle



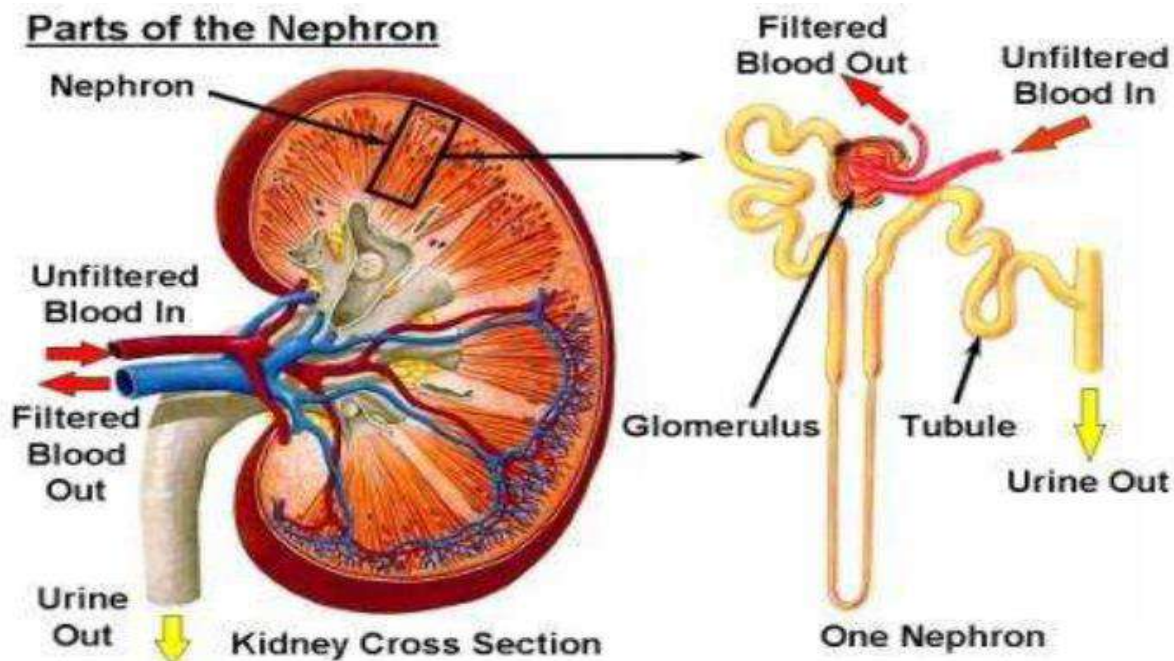
# Causes of increased blood urea concentration:-

## 1- Pre renal causes:-

- Congestive heart failure
- Gastrointestinal hemorrhage
- Dehydration
- Increased protein catabolism
- High-protein diet
- corticosteroid therapy

## 2- Renal causes:-

- Acute and chronic renal failure
- renal disease, including glomerular nephritis, tubular necrosis



**3- Post renal:** Post renal azotemia can be due to obstruction of urine flow anywhere in the urinary tract by

- stones in urinary tract
- tumors of the bladder or prostate
- Severe urinary tract infection.

## Causes of decreased blood urea concentration:-

- Low protein intake
- Severe vomiting and diarrhea
- Severe liver diseases

**Note:** An elevated concentration of urea in the blood is called **azotemia**. Very high blood urea concentration accompanied by **renal failure** is called **uremia**, or the **uremic syndrome**.

# Clinical significant of urea test

Measurement of urea concentration is used to

1. evaluate renal function
2. aid in the diagnosis of renal disease
3. And to verify adequacy of dialysis.
4. assess hydration status

Normal range (15-45 mg/dl)

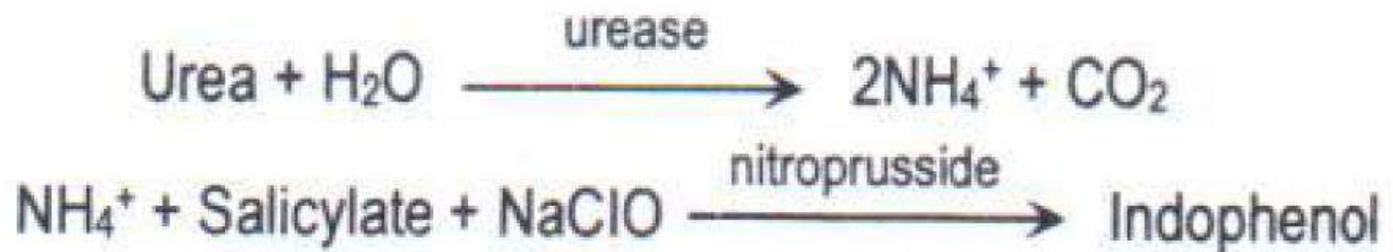
## PROCEDURE

	Blank	Standard	Sample
Reagent A	1 ml	1ml	1 ml
Urea Standard		10 µl	
Sample			10 µl
Mix and incubate for (5 minutes ) at 37 C			
Reagent B	1 ml	1 ml	1 ml
Mix and incubate for (5 minute ) at 37 C . Read the absorbance of Standard and Sample at (600 nm ) against the blank . The color is stable for at least 2hours .			

$$\text{Urea Conc. (mg / dl)} = \frac{\text{Abs. sample}}{\text{Abs. standard}} \times 50$$

# Principle of measurement

Enzymatic colorimetric measurement of urea depends on hydrolysis of serum urea by urease enzyme into ammonium ions & carbon dioxide, then ammonium ions in alkaline media forms with salicylate & chloride a green colored complex (indophenol) that measured at wavelength 600 nm.



# Home work

Q1) What is azotemia, and what are the causes of it?

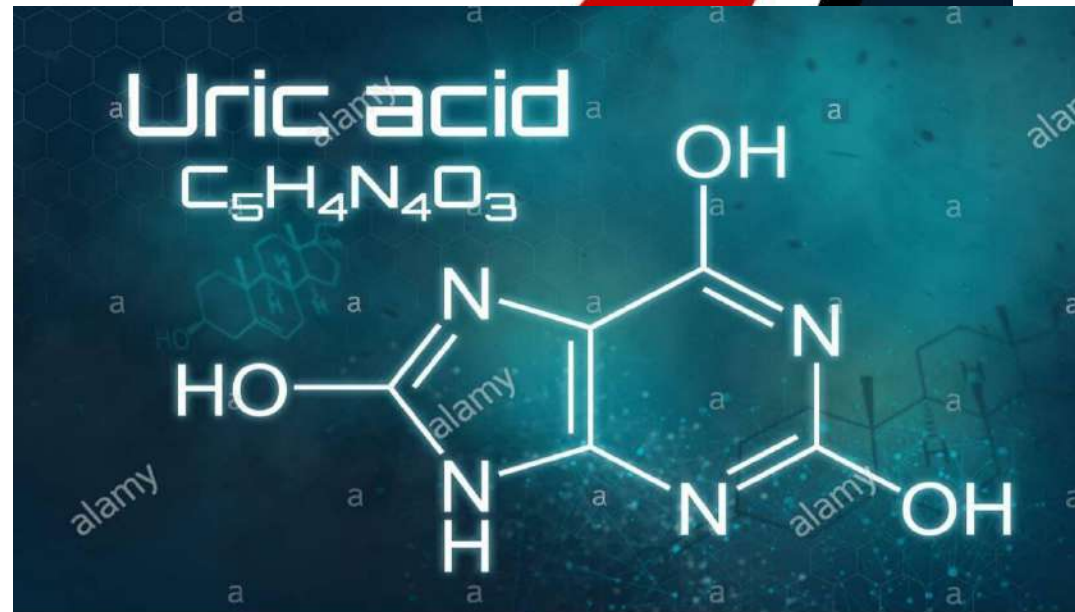
Q2) what is uremia and what are the causes of it ?



# URIC ACID BLOOD TEST



م.م ايمن رمزي محمد  
المرحلة الاولى / قسم التخدير



# The objective of the lecture

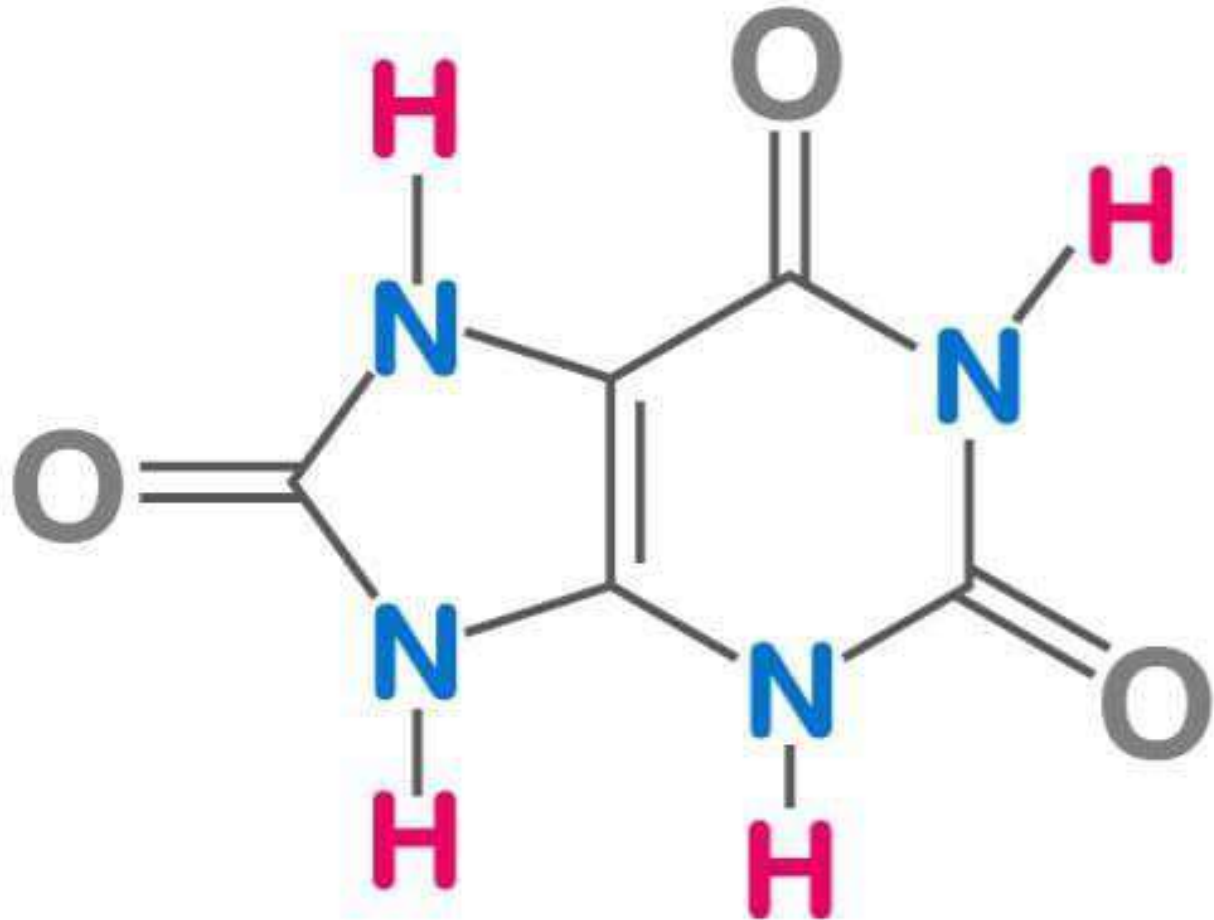


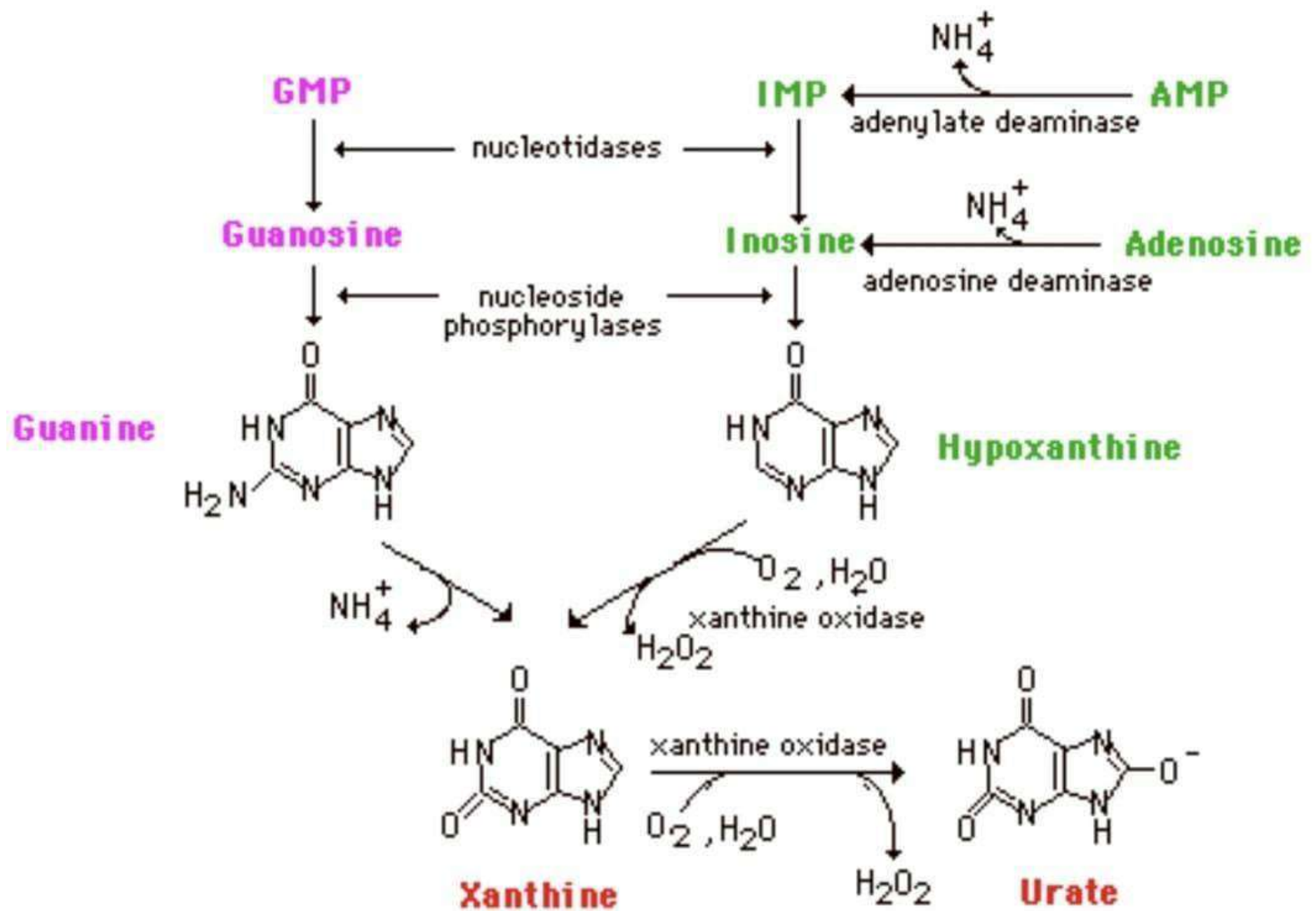
- Introduction of Uric Acid
- Define of Gout
- How control of Uric Acid
- What is hyperuricemia and hypouricemia
- Why is Uric Acid is done?

# Introduction of uric acid

- **Uric acid passes through the liver and enters to the bloodstream , most of it is excreted in to the urine ,or passes through intestines to regulate “normal” levels**
- **Also important to blood uric acid levels are purines , purines are nitrogen – containing compounds , which are made inside the cell of our body ( endogenous) ,or come from outside of our body, from foods containing purine ( exogenous). Purine breaks down into uric acid**

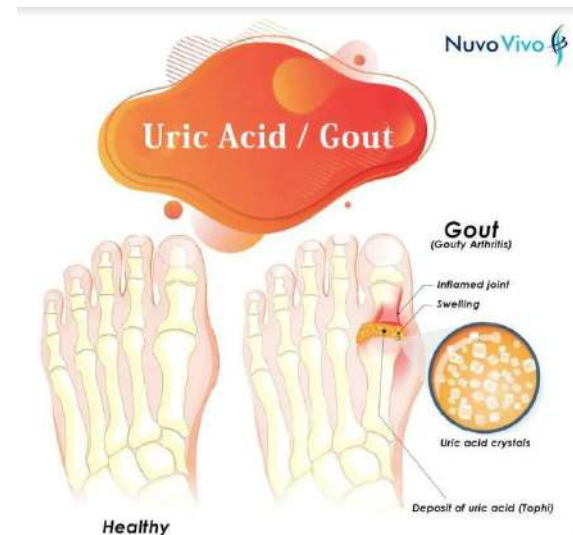
# URIC ACID STRUCTURAL FORMULA





# What is Gout

- **Gout** is the disease state resulting from deposition of monosodium urate ( MSU) crystals in tissues
- It is metabolic diseases
- Characteristic acute and chronic arthritis
- Middle age or elderly men
- Post menopausal women

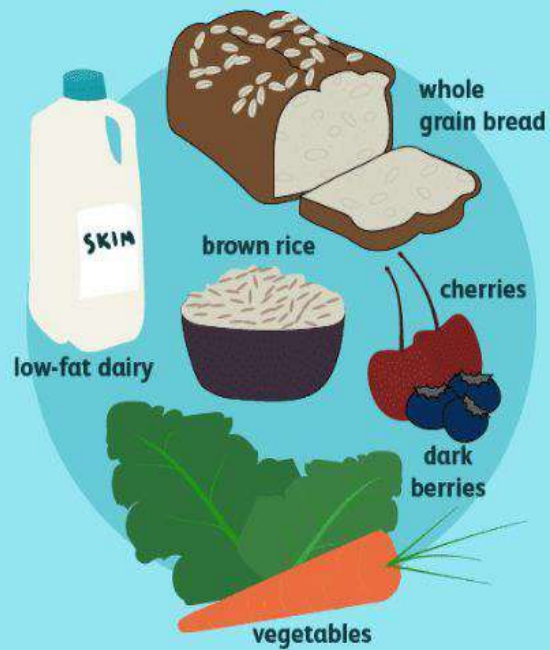


# Control of uric acid

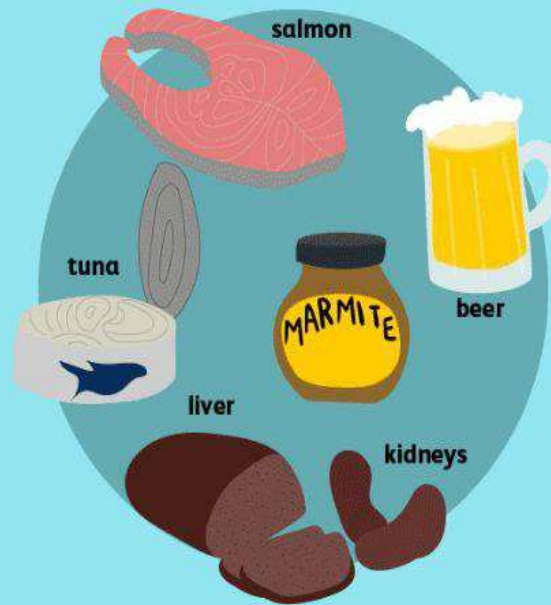
- 1. **adjust diet** : avoid eating foods high in purine
- 2. **limited alcohol** : because alcohol dehydrates the body
- 3. **water** : keep your body hydrated

# FOODS TO EAT AND AVOID WITH GOUT

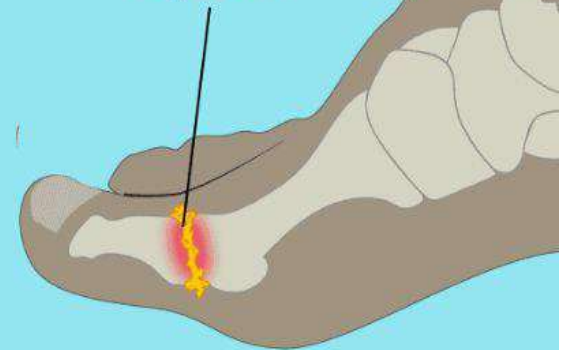
## Eat



## Avoid



## Uric acid crystals



# Hyperuricemia

Is an excess of uric acid in the blood .

**Causes of uric acid level:**

## **a. Primary hyperuricemia**

- Increased production of uric acid from purine
- When kidney cannot get rid of the uric acid in your blood , resulting in high level

## **b. Secondary hyperuricemia**

- **Kidney disease**
- **Certain cancer**
- **Medications can cause increased levels uric acid in the blood**
- **Certain of from diabetes ( types 2 diabetes)**

# **hypouricemia**

- 1. liver diseases** like cirrhosis or Wilson's disease
- 2. renal disease** that decrease renal tubular resorption
- 3. A vegetarian person**
- 4. Medications**

## Why is Uric acid test done?

This test is done to

- Diagnose gout
- Monitor uric acid levels in patients undergoing chemotherapy or radiotherapy
- Monitor the efficacy of treatment given to lower uric acid levels
- To assess the risk and cause of recurrent kidney stones

# PROCEDURE

	Blank	Standard	Test
Reagent	1 ml	1 ml	1 ml
D.W	25 µL		
Standard		25µL	
Serum			25µL

Mix & keep it for incubation at 37° C for 5 min Measure the intensity of color at (520 nm) , color is stable for 30 min

## Calculation :

$$\text{U.A. Conc.} = \frac{\text{Abs. Assay}}{\text{Abs. Standard}} \times \text{Standard Conc. (10) mg / dl}$$

# Normal range for Uric acid

Normal uric acid levels are:

**2.4 – 6.0** mg/dl ( female)

**3.4 – 7.0** mg/dl ( male )



- **What foods cause Uric Acid ?**
- **What is purines?**
- **What is an MSU and what causes ?**

# Glucose in blood

م.م ايمن رمزي محمد  
قسم التخدير / المرحلة الاولى

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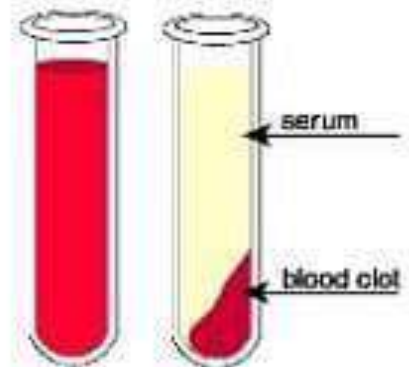
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Clotted



• serum = plasma - fibrinogen

# The objective of the lecture



- ✓ Introduction about blood glucose
- ✓ Types of glucose test
- ✓ Main types of diabetes
- ✓ methods of measuring blood glucose level

# **Blood glucose**

**A blood glucose test measure the a mount of a type of sugar called glucose in your blood**

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# Carbohydrates: Clinical applications

---

Carbohydrate metabolism disorders include:

- **Hyperglycemia**: increased blood glucose
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**VERY HIGH**  
**Blood Sugar Levels**

**250-400 (mg/dL)**  
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Blood glucose level rises.

In response to glycogen, the liver breaks down glycogen and releases glucose into the blood.

The pancreas releases insulin.

The pancreas releases glucagon.

In response to insulin, target cells take up glucose and the liver converts glucose to glycogen.

Blood glucose level falls.



# Main types of **DIABETES**



## **TYPE 1 DIABETES**

Body does not produce enough insulin



## **TYPE 2 DIABETES**

Body produces insulin but can't use it well



## **GESTATIONAL DIABETES**

A temporary condition in pregnancy

# Two methods of measuring blood glucose level:

1. Reduction method, which is based on the ability of glucose to **reduce**  $\text{Cu}^{++}$  to  $\text{Cu}^{+}$  → less sensitive, → substances that could reduce  $\text{Cu}^{++}$  : fructose, galactose, vitamin C, creatinin, uric acid, glutathion, etc.
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- Freshly drawn serum is the preferred specimen.
- Stability: serum , heparin or EDTA plasma (with addition of glycolytic inhibitor):
  - ❖ 2 days at 20-25°C
  - ❖ 7 days at 2-8° C

# PROCEDURE

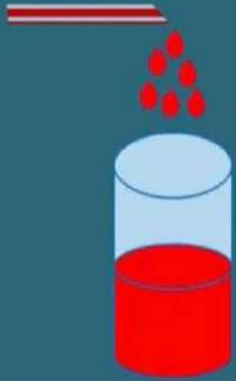
	Blank	Standard	Test
Reagent	1 ml	1 ml	1 ml
D.W	10 µL		
Standard		10µL	
Serum			10µL

Mix & keep it for incubation at 37° C for 10 min or at room temperature for 20 min. Measure the intensity of color at (500 nm)

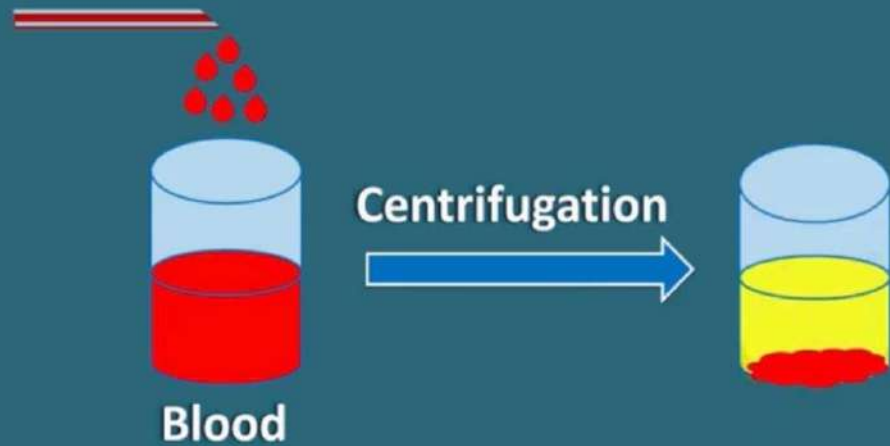
## Calculation :

$$\text{glu. Conc.} = \frac{\text{Abs. Assay}}{\text{Abs. Standard}} \times \text{Standard Conc. (100) mg / dl}$$

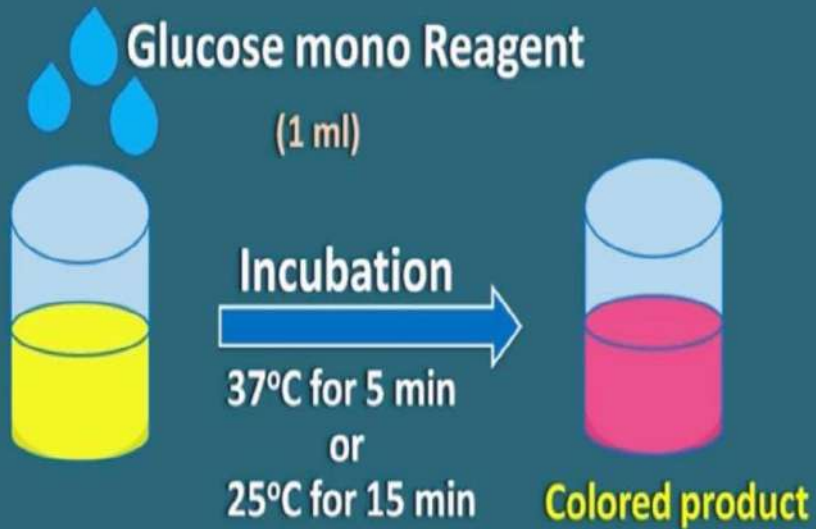
How it is estimated?



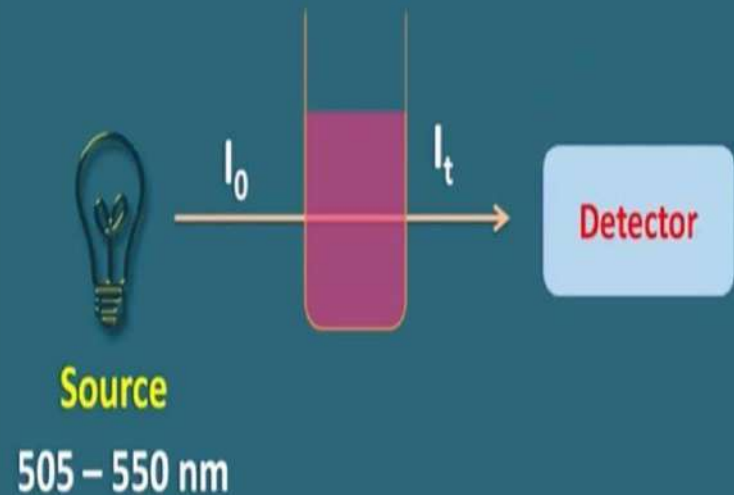
How it is estimated?



How it is estimated?



How it is estimated?



# Principle of blood glucose test

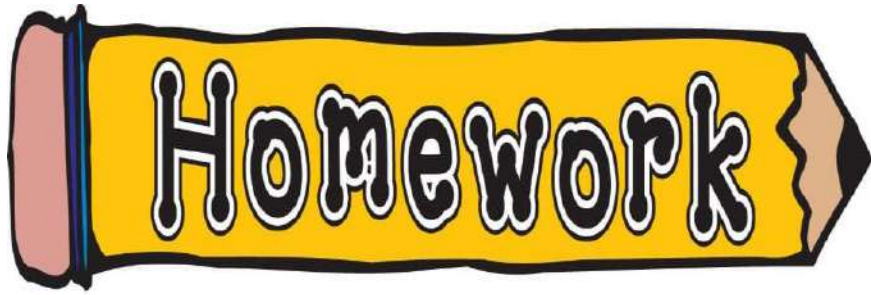
- Colorimetric, enzymatic method with glucose oxidase
- Glucose oxidase (GOD) catalyses the oxidation of glucose to gluconic acid and hydrogen peroxide.
- The formed hydrogen peroxide ( $H_2O_2$ ), react with phenol and aminophenazone in the presence of peroxidase (POD) to form a color complex quinone.
- The absorbance of coloured complex proportional to the concentration of glucose in the sample

# Principle



# Blood Sugar Levels Chart

	Normal	Prediabetic	Type 2 Diabetic
<b>Fasting</b>	70-100mg/dL (3.8-5.6 mmol/L)	100-125 mg/dL (5.6-6.9 mmol/L)	126mg/dl or greater (7mmol/L or greater)
<b>2 hours after eating</b>	<140 mg/dL (<7.8 mmol/L)	140-199 mg/dL (7.8-11 mmol/L)	200 mg/dL or more (>11 mmol/L)
<b>A1C</b>	6% or less	6% to 6.4%	6.5% or greater

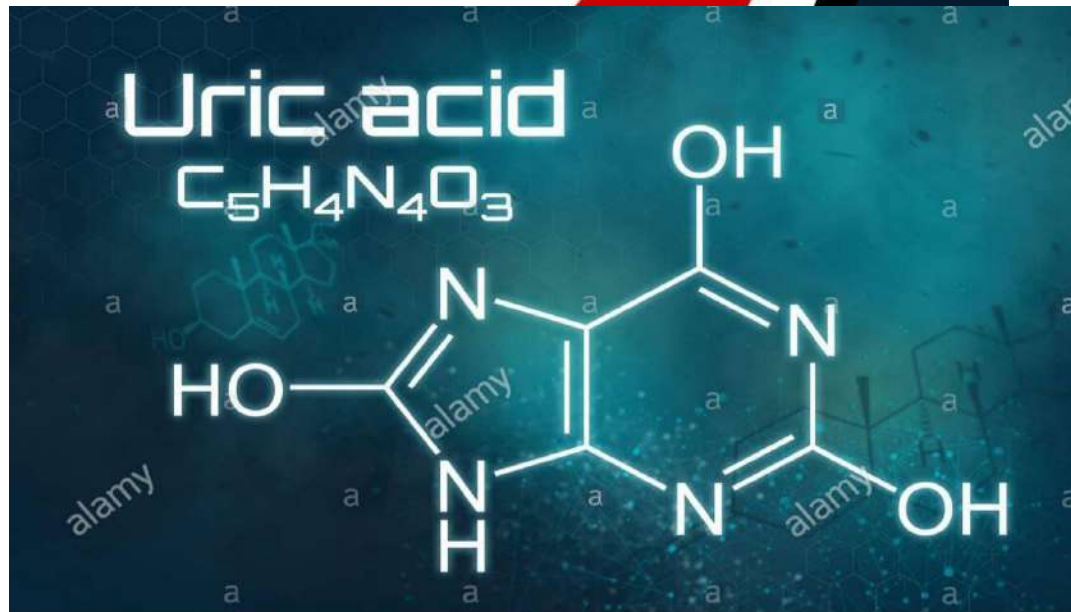


- 1. What affects glucose test ? •**
- 2. When is blood sugar the highest ?**
- 3. Who is responsible helping your body's cells use the glucose?**

# URIC ACID BLOOD TEST



م.م ایمان رمزي محمد  
المرحلة الاولى / قسم التخدير



# The objective of the lecture

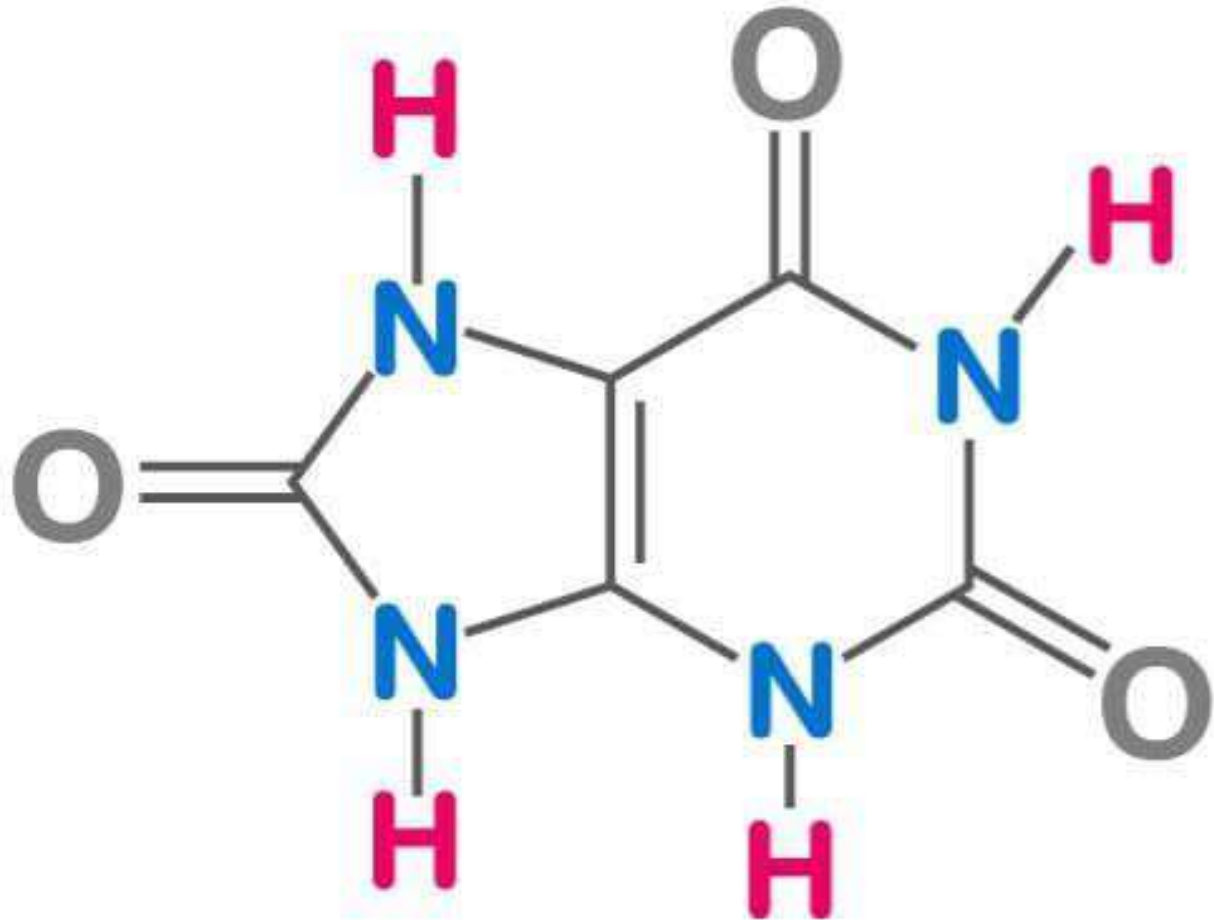


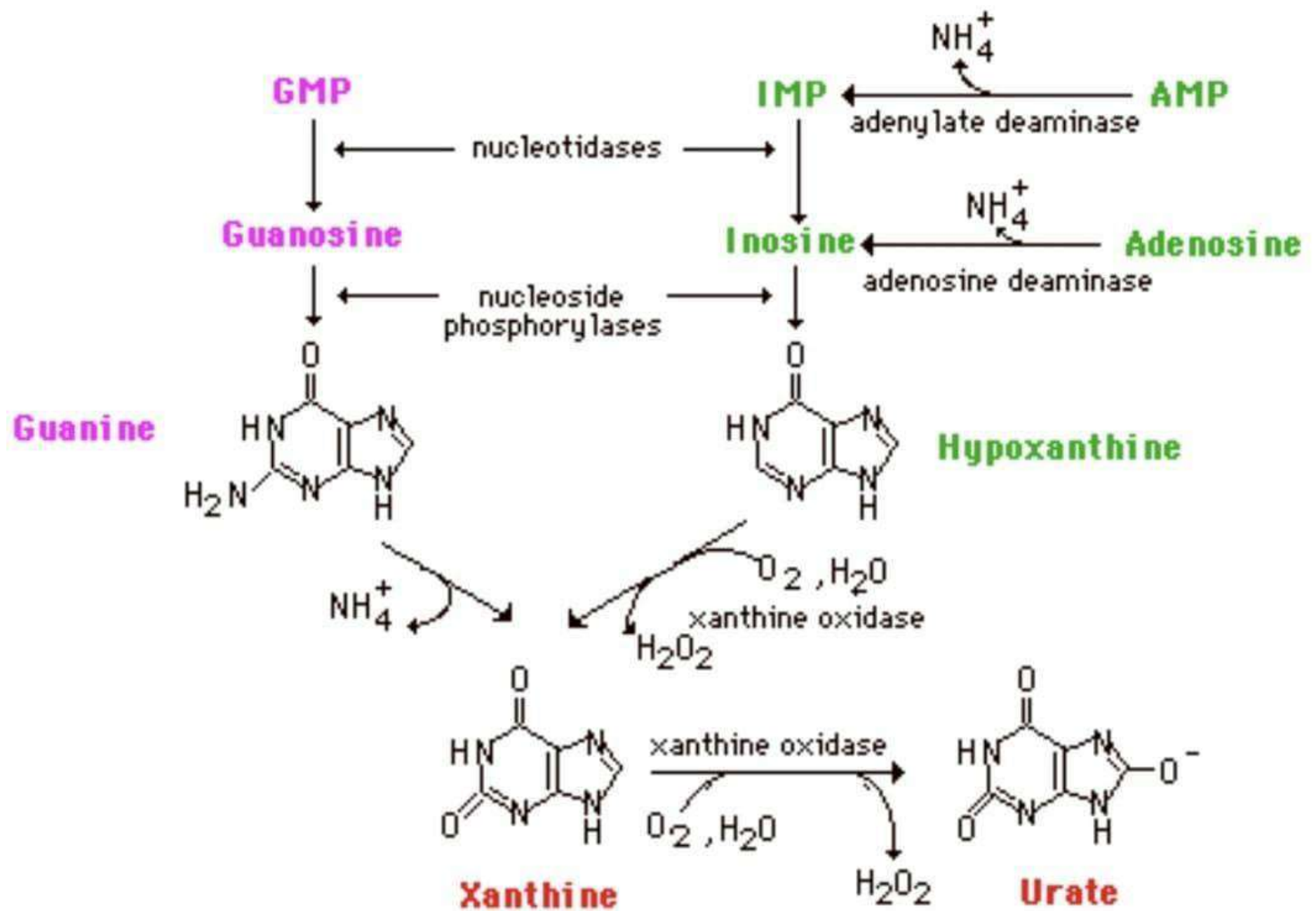
- Introduction of Uric Acid
- Define of Gout
- How control of Uric Acid
- What is hyperuricemia and hypouricemia
- Why is Uric Acid is done?

# Introduction of uric acid

- **Uric acid passes through the liver and enters to the bloodstream , most of it is excreted in to the urine ,or passes through intestines to regulate “normal” levels**
- **Also important to blood uric acid levels are purines , purines are nitrogen – containing compounds , which are made inside the cell of our body ( endogenous) ,or come from outside of our body, from foods containing purine ( exogenous). Purine breaks down into uric acid**

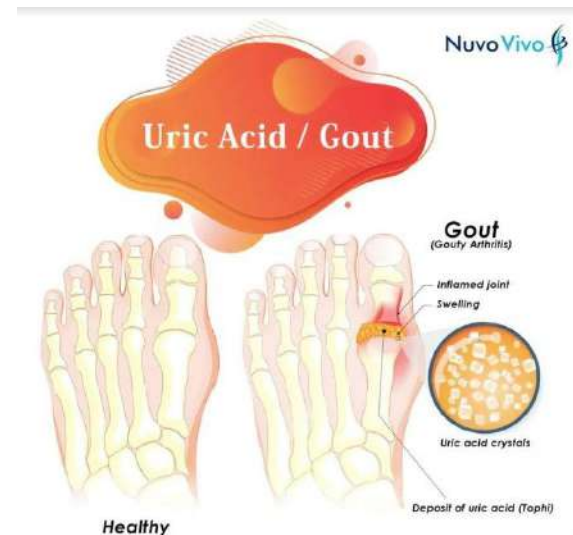
# URIC ACID STRUCTURAL FORMULA





# What is Gout

- **Gout** is the disease state resulting from deposition of monosodium urate ( MSU) crystals in tissues
- It is metabolic diseases
- Characteristic acute and chronic arthritis
- Middle age or elderly men
- Post menopausal women



# Control of uric acid

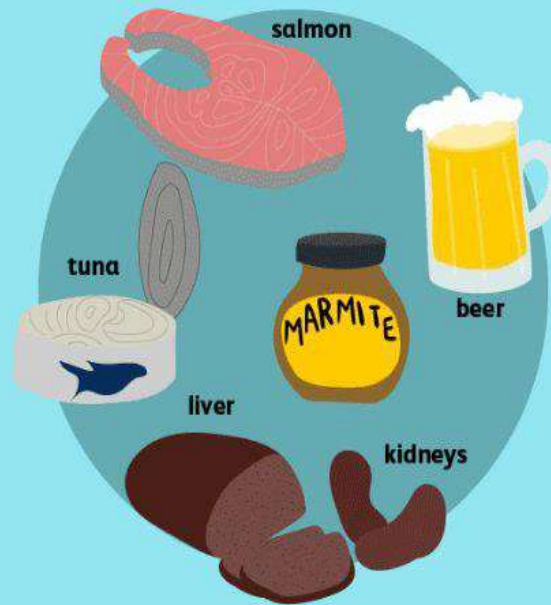
- 1. **adjust diet** : avoid eating foods high in purine
- 2. **limited alcohol** : because alcohol dehydrates the body
- 3. **water** : keep your body hydrated

# Foods to Eat and Avoid with Gout

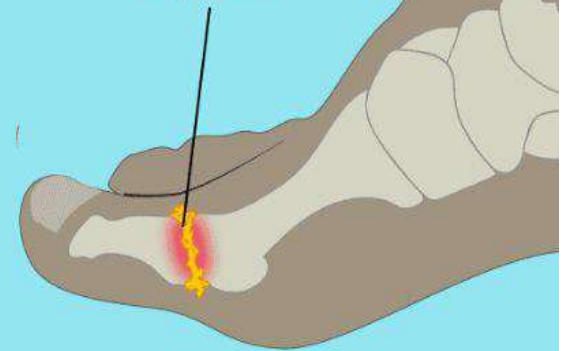
## Eat



## Avoid



Uric acid  
crystals



# Hyperuricemia

Is an excess of uric acid in the blood .

**Causes of uric acid level:**

## **a. Primary hyperuricemia**

- Increased production of uric acid from purine
- When kidney cannot get rid of the uric acid in your blood , resulting in high level

## **b. Secondary hyperuricemia**

- **Kidney disease**
- **Certain cancer**
- **Medications can cause increased levels uric acid in the blood**
- **Certain of from diabetes ( types 2 diabetes)**

# **hypouricemia**

- 1. liver diseases** like cirrhosis or Wilson's disease
- 2. renal disease** that decrease renal tubular resorption
- 3. A vegetarian person**
- 4. Medications**

## Why is Uric acid test done?

This test is done to

- Diagnose gout
- Monitor uric acid levels in patients undergoing chemotherapy or radiotherapy
- Monitor the efficacy of treatment given to lower uric acid levels
- To assess the risk and cause of recurrent kidney stones

# PROCEDURE

	Blank	Standard	Test
Reagent	1 ml	1 ml	1 ml
D.W	25 µL		
Standard		25µL	
Serum			25µL

Mix & keep it for incubation at 37° C for 5 min Measure the intensity of color at (520 nm) , color is stable for 30 min

## Calculation :

$$\text{U.A. Conc.} = \frac{\text{Abs. Assay}}{\text{Abs. Standard}} \times \text{Standard Conc. (10) mg / dl}$$

# Normal range for Uric acid

Normal uric acid levels are:

**2.4 – 6.0** mg/dl ( female)

**3.4 – 7.0** mg/dl ( male )



- **What foods cause Uric Acid ?**
- **What is purines?**
- **What is an MSU and what causes ?**

## **Lipids classification and properties**

### **What does the name lipids mean?**

- Lipid, any of a diverse group of organic compounds including fats, oils, hormones, and certain components of membranes that are grouped together because they do not interact appreciably with water.

### **What are the five functions of lipids?**

- Lipids are a group of naturally occurring molecules that include fats, waxes, sterols, fat-soluble vitamins (such as vitamins A, D, E, and K), glycerides, phospholipids, and others. The main biological functions of lipids include storing energy, signaling, and acting as components of cell membranes.

### **What do lipids tell you?**

- Lipid profiles are blood tests that are used to measure the total cholesterol and triglyceride level of an individual. The test provides detailed information on the amount of good and bad cholesterol that is present in the system.

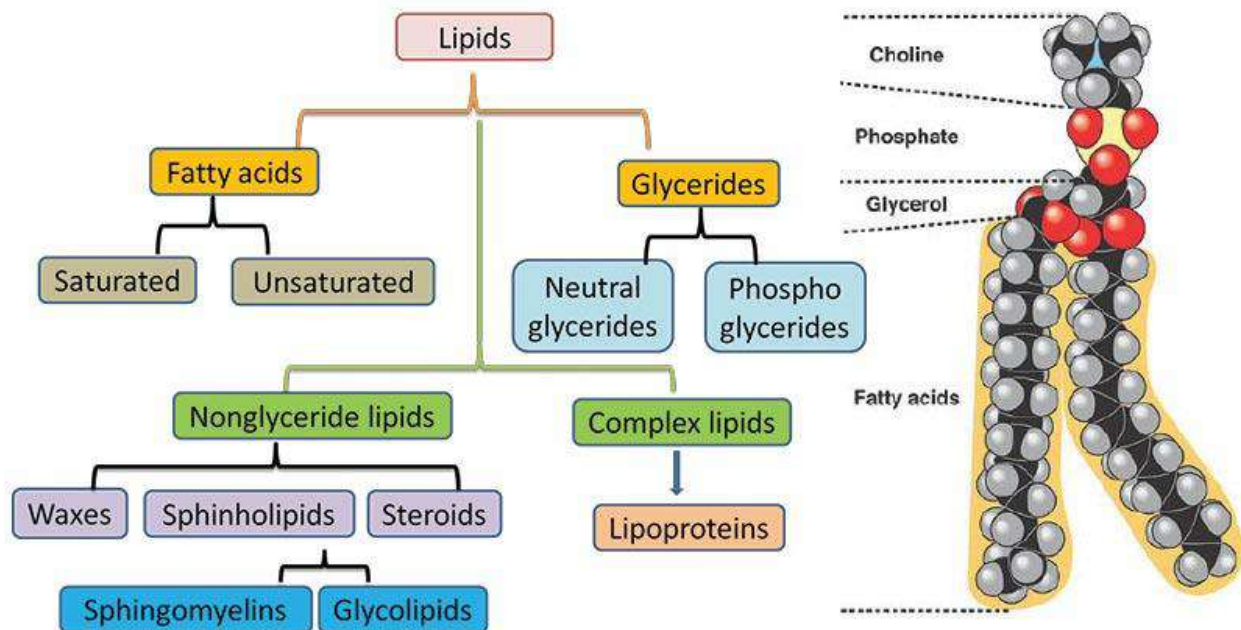
### **What are the three different types of lipids?**

- The three main types of lipids are triacylglycerol, phospholipids, and sterols. Triacylglycerol (also known as triglycerides) make up more than 95 percent of lipids in the diet and are commonly found in fried foods, vegetable

oil, butter, whole milk, cheese, cream cheese, and some meats.

## Lipids definition

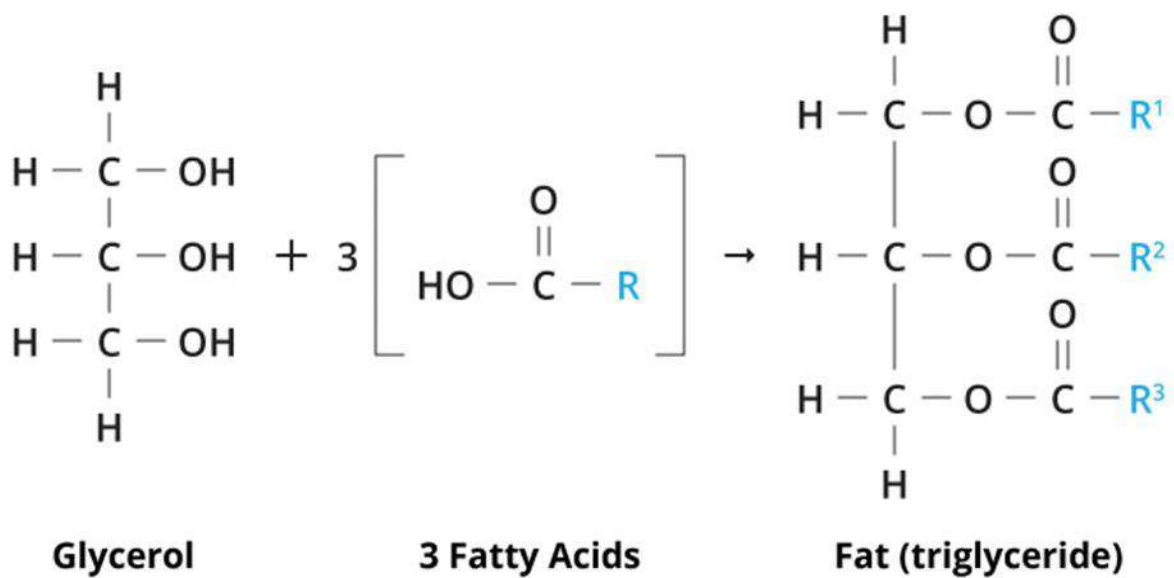
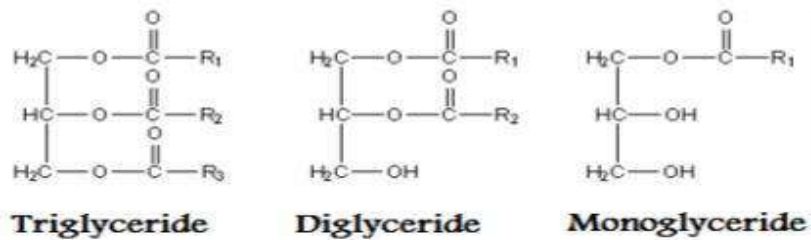
- Lipids are a heterogeneous group of organic compounds that are insoluble in water and soluble in non-polar organic solvents.
- They naturally occur in most plants, animals, microorganisms and are used as cell membrane components, energy storage molecules, insulation, and hormones.



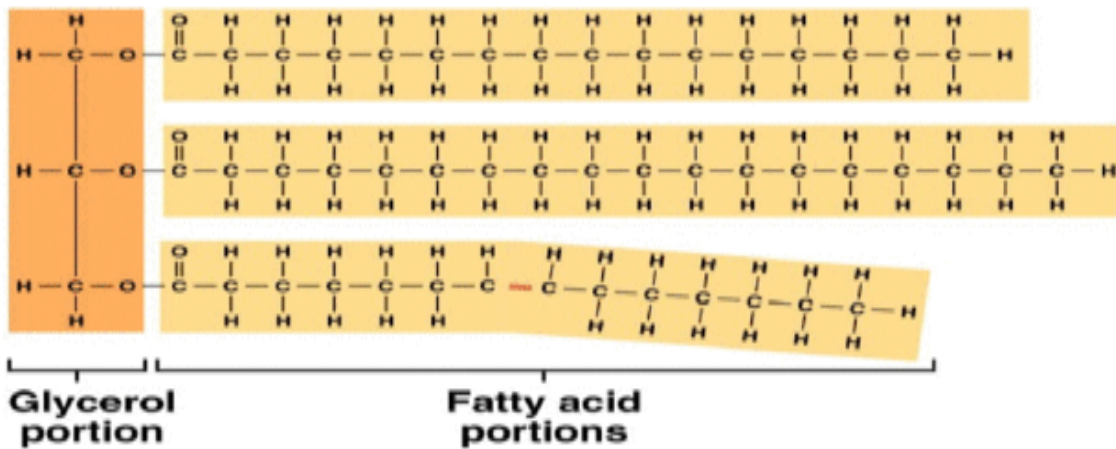
# CHEMISTRY

Fixed oils are esters of fatty acid with glycerol. These may be;

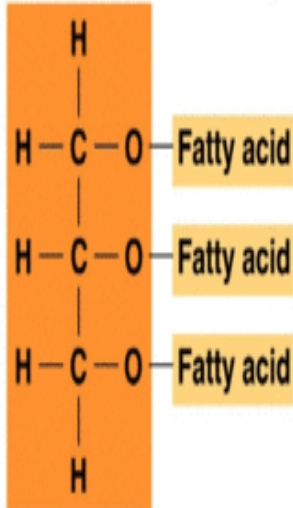
- Monoglycerides
- Diglycerides
- Triglycerides



# Chemical composition of lipids



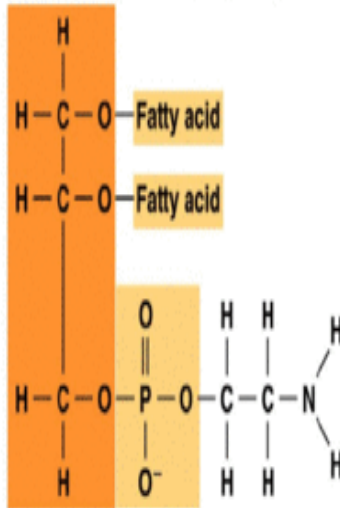
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Glycerol portion

(a) A fat molecule

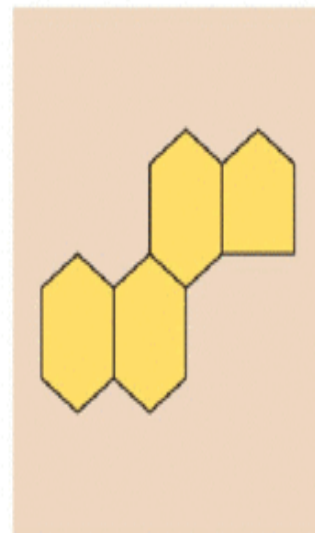
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Phosphate portion

(b) A phospholipid molecule  
(the unshaded portion may vary)

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(a) General structure of a steroid

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## **Properties of Lipids**

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- Lipids may be either liquids or non-crystalline solids at room temperature.
- Pure fats and oils are colorless, odorless, and tasteless.
- They are energy-rich organic molecules
- Insoluble in water
- Soluble in organic solvents like alcohol, chloroform, acetone, benzene, etc.
- No ionic charges
- Solid triglycerols (Fats) have high proportions of saturated fatty acids.
- Liquid triglycerols (Oils) have high proportions of unsaturated fatty acids.

### **1. Hydrolysis of triglycerols**

Triglycerols like any other esters react with water to form their carboxylic acid and alcohol— a process known as hydrolysis.

### **2. Saponification:**

Triacylglycerols may be hydrolyzed by several procedures, the most common of which utilizes alkali or enzymes called lipases. Alkaline hydrolysis is termed saponification because one of the products of the hydrolysis is a soap, generally sodium or potassium salts of fatty acids.

### 3. Hydrogenation

The carbon-carbon double bonds in unsaturated fatty acids can be hydrogenated by reacting with hydrogen to produce saturated fatty acids.

### 4. Halogenation

Unsaturated fatty acids, whether they are free or combined as esters in fats and oils, react with halogens by addition at the double bond(s). The reaction results in the decolorization of the halogen solution.

### 5. Rancidity:

The term rancid is applied to any fat or oil that develops a disagreeable odor. Hydrolysis and oxidation reactions are responsible for causing rancidity. Oxidative rancidity occurs in triacylglycerols containing unsaturated fatty acids.

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## Structure of Lipids

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- Lipids are made of the elements Carbon, Hydrogen and Oxygen, but have a much lower proportion of water than other molecules such as [carbohydrates](#).
- Unlike polysaccharides and proteins, lipids are not polymers—they lack a repeating monomeric unit.

- They are made from two molecules: **Glycerol and Fatty Acids.**
- A glycerol molecule is made up of three carbon atoms with a hydroxyl group attached to it and hydrogen atoms occupying the remaining positions.
- Fatty acids consist of an acid group at one end of the molecule and a hydrocarbon chain, which is usually denoted by the letter 'R'.
- They may be **saturated or unsaturated.**
- A fatty acid is saturated if every possible bond is made with a Hydrogen atom, such that there exist no C=C bonds.
- Unsaturated fatty acids, on the other hand, do contain C=C bonds. Monounsaturated fatty acids have one C=C bond, and polyunsaturated have more than one C=C bond.

### **Structure of Triglycerides**

- Triglycerides are lipids consisting of one glycerol molecule bonded with three fatty acid molecules.
- The bonds between the molecules are covalent and are called Ester bonds.
- They are formed during a condensation reaction.

- The charges are evenly distributed around the molecule so hydrogen bonds do not form with water molecules making them insoluble in water.

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## **Classification (Types) of Lipids**

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Lipids can be classified according to their hydrolysis products and according to similarities in their molecular structures. Three major subclasses are recognized:

### **1. Simple lipids**

- (a) **Fats and oils** which yield fatty acids and glycerol upon hydrolysis.
- (b) **Waxes**, which yield fatty acids and long-chain alcohols upon hydrolysis.

### **Fats and Oils**

- Both types of compounds are called triacylglycerols because they are esters composed of three fatty acids joined to glycerol, trihydroxy alcohol.
- The difference is on the basis of their physical states at room temperature. It is customary to call a lipid a fat if it is solid at 25°C, and oil if it is a liquid at the same temperature.

- These differences in melting points reflect differences in the degree of unsaturation of the constituent fatty acids.

## **Waxes**

- Wax is an ester of long-chain alcohol (usually mono-hydroxy) and a fatty acid.
- The acids and alcohols normally found in waxes have chains of the order of 12-34 carbon atoms in length.

•

## **2. Compound lipids**

(a) **Phospholipids**, which yield fatty acids, glycerol, amino alcohol sphingosine, phosphoric acid and nitrogen-containing alcohol upon hydrolysis.

They may be **glycerophospholipids** or **sphingophospholipid** depending upon the alcohol group present (glycerol or sphingosine).

(b) **Glycolipids**, which yield fatty acids, sphingosine or glycerol, and a carbohydrate upon hydrolysis.

They may also be **glyceroglycolipids** or **sphingoglycolipid** depending upon the alcohol group present (glycerol or sphingosine).

### **3. Derived lipids:**

Hydrolysis product of simple and compound lipids is called derived lipids. They include fatty acid, glycerol, sphingosine and steroid derivatives.

Steroid derivatives are phenanthrene structures that are quite different from lipids made up of fatty acids.

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### **Functions**

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It is established that lipids play extremely important roles in the normal functions of a cell. Not only do lipids serve as highly reduced storage forms of energy, but they also play an intimate role in the structure of cell membrane and organelle membranes. Lipids perform many functions, such as:

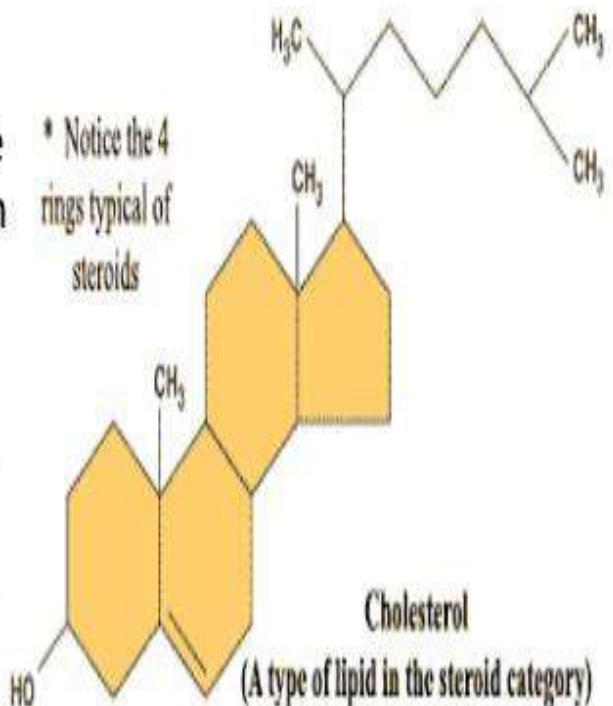
1. Energy Storage
2. Making Biological Membranes
3. Insulation
4. Protection – e.g. protecting plant leaves from drying up
5. Buoyancy
6. Acting as hormones
7. Act as the structural component of the body and provide the hydrophobic barrier that permits

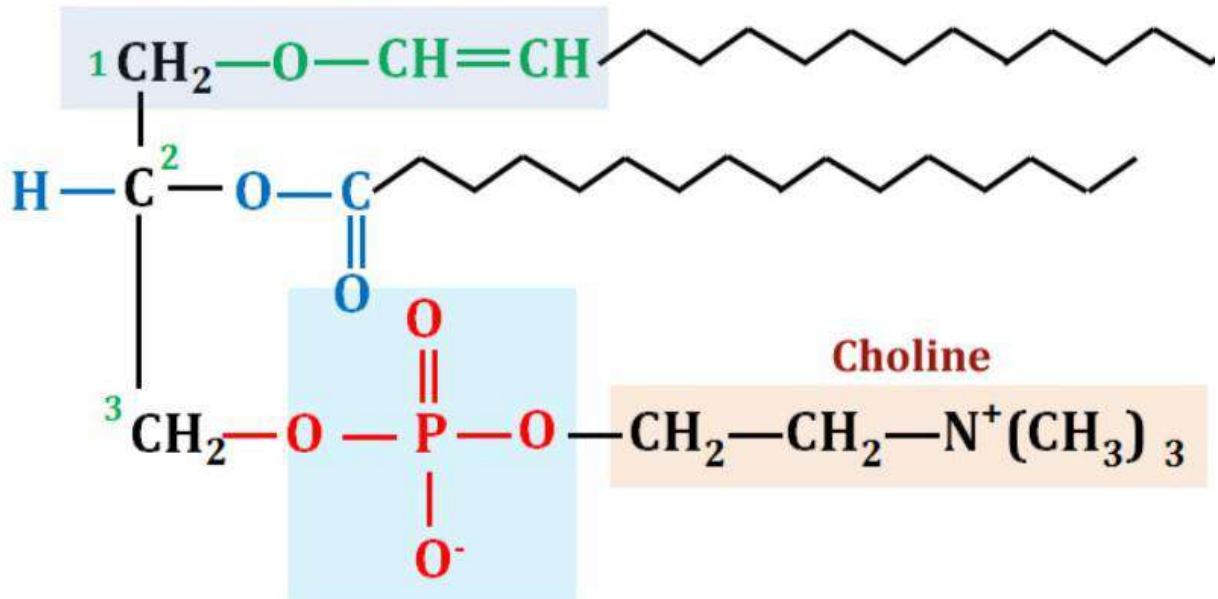
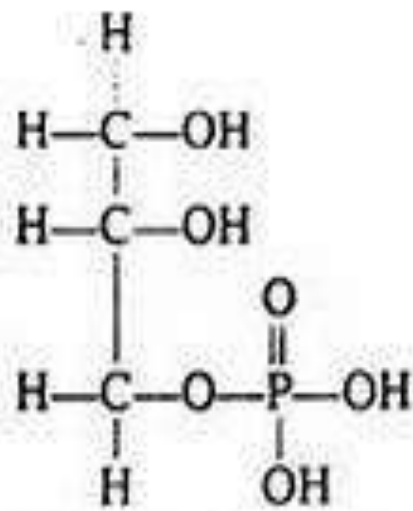
partitioning of the aqueous contents of the cell and subcellular structures.

8. Lipids are major sources of energy in animals and high lipid-containing seeds.
9. Activators of enzymes e.g. glucose-6-phosphatase.

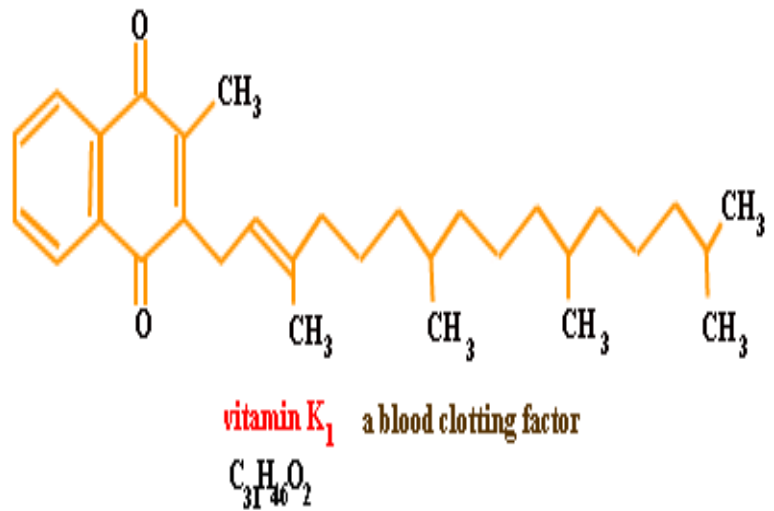
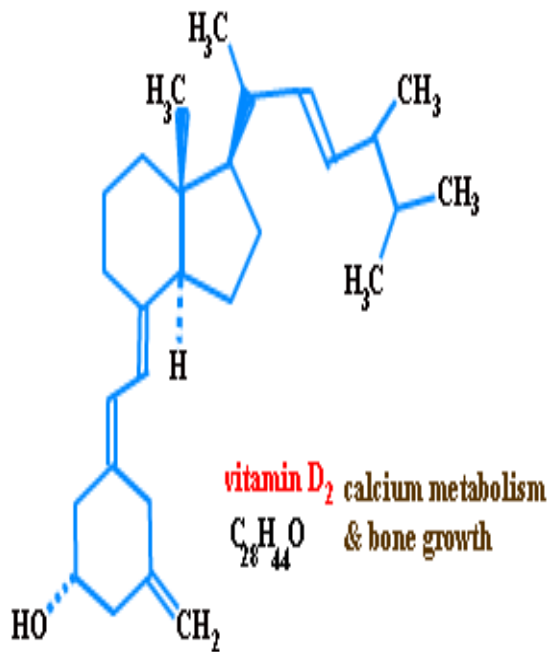
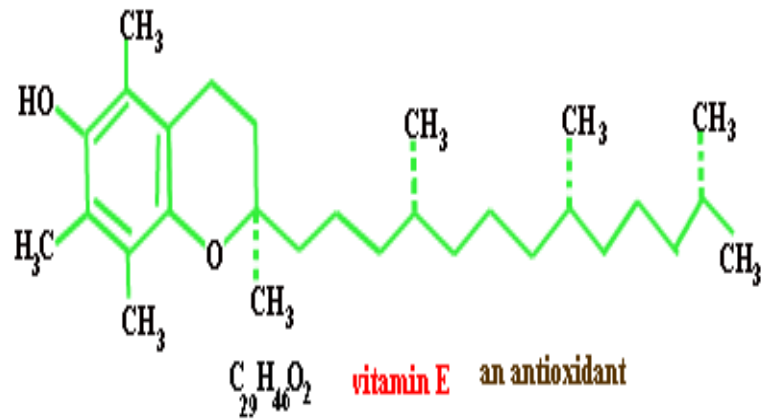
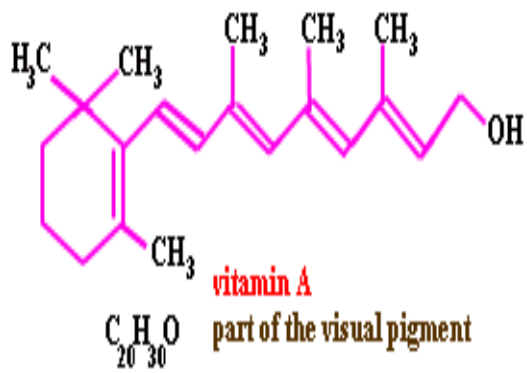
## ➤ Cholesterol

Cholesterol is a well-studied lipid, because of its strong correlation with the incidence cardiovascular disease. It is an important component of cell membranes and plasma lipoproteins, and is an important precursor of many biologically important substances like bile acids and steroid hormones. It is abundant in nerve tissues and is associated with gallstones.



**Ether Linked Alkene****Plasmalogen****Glycerol phosphate**

### Lipid Soluble Vitamins



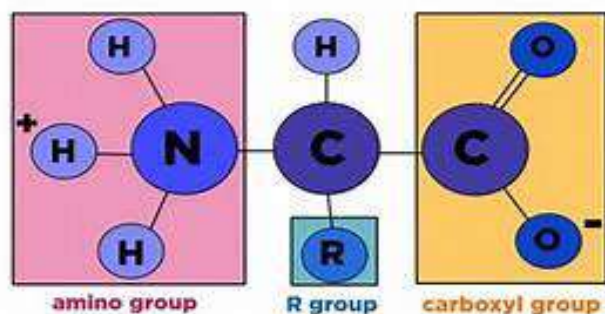
## Proteins

- Proteins (Greek proteios, “primary” or “of first Importance”) are biochemical molecules consisting of polypeptides joined by peptide bonds between the amino and carboxyl groups of amino acid residues.
- Proteins perform a number of vital functions:
  - Enzymes are proteins that act as biochemical catalyst.
  - Many proteins have structural or mechanical functions (e.g., actin and myosin in muscles).
  - Proteins are important in cell signaling, immune responses, cell adhesion, and the cell cycle.
  - Proteins are a necessary component in animal diets.

## Amino Acids

Amino Acids • All proteins are polymers containing chains of amino acids chemically bound by amide (peptide) bonds. • Most organisms use 20 naturally-occurring amino acids to build proteins. The linear sequence of the amino acids in a protein is dictated by the sequence of the nucleotides in an organisms’ genetic code. • These amino acids are called alpha (α)-amino acids because the amino group is attached to the first carbon in the chain connected to the carboxyl carbon.

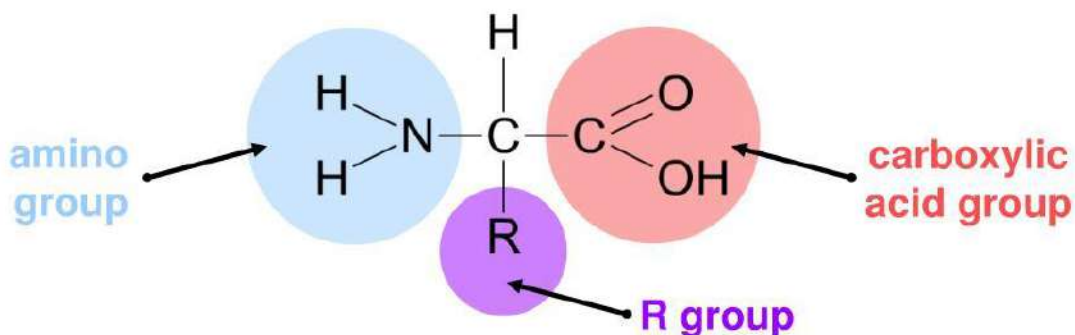
An amino acid consists of 3 major parts:



## The general structure of amino acids



All amino acids have the same general structure: the only difference between each one is the nature of the **R group**. The R group therefore defines an amino acid.

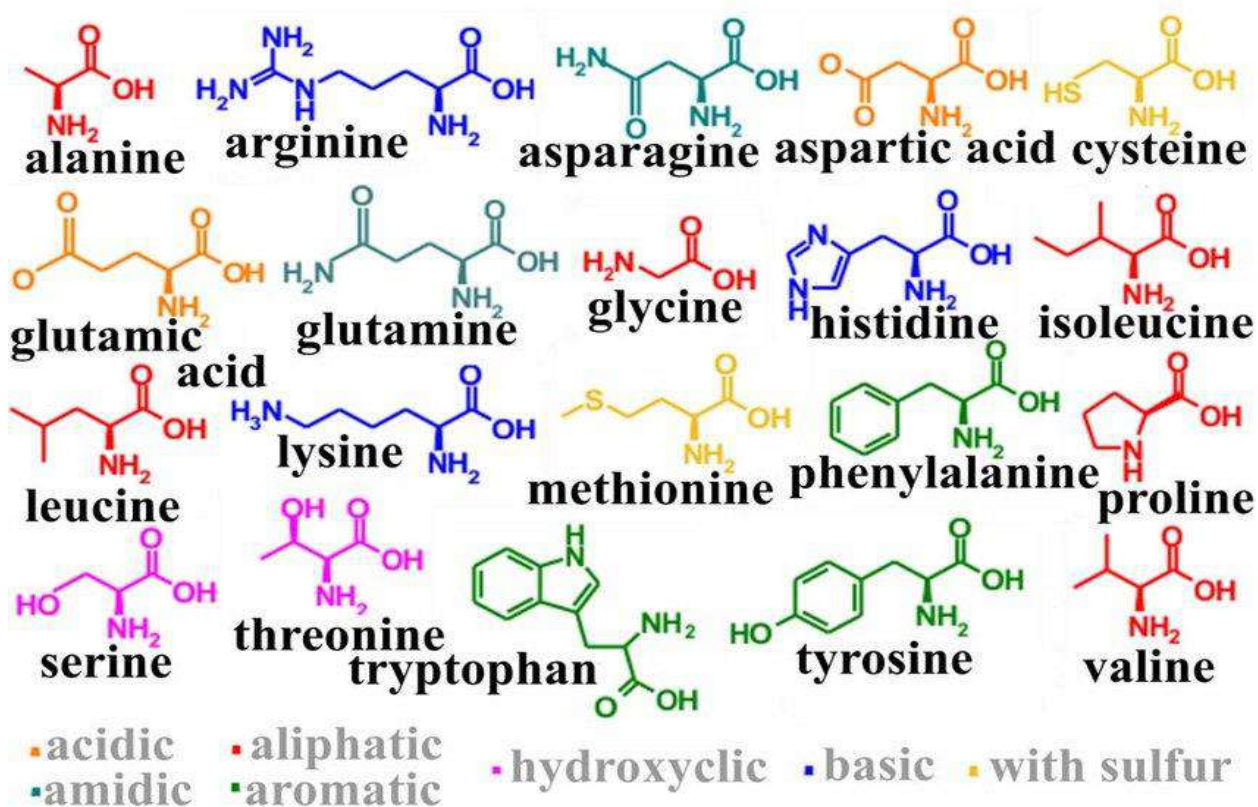


The R group represents a side chain from the central 'alpha' carbon atom, and can be anything from a simple hydrogen atom to a more complex ring structure.



## Amino Acids •

The amino acids are classified by the polarity of the R group side chains, and whether they are acidic or basic: – neutral, nonpolar – neutral, polar – basic, polar (contains an additional amino group) – acidic, polar (contains an additional carboxylate group) • All of the amino acids are also known by a threeletter and one-letter abbreviations.



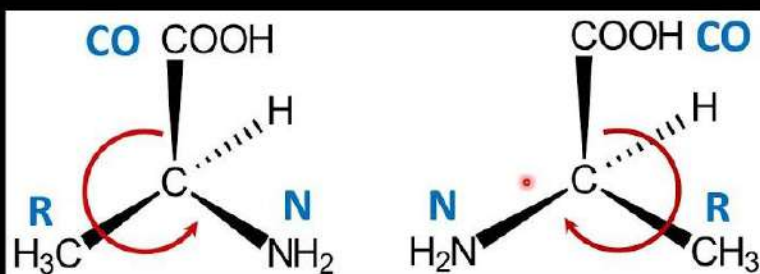
## Stereochemistry of the Amino Acids

- Since the amino acids (except for glycine) contain four different groups connected to the  $\alpha$ -carbon, they are chiral, and exist in two enantiomer forms:

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### Stereochemistry

The CORN rule can be applied to name the two stereoisomers.

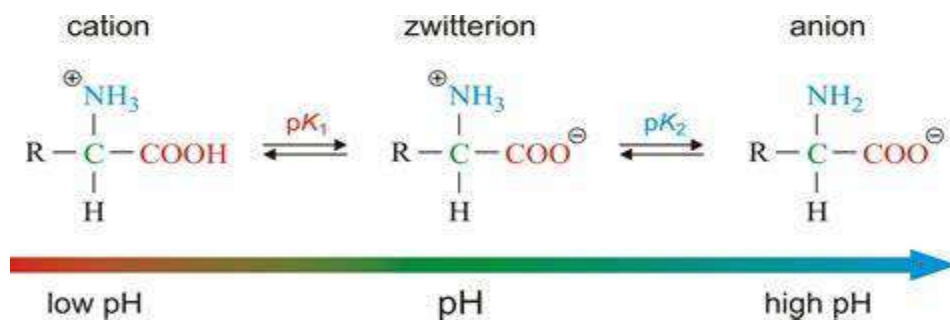


If the CORN (**COOH** – **R** – **NH<sub>3</sub>**) is clockwise, it is the D-isomer.

If the CORN (**COOH** – **R** – **NH<sub>3</sub>**) is counter-clockwise, it is the L-isomer.

## Zwitterions

Because amino acids contain both an acidic and a basic functional group, an internal acid-base reaction occurs, forming an ion with both a positive and a negative charge called a zwitterion:



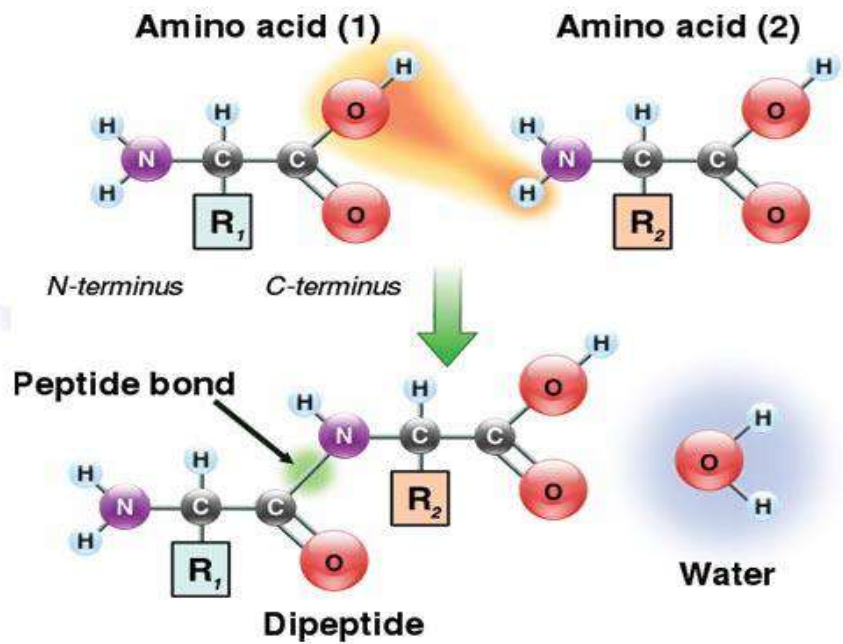
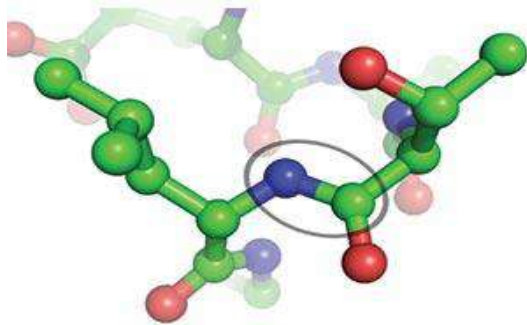
In solution, the structure of an amino acid can change with the pH of the solution:

### Zwitterions

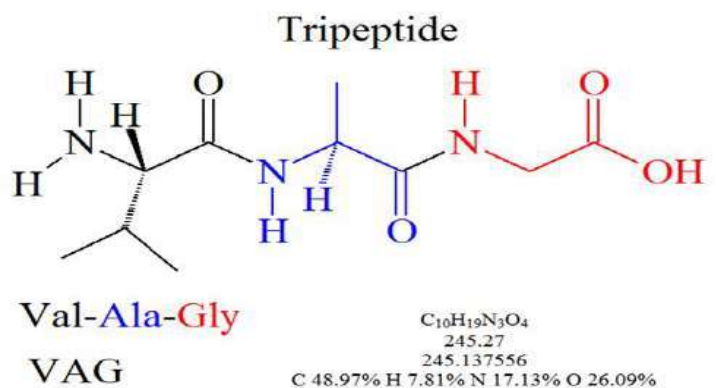
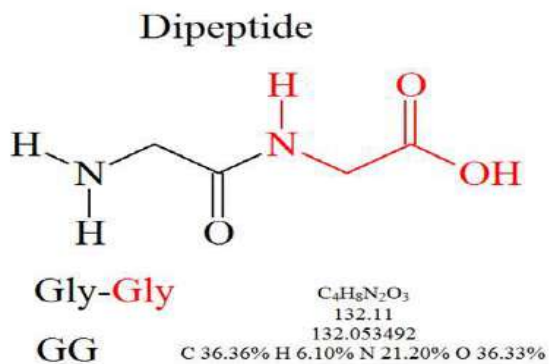
Since the pH of the solution affects the charge on the amino acid, at some pH, the amino acid will form a zwitterion. This is called the isoelectric point. • Each amino acid (and protein) has a characteristic isoelectric point: those with neutral R groups are near a pH of 6, those with basic R groups have higher values, and those with acidic R groups have lower values. • Because amino acids can react with both  $\text{H}_3\text{O}^+$  and  $\text{OH}^-$ , solutions of amino acids and proteins can act as buffers. (E.g., blood proteins help to regulate the pH of blood.)

## Reactions of Amino Acids

# Peptide and Peptide bond



## Peptides



## Peptides

- A fourth amino acid would form a tetrapeptide, a fifth would form a pentapeptide, and so on.
- Short chains are referred to as peptides, chains of up to about 50 amino acids are polypeptides, and chains of more than 50 amino acids are proteins.

(The terms protein and polypeptide are often used interchangeably.)

- Amino acids in peptide chains are called amino acid residues.
  - The residue with a free amino group is called the N-terminal residue, and is written on the left end of the chain.
  - The residue with a free carboxylate group is called the C-terminal residue, and is written on the right end of the chain. 19

## Peptides

- Peptides are named by starting at the N-terminal end and listing the amino acid residues from left to right.

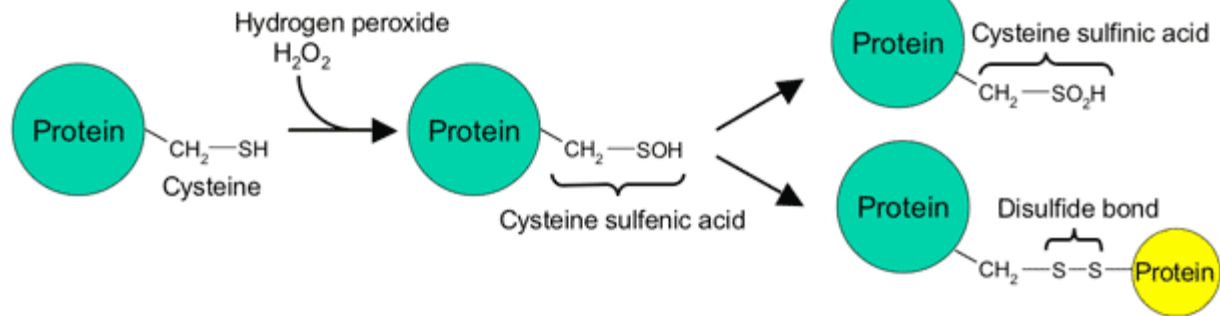
- Large amino acid chains are unwieldy to draw in their complete forms, so they are usually represented by their three-letter abbreviations, separated by dashes:
  - Gly-Ala (Gly = N-terminal, Ala = C-terminal)
  - Ala-Gly (Ala = N-terminal, Gly = C-terminal)
- The tripeptide alanylglycylvaline can be written as Ala-Gly-Val. (There are five other arrangements of these amino acids that are possible.)
- Insulin has 51 amino acids, with  $1.55 \times 10^{66}$  different possible arrangements, but the body produces only one.

### Oxidation of Cysteine

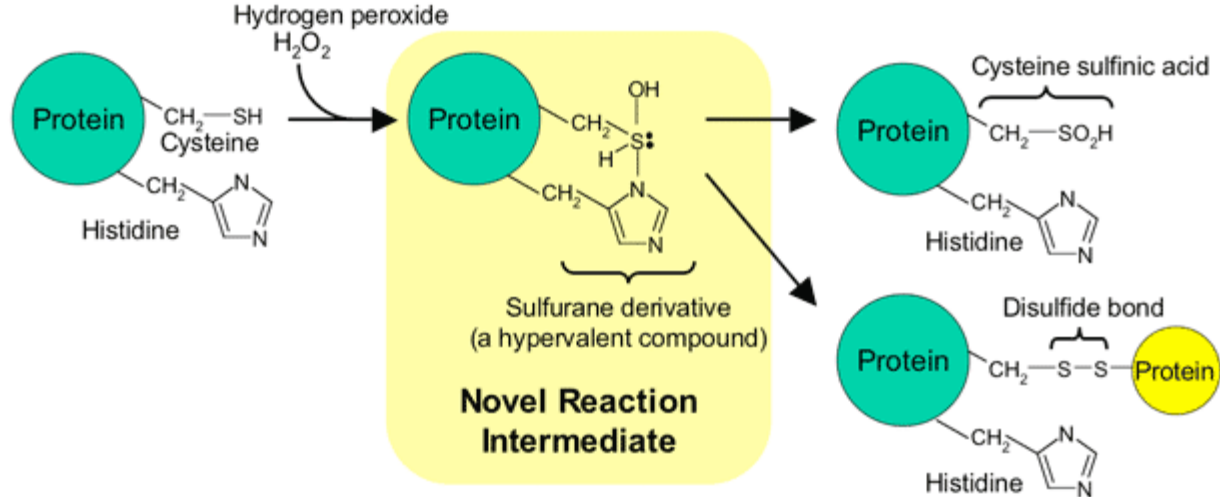
- Amino acids can undergo any of the reactions characteristic of the functional groups in the structure.
- Cysteine is the only amino acid that contains a sulfhydryl (Thiols, R—SH) group. Thiols are easily oxidized to form disulfide bonds (R—S—S—R).

This allows cysteine to dimerize to form cystine:

### (a) Conventional Model for Oxidation of Protein



### (b) Novel Model for Oxidation of Protein



## Characteristics of Proteins

### Size of Proteins

- Proteins are very large polymers of amino acids with molecular weights that vary from 6000 amu to several million amu.

– Glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) = 180 amu

– Hemoglobin ( $\text{C}_{2952}\text{H}_{4664}\text{O}_{832}\text{N}_{812}\text{S}_8\text{Fe}_4$ ) = 65,000 amu

28	Protein Molecular Weight (amu)	Number of Amino
	Acid Residues	Insulin 6,000

## Protein Function

- Proteins perform crucial roles in all biological processes.
1. Catalytic function: Nearly all reactions in living organisms are catalyzed by proteins functioning as enzymes. Without these catalysts, biological reactions would proceed much more slowly.
  2. Structural function: In animals structural materials other than inorganic components of the skeleton are proteins, such as collagen (mechanical strength of skin and bone) and keratin (hair, skin, fingernails).
  3. Storage function: Some proteins provide a way to store small molecules or ions, e.g., ovalbumin (used by embryos developing in bird eggs), casein (a milk protein) and gliadin (wheat seeds), and ferritin (a liver protein which complexes with iron ions).

4. Protective function: Antibodies are proteins that protect the body from disease by combining with and destroying viruses, bacteria, and other foreign substances. Another protective function is blood clotting, carried out by thrombin and fibrinogen.
5. Regulatory function: Body processes regulated by proteins include growth (growth hormone) and thyroid functions (thyrotropin).
6. Nerve impulse transmission: Some proteins act as receptors for small molecules that transmit impulses across the synapses that separate nerve cells (e.g., rhodopsin in vision).
7. Movement function: The proteins actin and myosin are important in muscle activity, regulating the contraction of muscle fibers.
8. Transport function: Some proteins bind small molecules or ions and transport them through the body. – Serum albumin is a blood protein that carries fatty acids between fat (adipose) tissue and other organs. – Hemoglobin carries oxygen from the lungs to other body tissues. – Transferrin is a carrier of iron in blood plasma.

- A typical human cell contains 9000 different proteins; the human body contains about 100,000 different proteins.

## Classification by Structural Shape

Proteins can be classified on the basis of their structural shapes:

- Fibrous proteins are made up of long rod-shaped or string like molecules that can intertwine with one another and form strong fibers.
  - insoluble in water
  - major components of connective tissue, elastic tissue, hair, and skin – e.g., collagen, elastin, and keratin.
- Globular proteins are more spherical in shape
  - dissolve in water or form stable suspensions.
  - not found in structural tissue but are transport proteins, or proteins that may be moved easily through the body by the circulatory system – e.g., hemoglobin and transferrin.

## Classification by Composition

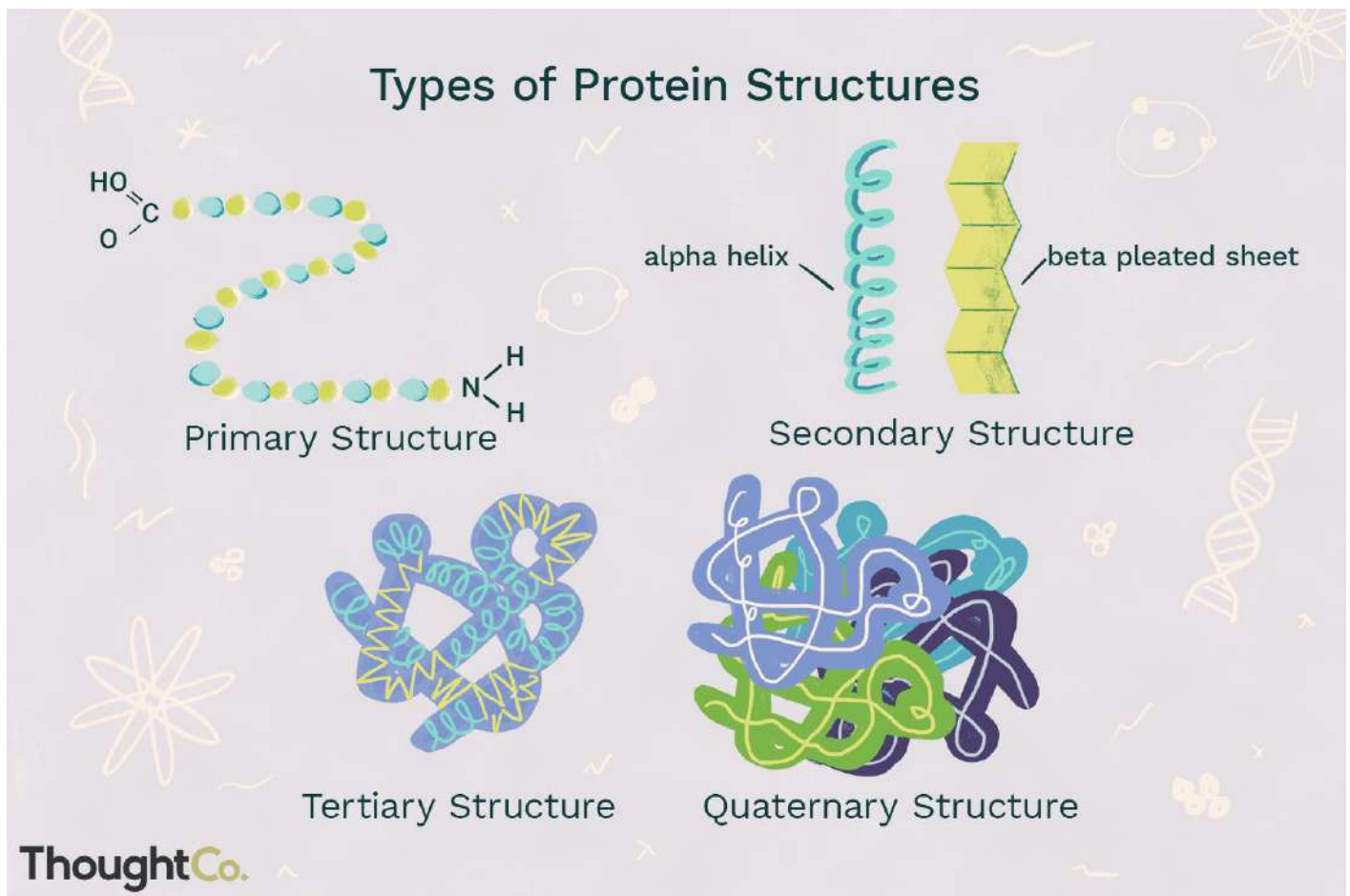
Proteins can also be classified by composition:

- **Simple proteins** contain only amino acid residues.
- **Conjugated proteins** also contain other organic or inorganic components, called prosthetic groups.
  - **nucleoproteins** — nucleic acids (viruses).
  - **lipoproteins** — lipids (fibrin in blood, serum lipoproteins)
  - **glycoproteins** — carbohydrates (gamma globulin in blood, mucin in saliva)
  - **phosphoproteins** — phosphate groups (casein in milk)
  - **hemoproteins** — heme (hemoglobin, myoglobin, cytochromes)
  - **metalloproteins** — iron (ferritin, hemoglobin) or zinc (alcohol dehydrogenase)

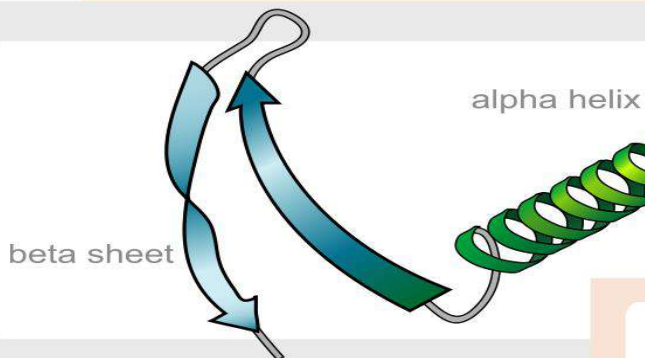
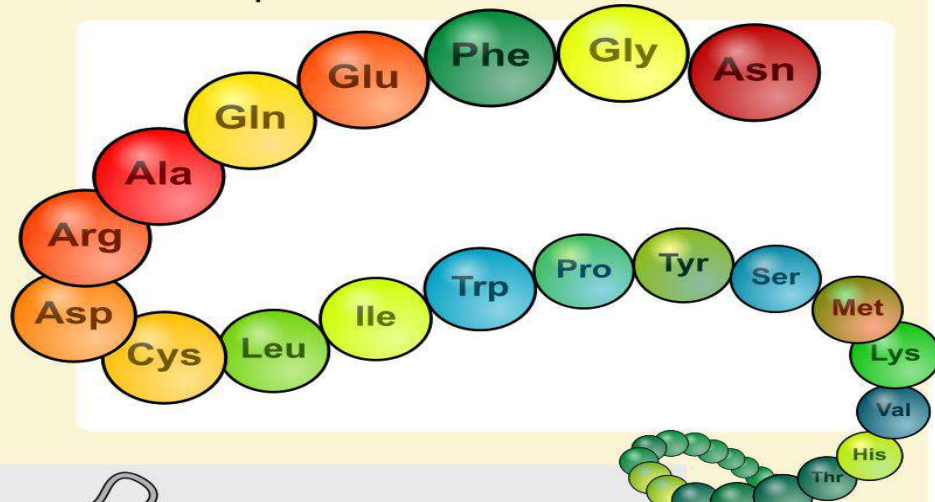
## Protein Structure

- The structure of proteins is much more complex than that of simple organic molecules. — Many protein molecules consist of a chain of amino acids twisted and folded into a complex three-dimensional structure.

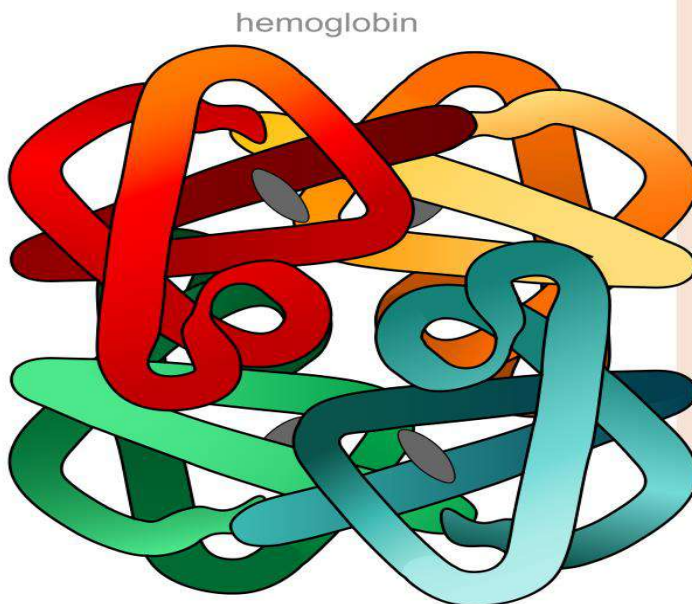
- The complex 3D structures of proteins impart unique features to proteins that allow them to function in diverse ways.
- There are four levels of organization in proteins structure: primary, secondary, tertiary, and quaternary.



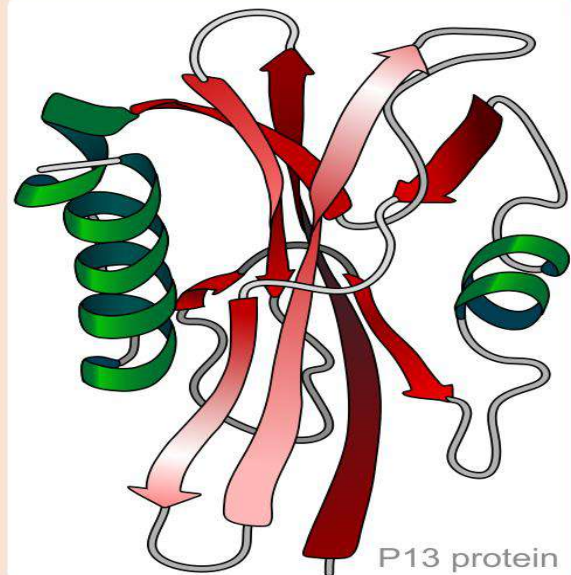
## Primary structure amino acid sequence



## Secondary structure regular sub-structures

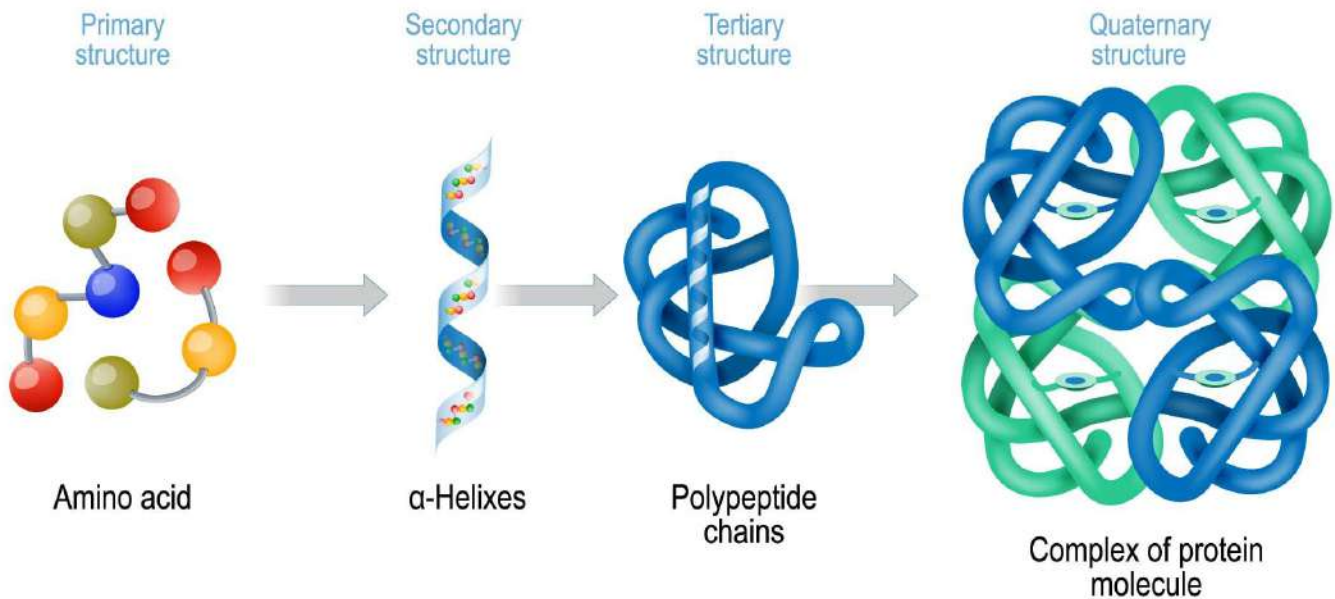


## Quaternary structure complex of protein molecules



## Tertiary structure three-dimensional structure

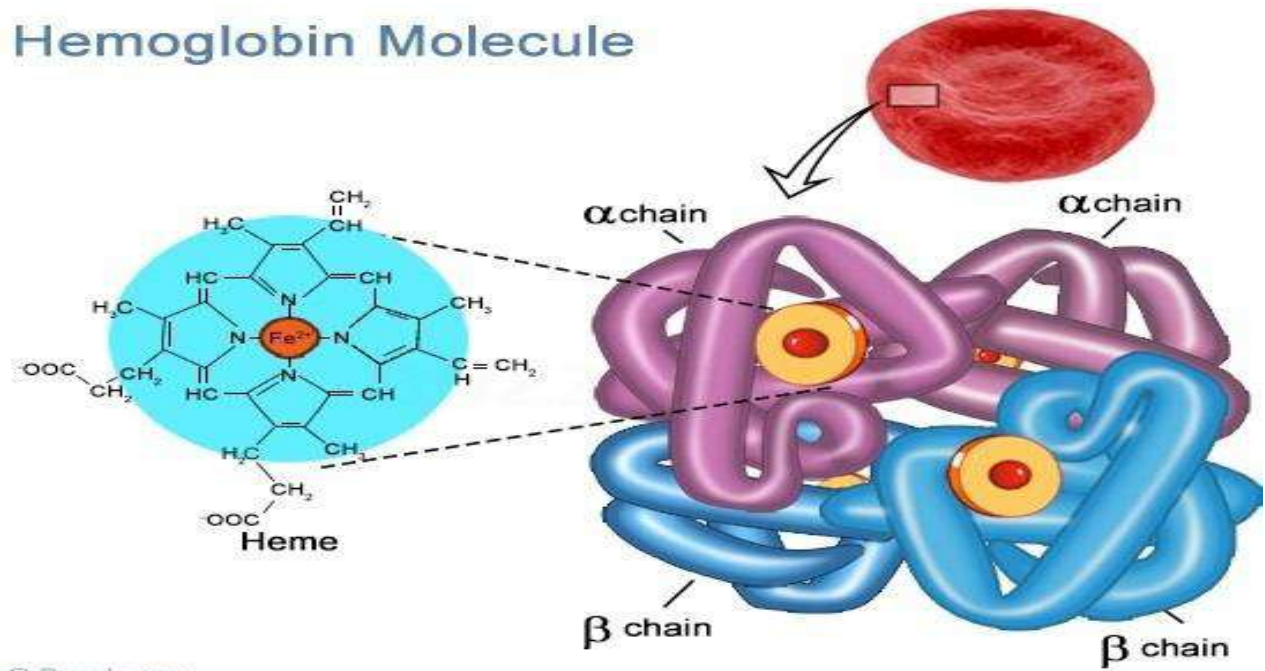
## Protein structure



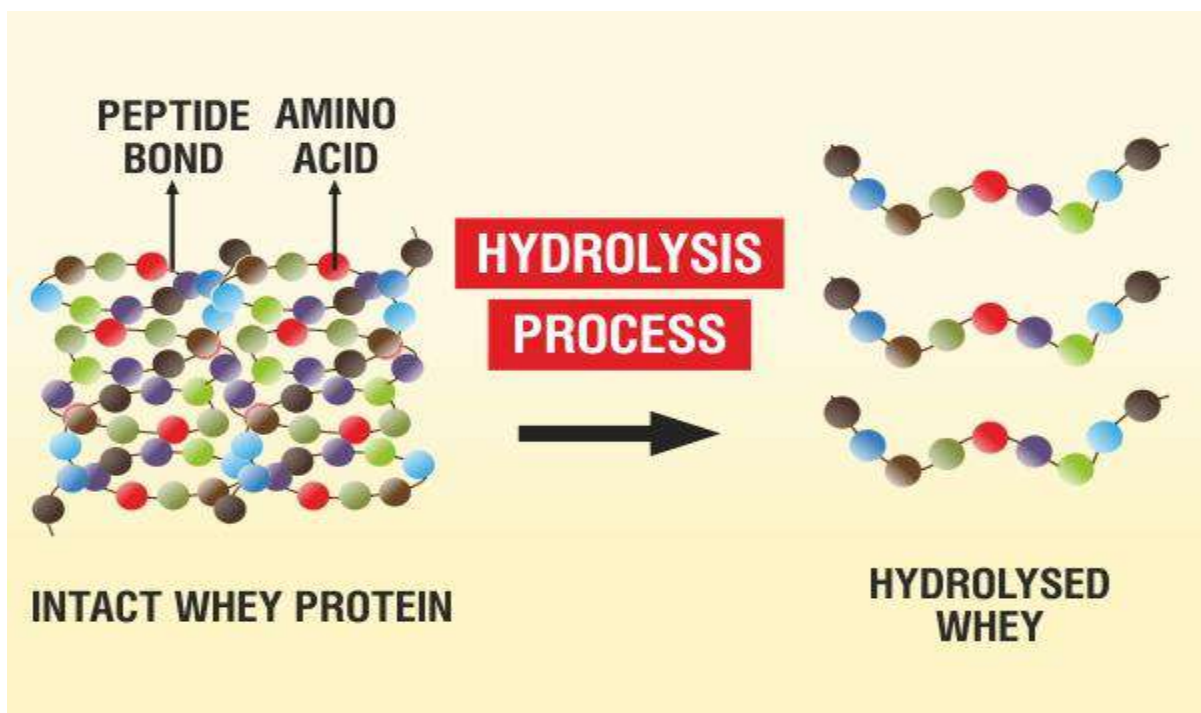
## Hemoglobin

- Hemoglobin is made of four subunits: two identical alpha chains containing 141 AA's and two identical beta chains containing 146 AA's. Each subunit contains a heme group located in crevices near the exterior of the molecule.

## Hemoglobin Molecule



## Protein Hydrolysis and Denaturation



Amides can be hydrolyzed under acidic or basic conditions.

- The peptide bonds in proteins can be broken down under acidic or basic conditions into smaller peptides, or all the way to amino acids, depending on the hydrolysis time, temperature, and pH
  - The digestion of proteins involves hydrolysis reactions catalyzed by digestive enzymes.
  - Cellular proteins are constantly being broken down as the body resynthesizes molecules and tissues that it needs.

## Denaturation

### DENATURATION OF PROTEINS

Denaturation occurs because the bonding interactions responsible for the secondary structure (hydrogen bonds to amides) and tertiary structure are disrupted. In tertiary structure there are four types of bonding interactions between "side chains" including: hydrogen bonding, salt bridges, disulfide bonds, and non-polar hydrophobic interactions, which may be disrupted. Therefore, a variety of reagents and conditions can cause denaturation. The most common observation in the denaturation process is the precipitation or coagulation of the protein.



- Proteins are maintained in their native state (their natural 3D conformation) by stable secondary and tertiary structures, and by aggregation of subunits into quaternary structures.
- Denaturation is caused when the folded native structures break down because of extreme temps. or pH values, which disrupt the stabilizing structures. The structure becomes random and disorganized.
- Most proteins are biologically active only over a temperature range of 0°C to 40°C. • Heat is often used to kill microorganisms and deactivate their toxins. The protein toxin from *Clostridium botulinum* is inactivated by being heated to 100°C for a few minutes; heating also deactivates the toxins that cause diphtheria and tetanus.
- Heat denaturation is used to prepare vaccines against some diseases. The denatured toxin can no longer cause the disease, but it can stimulate the body to produce substances that induce immunity.

### **Denaturation of proteins by salts of heavy metals:**

- The heavy metal salts usually contain  $\text{Hg}^{+2}$ ,  $\text{Pb}^{+2}$ ,  $\text{Ag}^{+1}$ ,  $\text{Ti}^{+1}$ ,  $\text{Cd}^{+2}$  and other metals with high atomic weights. Since salts are ionic in nature they disrupt salt bridges in proteins.
- The reaction of a heavy metal salt with a protein usually leads to an insoluble metal protein salt complex.
- This reaction is used for its disinfectant properties in external applications. For examples:
  - $\text{AgNO}_3$  is used to prevent gonorrhea infections in the eyes of new born infants.
  - Silver nitrate is also used in the treatment of nose and throat infections.
- Heavy metals may also disrupt disulfide bonds because of their high affinity and attraction for sulfur and will also lead to the denaturation of proteins.