→ Carbohydrates exactly mean **hyrates** (i.e. water) **of carbon**.

Learning Objective

- Know carbohydrates as source of energy and its importance play in biological system.
- Identify several major functions of carbohydrates
- Nomenclature of carbohydrates
- Classify monosaccharide, oligosaccharide and polysaccharide.
- Discuss the general reaction of monosaccharide
- Interconversion reaction of monosaccharide
- Discuss constitution of D-Glucose
- Explain mutarotation of glucose

Introduction

→ A carbohyrates mainly compsed of **Carbon**, **Hydrogen** and **Oxygen** elements.

→ General formula of carbohydrates is $\mathbf{C_n(H_2O)_m}$

→ Glucose, Fructose and Sucrose are well known examples of carbohydrates.

→ Carbohydrates defined as **optically active, polyhydroxy aldehydes** or **polyhydroxy ketones** or give these types of compound by **hydrolysis** reaction.

→ The source of carbohydrates mainly plant (60-90%), minor amount of present in animal.in plant they are synthesized by photosynthesis process of CO_2 and H_2O in green leaf present chlorophyll.

→ Low molecular weight carbohydrates are known as **Sugars** or **Saccharides**. for eg. Glucose, Fructose and sucrose.

→ High molecular weight carbohydrates are known as **Non-Sugars**.for eg. Starch, Cellulose.

→ Carbohydrates compound include only two functional group namely one is **aldehydes or ketone** and another **alcohol(-OH)** but it contain many **chiral centre**. Due to chirality study of carbohydrates structure huge challane for chemist and biochemist.

Nomenclature of Carbohydrates

→ Formula : **Reactive group + no. of C-atom in compound+ ose**

→ Carbohydrates compound include only two functional group namely one is carbonyl(**aldehydes or ketone**)and another **alcohol (-OH), out of both carbonl group consider as Reactive group because it more priority then alcohol.**

→ **If aldehyde present ⟶ Aldo &**

→ **If ketone present ⟶ Keto**

→ Carbohydrates compound start from minimum 3,4,5,6 corresponding trival name use tri, tetra, penta and hexa respectively.

→ For eg. Glucose contain aldehyde functional groups and total six carbon. Therefore its name is Aldo+hex+ose=Aldohexose. Similarly Fructose contains ketone functional groups and total six carbon. Therefore its name is Keto +hexa+ose = Ketohexose

→ Most of all sugar add –ose suffix.

Short Questions & Answer

Sr.No.	Quesitions	Answer
1.	What is general formula of carbohydrates?	$Cn(H_2O)m$
2.	Which functional group present in carbohydrates?	Carbonyl & alcohol
3.	Carbohyrates is source of _____	Energy
4.	When sugar heat after left black residue is ____	Carbon

Classification of carbohydrates

→ Carbohydrates are classified into major two groups Sugar (**Saccharides)** and non-sugar (**polysaccharides)**.

1) Sugar (Saccharides): Sugar are sweet in test, crystalline solid and water soluble. The molecular weight are known and fixed for composition. Sugar classified two groups **(a) monosaccharide** and **(b) polysaccharide**.

- **Based on number of simple sugars (mono, di and oligosacchride)**

→ The carbohydrates are divided into three major classes depending on the number of simple sugar unit present in their molecule. In other words, the basis of classification of carbohydrate will be the number of simple sugar molecules on hydrolysis. The molecules so obtained may be of same or different sugars.

1. Monosaccharaides

→ These are single unit carbohydrate that cannot be broken into simpler glucose and fructose.

→ Examples:

$C_6H_{12}O_6 + H_2O \longrightarrow$ **No Reaction.**

D-Glucose OR D-Fructose

2. Oligosaccharides

→ They are made of 2 to 10 units of monosaccharaides or simple sugars. The oligosaccharides containing two monosaccharaides units are called disaccharide and

those containing three units are trisaccharides. Thus sucrose, $C_{12}H_{22}O_{11}$ is disaccharides because on hydrolysis it gives one molecule of glucose and one molecule of fructose.

$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

Sucrose **Glucose** **Fructose**

$(C_6H_{12}O_5)_n + nH_2O \longrightarrow n\ C_6H_{12}O_6$

Cellulose **β-D-Glucose**

2) **<u>Non-Sugar (Non-Saccharide)</u>**

→ A carbohydrate not give sweet in test, insoluble in water and amorphous nature. **Poly saccharide** include in Non-Sugar**.**

1. Polysaccharides

→ They contain more than ten monosaccharide units in molecule. Thus one molecule of **starch** or **cellulose** on hydrolysis gives very large number of glucose units.

$(C_6H_{12}O_5)_n + nH_2O \longrightarrow n\ C_6H_{12}O_6$

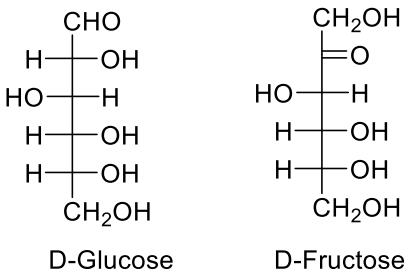
Cellulose **β-D-Glucose**

$(C_6H_{12}O_5)_n + nH_2O \longrightarrow n\ C_6H_{12}O_6$

Starch **α-D-Glucose**

- **Based on carbonyl function**

→ Those containing the aldehyde function, -CHO are called aldoses and other containing keto group -CO- are called ketoses.



- **Based on number of carbon atom**

→ The monosaccharaides containing 3, 4, 5, 6 etc. carbon atoms are designated as trioses, tetroses, pentoses, hexoses and so on as shown in table1.

→ For example, glucose a six carbon sugar with aldehyde function is **aldohexose**, fructose, a six carbon having ketone function is a **ketohexose**.

No. of Carbons	Molecular formula	Aldehyde	Ketones
3	$C_3H_6O_3$	Aldotriose	Ketotriose
4	$C_4H_8O_4$	Aldotetrose	Ketotetrose
5	$C_5H_{10}O_5$	Aldopentose	Ketopentose
6	$C_5H_{10}O_5$	Aldohexose	Ketohexose

Short Questions & Answer

Sr.No.	Quesitions	Answer
1.	Glucose & Fructose are _____	Monosaccharide
2.	Give one example of disaccharide___	Surcose
3.	Raffinose which type of saccharide?	Trisaccharide
4.	Glucose is also called?	Aldohexose
5.	What is suffix used in carbohydrates?	-Ose

Different notation OR Assignment of Monosaccharides

1. <u>D/L Notation OR Assignment</u>

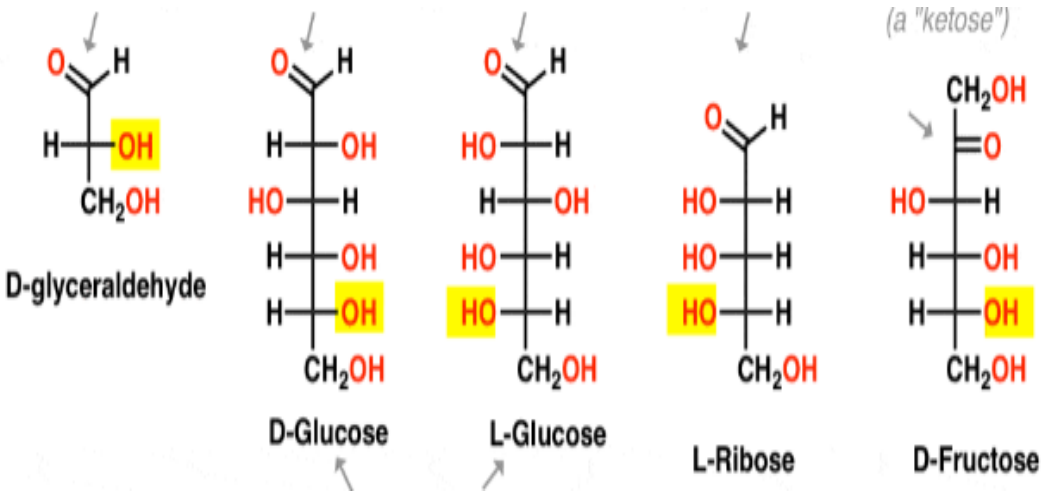
→ D- and L- notation provides a quick shorthand for designating **enantiomers**.

→ **D**-Glucose is the enantiomer of **L**-Glucose, for example. As L-Alanine is the enantiomer of D-Alanine.

→ It is assigned as follows. For a sugar drawn in the **Fischer projection** with the most oxidized carbon at the top (i.e. aldehyde or ketone)

→ If the OH on the bottom chiral center points to the **right**, it is referred to as **D-**.

→ If the OH on the bottom chiral center points to the **left**, it is referred to as **L-** .



→ In Carbohydrates D-Glyceraldehyde taken as standard and amino acid D- alanine taken as standard.

2. <u>detro-levo Notation(d/l) OR Assignment</u>

→ In 1813 **Jean Baptiste Biot** noticed that plane-polarized light was rotated either to the right or the left when it passed through single crystals of quartz or aqueous solutions of tartaric acid or sugar.

→ **Optical activity** is the ability of a chiral molecule to rotate the plane of plane-polairsed light, measured using a **polarimeter**. A simple polarimeter consists of a light source, polarising lens, sample tube and analysing lens.

→ In organic compound able to rotate the plane polarized light either **clockwise** is called **dextro rotatory** & if its rotate **anticlockwise** then its called **levorotatory**.

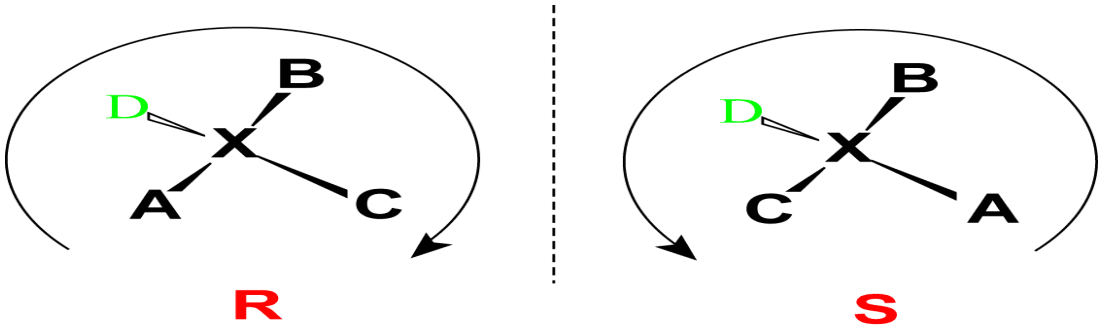
→ **dextro rotatory compound as notation d or (+)**

→ **levo rotatory compound as notation l or (-).**

3. R/S Notation OR Assignments

→ R/S Notation is also called **Absolute configuration** and its given by three scientist names are **Cahn, Ingold & Prelog**. This notation based on priority of group attached with chiral carbons.

→ **R** (means **Rectus**, clock wise rotation) & **S** (means **Sinister**, Anti-clock wise rotation)



→ R/S Notation given by **sequence rules** or **priority rules** it's also known as **CIP rules** describe given below.

→ **Priority rules:**

1. Highest atomic number give more priority**.**

For eg. I >Br > Cl > F

2. In case of same atom of isotopes, higher the atomic mass will be highest priority.

For eg. **D > H**

3. In case of same atom attached with chiral centre then move toward next atoms.

For eg $-CH_3$ & $-CH_2$-OH both are attached with same chiral carbon then priority- CH_2-OH first priority then $-CH_3$.

4. A double or triple bond is considered as equivalent to two or three atom attached its same atom. For eg. >C=C<, >C=O etc.

Short Questions & Answer

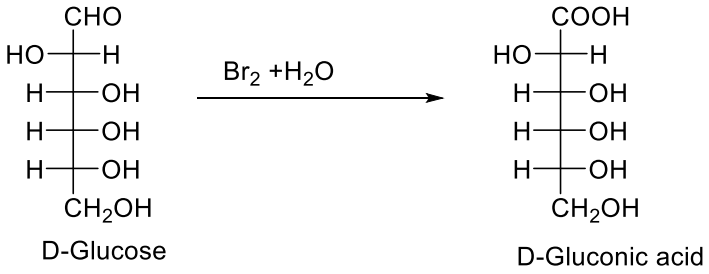
Sr.No.	Quesitions	Answer
1.	D & L isomer of carbohydrates?	Enantiomer
2.	Who scientist give d/l nomenclature?	Jean Baptiste Biot
3.	Which instrument used for determine optical activity?	polarimeter
4.	Dextrorotatory compound is represented by___	d or(+)
5.	Which assignment is called absolute representation?	R/S

Chemical reaction of Monosaccharaides

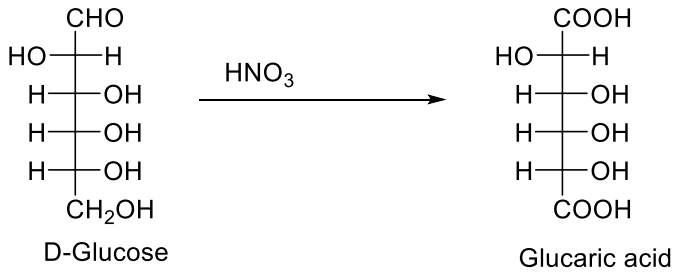
→ Monosaccharaides are polyhydroxy aldehydes or ketones they gives most of the characteristics reaction of the carbonyl group as well as alcoholic group.

(1) **Oxidation:** Product of oxidation reaction depend on nature of **oxidizing agents**. A large number of oxidizing agent such as bromine water, Nitric acid, periodic acid etc.

(a) Bromine water: bromine water selectively oxidise the –CHO group into –COOH group, but it can not oxidise the >C=O group in fructose molecules.



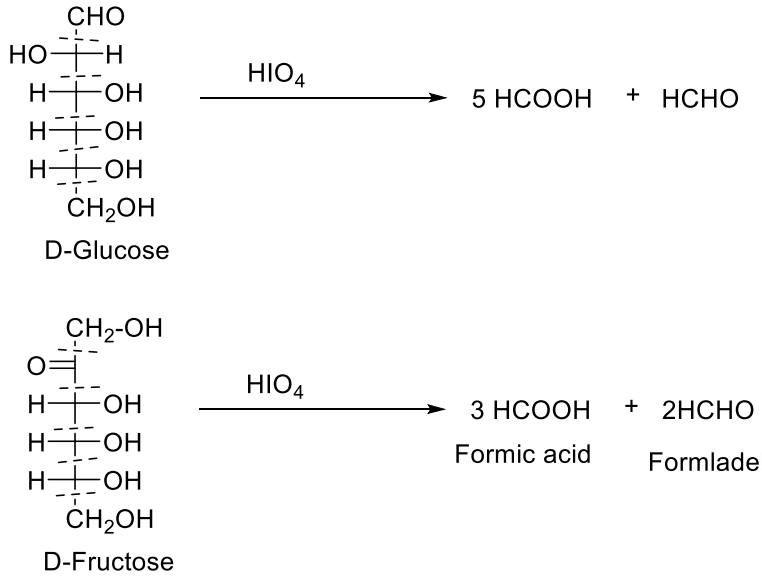
(b) Nitric acid: When D- Glucose oxidation with strong agent like nitric acid both the aldehyde and primary alcohol oxidized to obtains dicarboxylic acid. While D-Fructose oxidise to give mixture of acid having less carbons.



(c) Periodic acid (HIO_4) OR Malaprade reaction:

→ **Periodic acid will cleavage C-C bond produce carbonyl (acid, aldehyde or ketone) compound.**

→ The reaction of glucose with HIO_4 gives 5 mole of formic acid and one mole of formaldehyde, Although Fructose give 2 moles formaldehyde & 3 moles of formic acid.



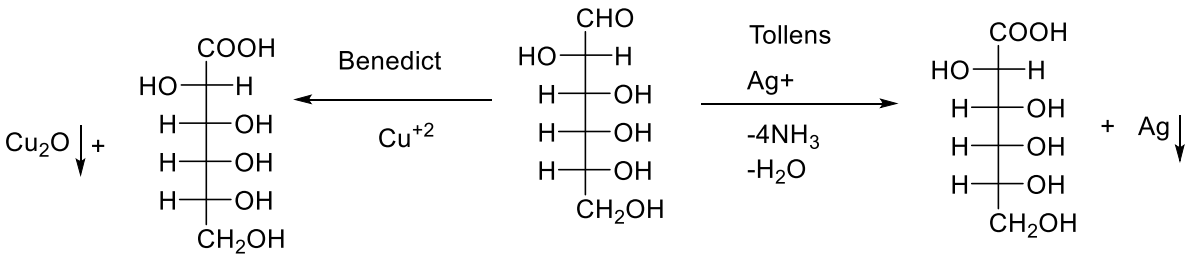
(d) Tollen's /Benedict/ Fehling reagent:

Tollen's reagent – Ammonical Silver nitrate $[Ag(NH_3)_2]OH$

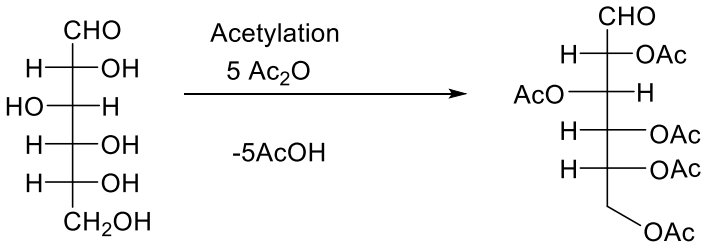
Fehling reagent – Feh.-A (**$CuSO_4$**) + Feh.-B (**NaOH+ Sodium-Potassium Tartrate**)

Benedict reagent – Ben-A (**$CuSO_4$**) + Ben-B (**Sodium Citrate**).

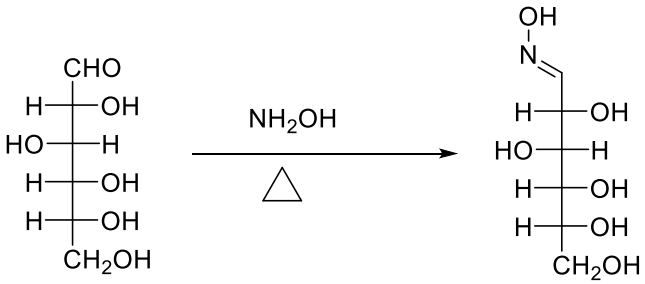
→ D-Glucose & D-Fructose give positive test above reagent, therefore it is also known as **Reducing sugars**.



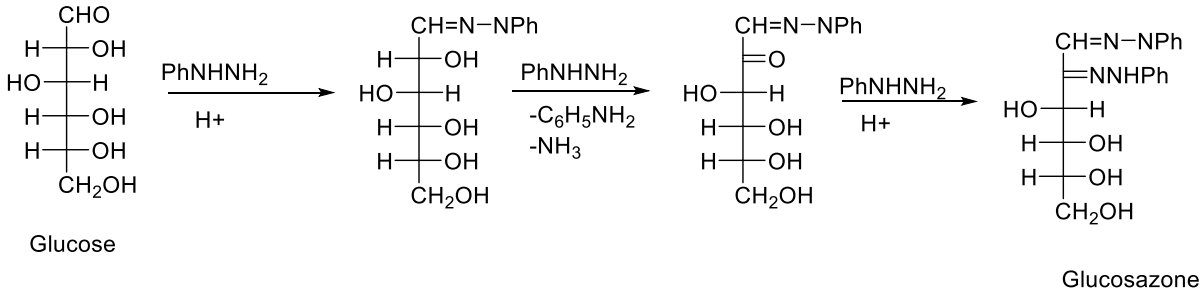
(e) Acetylation Reaction



(f) Oxime formation



(g) Osazone formation

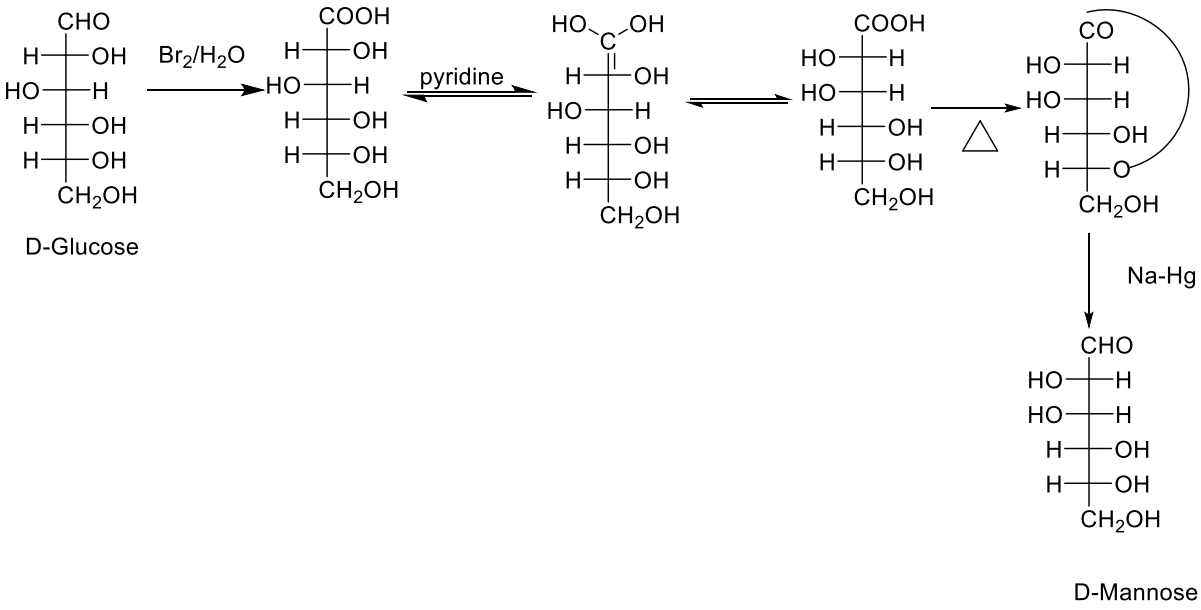


Glucose

Glucosazone

→ Glucose & Fructose both give same type of osazone products.

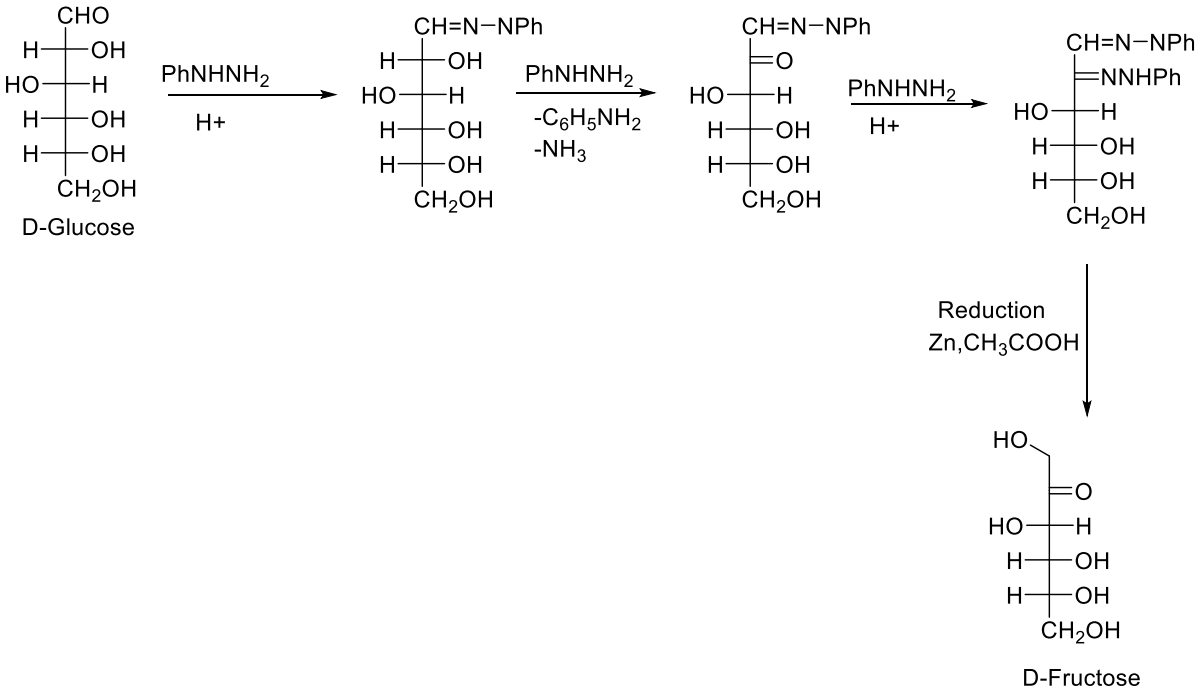
(h) Epimerization reaction



Interconversion of Monosacchride

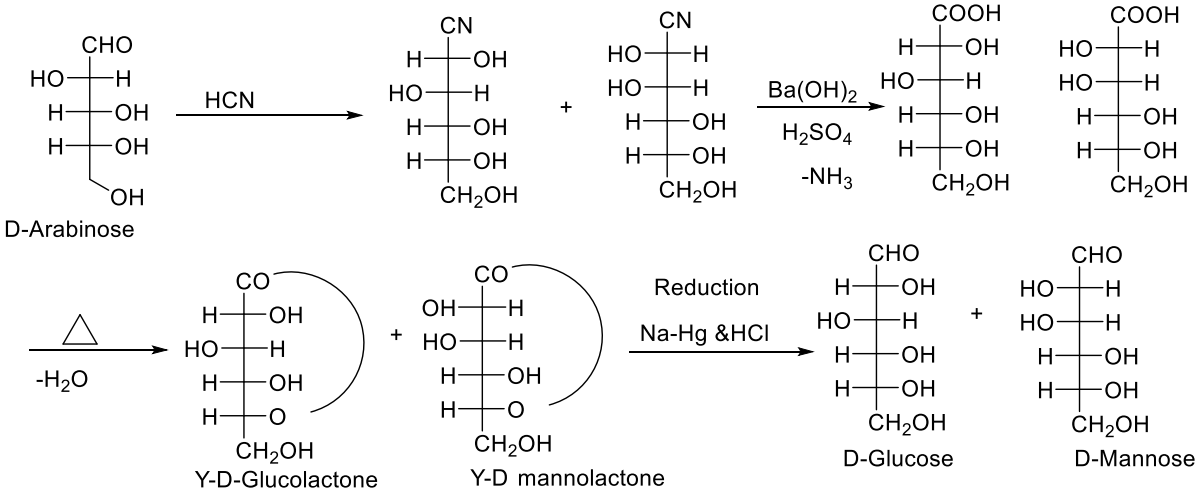
(a) Aldohexose to Ketohexose

For eg. Glucose to Fructose

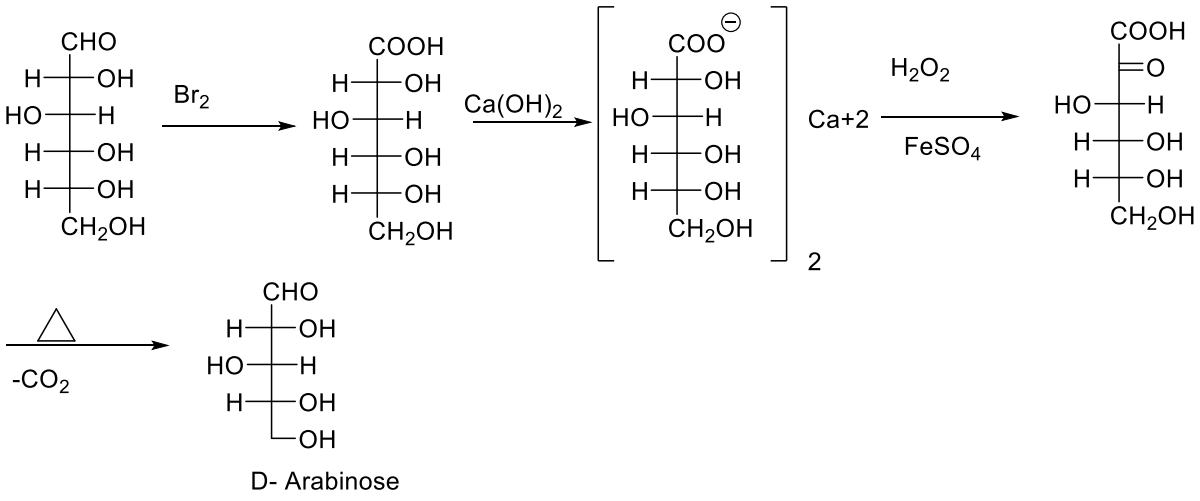


(b) Step-Up reaction (Ascending in aldose series) OR

Kiliani Reaction (D-Arabinose to D- Glucose)



(c)Step-Down Reaction (Descending in aldose series) OR Ruff Method



Constitution of D-Glucose OR Structure of D-Glucose

→ Molecular formula **$C_6H_{12}O_6$** of Glucose determine by using **elemental analysis** and **mass spectroscopy**.

→ It is reduction with **HI** to give **n-hexane**, it is indicate all six carbon atom are linked in straight chain.

→ It is treated with acetic anhydride to form penta acetate derivative, it indicate **5-OH group** present.

→ Formation of **Cyanohydrin** and **Oxime** indicate Carbonyl group present.i.e. aldehyde or ketone.

→ Its mild oxidation with bromine water to yield monocarboxylic acid having same number of carbon that indicate aldehyde group present.

→ But it oxidation with strong oxidizing like HNO3 to yield dicarboxylic acid having same number of carbon but **primary alcohol** oxidise**.**

→ Glucose is a stable compound and doesn't feel dehydration. It is indication of only hydroxyl group is bonded to single carbon atom.

→ On the above all evidence structure of D-Glucose may be written below.

$OHC\text{-}CHOH\text{-}(CHOH)_3\text{-}CH_2OH$

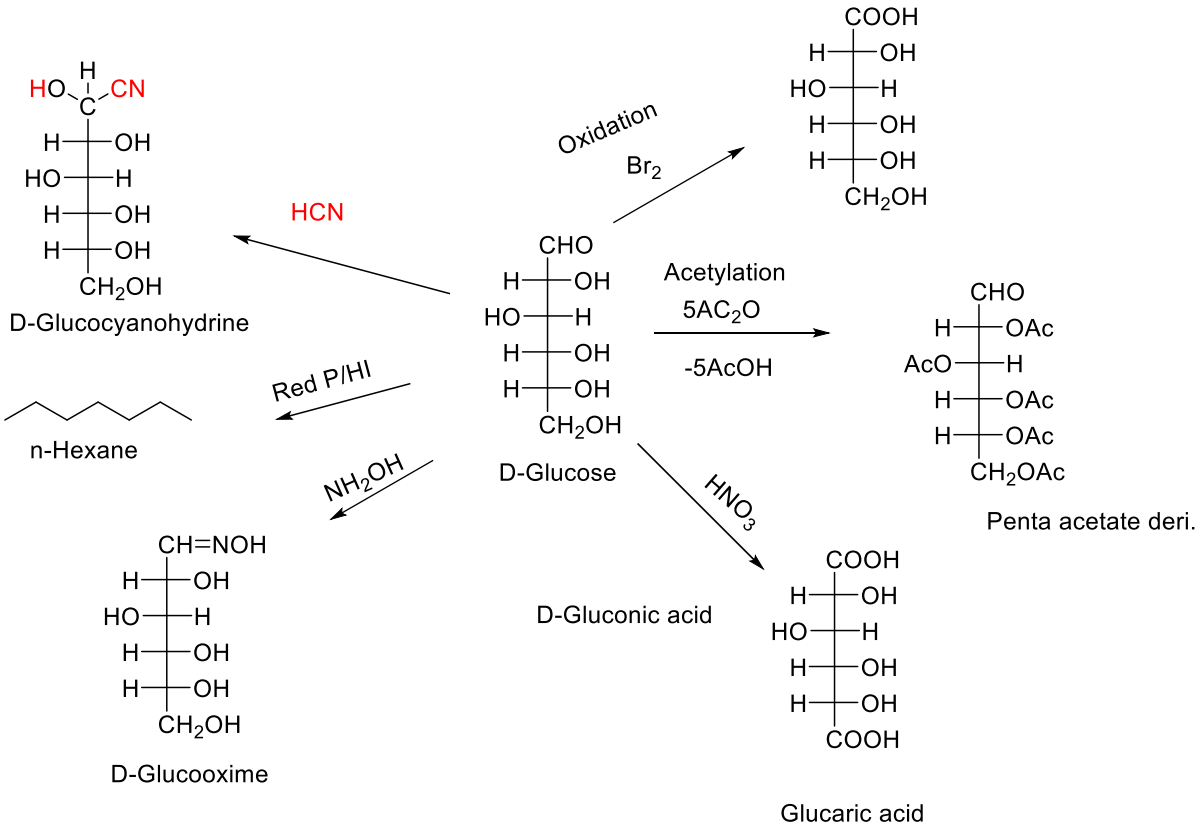
→ These all evidence chemical reaction written below.

Shree H.N.Shukla College of Science Rajkot

B.Sc. (Sem- 5) (CBCS)

CHEMISTRY: [502]

Unit-2 Chapter: -3 Carbohyrates



Short Questions & Answer

Sr.No.	Quesitions	Answer
1.	What is name of C2 Epimer of glucose?	Mannose
2.	Give the name of step-up reaction	Killani
3.	Glucose reaction with HI to give___	n-hexane
4.	Which sugar is also called fruit sugar?	Fructose
5.	Which reagent used in Osazone Form?	Phenyl hydrazine
6.	Give the name of step-up reaction.	Ruff method
7.	Reaction of glucose witth bromine water to give____	Gluconic acid

Mutarotation of D-Glucose

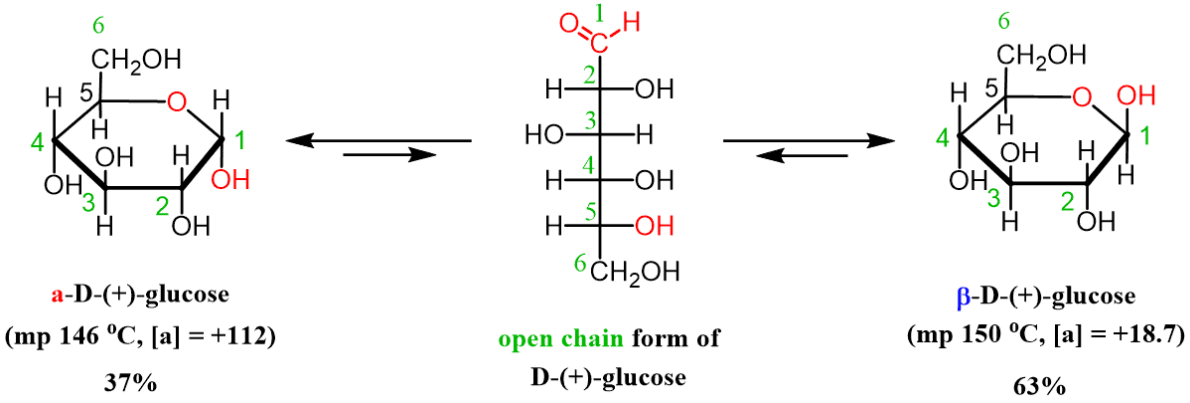
→ D-Glucose crystallize in cold ethanol solvent and then it dissolve water to determine the specific angle of rotation by using polarimeter instrument it is observed $+112^0$ but after some time it is gradually decrease to $+52^0$

→ **If** D-Glucose crystallize in pyridine solvent above 98°C and then it dissolve water to observed specific angle of rotation $+19^0$ but after some time it is gradually increase to $+52^0$.

→ It is proved that D-Glucose (**hemi-acetal** structure) exist in two isomeric form as **α-D-Glucosopyranose** and **β-D- Glucosopyranose** which have different specific rotation.

→ These isomer undergo complete hydrolysis in aqueous solution and interconvertible, solution on equilibrium stage consisting 63.6% of **β-anomer** and 36.4% of **α-anomer.**

→ The phenomenon of change in specific rotation is known as **Mutarotation**.



→ It is subjected to to both acid and base catalyst .In this reaction cyclic structure of hemiacetals involves, simultaneously ring opening and closing by proton transfer hydroxyl group to carbonyl oxygen.

Short Questions & Answer

Sr.No.	Quesitions	Answer
1.	Who was awarded noble prize in carbohydrates?	E.Fischer
2.	Which Saccaharide exhibit mutarotation?	Monosaccaharide
3.	Average specific rotation of glucose_____	$+52.5^0$

Learning Outcome

- Distinguish various carbohydrates found in foods and its useful to the human body.
- Describe the body's use of glucose to provide energy or to make glycogen and fat.
- Distinguish Mono, Oligo and Polysaccaharide.
- We aware to Suagr & Non-Sugar, its various application.
- Finally we study chemical interconversion from one sugar to another.