Atomic Energy Central School, Indore

Class XII Chemistry BIOMOLECULES Handout 1/3

Introduction

Biochemistry – The study that deals with the chemistry within a living cell or system.
Biomolecules – The complex molecules within a cell that perform prescribed functions. Ex. Proteins, Carbohydrates, Lipids and Nucleic acids.

1. Carbohydrates

Carbohydrates are generally ***produced by plants*** and most of them have a general formula, $C_x(H_2O)_y$, and were considered as hydrates of carbon from where the name carbohydrate was derived. For ex. Glucose ($C_6H_{12}O_6$) fits into the formula $C_6(H_2O)_6$.
Definition: the carbohydrates are optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis.

How are Carbohydrates classified?

Carbohydrates are classified

a) On their behavior towards hydrolysis,they are divided into
Monosacharides (Greek: *sakcharon* means sugar)– A polyhydroxy unit which cannot be further hydrolysed to smaller units containing an aldehyde or ketone functional group. *Ex. Glucose* $C_6H_{12}O_6$
Oligosacharide: These carbohydrates on hydrolysis give 2-10 monosachrides.Ex. Disacharides give 2 units on hydrolysis-*Sucrose(glucose+fructose),lactose* $C_{12}H_{22}O_{11}$
Polysacharides – These are high ,molecular weight carbohydrates which yield large number of monosachrides on hydrolysis. *Ex. Starch* $(C_6H_{10}O_5)_n$

b) According to the functional group present
   i) Aldose – If the carbohydrate contains an aldehyde. Aldotriose – containing three carbon atoms(*Ex. Glyceraldehyde*), aldotetrose, aldopentose (Ex. Ribose), aldohexose (*Ex. Glucose*)
   ii) Ketose - If the carbohydrate contains a ketone. Ketotriose, ketotetrose, ketopentose, ketohexose(*Ex. Fructose*)

c) As reducing or non reducing sugars - All those carbohydrates which reduce Fehling's solution and Tollens' reagent are referred to as reducing sugars. All monosaccharides whether aldose or ketose are *reducing sugars.*
In disaccharides, if the reducing groups of monosaccharides i.e., aldehydic or ketonic groups are bonded, these are non-reducing sugars e.g. sucrose. On the other hand, sugars in which these functional groups are free, are called reducing sugars, for example, maltose and lactose.

Glucose

Occurrence: Glucose occurs freely in nature as well as in the combined form.
Source: It is present in sweet fruits and honey.
Ripe grapes also contain glucose in large amounts.
Preparation:

1. From sucrose (Cane sugar): If sucrose is boiled with dilute HCl or H_2SO_4 in alcoholic solution, glucose and fructose are obtained in equal amounts.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

2. From starch**:** Commercially glucose is obtained by hydrolysis of starch by boiling it with dilute H_2SO_4 at 393 K under pressure.

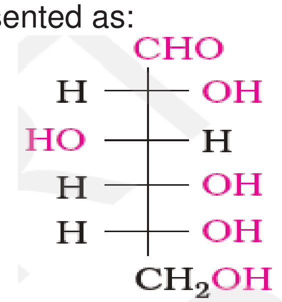
$$\underset{\text{Starch or Cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[393K,2\text{-}3\ atm]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

Structure of Glucose

Glucose is an aldohexose and is also known as dextrose. It was assigned the structure given below on the basis of the following ***evidences***.

Molecular formula $C_6H_{12}O_6$				
Glucose	Reaction	Reagent	Products	Proves that
$CHO-(CHOH)_4-CH_2OH$	On prolonged heating ***with HI***, it forms n-hexane	$\xrightarrow{HI,\ \Delta}$	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$ (*n*-Hexane)	all the six carbon atoms are linked in **a straight chain.**
	Glucose reacts with ***hydroxylamine*** to form an oxime and adds a molecule of ***hydrogen cyanide*** to give cyanohydrin.	$\xrightarrow{NH_2OH}$	$CH=N-OH$ / $(CHOH)_4$ / CH_2OH	These reactions confirm the **presence of a carbonyl group (>C = O)** in glucose.
		$\xrightarrow{HCN}$	$CH(CN)(OH)$ / $(CHOH)_4$ / CH_2OH	
	Glucose gets oxidised to six carbon carboxylic acid (gluconic acid) on reaction with a mild ***oxidising agent like bromine water.***	$\xrightarrow{Br_2\ water}$	$COOH$ / $(CHOH)_4$ / CH_2OH Gluconic acid	the carbonyl group is present as an **aldehydic group**.
	Acetylation of glucose ***with acetic anhydride*** gives glucose pentaacetate	$\xrightarrow{\text{Acetic anhydride}}$	CHO / $(CH-O-\overset{O}{\overset{\Vert}{C}}-CH_3)_4$ / $CH_2-O-\overset{O}{\overset{\Vert}{C}}-CH_3$	which confirms the presence of **five –OH groups attached to different carbon atoms.**
	On ***oxidation with nitric acid***, glucose as well as gluconic acid both yield a dicarboxylic acid, saccharic acid.	$\xrightarrow{\text{Oxidation}}$	Saccharic acid $COOH$ / $(CHOH)_4$ / $COOH$ $\xleftarrow{\text{Oxidation}}$ Gluconic acid $COOH$ / $(CHOH)_4$ / CH_2OH	This indicates the presence **of a primary alcoholic (–OH) group** in glucose.

Its configuration is correctly represented as:

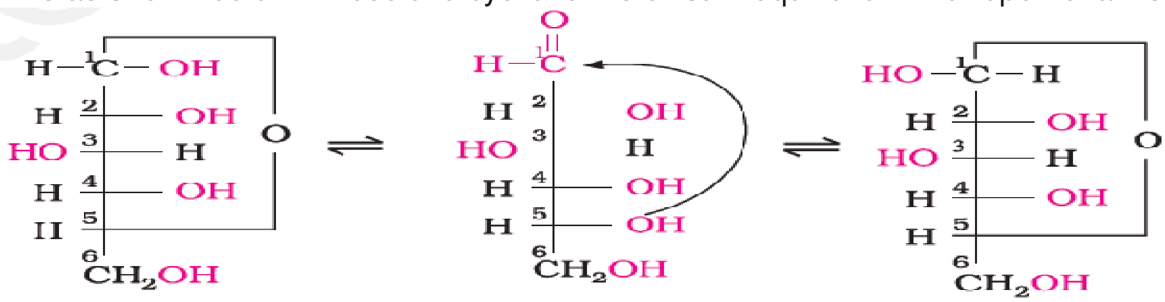


D(+)-glucose:

'D' before the name of glucose represents the configuration whereas '(+)' represents dextrorotatory nature of the molecule.

Cyclic structure of Glucose

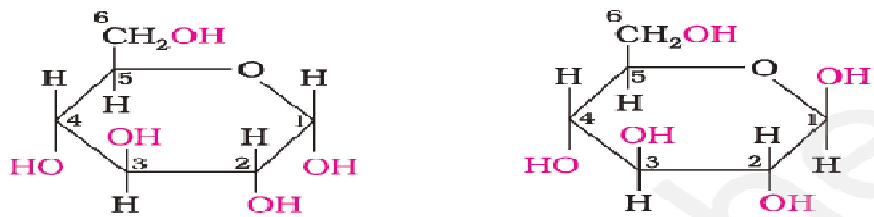
It was found that glucose forms a six-membered ring in which —OH at C-5 is involved in ring formation. This explains the absence of —CHO group and also existence of glucose in two forms as shown below. These two cyclic forms exist in equilibrium with open chain structure.



α – D – (+) – Glucose   β – D– (+) – Glucose

The two cyclic hemiacetal forms of glucose differ only in the configuration of the hydroxyl group at C1, called *anomeric carbon* (the aldehyde carbon before cyclisation). Such isomers, i.e., α-form and β-form, are called **anomers**.

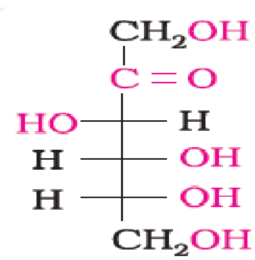
The cyclic ***pyranose structure of glucose*** is more correctly represented by Haworth structure as given below.



α D – (+) – Glucopyranose   β – D – (+) – Glucopyranose

Fructose

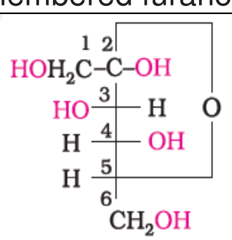
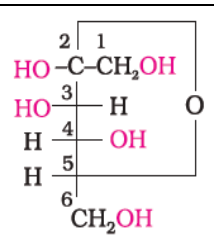
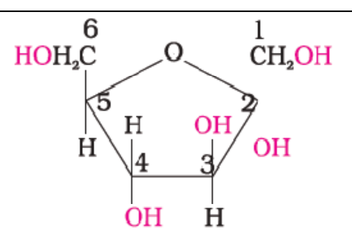
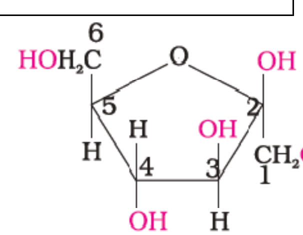
Fructose is an important ketohexose. It is obtained along with glucose by the hydrolysis of sucrose.



D – (–) – Fructose

Structure of Fructose

1. Its molecular formula is $C_6H_{12}O_6$.
2. It was found to contain a ***ketonic functional group at carbon number 2*** and six carbons in straight chain as in the case of glucose.
3. It belongs to D-series and is a laevorotatory compound. It is appropriately written as D-(–)-fructose.
   Its open chain structure is as shown:

Its two cyclic forms, **α and β,** are obtained by the addition of -OH at C5 to the (>C=O) group. The ring, thus formed, is a 5 membered furanose ring.	The cyclic structures of two **anomers** of fructose are represented by Haworth structures as given.
 α – D – (–) – Fructofuranose  β– D – (–) – Fructofuran	 α – D – (–) – Fructofuranose  β – D – (–) – Fructofurar

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