Complete CHEMISTRY

IIT-JEE · NEET · CBSE eBOOKS

CLASS 11&12th

CLASS 12th

Biomolecules

01. Introduction

Biomolecules *may be defined as complex lifeless chemical substances which form the basis of life. i.e. they not only build up living system (creatures) but are also responsible for their growth, maintenance and their ability to reproduce.*

02. Carbohydrates

One of the most important classes of biomolecules is carbohydrates. These include compounds like sugars, starch, glycogen, cellulose, dextrins and gums. Although they are widely distributed both in animal and plant kingdom yet they are obtained mainly from plants. They are formed in plants by a process known as *Photosynthesis* and make up about 70% of the solid plants material.

$$x\ CO_2 + y\ H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Carbohydrate}}{Cx(H_2O)y} + x\ O_2$$

Carbohydrates play a vital role in our daily life. They provide us with three basic necessities of life, *i.e.,* **food** (in the form of starch). **clothing** (cotton, lines and rayon are essentially cellulose) and **shelter** (wood in making houses and furniture is almost cellulose) and **shelter** (wood in making house and furniture is almost cellulose)

Carbohydrates are defined as optically active polhydroxy aldehydes or polyhydroxy ketones or substances which give these on hydrolysis.

Classification of Carbohydrates

Carbohydrates are also known as **saccharides** (Greek: **Sakcharon** means sugar). These are classified into the following three classes depending upon their behaviour towards hydrolysis.

(i) **Monosaccharides :** Their are the simplest carbohydrates which cannot be hydrolysed to smaller molecules. Their general formula is $(CH_2O)n$ where n = 3–7.

(ii) **Oilgosaccharides :** (Greek, *oligo* means a *few*). These are carbohydrates which on hydrolysis given 2-10 molecules of monosaccharides. Depending upon the number of monosaccharide molecules actually obtained upon hydrolysis, they are further classified as di, tri, tetrasaccharides, etc. For example,

- **Disaccharides :** *Carbohydrates which upon hydrolysis given two molecules of the same or different monosaccharides are called* **disaccharides.** For example, sucrose, maltose, lactose, etc Their general formula is $C_{12}H_{22}O_{11}$.
- **Trisaccharides :** Carbohydrates which on *hydrolysis give three molecules of the same or different monosaccharides are called* **trissaccharides.** For example, raffinose upon hydrolysis given one molecule each of glucose, fructose and galactose. Their general fructose and galactose. Their general formula is $C_{18}H_{32}O_{16}$.
- **Tetrasaccharides :** *Carbohydrates which upon hydrolysis give four molecules of the same or different monosaccharides are called* **tetrassaccharides.** For example, stachyrose upon hydrolysis gives one molecule each of glucose and fructose and two molecules of glycogen. Their general formula is $C_{24}H_{42}O_{21}$.

(iii) **Polysaccharides :** carbohydrates which upon hydrolysis give a large number of monosaccharide molecules are called polysaccharides. The most commonly occuring polysaccharides are starch, cellulose and glycogen. Their general formula is $(C_6H_{10}O_5)n$ where n = 100–3000.

Sugars and non-sugars : Carbohydrates are further classified as *sugars* and *non-sugars.* All the monoraccharides and oligosaccharides are crystalline solids, soluble in water and sweet in taste. These are collectively called **sugars.** The polysaccharides, on the other hand, are amorphous solids, insoluble in water in tasteless and thus are called **non-sugar.**

Reducing and non-reducing sugar or carbohydrates : Carbohydrates are also classified as *reducing and non-reducing.* sugars. *All those carbohydrates which contain aldehydic or ketonic group in the hemiacetal or hemiketal from and reduce Tollens regent or Fehling's solution are called reducing* ***carbohydrates or sugars*** *while others which do not reduce these reagents are called* **non-reducing carbohydrates or sugars**

Monosaccharides–Structures of pentoses and hexoses

As stated above, monosaccharides are the simplest carbohydrates which cannot be hydrolysed to smaller molecules. They contain 3 to 7 carbon atoms. There are about twenty monosaccharides which occur in nature. These are of two types:

(i) **Aldoses :** *Monosaccharides containing an aldehyde (—CHO) group are called* **aldoses.** Since the aldehyde group is monovalent, therefore, it is always present at one end of the carbon chain, i.e., at C_1.

(ii) **Ketoses :** Monosaccharides containing a keto (> C = O) group are called ketoses. Since the keto group is divalent, it can be present any where along the carbon chain, However, in all the naturally occurring ketoses, keto group is always present at a carbon atom next to the terminal carbon, i.e., at C_2.

Aldoses and ketose are further classified as *trioses, tetroses, pentoses, hexoses, heptoses, etc.* according as they contain three, four, five six, seven, etc. carbon atom respectively. This classification of monosaccharides is summarised in Table

Classification of Monosaccharides

Class	Molecular formula	Structural formula	Examples
		Aldoses	
Aldotrioses	$C_3H_6O_3$	$CH_2OH.CHOH.CHO$	Glyceraldehyde
Aldotetroses	$C_4H_8O_4$	$CH_2OH.(CHOH)_2.CHO$	Erythrose, threose
Aldopentoses	$C_5H_{10}O_5$	$CH_2OH.(CHOH)_3.CHO$	Arabinose, ribose, xylose, lyxose
Aldohexoses	$C_6H_{12}O_6$	$CH_2OH.(CHOH)_4.CHO$	Glucose, mannose, galactose, gulose, talose, idose, allose, altrose
Aldoheptoses	$C_7H_{14}O_7$	$CH_2OH.(CHOH)_5.CHO$	—
		Ketoses	
Ketotrioses	$C_3H_6O_3$	$CH_2OH.CO.CH_2HO$	Dihydroxyacetone
Ketotetroses	$C_4H_8O_4$	$CH_2OH.CO.CHOH.CH_2OH$	Erythrulose
Ketopentoses	$C_5H_{10}O_5$	$CH_2OH.CO.(CHOH)_2.CH_2OH$	Ribulose, xylulose
Ketohexoses	$C_6H_{12}O_6$	$CH_2OH.CO.(CHOH)_3.CH_2OH$	Fructose, sorbose, tagatose, etc.
Ketoheptoses	$C_7H_{14}O_7$	$CH_2OH.CO.(CHOH)_4.CH_2OH$	—

Occurrence and Preparation of Glucose (Dextrose, Grape sugar) $C_6H_{12}O_6$

Glucose occurs in nature in free as well as in the combined state. it occurs in large quantities (about 20%) in ripe grapes and that is why it is called **grape sugar.**

Preparation

(i) **From sucrose (Cane-sugar)**

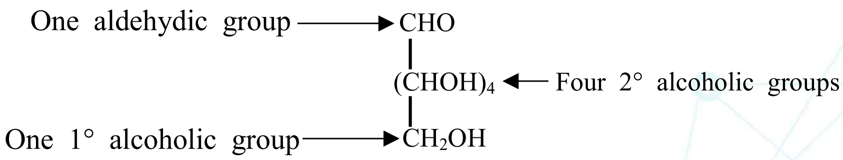
$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(ii) **From starch**

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + n\ H_2O \xrightarrow[393\ K, 2\text{–}3\ atm]{H^+} n\ C_6H_{12}O_6$$

Open Chain Structure of Glucose

The open chain structure of glucose was proposed by Baeyer. It contains one aldehyde (–CHO) group, one primary alcoholic (–CH_2OH) group and four secondary alcoholic (–CHOH) groups.

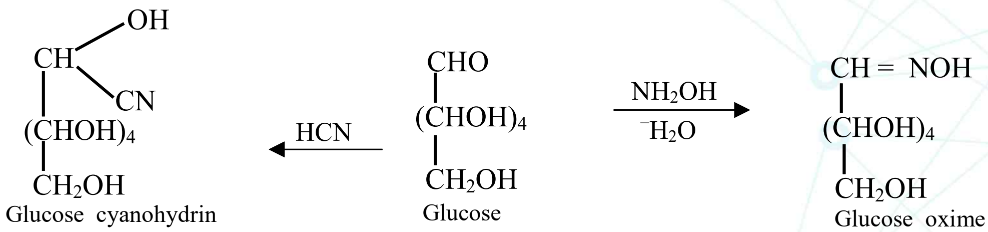


This structure was assigned on the basis of following evidence.

(i) **Molecular formula :** The molecular formula of glucose is $C_6H_{12}O_6$.

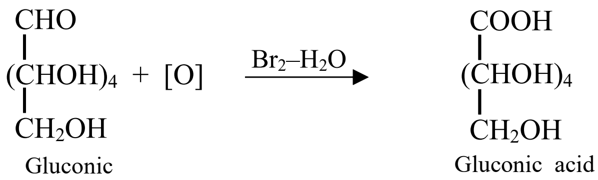
(ii) **Presence of an aldehyde group :**

(a)



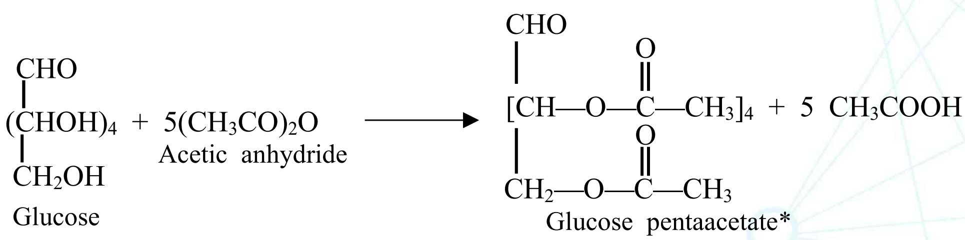
These reactions suggest that glucose contains a carbonyl group (C=O) group.

(b)

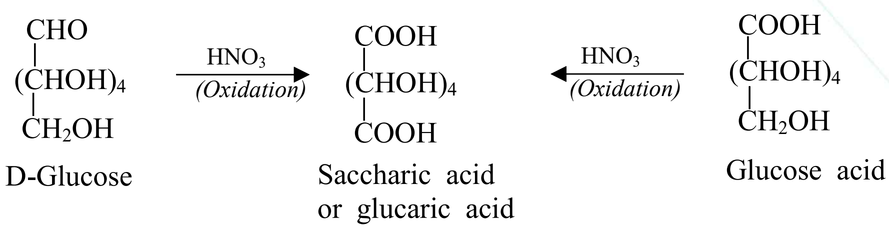


Since aldehyde (–CHO) is monovalent, it is always present at the end of the carbon chain.

(iii) **Presence of five hydroxyl groups :**



(iv) **Presence of one primary alcoholic group:**



The *primary alcoholic group (–CH_2OH) is always present at the end of the carbon chain.*