Course Code: CHEM3014
Course Name: Organic Chemistry V

Unit: 4
(Carbohydrate)
(Lecture-Part I)

For
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Semester: VI

By

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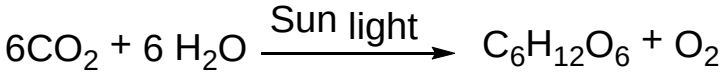
Carbohydrates: A General Introduction

- **Carbohydartes** are biomolecules which are essential for all living organism for various processes. Carbohydrates are also called **saccharides** (Greek: ***Sakcharon*** *means sugar).*

- **Common Examples**: Glucose, Sucrose or Table sugar, Lactose , Starch, Cellulose etc.

- **Sources**: In general plants are major sources of carbohydrate, where the formation of glucose occurs through the process of **photosynthesis**. (Scheme 1). At later stages, it further polymerizes into polymers such as cellulose, starch etc.

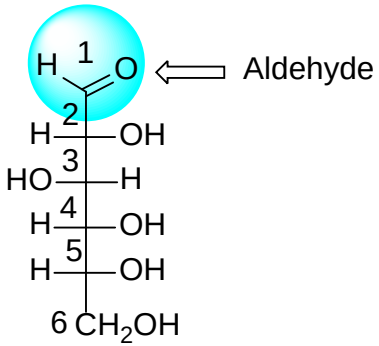


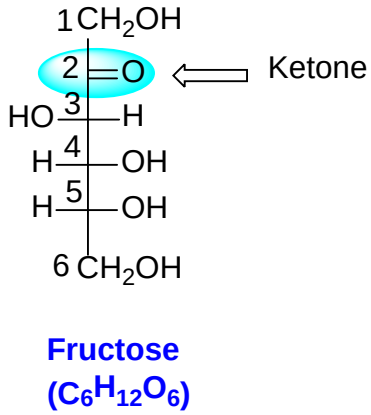
Scheme 1: Formation of glucose through photosynthesis

- Dietary carbohydrates provide the **major source of energy** required by organisms.

Carbohydrates: A Chemical Introduction

➢ Chemically carbohydrates are are polyhydroxy aldehydes or ketones with molecular formul as Cn(H2O)n. Structures of glucose (Polyhydroxy aldehyde) and fructose (Polyhydroxy ketone) are shown below.





➢ As formula indicates this class of compounds are considered as **hydrates of carbon** and that is why these are known as '**Carbohydrates**'. They exist primarily in their hemiacetal or acetal forms.

➢Remember: All carbohydartes may not fit into this general formula. Example: Rhamnose (C6H12O5).

➢ Similarly all the compounds with molecular formulas Cn(H2O)n may not be carbohydrates. Example: acetic acid (CH3COOH) fits into this general formula, C2(H2O)2 but is not a carbohydrate.

Probable Confusion In This Chapter

- **Before we move to the classifications and further discussion, following points must be kept in mind:**

(1) There are different criteria such as behavior on hydrolysis, presence of functional group etc. for the classification of carbohydrates.

(2) At the same time remember that these compounds contain asymmetric carbon also. so different stereoisomers, optical properties etc. will also be observed and therefore different notations and terminologies could be used to denote them.

(3) Different ways of representation such as Fischer projection, Haworth projection etc. for the same molecule could be used so don't get confused with all these.

- **So overall one has to be very careful while using a particular term and notation in carbohydrate chemistry**.

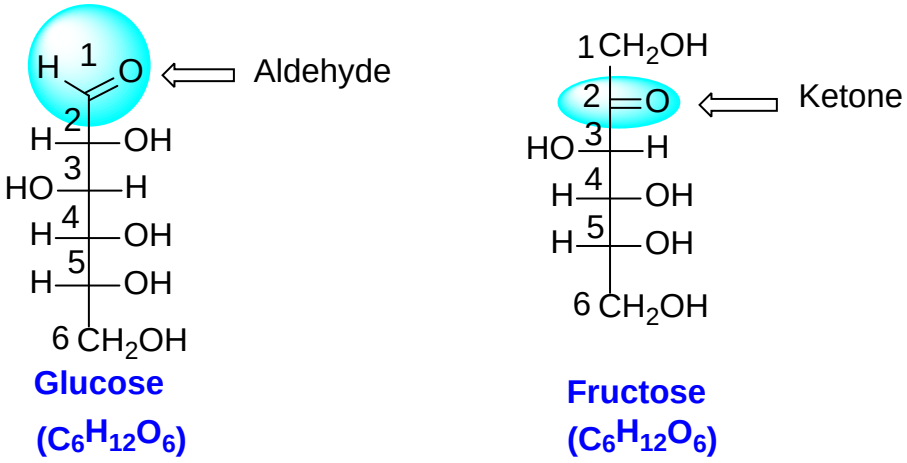
Continued…..

Monosaccharide

➢ On the basis of their **behavior on hydrolysis**, Carbohydrates could be classified into following **three categories**:

(a) **Monosacharide**: *('Mono' means 'one' and 'saccharide' means 'sugar) :* A carbohydrate that cannot be hydrolysed further into simpler unit of polyhydroxy aldehyde or ketone is called a mono-saccharide. This is the simplest form of carbohydrates. Here

➢ **Examples of monosacharide:** Glucose, Fructose, Ribose etc.



➢: **About 20 monosaccharides are known to occur in nature**

Oligosaccharides

- Carbohydrates that yield **two to ten monosaccharide units**, on hydrolysis, are known as oligosaccharides. **These units may or may not be the same.**

- Based on the number of monosaccharide units formed on hydrolysis, these oligosaccharadise could further be divided into following:

(a) Disaccharides: As term itself indicates, they provide two (***di***) monosaccharide units on hydrolysis, which may be the same or different. Example: Sucrose, Maltose etc.

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

Sucrose — Glucose + Fructose

(b) $C_{12}H_{22}O_{11} + H_2O \longrightarrow 2C_6H_{12}O_6$

Maltose — Glucose

Scheme 2: Hydrolysis of disaccharides sucrose (a) and maltose

- One mole of sucrose on hydrolysis gives one mole of each of glucose and fructose, whereas one mole of maltose provides two moles of glucose (Scheme 1).

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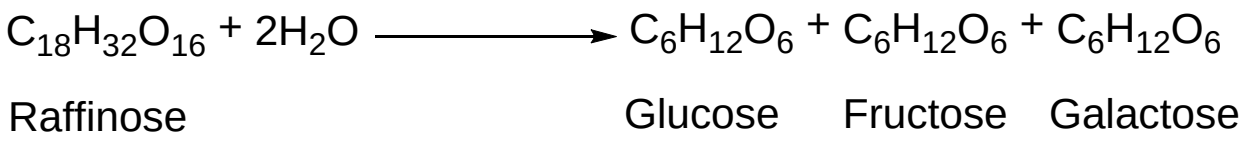
Oligosaccharide (Trisaccharides)

➢ **Trisaccharide**: As name indicates **three moles of** monosaccharide units could be obtained from the hydrolysis of **tri**saccharides.

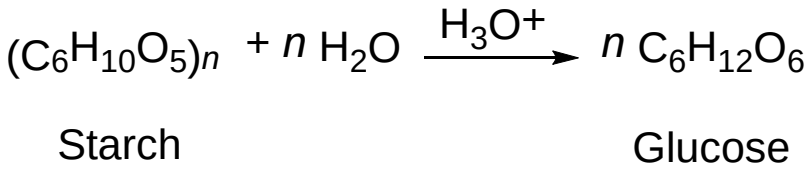
➢ For example, **Raffinose** is a trisaccharide which upon hydrolysis provides one mole of each galactose, glucose, and fructose.



Scheme 3: Hydrolysis of trisaccharide raffinose

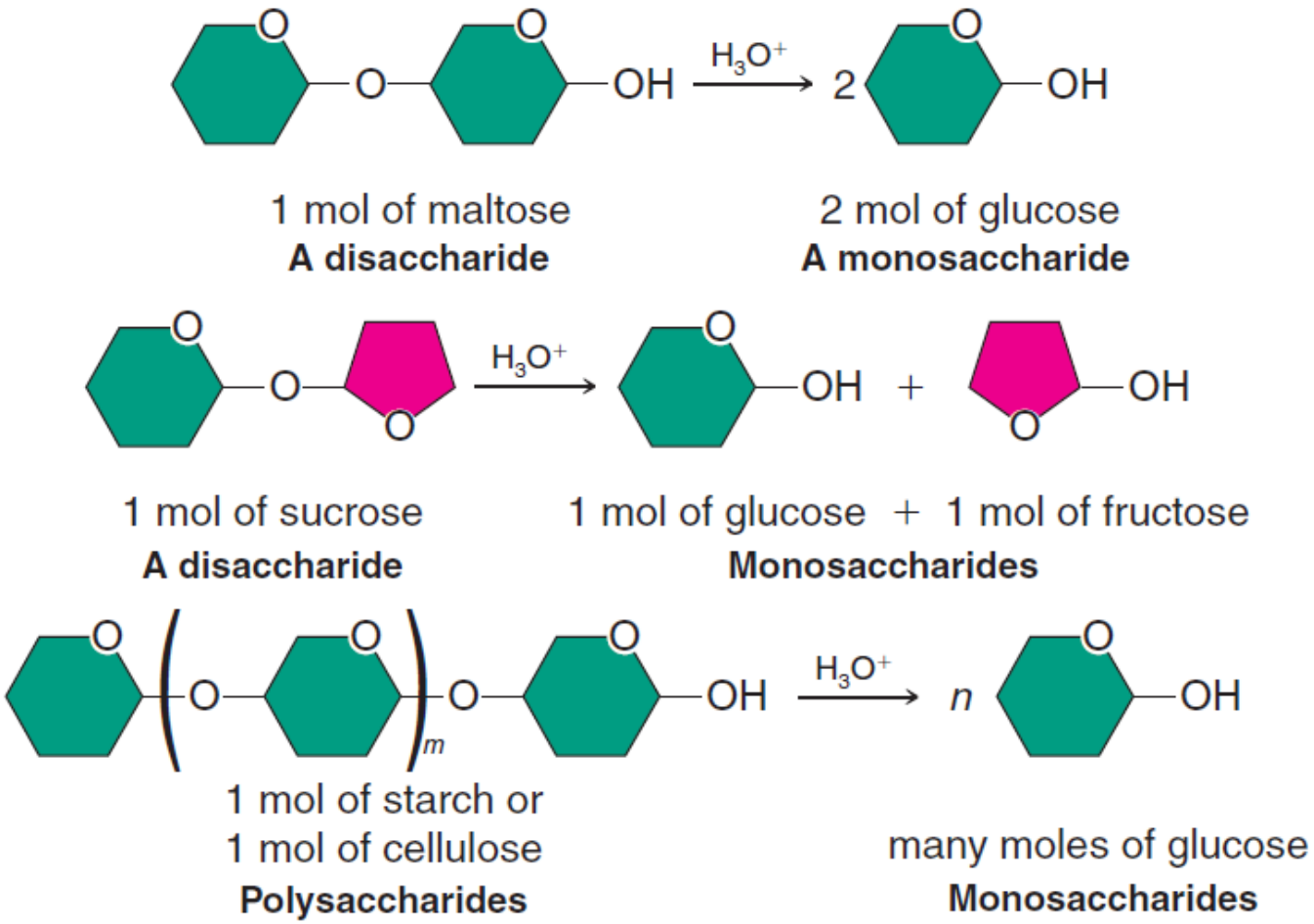
Polysaccharides

- Carbohydrates that yield a large number of molecules of monosaccharides (10) are known as **polysaccharides.**
- **Cellulose**, **starch**, glycogen are few common examples of polysaccharides**.**
- These are also known as non-sugar as they are not sweet in taste.
- The common and widely distributed polysaccharides correspond to the general formula $(C_6H_{10}O_5)n$.



Scheme 4: Hydrolysis of polysaccharide starch

Schematic Representation for the hydrolysis



(Picture adapted from *Chapter No. 22, 'Organic Chemistry' (10th edition) by T. W. G. Solomons and C. B. Fryhle.)*

Once again come back to Monosaccharide for detailed discussions!

Classification of Monosaccharides

- **Monosaccharides could be classified based on:**

(a) Number of carbon atoms present in the molecule

(b) Presence of aldehyde or keto group

- General terms used for different types of monosaccharidse based on this classification is summarised in Table 1.

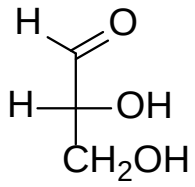
Table 1: Classification of Monosaccharides

S. No.	Carbon Atoms	General Term	Aldehyde	Ketone
1.	3	Triose	Aldotriose	Ketotriose
2.	4	Tetrose	Aldotetrose	Ketotetrose
3.	5	Pentose	Aldopentose	Ketopentose
4.	6	Hexose	Aldohexose	Ketohexose
5.	7	Heptose	Aldoheptose	Ketoheptose

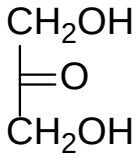
Continued…..

Examples of Trioses (Aldotriose and Ketotriose)

1. **Triose**: A monosaccharide containing three carbon atoms is called a *triose.* Glyceraldehyde and dihydroxyacetone examples of trioses with aldehyde and ketone functional groups respectively. Therefore these are examples of aldotriose and ketotriose respectively.



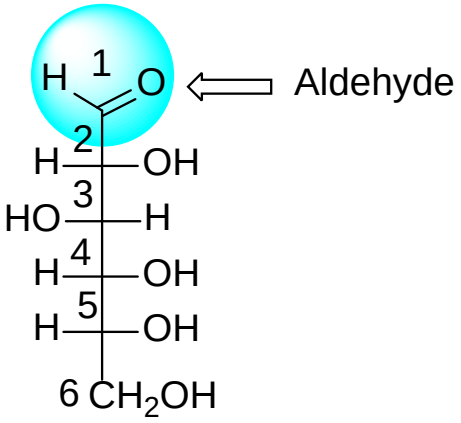
Glyceraldehyde (with 3 Carbon atoms (triose) and aldehyde group (aldose) :Therefore combinedly known as "***aldotriose***".



Dihydroxyacetone (with 3 Carbon atoms (triose) and keto group (ketose):Therefore combinedly known as "***ketotriose***".

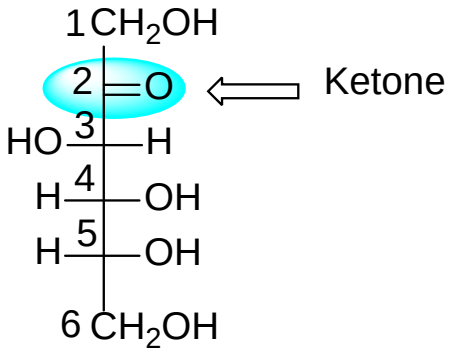
Examples of Hexoses (Aldohexose and Ketohexose)

- **Hexose**: A monosaccharide containing six carbon atoms are known as ***hexose.***
  Glucose and fructose are examples of hexoses with aldehyde and ketone functional groups respectively. Therefore these are examples of ***aldohexose*** and ***ketohexose*** respectively.



Glucose

($C_6H_{12}O_6$)



Fructose

($C_6H_{12}O_6$)

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References

- *Student may also consult following study materials and books:*

1. *Chapter 22, Organic Chemistry (10th edition); Publisher: John Wiley & Sons Inc. Authors: T. W. G. Solomons and C. B. Fryhle.*

1. *Unit: 14, Chemistry for XII published by NCERT.*

- ***Rest of the topics of this unit will be discussed in next part of the lecture.***