Monosaccharides & its Chemical Reactions

Monosaccharides are the simplest form of sugars and considered as building block of carbohydrate. It is found in numerous common food items such as honey, cane sugar, ripen fruits. They are defined as any carbohydrates (or sugars) that cannot be hydrolyzed any further to give simpler sugars are called monosaccharides.

The empirical and chemical formula derived of most abundant monosaccharides from $C_x(H_2O)_y$, where generally $x \& y \geq 3$ and maximum up to 10. The molecule is always formed by three elements and three elements only: Carbon (C), Hydrogen (H) and Oxygen (O). The molecule of monosaccharides is very small and compact in size.

The most abundant monosaccharide found in nature is in fact glucose and fructose. It is the most abundant organic compound on earth. We can find glucose in many fruits, honey and even in starch and cane sugar. We obtain a large part of the energy in our bodies from glucose through the foods we eat. It is an aldohexose, and fructose is a ketohexose which means both has six carbon atoms in its molecule. Its chemical formula is $C_6H_{12}O_6$ but both have different structural formula.

![Chemical structures of D-Glucose, L-Glucose, D-Fructose, L-Fructose](image)

**Properties of Monosaccharides:**

Monosaccharides are colourless, crystalline compounds soluble in water but insoluble in organic solvents such as ether, chloroform, hexane etc. the aqueous solution or itself when heated they char and give characteristic smell of burnt sugars. Chemically monosaccharides exhibit the reactions of alcohols and aldehydes/ ketones. Glucose and Fructose are the representatives of aldoses and ketones respectively hence the chemistry of these two have to study in detailed.

**Glucose** (aldohexose), Chemical formula $C_6H_{12}O_6$.
Glucose, also called dextrose or grape sugar or blood sugar, one of a group of carbohydrates known as simple monosaccharides sugars. It is found in ripen fruits and honey and is the major free sugar circulating in the blood of human and higher animals. It is the source of energy in cell function, and the regulation of its metabolism is of great importance for survival. Molecules of starch, the major energy-reserve carbohydrate of plants, consist of thousands of linear glucose units. Another major compound composed of glucose is cellulose, which is also linear.

Methods of Preparation of Glucose:

1: Preparation of glucose from sucrose: The hydrolysis of an aqueous solution of sucrose with dilute HCl or dilute H\textsubscript{2}SO\textsubscript{4} followed by boiling, glucose and fructose are formed in equimolar ratio.

\[
\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \xrightarrow{\text{H}^+} \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6
\]

2: Manufacture: By the hydrolysis of starch with hot dilute mineral acids such as HCl, H\textsubscript{2}SO\textsubscript{4} first give Dextrin then Maltose and finally Glucose. This hydrolysis followed by boiling of Starch, with dilute H\textsubscript{2}SO\textsubscript{4} at 393 K under 2 to 3-atmosphere pressure, it gives glucose.

\[
(C_6H_{10}O_5)_n + n\text{H}_2\text{O} \xrightarrow{\text{H}^+_{393K, 2 to 3 atm}} n\text{C}_6\text{H}_{12}\text{O}_6
\]

The hydrolyzed filtrate is decolorized from animal charcoal and finally recrystallized with alcohol. The common sources of starch are maize, rice and potatoes.
Physical properties of Glucose -

- It is crystalline solid.
- Melting Point: 294.8°F(146°C)
- Density: 1.54 g/cm³
- Weight: 180.16 g/mol
- It is soluble in water and acetic acid but in soluble in organic solvents such as Ether, hexane etc.
- It has a sweet taste.
- It has no odor.
- All forms of glucose is colourless and is also clear.
- Non toxic and edible.
- Highly combustible (powdered glucose is highly flammable and)
- Its finely dispersed particles can become explosive when they are exposed to air.
- It can emit heat when it burns.

Chemical Properties of Glucose: A chemical property refers to the different products obtained from different reagents.

1: Reaction with HCN - Glucose form gluco-cyanohydrin when subjected for the reaction with hydrogen cyanide.

What will be A & B in the following conversion reaction-

Glucose $\xrightarrow{HCN}$ A $\xrightarrow{\text{hydrolysis} + HI}$ B + C

(A) (B) Gluonic Acid (C)
(2) Reaction with hydroxyl amine: (Formation of Oxime) - The reaction is named after the German chemist Alfred Wohl (1863–1939). In one modification, D(+)-glucose is converted to the glucose oxime by reaction with hydroxylamine and sodium methoxide.

**Mechanism:**

**Step (1)** hydroxyl amine acts as a nucleophile due the presence of lone pair electron on nitrogen and aldehydic carbon in glucose is the best site for nucleophilic attack due to electrometric effect. Hence nucleophilic addition reaction takes place and forms intermediate addition product (2).

**Step (2)** rearrangement through hydrogen ion transfer give to product (3).

**Step (3)** formation of oxime through release of water molecule (4).

Conversion of higher aldoses to lower aldoses of one carbon less by Alfred wohl degradation procedure.