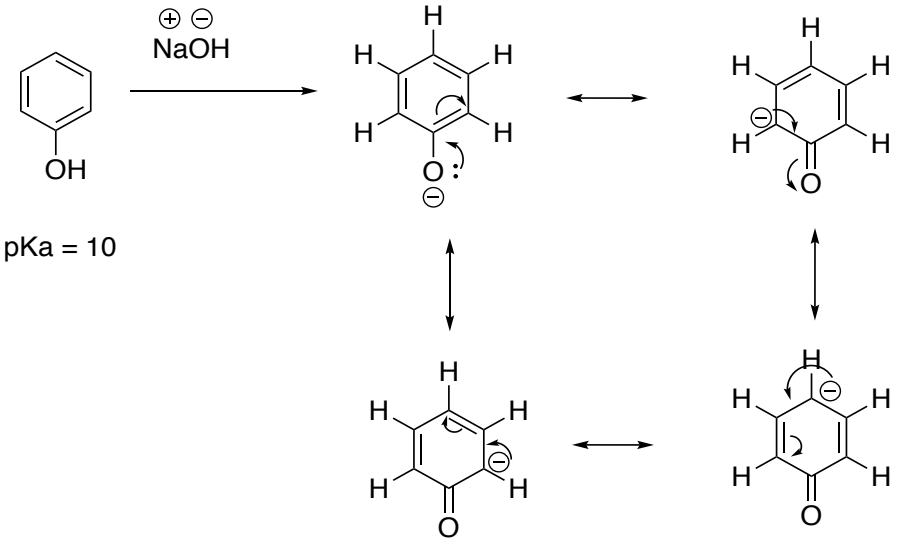
Recall :

pKa 16-19
Ka = 10^{-16} → 10^{-19}

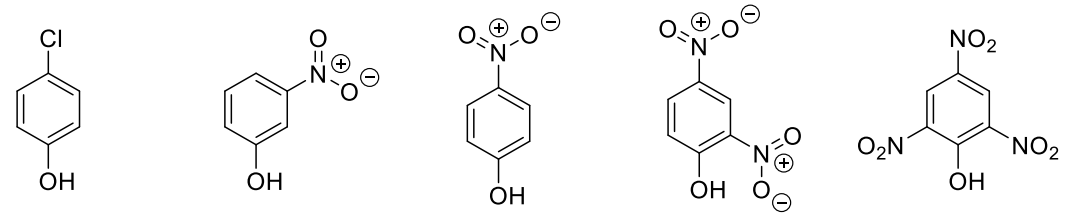
Example
Phenol



pKa = 10

The alkoxide of phenol is a conjugated anion and is therefore phenol much more acidic

More example:



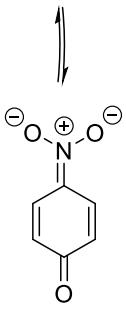
pKa 9.3
Cl is electron withdrawing so helps stabilize negative charge

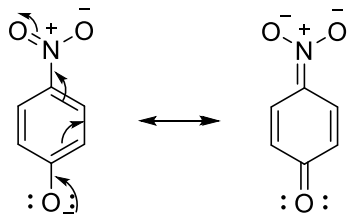
pKa 9.3

pKa 7.3

pKa 4.5

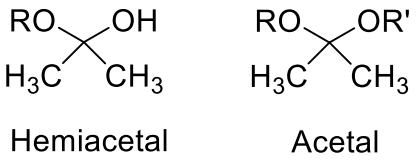
pKa 0.5



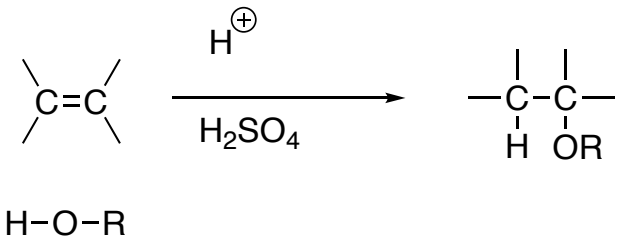


- As you get more resonance possibilities, the negative charge is more spread out across the molecules, and is more stabilized, resulting in lower pKa (more acidic).

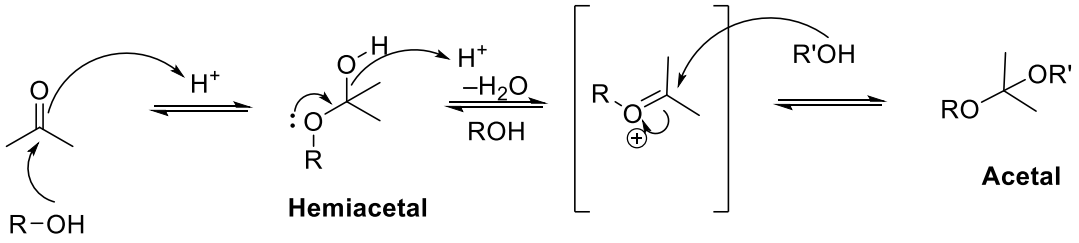
Hemiacetal and acetal formation



Recall addition reaction across a double bond (i.e., ether formation)



Similarly, addition reactions can be done on carbonyls (Ketones and Aldehydes) in the presence of an acid catalyst:



Carbohydrates ($C_NH_{2N}O_N$)

Sugars
Saccharides

Nomenclature of Sugars

General formula of sugars: $C_NH_{2N}O_N$ *(approx.)*
The number of carbons is indicated as follows:

3 carbon sugar (C_3) – triose
4 carbon sugar (C_4) – tetrose
5 carbon sugar (C_5) – pentose
6 carbon sugar (C_6) – hexose

The carbonyl group is indicated by the prefix:

Aldo

Aldo – aldehyde
Keto – ketone

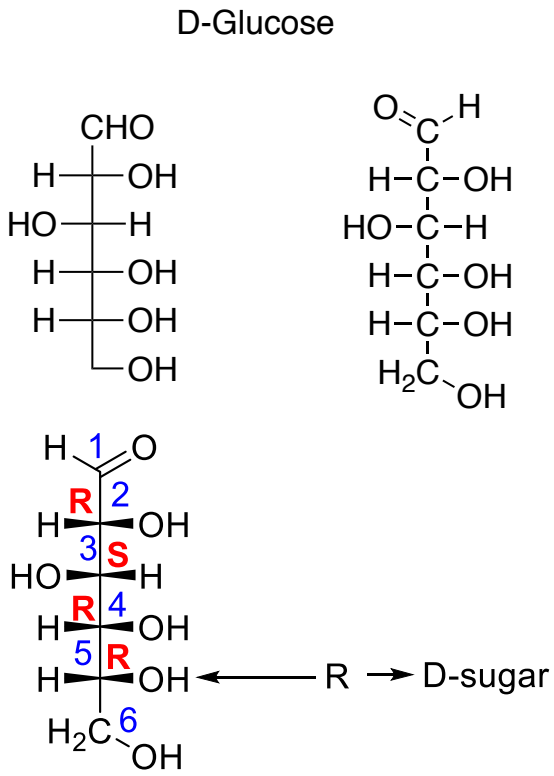
Keto

A familiar equation:

$$6\,CO_2 + 6\,H_2O \xrightarrow[photosynthesis]{h\nu} C_6H_{12}O_6 + 6\,O_2$$

- about 4 x 10^{11} metric tons of carbon dioxide is converted into glucose by plants
- the process of photosynthesis only uses 0.02% of the suns total energy on Earth
- the sugar produced is known as D-glucose, shown below in a Fischer Projection

Example 1: D-Glucose



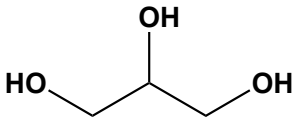
D-Glucose is an Aldohexose

Note: The sugar backbone is numbered such that the C=O is assigned the lowest number possible.

Additionally, an allocation of D or L is given to indicate the stereochemistry of the highest numbered (last) stereocentre.

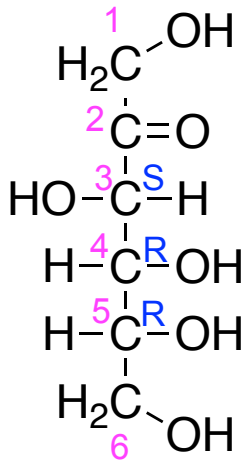
D sugar – highest numbered stereocentre in *R* configuration.
L sugar – highest numbered stereocentre in *S* configuration.

Example 2: Glycerol



Triose

Example 3: D-Fructose

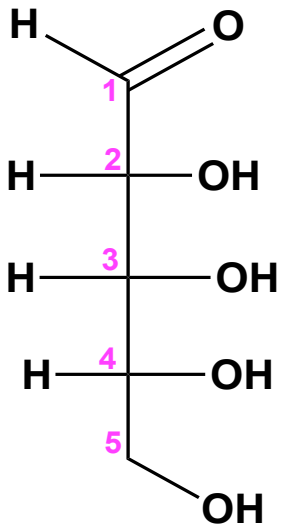


D-Fructose

Based on the above nomenclature, D-Fructose is a **ketohexose** (ketone, 6 carbons)

The above structure is labelled as "D" because the R configuration occurs at carbon 5 *(note that carbon 6 is not a stereocentre).*

Example 4: D-Ribose



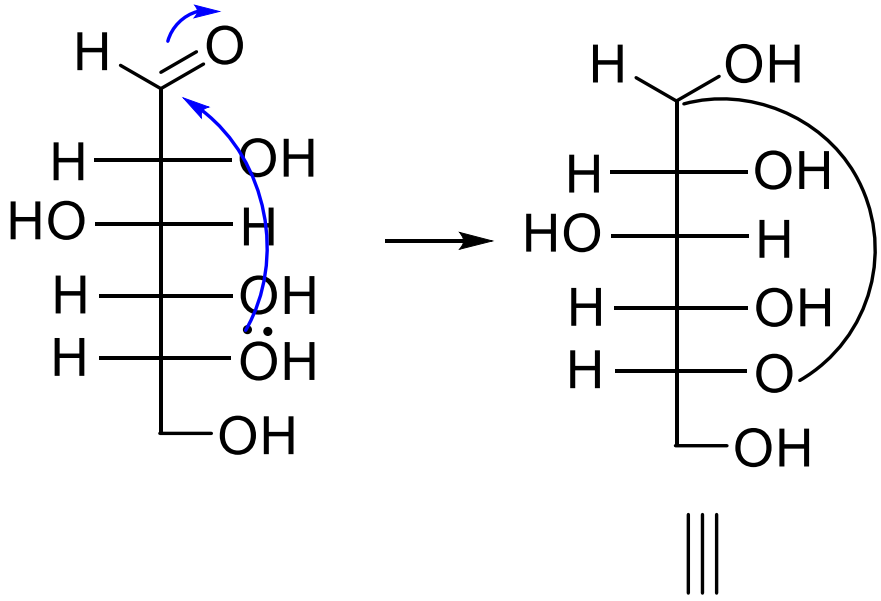
An aldopentose (aldehyde, 5 carbons long). At the highest numbered stereocentre (carbon 4) the stereochemistry is R.

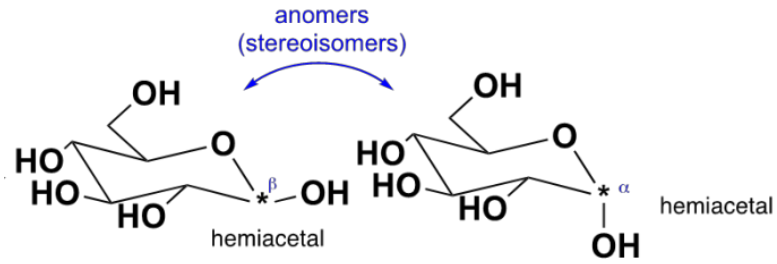
The name of this is D-ribose (found in RNA! – deoxyribose is in DNA)

These sugars can cyclize (form rings)

- 6-ring sugar is a pyranose
- 5-ring sugar is a furanose

Example 5 – Glucose

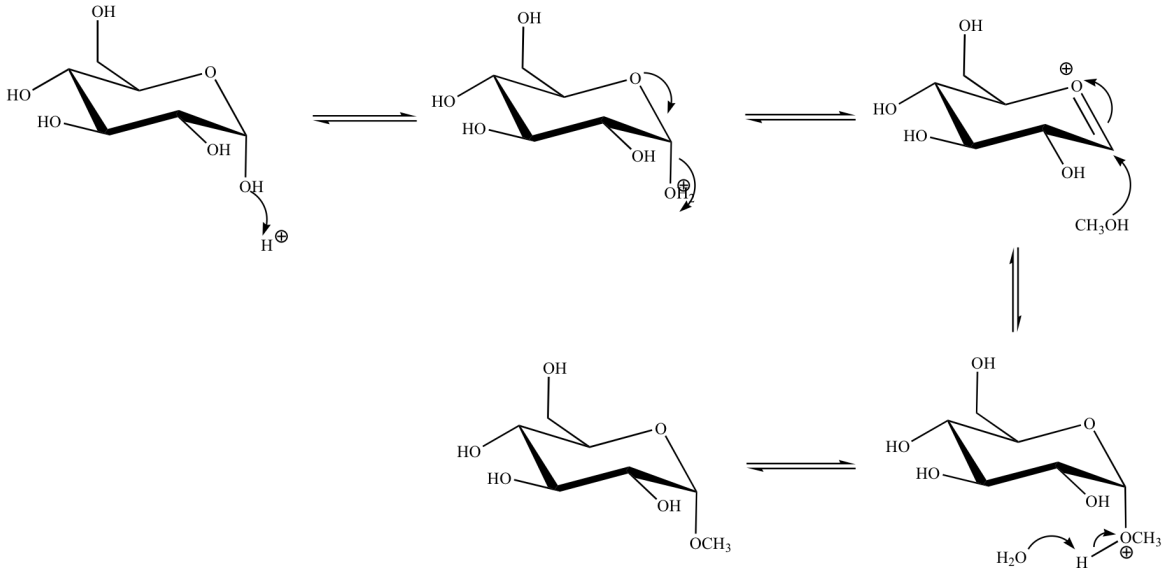




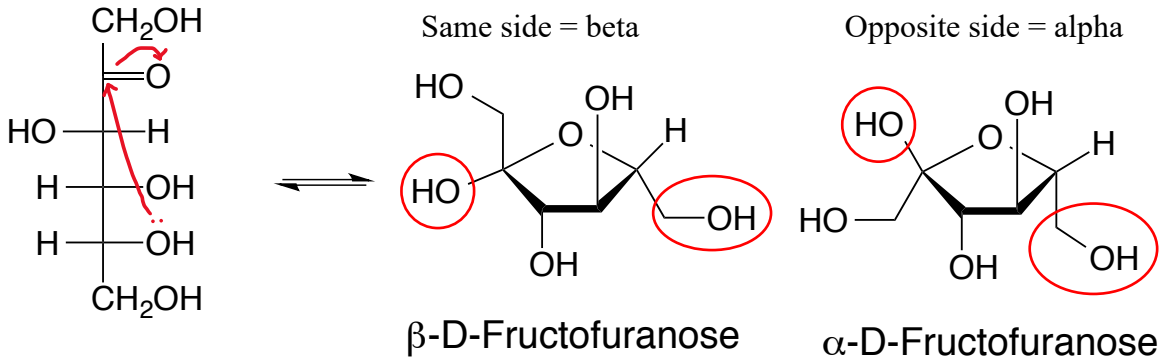
β-D-glucopyranose **α-D-glucopyranose**

- This is a favored reaction. The sugar interconverts between the linear (or open) and ring form but the ring form (hemiacetal) is generally more favored.
- If OH at the anomeric carbon (C with 2 oxygens attached) is on same side of ring as CH_2OH then the configuration called **β (beta)** – if on opposite side it is **α (alpha)**
- For glucose, the alpha and beta anomer are present in the same amount. However, for other sugars, the alpha anomer is generally more favored.
- 6-Membered sugar rings are called pyranose
- 5-Membered sugar rings are called furanose

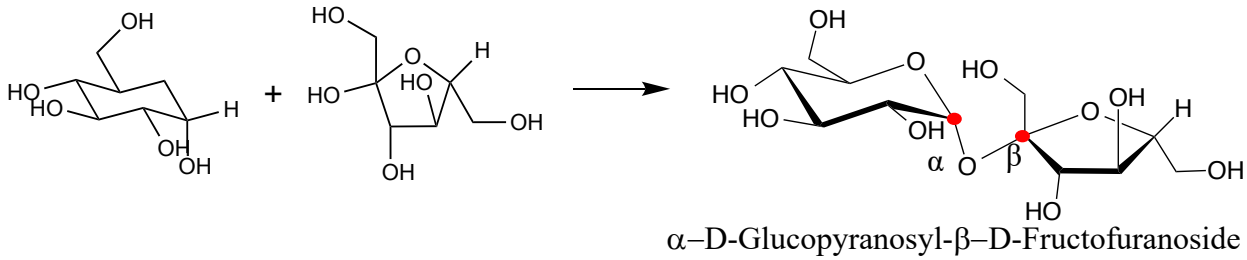
Acetals of sugars



Example 6 - Fructose



Example 7 - Table Sugar (Sucrose):



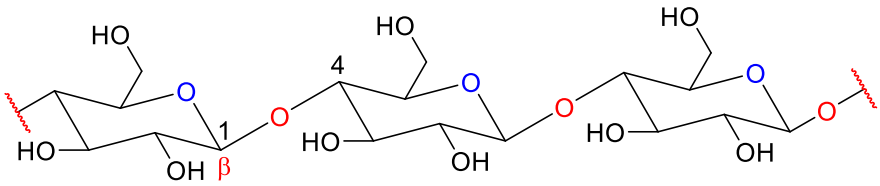
- Has 2 anomeric carbons
- Non-reducing sugar since it contains an acetal group and does not contain hemiacetals, aldehydes, or alpha-hydroxy ketone
- Can be broken down by the body to glucose and fructose monomer

Monosaccharides – simple sugars such as glucose and fructose – can't be converted to smaller sugars by chemical reaction (i.e., hydrolysis)

Polymers of Sugars (Polysaccharides)

- **Disaccharide:** sugars that are composed of 2 monosaccharide units
- **Trisaccharide:** sugars that are composed of 3 monosaccharide units
- **Tetrasaccharide:** sugars that are composed of 4 monosaccharide units
- **Oligosaccharides:** sugars that are composed of 3 to 10 monosaccharide units
- **Polysaccharides:** long chain of carbohydrates containing more than ten (> 10) monosaccharide monomers.

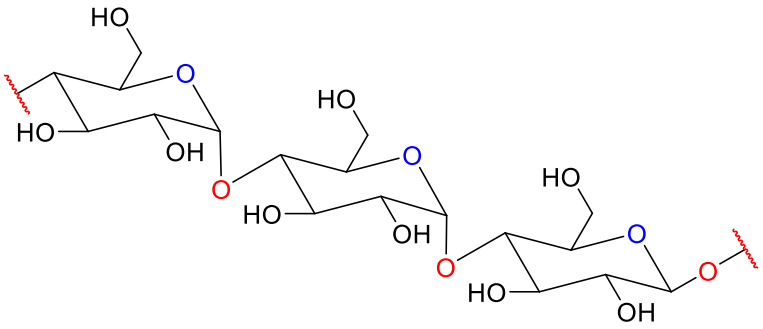
Cellulose



β-(1→4)-D-Glucopyranoside polymer (Cellulose)

- Cellulose is a polysaccharide composed of D-glucose monomers linked via **β-1,4 glycosidic linkages**.
- Cellulose is a main component of cotton and paper
- Cellulose is also a raw material for producing cellulose nitrate which is the major component of smokeless powder used as a propellant in ammunition of firearms and artillery.
- β-linkages cannot be digested by most mammals

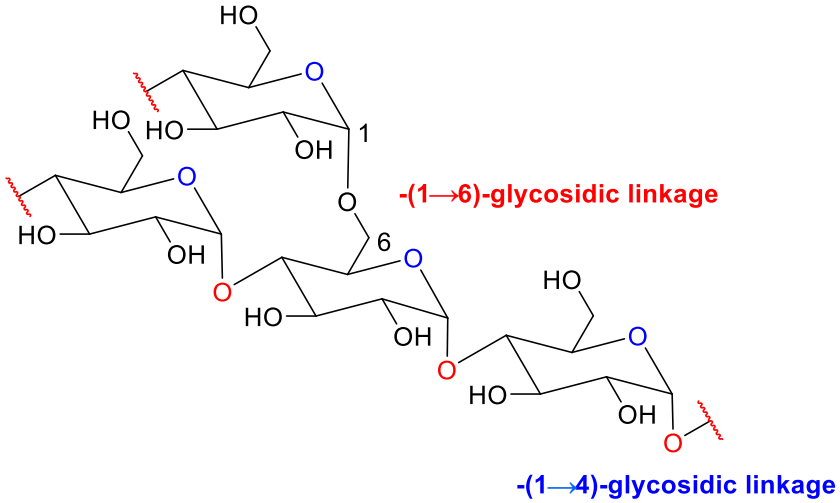
Starch (Amylose)



α-(1→4)-D-Glucopyranoside polymer (Amylose)

- Amylose (accounts for 20% of the weight of starch) is a polysaccharide composed of D-glucose units linked via α-1,4 glycosidic linkages

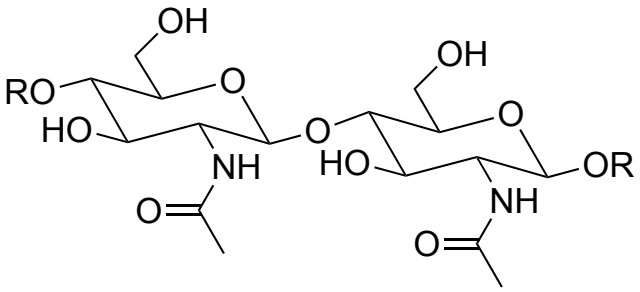
Starch (Amylopectin)



Amylopectin: α-(1→4) and α-(1→6) linked D-glucopyranoside polymer

- Amylopectin is the main component of starch (80% dry weight)
- Amylopectin is characterized by branching via α-(1→6)-glycosidic linkages in approximately every 25 glucose units along the main polymer chain.

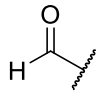
Chitin



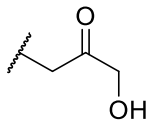
Other Examples and Information

Reducing Sugars

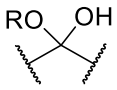
- Contains either an aldehyde, α-hydroxyketone, or a hemiacetal
- All aldoses are reducing sugars



Aldehyde



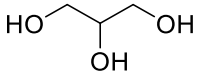
-Hydroxyketone



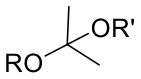
Hemiacetal

Non-reducing sugars

- Any sugars that do not contain any of the above functionality (i.e., glycerol) or an acetal group (i.e., sucrose)



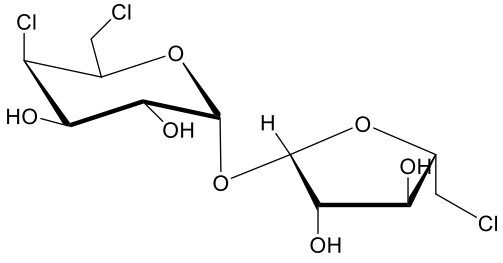
Glycerol
A Triose



Acetal

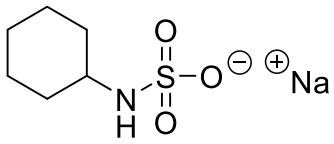
Artificial Sweeteners

Sucralose

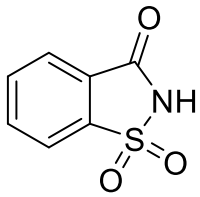


- Non-reducing sugar

Sodium Cyclamate



Saccharine



Aspartame