



STUDY MATERIAL

VIVEKANANDA COLLEGE

THAKURPUKUR

NAAC Accredited Grade—A

Topic: **Amino Acids and Carbohydrates**

Course Title: **Core Course CC4/GE4**

Course Paper: **paper 4**

Unit: **NA**

Semester: **4**

Name of the Teacher: **Dr.Md.Selim**

Name of the Department: **Chemistry**

Amino Acids and Carbohydrates

Syllabus:

Amino Acids: Preparations (glycine and alanine only): Strecker synthesis, Gabriel's phthalimide synthesis; general properties; zwitterion, isoelectric point.

Carbohydrates:

Classification and general properties; glucose and fructose: constitution; osazone formation; oxidation-reduction reactions; ascending (Kiliani Fischer method) and descending (Ruff's method) in monosaccharides (aldoses only); mutarotation

Amino acids

Amino acids are organic compounds that contain amine (-NH_2) and carboxyl (-COOH) functional groups, along with a side chain (R group) specific to each amino acid.

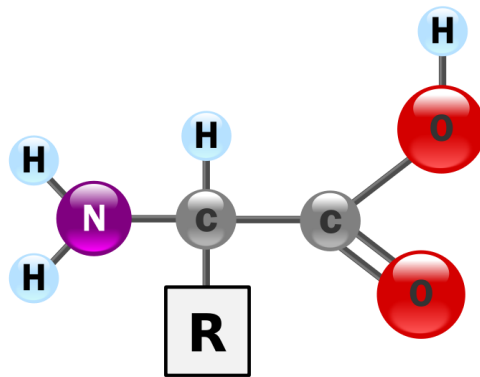


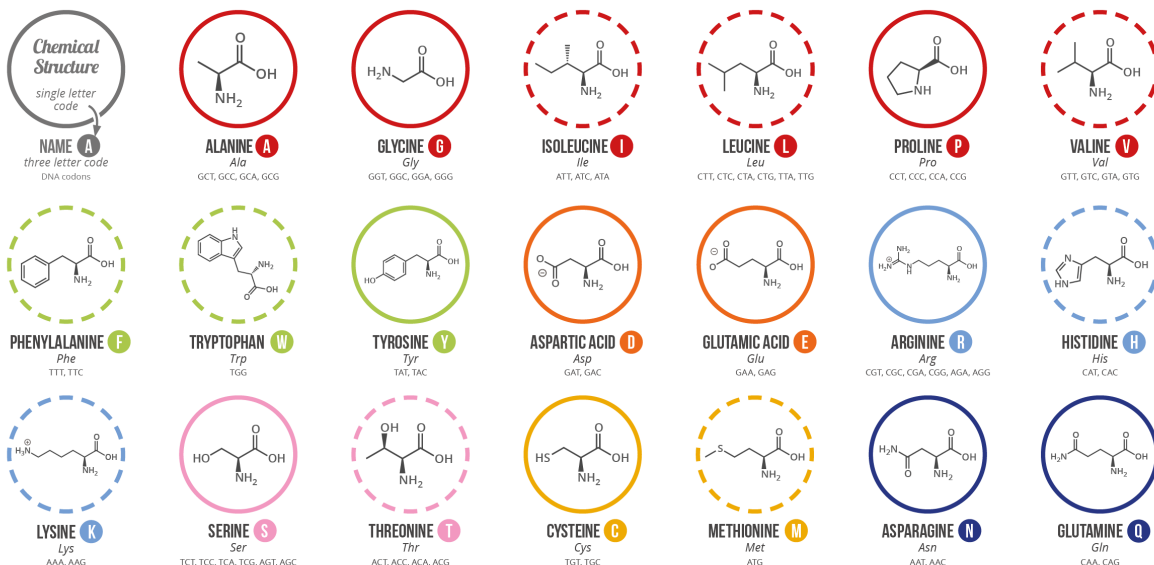
Figure : Amino acid

Lists of amino acids

A GUIDE TO THE TWENTY COMMON AMINO ACIDS

AMINO ACIDS ARE THE BUILDING BLOCKS OF PROTEINS IN LIVING ORGANISMS. THERE ARE OVER 500 AMINO ACIDS FOUND IN NATURE - HOWEVER, THE HUMAN GENETIC CODE ONLY DIRECTLY ENCODES 20. 'ESSENTIAL' AMINO ACIDS MUST BE OBTAINED FROM THE DIET, WHILST NON-ESSENTIAL AMINO ACIDS CAN BE SYNTHESISED IN THE BODY.

Chart Key: ● ALIPHATIC ● AROMATIC ● ACIDIC ● BASIC ● HYDROXYLIC ● SULFUR-CONTAINING ● AMIDIC ○ NON-ESSENTIAL ○ ESSENTIAL



Note: This chart only shows those amino acids for which the human genetic code directly codes for. Selenocysteine is often referred to as the 21st amino acid, but is encoded in a special manner. In some cases, distinguishing between asparagine/aspartic acid and glutamine/glutamic acid is difficult. In these cases, the codes asx (B) and glx (Z) are respectively used.

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Essential Amino Acids

There are nine essential amino acids: **histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine**. Since your body can't produce or store essential amino acids, it is important to regularly supply your body with these important building blocks. Fill your diet with chicken, eggs, fish, beef, tuna, soybeans, nuts, chia seeds and quinoa, and take a look at the amino acid content of your favorite protein-rich foods.

Nonessential Amino Acids

Nonessential amino acids support tissue growth and repair, immune function, red blood cell formation, and hormone synthesis. However, unlike essential amino acids, a healthy body can create these proteins if given enough protein sources with essential amino acids. There are 11 nonessential amino acids: **arginine, glutamine, tyrosine, cysteine, glycine, proline, serine, ornithine, alanine, asparagine, and aspartate.**

Essential Amino Acids:

- Arginine
- Isoleucine
- Histidine
- Leucine
- Methionine
- Lysine
- Phenylalanine
- Tryptophan
- Threonine
- Valine

Non-Essential Amino Acids:

- Alanine
- Arginine
- Asparagine
- Aspartic Acid
- Cysteine
- Glutamic Acid
- Glutamine
- Glycine
- Proline
- Serine
- Tyrosine

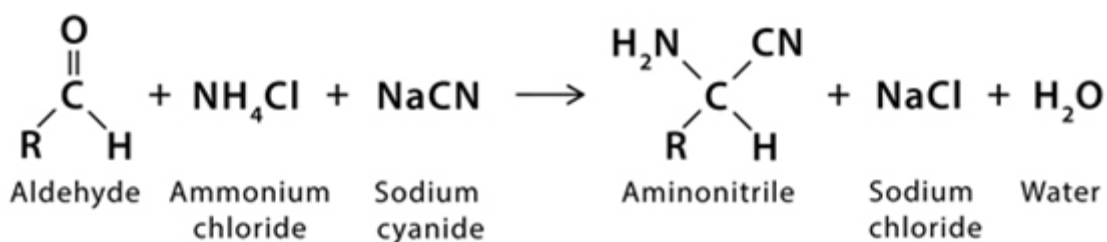
Figure: Essential and non essential amino acids

Strecker amino acid synthesis:

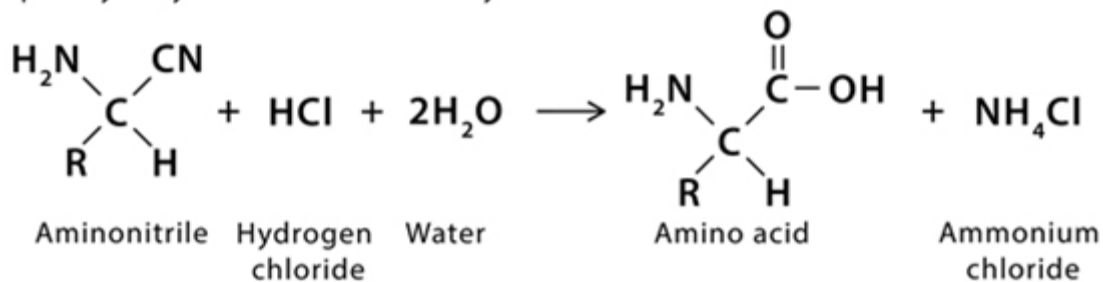
It is a method for the synthesis of amino acids by the reaction of an aldehyde with [ammonium chloride](#) in the presence of potassium cyanide. The [condensation reaction](#) yields an α -aminonitrile, which is subsequently hydrolyzed to give the desired amino acid.

Strecker Synthesis

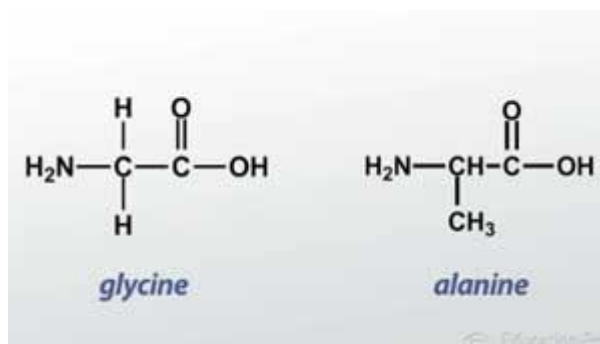
Step 1: Formation of aminonitrile



Step 2: Hydrolysis of aminonitrile to yield amino acid

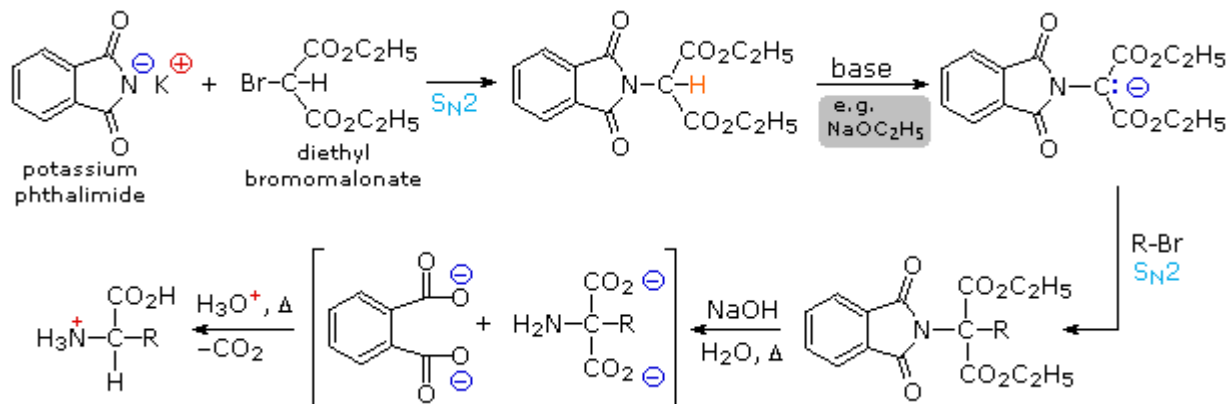


When R=H, Glycine and When R=-CH₃, alanine



Gabriel phthalimide synthesis of amino acids:

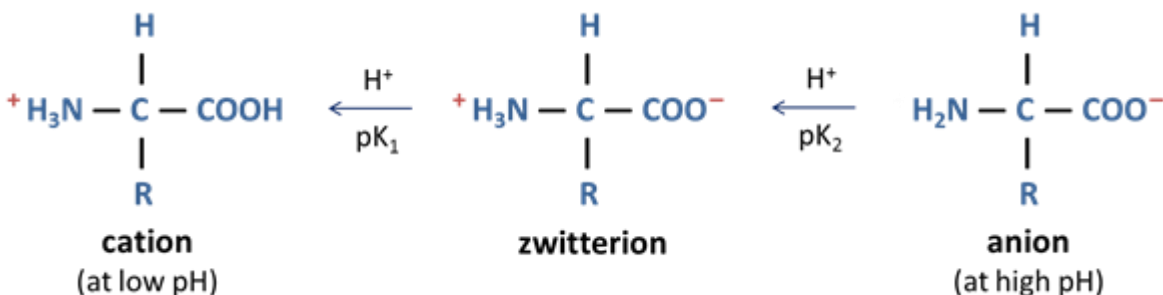
The Gabriel synthesis is a chemical reaction that transforms primary alkyl halides into primary amines. Traditionally, the reaction uses potassium phthalimide.



General Properties:

Zwitterion :

A zwitterion is a molecule that contains an equal number of positively-charged functional group and negatively-charged functional group.



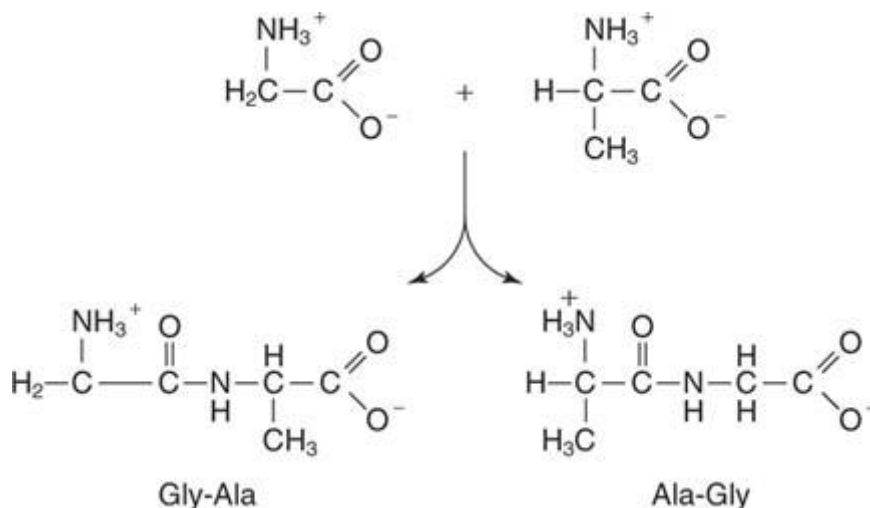
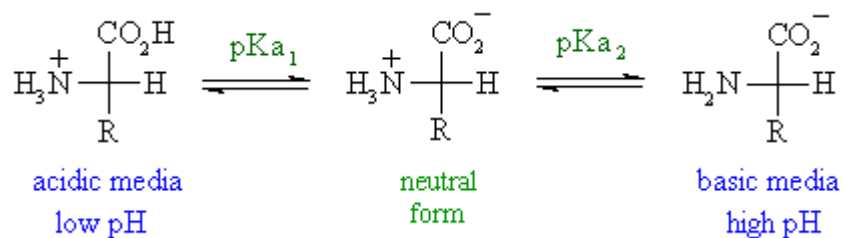


Figure: Zwitterion of glycine and alanine

Isoelectric Point:

The word isoelectric or isoelectronic comes from ‘iso,’ which means the same, and ‘electric,’ which implies charge. The isoelectric point or pI of an amino acid is the pH at which an amino acid **has a net charge of zero**.

For the simplest amino acid, glycine, pK_{a1} = 2.34 and pK_{a2} = 9.6, pI = 5.97.



Carbohydrates

Carbohydrates are a class of organic biomolecules that are optically active and have polyhydroxy aldehydes or polyhydroxy ketones groups. **Example** ,Glucose & Fructose.

Classification of Carbohydrates:

- A. Depending on the number of hydrolysis products carbohydrates are classified into the following categories:
1. Monosaccharides
 2. Disaccharides
 3. Oligosaccharides
 4. Polysaccharides

Monosaccharides: Monosaccharides are carbohydrates that cannot be broken down into simpler units by hydrolysis. Example: Glucose & Fructose.

Disaccharides: A disaccharide is a sugar that can be hydrolyzed to only two monosaccharides.

Example: Sucrose & Maltose.

Oligosaccharides: An oligosaccharide contains relatively few (2-10) monosaccharide units.

Example: Raffinose & Stachyose.

Polysaccharides: Carbohydrates that can be hydrolyzed into many(10 or more) monosaccharide units. They are naturally occurring polymers of monosaccharides. Example: Cellulose, Starch.

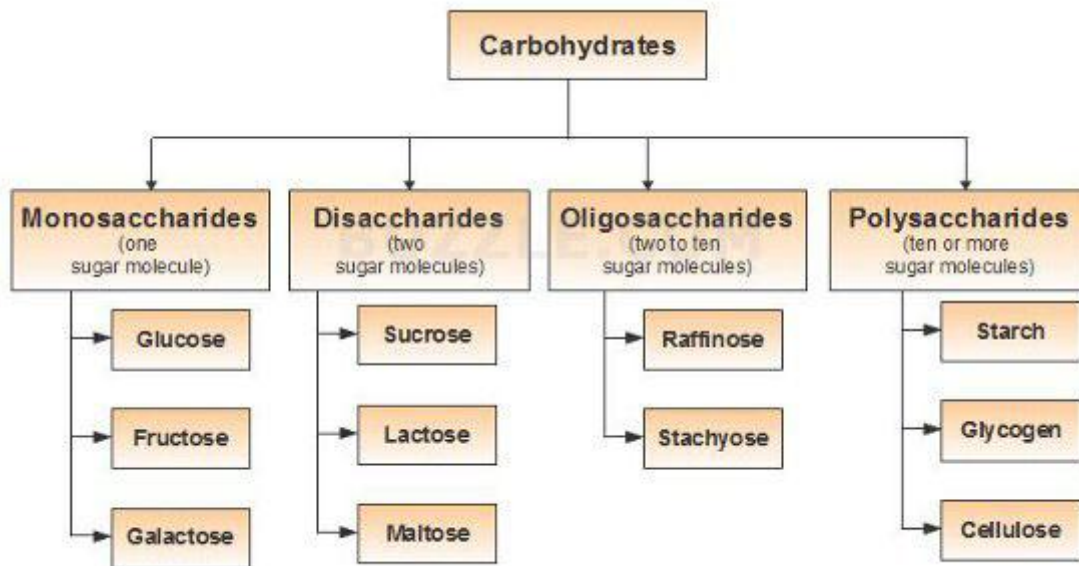


Figure: Classification of carbohydrates on the basis of hydrolysis product

Classification of Monosaccharides: Monosaccharides are classified based on the number of carbons in the molecule. General categories are identified using a prefix that indicates the number of carbons and the suffix *-ose*, which indicates a saccharide; for example, triose (three carbons), tetrose (four carbons), pentose (five carbons), and hexose (six carbons)

| Number of 'C' atoms | Name of the monosaccharide | Aldose | Ketose |
|---------------------|----------------------------|----------------------------|------------------|
| 3 | Triose | Glyceraldehyde (Glycerose) | Dihydroxyacetone |
| 4 | Tetrose | Erythrose | Erythrulose |
| 5 | Pentose | Ribose | Ribulose |
| 6 | Hexose | Glucose | Fructose |
| 7 | Heptose | Glucoheptose | Sedoheptulose |

Figure: classification of Monosaccharide on the basis of number of carbons in the molecule.

Monosaccharides

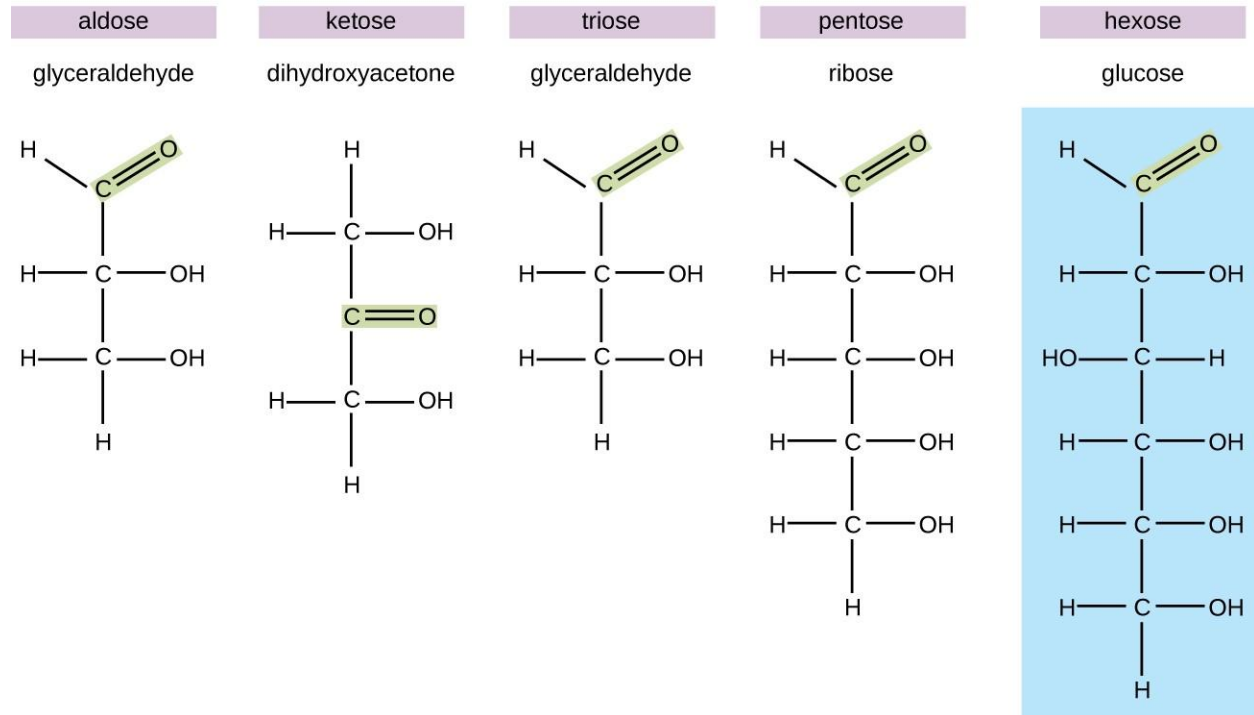


Figure: Examples of Monosaccharide

Aldehyde monosaccharide:

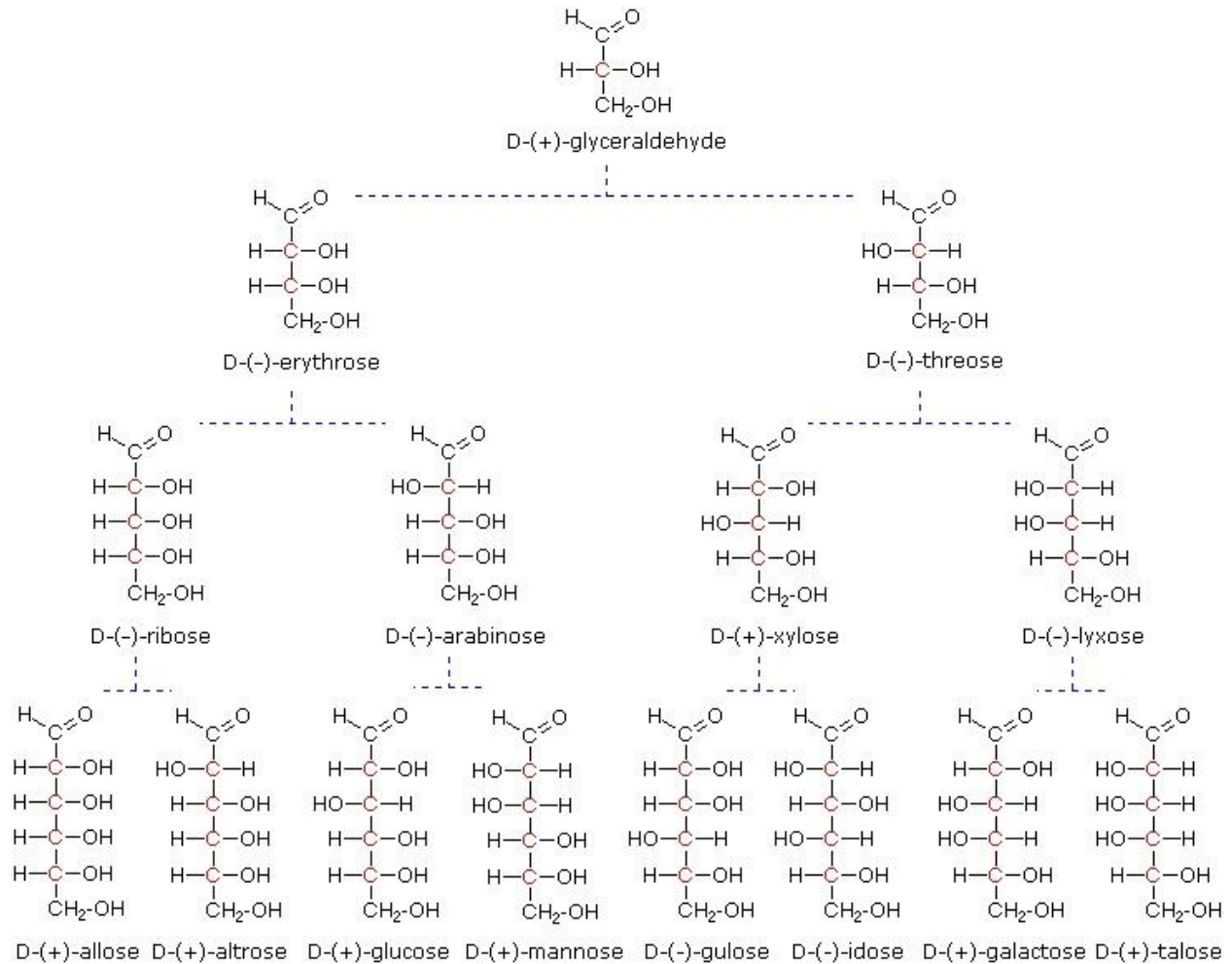


Figure: Aldehyde monosaccharides

Glucose ($C_6H_{12}O_6$) or Aldo-hexose:

Glucose is known as dextrose because it occurs in nature as the optically active dextrorotatory isomer. It is also called grape sugar as it is found in most sweet fruits especially grapes.

Glucose can be prepared in the laboratory by boiling sucrose (cane sugar) with dilute hydrochloric acid or sulphuric acid for about two hours. This hydrolyzes sucrose to glucose and fructose. In order to separate glucose from fructose, alcohol is added during cooling. Glucose is almost insoluble in alcohol.

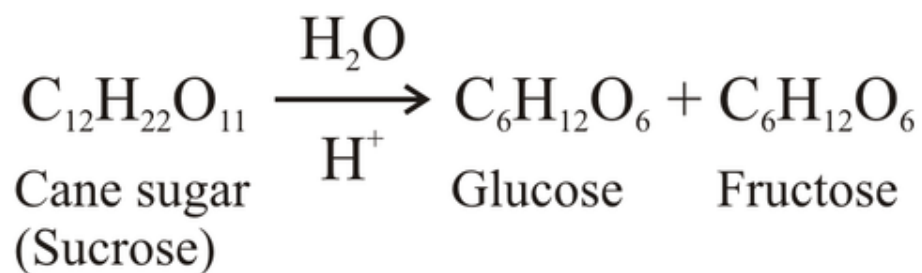


Figure : Laboratory preparation of Glucose

Reaction of glucose :

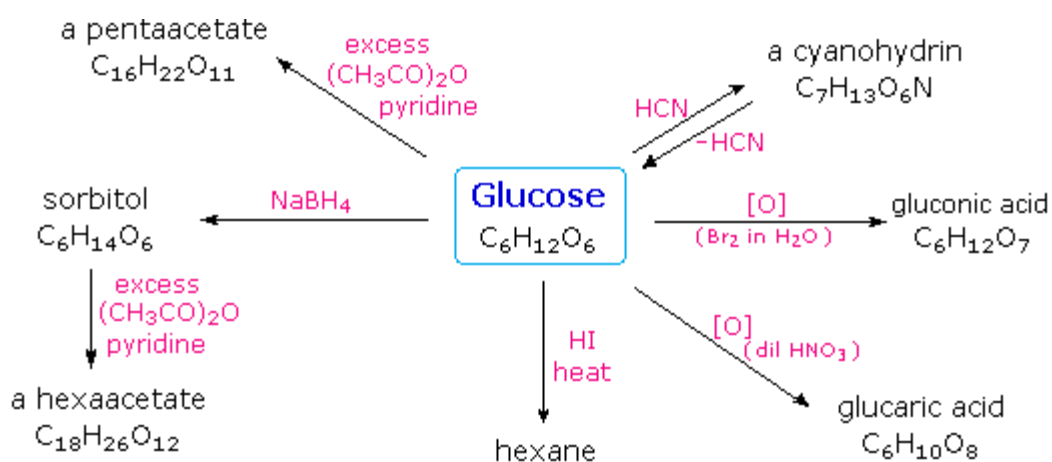


Figure : Reaction of Glucose

Osazone formation of glucose:

Glucose:

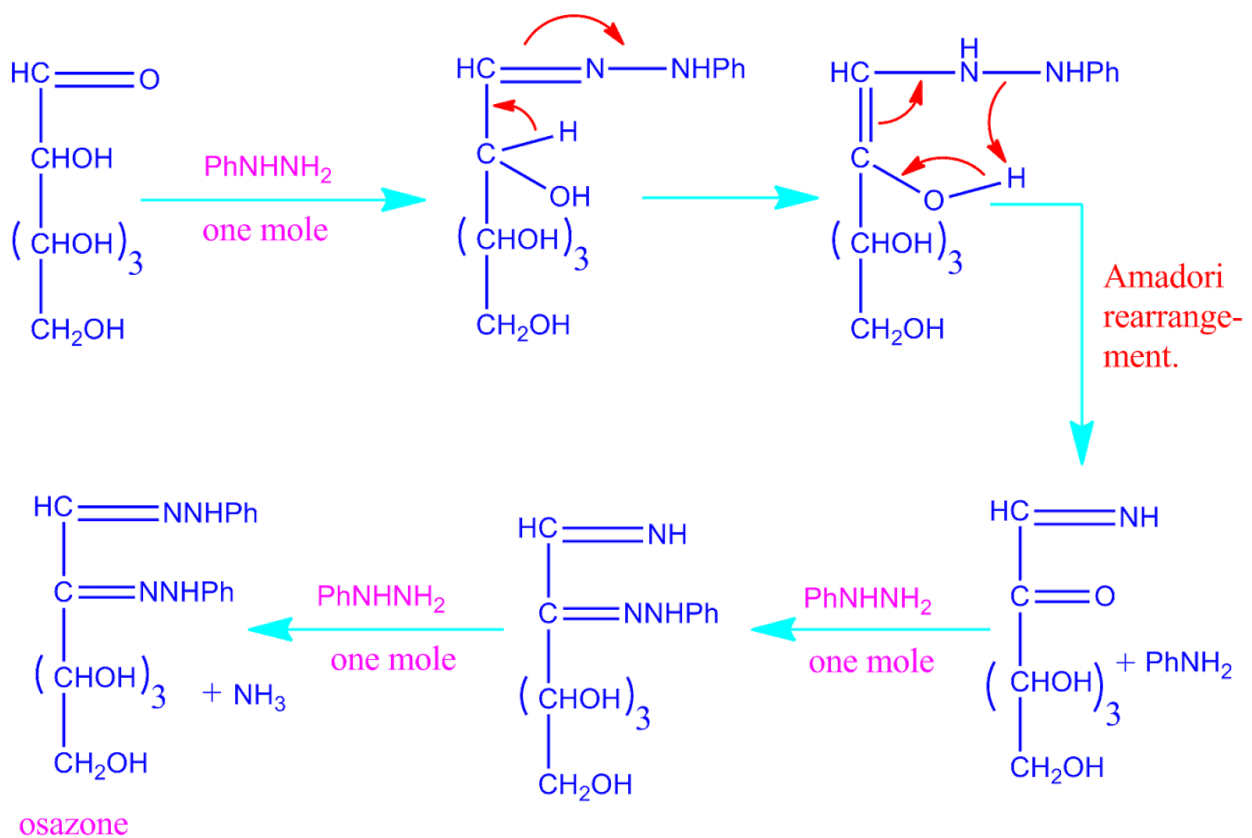


Figure : Osazone formation of Glucose

Ruff degradation :

Ruff degradation is a series of reactions that removes the reducing carbon (C=O) from a sugar and decreases the number of chiral centers by one; used to relate configuration. Therefore, Ruff degradation is a synthetic protocol used to remove one carbon atom from the molecule of an aldose.

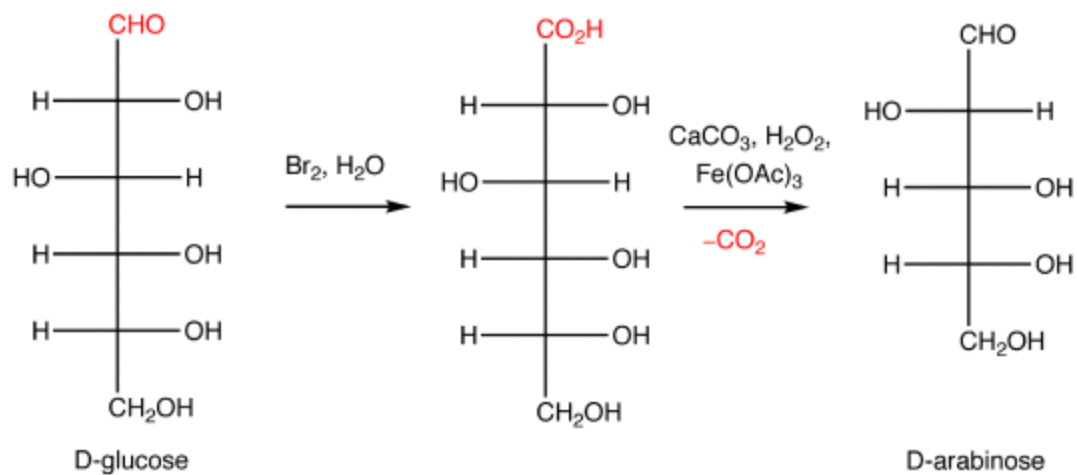


Figure: Ruff degradation of glucose

Kiliani-Fischer synthesis: It is a series of reactions that extends the carbon chain in a carbohydrate by one carbon and one chiral center.

Kiliani-Fischer Synthesis

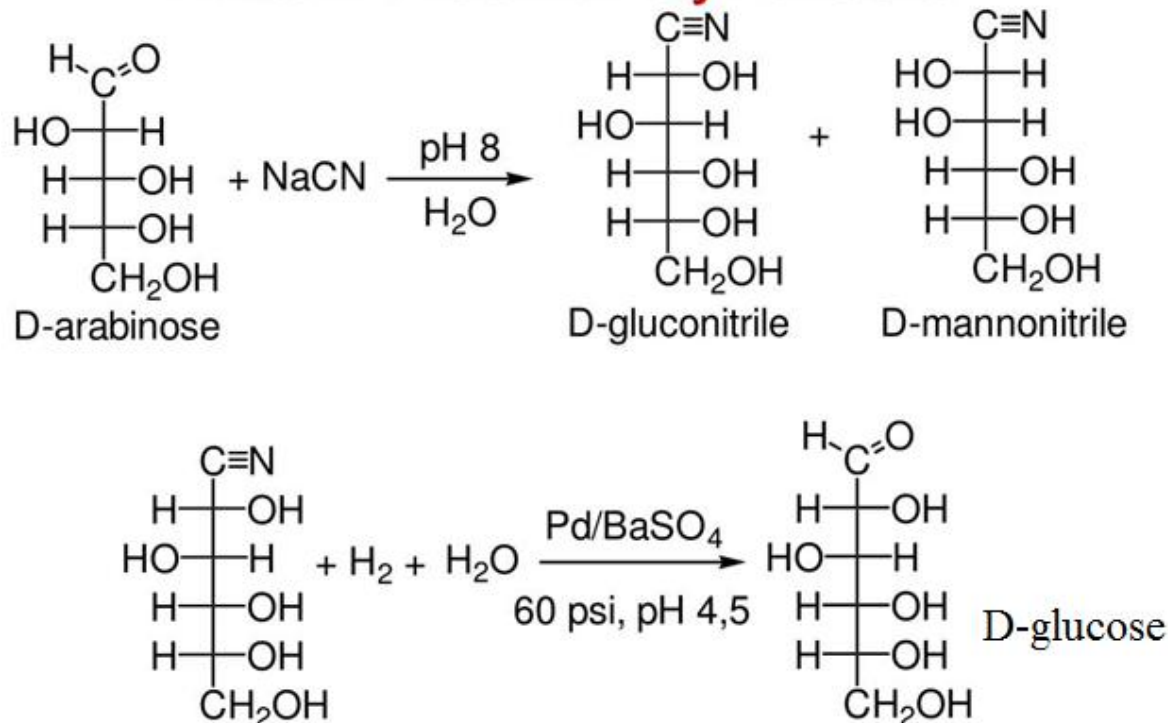


Figure: Kiliani-Fischer synthesis of Arabinose

Mutarotation : Mutarotation is the change in the optical rotation because of the change in the equilibrium between two anomers, when the corresponding stereocenters interconvert. Ordinary glucose is α -glucose, with a fresh aqueous solution has specific rotation, $+111^{\circ}$. On keeping the solution for some time; α -glucose slowly changes into an equilibrium mixture of α -glucose (36%) and β -glucose (64%) and the mixture has specific rotation $+52.5^{\circ}$. Similarly a fresh aqueous solution of β -glucose having specific rotation, $+19.7^{\circ}$, on keeping (standing) gradually changes into the same equilibrium mixture $+52.5^{\circ}$. So an aqueous solution of glucose shows a physical property, known as mutarotation, i.e., a change in the value of specific rotation (muta=change; rotation = specific rotation) is called mutarotation .

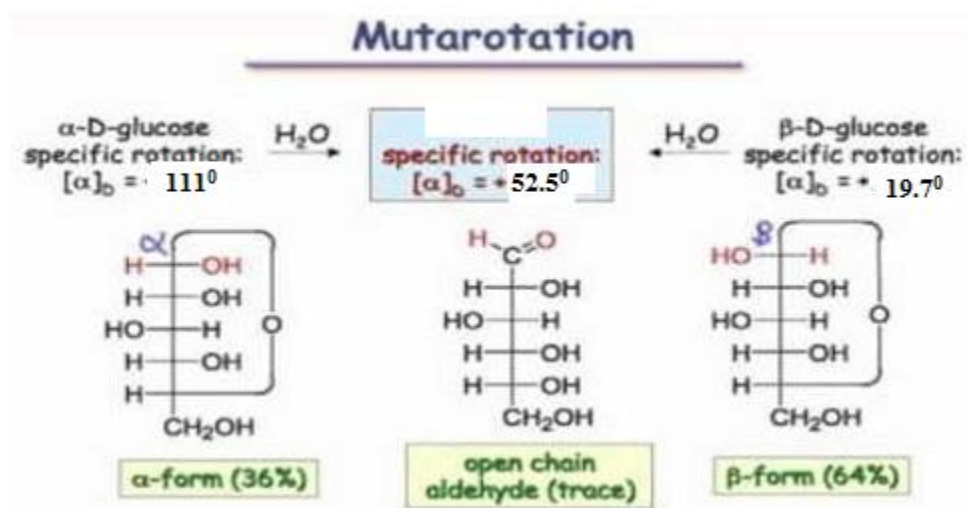


Figure: Mutarotation

Reference: 1. <https://en.wikipedia.org/wiki/Carbohydrate>.

2. <http://www.chem.ucalgary.ca/courses/351/Carey5th/Ch25/ch25-3-3.html>

3. https://en.wikipedia.org/wiki/Amino_acid

4. <https://www.sciencedirect.com/topics/medicine-and-dentistry/amino-acid>