

# Biomolecules

The hydrates of carbon was originally defined as carbohydrates, with general formula of  $C_n(H_2O)_y$ . But this definition has found several limitations today.

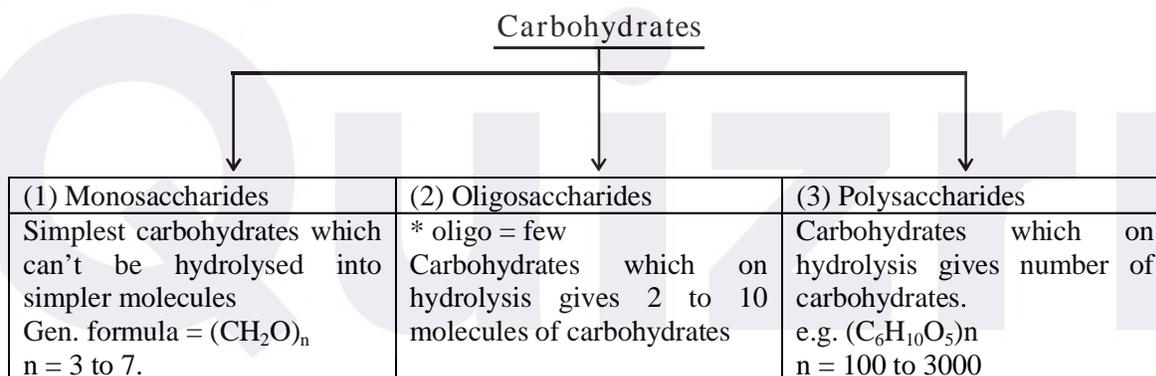
- (i) Carbon do not forms hydrates
- (ii) There are number of organic molecules having  $C_n(H_2O)_y$  formula but are not carbohydrates.  
e.g. (a) Formaldehyde (HCHO) :  $CH_2O$   
(b) Acetic acid  $CH_3COOH$  :  $C_2H_4O_2$  etc.
- (iii) A number of carbohydrates do not have  $C_n(H_2O)$  formula.  
e.g. (i) Rhamnose -  $C_6H_{12}O_5$   
(ii) Deoxyribose -  $C_5H_{10}O_4$

## MODERN DEFINITION :

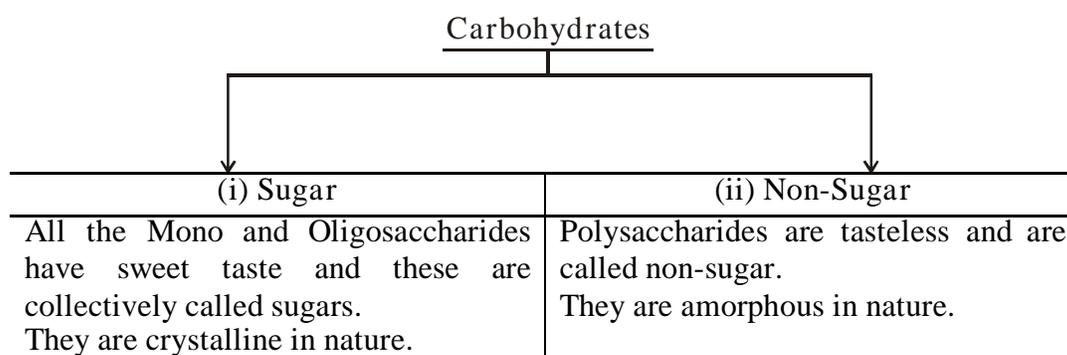
Polyhydroxy aldehyde or Ketone or substances which gives these on hydrolysis is called carbohydrates. They have at least one chiral carbon is general

## CLASSIFICATION :

### TYPE : 1



### TYPE : 2

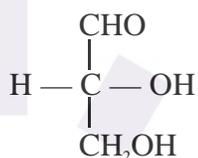


TYPE : 3

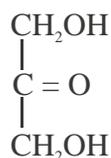
Carbohydrates

(i) Reducing	(ii) Non-Reducing
All those carbohydrates which has aldehydic or ketonic group in their hemiacetal and hemiketal structures have the ability to reduce Tollen's Reagent or Fehling solution. They are called Reducing sugar. * All Monosaccharides whether aldose or ketose are reducing sugars.	The carbohydrates which can not reduce Tollen's reagent or Fehling solutions are called as Non-reducing. * All Polysaccharides are non reducing. e.g. Starch, Cellulose, dextrans, Glycogens etc.

Simplest Triose : The simplest monosaccharides are triose.



Aldotriose  
Glyceraldehyde



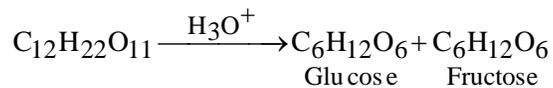
Aldoketose  
Dihydroxy acetone

GLUCOSE

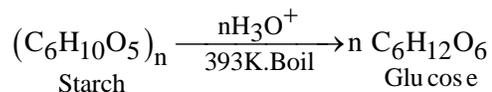
- \* They are also called as Grape sugar or Dextrose. It is present in sweet fruits.  
Molecular formula —  $\text{C}_6\text{H}_{12}\text{O}_6$   
It is aldohexose sugar

PREPARATION OF GLUCOSE :

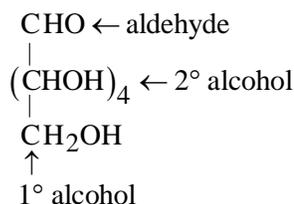
(i) From Sucrose (Cane - Sugar) : By acidic hydrolysis.



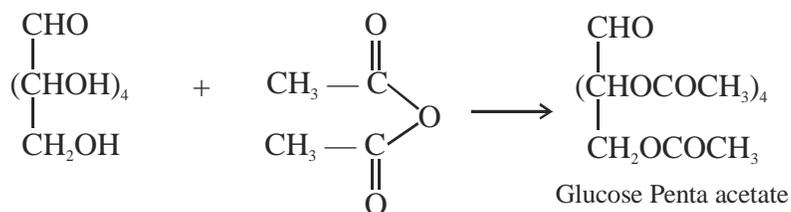
(ii) From Starch : Commercial method.



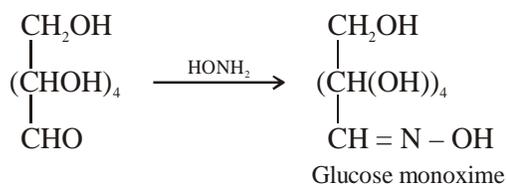
CHEMICAL REACTION OF GLUCOSE :



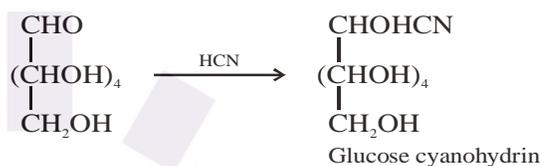
### 1. Reaction with Acetic anhydride : Acetylation



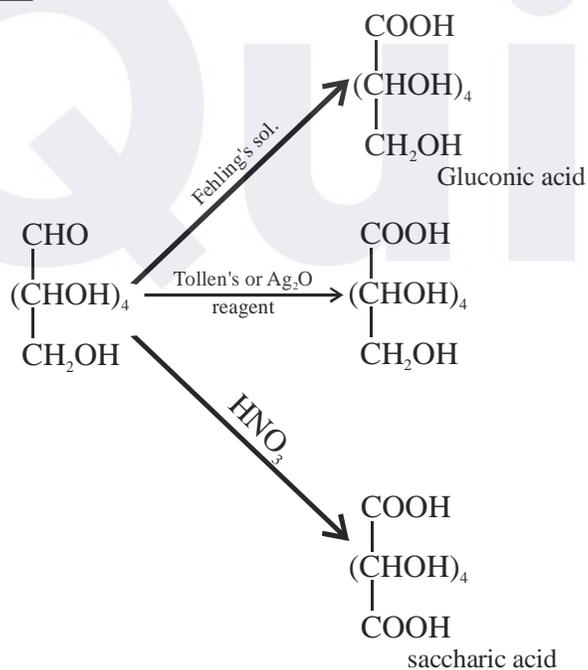
### 2. Reaction with hydrosylamines :



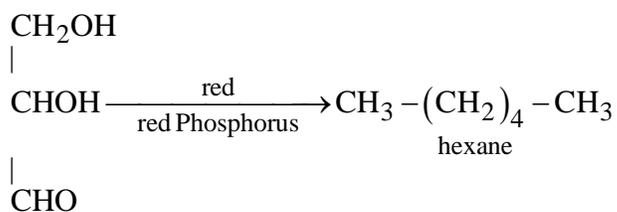
### 3. Reaction with HCN :



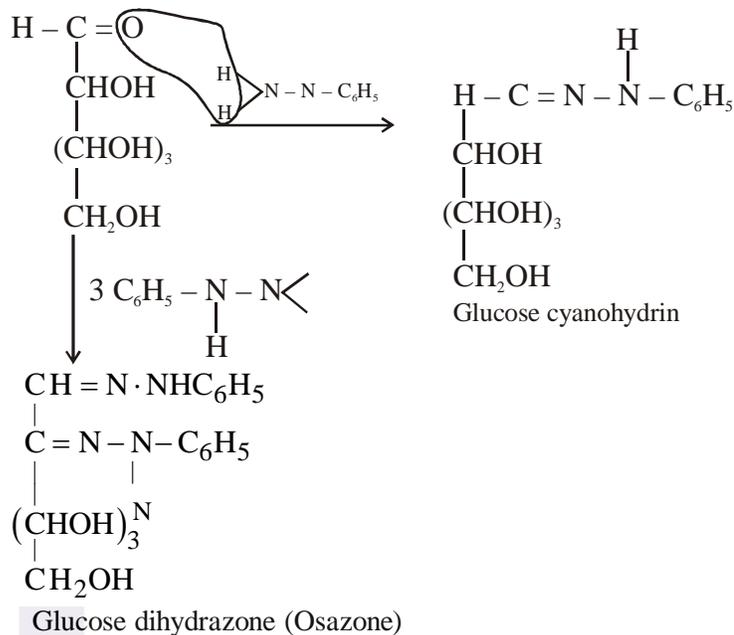
### 4. Oxidation :



### 5.Reduction :



6. Reaction with Phenyl hydrazine :



7. Action of Alkali : Lobry de Bruyn-van Ekenstein reaction

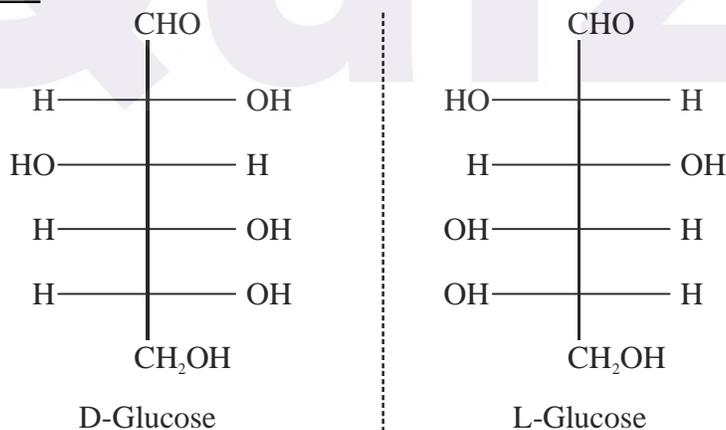


On adding concentrated solution of NaOH this occurs.

⇒ It is probably on account of this isomerisation, that fructose reduces Fehling's solution and Tollen's Reagent in alkaline medium.

STRUCTURE OF GLUCOSE

Open-chain strs :



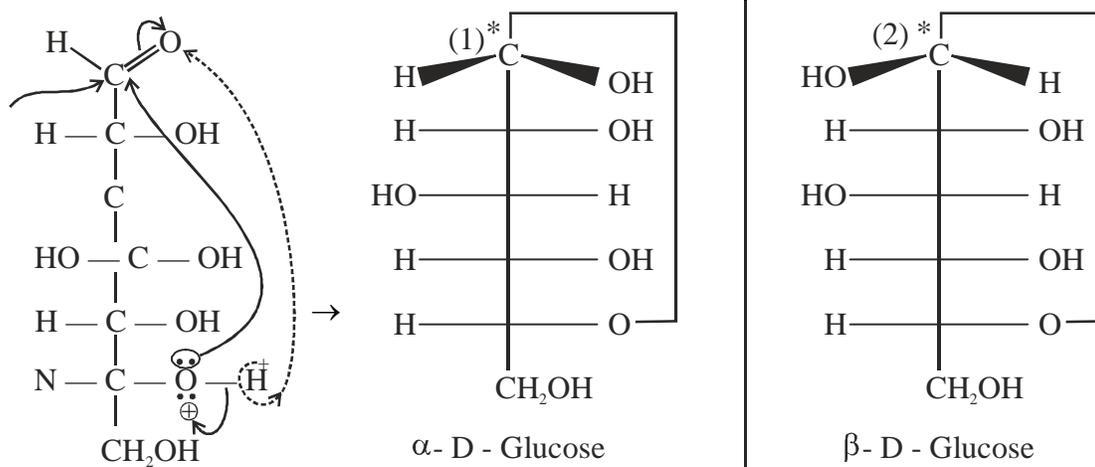
Limitation of open-chain strs :

- (i) Glucose doesn't undergo characteristic reaction of aldehydes such as
  - (a) Glucose does not react with NaHSO<sub>3</sub> (sodium bisulphate)
  - (b) Glucose does not respond to Schiff's test.
- (ii) Glucose doesn't react with G.R.

Cyclic structures of Glucose :

α - D and β - D Glucose : (Hemiacetal structures)

- In  $\alpha$ -D-Glucose OH group is towards right while in  $\beta$ -D-Glucose the OH group is towards left at  $C_1$ .



### ANOMERS :

“The stereo isomers which differs in configuration at “ $C_1$ ” is called anomers”.

The “ $C_1$ ” is also called as anomeric carbon or Glycosidic carbon.

Note : ‘ $\alpha$ ’ and ‘ $\beta$ -D’ Glucose are not enantiomers, since the configuration at other carbon remains same.

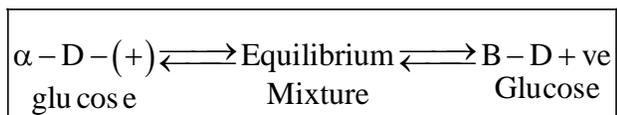
### Mutarotation :

When Glucose is crystallized from a concentrated solution at 300 K,  $\alpha$  form of D-Glucose is isolated. But, from a hot saturated solution (aqueous) at a temperature in excess of  $100^\circ\text{C}$ , the  $\beta$ -Glucose is obtained.

Term	$\alpha$	$\beta$
M.pt :	$146^\circ\text{C}$	$150^\circ\text{C}$
Sp. rotation :	$+111^\circ$	$+19.2^\circ$

If either of the two forms is dissolved in water and allowed to stand, the specific rotation of the solution slowly changes and reaches a constant value of  $+52.5^\circ$ .

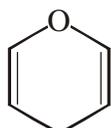
“The spontaneous change in specific rotation of an optically active compound is called mutarotation”.



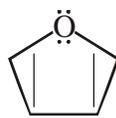
Haworth structures of Glucose : The molecules of glucose and fructose can exist in any of the two cyclic structures.

- (a) Pyranose structure  
Six membered ring  
Derived from pyran

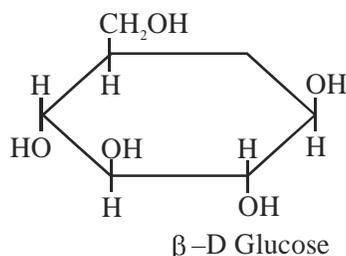
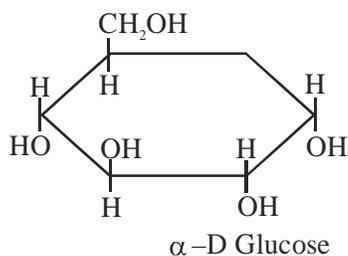
- (b) Furanose structure  
5 Membered Ring  
Derived from furan



Pyran



Furan



## OLIGOSACCHARIDES

These are carbohydrates which gives 2 to 10 molecules of monosaccharides.

\* In some standard text (particularly in Biology)  $n = 2$  to 7 has been frequently used.

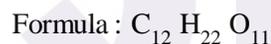
Example

- (1) Disaccharides : Sucrose, Maltose, Lactose
- (2) Trisaccharides : Raffinose
- (3) Tetrasaccharides : Stachyrose

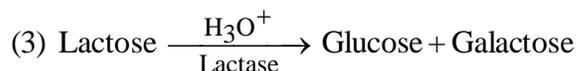
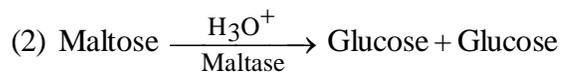
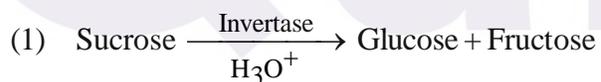
Disaccharides :

Gives two molecules of same or different monosaccharides.

General formula :

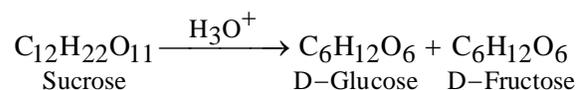


Examples and its monomers :



- The disaccharides can be reducing or non reducing. If carbonyl group is free, sugar is reducing.

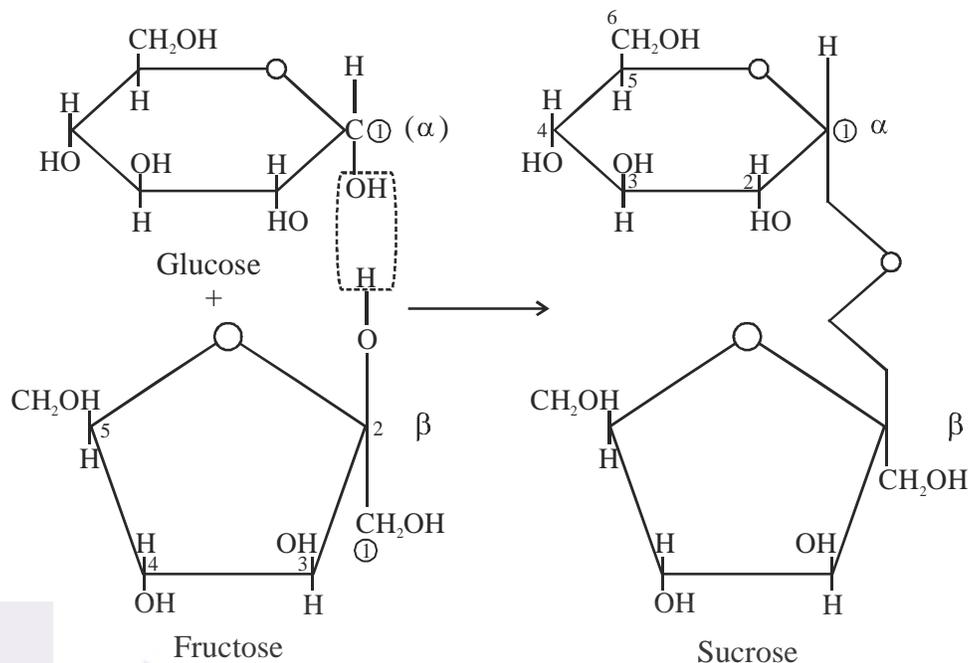
Sucrose or cane sugar or Table Sugar :



Specific rotation    + 66.5°                      +52.5°                      -92.4°

Since the laevorotation of fructose is more than the dextro rotation of glucose, the resulting solution will be laevo rotatory. This overall process is called inversion of sugar.

## HAWORTH STRUCTURE OF SUCROSE :



- Determination of ring size by spectral methods has revealed that, in sucrose glucose is in its pyranose form and fructose it is furanose form.
- There is thus,  $\alpha, \beta$  glucosidic bond between glucose and fructose as monomers.

## POLYSACCHARIDES :

Polysaccharides are formed when large number of monosaccharide joins together with simultaneous elimination of water molecules.

Some common polysaccharides are :

- (i) Cellulose    (ii) Starch    (iii) Glycogen    (iv) Dextrin

## STARCH :

- (i) It is also called as Amylum.

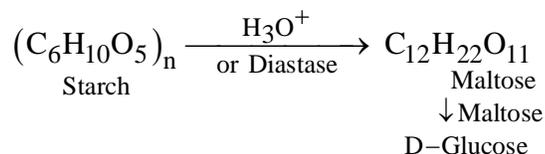
General formula -  $(C_6H_{10}O_5)_n$

where,  $n \cong 100$  to 300

It is the chief food storage material in plants.

- (ii) Starch is white amorphous powder which is sparingly soluble in water.

- (iii) Hydrolysis of starch :



- (iv) Starch does not reduce Fehling solution or Tollen's reagent and does not form osazone. This clearly suggests that all hemiacetal hydroxy group of glucose unit at  $C_1$  is involved in glycosidic linkage.

- (v) Starch is a mixture of two poly saccharides Amylose and Amylopectins.

Natural starch has

Amylose : 10 to 20%

Amylopectin : 80 to 90%

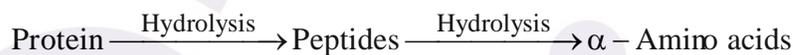
## CELLULOSE :

- (i) It is the major constituent material of plant cell wall. In general, wood contains 50% cellulose and cotton contains 90-95% cellulose.
- (ii) It is a colourless, amorphous solid which can be decomposed by heating.
- (iii) It is almost linear and its individual monomeric units are joined through multiple H-bond.
- (iv) Cellulose does not reduce Fehling solution, Tollen's reagent and does not forms osazone.
- (v) Large population of cellulotic bacteria is present in the stomach of ruminant mammals. These bacteria causes decomposition of cellulose in stomach cellulose is digested as glucose in ruminant mammals.
- (vi) Human does not have any system to digest cellulose.
- (vii) Structure of Cellulose : Cellulose is a straight chain polymer of D-glucose which are joined by  $\beta$ -Glucosidic bond b/w  $C_1$  of one glucose and  $C_4$  of other glucose.

## PROTEINS

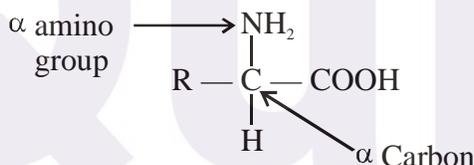
Proteins are vital chemical substance essential for the growth and maintenance of life. Chemically proteins are condensation polymers in which the monomeric unit is  $\alpha$  amino acids. All proteins contain the elements like carbon, hydrogen, oxygen nitrogen and sulphur in major.

### HYDROLYSIS OF PROTEINS



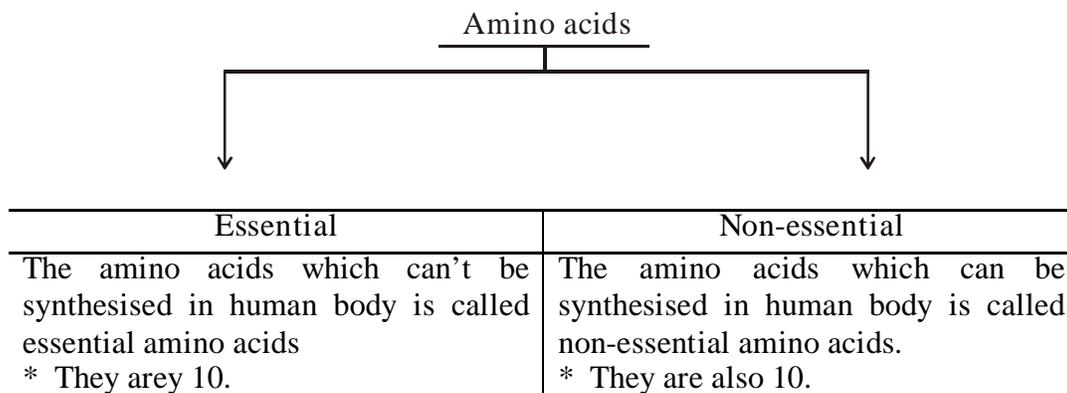
### $\alpha$ Amino acids :

$\alpha$  amino acids are the building block of proteins.

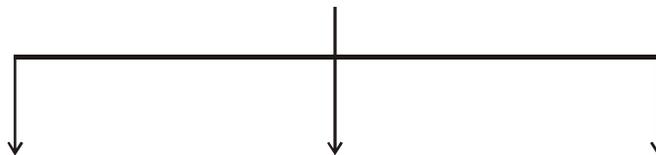


The total of 20 amino acids has been isolated by hydrolysis of various proteins.

### Classification of $\alpha$ Amino acids :



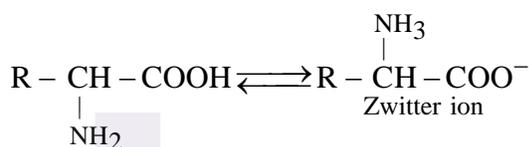
α - Amino acids



(a) Neutral	(b) Alkaline	(c) Acidic
Has one NH <sub>2</sub> group and one COOH group.	Two NH <sub>2</sub> group and one COOH group	Has two COOH group and one NH <sub>2</sub> group

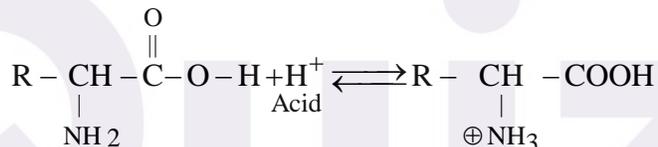
Zwitterion ion structure :

α - amino acid largely exists as dipolar ion.



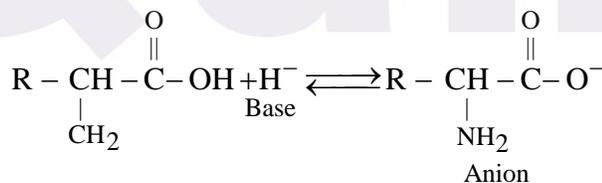
Electrical behaviour of Amino acids :

- (a) In acidic solution : α amino acid exist as cations and thus will migrat towards the cathode under electrical field.



The cation will migrat towards cathode.

- (b) In alkaline solution : α Amino acid exist as



The anion will migrat towards +ve electrode i.e. Anode.

Iso electric point :

The pH at which amino acid has no net migration towards any of the electrode under influence of electric field is called isoelectric point.

Each amino acid has a characteristic isoelectric point.

Amino acid	Iso electric point (pH)
(1) Neutral	Slightly less than 7 (≅ 6.1)
(2) Acidic	3.2 to 3.5
(3) Alkaline	7.6 to 10.8

At isoelectric point amino acids have least solubility.

