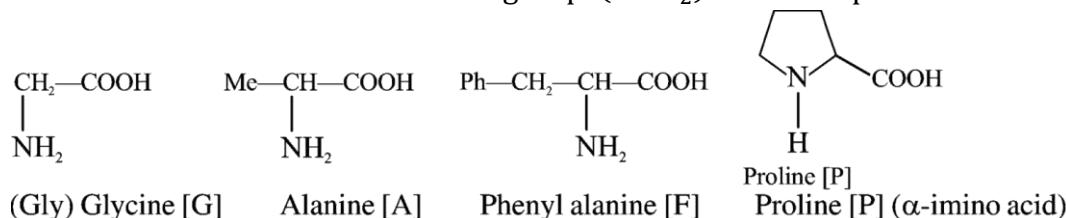


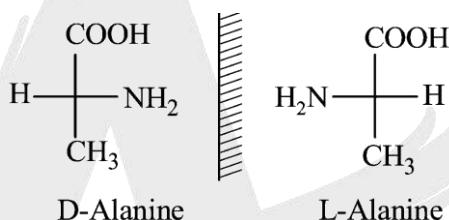
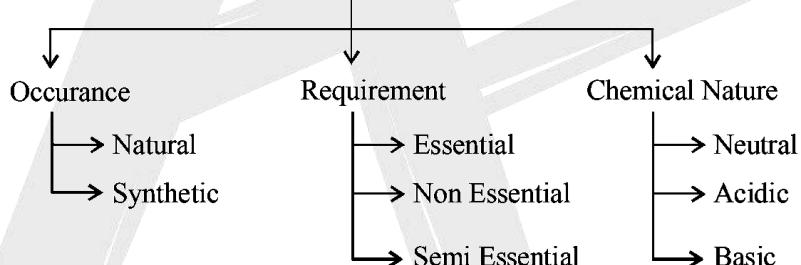
**AMINO ACIDS AND PROTEINS**

Bifunctional compounds having an acidic carboxylic group & a basic amino group are known as amino acid.

There are 20 amino acids commonly found in proteins and are standard amino acids. All are  $\alpha$  amino acids. Most of them have 1° amino group. ( $-\text{NH}_2$ ). However proline is a 2° amino.



All amino acids are chiral molecules with atleast one chiral carbon (except glycine,  $\text{H}_3\text{N}^+\text{CH}_2\text{COO}^-$ ). Except Glycine all other amino acids are optically active & can be assigned D & L configuration.

**Classification of Amino acids****Based on requirement.**

1. Essential amino acids can not be synthesized in human body so dietary intake is required. For any human being 1gm a day is required.
2. Semi essential amino acids can be synthesized in human body but dietary intake is required during growing stages (when more of cell division is required).  
**For example :** Early childhood, pregnancy and lactating mother.
3. Non essential amino acid - Body can synthesize them.

**Based on chemical nature**

**Neutral** - Amino acid having equal number of  $\text{NH}_2$  and  $\text{COOH}$ .

Neutral amino acids are further classified as polar and nonpolar depending on whether their side chains have polar substituents (for example, asparagine with an  $\text{NH}_2\text{CO}$  group) or are completely hydrocarbon in nature (for example alanine, valine etc.).

**Acidic** - Amino acid having more  $\text{COOH}$  than  $\text{NH}_2$  group.

**For example :** Aspartic acid and glutamic acids, each with a second  $\text{CO}_2\text{H}$  in their side chain are acidic amino acids.

**Basic** - Amino acid having more  $\text{NH}_2$  than  $\text{COOH}$  group.

**For example :** Lysine, arginine and histidine)

**Proteins:** The name protein is taken from the Greek word "proteios", which means "first". Of all chemical compounds, proteins must almost certainly be ranked first, for they are the substance of life. Proteins make up a large part of the animal body, they hold it together and they run it. They are found in all living cells. Chemically, proteins are high polymers. They are polyamides and the monomers from which they are derived are the  $\alpha$ -amino carboxylic acids. A single protein molecule contains hundreds or even thousands of amino acid units. These units can be of twenty-odd different kinds. The number of different combinations, i.e., the number of different protein molecules that are possible, is almost infinite.

<i>A - I. Neutral amino acids (with nonpolar side chains)</i>			
NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT [pI]
<sup>@</sup> Glycine	Gly(G)	$\begin{array}{c} \text{NH}_2 \\   \\ \text{H}_2\text{C} \\   \\ \text{C=O} \\   \\ \text{OH} \end{array}$	6.0
Alanine	Ala(A)	$\begin{array}{c} \text{NH}_2 \\   \\ \text{H}_3\text{C}-\text{CH} \\   \\ \text{C=O} \\   \\ \text{OH} \end{array}$	6.0
Valine*	Val(V)	$\begin{array}{c} \text{H}_3\text{C}-\text{CH} - \underset{\text{CH}_3}{\text{C}}-\text{NH}_2 \\   \\ \text{CH}_3 \quad \underset{\text{OH}}{\text{C=O}} \end{array}$	6.0
Leucine*	Leu(L)	$\begin{array}{c} \text{H}_3\text{C}-\text{CH} - \text{CH}_2 - \underset{\text{CH}_3}{\text{C}}-\text{NH}_2 \\   \\ \text{CH}_3 \quad \underset{\text{OH}}{\text{C=O}} \end{array}$	6.0
Isoleucine*	Ile(I)	$\begin{array}{c} \text{CH}_3 \quad \text{NH}_2 \\   \quad   \\ \text{CH}_3\text{CH}_2\text{CH}-\text{CHCO}_2\text{H} \end{array}$	6.0
Methionine*	Met(M)	$\begin{array}{c} \text{NH}_2 \\   \\ \text{CH}_3\text{SCH}_2\text{CH}-\text{CHCO}_2\text{H} \end{array}$	5.7
<sup>@@</sup> Proline	Pro(P)	$\begin{array}{c} \text{NH} \\   \\ \text{Cyclohexyl ring} \\   \\ \text{CO}_2\text{H} \end{array}$	6.3
Phenylalanine*	Phe(F)	$\begin{array}{c} \text{NH}_2 \\   \\ \text{C}_6\text{H}_5-\text{CH}_2-\text{CHCO}_2\text{H} \end{array}$	5.5
Tryptophan*	Trp(W)	$\begin{array}{c} \text{NH}_2 \\   \\ \text{C}_6\text{H}_4-\text{CH}_2-\text{CHCO}_2\text{H} \\   \\ \text{N} \quad \text{H} \end{array}$	5.9

*A -2. Neutral amino acids (with polar, but nonionized side chains)*

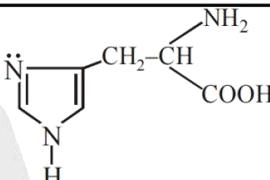
NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Asparagine	Asn(N)	$\text{H}_2\text{N}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\overset{\text{C}=\text{O}}{\underset{\diagup}{\text{C}}}-\text{OH}$	5.4
Glutamine	Gln(Q)	$\text{H}_2\text{N}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\overset{\text{C}=\text{O}}{\underset{\diagup}{\text{C}}}-\text{OH}$	5.7
Serine	Ser(S)	$\text{HO}-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\overset{\text{C}=\text{O}}{\underset{\diagup}{\text{C}}}-\text{OH}$	5.7

*A -3. Neutral amino acids (with polar, but nonionized side chains)*

NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Threonine*	Thr	$\begin{matrix} \text{OH} & \text{NH}_2 \\ &   \\ \text{CH}_3\text{CH}-\text{CHCO}_2\text{H} \end{matrix}$	5.6
Tyrosine	Tyr(Y)	$\text{HO}-\text{C}_6\text{H}_4-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\overset{\text{C}=\text{O}}{\underset{\diagup}{\text{C}}}-\text{OH}$	5.7
Cysteine	Cys	$\text{HSCH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\text{CHCO}_2\text{H}$	5.1
‡ Cystine	Cys-Cys	$\begin{matrix} \text{NH}_2 & \text{NH}_2 \\ &   \\ \text{HOOCCHCH}_2\text{S}-\text{SCH}_2\text{CHCOOH} \end{matrix}$	

*B - Acidic amino acids (side chain with carboxylic acid group)*

NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Aspartic acid	Asp(D)	$\text{HO}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{CH}}}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{OH}$	2.8
Glutamic Acid	Glu(E)	$\text{O}=\overset{\text{O}}{\underset{\diagup}{\text{C}}}-\text{CH}_2-\text{CH}_2-\overset{\text{NH}_2}{\underset{\diagdown}{\text{C}}}-\overset{\text{C}=\text{O}}{\underset{\diagup}{\text{C}}}-\text{OH}$	3.2

<i>C - Basic amino acids (side chain with nitrogenous basic group)</i>			
NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Lystine*	Lys(K)	$\text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}(\text{NH}_2)-\text{C}(=\text{O})-\text{OH}$	9.7
Arginine*	Arg(R)	$\text{H}_2\text{N}-\overset{\text{NH}}{\underset{\text{II}}{\text{C}}}-\text{NH}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}(\text{NH}_2)-\text{C}(=\text{O})-\text{OH}$	10.8
Histidine*	His(H)		7.6

**Note:**

Amino acids with an asterisk are essential amino acids.

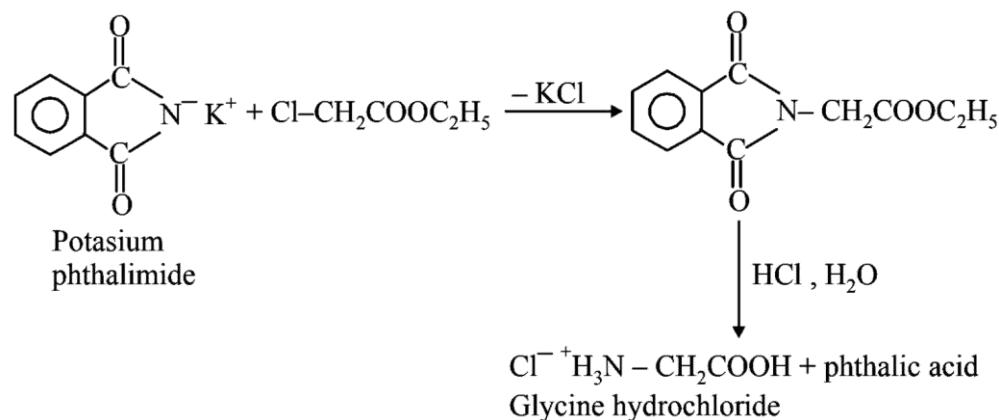
At pH = 7, Asp and Glu have a net negative charge and exist as anions. At pH = 7, Lys and Arg have a net positive charge and exist as cations. Rest of the amino acids at this pH exist in the neutral form.

Structurally, in cystine, the two cysteine molecules are joined through sulfur (disulfide linkage). Proline is an  $\alpha$ -imino acid, all amino acids are primary amines except proline and 4-hydroxyproline, which are  $2^\circ$  amines.

Except Glycine all other amino acids are optically active.

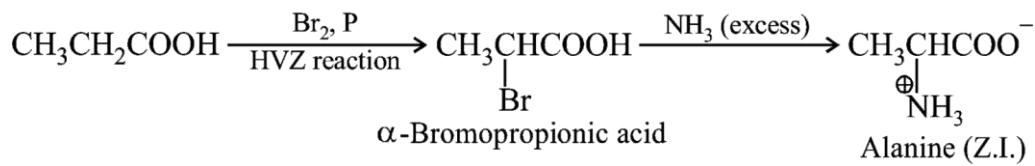
**Preparation of amino acids****(a) Gabriel Phthalimide synthesis**

Good yields of amino acids are generally obtained by the Gabriel phthalimide synthesis; In this method  $\alpha$ -halo esters are used instead of  $\alpha$ -halo acids.

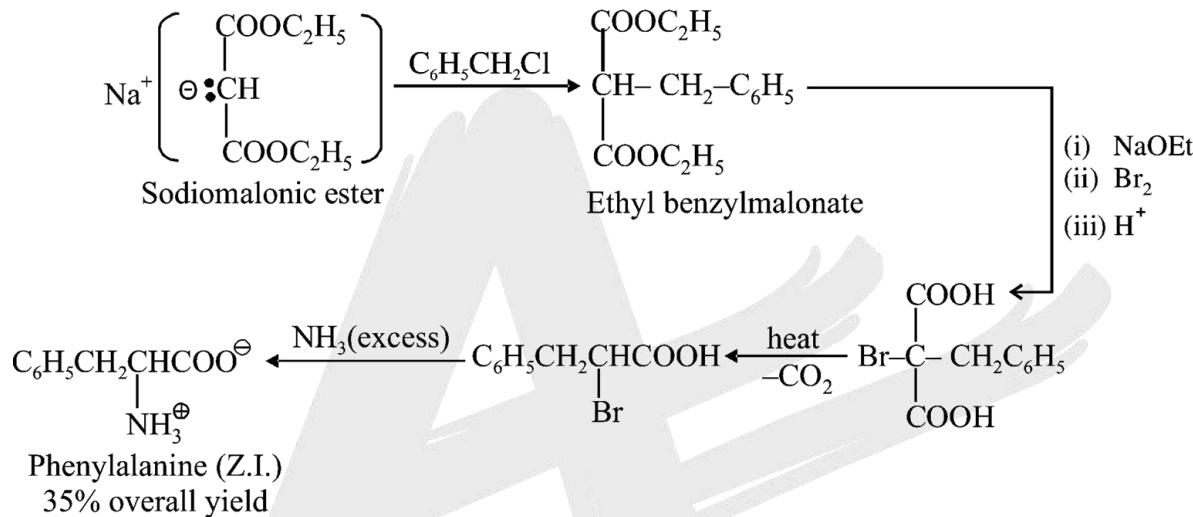


(b) Amination of  $\alpha$ - Halo acids

Sometimes an  $\alpha$ -chloro or  $\alpha$ -bromo acid is subjected to direct ammonolysis with excess of concentrated ammonia.

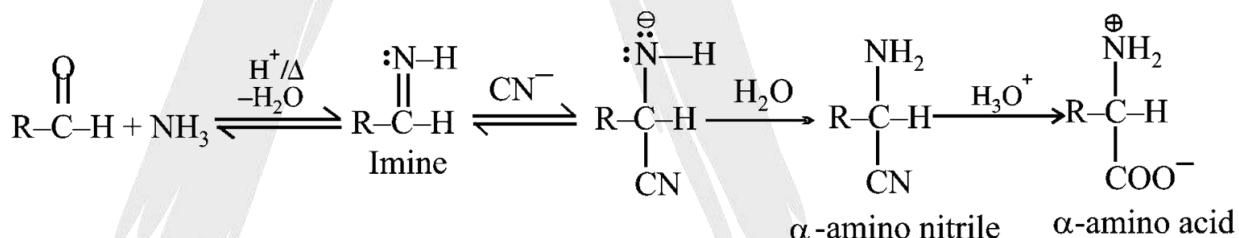


## (c) From diethyl malonate

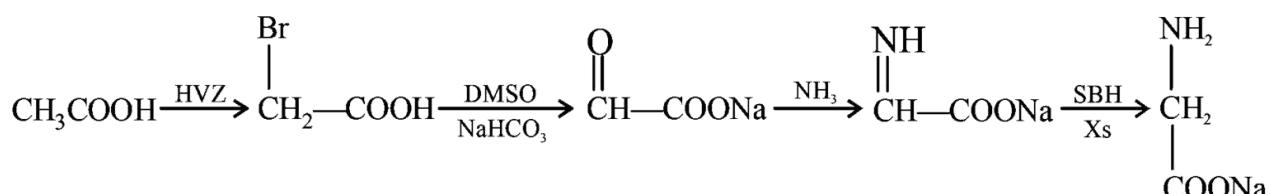


## (d) Strecker's synthesis

Strecker's synthesis is also used for preparing  $\alpha$ -amino acids



## (e) Using KOOP synthesis

Properties of Amino acids

Although the amino acids are commonly shown as containing an amino group and a carboxyl group,  $\text{H}_2\text{NCHRCOOH}$ , certain properties, (both physical and chemical) are not consistent with this structure



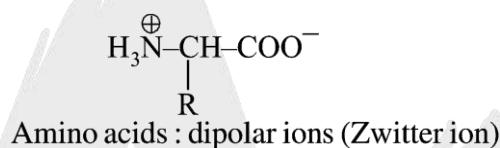
## I. Physical properties

In contrast to amines and carboxylic acids, the amino acids are nonvolatile crystalline solids, which melt with decomposition at fairly high temperatures. They are insoluble in non-polar solvents like petroleum ether, benzene or ether and are appreciably soluble in water. Their aqueous solutions behave like solutions of substances of high dipole moment due to existence.

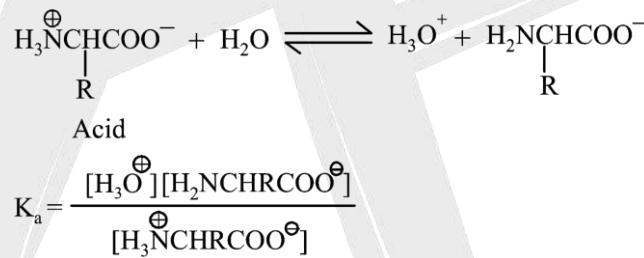
### Amino acids as dipolar ions as zwitter ion

Acidity and basicity constant are ridiculously low for  $-COOH$  and  $-NH_2$  groups. Glycine, for example, has  $K_a = 1.6 \times 10^{-10}$  and  $K_b = 2.5 \times 10^{-12}$ , whereas most carboxylic acids have  $K_a$  values of about  $10^{-5}$  and most aliphatic amines have  $K_b$  values of about  $10^{-4}$ .

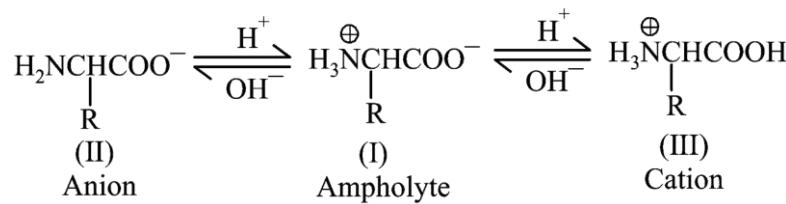
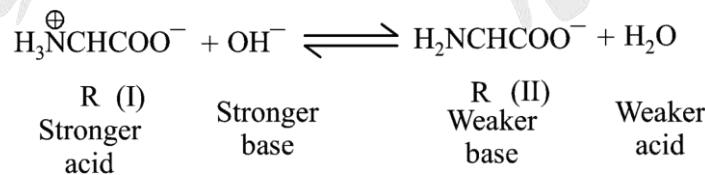
All these properties are quite consistent with a dipolar ion structure for the amino acids (I)



**Physical properties** - melting point, solubility, high dipole moment - are just what would be expected of such a salt. The acid-base properties also become understandable when it is realized that the measured  $K_a$  actually refers to the acidity of an ammonium ion,  $RNH_3^+$ ,



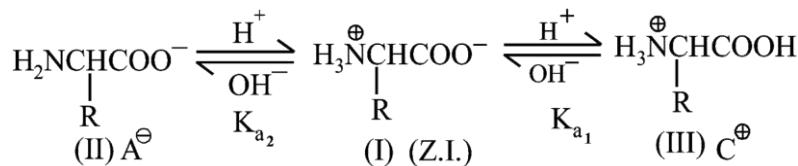
When the solution of an amino acid is made alkaline, the dipolar ion (I) is converted into the anion (II). The stronger base, hydroxide ion, removes a proton from the ammonium ion and displaces the weaker base, the amine.



Wherever feasible, we can speed up a desired reaction by adjusting the acidity or basicity of the solution in such a way as to increase the concentration of the reactive species.

Isoelectric point of amino acids

What happens when a solution of an amino acid is placed in an electric field depends upon the pH of the solution.



In quite alkaline solution, anions (II) exceed cations (III), and there is a net migration of amino acid toward the anode. In quite acidic solution, cations (III) are in excess, and there is a net migration of amino acid toward the cathode. If (II) and (III) are exactly balanced, there is no net migration ; under such conditions any one molecule exists as a positive ion and as a negative ion for exactly the same amount of time, and any small movement in the direction of one electrode is subsequently cancelled by an equal movement back towards the other electrode. The hydrogen ion concentration of the solution in which a particular amino acid does not migrate under the influence of an electric field is called the isoelectric point (pI) of that amino acid. The isoelectric point (pI) is the pH at which the amino acid exists only as a dipolar ion with net charge zero.

For glycine, for example, the isoelectric point is at pH6.1.

An amino acid usually shows its lower solubility in a solution at the isoelectric point, since here there is the highest concentration of the dipolar ion. As the solution is made more alkaline or more acidic, the concentration of one of the more soluble ions, (II) or (III) increases.

$$\text{K}_{\text{a}_1} = \frac{[\text{Z.I.}] [\text{H}^\oplus]}{[\text{C}^\oplus]} \quad \text{K}_{\text{a}_2} = \frac{[\text{A}^\ominus] [\text{H}^\oplus]}{[\text{DI}]} \text{ at pI } [\text{A}^\ominus] = [\text{C}^\oplus]$$

$$\frac{[\text{Z.I.}] [\text{H}^\oplus]}{\text{K}_{\text{a}_1}} = \frac{\text{K}_{\text{a}_2} [\text{DI}]}{[\text{H}^\oplus]} \quad [\text{H}^\oplus]^2 = \text{K}_{\text{a}_1} \& \text{K}_{\text{a}_2}$$

$$\text{on taking antilog pI} = \frac{\text{P}^{\text{K}_{\text{a}_1}} + \text{P}^{\text{K}_{\text{a}_2}}}{2}$$

An amino acid having  $-\text{COOH}$  group more than  $\text{NH}_2$  group or such amino acid have pI less than 7.

An amino acid having more  $-\text{NH}_2$  more than  $\text{COOH}$  group such amino acid have pI more than 7.

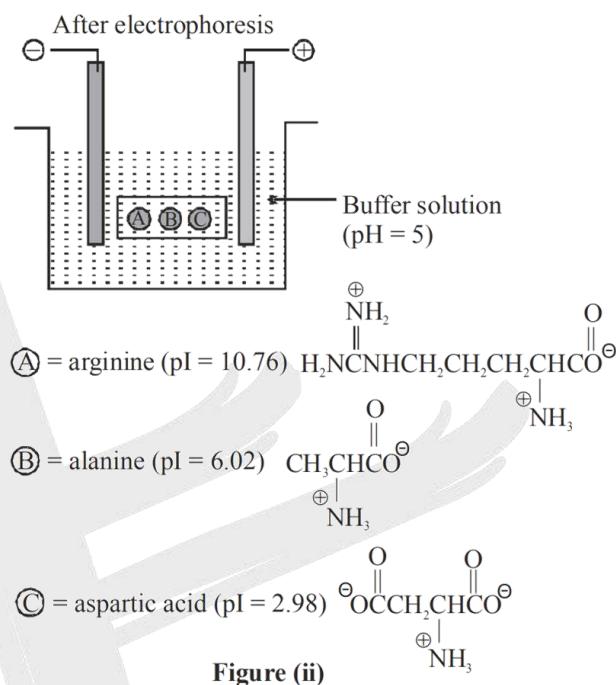
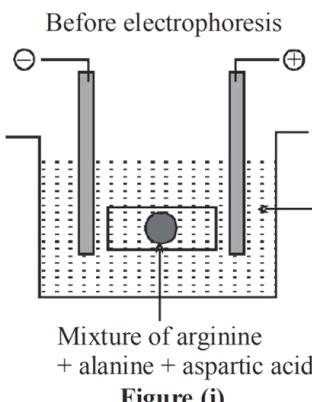
**Q. Write the structure of alanine at pH2.5, 10.5 and 6.**

Electrophoresis

The movement of charged molecules (like amino acid) under the influence of an electric field is called electrophoresis. Electrophoresis separates amino acids on the basis of their pI values. Amino acid is positively charged (moves towards cathode) if pH of the solution  $<$  pI  
Amino acid is negatively charged (moves towards anode) if pH of the solution  $>$  pI

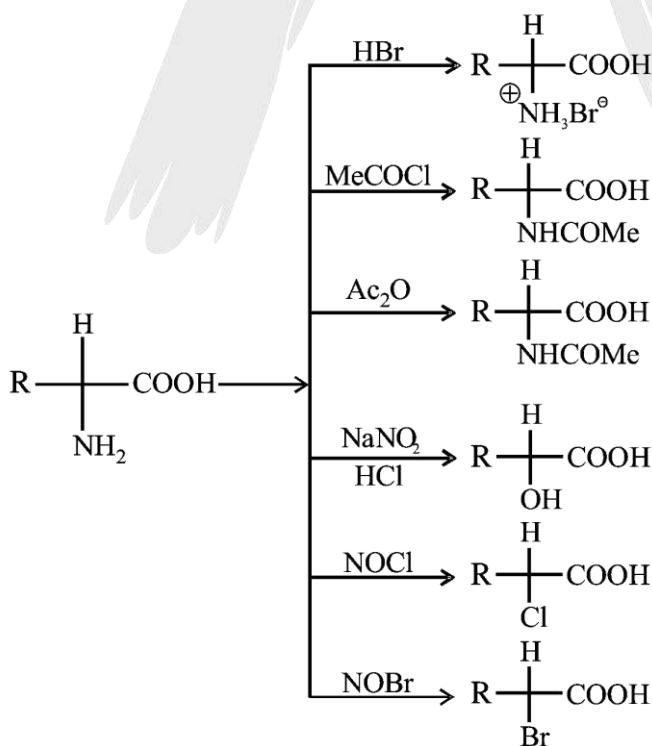
**Q. How will you separate a ternary mixture of arginine, alanine & aspartic acid?**

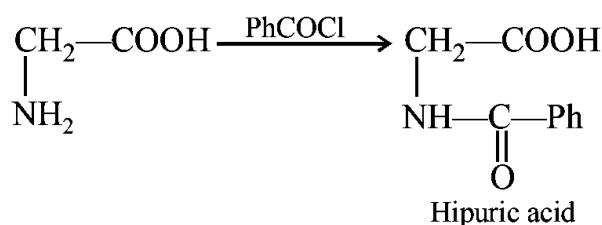
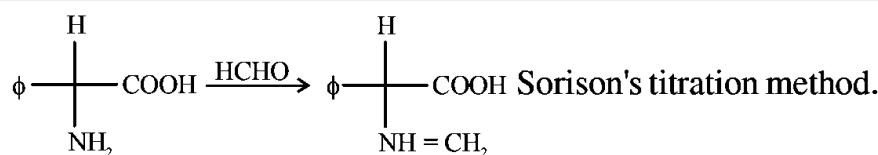
**Ans.** A few drops of a solution of an amino acid mixture are applied to the middle of a piece of filter paper. When the paper is placed in a buffer solution ( $\text{pH} = 5$ ) between the two electrodes and an electric field is applied then arginine & alanine with  $\text{pI} > \text{pH}$  move towards the cathode and aspartic acid with  $\text{pI} < \text{pH}$  moves towards the anode. Out of arginine & alanine, alanine will move slowly towards the cathode due to lesser positive charge.



### General reactions of amino acids

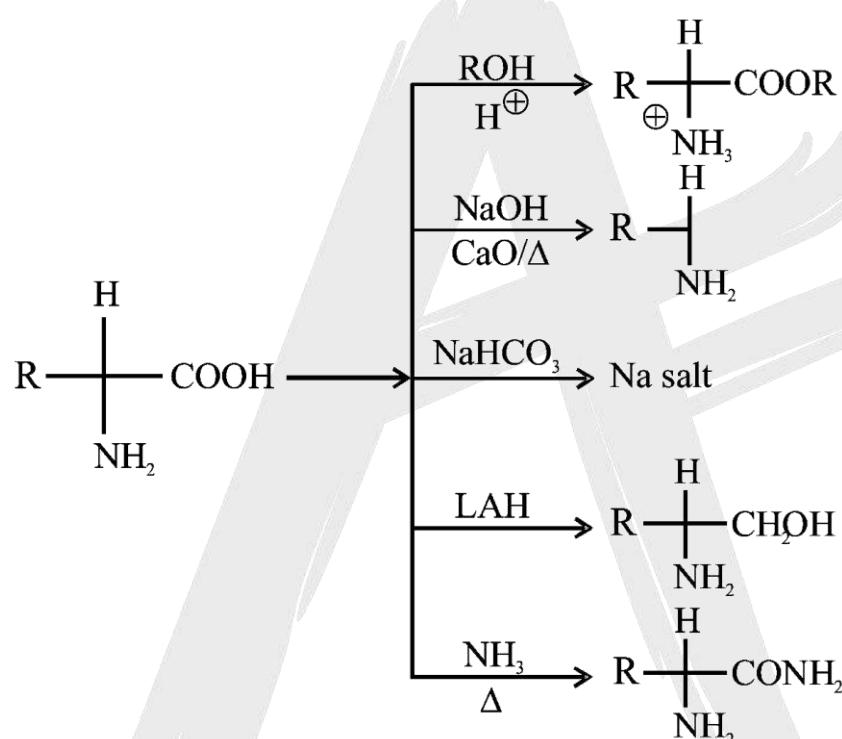
#### (1) Reactions due to $-\text{NH}_2$ group





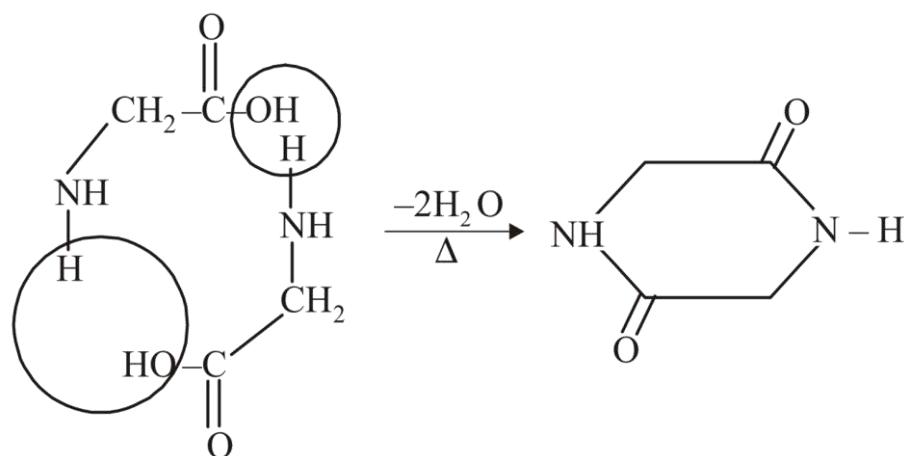
Reactions used to block  $-\text{NH}_2$  group during volumetric analysis in.

### (2) Reactions due to $-\text{COOH}$ group.



### (3) Heating Effect

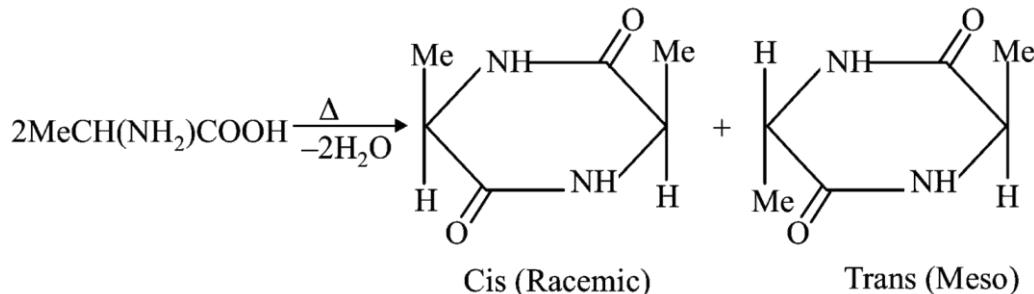
- (i) Heating of amino acids leads to intermolecular dehydration to form cyclic diamides.





## (Organic Chemistry)

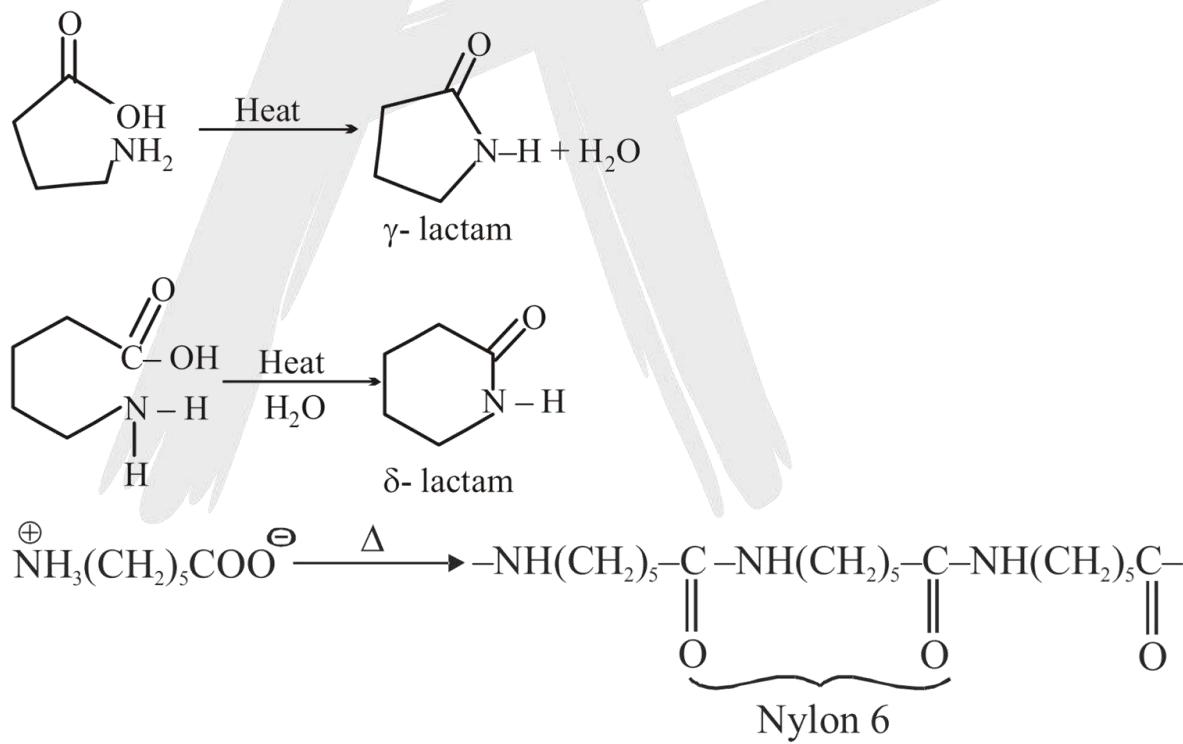
- (ii) When alanine is heated, then two diastereomers are obtained. One of them (trans) is not resolvable.



- (iii) When  $\beta$  - amino acids are heated,  $\alpha, \beta$  - unsaturated salt are formed.



- (iv)  $\gamma, \delta, \varepsilon$  - amino acids when heated alone gives  $\gamma, \delta$  - lactam and polymer respectively. The reason for the formation of polymer is that when  $\varepsilon$  - amino cyclises intramolecularly, it leads to large angle strain within the compound

(4) Peptide

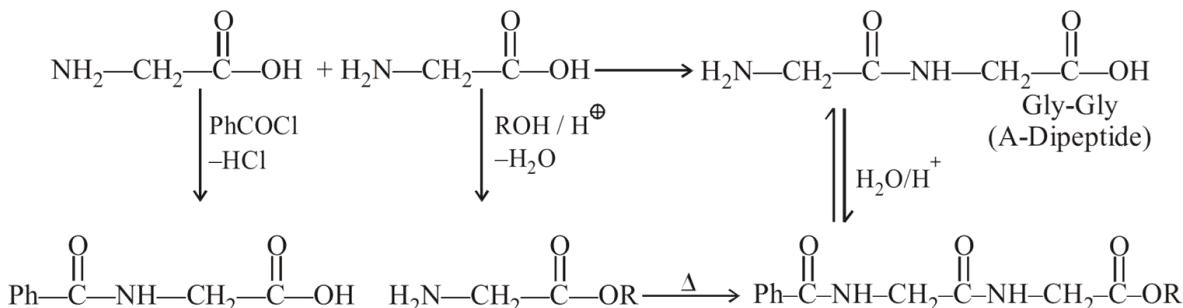
A peptide is a kind of amide formed by intermolecular reaction of the amino group of one amino acid and the carboxyl group of a second amino acid. Dipeptides are made from two amino acids, tripeptides from three amino acids, etc, which may be the same or different. If there are three to ten amino acid residues, the peptide is also called an oligopeptide.

If they give 3 to 10 amino acid they are oligopeptide

If they give 11 to 100 amino acid they are Polypeptide

For more than 100 it is Macropeptide

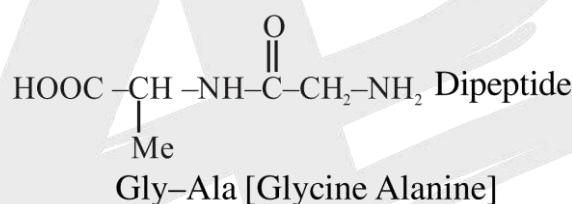
- Peptides can be prepared by blocking technique



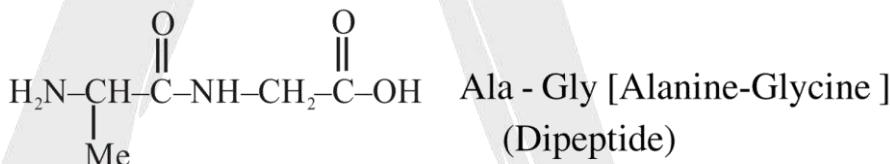
Firstly, the amino and carboxyl groups that are not to be linked in peptide bonds must be blocked to make unreactive.

#### Naming of Dipeptide :

Abbreviated name of amion acid with free  $\text{NH}_2$  is written first.



By convention, the amino acid with the free amino group ( N-terminal) is written at the left end and the one with the unreacted carboxyl group (C-terminal) at the right end.



- When different amino acids are involved in pepetide formation.

Then total number of polypeptide possible =  $X^n$

[ $X$  = type of amino acid interacting,  $n$  = number of amino acid molecule are interacting.]

- |   |                     |
|---|---------------------|
| <b>Q. Glycine can form how many Dipeptide ?</b>                 | <b>[Ans. One]</b>   |
| <b>Q. Glycine can form how many Tripeptide ?</b>                | <b>[Ans. One]</b>   |
| <b>Q. Glycine and Ala can form how many Dipeptide?</b>          | <b>[Ans. Four]</b>  |
| <b>Q. Gly, Ala, and Phenyl Ala can form how many Dipeptide?</b> | <b>[Ans. Nine]</b>  |
| <b>Q. Gly, Ala, can form how many Tripeptide ?</b>              | <b>[Ans. Eight]</b> |

A polypeptide with more than hundred amino acid residues, having molecular mass higher than 10,000 is called a protein. However, the distinction between a polypeptide and a protein is not very sharp. Polypeptides with fewer amino acids are likely to be called proteins they ordinarily have a well defined conformation of a protein such as insulin which contains 51 amino acids. Proteins can be classified into two types on the basis of their molecular shape.

**(a) Fibrous proteins**

When the polypeptide chains run parallel and are held together by hydrogen and disulphide bonds, then fibre-like structure is formed. Such proteins are generally insoluble in water. Some common examples are keratin (present in hair, wool, silk) and myosin (present in muscles), etc.

**(b) Globular proteins**

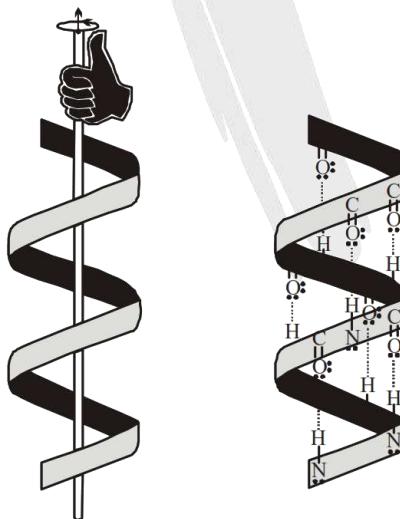
This structure results when the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water. Insulin and albumins are the common examples of globular proteins.

**Structure of Proteins**

Structure and shape of proteins can be studied at four different levels, i.e., primary, secondary, tertiary and quaternary, each level being more complex than the previous one.

- (i) Primary structure of proteins :** Proteins may have one or more polypeptide chains. Each polypeptide in a protein has amino acids linked with each other in a specific sequence and it is this sequence of amino acids that is said to be the primary structure of the protein. Any change in this primary structure i.e., the sequence of amino acids creates a different protein.
- (ii) Secondary structure of proteins :** The secondary structure of protein refers to the shape in which a long polypeptide chain can exist. They are found to exist in two different types of structures viz.  $\alpha$ -helix and  $\beta$ -pleated sheet structure. These structures arise due to the regular folding of the backbone

of the polypeptide chain due to hydrogen bonding between  $\text{—C=O}$  and  $\text{—NH—}$  groups of the peptide bond.



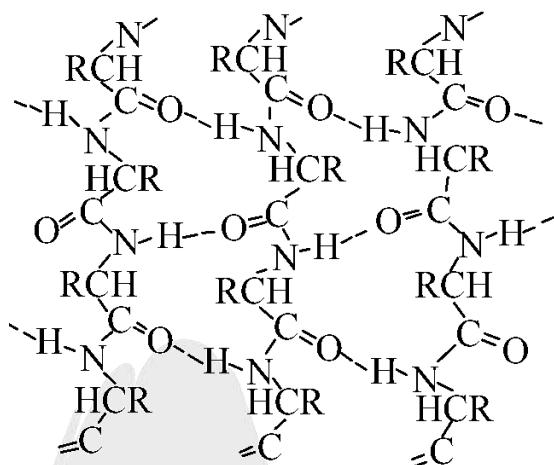
$\alpha$ -Helix structure of proteins

$\alpha$ -Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the  $\text{—NH}$  group of each amino acid residue hydrogen bonded to the

$\text{C=O}$  of an adjacent turn of the helix as shown in



figure. In  $\beta$ -structure all peptide chains are stretched out to nearly maximum extension and then laid side by side which are held together, by intermolecular hydrogen bonds. The structure resembles the pleated folds of drapery and therefore is known as  $\beta$ -pleated sheet.



$\beta$ -Pleated sheet structure of proteins

- (i) Ionic bonding : between  $\text{COO}^-$  and  $\text{NH}_3^+$  at different sites
- (ii) H-bonding : mainly between side-chain  $\text{NH}_2$  and  $\text{COOH}$ , also involving OH's (Of serine, for example) and the N – H of tryptophan.
- (iii) Weakly hydrophobic Van der Waal's attractive forces engendered by side-chain R groups and
- (iv) Disulfide cross linkages between loops of the polypeptide chain.

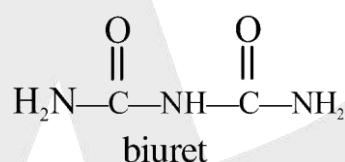
The same kind of attractive and repulsive forces responsible for the tertiary structure operate to hold together and stabilize the subunits of the quaternary structure.

- (iii) **Tertiary structure of proteins:** The tertiary structure of proteins represents overall folding of the polypeptide chains i.e., further folding of the secondary structure. It gives rise to two major molecular shapes viz. fibrous and globular. The main forces which stabilise the  $2^\circ$  and  $3^\circ$  structures of proteins are hydrogen bonds, disulphide linkages, van der walls and electrostatic forces of attraction.
- (iv) **Quaternary structure of proteins:** Some of the proteins are composed of two or more polypeptide chains referred to as sub-units. The spatial arrangement of these subunits with respect to each other is known as quaternary structure. Example : Haemoglobin, Chlorophyll. According to their biological action, they are classified as enzymes, hormones, antibodies, etc. Protein found in living system with definite configuration and biological activity is termed as native protein. If a native protein is subjected to physical or chemical treatment, which may disrupt its higher structures (conformations) without affecting its primary structure, the protein is said to be denatured. During denaturation, the protein molecule uncoils from an ordered and

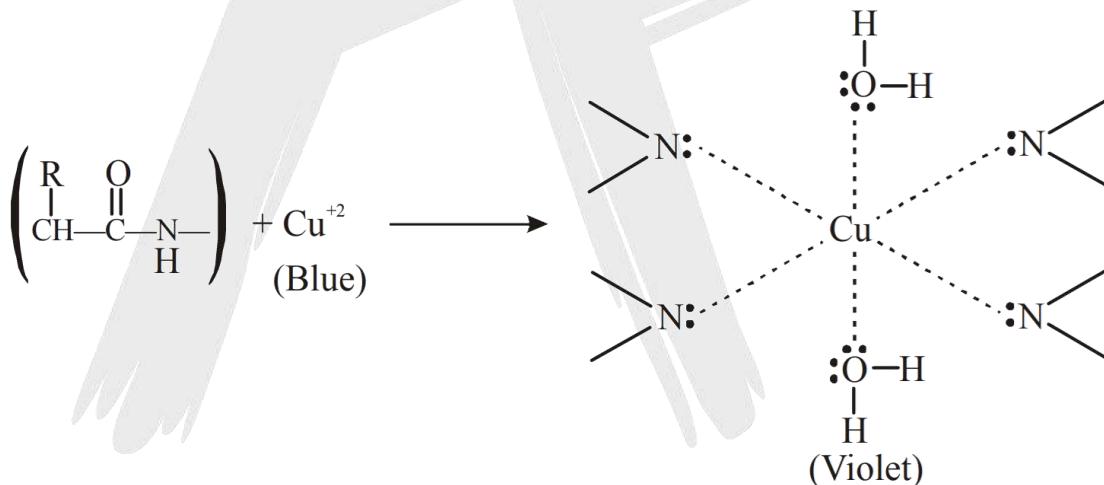
specific conformation into a more random conformation leading to precipitation. Thus denaturation leads to increase in entropy and loss of biological activity of the protein. The denaturation may be reversible or irreversible. Thus, the coagulation of egg white on boiling of egg protein is an example of irreversible protein denaturation. However, in certain cases it is found that if the disruptive agent is removed the protein recovers its original physical and chemical properties and biological activity the reverse of denaturation is known as renaturation.

### Tests of Proteins:

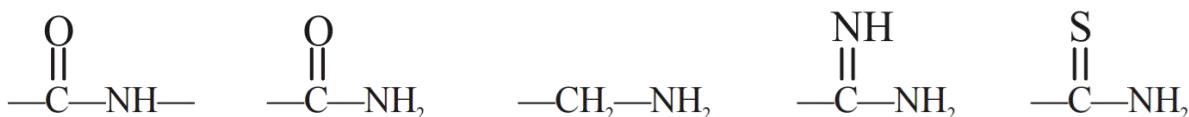
**Biuret test:** Addition of a very dilute solution of  $\text{CuSO}_4$  to an alkaline solution of a protein is done. A positive test is indicated by the formation of a pink violet to purple violet color. The name of test is derived from a specific compound, biuret, which gives a positive test with this reagent



When a protein reacts with copper (II) sulfate (blue), the positive test is the formation of a violet colored complex.



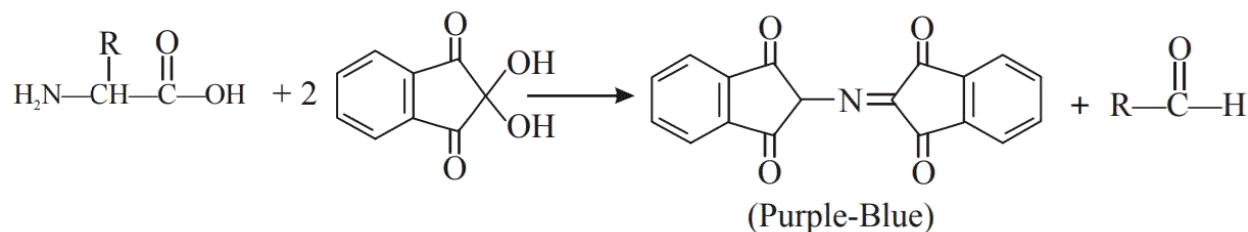
The biuret test works for any compound containing two or more of the following groups.



**Ninhydrin Test:** The ninhydrin test is a test for amino acids and proteins with a free  $-\text{NH}_2$  group. Amino acids are detected by ninhydrin test. All amino acids give violet - coloured product with ninhydrin (triketo hydroindene hydrate) except proline and 4 - hydroxy proline, which gives yellow colour with it.



When such an  $-NH_2$  group reacts with ninhydrin, a purple-blue complex is formed.



The same violet coloured dye forms from all  $\alpha$  - AA's with  $1^\circ$  amino groups because only their nitrogen is incorporated into it. The  $2^\circ$  amines proline and 4 - hydroxyproline give different adducts that absorb light at a different and thus have a different yellow colour.

**CARBOHYDRATES**

Carbohydrates (hydrates of carbon) are naturally occurring compounds having general formula  $C_x(H_2O)_y$ , which are constantly produced in nature & participate in many important bio-chemical reactions.

<b>Ex. -</b>	Glucose	$C_6H_{12}O_6$	$C_6(H_2O)_6$
	Fructose	$C_6H_{12}O_6$	$C_6(H_2O)_6$
	Cellulose and Starch	$(C_6H_{10}O_5)_n$	$(C_6(H_2O)_5)_n$

- Sucrose (Cane sugar) -  $C_{12}H_{22}O_{11}$ , and
- Maltose (Malt Sugar)  $C_{12}(H_2O)_{11}$

But some compounds which have formula according to  $C_x(H_2O)_y$  are not known as carbohydrate

<b>Ex.</b>	$CH_2O$	Formaldehyde
	$C_2(H_2O)_2$	Acetic acid
	$C_3(H_2O)_3$	lactic acid

There are many compounds, which shows chemical behavior of carbohydrate but do not confirm the general formula  $C_x(H_2O)_y$  such as  $-C_5H_{10}O_4$  (2-deoxyribose),  $C_6H_{12}O_5$  (Rhamnose)  $C_7H_{14}O_6$  (Rhamnosehexose)

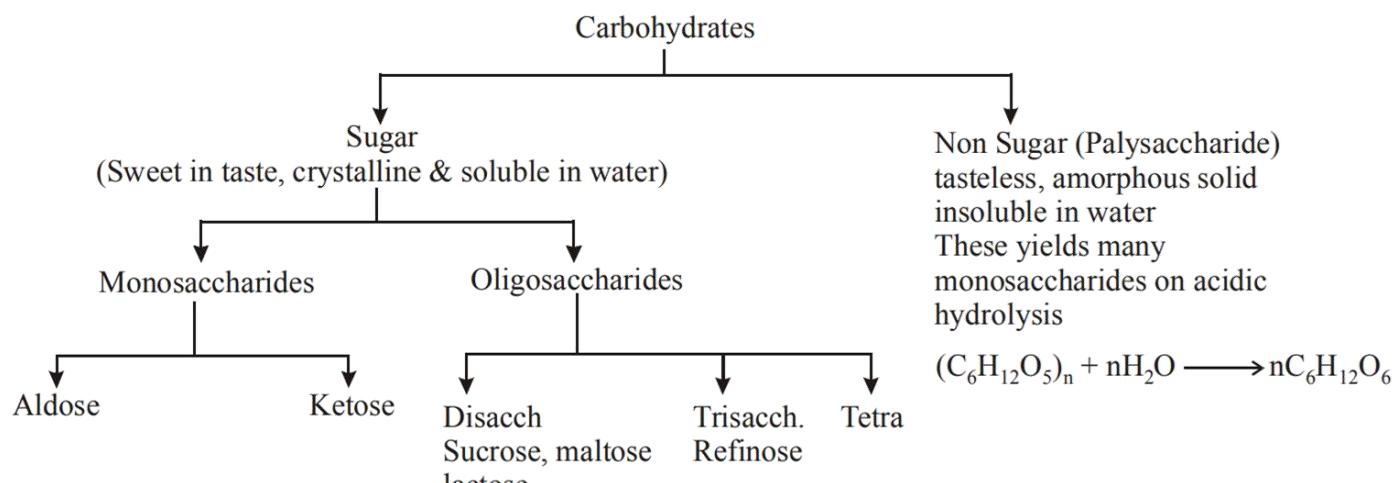
**Modern Concept :** Carbohydrates are polyhydroxy aldehyde or ketone

**Or**

Substances which yield these  
(polyhydroxy aldehyde or ketone) on hydrolysis

- Carbohydrates  $\xrightarrow{H_2O/H^+}$  Polyhydroxy aldehyde or ketone
  - Carbohydrates are also known as Saccharides.
  - In plants carbohydrates are synthesised by photosynthesis
- Classification of carbohydrates :

### Classification of carbohydrates:



### Monosaccharides : (simple sugars)

These are the sugars which cannot be hydrolysed into smaller molecules.

General formula is  $C_nH_{2n}O_n$

Ex. - Glucose, Fructose, Ribose, Deoxynbose

- If aldehyde group is present in monosaccharide, then it is known as aldose.
- If ketone group is present in monosaccharide , then it is known as ketose.

### Oligosaccharides:-

These are the sugars which yeilds 2-10 monosaccharides units on hydrolysis. such as.

These are of following types

(a) Disaccharides :- Gives two monosaccharide unit on hydrolysis (may or may not be same).

Ex. - Sucrose, Maltose, Lactose

**(b) Trisaccharides :-** Gives Three monosaccharide unit on hydrolysis.

**Polysaccharides :-** These are the non sugars which yeild a large no of monosaccharide units on hydrolysis General formula -  $(C_6H_{10}O_5)_n$ . Ex.- Starch, Cellulose, Glycogen

**Note :-** A group of polysaccharides which are not so widely used in nature is pentosans

$(C_5H_8O_4)_n$  Monosaccharides, General formula  $C_x(H_2O)_y$   $x = 3 - 8$ . Nomenclature of monosaccharides are given according to the no. of carbons present in them.

On the basis of C-atom monosaccharides can be farther classified as, Trioses, Tetroses, Pentoses, Hexoses.

**Table**



		Aldoses	Ketoses
3C	Tropose or Triose	Aldotriose	Ketotriose
4C	Tetrose	Aldotetrose	Ketotetrose
5C	Pentose	Aldopentose	Ketopentose
5C	Including -CHO	Aldopentose (Ribose)	$  \begin{array}{c}  \text{H} - \text{C} = \text{O} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $
5C	Including $-\text{C}=\text{O}$	Ketopentose	$  \begin{array}{c}  \text{CH}_2\text{OH} \\    \\  \text{C} = \text{O} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $
6C	Hexose	Aldohexose	Keto hexose
6C	Including -CHO	Aldohexose (Glucose)	$  \begin{array}{c}  \text{CHO} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{HO} - \text{C} - \text{H} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $ <p>D-glucose</p> $  \begin{array}{c}  \text{CH}_2\text{OH} \\    \\  \text{C} = \text{O} \\    \\  \text{HO} - \text{C} - \text{H} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $ <p>D-fructose</p>
6C	Including $-\text{C}=\text{O}$	Keto hexose (Fructose)	

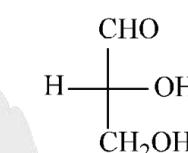
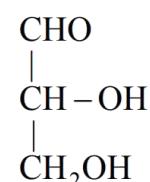
Stereochemistry of carbohydrates:

D & L-Sugars: The series of aldoses or ketoses in which the configuration of the penultimate C-atom (C-next to CH<sub>2</sub> – OH group) is described as D-sugars if -OH is towards RHS & L-sugars if it is towards LHS.

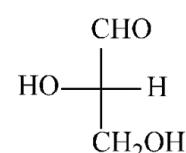
**Smallest carbohydrate**

\* Aldotriose

\* Glyceraldehyde



D-Glyceraldehyde (+)

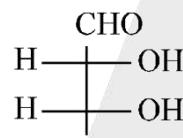


L-Glyceraldehyde (-)

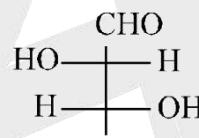
Classification of Aldotetros:

(ii) Threose

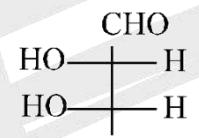
C-4



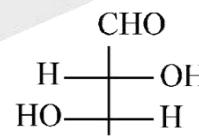
D-Erythrose



D-Threose



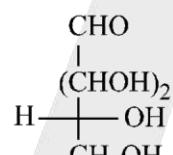
L-Erythrose



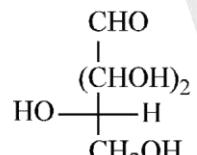
L-Threose

**D-Aldopentose :**

C-5



D-Aldopentose



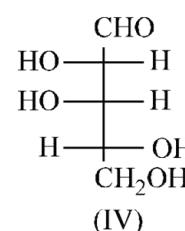
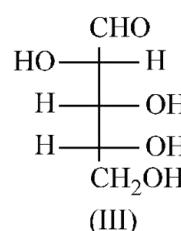
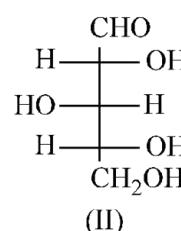
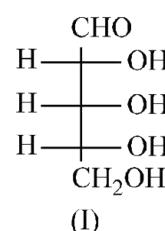
L-Aldopentose

No. of C\* = 3 (in Aldopentose)

No. of optical isomers  $2^3 = 8$ 

No. of D Sugars 4

No. of L Sugars 4



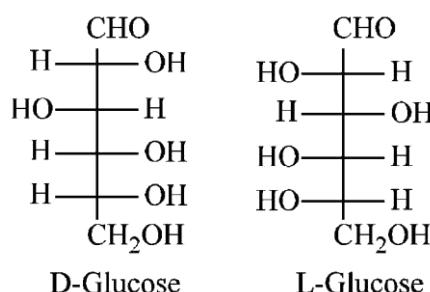
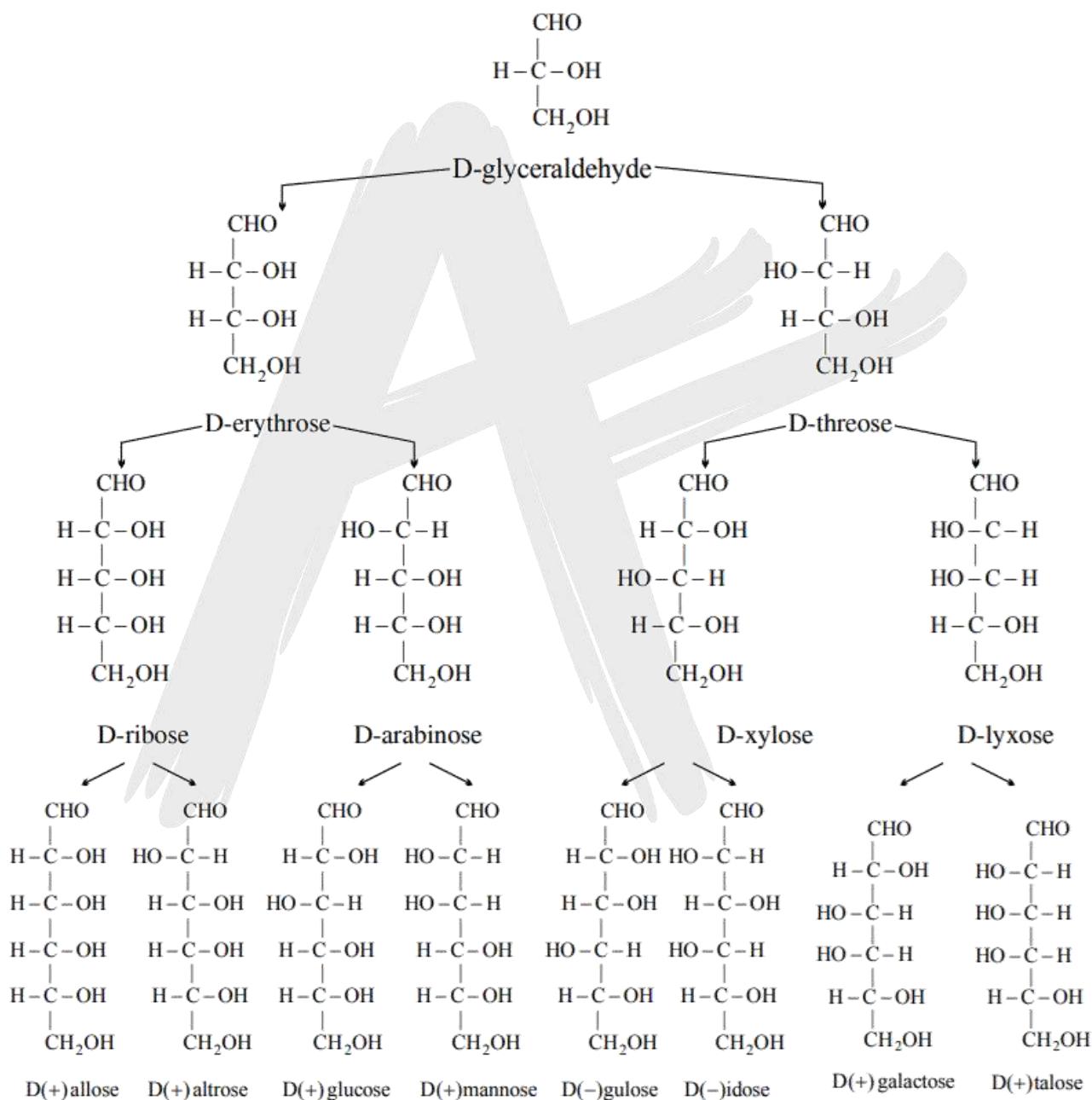
D-Aldohexose

No. of C\* = 4

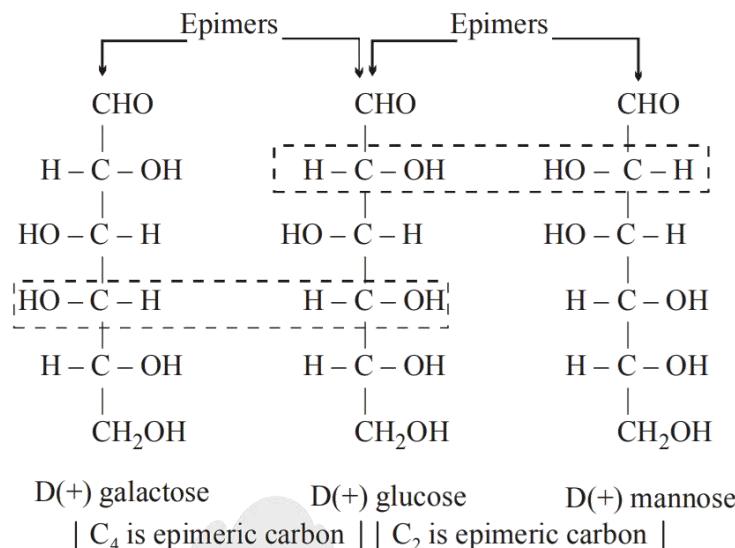
No. of stereoisomers =  $2^4 = 16$ 

No. of D-sugars = 8

No. of L-sugars = 8

The D-family aldoses

**Epimers:** A pair of diastereomers that differ only in the configuration about of a single carbon atom are said to be epimers. D(+) - glucose is epimeric with D(+) - mannose and D(+) - galactose as shown below.



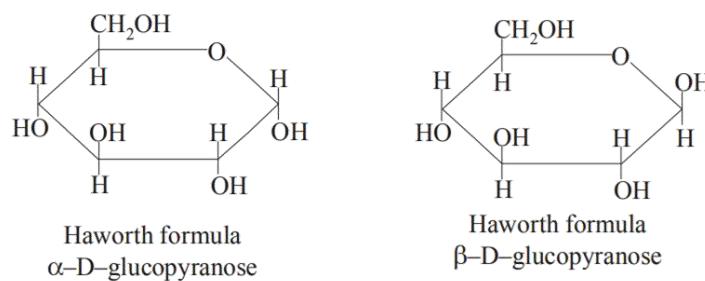
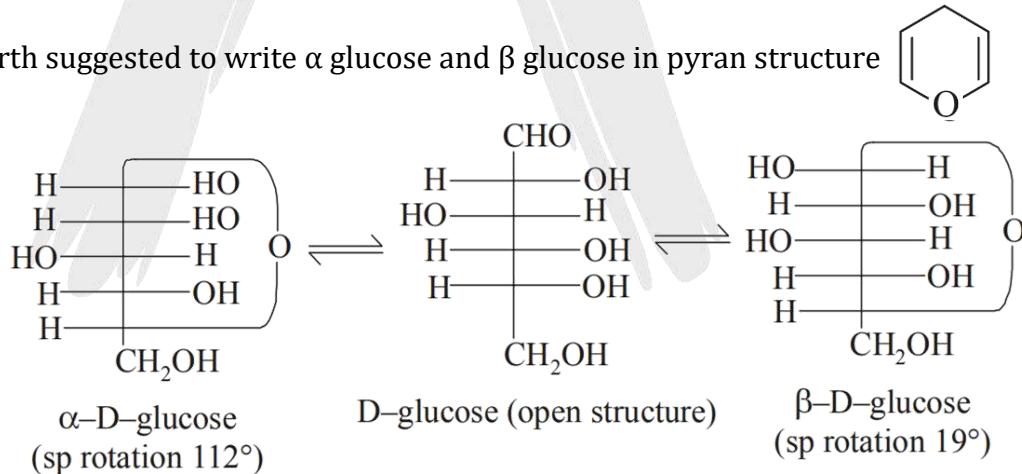
Another example with C<sub>2</sub> epimeric carbon is



**Anomers:** Anomers are the stereoisomers which differ at a single chiral centre out of many & are ring chain tautomer of the same open chain compound.

The two sugars that differ in configuration only on the carbon that was the carbonyl carbon in the open chain form are called anomers.  $\alpha$ -D-glucose and  $\beta$ -D-glucose are known as anomers. Their equilibrium mixture contains 36%  $\alpha$ -D-glucose, 63.8%  $\beta$ -D-glucose and 0.2% open chain form. C<sub>1</sub> Carbon is known as anomeric carbon.

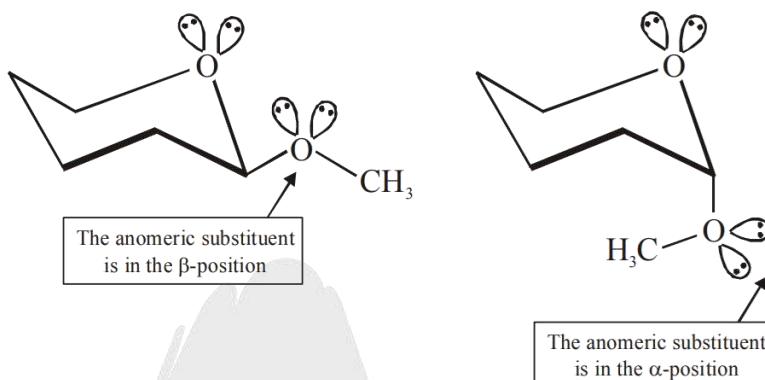
Haworth suggested to write  $\alpha$  glucose and  $\beta$  glucose in pyran structure



Anomers are epimers but epimers may not be anomers.

**Anomeric effect :**

$\beta$ -D-glucose is more stable than  $\alpha$ -D glucose because there is more room for a substituent in the equatorial position. However when glucose reacts with an alcohol to form a glucoside, the major product is the  $\alpha$ -glucoside. The preference for the axial position by certain substituents bonded to the anomeric carbon is called anomeric effect.



What is responsible for the anomeric effect? One clue is that all the substituents that prefer the axial position have lone pair electrons on the atom bonded to the ring. The lone pair electrons of the anomeric substituent have repulsive interaction with the lone pair electron of the ring oxygen if the anomeric substituent is the  $\beta$ -position, but not if it the  $\alpha$ -position.

Apparently attractive interaction of the hydrogen of the anomeric OH group of D-glucose with the lone pair electron of the ring oxygen decreases the importance of the anomeric effect making  $\beta$ -D glucose more stable than  $\alpha$ -D glucose. However, when the hydrogen is replaced by an alkyl group, the anomeric effect decreases the stability of the  $\beta$ -position so,  $\alpha$ -glycosides are more stable than  $\beta$ -glycosides.

**Cyclic structures of monosaccharides**

Many five membered and six membered monosaccharides occur in cyclic form. Cyclic structures of monosaccharides are established by many experiments. The cyclic structure is due to intramolecular hemiacetal formation between aldo / keto group and OH of any one carbon. The ring formed are generally six membered (pyranose) or five membered (furanose). Each cyclization results in creation of a new asymmetric centre apart from the existing ones. The isomers resulting from cyclizations are called anomers. example, when D-glucose (open structure) cyclise, it gives  $\alpha$ -D-glucose and  $\beta$ -D-glucose.

**Haworth projection :-**

Many of monosaccharides form cyclic structures. The actual structure is almost planer and be represented by Haworth projection, which is a way of depicting three - dimensional cyclic structure.

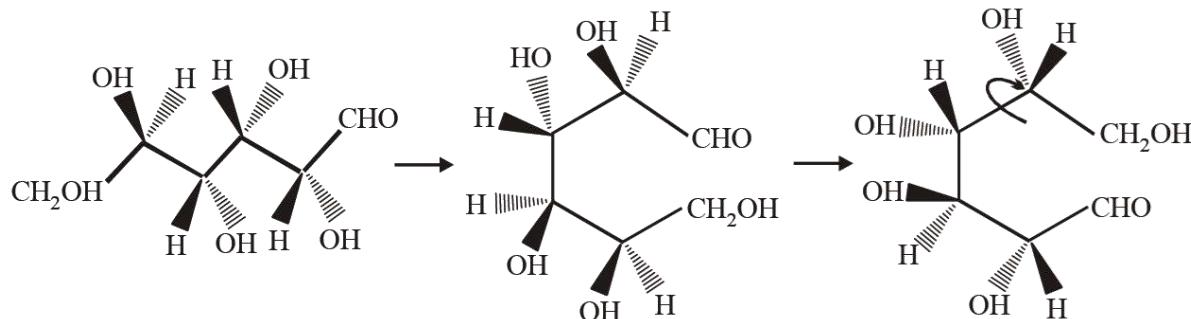
**Rule -1 :-** In a Haworth projection draw a fisher projection in which ring oxygen is in a down position.

**Rule -2 :-** Imagine that carbon chain of fisher projection is folded around a barrel or drum, which provide a ring lies in a plane  $\perp$  to the page.

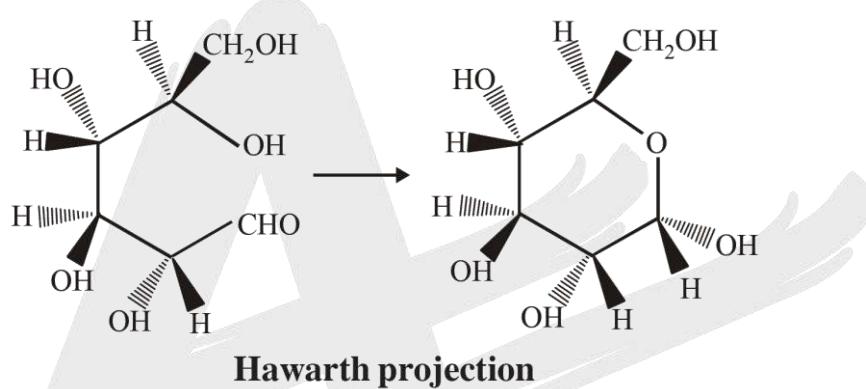


**Rule -3 :-** Now plane of ring is turned  $90^\circ$  so that anomeric carbon is on the right and the ring oxygen is in the rear. Obtained projection is a Haworth projection.

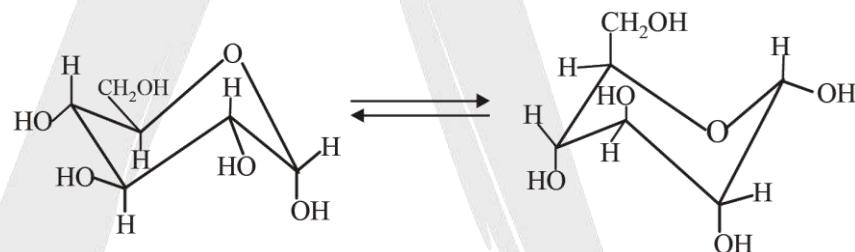
**Example :** (D-glucose)



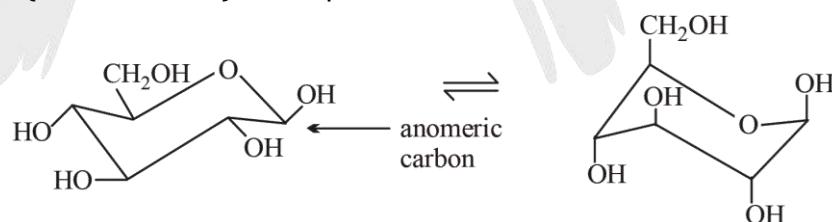
## Projection :



⇒ Chair conformation of D-glucose

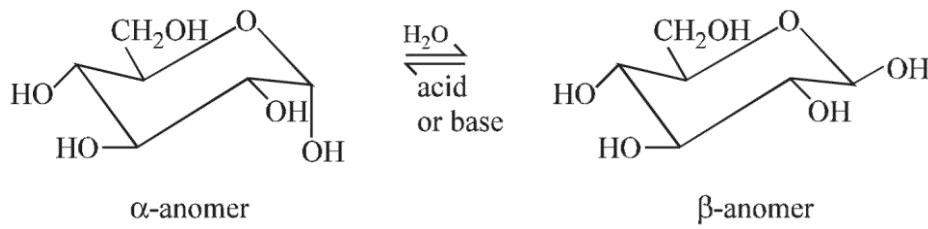


### Chair forms of (conformation) $\alpha$ and $\beta$ D-Glucose :



**$\alpha$ -D-Glucose –OH group at anomeric carbon is axial.**

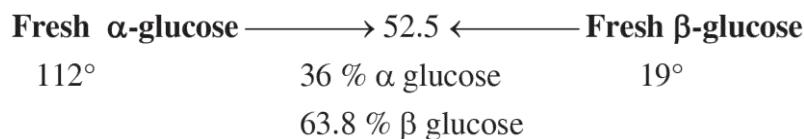
## Mutarotation



Specific rotation of  $\alpha$  glucose +112°

Specific rotation of  $\beta$  glucose +19°

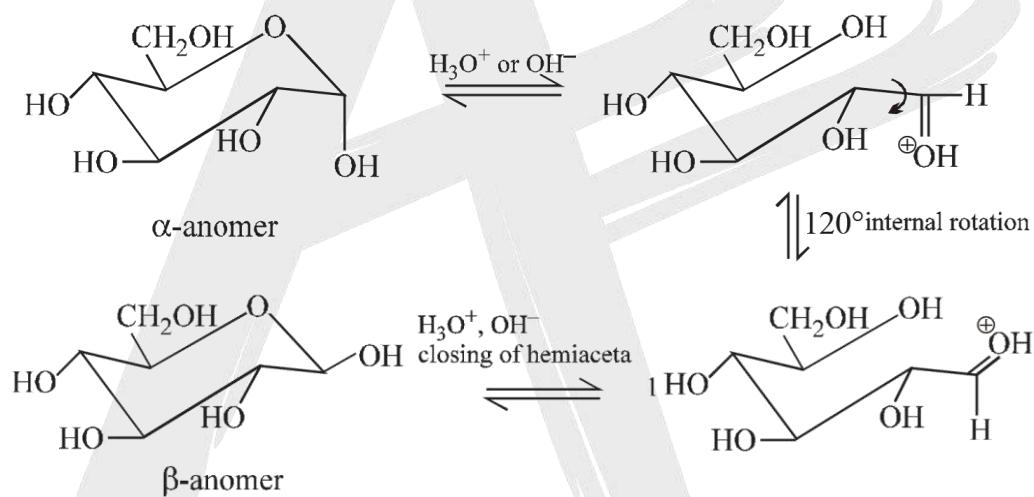
Equilibrium mixture  $[\alpha]_D = 52.5$  degree mLg<sup>-1</sup>dm<sup>-1</sup>



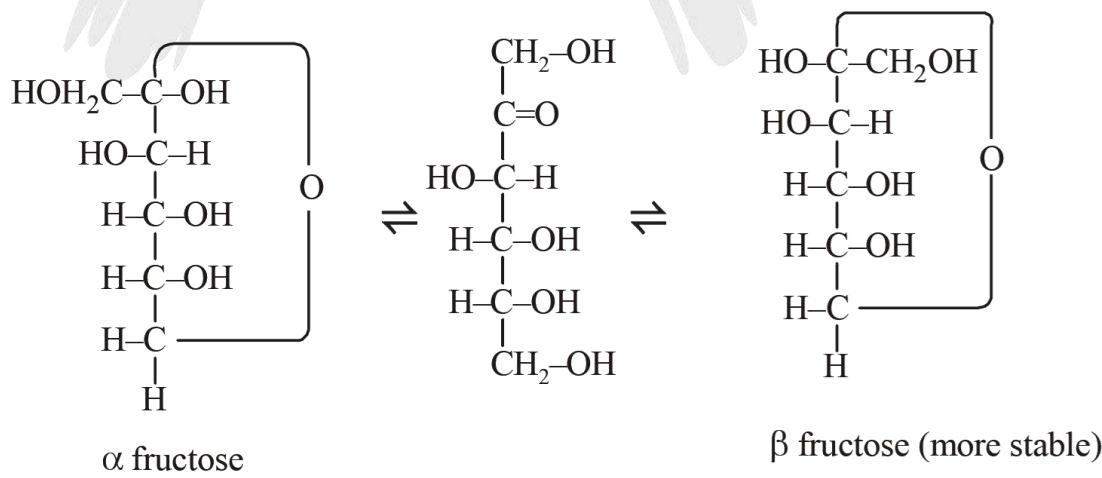
When pure  $\alpha$ -D glucose is dissolved in water its specific rotation is found to be  $+112^\circ$  with time, however the specific rotation of the solution decreases ultimately reaches stable value of  $+52.5^\circ$ . When  $\beta$ -D-glucose is dissolved in water, it has a specific rotation of  $19^\circ$ . The specific rotation of this solution increases with time also to  $+52.5^\circ$ .

It is caused by the conversion of  $\alpha$  and  $\beta$  glucopyranose anomers into an equilibrium mixture of both. Mutarotation is catalyzed by both acid and base, but also occurs even in pure water. Mutarotation is characteristic of the cyclic hemiacetal form of glucose.

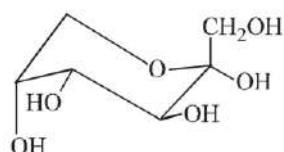
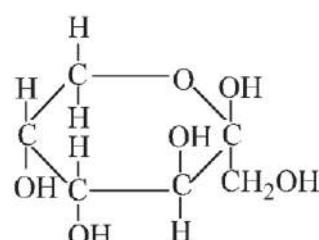
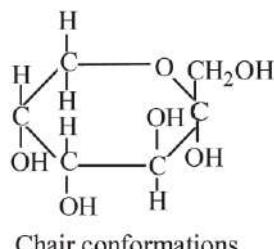
Mutarotation occurs first by opening of the pyranose ring to the free aldehyde form.



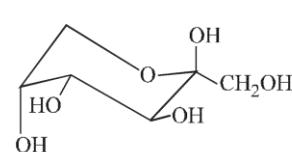
## Structure of fructose



Ring structure of fructose C, Pyranose structures 6 membered ring, C<sub>2</sub> – C<sub>6</sub> linkage

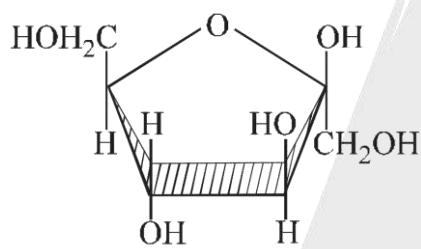


$\alpha$ -D-fructopyranose

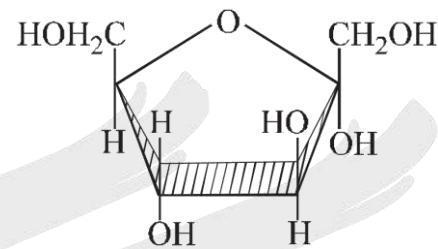


$\beta$ -D-fructopyranose

Furanose structure (5 membered ring)

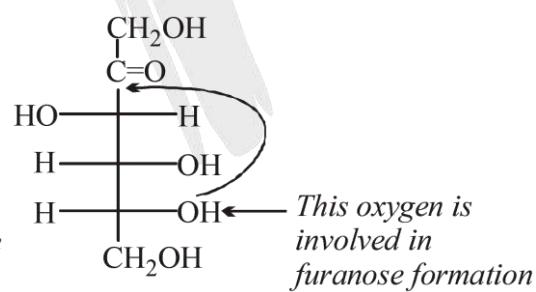
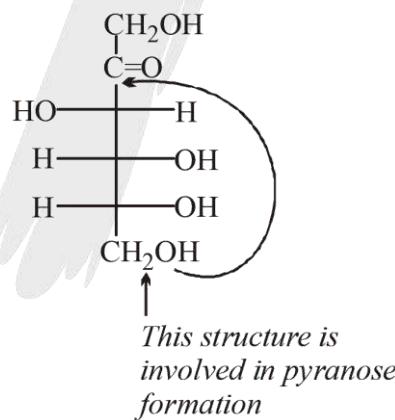


$\beta$ -D-fructofuranose

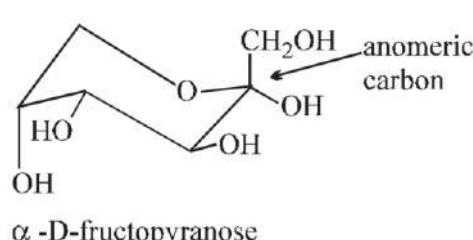
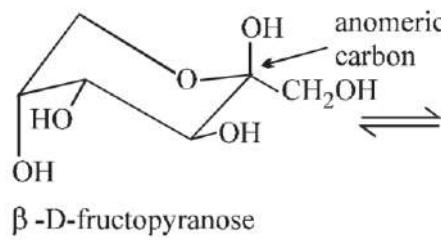


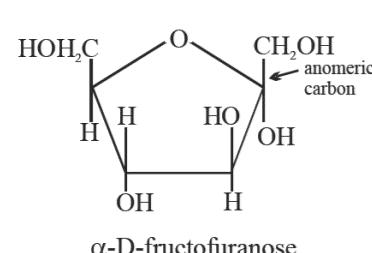
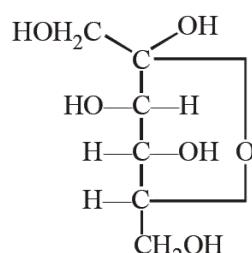
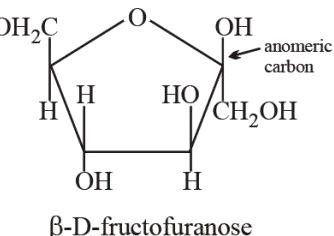
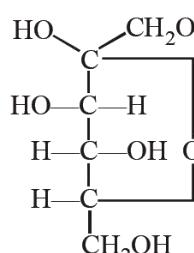
$\alpha$ -D-fructofuranose

**Mutarotation:** Fructose undergoes complex mutarotation. The structure of the cyclic hemiacetal form of D-fructose can be derived from its carbonyl (Ketone) form using the methods described as follows.



It happens that the crystalline form of D-fructose is  $\beta$ -D-Fructopyranose. When crystals of this form are dissolved in water, it equilibrates to both pyranose & furanose forms.

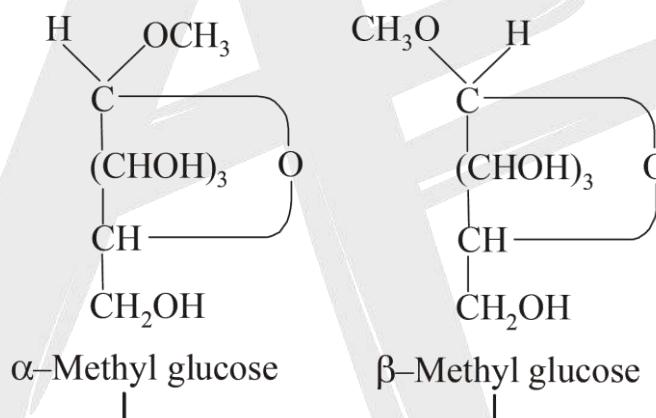




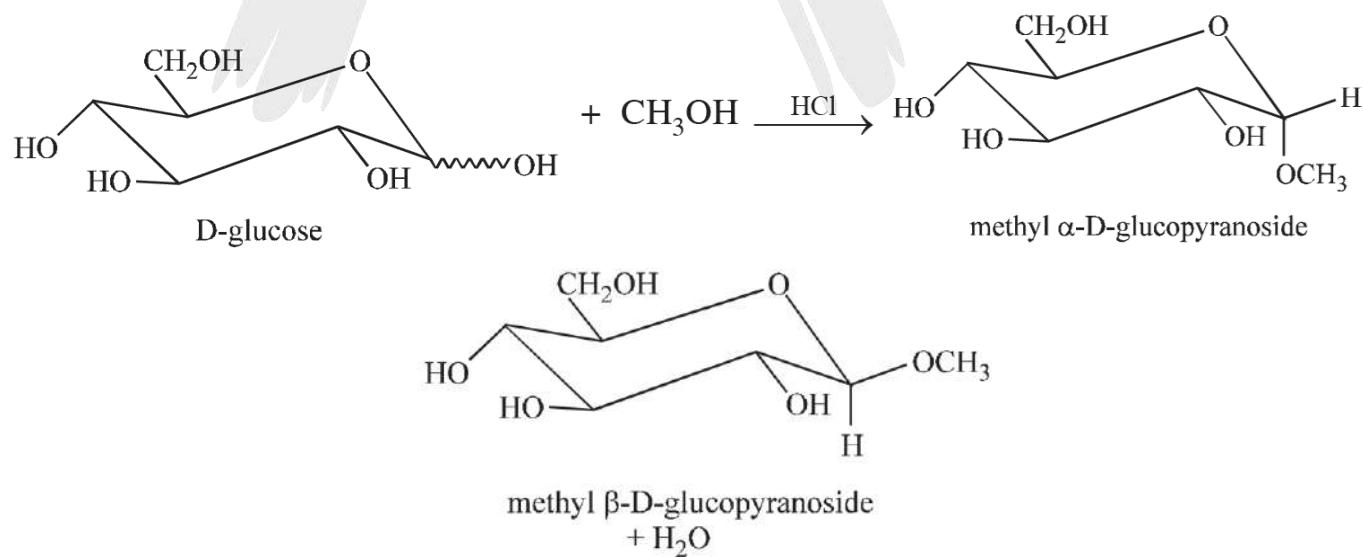
- \* All monosaccharides are reducing sugars and they show mutarotation.
- \* Starch, cellulose are Polymers of Glucose
- \* Lactose and sucrose are disaccharides
- \* Sucrose is a non reducing sugar, gives negative test for Benedict and tollen's reagent, they do not form osazone and do not show mutarotation.
- \* Acetals of carbohydrates are called as GLYCOSIDE

### Formation of Glycosides

Glucose reacts with methyl alcohol in presence of dry HCl to form  $\alpha$  and  $\beta$ -methyl glycoside of glucose. The reaction takes place only on OH of hemi-acetylic carbon. Other hydroxyl groups are unreactive.



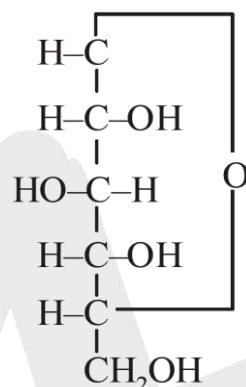
To methylate all the OH groups, methylating agent used is dimethyl sulphate.



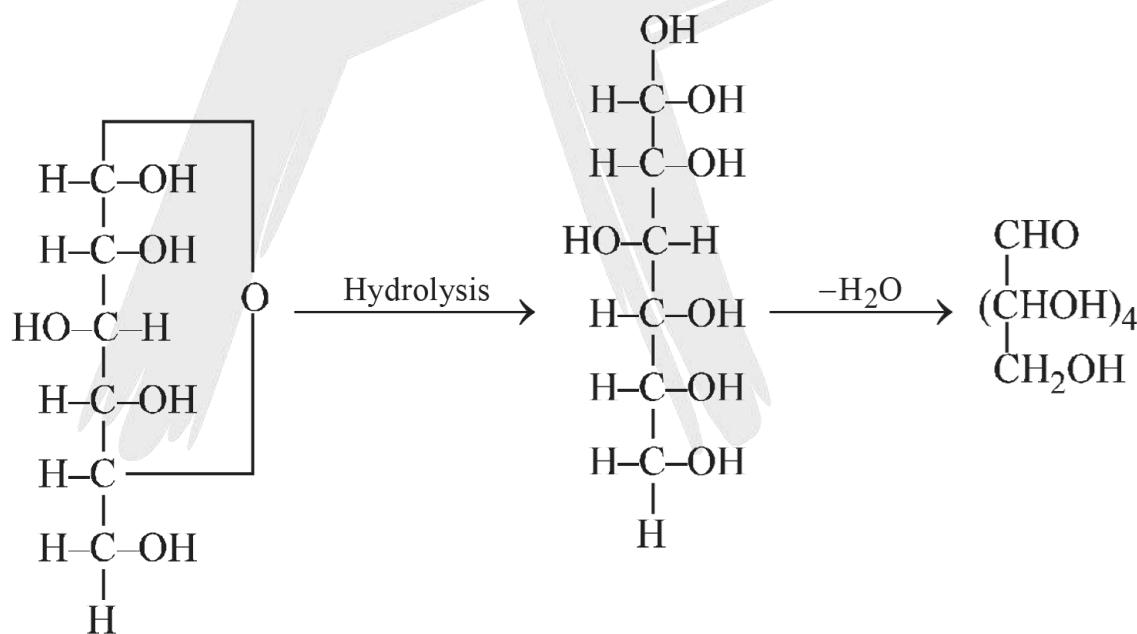
Such compounds are called glucoside (cyclic acetals). They are special type of acetals in which one of the oxygen of the acetal linkage is the ring oxygen of the pyranose or furanose.

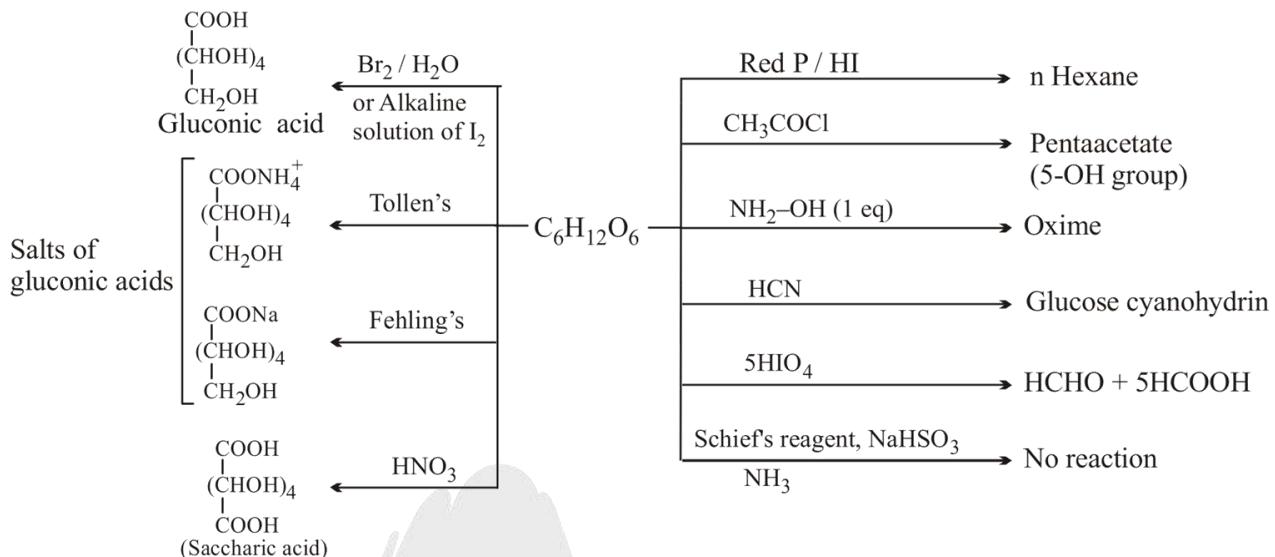
### Ring structure of glucose :

- (i) Glucose does not give pink colour with schief reagent.
- (ii) Does not form adduct with  $\text{NaHSO}_3$ ,  $\text{NH}_3$
- (iii) Glucose exist in two isomeric form
- (iv) It show mutarotation

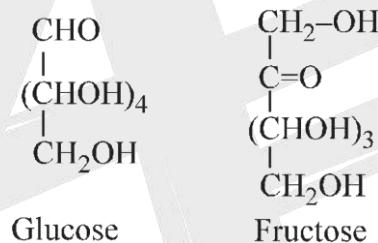
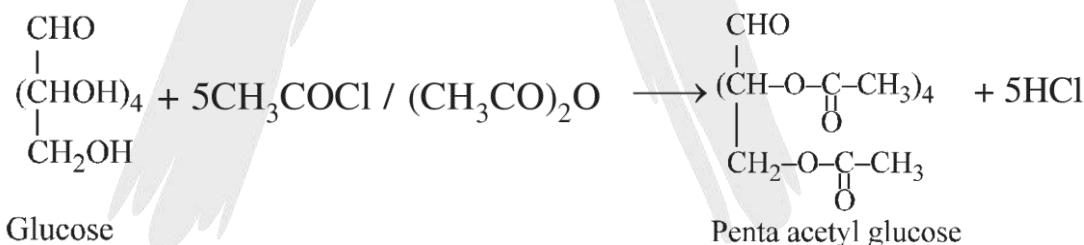


Since there is no free aldehyde group, so it does not react with weak reagent ( $\text{NH}_3$ ,  $\text{NaHSO}_3$ ) but strong reagent ( $\text{HCN}$ ,  $\text{NH}_2\text{OH}$ ,  $\text{C}_6\text{H}_5\text{NH} - \text{NH}_2$ ) break up ring



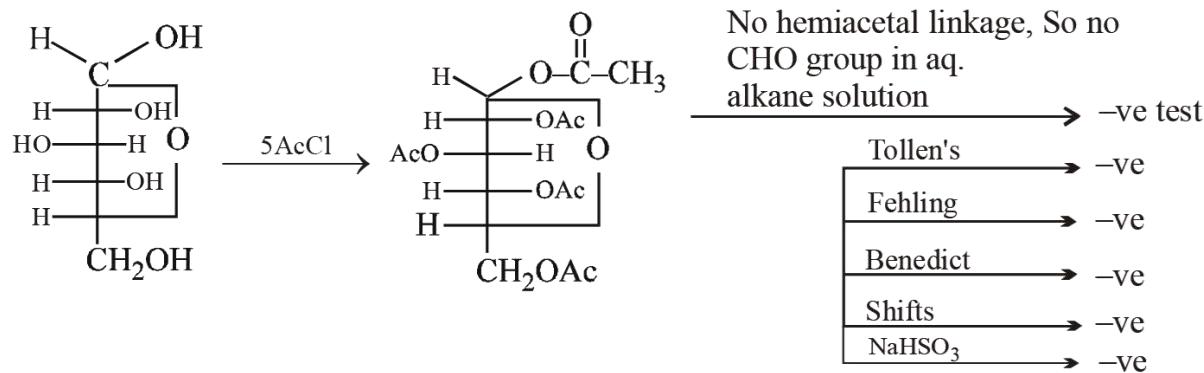
**REACTIONS OF GLUCOSE**

These reactions indicate that glucose has 6-C straight chain with one - CHO group & 5-OH group.

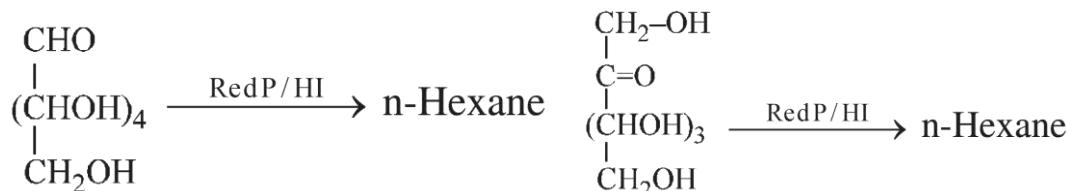
**General reactions of monosaccharides****1. Acetylation :**

This reaction suggests presence of 5(OH) group.

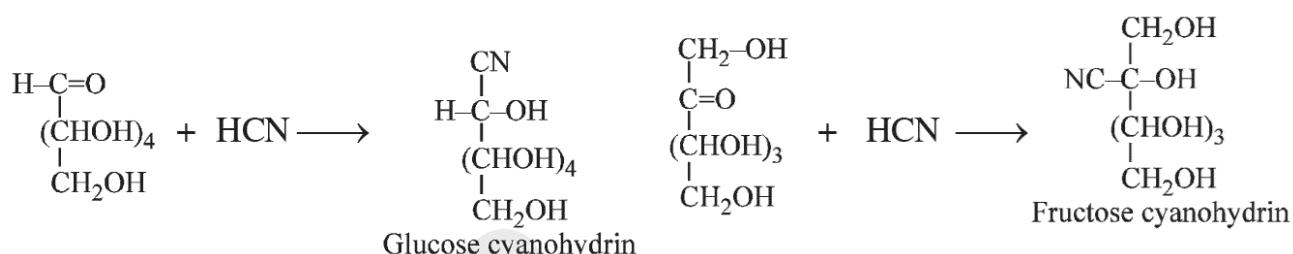
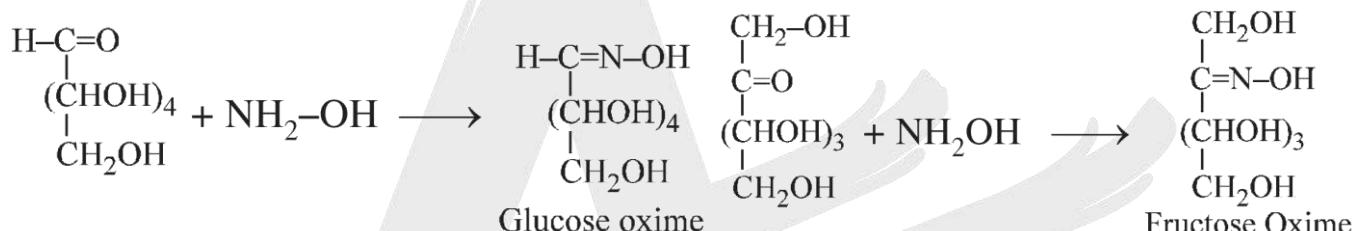
Q. The penta acetate of glucose give -ve test with Tollen's reagent & Fehling solution, explain?



## 2. Red by HI / Red P :

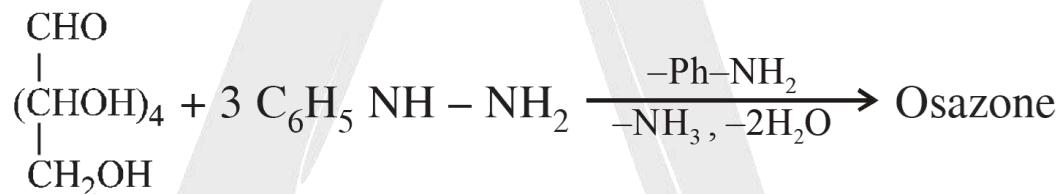


## 3. Reaction with HCN:

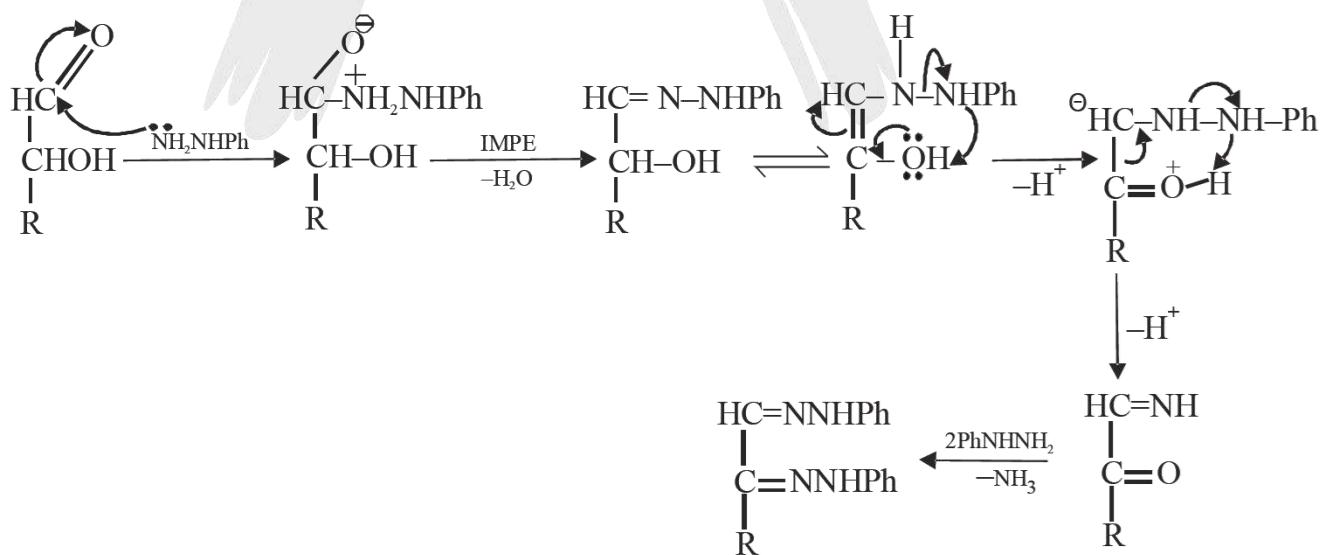
4. Reaction with NH<sub>2</sub> – OH (hydroxyl amine):

## 5. Reaction with phenyl hydrazine: Both glucose and fructose give "osazone". Reaction with glucose :

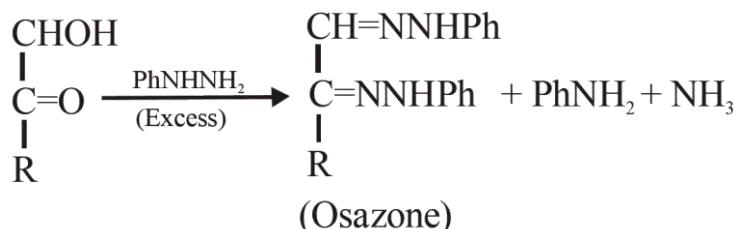
Reaction with glucose :



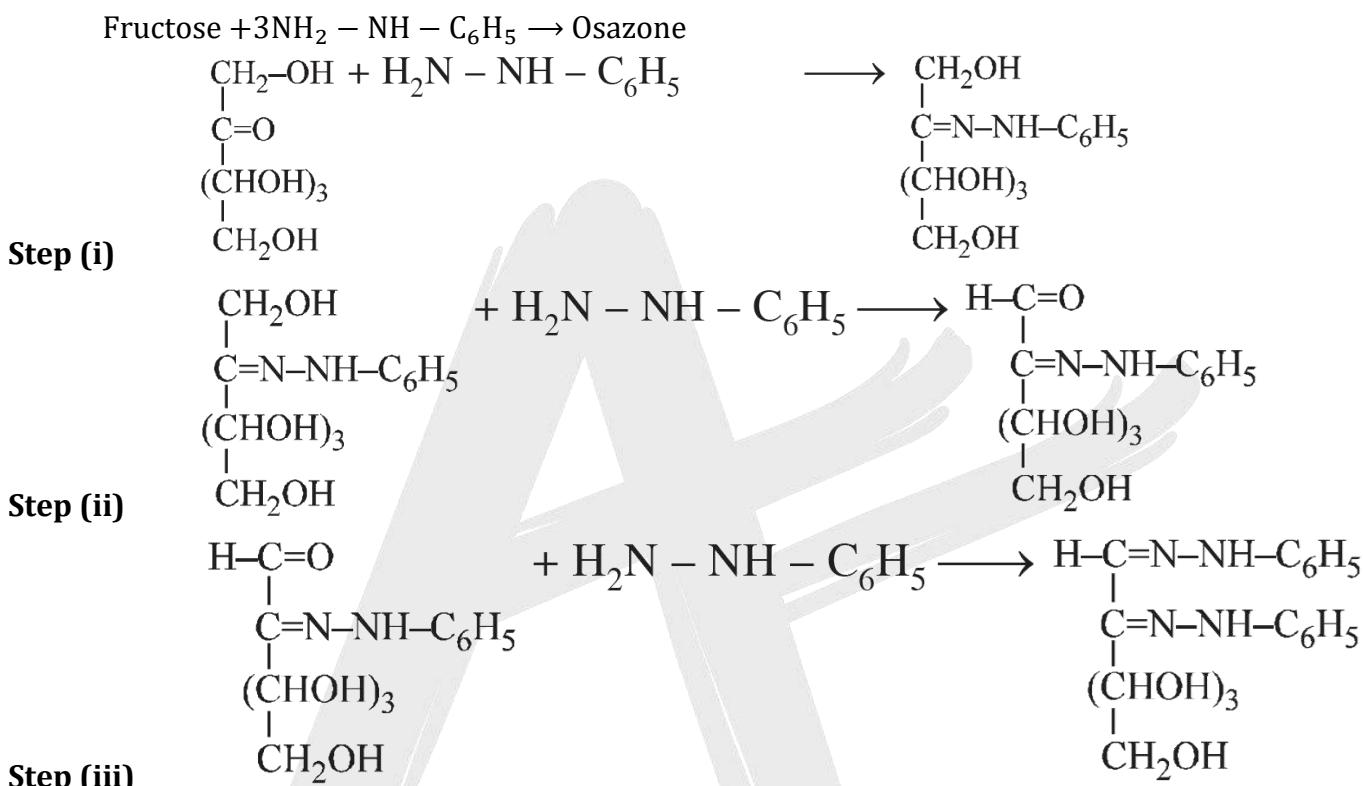
## Mechanism :



**Propose Mechanism for :**



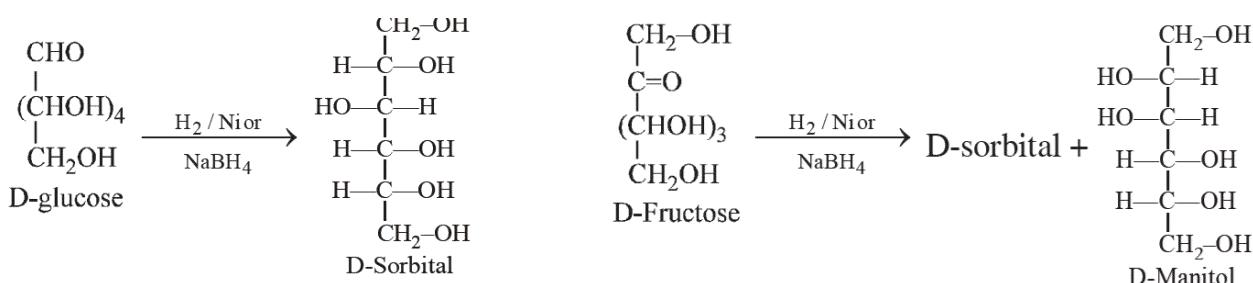
**Reaction with fructose :**



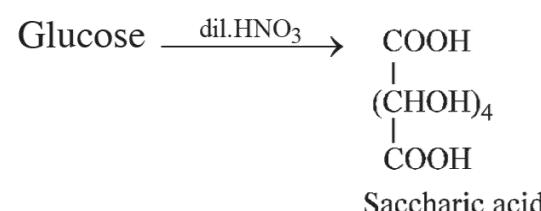
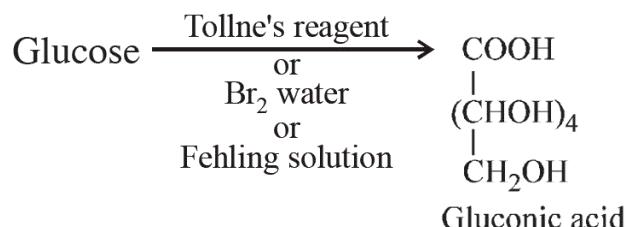
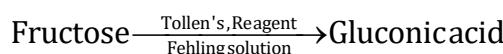
Glucose , Mannose & Fructose give same osazone because structure of last four carbons in these carbohydrates is same.

Only C-1 and C-2 in glucose and fructose are involved in osazone formation addition reaction do not run through out the chain. The failure to undergo further reaction has been explained by stabilization of the osazone by chelation.

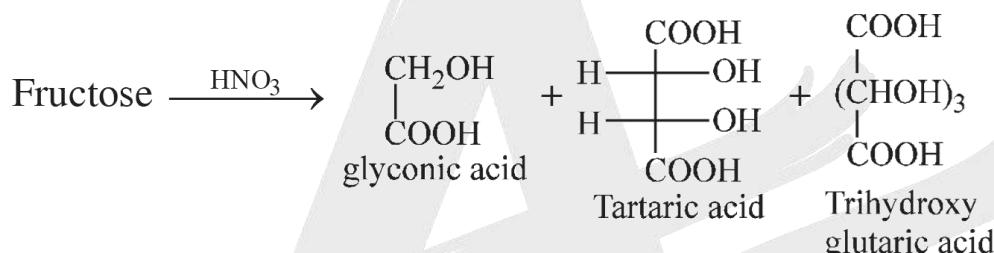
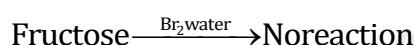
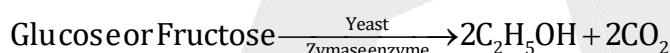
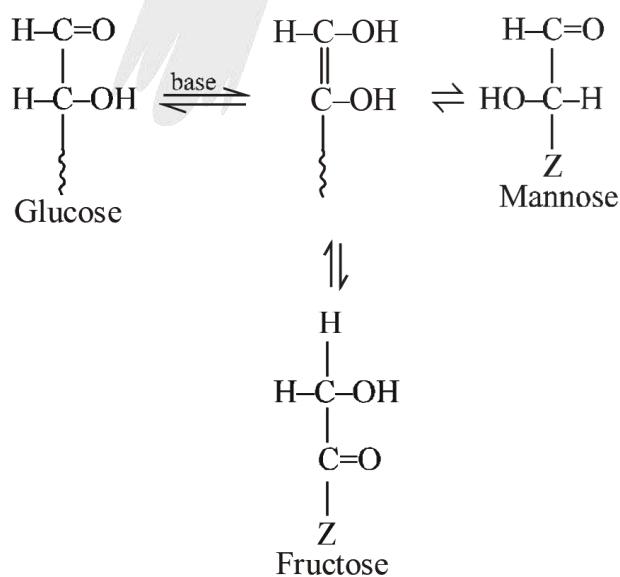
#### 6. Catalytic reduction:



#### 7. Oxidation:

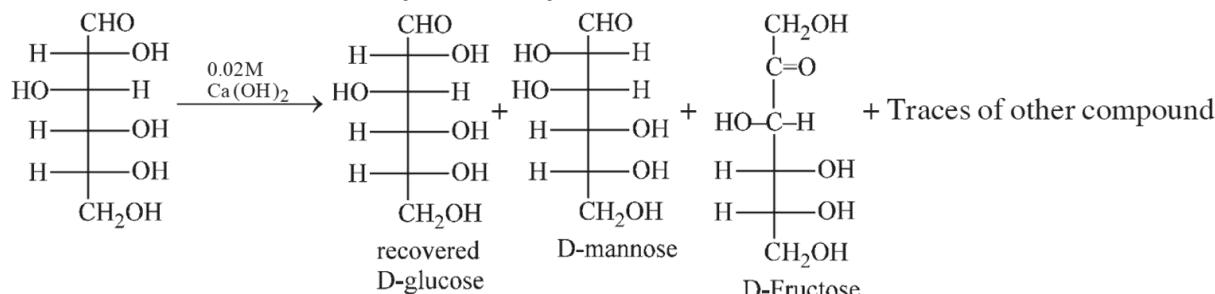
**Oxidation of fructose :**

Fructose also reduces tollen's & fehling reagent because in basic medium fructose isomerises to glucose.

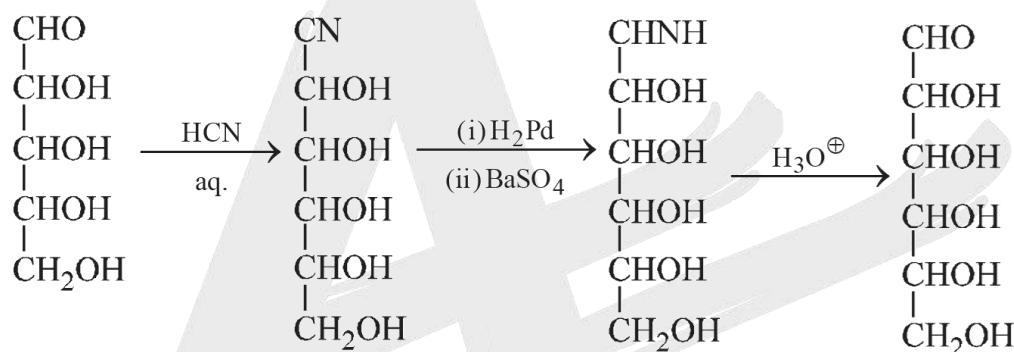
**8. Reaction with enzyme:****9. Reaction with dil NaOH / Ca(OH)<sub>2</sub>****Mechanism :**

**Base-catalyzed isomerisation of aldoses and Ketoses:**

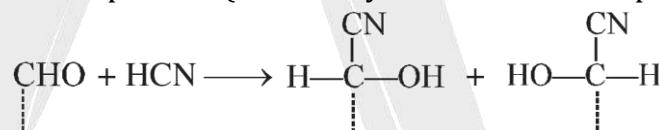
Although glucose in solution exists mostly in its cyclic hemiacetal forms it is also in equilibrium with a small amount of its acyclic aldehyde form.



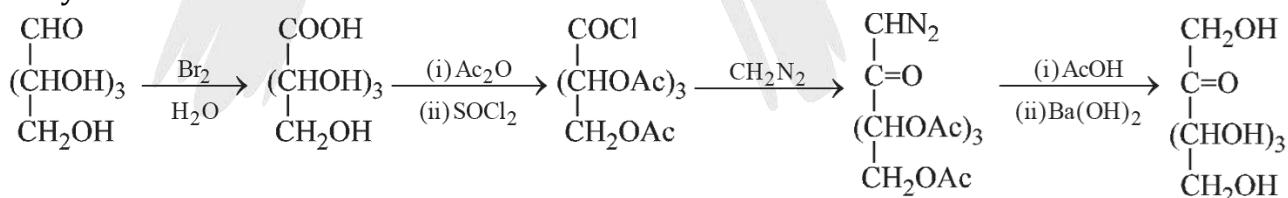
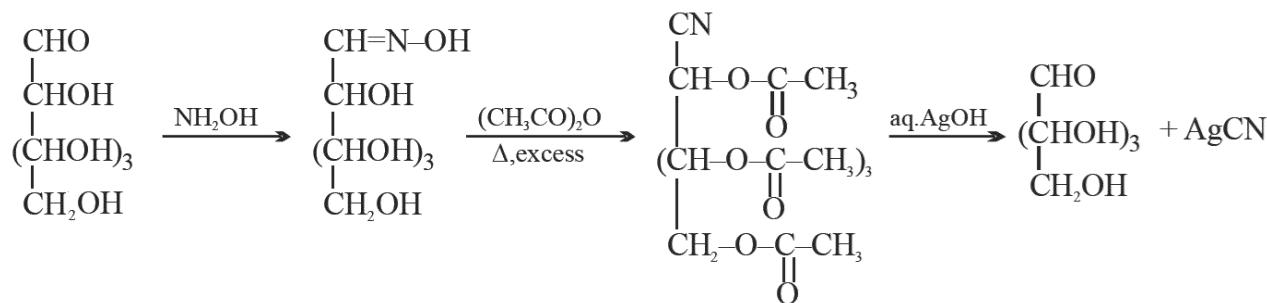
**Method of ascending the sugar series:** An aldose may be converted into its next higher aldose eg. an aldopentose into an aldohexose.

**By Kiliani Fischer upgradation:**

Theoretically two lactones are possible, since two cyanohydrin may be formed when hydrogen cyanide adds on to the aldopentose (a new assymetrical carbon is produced)



**Wolfrom reaction:** Wolfrom have stepped up an aldose to a ketose with one more carbon atom by a modified Arndt-Eistere reaction.

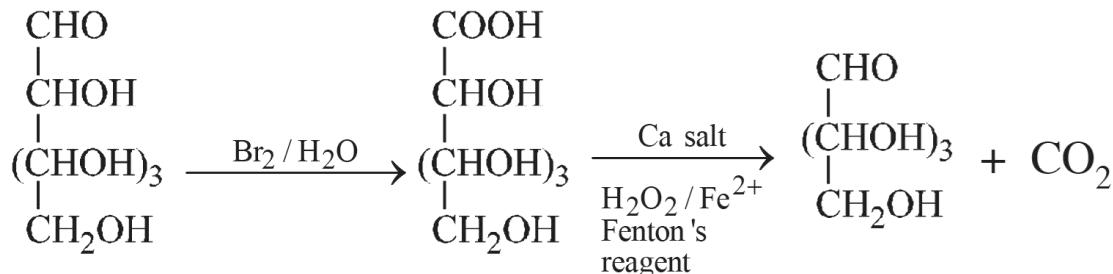
**Method of descending the sugar series:****Wohl's method:**

## **(Organic Chemistry)**

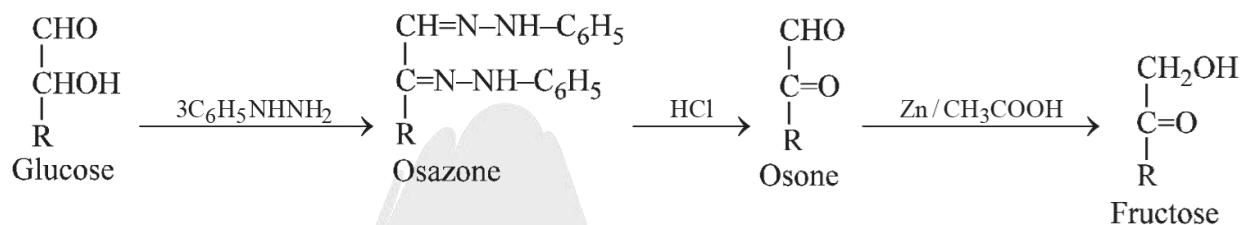
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BIOMOLECULES

## Ruff's method:

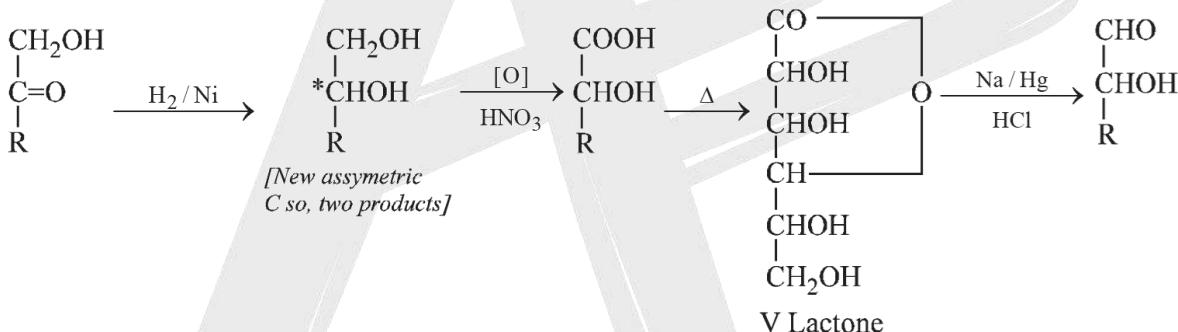


### **Conversion of an aldose into a ketose :**



**An aldehyde group is reduced more readily than a ketonic group.**

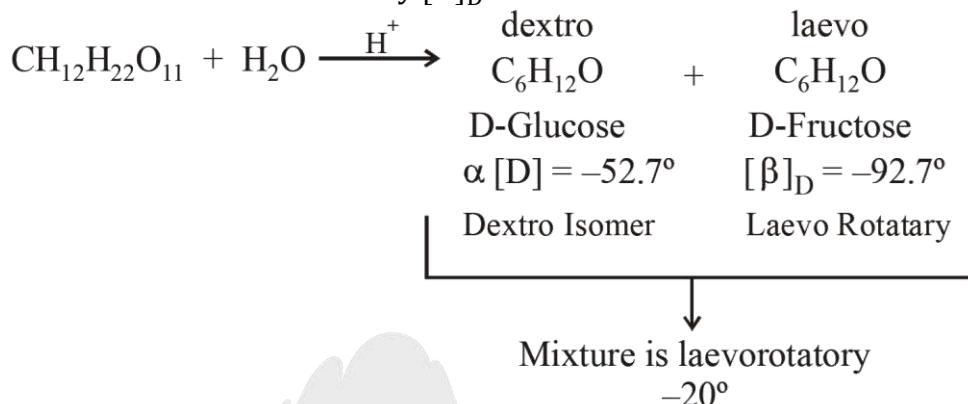
## **Conversion of a Ketose into an aldose :**



## SOME IMPORTANT CARBOHYDRATES

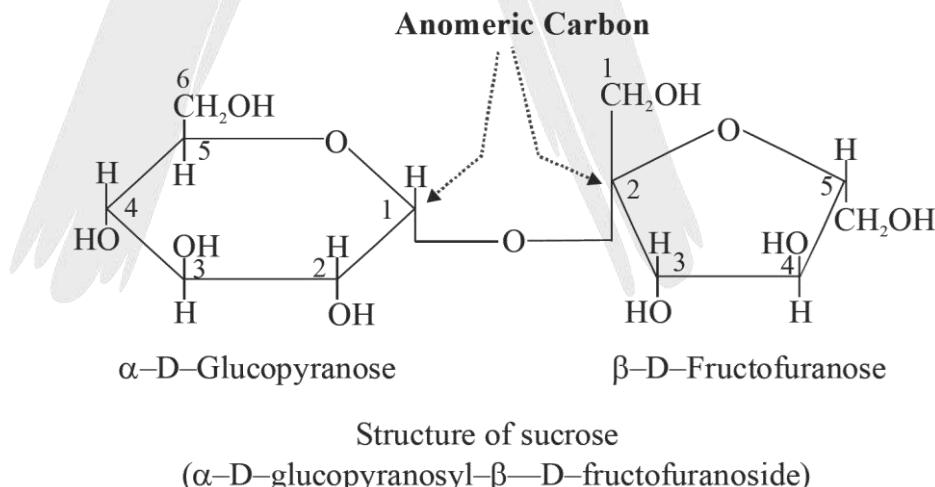
1. Sucrose ( $C_{12}H_{22}O_{11}$ ): → A dimer of  $\alpha$ -D-Glucose &  $\beta$ -D-Fructose. It is white, crystalline & sweet substance soluble in water obtained from the sugar cane. When heated above its melting point. It forms a brown substance known as caramel.

It's aqueous solution is dextrorotatory  $[\alpha]_D = +66.5^\circ$

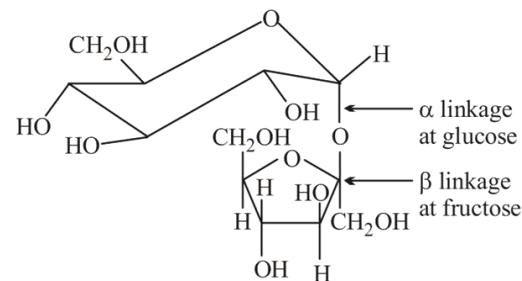
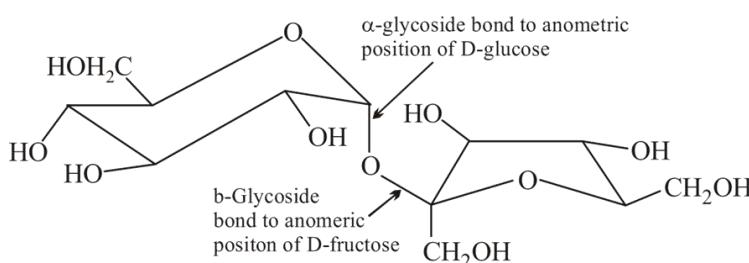


Thus hydrolysis of sucrose brings about a change in the sign of rotation, from dextro (+) to leavo (-) & such a change is known as inversion of sugar and the mixture obtained on acidic hydrolysis is known as invert sugar.

- The inversion of cane-sugar may also be done by the enzyme invertase which is found in yeast.
- Sucrose is non-reducing sugar because it has stable acetal linkage & in aq. solution it does not give free carbonyl group and so it does not reduce Tollen's & Fehling's solution.
- This indicates that neither the aldehyde group of glucose nor the ketonic group of fructose is free in sucrose.



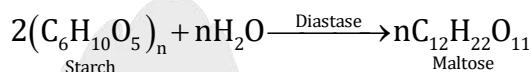
Do not show mutarotation.



## 2. Maltose :

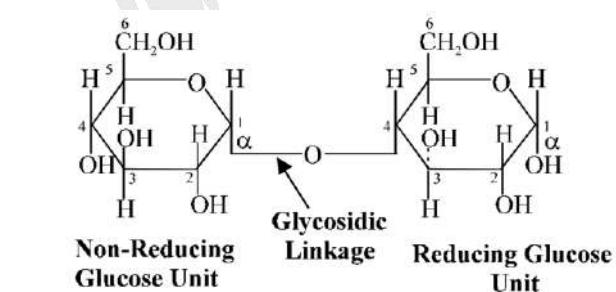
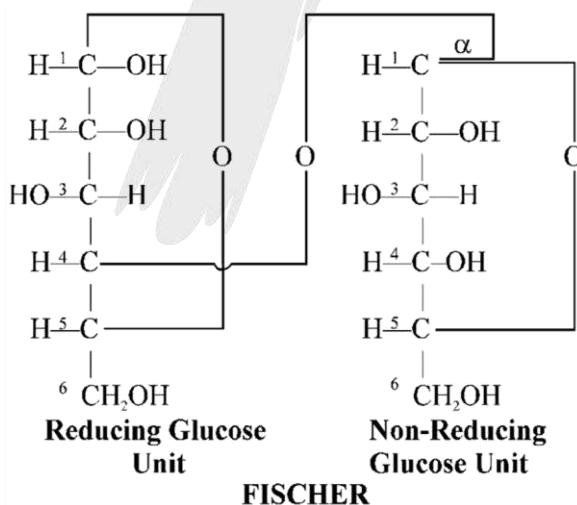
- It is dimer of  $\alpha$ -D-Glucose

It is obtained by partial hydrolysis of starch by the enzyme diastase present in malt i.e., sprouted barely seeds.



- Hydrolysis of one mole of maltose yields two moles of D-glucose.
- Maltose is a reducing sugar since it forms an osazone, undergoes mutarotation and also reduces Tollen's reagents and Fehling's solutions, Methylation studies have revealed that
  - Both glucose units are present in the pyranose form.
  - $C_1$  of one glucose unit is linked to  $C_4$  of the other

Further since maltose is hydrolysed by the enzyme maltose which specifically hydrolyses  $\alpha$ -glycosidic linkage, therefore, the non-reducing glucose unit in maltose must be present in the  $\alpha$ -form. In other words,  $C_1 - \alpha$  of non-reducing glucose unit is attached to  $C_4$  of the reducing glucose unit as shown in the figure on next page.



HAWORTH PROJECTION FORMULAE OF  $\alpha$ -D-MALTOSE

## 3. Lactose (Milk sugar) $C_{12}H_{22}O_{11}$

Lactose occurs in milk and that is why it is called milk sugar.

Lactose on hydrolysis with dilute acid or by enzyme lactase, yields an equimolar mixture of D-glucose and D-galactose. It is a reducing sugar it forms an osazone, undergoes



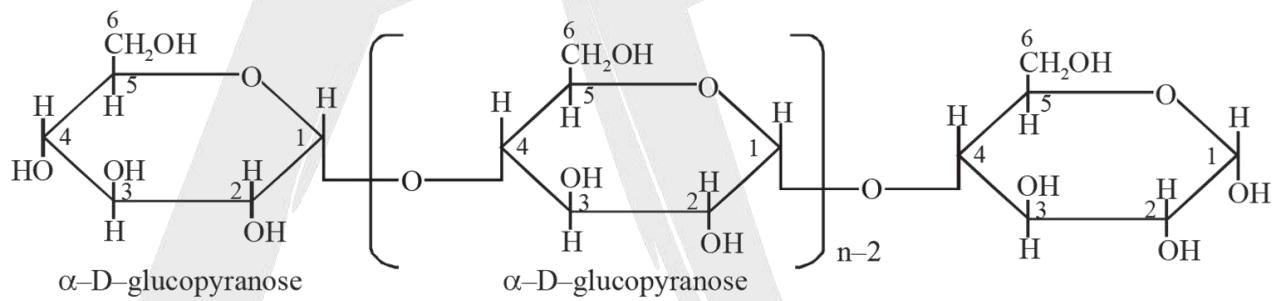
mutarotation and also reduces Tollen's or Fehling's solution. Methylation studies have revealed that

- (i) both glucose and galactose are present in the pyranose form.
  - (ii) glucose is the reducing half while  $\beta$ -galactose is the non-reducing half.
  - (iii) C<sub>1</sub> of galactose unit is connected to C<sub>4</sub> of glucose unit.

#### **4. Starch Amylum, $(C_6H_{10}O_5)_n$**

**Occurrence :** The value of n (100 – 3000) generally however it may varies from source to source. It is the chief food reserve material or storage polysaccharide of plants and is found mainly in seeds, roots tubers wheat, maize, rice, potatoes, barley, bananas and sorghum are the main sources of starch. Starch occurs in the form of granules, which vary in shape and size depending upon their plant source.

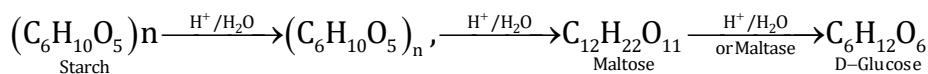
Occurs in all green plants. Starch consists of two fractions, one being known as (amylose), which gives blue colour with iodine. This blue colour is believed to be due to the formation of an inclusion complex. An aqueous solution of  $\alpha$ - amylose slowly forms a precipitate, since  $\alpha$ - amylose has a strong tendency to 'revert' to the insoluble state in solution. Amylopectin is insoluble in water and is stable towards both hydrolysis to maltose by the enzyme diastase and to D(+) glucose by dilute acids (amylopectin gives about 50 percent of maltose).



### Structure of Starch ( $\alpha$ -D-glucoamylose)

$\alpha$ -amylose consists of an unbranched chain, with a molecular weight varying between 10,000( $n \approx 60$ ) and 10,00,000( $n \approx 6,000$ ), The value of  $n$  depends on the source and treatment of  $\alpha$ -amylose.

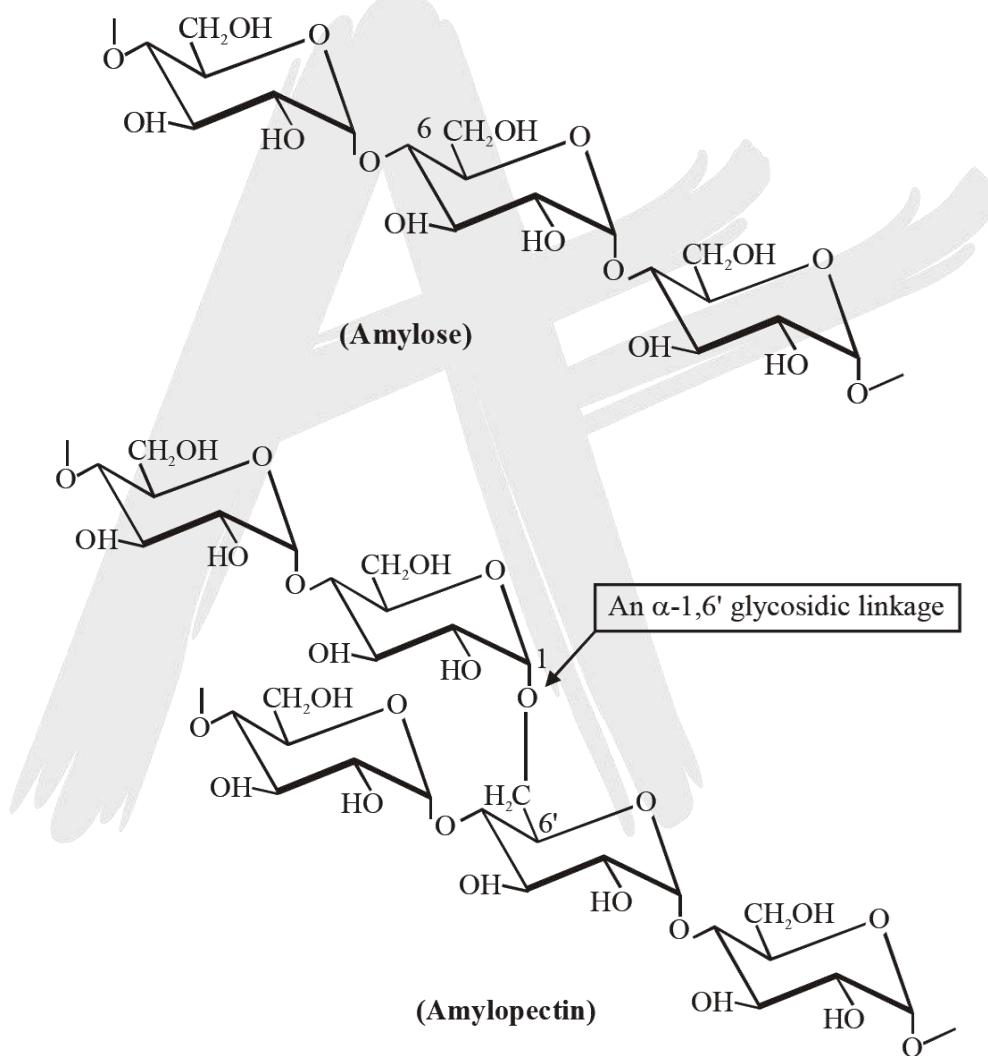
**Properties :** (i) Starch is a white amorphous powder sparingly soluble in water. Its aqueous solution gives a blue colour with iodine solution due to the formation of an inclusion complex. The blue pears on cooling. (ii) On hydrolysis with dilute mineral acids or enzymes, starch breaks down first to smaller molecules ( $n > n'$ ), then to maltose and finally to D-glucose.



(iii) Starch is a non-reducing saccharide. It neither reduces Tollen's reagent or Fehling's solution nor forms an osazone. This suggests that all hemiacetal OH groups of glucose units at C<sub>1</sub> are not free but are involved in glycosidic linkages.

**Composition :** Starch is not a single compound but is a mixture of two components-a water soluble component called amylose (10-20%) and a water insoluble component called amylopectin (80-90%). Both amylose and amylopectin are polymers of α-D-glucose.

**Structure of amylose :** Amylose is water soluble and gives blue colour with iodine solution. It may have 100-3000 glucose units, i.e., its molecular mass can vary from 10,000 to 500,000. It is a linear polymer of α-D-glucose in which C<sub>1</sub> of one glucose unit is attached to C<sub>4</sub> of the other through α glycosidic linkage as shown in figure.



### Pectins

Pectins are found in plant and fruit juices. Their characteristic property is the ability of their solutions to gelate, i.e. form jellies. They have a high molecular weight and are polygalacturonic acid (linked 1,4) with the carboxyl groups partially esterified with methanol.

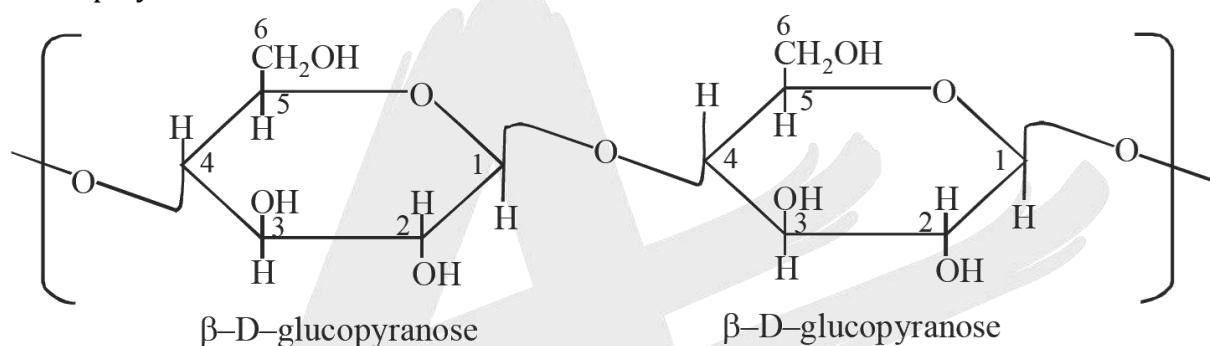
### Glycogen ( $C_6H_{10}O_5)_n$ :

Glycogen is found in nearly all animals cells, occurring mainly in liver. It is the reserve carbohydrate of animals and so is often known as 'animal starch'. It has also been isolated from plant sources. Glycogen is a white powder, soluble in water, the solution giving a purplish-red colour with iodine. On hydrolysis with dilute acid, glycogen gives D(+) - glucose. The molecular weight of glycogen has been given as 10,00,000 to 50,00,000 and glycogen contains highly branched chains. Glycogen has a structure similar to amylopectin, except that it has more cross-linking.

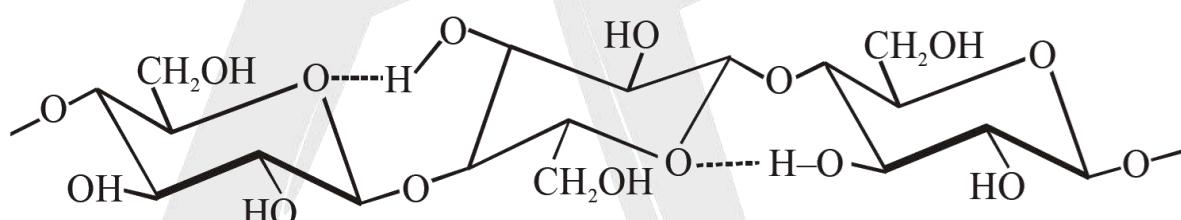
## 5.

**Cellulose:**

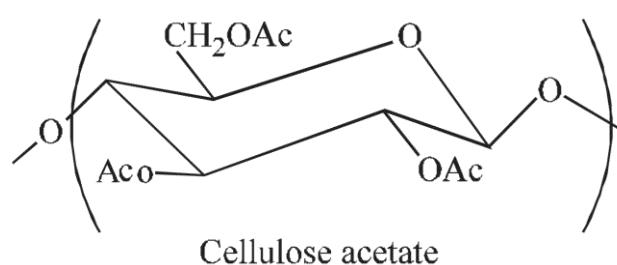
Cellulose is colourless, solid which is insoluble in water & organic solvents. But it is soluble in ammonical cupric hydroxide (Schweizer's reagent) or in conc. HCl cellulose is a regular polymer of d-glucopyranose residues connected by  $\beta - 1,4$  glycosidic linkages. It is straight chain polymer.



(Structure of Cellulose)

**Some points about cellulose :**

1. General empirical formula ( $C_6H_{10}O_5$ )
2. Cellulose  $+H_2O \xrightarrow{H^+}$  96% of crystalline D-glucose
3. No. of monomer units in cellulose are 1000 – 1500 in one molecule.
4. Cellulose doesn't show mutarotation (like starch)
5. It is non reducing sugar because there is no hemiacetal linkage.
6. Acetylation, nitration & methylation of cellulose give trisubstituted cellulose which suggest that only three - OH groups are free.



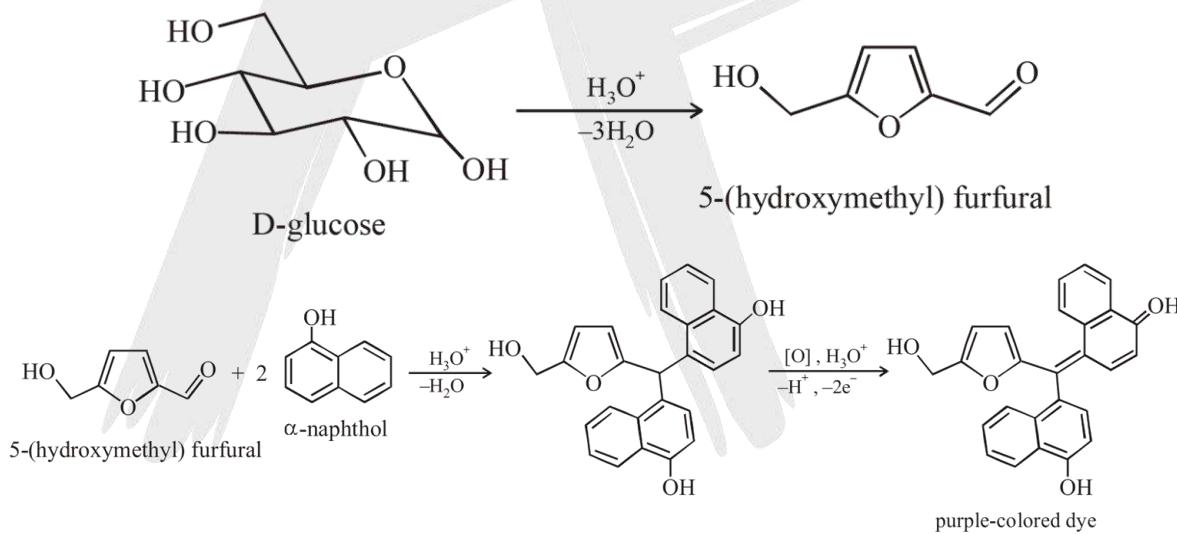
**Tests for carbohydrates:**

(i) When heated in a dry test tube, it melts, turns brown and finally black, giving a characteristic smell of burning sugar.

(ii) When warmed with a little concentrated  $H_2SO_4$ , it leaves a charred residue of carbon.

(iii) Molisch's Test (named after Austrian botanist Hans Molisch) is a sensitive chemical test for the presence of carbohydrates, based on the dehydration of the carbohydrate by sulfuric acid to produce an aldehyde, which condenses with two molecules of phenol (usually  $\alpha$ -naphthol, though other phenols (e.g. resorcinol, thymol) also give colored products) resulting in a red- or purple-colored compound. The test solution is combined with a small amount of Molisch's reagent ( $\alpha$ -naphthol dissolved in ethanol) in a test tube. After mixing, a small amount of concentrated sulfuric acid is slowly added down the sides of the sloping test-tube, without mixing, to form a bottom layer. A positive reaction is indicated by appearance of a purple ring at the interface between the acid and test layers.

All carbohydrates - monosaccharides, disaccharides, and polysaccharides — should give a positive reaction, and nucleic acids and glycoproteins also give a positive reaction, as all these compounds are eventually hydrolyzed to monosaccharides by strong mineral acids. Pentoses are then dehydrated to furfural, while hexoses are dehydrated to 5-hydroxymethylfurfural. Either of these aldehydes, if present, will condense with two molecules of naphthol to form a purple-colored product, as illustrated below by the example of glucose:

**NUCLEIC ACIDS**

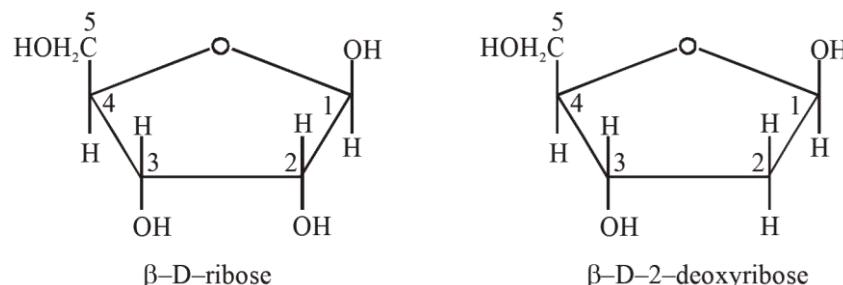
The particles in nucleus of the cell, responsible for heredity, are called chromosomes which are made up of proteins and another type of biomolecules called nucleic acids. These are mainly of two types, the deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Since nucleic acids are long chain polymers of nucleotides, so they are also called polynucleotides.

**Chemical Composition of Nucleic Acids**

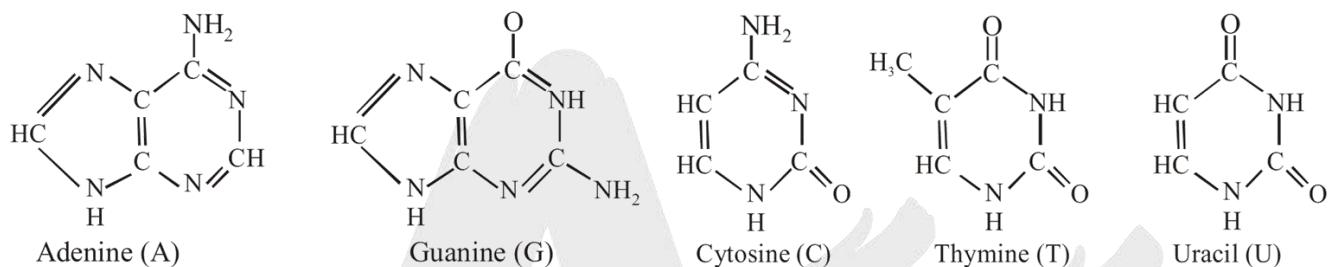
**Chemical Composition of Nucleic Acids**

Complete hydrolysis of DNA (or RNA) yields a pentose sugar, phosphoric acid and nitrogen

containing heterocyclic compounds (called bases). In DNA molecules, the sugar moiety is  $\beta$ -D-2-deoxyribose whereas in RNA molecule, it is  $\beta$ -D-ribose.

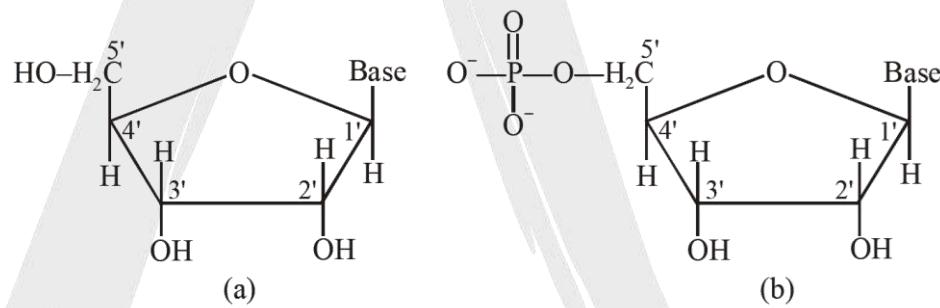


DNA contains four bases viz. adenine (A), guanine (G), cytosine (C) and thymine (T). RNA also contains four bases, the first three bases are same as in DNA but the fourth one is uracil (U).



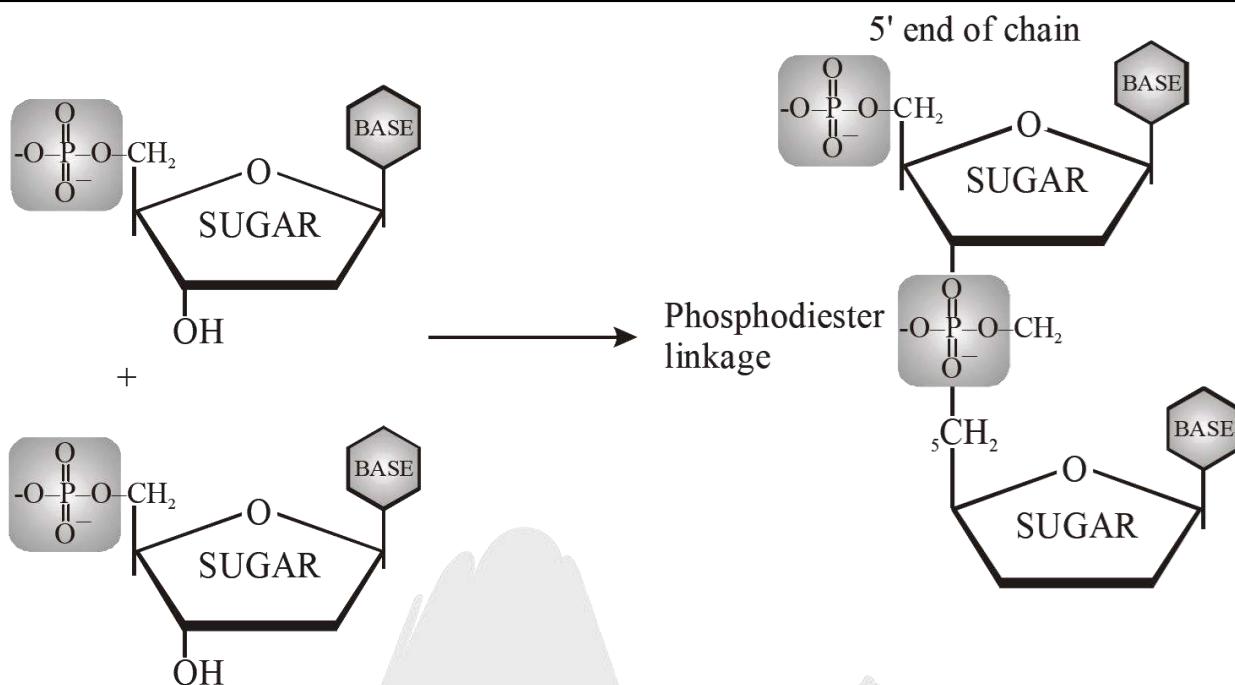
### Structure of Nucleic Acids

A unit formed by the attachment of a base to 1' position of sugar is of known as nucleoside. In nucleosides, the sugar carbons are numbered as 1', 2', 3', etc. in order to distinguish these from the bases. When nucleoside is linked to phosphoric acid at 5'-position of sugar moiety, we get a nucleotide



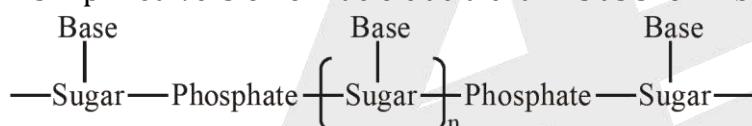
Structure of (a) a nucleoside and (b) a nucleotide

Nucleotides are joined together by phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar. The formation of a typical dinucleotide is shown in Fig.



### Formation of dinucleotide

A simplified version of nucleic acid chain is as shown below.

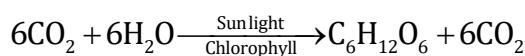


Information regarding the sequence of nucleotides in the chain of a nucleic acid is called its primary structure. Nucleic acids have a secondary structure also. James Watson and Francis Crick gave a double strand helix structure for DNA (Fig. 14.7). Two nucleic acid chains are wound about each other and held together by hydrogen bonds between pairs of bases. The two strands are complementary to each other because the hydrogen bonds are formed between specific pairs of bases. Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

In secondary structure of RNA, helices are present which are only single stranded. Sometimes they fold back on themselves to form a double helix structure. RNA molecules are of three types and they perform different functions. They are named as messenger RNA (m-RNA), ribosomal RNA (r-RNA) and transfer RNA (t-RNA).

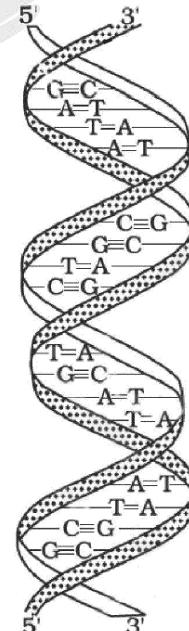
**Fig. : Double strand helix structure for DNA Photosynthesis**

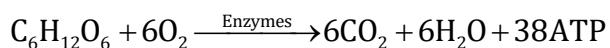
### Photosynthesis



- 3ATP are required to fix 1 mole of CO<sub>2</sub>. Therefore 18ATP are required to fix 6 mole of CO<sub>2</sub>.

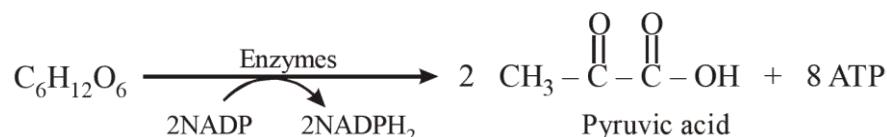
### **Cellular Respiration**



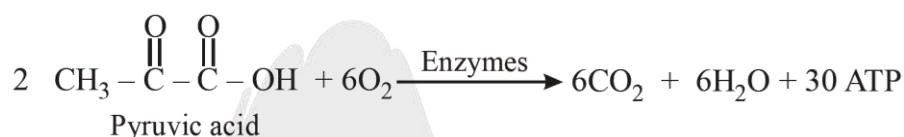


- 38 ATP are generated by complete oxidation of 1 mole of glucose. But net gain of ATP are 36, because 2 ATP are consumed when pyruvic acid enter in mitochondria.
- Complete oxidation takes place in two steps

**Step - 1 : Glycolysis or EMP or HMP (Completes in cytoplasm)**



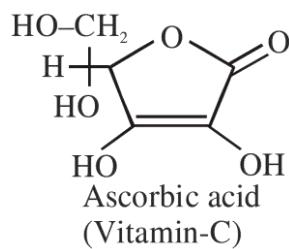
**Step - 2 : Kreb cycle (Completes in mitochondria)**



**VITAMINES****Table : Some important Vitamins, their Sources and their Deficiency Diseases**

S. NO.	Name of Vitamins	Sources	Deficiency diseases
1.	Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye) Night blindness
2.	Vitamin B <sub>1</sub> (Thiamine)	Yeast, milk, green vegetables and cereals	Beri beri (loss of appetite, retarded growth)
3.	Vitamin B <sub>3</sub> (Riboflavin)	Milk, egg white, liver, kidney	Cheilosis (fissuring at corners of mouth and lips), digestive disorders and burning sensation of the skin.
4.	Vitamin B <sub>3</sub> (Pyridoxine)	Yeast, milk, egg yolk, cereals and grams	Convulsions
5.	Vitamin B <sub>12</sub>	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
6.	Vitamin B <sub>5</sub> (Ascorbic acid)	Citrus fruits, amal and green leafy vegetables	Scurvy (bleeding gums)
7.	Vitamin D	Exposure to sunlight, fish and egg yolk	Rickets (bone deformities in children) and osteomalacia (soft bones and joint pain in adults)
8.	Vitamin E	Vegetable oils like wheat germ oil, etc.	Increased fragility of RBCs and muscular weakness
9.	Vitamin K	Green leafy vegetables	Increased blood clotting time

**NOTE :** Vitamin-D , E , K , A are fat soluble vitamins. Vitamin-B, C are water soluble vitamins.





## EXERCISE-I

**Q.1** Iso-electric point of alanine is (pH = 6). At which pH, maximum concentration of zwitter ion of alanine will be present?

- (A) pH > 6      (B) pH < 6      (C) pH = 6      (D) pH = 7

**Q.2** At iso-electric point :

- (A) Concentration of cation is equal to concentration of anion
- (B) Net charge is zero
- (C) Maximum conc. of di-pole ion (Zwitter ion) will be present
- (D) All of the above

**Q.3** Which of following amino acid has lowest iso-electric point ?

- (A) Glycine      (B) Alanine      (C) Aspartic acid      (D) Lysine

**Q.4**  $\text{H}-\text{C}\equiv\text{C}-\text{H} \xrightarrow[\text{H}_2\text{SO}_4]{\text{HgSO}_4} (\text{A}) \xrightarrow[(2)\text{H}_3\text{O}^+]{(1)\text{NH}_3+\text{HCN}} (\text{B})$ ; Product (B) of given reaction is :

- (A) Glycine      (B) Alanine      (C) Valine      (D) Leucine

**Q.5** Which amino acid does not contain chiral centre?

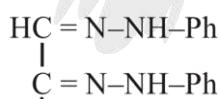
- (A) Valine      (B) Leucine      (C) Glycine      (D) Iso-leucine

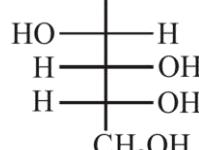
**Q.6** Which of the following is Sanger reagent ?

- |                                 |                               |
|---------------------------------|-------------------------------|
| (A) 2,4-Di-nitro flurobenzene   | (B) Phenyl isocyanane         |
| (C) 2,4-Di-nitro chlororbenzene | (D) 12,4-Di-nitro-iodobenzene |

**Q.7** A D-carbohydrate is :

- (A) Always dextrorotatory
- (B) Always laevorotatory
- (C) Always the mirror of the corresponding L-carbohydrate
- (D) None of these



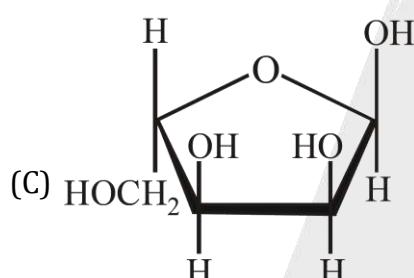
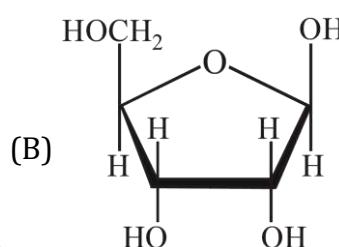
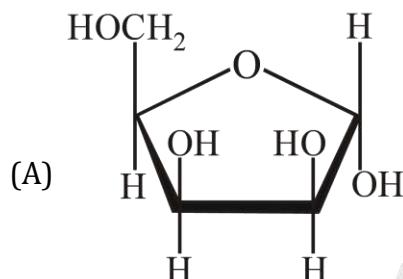
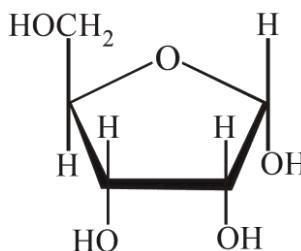
**Q.8**  The given osazone can be obtained by :

- (A) D-glucose      (B) D-mannose      (C) D-Idose      (D) Both (A) & (B)

**Q.9** Which of the following pair gives same phenyl osazone?

- |                             |                             |
|-----------------------------|-----------------------------|
| (A) D-Glucose and D-Allose  | (B) D-Glucose and D-Altrose |
| (C) D-Glucose and D-Mannose | (D) D-Glucose and D-Talose  |

**Q.10** Which of the following represents the anomer of the compound shown?



(D) None of these

**Q.11** For the complex conversion of D-glucose into the corresponding osazone, the minimum number of equivalents of phenyl hydrazine required is :

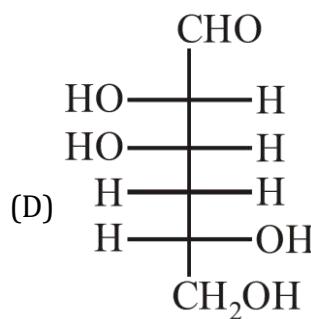
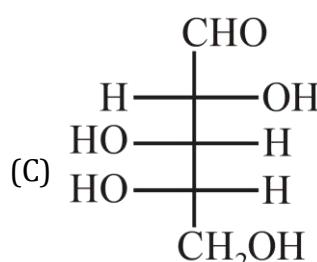
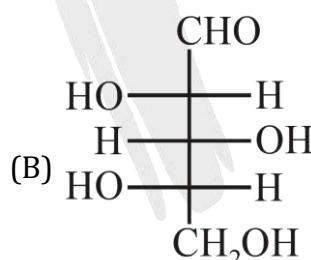
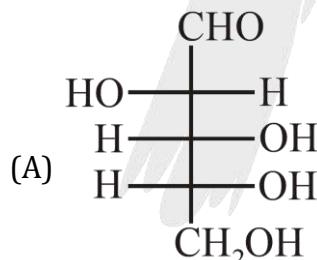
(A) Two

(B) Three

(C) Four

(D) Five

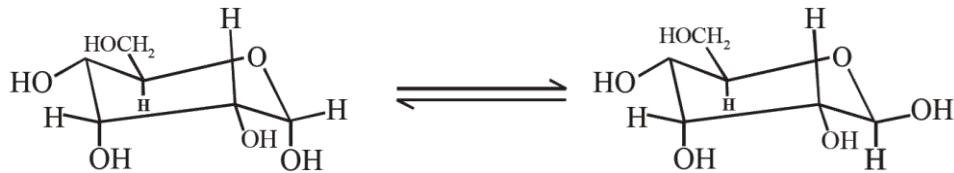
**Q.12** Which of the following structure is L-arabinose?



## (Organic Chemistry)

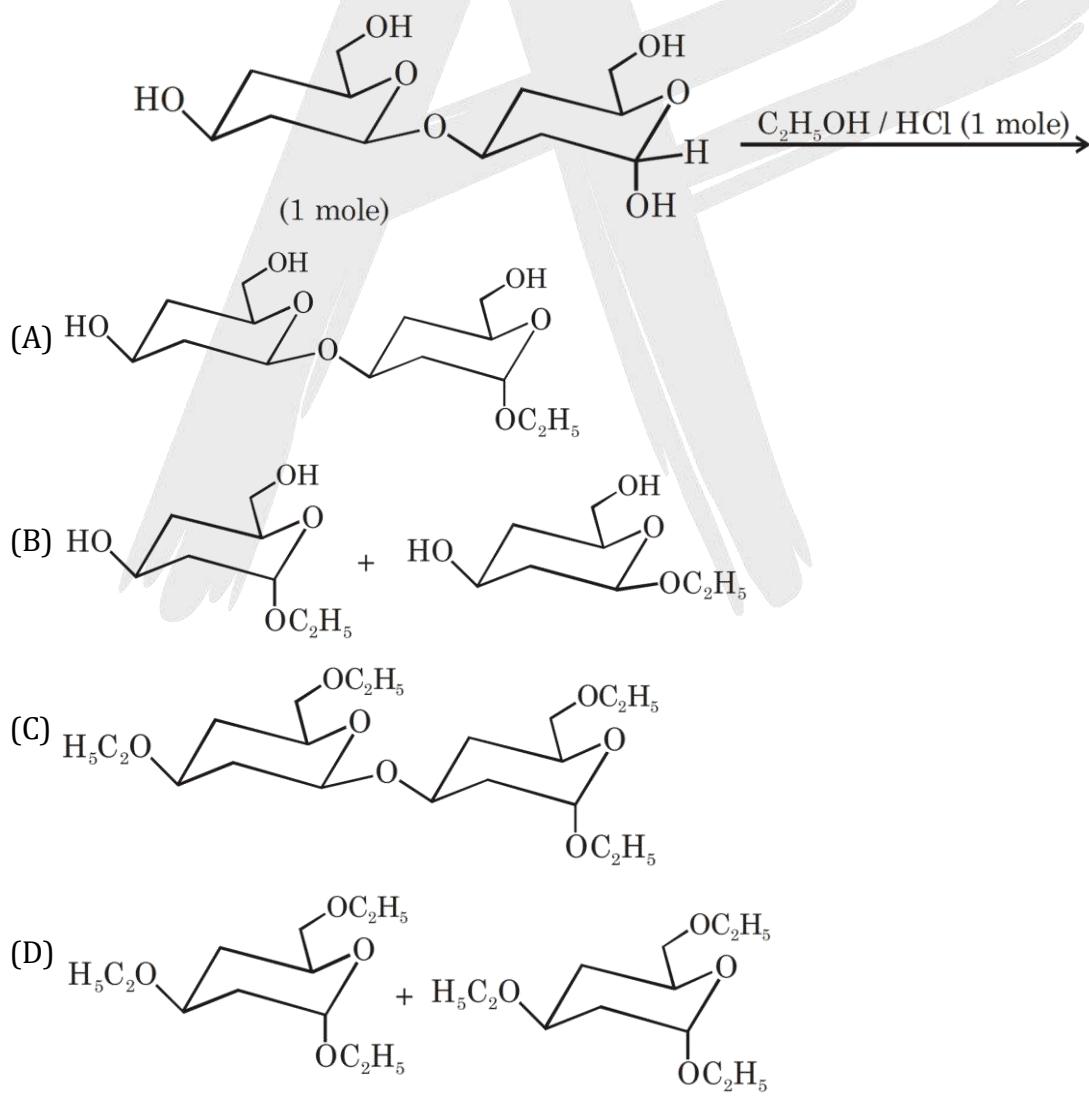
BIOMOLECULES

**Q.13** Which one of the statements concerning the equilibrium shown is true?

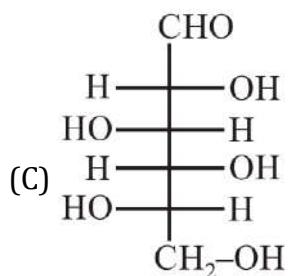
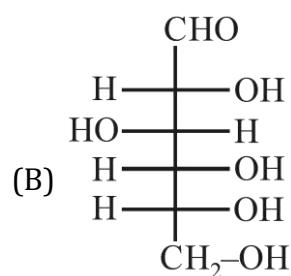
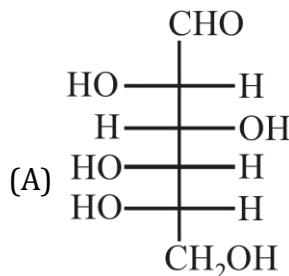


- (A) The two structures are enantiomers of each other. They have equal but opposite optical rotations and recemize slowly at room temperature
  - (B) The two structures are enantiomers of each other. They racemize too rapidly at room temperature for their optical rotations to be measured
  - (C) The two structures are diastereomers of each other. Their interconversion is called mutarotation
  - (D) The two structures are diastereomers of each other. Their interconversion does not require breaking and making bonds, only a change in conformation

**Q.14** Major product of following reaction is :

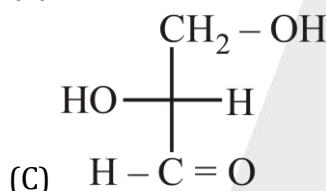
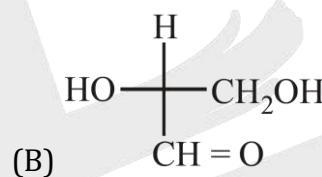
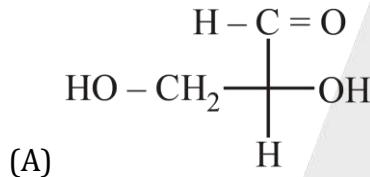


**Q.15** What is the structure of L-glucose?



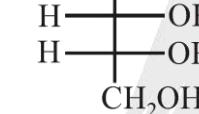
(D) None of these

**Q.16** What is the structure of L-glyceraldehyde?



(D) Both (A) and (B)

**Q.17** the given is enol form of :



- (A) D-glucose      (B) D-mannose      (C) D-fructose      (D) All of these

**Q.18** D-glucose & D-fructose can be differentiated by :

- (A) Fehling solution    (B) Tollen's reagent    (C) Benedict test    (D)  $\text{Br}_2/\text{H}_2\text{O}$

**Q.19** D-Glucose exist in x different forms. The value of x (stereoisomer) is :

- (A) 2      (B) 3      (C) 4      (D) 5

**Q.20** D-Mannose  $\xrightleftharpoons{\text{HO}^-}$  D-Glucose  $\xrightleftharpoons{\text{HO}^-}$  (A) ;

Product (A) of above reaction is :

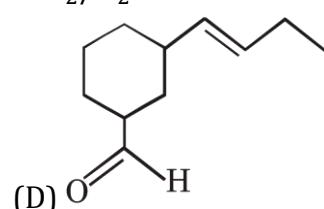
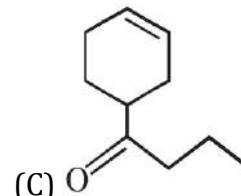
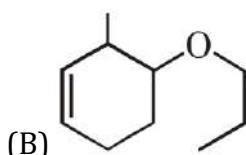
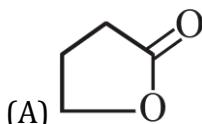
- (A) D-glucose      (B) D-fructose      (C) D-talose      (D) D-idose

**Q.21** Which of the following statement is not correct for maltose.

- |                            |  |
|----------------------------|--|
| (A) It is a disaccharide   | (B) It undergoes mutarotation          |
| (C) It is a reducing sugar | (D) It does not have hemiacetal group. |

**BIOMOLECULES**

**Q.22** A compound which does not react with Brady's reagent but decolourise  $\text{Br}_2/\text{H}_2\text{O}$  solution is :



**Q.23** Maltose is made up of two sugars-

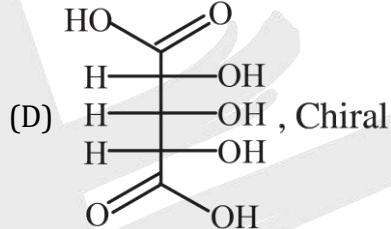
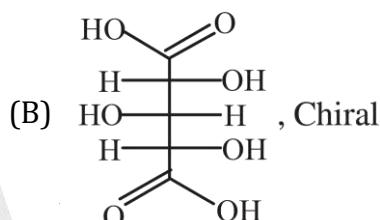
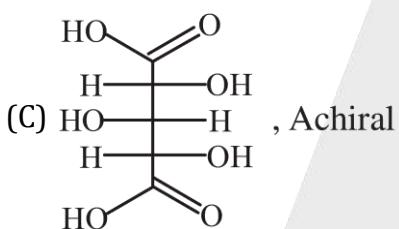
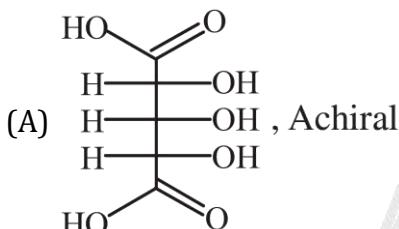
(A) Glucose

(B) Fructose

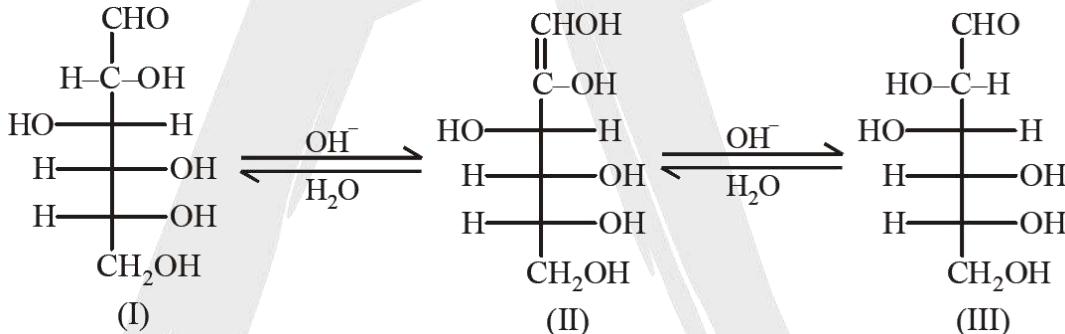
(C) Glucose & galactose

(D) Glucose & fructose

**Q.24** D-Ribose when treated with dilute  $\text{HNO}_3$  forms.



**Q.25** Consider the given process



and identify the incorrect statement.

- (A) Configuration at C – 2 is lost on enolization
- (B) I and III are epimers
- (C) Proton transfer from water to C – 1 converts ene diol to an aldose.
- (D) D-glucose can isomerise to D-fructose through enol intermediate.

**Q.26** When methyl D-glucopyranoside is treated with  $\text{HIO}_4$  its number of mole consumed per mole of the sugar is -

(A) 2

(B) 3

(C) 4

(D) 5

**Q.27**  $\alpha$  - amino acid when heated with  $\text{NaOH}/\text{CaO}$  forms -

(A)  $\alpha, \beta$  - unsaturated acid

(B)  $\alpha, \beta$  - unsaturated amine

(C) Carboxylic acid

(D) Amine

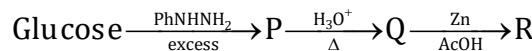
**Q.28** The configuration of the C – 2 epimer of D-glucose is-

- (A) 2R, 3 S, 4R, 5 S    (B) 2 S, 3 S, 4R, 5R    (C) 2 S, 3R, 4 S, 5R    (D) 2R, 3 S, 4R, 5R

**Q.29** Mutarotation involve-

- |                        |                              |
|------------------------|------------------------------|
| (A) Racemisation       | (B) Diastereomerisation      |
| (C) Optical resolution | (D) Conformational inversion |

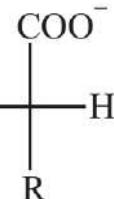
**Q.30** Consider the reaction sequence -



The product R is -

- |               |              |              |             |
|---------------|--------------|--------------|-------------|
| (A) Arabinose | (B) Sorbitol | (C) Fructose | (D) Mannose |
|---------------|--------------|--------------|-------------|

**Q.31** The pH of the solution containing following zwitter ion species is



- |       |       |       |       |
|-------|-------|-------|-------|
| (A) 4 | (B) 5 | (C) 7 | (D) 9 |
|-------|-------|-------|-------|

**Q.32** Peptide linkage is -

- |                                   |                                     |                                     |   |
|-----------------------------------|-------------------------------------|-------------------------------------|---|
| (A) $\text{O}=\text{C}-\text{O}-$ | (B) $\text{O}=\text{C}-\text{NH}_2$ | (C) $\text{O}=\text{C}-\text{NH}_2$ | (D) $\text{O}=\text{C}-\text{NH}-\text{NH}_2$ |
|-----------------------------------|-------------------------------------|-------------------------------------|---|

**Q.33** Same osazone derivative is obtained in case of D-glucose, D-Mannose and D-Fructose due to

- (A) The same configuration at C – 5
- (B) The same constitution.
- (C) The same constitution at C – 1 and C – 2
- (D) The same constitution and acid configuration at C-3, C-4, C-5 and C-6 but different constitution and configuration at C – 1 and C – 2 which becomes identical by osazone formation.

**Q.34**  $\text{D}(-)\text{-Erythrose} \xrightarrow{\text{NaBH}_4} (\text{P})$

$\text{D}(-)\text{-Threose} \xrightarrow{\text{NaBH}_4} (\text{R})$

Which of the following statement is correct about P and R ?

- (A) Both are optically active
- (B) Both are optically inactive
- (C) P is optically inactive and R is optically active
- (D) Neither P nor R has asymmetric carbon.

**Q.35** The monomer of nucleic acids are held together by

- |                            |                   |
|----------------------------|-------------------|
| (A) Phosphodiester linkage | (B) Amide linkage |
| (C) Glycosidic linkage     | (D) Ester linkage |

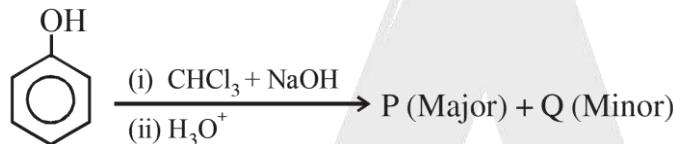
**Q.36** Select the incorrect statement about Nylon 2-nylon-6.

- (A) It is a copolymer.
- (B) It is biodegradable.
- (C) It is an alternating polyamide.
- (D) It is made up of  $\text{CH}_3 - \underset{\substack{| \\ \text{NH}_2}}{\text{CH}} - \text{COOH}$  and  $\text{H}_2\text{N}(\text{CH}_2)_5\text{COOH}$ .

**Q.37** The monomer that can undergo radical, cationic and anionic polymerisation with equal ease-

- (A)  $\text{Me}-\underset{\substack{| \\ \text{Me}}}{\text{C}}=\text{CH}_2$
- (B)  $\text{Ph}-\text{CH}=\text{CH}_2$
- (C)  $\text{CH}_2=\text{CH}_2$
- (D)  $\text{CH}_2=\text{CH}-\text{CN}$

**Q.38** Consider the reaction-



Mixture of A and B can be best separated by -

- (A) Steam distillation
- (B) Vacuum distillation
- (C) Fractional distillation
- (D) Crystallisation

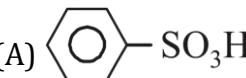
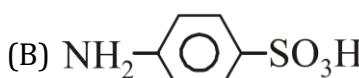
**Q.39** Which of the following statements are incorrect :

- (A) Copolymer of 1,3-butadiene & acrylonitrile is Buna-S
- (B) HDPE is obtained by Ziegler-Natta polymerization
- (C) Polymer dacron can be polyester fabric
- (D) Phenol & formaldehyde resin is called novolac

**Q.40** A segment (X) of cellulose obtained on partial hydrolysis has molecular mass 1476gm. On complete acidic hydrolysis, mass of the product obtained is 1620gm. Find out the number of glycosidic linkage(s) present in segment (X) :

- (A) 8
- (B) 6
- (C) 4
- (D) 10

**Q.41** When solidum extract is treated with  $\text{FeCl}_3$  solution a blood red coloured is obtained due to the presence of -

- (A) 
- (B) 
- (C) 
- (D) 

**Q.42** The monomer that undergo radical polymerisation most easily is

- (A)  $\text{CH}_2=\text{CH}_2$
- (B)  $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$
- (C)  $\text{CH}_2=\text{C}(\text{Me})_2$
- (D)  $\text{CH}_3-\text{CH}=\text{CH}_2$



## EXERCISE # II

- Q.1** Carbohydrates may be:
- (A) Sugars
  - (B) Starch
  - (C) Polyhydroxy aldehyde/ketones
  - (D) Compounds that can be hydrolysed to sugar
- Q.2** Select the correct statement :
- (A) Glycosides do not undergo mutarotation
  - (B) All OH groups of a cyclic monosaccharides are converted to ethers by treatment with base and an alkyl halide
  - (C)  $\alpha$ -D glucose reacts with  $\text{Ag}_2\text{O}$  and excess  $\text{CH}_3\text{I}$  to form tetramethyl ether
  - (D) D-glucose upon treatment with warm  $\text{HNO}_3$  forms D-glucaric acid
- Q.3** "Aspartame" is roughly 100 times as sweet as cane sugar. On complete hydrolysis of aspartame, products obtained is/are :
- (A)  $\text{PhCH}_2-\underset{\text{CO}_2\text{H}}{\underset{|}{\text{CH}}}-\text{NH}_2$  (B)  $\text{H}_2\text{N}-\underset{\text{CH}_2\text{CO}_2\text{H}}{\underset{|}{\text{CH}}}-\text{CO}_2\text{H}$  (C)  $\text{CH}_3\text{OH}$  (D)  $\text{CH}_3-\underset{\text{CO}_2\text{H}}{\underset{|}{\text{CH}}}-\text{NH}_2$
- Q.4** Starch molecules are polymer with repeating glucose units. Select the correct statement(s).
- (A) Glucose units are joined through  $\alpha$ -glycosidic linkage
  - (B) The branches of amylopectin are linked to the chain with  $\alpha - 1,6'$ -glycosidic linkages
  - (C) The linear linkages of amylopectin are formed by  $\alpha - 1,6$ -glycosidic bond
  - (D) Amylose has an unbranched skeleton of glucose molecules with  $\alpha - 1,4$ '-glycosidic linkages
- Q.5** Select the correct option.
- (A) Isoelectric point is the pH at which an amino acid exists primarily in its neutral form.
  - (B) Isoelectric point is the average of  $\text{pK}_a$  values of  $\alpha - \text{COOH}$  amino  $\alpha - \text{NH}_3^+$  groups [ valid only for neutral amino acid]
  - (C) Glycine is characterised by two  $\text{pK}_a$  values
  - (D) For neutral amino acid the concentration of zwitter ion is maximum at its isoelectric point
- Q.6** Amino acids are synthesised from
- (A)  $\alpha$ -Halo acids by reaction with  $\text{NH}_3$
  - (B) Aldehydes by reaction with  $\text{NH}_3$  and cyanide ion followed by hydrolysis
  - (C) Pyruvic acid is treated with  $\text{NH}_3$  followed by addition of  $\text{H}_2(\text{Ni})$
  - (D) Alcohols by reaction with  $\text{NH}_3$  and  $\text{CN}^-$  ion followed by hydrolysis.

- Q.7** Which of the following carbohydrates develops blue colour on treatment with iodine solution?
- (A) Glucose      (B) Amylose      (C) Starch      (D) Fructose
- Q.8** Select the correct statement
- (A) High density polythene is a linear polymer.  
 (B) Low density polythene is a branched chain polymer.  
 (C) Chain growth polymers are also known as addition polymer.  
 (D) Step growth polymer is also known condensation polymer.
- Q.9** Select the correct statement.
- (A) Elastomers have the weakest intermolecular forces  
 (B) Buna-N is example of synthetic copolymer  
 (C) Some fibres have crystalline nature  
 (D) Thermoplastic polymers have stronger intermolecular forces than fibres
- Q.10** Which of the following options are correct :
- (A) + AgNO<sub>3</sub> → + AgCl↓
- (B) Na extract of sample containing chlorobenzene  $\xrightarrow{+AgNO_3}$  white ppt. of AgCl
- (C) Na extract of sample containing chlorobenzene  $\xrightarrow{+AgNO_3}$  No ppt. of AgCl
- (D) + AgNO<sub>3</sub> → No ppt. of AgCl
- Q.11** + Ac<sub>2</sub>O  $\xrightarrow{AcONa}$  (P)
- Before isolating (P) unreacted Ph – CHO is removed first. Select the correct statement.
- (A) P is cinnamaldehyde      (B) P is crotonic acid  
 (C) Removal is done by simple distillation      (D) P is cinnamic acid.
- Q.12** If on a strand of DNA the base sequence is ATTGACGCCAT then the sequence transcription on RNA would be -
- (A) UAACUGCGUA      (B) AUUCUGCGUA      (C) UAACTGCGUA      (D) TAACTGCGTA
- Q.13** Select the correct statement among following
- (A) Number of chiral atom in α-D-glucose is less than D-glucose  
 (B) D-glucose and D-fructose give same product with HIO<sub>4</sub>  
 (C) D-glucose and D-fructose give same product with H<sub>2</sub>NOH  
 (D) D-glucose and D-fructose form same product with H<sub>2</sub>N – NH – Ph

**Q.14** The N-base which differentiate DNA with RNA is :

- (A) Cytosine      (B) Uracil      (C) Adenine      (D) Guanine

**Q.15** Correct statement

- (A) Nylon-66 is example of addition polymer
- (B) Alanin having pH9 at isoelectric point
- (C) Fructose when reacts with fehling solution reddish brown ppt. formed
- (D) All of these

**Q.16** Match the column :

**Column I**

- (A) Sucrose
- (B) Maltose
- (C) Lactose
- (D) Cellulose

**Column II**

- (P) Two acetals
- (Q) No hemiacetal
- (R)  $\beta - 1,4'$ -glycosidic bond
- (S) One of the hydrolysis product is glucose

**Q.17** Match the column

**Column I**

- (Component of mixture)
- (A) Crystalline  $\text{Na}_2\text{CO}_3$  +  
Sodium citrate + $\text{CuSO}_4$  (aq. sol.)
- (B)  $\text{CuSO}_4$  + Rochelle Salt + $\text{NaOH}$  (Aq. sol.)
- (C) 10% $\alpha$  - naphthol in alcohol
- (D)  $\text{HgCl} + \text{KI} + \text{KOH}$  (aq. sol.)

**Column II**

- (Reagent)
- (P) Fehling solution
- (Q) Nessler's Reagent
- (R) Benedict's solution
- (S) Molisch's Reagent



## EXERCISE # III

**Assertion Reason**

**Q.1 Statement 1 :** Furanose ring, like pyranose rings are not planar.

**Statement 2 :** The most stable conformation of furanose is envelope form.

(A) Statement- 1 is true, statement- 2 is true and statement- 2 is correct explanation for statement- 1 .

(B) Statement- 1 is true, statement- 2 is true and statement- 2 is NOT the correct explanation for statement- 1 .

(C) Statement-1 is true, statement- 2 is false.

(D) Statement- 1 is false, statement- 2 is true.

**Q.2 Statement 1 :** Bromine water changes glucose to gluconic acid.

**Statement 2 :** Bromine water acts as oxidising agent.

(A) Statement- 1 is true, statement- 2 is true and statement- 2 is correct explanation for statement- 1 .

(B) Statement- 1 is true, statement- 2 is true and statement- 2 is NOT the correct explanation for statement-1.

(C) Statement- 1 is true, statement- 2 is false.

(D) Statement- 1 is false, statement- 2 is true.

**Q.3 Statement 1 :** All monosaccharide ketoses are reducing sugars.

**Statement 2 :** Monosaccharide ketose give positive Tollen's and Fehling's test.

(A) Statement- 1 is true, statement- 2 is true and statement- 2 is correct explanation for statement- 1 .

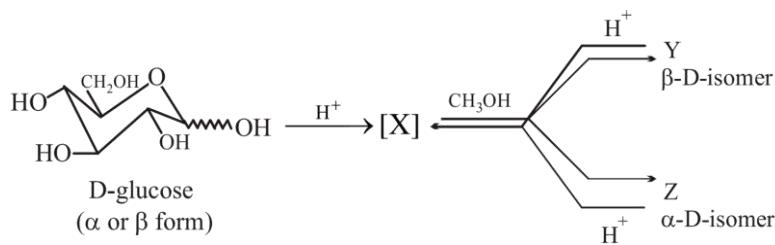
(B) Statement- 1 is true, statement- 2 is true and statement- 2 is NOT the correct explanation for statement- 1 .

(C) Statement-1 is true, statement- 2 is false.

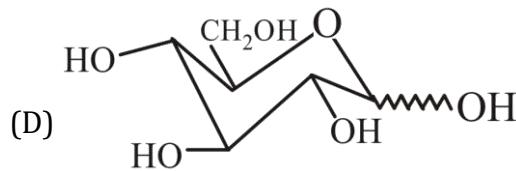
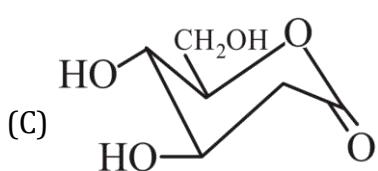
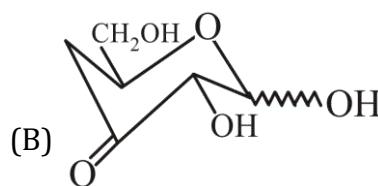
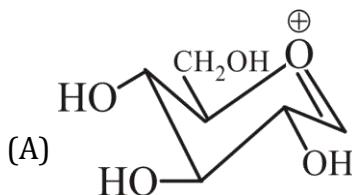
(D) Statement- 1 is false, statement- 2 is true.

**Comprehension (Q.4 to Q.6)**

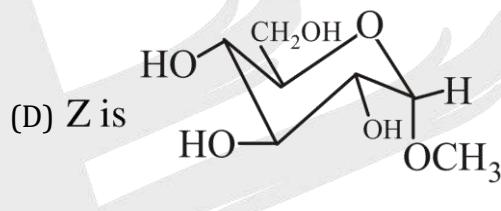
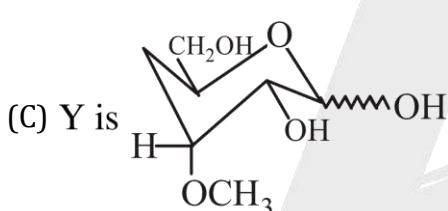
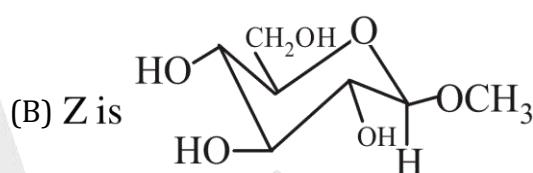
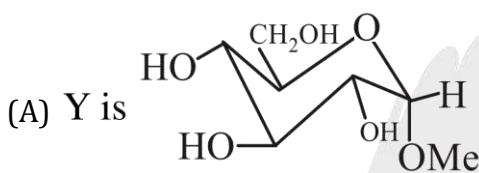
Consider the following reversible process for a reaction of D-glucose.



#### **Q.4** The structure of intermediate [X] is



**Q.5** Select the correct option.



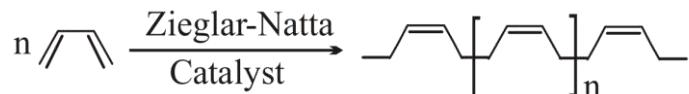
**Q.6** Select the correct statement.

- (A) Y is more stable than Z due to H-bond
  - (B) Y is less stable than Z due to anomeric effect.
  - (C) Y is more stable than Z due to anomeric effect
  - (D) Y is less stable than Z due to H-bond.

## Comprehension (Q.7 to Q.9)



The monomer  (G = Me or Cl) when treated with Ziegler - Natta catalyst undergo polymerisation in the manner given below –



### cis-poly-1,3-butadiene

**Q.7** The Ziegler-Natta catalyst is

- (A)  $\text{TiCl}_4$       (B)  $\text{R}_3\text{Al}$       (C)  $\text{R}_3\text{Al}/\text{TiCl}_4$       (D)  $\text{R}_3\text{B}/\text{TiCl}_4$

**Q.8** The polymer obtained when monomeric unit used is  $\text{CH}_2=\overset{\cdot}{\underset{\cdot}{\text{C}}}-\text{CH}=\text{CH}_2$ ,

- (A) Neoprene      (B) Stilbene      (C) Styrene      (D) Chloropicrin

**Q.9** Which of the following statement is not true considering the process given above.

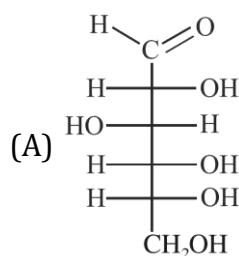
- (A) The general class of polymer formed is known as homopolymer
- (B) The polymer obtained is stereoregular
- (C) Buna- N can be prepared using above process
- (D) Synthetic rubber can be formed by above process using 1,3- butadiene.

Match the Column

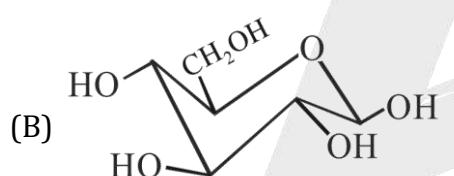
**Q.10** Match the compounds given below existing in equilibrium mixture with their percentage given in the right hand side.

**Column I**

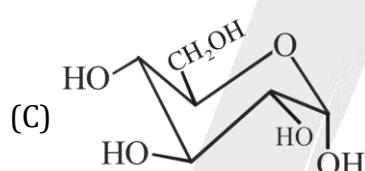
**Column II**



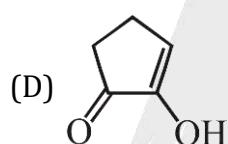
(P) 36%



(Q) 63.8%



(R) 99.9%



(S) 0.2%

**Q.11** Match the column:

**Column I**

**(Carbohydrate)**

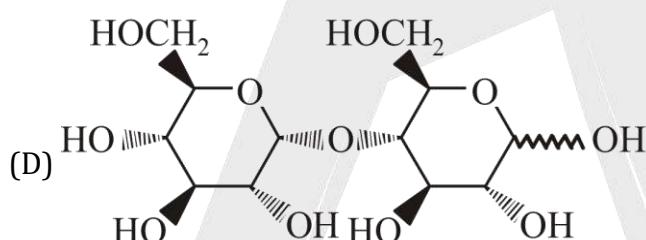
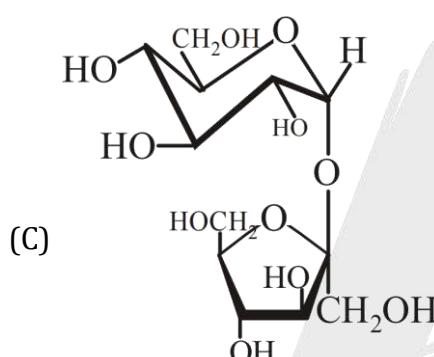
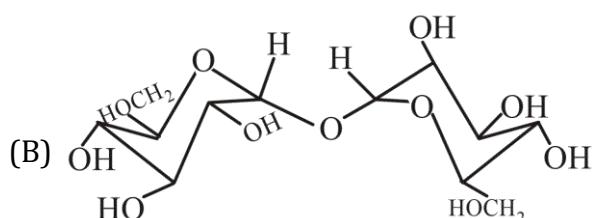
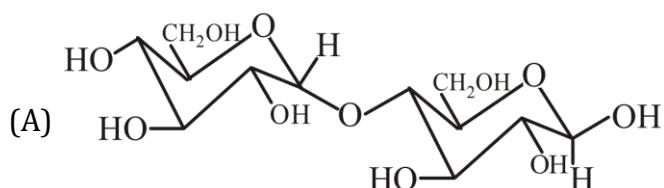
- (A) Starch
- (B) Sucrose
- (C) Lactose
- (D) Maltose

**Column II**

**(Properties)**

- (P) Mutarotation
- (Q) Non reducing sugar
- (R)  $\beta$ -glycosidic bond
- (S)  $\alpha$ -glycosidic bond
- (T) Reducing sugar
- (U) Hemiacetal

**Q.12** Match the column:

**Column I****Column II**

(P)  $\alpha$ -glycoside bonds

(Q) Reducing sugar

(R) Forms enediol intermediate

(S)  $\beta$ -glycoside bond

**Q.13** Match the column

**Column I**

(Functional group)

(A) Aldehydic

(B) Phenolic

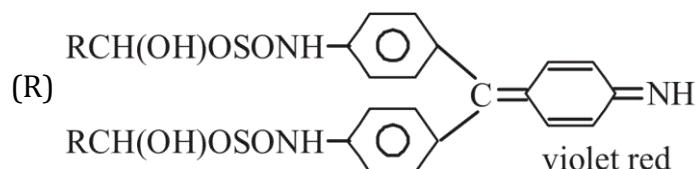
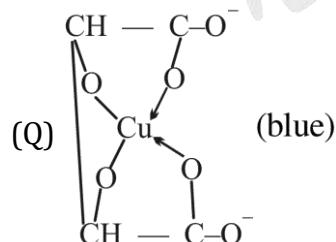
(C) Alcohol

(D)  $\alpha$ -D- Glucopyranose

**Column II**

(Test used or complex formed during confirmatory test)

(P)  $[(C_6H_5O)_6Fe]^{3-}$  (violet)



(S)  $(ROH)_2Ce(NO_3)_4$  (Red)

(T) Molisch's Test

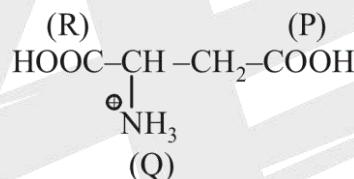
**Q.14** Match the column:

- | <b>Column I</b>          | <b>Column II</b> |
|--------------------------|------------------|
| (A) Addition polymer     | (P) Buna-S       |
| (B) Condensation polymer | (Q) Buna-N       |
| (C) Homopolymer          | (R) Polythene    |
| (D) Copolymers           | (S) Nylon 6,6    |

**Q.15** Match the column

Presence of the element in Complex formed in one Colour of the complex

- | Na – extract         | of the test  |                   |
|----------------------|--|-------------------|
| (A) N                | (P) $\text{Na}_4[\text{Fe}(\text{CN})_5\text{NO}]$ | (W) Prussian Blue |
| (B) S                | (Q) $\text{Fe}(\text{CNS})_3$                      | (X) Black         |
| (C) N and S together | (R) $\text{PbS}$                                   | (Y) Violet        |
|                      | (S) $\text{Fe}_4[\text{Fe}(\text{CN})_6]$          | (Z) Blood Red     |

**Subjective Type:****Q.16** The pKa values for the three acidic group P, Q, R are 4.3, 9.7 and 2.2 respectively

Calculate the isoelectric point of the amino acid?

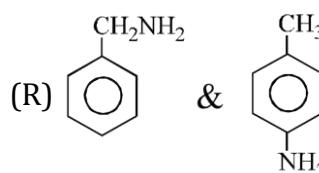
**Q.17** How will you separate?

- |   |  |                        |
|---|--|------------------------|
| (a) Ethane & Ethyne                                 | (b) 1-Butyne & 2-Butyne                          | (c) Phenol & Propanol  |
| (d) 2-Propanol & Propanone                          | (e) $\text{CH}_3\text{COOH}$ & $\text{HCOOCH}_3$ | (f) PhOH & PhCOOH      |
| (g) $\text{C}_2\text{H}_4$ & $\text{C}_2\text{H}_2$ | (h) $\text{EtNH}_2$ & $\text{Me}_2\text{NH}$     | (i) EtOH & Et – O – Et |

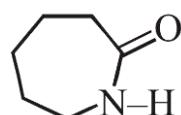
**Q.18** How will you differentiate?

- |   |   |
|---|---|
| (a) Propane & Propene                         | (b) 1,1-Dichloroethane & 1,2-Dichloroethane |
| (c) Chloroethane & Chloroethene               | (d) Pure & Oxidized $\text{CHCl}_3$         |
| (e) p-chlorotoluene & benzylchloride          | (f) n-propylchloride & isopropylchloride    |
| (g) Methanol & ethanol                        | (h) Isobutanol & tert-butanol               |
| (i) 2-Pentanol & 3-pentanol                   | (j) O-cresol & benzylalcohol                |
| (k) Ethanol & Propanol                        | (l) Propanone & Ethanol                     |
| (m) HCHO & PhCHO                              | (n) Glucose & Fructose                      |
| (o) $\text{HCOOH}$ & $\text{CH}_3\text{COOH}$ | (p) $\text{HCOOH}$ & HCHO                   |

- (q)  $\text{MeNH}_2$  &  $\text{Me}_2\text{NH}$



**Q.19** (a) What is the structure of nylon-6, made by alkaline polymerisation of caprolactum.



(b) Suggest mechanism for the process. Is polymerisation of the chain reaction or step reaction type.

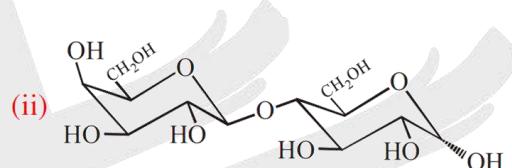
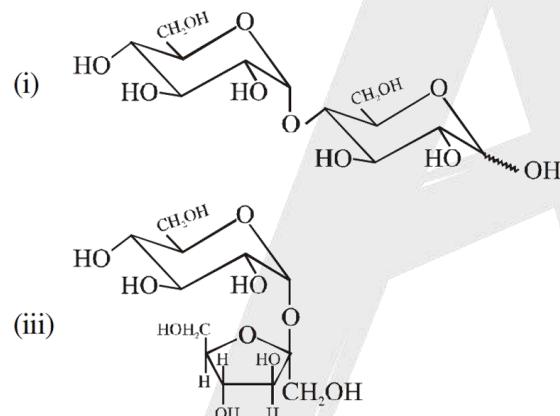
**Q.20** Compound (A)  $C_5H_{10}O_5$  give a tetra-acetate with  $Ac_2O$  & oxidation of A with  $Br_2/H_2O$  gives an acid  $C_5H_{10}O_6$ . Reduction of A with HI&RedP. Give 2-methyl butane. What is structure of 'A'

**Q.21** (i) Sulphanilic acid although has acidic as well as basic group. It is soluble in alkali but insoluble in mineral acid. Explain.

(ii) Explain why sulphonic acid is not soluble in organic solvents.

**Q.22** Account for the fact that 2-amino ethanoic acid (glucine) exist as a dipolar ion as does p-aminobenzene sulphonic acid but p-amino benzoic acid does not.

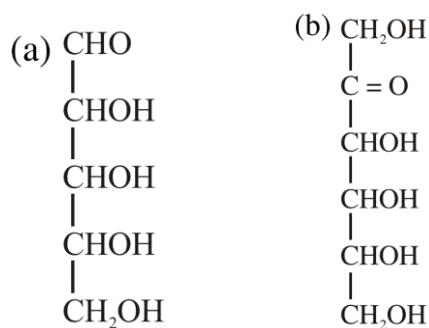
**Q.23** For given compound



- (a) Which glycosidic linkage is present  
 (c) Products obtained on hydrolysis  
 (e) Number of moles of  $HIO_4$  consumed  
 (g) Number of moles of  $CH_3COCl$  consumed per mole of compound.

- (b) Name of the compound  
 (d) Is it reducing sugar  
 (f) Is mutarotation possible

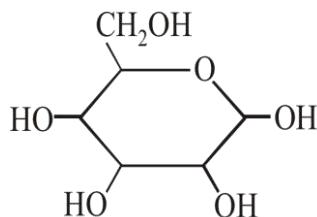
**Q.24** For given compound



- (i) Number of possible isomers  
 (ii) Number of possible D-configuration isomers  
 (iii) Number of possible L-configuration isomers



**Q.25** Number of possible isomers of  $\alpha$ -D-gluco pyronose configuration.

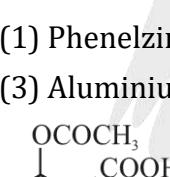


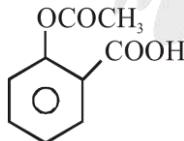
**Q.26** Calculate isoelectric point of following amino acid

	pKa <sub>1</sub> ( $\alpha$ -COOH)	pKa <sub>2</sub> ( $\alpha$ -COOH)	pKa (side chain)
(a) Glycine $\text{NH}_3^+ - \text{CH}_2 - \text{COOH}$	2.3	9.6	—
(b) Serine $\begin{matrix} \text{CH}_2 & \\   & \\ \text{OH} & \text{NH}_3^+ \end{matrix} - \text{CH} - \text{COOH}$	2.2	9.2	—
(c) Alanine $\text{CH}_3 - \text{CH} - \text{COOH}$	2.3	9.7	—
(d) Aspartic acid $\text{HOOC} - \text{CH}_2 - \text{CH}(\text{NH}_3^+) - \text{COOH}$	2.1	9.8	3.9
(e) Lysine $\text{NH}_3^+ - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}(\text{NH}_3^+) - \text{COOH}$	2.2	9.0	10.5



## **EXERCISE # IV (JEE-MAIN)**

- |   |  |                                |                                |  |
|---|--|--------------------------------|--------------------------------|--|
| <b>Q.1</b>  | Which of the following pairs give positive Tollen's test?  | [JEE-Main-2004]                |                                |  |
| (1) Glucose, sucrose  | (2) Glucose, fructose  |                                |                                |  |
| (3) Hexanal, Acetophenone   | (4) Fructose, sucrose  |                                |                                |  |
| <b>Q.2</b>  | Two forms of D-glucopyranose, are called.  | [JEE-Main-2005]                |                                |  |
| (1) Enantiomers   | (2) Anomers  | (3) Epimers                    | (4) Diastereomers              |  |
| <b>Q.3</b>  | When benzene sulfonic acid and p-nitrophenol are treated with $\text{NaHCO}_3$ , the gases released respectively are | [JEE-Main-2006]                |                                |  |
| (1) $\text{SO}_2, \text{NO}_2$  | (2) $\text{SO}_2, \text{NO}$   | (3) $\text{SO}_2, \text{CO}_2$ | (4) $\text{CO}_2, \text{CO}_2$ |  |
| <b>Q.4</b>  | <b>Statement-1 :</b> Glucose gives a reddish-brown precipitate with Fehling's solution. because                      | [JEE-Main-2007]                |                                |  |
|   | Statement-2 : Reaction of glucose with Fehling's solution gives CuO and gluconic acid.                               |                                |                                |  |
| (1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.     |  |                                |                                |  |
| (2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1. |  |                                |                                |  |
| (3) Statement-1 is True, Statement-2 is False.  |  |                                |                                |  |
| (4) Statement-1 is False, Statement-2 is True.  |  |                                |                                |  |
| <b>Q.5</b>  | Which one of the following bases is not present in DNA ?   | [JEE-Main-2014]                |                                |  |
| (1) Cytosine  | (2) Thymine  | (3) Quinoline                  | (4) Adenine                    |  |
| <b>Q.6</b>  | Which one is classified as a condensation polymer?   | [JEE-Main- 2014]               |                                |  |
| (1) Teflon  | (2) Acrylonitrile  | (3) Dacron                     | (4) Neoprene                   |  |
| <b>Q.7</b>  | Which of the vitamins given below is water soluble?  | [JEE-Main- 2015]               |                                |  |
| (1) Vitamin E   | (2) Vitamin K  | (3) Vitamin C                  | (4) Vitamin D                  |  |
| <b>Q.8</b>  | Which of the following compounds is not an antacid?  | [JEE-Main- 2015]               |                                |  |
| (1) Phenelzine  | (2) Ranitidine   |                                |                                |  |
| (3) Aluminium hydroxide   | (4) Cimetidine   |                                |                                |  |
| <b>Q.9</b>  |  is used as:                      | [JEE-Main-2015]                |                                |  |
| (1) Insecticide   | (2) Antacid  | (3) Antihistamine              | (4) Analgesic                  |  |
| <b>Q.10</b>   | Thiol group is present in :  | [JEE-Main-2016]                |                                |  |
| (1) Methionine  | (2) Cytosine   | (3) Cystine                    | (4) Cysteine                   |  |
| <b>Q.11</b>   | The distillation technique most suited for separating glycerol from spent-lye in the soap industry is                | [JEE-Main-2016]                |                                |  |
| (1) Distillation under reduced pressure   | (2) Simple distillation  |                                |                                |  |
| (3) Fractional distillation   | (4) Steam distillation   |                                |                                |  |



**Q.12** Which of the following statements about low density polythene is FALSE? [JEE-Main-2016]

- (1) It is used in the manufacture of buckets, dust-bins etc
- (2) Its synthesis requires high pressure
- (3) It is a poor conductor of electricity
- (4) Its synthesis requires dioxygen or a peroxide initiator as a catalyst.

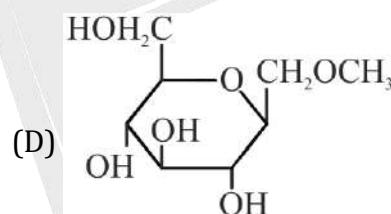
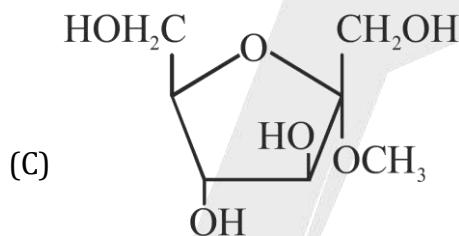
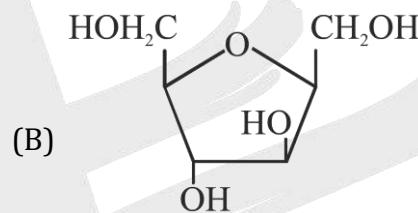
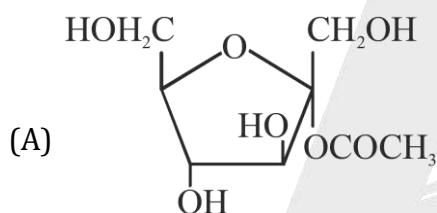
**Q.13** Which of the following is an anionic detergent? [JEE-Main-2016]

- |                            |                                     |
|----------------------------|-------------------------------------|
| (1) Glyceryl oleate        | (2) Sodium stearate                 |
| (3) Sodium lauryl sulphate | (4) Cetyltrimethyl ammonium bromide |

**Q.14** The formation of which of the following polymers involves hydrolysis reaction? [JEE-Main-2017]

- (1) Nylon 6
- (2) Bakelite
- (3) Nylon 6,6
- (4) Terylenes

**Q.15** Which of the following compounds will behave as a reducing sugar in an aqueous KOH solution? [JEE-Main-2017]



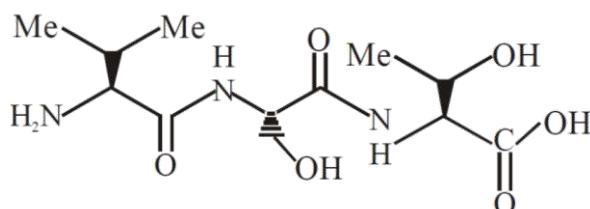
**Q.16** Glucose on prolonged heating with HI gives : [JEE-Main-2018]

- (1) 6-iodohexanal
- (2) n-Hexane
- (3) 1-Hexene
- (4) Hexanoic acid

**Q.17** The increasing order of pKa of the following amino acids in aqueous solution is : Gly Asp Lys Arg [JEE-MAIN2019]

- |                           |                           |
|---------------------------|---------------------------|
| (1) Asp < Gly < Arg < Lys | (2) Arg < Lys < Gly < Asp |
| (3) Gly < Asp < Arg < Lys | (4) Asp < Gly < Lys < Arg |

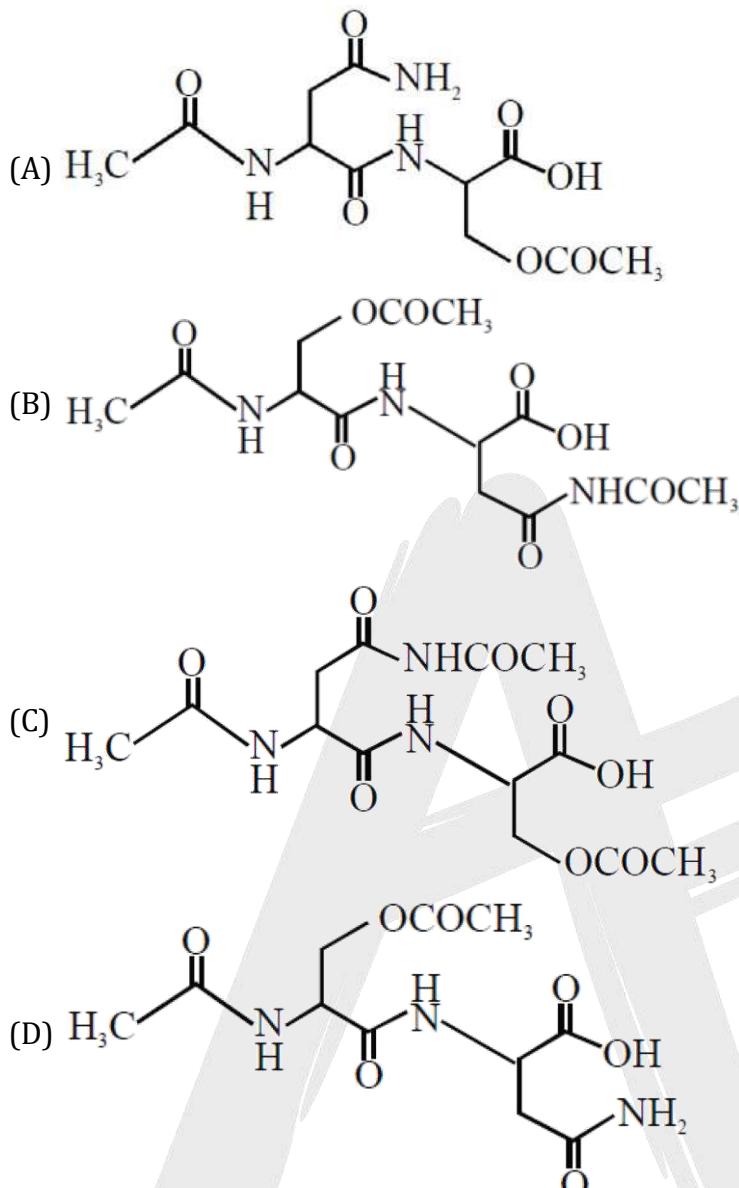
**Q.18** The correct sequence of amino acids present in the tripeptide given below is : [JEE MAIN-2019]



- (1) Val - Ser - Thr
- (2) Leu - Ser - Thr
- (3) Thr - Ser - Leu
- (4) Thr - Ser - Val

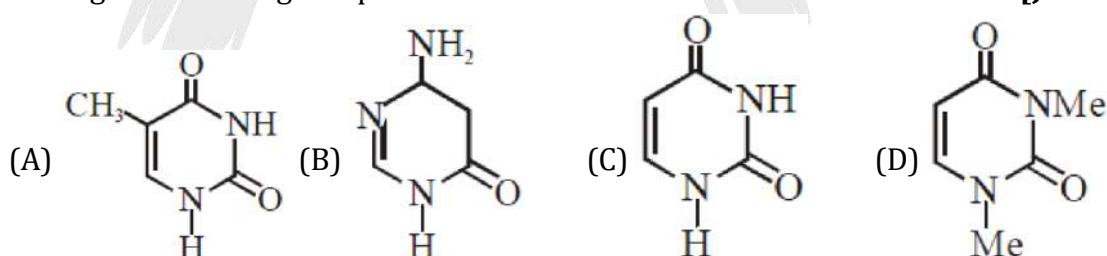
**Q.19** The correct structure of product 'P' in the following reaction is :

[JEE MAIN-2019]



**20.** Among the following compound which one is found in RNA ?

[JEE MAIN-2019]



**21.** The correct match between Item I and Item II is :-

[JEE MAIN-2019]

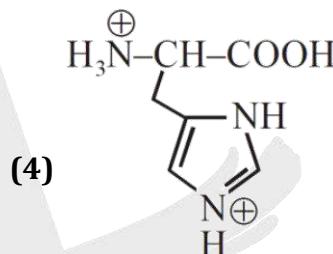
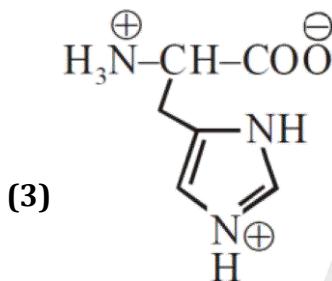
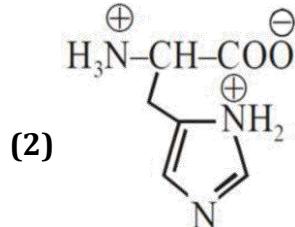
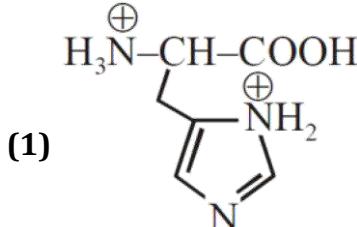
**Item I**

- (A) Ester test
- (B) Carbylamine test
- (C) Phthalein dye test

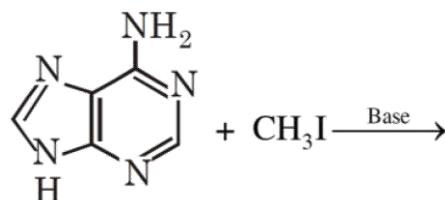
**Item II**

- (P) Tyr
- (Q) Asp
- (R) Ser
- (S) Lys

- (1) (A)→(R); (B)→(S); (C)→(Q)  
 (3) (A)→(Q); (B)→(S); (C)→(R)      (2) (A)→(R); (B)→(Q); (C)→(P)  
 (4) (A)→(Q); (B)→(S); (C)→(P)
22. Among the following compounds most basic amino acid is : [JEE MAIN-2019]  
 (1) Lysine      (2) Asparagine      (3) Serine      (4) Histidine
23. The correct structure of histidine in a strongly acidic solution (pH = 2) is [JEE MAIN-2019]



24. Amylopection is composed of : [JEE MAIN-2019]  
 (1)  $\alpha$ -D-glucose, C<sub>1</sub> – C<sub>2</sub> and C<sub>1</sub> – C<sub>6</sub> linkages  
 (2)  $\beta$ -D-glucose, C<sub>1</sub> – C<sub>4</sub> and C<sub>1</sub> – C<sub>6</sub> linkages  
 (3)  $\beta$ -D-glucose, C<sub>1</sub> – C<sub>4</sub> and C<sub>2</sub> – C<sub>6</sub> linkages  
 (4)  $\alpha$ -D-glucose, C<sub>1</sub> – C<sub>4</sub> and C<sub>2</sub> – C<sub>6</sub> linkages
25. Number of stereo centers present in linear and cyclic structures of glucose are respectively : [JEE MAIN-2019]  
 (1) 4 & 4      (2) 4 & 5      (3) 5 & 5      (4) 5 & 4
26. Glucose and Galactose are having identical configuration in all the positions except position. [JEE MAIN-2019]  
 (1) C – 5      (2) C – 3      (3) C – 2      (4) C – 4
27. Which of the following statements is not true about RNA? [JEE MAIN-2019]  
 (1) It has always double stranded  $\alpha$ -helix structure  
 (2) It usually does not replicate  
 (3) It is present in the nucleus of the cell  
 (4) It controls the synthesis of protein
28. Which of the given statements is INCORRECT about glycogen? [JEE MAIN-2019]  
 (1) Only  $\alpha$ -linkages are present in the molecule.  
 (2) It is present in animal cells.  
 (3) It is present in some yeast and fungi.  
 (4) It is a straight chain polymer similar to amylose.

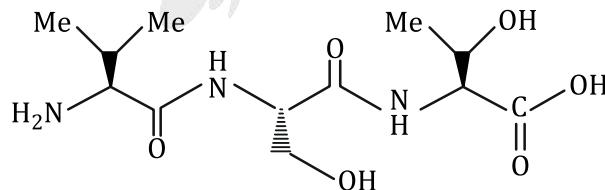


- (1)  (2)  (3)  (4) 

31. Fructose and glucose can be distinguished by : [JEE MAIN-2019]  
(1) Fehling's test    (2) Benedict's test    (3) Seliwanoff's test    (4) Barfoed's test

32. Which of the following statements is not true about sucrose ? [JEE MAIN-2019]  
(1) It is also named as invert sugar  
(2) On hydrolysis, it produces glucose and fructose  
(3) The glycosidic linkage is present between C<sub>1</sub> of α-glucose and C<sub>1</sub> of β-fructose  
(4) It is a non reducing sugar

33. The peptide that gives positive ceric ammonium nitrate and carbylamine tests is :



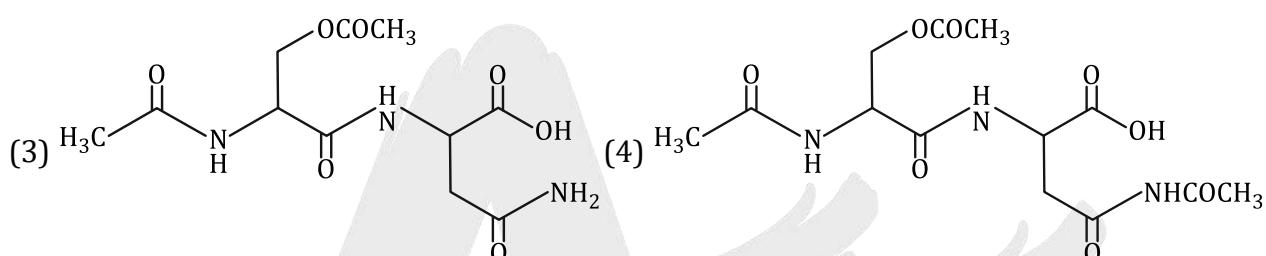
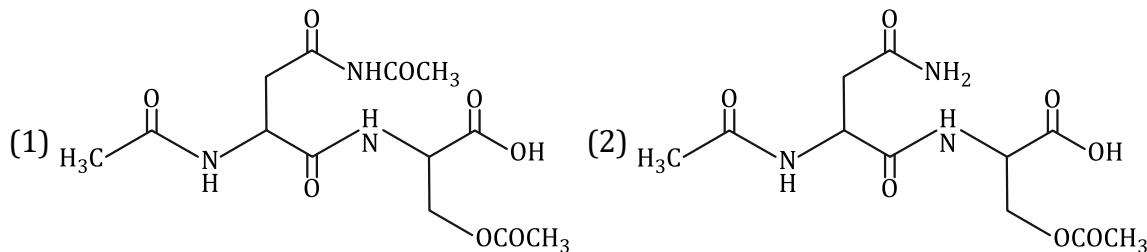
- (1) Val - Ser - Thr    (2) Thr - Ser - Val    (3) Leu - Ser - Val    (4) Thr - Ser - Leu

[JEE MAIN-2019]

Gly Asp Lys Arg

36. The correct structure of product 'P' in the following reaction is:

[JEE MAIN-2019]



37. The correct match between Item I and Item II is:

[JEE MAIN-2019]

**Item I**

- (I) Ester test
- (II) Carbylamine test
- (III) Phthalein dye test

**Item II**

- (P) Tyr
- (Q) AsP
- (R) Ser
- (S) Lys

(1) (I)  $\rightarrow$  (Q, R); (II)  $\rightarrow$  (S); (III)  $\rightarrow$  (P)

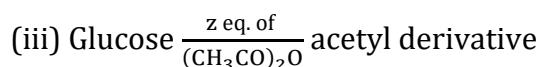
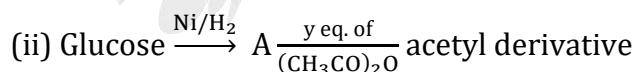
(2) (I)  $\rightarrow$  (R); (II)  $\rightarrow$  (Q); (III)  $\rightarrow$  (P)

(3) (I)  $\rightarrow$  (R); (II)  $\rightarrow$  (S); (III)  $\rightarrow$  (Q)

(4) (I)  $\rightarrow$  (Q); (IV)  $\rightarrow$  (S); (III)  $\rightarrow$  (R)

38. Consider the following reactions:

[JEE MAIN-2020]

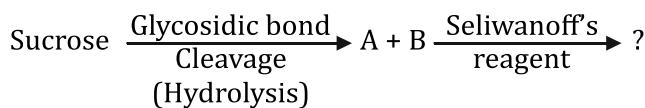


'x', 'y' and 'z' in these reactions are respectively.

- (A) 4,5&5
- (B) 4,6&5
- (C) 5,4&5
- (D) 5,6&5

39. The correct observation in the following reactions is

[JEE MAIN-2020]



- (A) Gives no colour
- (C) Formation of violet colour

- (B) Formation of red colour
- (D) Formation of blue colour

40. Which one of the following statements is not true? [JEE MAIN-2020]

- (A) Lactose contains  $\alpha$ -glycosidic linkage between C<sub>1</sub> of galactose and C<sub>4</sub> of glucose
- (B) Lactose is a reducing sugar and it gives Fehling's test
- (C) On acid hydrolysis, lactose gives one molecule of D(+) -glucose and one molecule of D(+) galactose
- (D) Lactose (C<sub>11</sub>H<sub>22</sub>O<sub>11</sub>) is a disaccharide and it contains 8 hydroxyl groups

41. A, B and C are three biomolecules. The results of the tests performed on them are given below:  
A, B and C are respectively: [JEE MAIN-2020]

	Molisch's Test	Barfoord Test	Biuret Test
A	Positive	Negative	Negative
B	Positive	Positive	Negative
C	Negative	Negative	Positive

- (A) A = Lactose, B = Glucose, C = Alanine
- (B) A = Glucose, B = Fructose, C = Albumin
- (C) A = Lactose, B = Glucose, C = Albumin
- (D) A = Lactose, B = Fructose, C = Alanine

42. A peptide synthesized by the rejections of one molecule each of Glycine, Leucine, Aspartic acid and Histidine will have \_\_\_ peptide linkages. [JEE MAIN-2021]

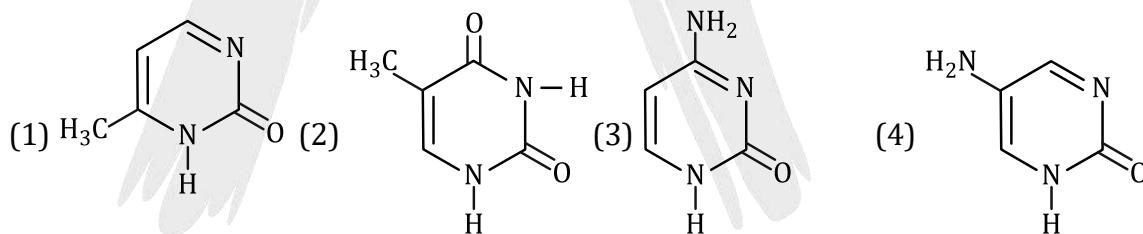
43. Hydrolysis of sucrose gives :

- (1)  $\alpha$ -D-(-)-Glucose and  $\beta$ -D- (-)-Fructose
- (2)  $\alpha$ -D-(+)-Glucose and  $\alpha$  – D – (–)-Fructose
- (3)  $\alpha$ -D-(-)-Glucose and  $\alpha$ -D-(+)-Fructose
- (4)  $\alpha$ -D-(+)-Glucose and  $\beta$  – D – (–)-Fructose

44. The water soluble protein is

- (1) Fibrin
- (2) Albumin
- (3) Myosin
- (4) Collagen

45. Which one of the following is correct structure for cytosine? [JEE MAIN-2021]



46. Match List I with List II. [JEE MAIN-2022]

List-I Enzyme		List -II Conversion of	
P.	Invertase	I.	Starch into maltose
Q.	Zymase	II.	Maltose into glucose
R.	Diastase	III.	Glucose into ethanol
S.	Maltase	IV.	Cane sugar into glucose

Choose the most appropriate answer from the options given below :

- (1) P-III, Q-IV, R-II, S-I
- (2) P-III, Q-II, R-I, S-IV
- (3) P-IV, Q-II, R-I, S-II
- (4) P-IV, Q-II, R-III, S-I



47. Given below are two statements.

[JEE MAIN-2022]

**Statements I:** Maltose has two  $\alpha$ -D-glucose units linked at C<sub>1</sub> and C<sub>4</sub> and is a reducing sugar.

**Statement II:** Maltose has two monosaccharides:  $\alpha$ -D-glucose and  $\beta$ -D-glucose linked at C<sub>1</sub> and C<sub>6</sub> and it is a non-reducing sugar.

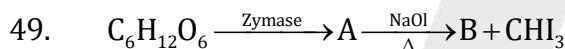
In the light of the above statements, choose the correct answer from the options given below.

- (A) Both Statement I and Statement II are true
- (B) Both Statement I and Statement II are false
- (C) Statement I is true but Statement II is false
- (D) Statement I is false but Statement II is true

48. Stability of  $\alpha$ -Helix structure of proteins depends upon

[JEE MAIN-2022]

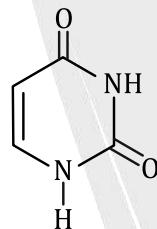
- (A) dipolar interaction
- (B) H-bonding interaction
- (C) van der Waals forces
- (D)  $\pi$ -stacking interaction



The number of carbon atoms present in the product B is

[JEE MAIN-2022]

50. Uracil is base present in RNA with the following structure. % of N in uracil is



Given:

Molar mass N = 14 g mol<sup>-1</sup>; O = 16 g mol<sup>-1</sup>; C = 12 g mol<sup>-1</sup>; H = 1 g mol<sup>-1</sup>; [JEE MAIN-2023]

**EXERCISE # V (A) (JEE-ADVANCE) (OBJECTIVE)**

**Q.1 Statement-1 :** p-Hydroxybenzoic acid has a lower boiling point than o-hydroxybenzoic acid.  
Because [JEE 2007]

**Statement-2 :** o-Hydroxybenzoic acid has intramolecular hydrogen bonding.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.  
(C) Statement-1 is True, Statement-2 is False.  
(D) Statement-1 is False, Statement-2 is True.

**Q.2** Match the chemical substances in Column I with type of polymers / type of bonds in Column II.  
Indicate your answer by darkening the appropriate bubbles of the  $4 \times 4$  matrix given in the ORS. [JEE 2007]

**Column I**

- (A) Cellulose  
(B) Nylon-6, 6  
(C) Protein  
(D) Sucrose

**Column II**

- (P) Natural polymer  
(Q) Synthetic polymer  
(R) amide linkage  
(S) Glycoside linkage

**Q.3** Match the compounds/ion in column I with their properties/ reaction in Column II. Indicate your answer by darkening the appropriate bubbles of the  $4 \times 4$  matrix given in the ORS.

[JEE 2007]

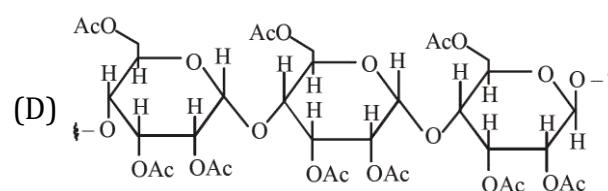
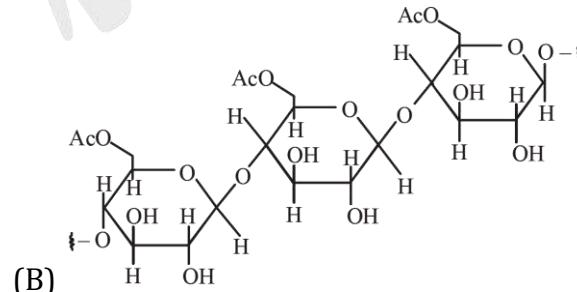
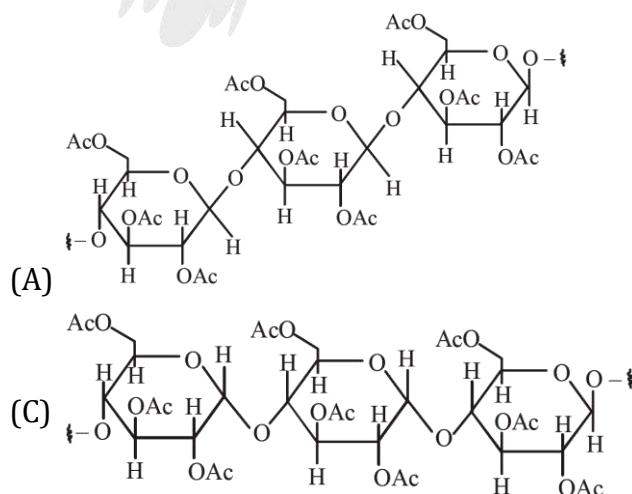
**Column I**

- (A)  $C_6H_5CHO$   
(B)  $CH_3C \equiv CH$   
(C)  $CN^-$   
(D)  $I^-$

**Column II**

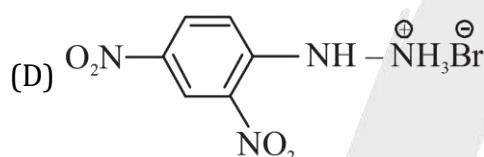
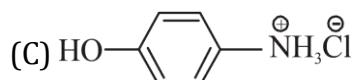
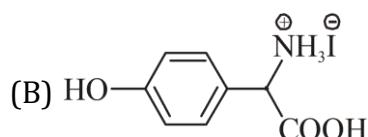
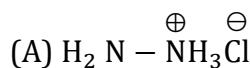
- (P) gives precipitate with 2,4-dinitrophenylhydrazine  
(Q) gives precipitate with  $AgNO_3$   
(R) is a nucleophile  
(S) is involved in cyanohydrin formation

**Q.4** Cellulose upon acetylation with excess acetic anhydride /  $H_2SO_4$  (catalytic) gives cellulose triacetate whose structure is [JEE 2008]



**Q.5** Match the compounds in Column I with their characteristic test(s)/reaction(s) given in Column II. Indicate your answer by darkening the appropriate bubbles of the  $4 \times 4$  matrix given in the ORS.

[JEE 2008]

**Column-I****Column II**

(P) Sodium fusion extract of the compound gives Prussian blue colour with  $\text{FeSO}_4$

(Q) Gives positive  $\text{FeCl}_3$  test

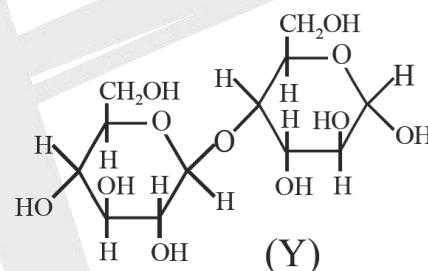
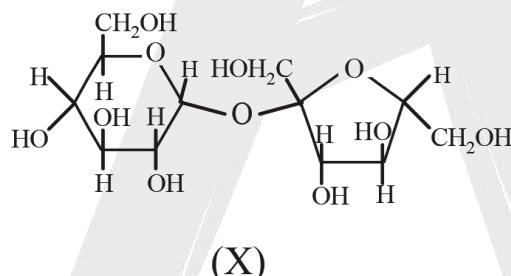
(R) Gives white precipitate with  $\text{AgNO}_3$

(S) Reacts with aldehydes to form the

corresponding Hydrazone derivative

**Q.6** The correct statement(s) about the following sugars X and Y is(are)

[JEE 2009]



- (A) X is a reducing sugar and Y is a non-reducing sugar
- (B) X is a non-reducing sugar and Y is a reducing sugar
- (C) The glucosidic linkages in X and Y are  $\alpha$  and  $\beta$ , respectively.
- (D) The glucosidic linkages in X and Y are  $\beta$  and  $\alpha$ , respectively

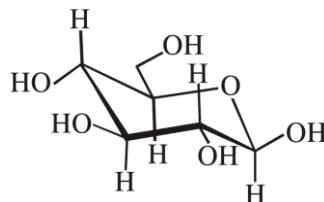
**Q.7** Among cellulose, poly (vinyl chloride), nylon and natural rubber, the polymer in which the intermolecular force of attraction is weakest is

[JEE 2009]

- (A) Nylon
- (B) Poly (vinyl chloride)
- (C) Cellulose
- (D) Natural Rubber

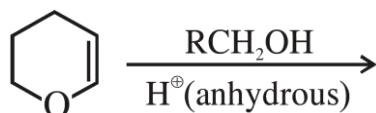
**Q.8** The following carbohydrate is

[JEE 2011]



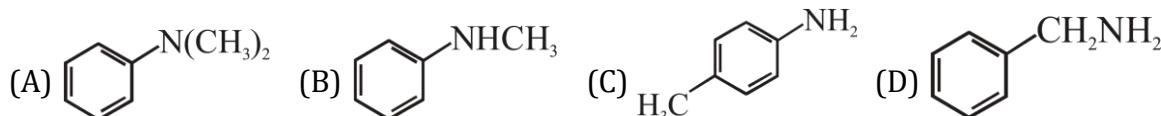
- (A) a ketohexose
- (B) an aldohexose
- (C) an  $\alpha$ -furanose
- (D) an  $\alpha$ -pyranose

**Q.9** The major product of the following reaction is

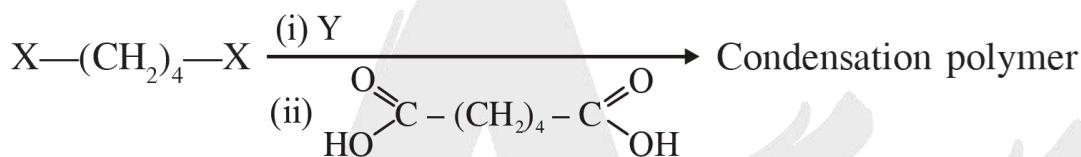


- (A) a hemiacetal    (B) an acetal    (C) an ether    (D) an ester

**Q.10** Amongst the compounds given, the one that would form a brilliant coloured dye on treatment with  $\text{NaNO}_2$  in dil.  $\text{HCl}$  followed by addition to an alkaline solution of  $\beta$ -naphthol is-[JEE 2011]

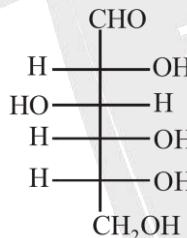


**Q.11** The correct functional group X and the reagent/reaction conditions Y in the following scheme are [JEE 2011]



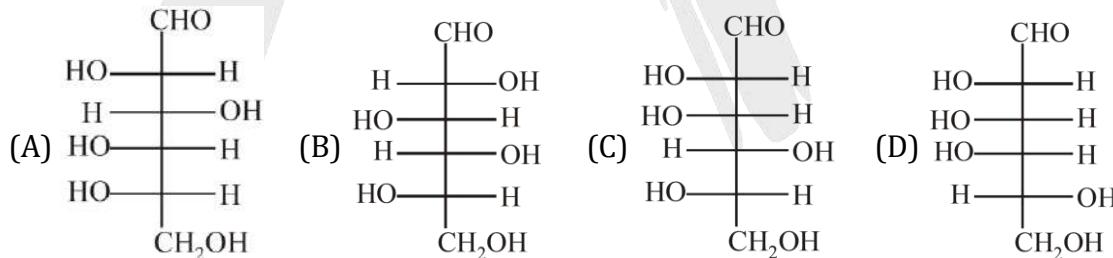
- (A)  $\text{X} = \text{COOCH}_3$ ,  $\text{Y} = \text{H}_2/\text{Ni}/\text{heat}$   
 (B)  $\text{X} = \text{CONH}_2$ ,  $\text{Y} = \text{H}_2/\text{Ni}/\text{heat}$   
 (C)  $\text{X} = \text{CONH}_2$ ,  $\text{Y} = \text{Br}_2/\text{NaOH}$   
 (D)  $\text{X} = \text{CN}$ ,  $\text{Y} = \text{H}_2/\text{Ni}/\text{heat}$

**Q.12** The structure of D-(+)-glucose is



[IIT 2011]

The structure of L(-)-glucose is



**Q.13** For 'invert sugar', the correct statement(s) is (are) :

[JEE 2016]

(Given : specific rotations of (+)-sucrose, (+)-maltose, L-(-)-glucose and L-(+)-fructose in aqueous solution are  $+66^\circ$ ,  $+140^\circ$ ,  $-52^\circ$  and  $+92^\circ$ , respectively)

- (A) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose  
 (B) 'invert sugar' is an equimolar mixture of D- (+) glucose and D- (-) fructose  
 (C) specific rotation of 'invert sugar' is  $-20^\circ$   
 (D) on reaction with  $\text{Br}_2$  water, 'invert sugar' forms saccharic acid as one of the products

## Comprehension : Q.No. 14 to 15

Treatment of compound O with  $\text{KMnO}_4/\text{H}^+$  gave P, which on heating with ammonia gave Q. The compound Q on treatment with  $\text{Br}_2/\text{NaOH}$  produced R. On strong heating, Q gave S, which on further treatment with ethyl 2-bromopropanoate in the presence of KOH following by acidification, gave a compound T.



Q.14 The compound R is:

[JEE 2016]

- (A)
- (B)
- (C)
- (D)

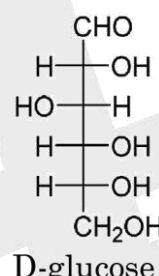
Q.15 The compound T is:

[JEE 2016]

- (A) Glycine                    (B) Alanine                    (C) Valine                    (D) Serine

Q.16 The Fischer presentation of D-glucose is given below.

[JEE 2018]

The correct structure(s) of  $\beta$ -L-glucopyranose is (are)

- (A)
- (B)
- (C)
- (D)

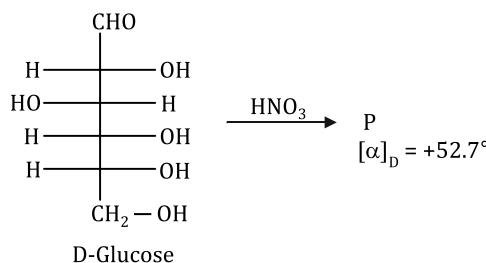
17. Which of the following statement(s) is(are) true?

[JEE 2019]

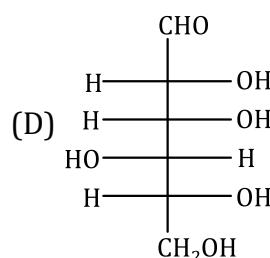
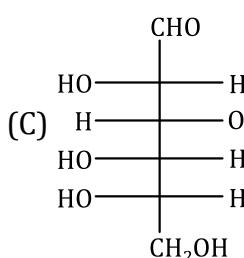
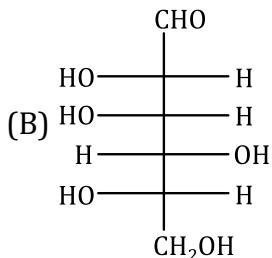
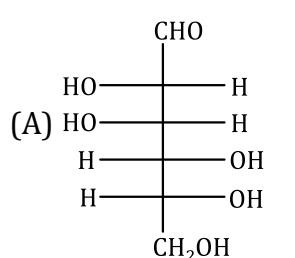
- (A) The two six-membered cyclic hemiacetal forms of D – (+)-glucose are called anomers
- (B) Monosaccharides cannot be hydrolysed to give polyhydroxy aldehydes and ketones
- (C) Oxidation of glucose with bromine water gives glutamic acid
- (D) Hydrolysis of sucrose gives dextrorotatory glucose and laevorotatory fructose

18. Given:

[JEE-2021]

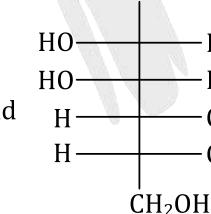
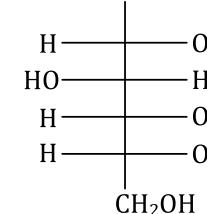
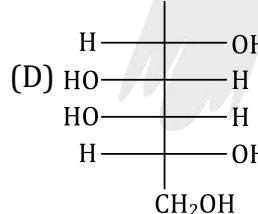
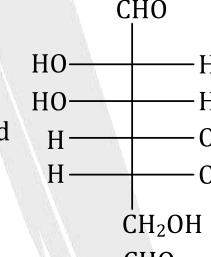
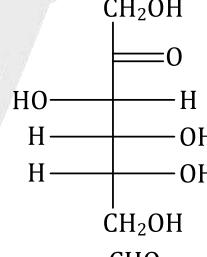
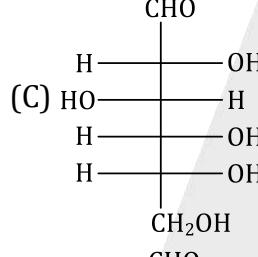
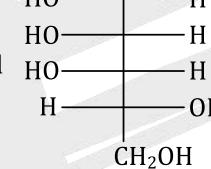
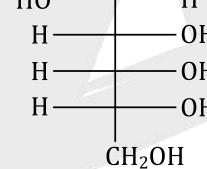
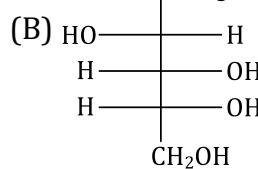
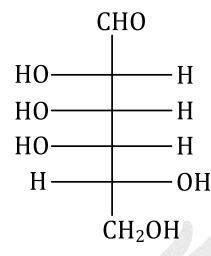
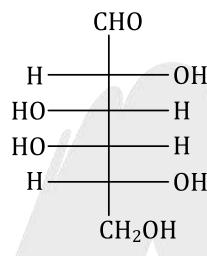
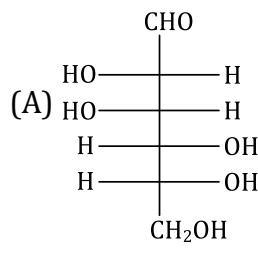


The compound(s), which on reaction with  $\text{HNO}_3$  will give the product having a degree of rotation,  $[\alpha]_D = -52.7^\circ$  is(are);



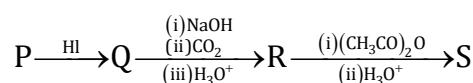
19. Treatment of D-glucose with aqueous  $\text{NaOH}$  results in a mixture of monosaccharides, which are

[JEE- 2022]



20. In the given reaction scheme, **P** is a phenyl alkyl ether, **Q** is an aromatic compound; **R** and **S** are the major products.

[JEE-2023]

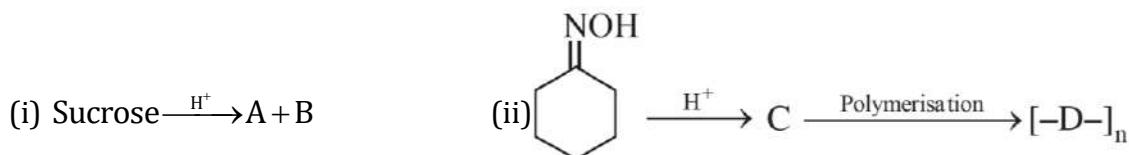


The correct statement about **S** is

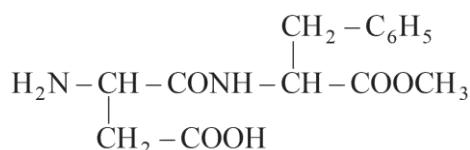
- (A) It primarily inhibits noradrenaline degrading enzymes.
- (B) It inhibits the synthesis of prostaglandin.
- (C) It is a narcotic drug.
- (D) It is ortho-acetyl benzoic acid.

**EXERCISE # V (B) (JEE-ADVANCE) (SUBJECTIVE)**

**Q.1** Give the structures of the products in each of the following reactions. [JEE 2000]



**Q.2** Aspartame, an artificial sweetener, is a peptide and has the following structure: [JEE 2001]



(i) Identify the four functional groups.

(ii) Write the zwitterionic structure.

(iii) Write the structures of the amino acids obtained from the hydrolysis of aspartame.

(iv) Which of the two amino acids is more hydrophobic?

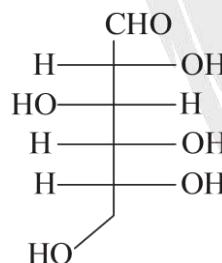
**Q.3** Following two amino acids lysine and glutamine form dipeptide linkage. What are two possible dipeptides? [JEE 2003]



**Q.4** The structure of D-Glucose is as follows- [JEE 2004]

(a) Draw the structure of L-Glucose

(b) Give the reaction of L - Glucose with Tollens reagent.



**Q.5** Monomer A of a polymer on ozonolysis yields two moles of HCHO and one mole of CH<sub>3</sub>COCHO. [JEE 2005]

(a) Deduce the structure of A.

(b) Write the structure of "all cis" - form of polymer of compound A.

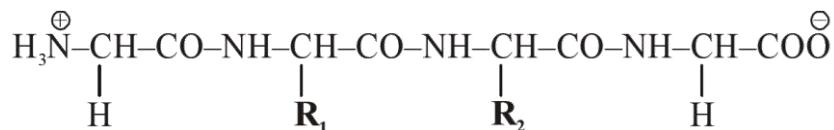
**Q.6** A decapeptide (Mol. Wt. 796) on complete hydrolysis gives glycine (Mol. Wt. 75), alanine and phenylalanine. Glycine contributes 47.0% to the total weight of the hydrolysed products. The number of glycine units present in the decapeptide is [JEE 2011]



## **(Organic Chemistry)**

# BIOMOLECULES

- Q.7** The substitutes  $R_1$  and  $R_2$  for nine peptides are listed in the table given below. How many of these peptides are positively charged at pH = 7.0 ? [JEE 2012]



Peptide	$\mathbf{R}_1$	$\mathbf{R}_2$
I	H	H
II	H	$\text{CH}_3$
III	$\text{CH}_2\text{COOH}$	H
IV	$\text{CH}_2\text{CONH}$	$(\text{CH}_2)_4\text{NH}_2$
V	$\text{CH}_2\text{CONH}_2$	$\text{CH}_2\text{CONH}_2$
VI	$(\text{CH}_2)_4\text{NH}_2$	$(\text{CH}_2)_4\text{NH}_2$
VII	$\text{CH}_2\text{COOH}$	$\text{CH}_2\text{CONH}_2$
VIII	$\text{CH}_2\text{OH}$	$(\text{CH}_2)_4\text{NH}_2$
IX	$(\text{CH}_2)_4\text{NH}_2$	$\text{CH}_3$

- Q.8** When the following aldohexose exists in its d-configuration, the total number of stereoisomers in its pyranose form is - [JEE 2012]



- Q.9** A tetrapeptide has  $-COOH$  group on alanine. This produces glycine (Gly), valine (Val), phenylalanine (Phe) and alanine (Ala), on complete hydrolysis. For this tetrapeptide, the number of possible sequences (Primary structures) with  $-NH_2$  group attached to a chiral center is

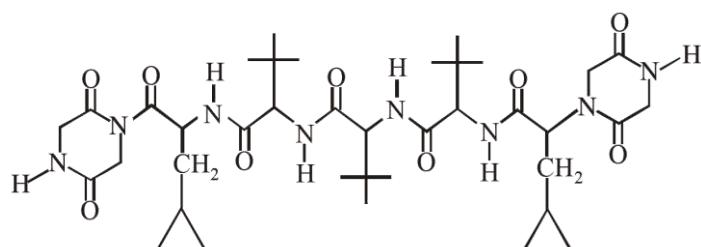
[JEE 2013]

- Q.10.** The total number of lone-pairs of electrons in melamine is:

[JEE 2013]

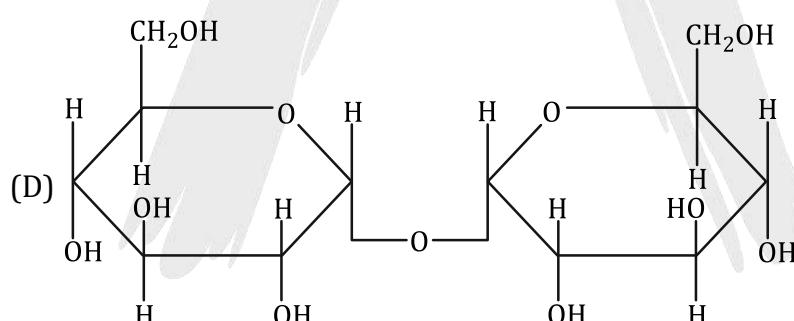
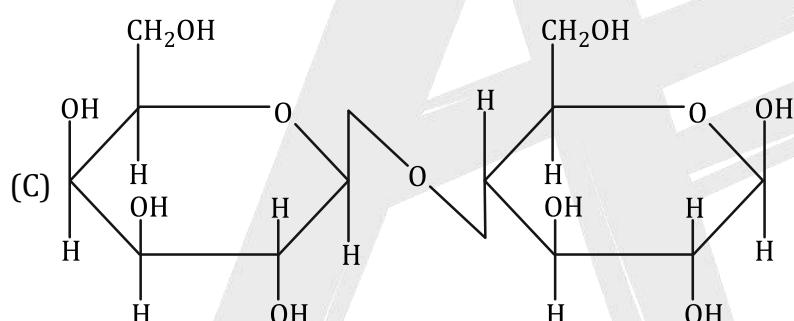
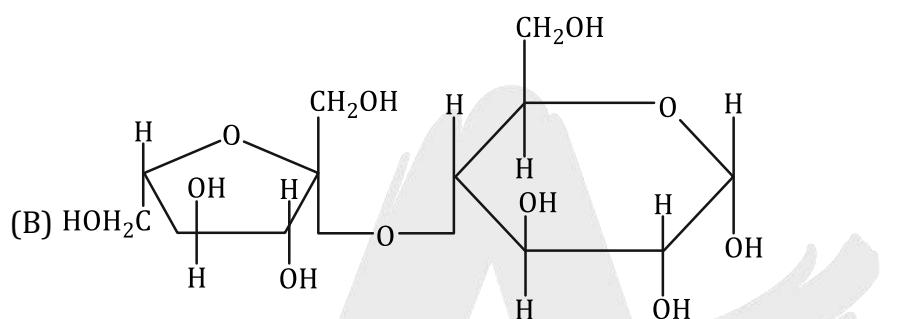
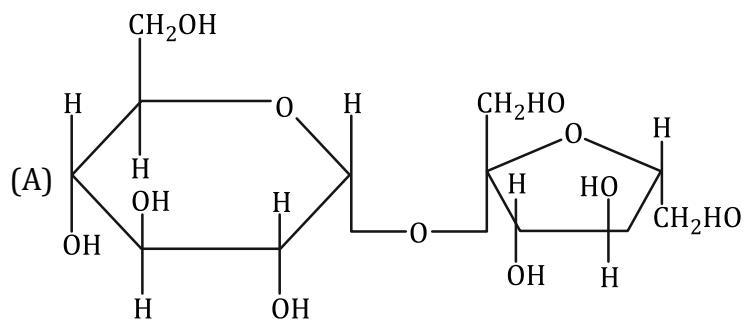
- Q.11** The total number of distinct naturally occurring amino acids obtained by complete acidic hydrolysis of the peptide shown below is [JEE 2014]

[JEE 2014]



**Q.12** A disaccharide X cannot be oxidised by bromine water. The acid hydrolysis of X leads to a laevo-rotatory solution. The disaccharide X is

[JEE ADV. 2023]





## ANSWER KEY

## EXERCISE-I

1.	C	2.	D	3.	C	4.	B	5.	C	6.	A	7.	C
8.	D	9.	C	10.	B	11.	B	12.	C	13.	C	14.	A
15.	A	16.	D	17.	D	18.	D	19.	B	20.	B	21.	D
22.	B	23.	A	24.	A	25.	C	26.	A	27.	D	28.	B
29.	B	30.	C	31.	C	32.	C	33.	D	34.	C	35.	A
36.	D	37.	B	38.	C	39.	A	40.	A	41.	B	42.	B

## EXERCISE-II

1.	ABCD	2.	ABD	3.	ABC	4.	ABD	5.	ABD	6.	ABC	7.	BC
8.	ABCD	9.	ABC	10.	BD	11.	D	12.	A	13.	D	14.	B
15.	C												
16.	(A)→PQS; (B)→S; (C)→RS; (D)→QRS;												
17.	(A)→R; (B)→P; (C)→; (D)→Q;												

## EXERCISE-III

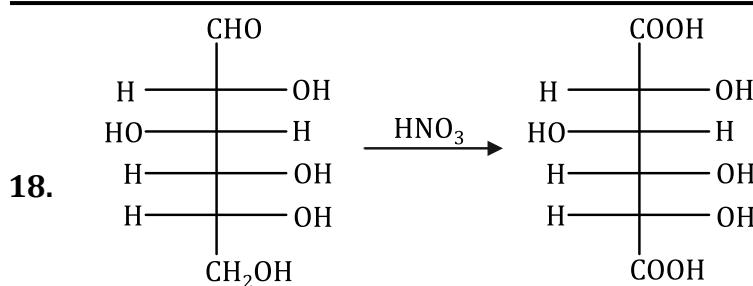
1.	A	2.	A	3.	A	4.	A	5.	D	6.	B	7.	C
8.	A	9.	C										
10.	(A)→S; (B)→Q; (C)→P; (D)→R;												
11.	(A)→QS; (B)→QRS; (C)→PRTU; (D)→PSTU;												
12.	(A)→PQR; (B)→P; (C)→PS ; (D)→PQR;												
13.	(A)→QR; (B)→P; (C)→S; (D)→T;												
14.	(A)→PQR; (B)→S; (C)→R; (D)→PQS;												
15.	(A)→S-W; (B)→P-Y; R-X (C)→Q-Z												
16.	3.25												

## EXERCISE-IV (JEE-MAIN)

1.	2	2.	2	3.	4	4.	3	5.	3	6.	3	7.	3
8.	1	9.	4	10.	4	11.	1	12.	1	13.	3	14.	1
15.	1	16.	2	17.	4	18.	1	19.	1	20.	3	21.	4
22.	4	23.	4	24.	4	25.	2	26.	4	27.	1	28.	4
29.	1	30.	Bonus	31.	3	32.	3	33.	2	34.	C	35.	A
36.	B	37.	A	38.	D	39.	B	40.	A	41.	C	42.	3
43.	D	44.	B	45.	C	46.	C	47.	C	48.	B	49.	1
50.	25												

## EXERCISE # V(A) (JEE-ADVANCE) OBJECTIVE

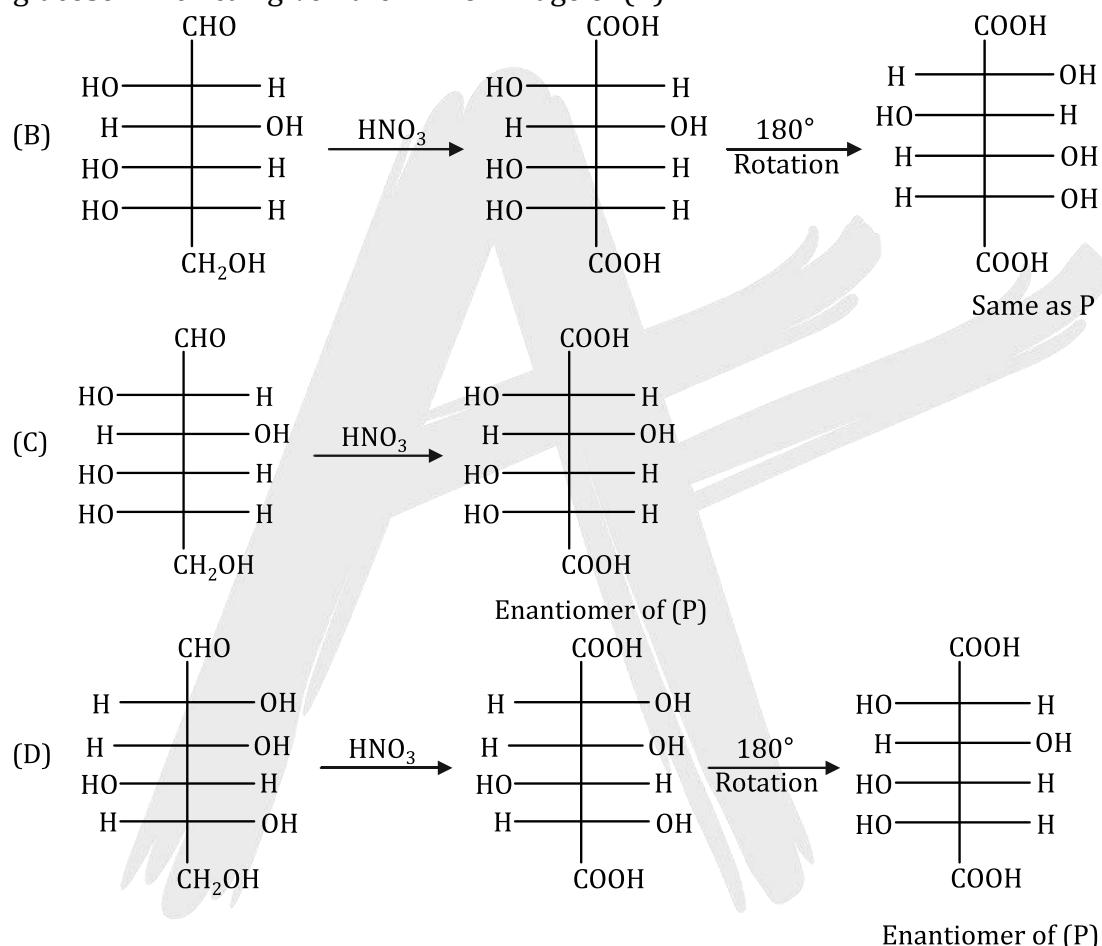
1.	D												
2.	(A)→PS; (B)→QR; (C)→PR; (D)→S;												
3.	(A)→PS; (B)→Q; (C)→QRS; (D)→QR;												
4.	A												
5.	(A)→RS; (B)→PQ; (C)→PQR; (D)→PS												
6.	BC												
7.	D	8.	B	9.	B	10.	C	11.	ABCD	12.	A	13.	BC
14.	A	15.	B	16.	D	17.	AD	18.	C,D	19.	C	20.	B



$$\alpha = +52.7^\circ$$

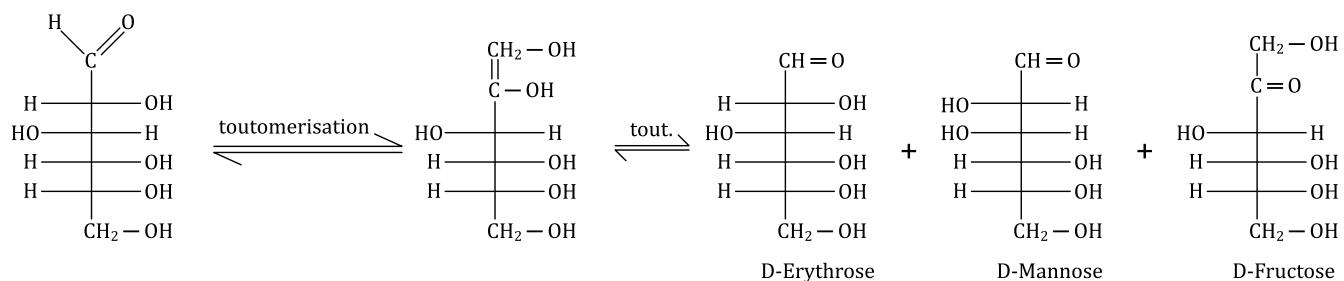
(P)

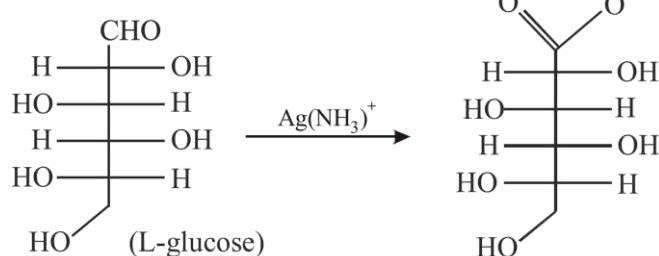
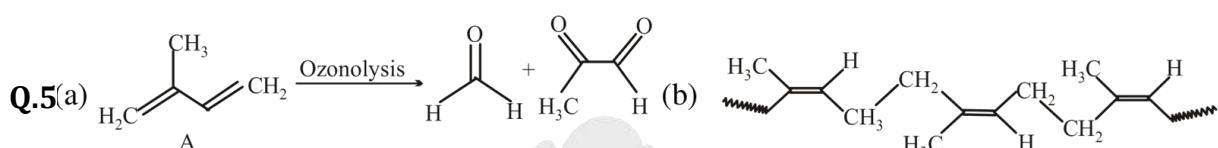
The enantiomer of (P) will have  $-52.7^\circ$  rotation. So the reactant must be an isomer of D-glucose which can give the mirror image of (P)



So answer must be C and D

19.



**EXERCISE # V(B) (JEE-ADVANCE) SUBJECTIVE****Q.2 (i) Amine, carboxylic acid, Amide, Ester****Q.4****Q.5(a)****Q.6**

6

**Q.7**

4

**Q.8**

8

**Q.9**

4

**Q.10**

6

**Q.11**

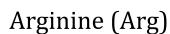
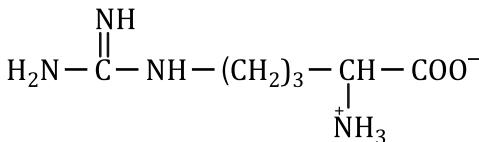
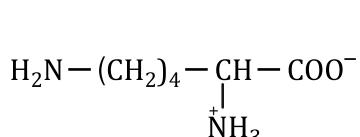
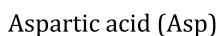
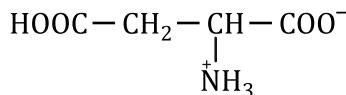
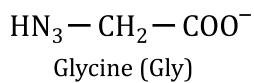
1

**Q.12 (A)**

## SOLUTION

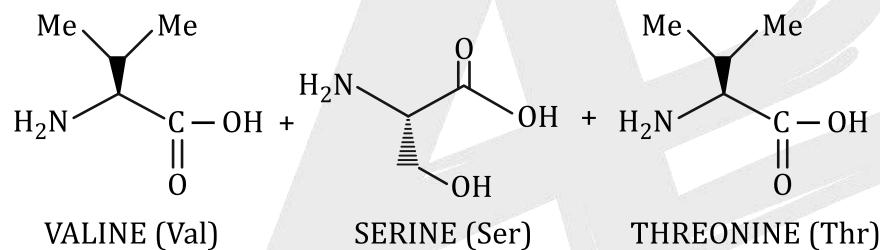
## EXERCISE-IV (JEE-MAIN)

34. Structure of the given  $\alpha$ -amino acids are:

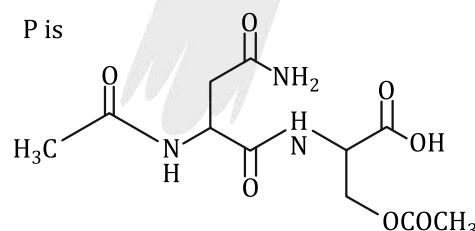
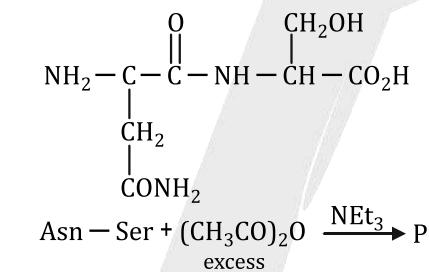


Here, aspartic acid is an acidic and glycine is a neutral amino acid while lysine and arginine are basic amino acids. Also, arginine is more basic due to the stronger basic functional groups.  
 $\therefore$  The order of  $pK_a$  value is directly proportional to the basic strength of amino acids, i.e. Arg > Lys > Gly > Asp.

35.



36.



37.

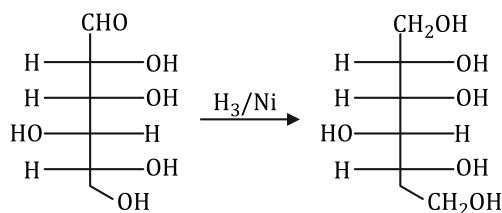
	Name	Abrevation	Functional group	Test
(P)	Tyrosine	Tyr	$(-\text{CH}_3 - \text{C}_6\text{H}_4 - \text{OH})$	Phthalein dye test (C)
(Q)	Aspartic acid	Asp	$(-\text{CH}_2\text{COOH})$	Ester test (A)
(R)	Serine	Ser	$(-\text{CH}_2\text{OH})$	Ester test (A)
(S)	Lysine	Lys	$(-(\text{CH}_2)_4-\text{NH}_2)$	Carbylamine test (B)

## (Organic Chemistry)

## BIOMOLECULES

38. 5 eq. of  $(CH_3CO)_2O$  is used in (i) reaction. 6 eq. of  $(CH_3CO)_2O$  is used in (ii) reaction

5 eq. of  $(CH_3CO)_2O$  is used in (iii) reaction



5 eq. of  $(CH_3CO)_2O$   
will be used in this case

6 eq. of  $(CH_3CO)_2O$   
will be used in this case

Sucrose  $\xrightarrow{\text{Hydrolysis}}$  Glucose + Fructose

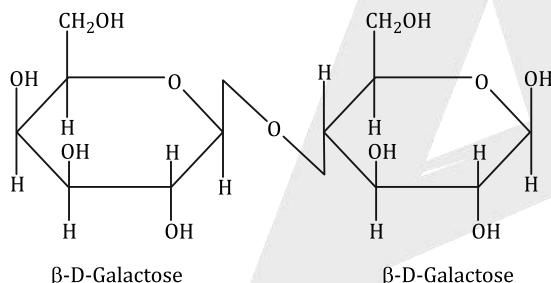
39.

Seliwanoff's reagent

Red colour will  
be observed

Ketose with seliwanoff's reagent gives red colour. It is a specific test for ketose.

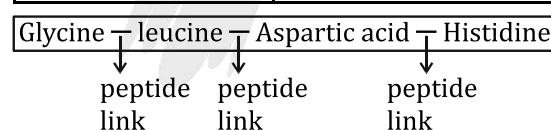
40. Lactose contains  $\beta$ -glycosidic linkage between C<sub>1</sub> of galactose and C<sub>4</sub> of glucose.



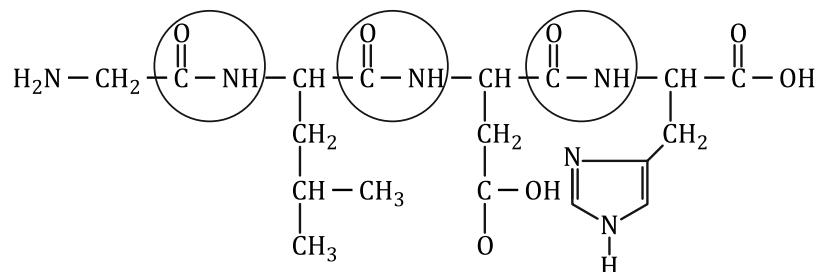
41.

Lab tests	Molisch's test	Barfoed test	Biuret test
Given by	Lactose, Glucose, Fructose	Glucose	Albumin
Do not given by		Fructose	Alanine

42.

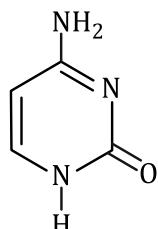


Total (3) peptide linkages are present



3 peptide linkage

43. Sucrose is formed by  $\alpha - D(+)$ . Glucose +  $\beta - D(-)$  Fructose. we obtain these monomers on hydrolysis.
44. Albumin is water soluble.
45. The correct structure of cytosine

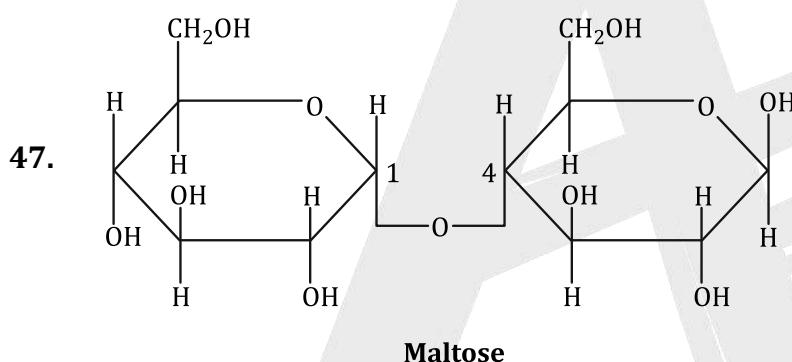


46. **Invertase:** Cane sugar  $\rightarrow$  Glucose and fructose

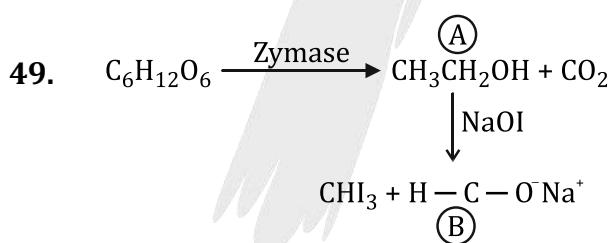
**Zymase:** Glucose  $\rightarrow$  Ethanol and  $CO_2$

**Diastase:** Starch  $\rightarrow$  Maltose

**Maltase:** Maltose  $\rightarrow$  Glucose



48. Mostly H-bonding is responsible for the stability of  $\alpha$ -helix form.



no. of carbon atoms present in B is 1

50. Mol. Wt of  $C_4N_2H_4O_2 = 112$

$$\% N = \frac{28}{112} \times 100 = 25\%$$