# BIOMOLECULES (AMINO ACIDS AND PROTEINS)

**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.

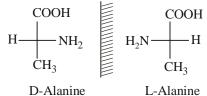
Chemically, proteins are high polymers. They are polyamides and the monomers from which they are derived are the  $\alpha$ - amino carboxylic acids. A single protein molecule contains hundreds or even thousands of amino acid units. These units can be of twenty-odd different kinds. The number of different combinations, i.e., the number of different protein molecules that are possible, is almost infinite.

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

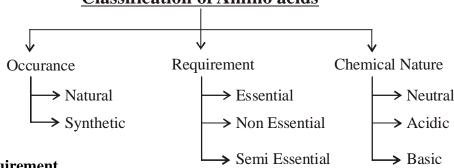
There are 20 amino acids commonly found is proteins and are standard amino acids. All are  $\alpha$  amino acids. Most of them have 1° amino group.(– NH<sub>2</sub>). However proline is a 2° amino.

(Gly) Glycine [G] Alanine [A] Phenyl alanine [F] Proline [P] ( $\alpha$ -imino acid)

All amino acids are chiral molecules with at least one chiral carbon (except glycine,  $H_3N^{\oplus}CH_2COO^{-}$ ). 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 1 gm 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, pregrancy and lactating mother.

3. Non essential amino acid - Body can synthesize them.

# **Based on chemical nature**

**Neutral** - Amino acid having equal number of NH<sub>2</sub> and 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 NH<sub>2</sub>CO group) or are completely hydrocarbon in nature (for example alanine, valine etc.).

Acidic - Amino acid having more COOH than NH<sub>2</sub> group.

For example : Aspartic acid and glutamic acids, each with a second CO<sub>2</sub>H in their side chain are acidic amino acids.

**Basic** - Amino acid having more NH<sub>2</sub> than COOH group. For example : Lysine, arginine and histidine)

A -1. Neutral amino acids (with nonpolar side chains)			
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)	$H_3C$ — $CH$ $C = O$ $OH$	6.0
Valine*	Val(V)	$\begin{array}{ccc} H_3C-CH-C-NH_2\\ & C\\ CH_3 & OH \end{array}$	6.0
Leucine*	Leu(L)	$H_3C-CH-CH_2-C-NH_2$ $CH_3$ $C=O$ $OH$	6.0
Isoleucine*	Ile(I)	CH <sub>3</sub> NH <sub>2</sub> 	6.0
Methionine*	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		5.7
<sup>@@</sup> Proline	Proline $Pro(P)$ $NH$ $CO_2H$		6.3
Phenylalanine*	Phe(F) CH <sub>2</sub> -CHCO <sub>2</sub> H		5.5
Tryptophan* Trp(W)		CH <sub>2</sub> -CHCO <sub>2</sub> H	5.9

A -2. Neutral amino acids (with polar, but nonionized side chains)			
NAME ABBREVIATIONS		STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Asparagine**	Asn(N)	$\begin{array}{c} O \\ H_2N - C - CH_2 - CH \\ C = O \\ OH \end{array}$	5.4
Glutamine**	Gln(Q)	$H_2N$ — $C$ — $CH_2$ — $CH_2$ — $CH$ $C = O$ $OH$	5.7
Serine**	Ser(S)	$HO-CH_2-CH$ $C=O$ $OH$	5.7

A -3. Neutral amino acids (with polar, but nonionized side chains)			
NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Threonine*	Thr	OH NH <sub>2</sub>     H CH <sub>3</sub> CH–CHCO <sub>2</sub> H	5.6
Tyrosine**	Tyr(Y)	$HO CH_2$ $CH_2$ $CH_2$ $CH_3$ $CH_4$ $CH_5$ $CH_5$ $CH_5$ $CH_6$ $CH_7$ $C$	5.7
Cysteine	Cys	HSCH <sub>2</sub> -CHCO <sub>2</sub> H	
‡ Cystine	Cys–Cys	NH <sub>2</sub> NH <sub>2</sub> HOOCCHCH <sub>2</sub> S–SCH <sub>2</sub> CHCOOH	

	B - Acidic amino acids (side chain with carboxylic acid group)			
	NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
A	spartic acid**	Asp(D)	О NH <sub>2</sub> О НО-С-СН <sub>2</sub> -СН-С-ОН	2.8
C	Glutamic Acid	Glu(E)	$O = C - CH_2 - CH_2 - CH_2 - C - OH$	3.2

C - Basic amino acids (side chain with nitrogenous basic group)			
NAME	ABBREVIATIONS	STRUCTURAL FORMULAE	ISOELECTRIC POINT[pI]
Lysine*	Lys(K)	$H_2N - CH_2 - $	9.7
Arginine*	Arg(R)	$\begin{array}{c} \text{NH} \\ \text{H}_2\text{N} - \overset{\text{N}}{\text{C}} - \text{NH} - \text{CH}_{\overline{2}} \text{ CH}_{\overline{2}} \text{ CH}_{\overline{2}} \text{ CH}_{\overline{2}} \\ \text{C} = \text{O} \\ \text{OH} \end{array}$	10.8
Histidine*	His(H)	ÖH2-CH COOH	7.6

#### *Note:*

- \* Amino acids with an asterisk are essential amino acids.
- \*\* Amino acids with an asterisk are non 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).
- <sup>@@</sup> 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.

$$\begin{array}{c} O \\ C \\ N^- \\ K^+ + Cl - CH_2COOC_2H_5 \end{array} \xrightarrow{- KCl} \begin{array}{c} O \\ C \\ N - CH_2COOC_2H_5 \end{array}$$
 Potasium phthalimide 
$$\begin{array}{c} O \\ N - CH_2COOC_2H_5 \end{array}$$

Cl<sup>-</sup> <sup>+</sup>H<sub>3</sub>N – CH<sub>2</sub>COOH + phthalic acid Glycine hydrochloride

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

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

$$\begin{array}{c} \text{CH}_{3}\text{CH}_{2}\text{COOH} \xrightarrow{\text{Br}_{2}, \text{ P}} \text{CH}_{3}\text{CHCOOH} \xrightarrow{\text{NH}_{3} \text{ (excess)}} \text{CH}_{3}\text{CHCOO} \\ & \text{Br} & \text{NH}_{3} \\ & \alpha\text{-Bromopropionic acid} & \text{Alanine (Z.I.)} \end{array}$$

# (c) From diethyl malonate

$$Na^{+} \bigcirc COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$COOC_{2}H_{5}$$

$$Ethyl benzylmalonate$$

$$CoOH \leftarrow CH_{2}COOH \leftarrow CH_{2}COOH \leftarrow COOH \leftarrow COOH$$

$$COOH \leftarrow COOH \leftarrow COOH$$

$$COOH \leftarrow$$

Phenylalanine (Z.I.) 35% overall yield

# (d) Strecker's synthesis

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

#### (e) Using KOOP synthesis

$$CH_{3}COOH \xrightarrow{HVZ} CH_{2} COOH \xrightarrow{DMSO} CH COONa \xrightarrow{NH_{3}} CH COONa \xrightarrow{NH_{2}} CH_{2}$$

$$COONa \xrightarrow{COONa} CH_{2} COONa \xrightarrow{COONa} COONa \xrightarrow{COONa} CH_{2} COONa$$

# **Properties of Amino acids**

Although the amino acids are commonly shown as containing an amino group and a carboxyl group, H<sub>2</sub>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 existance.

# 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)

Amino acids: dipolar ions (Zwitter ion)

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,  $RNH_3^+$ ,

$$H_{3}^{\Theta} \stackrel{\square}{\text{NCHCOO}}^{-} + H_{2}O \Longrightarrow H_{3}O^{+} + H_{2}N\text{CHCOO}^{-}$$

$$R$$

$$Acid$$

$$K_{a} = \frac{[H_{3}O][H_{2}N\text{CHRCOO}^{\bullet}]}{[H_{2}N\text{CHRCOO}^{\bullet}]}$$

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 of the solution.

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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 pH 6.1.

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.

$$Ka_1 = \frac{[Z.I.] \quad [H^{\oplus}]}{[C^{\oplus}]} \quad Ka_2 = \frac{[A^-] \ [H^{\oplus}]}{[DI]} \ \text{ at pI } [A^{\Theta}] = [C^{\oplus}]$$

$$\frac{[Z.I.] \ [H^{\oplus}]}{Ka_1} = \frac{Ka_2[DI]}{[H^{\oplus}]} \qquad [H^{\oplus}]^2 = Ka_1 \& Ka_2$$

on taking antilog pI = 
$$\frac{P^{Ka_1} + P^{Ka_2}}{2}$$

An amino acid having -COOH group more than  $NH_2$  group or such amino acid have pI less than 7. An amino acid having more  $-NH_2$  more than COOH group such amino acid have pI more than 7.

Q. Write the structure of alanine at pH 2.5, 10.5 and 6.

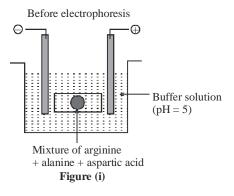
#### **Electrophoresis**

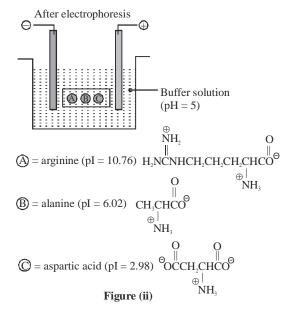
The movement of charged molecules (like amino acid) under the influence of an electric field is called electrophoresis. Electrophoresis separates amino acids on the basis of their pI values.

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 (pH = 5) between the two electrodes and an electric field is applied then arginine & alanine with pI > pH move towards the cathode and aspartic acid with pI < 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 $-NH_2$ group

$$R \xrightarrow{HBr} R \xrightarrow{H} COOH$$

$$\longrightarrow NH_3Br^{\circ}$$

$$H$$

$$MeCOCl \Rightarrow R \xrightarrow{H} COOH$$

$$NHCOMe$$

$$Ac_2O \Rightarrow R \xrightarrow{H} COOH$$

$$NHCOMe$$

$$NHCOOH$$

$$NHCOOH$$

$$OH$$

$$NOCl \Rightarrow R \xrightarrow{H} COOH$$

$$Cl$$

$$NOBr \Rightarrow R \xrightarrow{H} COOH$$

$$\phi \xrightarrow{H} COOH \xrightarrow{HCHO} \phi \xrightarrow{H} COOH Sorison's titration method.$$

$$NH_2 \qquad NH = CH_2$$

$$\begin{array}{ccc} \text{CH}_2\text{--COOH} & \xrightarrow{\text{PhCOCl}} & \text{CH}_2\text{--COOH} \\ | & & | & | \\ \text{NH}_2 & & \text{NH}\text{--C}\text{--Ph} \\ | & & | & | \\ \text{O} & & | \\ \end{array}$$

Hipuric acid

Reactions is used to  $block - NH_2$  group during volumetric analysis in.

# (2) **Reactions due to – COOH group.**

$$ROH \rightarrow R \xrightarrow{H} COOR$$

$$ROH \rightarrow R \rightarrow NH_3$$

$$R \rightarrow NaOH \rightarrow R \rightarrow NH_2$$

$$NaHCO_3 \rightarrow Na salt$$

$$NH_2 \rightarrow NH_2$$

$$LAH \rightarrow R \rightarrow CHQH$$

$$NH_2 \rightarrow NH_3 \rightarrow R \rightarrow CONH_2$$

$$NH_3 \rightarrow R \rightarrow CONH_2$$

# (3) <u>Heating Effect</u>

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

$$\begin{array}{c|c} & O \\ & CH_2-C + OH \\ & H \\ & NH \\ & NH \\ & CH_2 \\ & O \\$$

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

$$2 \text{MeCH(NH}_2) \text{COOH} \xrightarrow{\Delta} \text{HOOME} \text{NHOOME} + \text{HOOME} \text{NHOOME} \text{NHO$$

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

$$\begin{array}{c} \text{RCHCH}_2\text{COOH} & \xrightarrow{\Delta} \text{RCH} = \text{CH-COONH}_4 \\ \mid & \text{NH}_2 \end{array}$$

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

OH NH<sub>2</sub> N-H + H<sub>2</sub>O 
$$\gamma$$
- lactam

### (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.

Abbreviated name of amion acid with free NH<sub>2</sub> is written first.

Gly–Ala [Glycine Alanine]

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.

Q.	Glycine can form how many Dipeptide?	[Ans. One]
Q.	Glycine can form how many Tripeptide?	[Ans. One]
Q.	Glycine and Ala can form how many Dipeptide?	[Ans. Four]
Q.	Gly, Ala, and Phenyl Ala can form how many Dipeptide?	[Ans. Nine]

Q. Gly, Ala, can form how many Tripeptide? [Ans. Eight]

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.

# **Structure of Proteins**

Proteins can be classified into two types on the basis of their molecular shape.

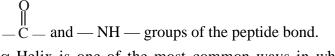
# (a) <u>Fibrous proteins</u>

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.

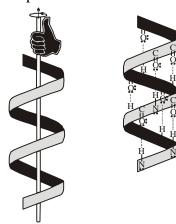
# (b) Globular proteins

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 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



 $\alpha$ -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 — NH group of each amino acid residue hydrogen bonded to the



α-Helix structure of proteins

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.

β-Pleated sheet structure of proteins

- (i) Ionic bonding: between COO<sup>-</sup> and NH<sub>3</sub><sup>+</sup> at different sites.
- (ii) H-bonding: mainly between side-chain NH<sub>2</sub> and 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° and 3° structures of proteins are hydrogen bonds, disulphide linkages, van der walls and electrostatic forces of attraction.
- **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: Heamoglobin, Chlorophyll.

According the 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 form 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 reversible. 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.

#### **Test Of Amino acids and Proteins**

1. Biurate Test 2. Nin hydrin Test 3. Xanthoproteic test

4. Sakaguchi test 5. Millon's Test

#### 1. Biurate Test

Addition of a very dilute solution of CuSO<sub>4</sub> 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.

### 2. Nin hydrin Test

The ninhydrin test is a test for amino acids and proteins with a free –NH<sub>2</sub> 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<sub>2</sub> group reacts with ninhydrin, a purple-blue complex is formed.

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

#### 3. Xanthoproteic test

This test is used for aromatic amino acids which give positive result from other amino acids. Such as tyrosine, and tryptophan gives Xanthoproteic test, phenyl alanine does not respond with this test.

# **Principle:**

Xanthoproteic test is used to detect amino acids containing an aromatic nucleus (tyrosine, tryptophan and phenylalanine) in a protein solution which gives yellow color nitro derivatives on heating with conc. HNO<sub>3</sub>. The aromatic benzene ring undergoes nitration to give yellow colored product. Phenylalanine gives negative or weakly positive reaction though this amino acid contains aromatic nucleus because it is difficult to nitrate under normal condition. On adding alkali to these nitro derivative salts, the color change for yellow to orange.

#### 4. Sakaguchi test

The Sakaguchi test is a chemical test used for detecting the presence of arginine in proteins Sakaguchi reagent consists of  $\alpha$ -Naphthol and a drop of sodium hypobromite. The guanidine group in arginine reacts with Sakaguchi reagent to form a red-coloured complex.

Sakaguchi Reaction

$$NH_2 \qquad NH \qquad OH \qquad + NaBrO \qquad Br \qquad NH \qquad NH \qquad + NaBrO \qquad NH \qquad NH \qquad - NaBr \qquad -NaBr \qquad CH_2 \qquad COOH \qquad COOH$$

$$L-Arginine \qquad Red compound \qquad Red co$$

#### 5. Millon's Test

Millon's reagent is an analytical reagent used to detect the presence of soluble proteins. A few drops of the reagent are added to the test solution, which is then heated gently. A reddish-brown coloration or precipitate indicates the presence of tyrosine residue which occur in nearly all proteins

Tyrosine Here 
$$R = -CH_2CH(NH_2)COOH$$
.

 $R \longrightarrow OH \longrightarrow R \longrightarrow OH$ 
 $R \longrightarrow OH \longrightarrow R$ 
 $R \longrightarrow OH \longrightarrow R$ 
 $R \longrightarrow OH \longrightarrow R$ 
 $R \longrightarrow OH$ 
 $R \longrightarrow$ 

reddish-brown colored complex

# Sanger's Method of sequencing of Amino acids of polypeptide chain

It is N-terminal amino acid analysis

Sanger's reagent (1-fluoro-2,4-dinitrobenzene)

Step 1 React the peptide with a reagent that will selectively label the N-terminal amino acid.

**Step 2** Hydrolyse the protein.

**Step 3** Determine the amino acid by chromatography and comparison with standards.

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# **CARBOHYDRATES**

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

- Sucrose (Cane suger) C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>, and
- Maltose (Malt Suger) C<sub>12</sub>(H<sub>2</sub>O)<sub>11</sub>

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

Ex. 
$$CH_2O$$
 Formaldehyde  $C_2(H_2O)_2$  Acetic acid  $C_3(H_2O)_3$  lactic acid

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

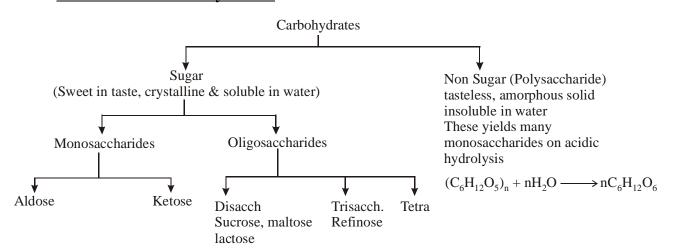
**Modern Concept:** Carbohydrates are polyhydroxy aldehyde or ketone

or

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

- Carbohydrates  $\xrightarrow{\text{H}_2\text{O}/\text{H}^+}$  Polyhydroxy aldehyde or ketone
- Carbohydrates are also known as Saccharides.
- In plants carbohydrates are synthesised by photosynthesis

### Classification of carbohydrates:



**Monosaccharides:** (simple sugars)

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

General formula is  $C_n H_{2n} O_n$ 

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.

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

		Г	
		Aldoses	Ketoses
3C	Tropose or Triose	Aldotriose	Ketotriose
4C	Tetrose	Aldotetrose	Ketotetrose
5C	Pentose	Aldopentose	Ketopentose
5C	Including –CHO	Aldopentose (Ribose)	H_C_O H_C_OH H_C_OH H_C_OH CH <sub>2</sub> OH
5C	Including -C-    O	Ketopentose	$\begin{array}{c} \mathrm{CH_2OH} \\   \\ \mathrm{C} \\ \mathrm{C=O} \\   \\ \mathrm{H-C-OH} \\   \\ \mathrm{H-C-OH} \\   \\ \mathrm{CH_2OH} \end{array}$
6C	Hexose	Aldohexose	Ketohexose
6C	Including –CHO	Aldohexose (Glucose)	CHO $H-C-OH$ $HO-C-H$ $H-C-OH$ $H-C-OH$ $CH_{2}OH$ $D-glucose$
6C	Including – C –    O	Ketohexose (Fructose)	$CH_{2}OH$ $C = O$ $HO - C - H$ $H - C - OH$ $H - C - OH$ $CH_{2}OH$ $D - fructose$

# 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.

These are the non sugars which yeild a large no of monosaccharide units on **Polysaccharides** :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  $C_x(H_2O)_v x = 3 - 8$ . Nomenclature of monosaccharides are given according to the no. of carbons present in them.

# **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 CH - OHCH<sub>2</sub>OH

Fischer projection

D-Glyceraldehyde (+)

L-Glyceraldehyde (–)

CHO

#### **Classification of Aldotetrose:**

- (i) Erythrose
- (ii) Threoese

C-5 CHO CHO 
$$(CHOH)_2$$
  $(CHOH)_2$   $(CHOH)_2$ 

No. of  $C^* = 3$  (in Aldopentose)

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

L-Aldopentose No. of D Sugars 4 **D-Aldopentose** 

No. of L Sugars

# **D-Aldopentose:**

All Isomeric D-sugars are diastereomers.

#### **Aldohexose:**

No. of 
$$C^* = 4$$

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

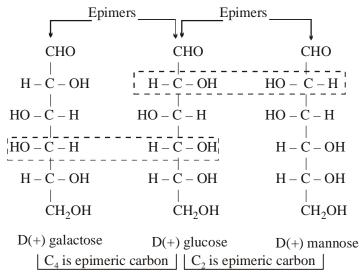
No. of D-sugars 
$$= 8$$

No. of L-sugars 
$$= 8$$

#### CHO CHO — OH —Н НО-HO-—H H-OH-OH-**–**Н HO-**–** ОН -HHO-ĊH<sub>2</sub>OH ĊH<sub>2</sub>OH D-Glucose L-Glucose

### 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.



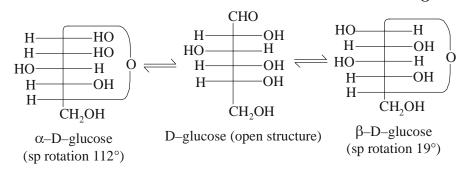
Example with  $C_2$  epimeric carbon is

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

The two sugars that differs in configuration only on the carbon that was the carbonyl carbon in the open chain form is called as anomers  $\alpha$  glucose and  $\beta$  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 then  $\alpha$ -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.

The anomeric substituent is in the 
$$\beta$$
-position

The anomeric substituent is in the  $\alpha$ -position

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° so that anomeric carbon is on the right and the ring oxygen is in the rear. Obtained projection is a Haworth projection.

Ε

# Example:

(D-glucose)

# **Projection:**

# Hawarth projection

# ⇒ Chair conformation of D–glucose

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

 $\beta$ -D-Glucose (most stable glucose form) all groups are equatorial.

α-D-Glucose –OH group at anomeric carbon is axial.

### **Mutarotation**

HO OH OH 
$$\alpha$$
-anomer  $\alpha$ -anomer

Specific rotation of α glucose + 112°

Specific rotation of  $\beta$  glucose + 19°

Equilibrium mixture  $[\alpha]_D = 52.5$  degree mL  $g^{-1}$  dm<sup>-1</sup>

Fresh 
$$\alpha$$
-glucose  $\longrightarrow$  52.5  $\longleftarrow$  Fresh  $\beta$ -glucose 112° 36 %  $\alpha$  glucose 19° 63.8 %  $\beta$  glucose

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°. The specific rotation of this solution increases with time also to  $+52.5^{\circ}$ .

This change of optical rotation with time is called mutarotation. 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 is 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

HOH<sub>2</sub>C-C-OH 
$$C=O$$
H  $C=O$ H  $C$ 

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ALLEN

Ring structure of fructose C, Pyranose structures 6 membered ring,  $C_2 - C_6$  linkage

Furanose structure (5 membered ring)

**Mutarotation:** Fructose undergo complex mutarotation. The structure of the cyclic hemiacetal form of d-fructose can be derived from it's carbonyl (Ketone) form using the methods described as follows.

anomeric

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.

DBO-BA \Kola \LEE(Advanced)\Leader\Che\Shee\\Biomolecules\Eng.p65

- \* 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.

H OCH<sub>3</sub> 
$$CH_3O$$
 H

(CHOH)<sub>3</sub>  $O$  (CHOH)<sub>3</sub>  $O$ 

CH

CH

CH

CH

CH

CH<sub>2</sub>OH

CH<sub>2</sub>OH

 $CH_2OH$ 
 $CH_2OH$ 
 $CH_2OH$ 
 $CH_2OH$ 
 $CH_2OH$ 
 $CH_2OH$ 
 $CH_2OH$ 

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

$$\begin{array}{c} \text{CH}_2\text{OH} \\ \text{OO} \\$$

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 NaHSO<sub>3</sub>, NH<sub>3</sub>
- (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

H-C H-C-OH HO-C-H H-C-OH H-C CH<sub>2</sub>OH

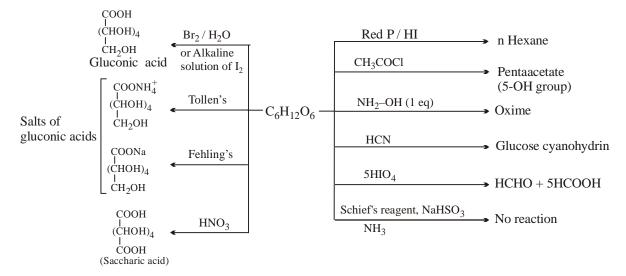
ode06\B0B0-BA\Kota\JEE(Advanced)\Leader\Che\Sheet\Biomolecules\En

26

ALLEN

(NH<sub>3</sub>, NaHSO<sub>3</sub>) but strong reagent (HCN, NH<sub>2</sub>OH, C<sub>6</sub>H<sub>5</sub>NH – NH<sub>2</sub>) 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 monosaccharies

CHO 
$$\begin{array}{c} \text{CH}_2\text{-OH} \\ | \\ \text{(CHOH)}_4 \\ | \\ \text{CH}_2\text{OH} \\ \end{array}$$
  $\begin{array}{c} \text{CH}_2\text{-OH} \\ | \\ \text{(CHOH)}_3 \\ | \\ \text{CH}_2\text{OH} \\ \end{array}$  Glucose Fructose

# 1. Acetylation:

CHO
$$(CHOH)_4 + 5CH_3COC1 / (CH_3CO)_2O$$

$$CH_2OH$$
CH2OH

CH2OH

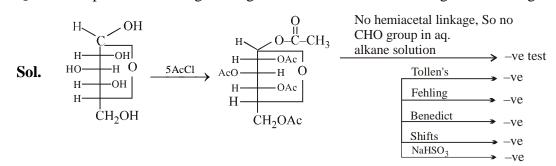
CH3COC1 / (CH3CO)\_2O

$$CH_2-O-C-CH_3$$
CH2-O-C-CH3

OPenta acetyl glucose

This reaction suggests presence of 5(OH) group.

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



2. Red by HI / Red P:

CHO
$$\begin{array}{c}
\text{CHO} \\
\text{CHOH})_4 \xrightarrow{\text{Red P/HI}} & \text{n-Hexane} \\
\text{CH}_2\text{OH}
\end{array}$$

$$\begin{array}{c}
\text{CH}_2\text{-OH} \\
\text{CHOH})_3 \xrightarrow{\text{Red P/HI}} & \text{n-Hexane} \\
\text{CH}_2\text{OH}$$

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:

CHO 
$$(CHOH)_4 + 3 C_6H_5 NH - NH_2 \xrightarrow{-Ph-NH_2} Osazone$$
 CH<sub>2</sub>OH

Mechanism:

Propose Mechanism for:

CHOH
$$C=O \xrightarrow{PhNHNH_2} \xrightarrow{(Excess)} R$$

$$CH=NNHPh$$

$$C=NNHPh + PhNH_2 + NH_2$$

$$R$$

$$(Osazone)$$

Reaction with fructose:

Fructose + 3 
$$NH_2$$
- $NH$ - $C_6H_5$   $\longrightarrow$  Osazone

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:**

Glucose 
$$\xrightarrow{\text{HIO}_4}$$
 5HCOOH + HCHO + 5HIO<sub>3</sub>

### **Oxidation of fructose:**

$$Fructose \xrightarrow{Tollen's, Reagent} Gluconic acid$$

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

Fructose 
$$\xrightarrow{Br_2water}$$
 No reaction

Fructose 
$$\xrightarrow{\text{HNO}_3}$$
  $\xrightarrow{\text{CH}_2\text{OH}}$   $\xrightarrow{\text{COOH}}$   $\xrightarrow$ 

# 8. **Reaction with enzyme:**

Glucose or Fructose 
$$\xrightarrow{\text{Yeast}}$$
  $2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$ 

# 9. **Reaction with dil NaOH / Ca(OH)**<sub>2</sub>

Mannose or Glucose or fructose  $\xrightarrow{\text{dil. NaOH}}$  Glucose + Fructose + Mannose Mechanism :

Fructose

# 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 it's acyclic aldehyde form.

# Method of ascending the sugar series:

An aldose may be converted into it's 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:

### **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:**

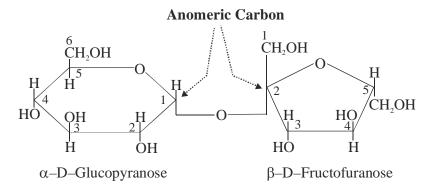
# SOME IMPORTANT CARBOHYDRATES

1. <u>Sucrose</u>  $(C_{12}H_{22}O_{11}): \to A$  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  $[\infty]_D = +66.5^\circ$ 

$$CH_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} \begin{array}{c} dextro & laevo \\ C_6H_{12}O & + & C_6H_{12}O \\ \\ D\text{-Glucose} & D\text{-Fructose} \\ \\ \alpha \left[D\right] = -52.7^{\circ} & \left[\beta\right]_D = -92.7^{\circ} \\ \\ Dextro \ Isomer & Laevo \ Rotatary \\ \\ \hline \\ Mixture \ is \ laevorotatory \\ -20^{\circ} \\ \end{array}$$

- 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 reduces Tollen's & Fehling's solution.
- This indicates that neither the aldehyde group of glucose nor the ketonic group of fructose is free in sucrose.



 $Structure \ of \ sucrose \\ (\alpha-D-glucopyranosyl-\beta-D-fructofuranoside)$ 

Do not show mutarotation.

Fig. Showing Sucrose in other structure

Fig. Showing Sucrose in other structure

#### 2. Maltose:

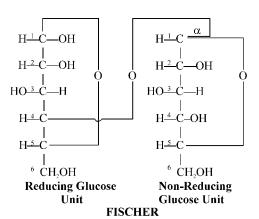
• It is dimer of α-D-Glucose

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

$$2 (C_6H_{10}O_5)_n + n H_2O \xrightarrow{Diastase} n C_{12}H_{22}O_{11}$$
Starch
Maltose

- 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
- (i) Both glucose units are present in the pyranose form.
- (ii) C<sub>1</sub> of one glucose unit is linked to C<sub>4</sub> 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. <u>Lactose</u> (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)  $C_1$  of galactose unit is connected to  $C_4$  of glucose unit.

Further since emulsin, as, enzyme which specifically hydrolyses β-glycosidic linkages also hydrolyses

lactose, therefore, galactose must be present in the  $\beta$ -form. In other words, in lactose,  $C_1 - \beta$  of galactose is attached to  $C_4$  of glucose as shown in figure.

**FISCHER** 

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

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**Occurrence:** The value of n (100 - 3000) generally hewever 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 beaks down first to smaller molecules (n > n'), then to maltose and finally to D-glucose.

$$(C_6H_{10}O_5)n \xrightarrow{H^+/H_2O} (C_6H_{10}O_5)_n, \xrightarrow{H^+/H_2O} C_{12}H_{22}O_{11} \xrightarrow{H^+/H_2O} C_6H_{12}O_6$$
Starch Maltose 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  $C_1$  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  $\alpha$ -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  $\alpha$ -D-glucose in which  $C_1$  of one glucose unit is attached to  $C_4$  of the other through  $\alpha$ -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.

# <u>Glycogen</u> $(C_6H_{10}O_5)_n$ :

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  $(C_6H_{10}O_5)$
- 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.

Molish Test
 Barfoed Test
 Salivanoff's Test.
 Bial's Test

5. Osazone Test 6. Benedict Test 7. Fehling Test 8. Tollen's Test

9. Iodine Test

1. Molish Test

Molish test is the general test for the identification of all carbohydrates (Monosaccharides, Disaccharides and Poly saccharides ) and Glycoprotein, Sulphuric acid is added to hydrolyzes the all glycosidic linkage to yield monosaccharides, which on dehydration form furfural or its derivative in presence of acid.which condened with  $\alpha$ -naphthol to give a violet colored complex.

Oligosaccharide or poly saccharides +  $H_2SO_4$   $\xrightarrow{H_3O^+(Hydrolysis)}$  Monosaccharides

D-glucose (monosaccharide)

5-(hydroxymethyl) furfural

purple colored dye or violet colored complex

#### 2. Barfoed Test

This test is used to differentiate reducing monosaccharide from a disaccharide sugar It is done in mild acidic medium.

RCHO + 
$$2Cu^{2+}$$
 +  $2H_2O \longrightarrow RCOOH + Cu_2O ppt +  $4H^+$$ 

It is based on the reduction of <u>copper(II)</u> acetate to <u>copper(I)</u> oxide (Cu<sub>2</sub>O), which forms a brick-red precipitate.

Reducing monosaccharides react with Barfoed's reagent much faster than disaccharides and produce red precipitate of copper (I) oxide within three minutes.

Disaccharide sugars as they are weaker reducing agents, react at a slower rate, so they do not form red precipitate even for ten minutes.

#### 3. Selivanoff's Test

It is test of Ketose sugar (eg Fructose), it is used to differentiate Ketose sugar from aldose sugar.

This test relies on the principle that keto hexose are more rapidly dehydrated than aldoses to form 5-Hydroxy methyl furfural when heated in acidic medium, which on condensation with resorcinol, a cherry red (or Brown red) colored complex is formed rapidly indicating a positive test.

#### 4. Bial's Test

Bial's test is positive for Pentoses

This test is used to differentiate Pentose and Hexose sugar

The test reagent dehydrates pentoses to form furfural. Furfural further reacts with Bial's reagent (a solution of orcinol, HCl and ferric chloride). orcinol and the iron ion present in the test reagent to produce a bluish product.

Figure insert

Specifically Pentose sugar gives bluish colored complex.

All other colors indicate a negative result for pentoses.

Note: hexoses generally react to form green, red, or brown products.

#### 5. Osazone Test

Reducing Sugars when heated with Phenyl Hydrazine, Characteristic yellow crystals of Osazone are formed with specific shape.

Glucose, Mannose & Fructose gives same Osazone crystals, like NEEDLE SHAPED.

Maltose gives Maltosazone crystals, like SUNFLOWER SHAPED.

Lactose gives lactosazone crystals,

like TIGHT BALL or POWDER PUFF SHAPED..

#### 6. Benedict test

Carbohydrates which has Aldehyde functional group (Not Aromatic Aldehyde) or Having alpha hydroxy ketone gives positive Benedict Test

It is in mild Basic Medium.

$$CuSO_4 \longrightarrow Cu^{++} + SO_4^{-2-}$$

$$Cu^+ \longrightarrow Cu_2O$$
 ppt

Glucose (Blue Red Solution), Galactose (Orange Red Solution)

Maltose ( Dark Brown with Brick Red Solution),,Fructose ( Dark Brown with Brick Red Solution) Xylose ( Brick Red solution )

#### 7. Fehling's test

All reducing Carbohydrates give Positive Fehling's test with Fehling solution. Carbohydrates which has Aldehyde functional group (Not Aromatic Aldehyde) and alpha hydroxy carbonyl also gives positive Fehling's test (e.g. fuctose). While Ketones give negative fehling test. During this reaction the aldehyde group is oxidised to acid while the copper ions are reduced to red/brown precipitate of Cu<sub>2</sub>O. This is a common test used to detect glucose in urine as positive indication of diabetes.

CuSO<sub>4</sub> 
$$\longrightarrow$$
 Cu<sup>++</sup> + SO<sub>4</sub><sup>2-</sup>  
2Cu<sup>++</sup> + Reducing Sugar  $\longrightarrow$  Cu<sub>2</sub>O (Red / Brown ppt)

#### 8. Tollen's test

This test is also given by reducing sugars. Carbohydrates reacts with Tollens reagent forms a silver mirror on the inner walls of the test tube. This confirms the presence of reducing sugars. Silver ions are reduced to metallic silver.

RCHO 
$$\xrightarrow{\text{(i)}\left[\text{Ag(NH}_3)_2\right]\text{OH}}$$
 RCOOH + Ag (Silver mirror)

Note: Sucrose, poly sachharides also others non reducing sugar do not give Benedict test, Fehling test and Tollen's Test.

#### 9. Iodine Test

The iodine test is used to test for the presence of starch. Starch turns into an intense 'Deep blue' colour upon addition of aqueous solutions of the triodide anion.

#### **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**

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 b-D-2-deoxyribose whereas in RNA molecule, it is b-D-ribose.

HOH<sub>2</sub>C OH HOH<sub>2</sub>C OH HOH<sub>2</sub>C OH 
$$\frac{5}{4}$$
 H  $\frac{1}{3}$   $\frac{1}{2}$  H  $\frac{3}{9}$  OH OH OH  $\frac{5}{9}$  OH  $\frac{5}{9}$ 

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).

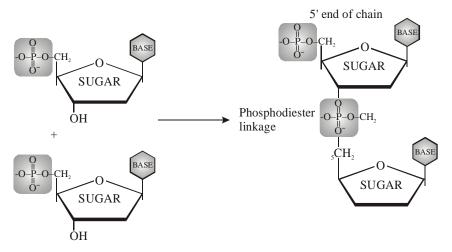
#### **Structure of Nucleic Acids**

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

$$HO-H_2\overset{5'}{C}$$
 O Base  $O-P-O-H_2\overset{5'}{C}$  O Base  $O-P-O-H_2\overset{5'}{C}$  O OH OH

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

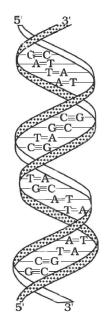
Nucleotides are joined together by phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar. The formation of a typical dinucleotide is shown in Fig.



#### Formation of dinucleotide

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

$$\begin{array}{c|c} Base & Base & Base \\ \hline --Sugar --Phosphate --Phosphat$$



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 gav, 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**

$$6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{Sun light}} \textbf{C}_6\text{H}_{12}\text{O}_6 + 6\text{CO}_2$$

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

#### **Cellular Respiration**

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{Enzymes} 6CO_2 + 6H_2O + 38 ATP$$

- \* 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

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

$$C_6H_{12}O_6$$
 Enzymes  $\begin{array}{c} O & O \\ \parallel & \parallel \\ 2NADP & 2NADPH_2 \end{array}$   $\begin{array}{c} C & C & O \\ \parallel & \parallel \\ 2NADP & 2NADPH_2 \end{array}$  Pyruvic acid

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

2 
$$CH_3 - C - C - OH + 6O_2 \xrightarrow{Enzymes} 6CO_2 + 6H_2O + 30 ATP$$
  
Pyruvic acid

#### **VITAMINES**

## Table: Some important Vitamins, their Sources and their Deficiency Diseases

Sl. No.	Name of Vitamins	Sources	Deficiency diseases
1	Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthamlia (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, eggwhite, 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, amla 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	Vegatable oils like wheat germ oil, sunflower 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-O-I**

- 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

**BM0001** 

- 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

**BM0002** 

- 3 Which of following amino acid has lowest iso-electric point?
  - (A) Glycine
- (B) Alanine
- (C) Aspartic acid
- (D) Lysine

**BM0003** 

- **4** H—C = C—H  $\xrightarrow{\text{HgSO}_4}$  (A)  $\xrightarrow{\text{(1) NH}_3 + \text{HCN}}$  (B) ; Product (B) of given reaction is :
  - (A) Glycine
- (B) Alanine
- (C) Valine
- (D) Leucine

**BM0004** 

- 5 Which amino acid does not contain chiral centre?
  - (A) Valine
- (B) Leucine
- (C) Glycine
- (D) Iso-leucine

**BM0005** 

- **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

**BM0006** 

- 7 A D-carbohydrate is:
  - (A) Always dextrorotatory
  - (B) Always laevorotatrory
  - (C) Always the mirror of the corresponding L-carbohydrate
  - (D) None of these

8

$$\dot{C} = N-NH-Ph$$
 $HO \longrightarrow H$ 
 $H \longrightarrow OH$ 
 $H \longrightarrow OH$ 
 $CH_2OH$ 

HC = N-NH-Ph

The given osazone can be obtained by:

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

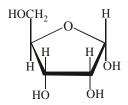
**BM0008** 

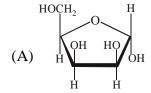
- 9 Which of the following pair gives same phenyl osazone?
  - (A) D-Glucose and D-Allose

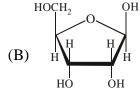
- (B) D-Glucose and D-Altrose
- (C) D-Glucose and D-Mannose
- (D) D-Glucose and D-Talose

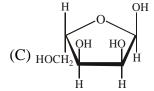
**BM0009** 

10 Which of the following represents the anomer of the compound shown?









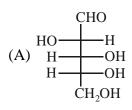
(D) None of these

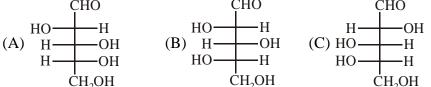
**BM0010** 

- 11 For the complex conversion of D-glucose into the corresponding osazone, the minimum number of equivalents of phenyl hydrzine required is:
  - (A) Two
- (B) Three
- (C) Four
- (D) Five

**BM0011** 

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





HO-HO-

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 oppostie 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

**BM0013** 

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

(C) 
$$H_5C_2O$$

$$OC_2H_5$$

$$OC_2H_5$$

$$OC_2H_5$$

$$OC_2H_5$$

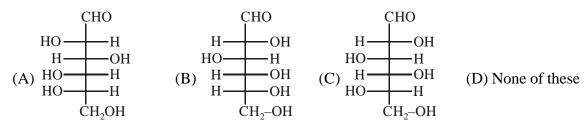
$$OC_2H_5$$

$$OC_2H_5$$

$$OC_2H_5$$

**BM0014** 

What is the structure of L-glucose?



16 What is the structure of L-glyceraldehyde?

$$\begin{array}{c|c} H-C=O\\ \hline (A)\ HO-CH_2 & ---OH\\ \hline \end{array}$$

(B) HO 
$$\stackrel{\text{H}}{\longrightarrow}$$
 CH<sub>2</sub>OH

(C) HO 
$$\stackrel{\text{CH}_2-\text{OH}}{\longrightarrow}$$
 H H - C = O

(D) Both (A) and (B)

BM0016

17 
$$\begin{array}{c|c} HC - OH \\ C - OH \\ HO - H \\ OH \\ OH \\ CH_2OH \\ \end{array}$$
, the given is enol form of :

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

**BM0017** 

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

- (A) Fehling solution
- (B) Tollen's reagent (C) Benedict test
- (D)  $Br_2 / H_2O$

**BM0018** 

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

(A) 2

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

**BM0019** 

D-Mannose  $\longrightarrow$  D-Glucose  $\longrightarrow$  (A); 20

Product (A) of above reaction is:

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

**BM0020** 

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.

22 A compound which does not react with Brady's reagent but decolourise Br<sub>2</sub> / H<sub>2</sub>O solution is :

$$(A) \bigcirc \bigcirc^{C}$$

**BM0022** 

23 Maltose is made up of to two sugars—

(A) Glucose

(B) Fructose

(C) Glucose & galactose

(D) Glucose & fructose

BM0023

24 D-Ribose when treated with dilute HNO<sub>3</sub> forms.

BM0024

25 Consider the given process

and identify the incorrect statement.

- (A) Configuration at C-2 is lost on enolisation
- (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.

- When methyl D-glucopyranoside is treated with HIO<sub>4</sub> its number of mole consumed per mole of the 26 sugare is -
  - (A) 2

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

**BM0026** 

- α amino acid when heated with NaOH/CaO forms -27
  - (A)  $\alpha$ ,  $\beta$  unsaturated acid

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

(C) Carboxylic acid

(D) Amine

**BM0027** 

- 28 The configuration of the C-2 epimer of D-glucose is-
  - (A) 2R, 3S, 4R, 5S

(B) 2S, 3S, 4R, 5R

(C) 2S, 3R, 4S, 5R

(D) 2R, 3S, 4R, 5R

**BM0028** 

- 29 Mutarotation involve-
  - (A) Racemisation

(B) Diastereomerisation

(C) Optical resolution

(D) Conformational inversion

**BM0029** 

**30** Consider the reaction sequence -

Glucose 
$$\xrightarrow{\text{PhNHNH}_2} P \xrightarrow{\text{H}_3\text{O}^+} Q \xrightarrow{\text{Zn}} R$$

The product R is -

- (A) Arbinose
- (B) Sorbitol
- (C) Fructose
- (D) Mannose

**BM0030** 

- COO The pH of the solution containing following zwitter ion species is  $\stackrel{\oplus}{N}_{H_3}$ — 31
  - (A) 4

- (B) 5
- (C)7
- (D) 9

#### **32** Peptide linkage is -

#### BM0032

- 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.

**BM0033** 

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

**BM0034** 

- The monomer of nucleic acids are held together by 35
  - (A) Phosphodiester linkage

(B) Amide linkage

(C) Glycosidic linkage

(D) Ester linkage

**BM0035** 

- 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  $CH_3 CH COOH$  and  $H_2N(CH_2)_5COOH$

**BM0036** 

**BM0037** 

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

(B) 
$$Ph - CH = CH_2$$
 (C)  $CH_2 = CH_2$ 

(C) 
$$CH_2 = CH_2$$

(D) 
$$CH_2 = CH - CN$$

50

38 Consider the reaction-

$$\begin{array}{c}
OH \\
\hline
(i) CHCl_3 + NaOH \\
\hline
(ii) H_3O^+
\end{array}$$

$$P (Major) + Q (Minor)$$

Mixture of A and B can be best separated by -

(A) Steam distillation

(B) Vacuum distillation

(C) Fractional distillation

(D) Crystallisation

**BM0038** 

- **39** Which of the following statements are incorrect:
  - (A) Copolymer of 1,3-butandiene & acrylonitrile is Buna-S
  - (B) HDPE is obtained by Ziegler-Natta polymerisation
  - (C) Polymer dacron can be polyester fabric
  - (D) Phenol & formaldehyde resin is called novolac

**BM0039** 

- **40** A segment (X) of cellulose obtained on partial hydrolysis has molecular mass 1476 gm. On complete acidic hydrolysis, mass of the product obtained is 1620 gm. Find out the number of glycosidic linkage(s) present in segment (X):
  - (A) 8

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

**BM0040** 

- When solidum extract is treated with FeCl<sub>3</sub> solution a blood red coloured is obtained due to the 41 presence of -

**BM0041** 

- 42 The monomer that undergo radical polymerisation most easily is
- (A)  $CH_2 = CH_2$  (B)  $C_6H_5CH = CH_2$  (C)  $CH_2 = C \underbrace{Me}_{Me}$  (D)  $CH_3 CH = CH_2$

#### **EXERCISE#O-II**

- 1 Carbohydrates may be:
  - (A) Sugars
  - (B) Starch
  - (C) Polyhydroxy aldehyde/ ketones
  - (D) Compounds that can be hydrolysed to sugar

**BM0043** 

- 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  $Ag_2O$  and excess  $CH_3I$  to form tetramethyl ether
  - (D) D-glucose upon treatment with warm HNO<sub>3</sub> forms D-glucaric acid

**BM0044** 

3 "Aspartame" is roughly 100 times as sweet as cane sugar. On complete hydrolysis of aspartame, products obtained is/are:

- (A) PhCH<sub>2</sub>-CH-NH<sub>2</sub> | | CO<sub>2</sub>H
- (C) CH<sub>3</sub>OH

D) CH<sub>3</sub>-CH-NH<sub>2</sub> | | CO<sub>2</sub>H

**BM0045** 

- 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

- 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 pK<sub>a</sub> values of  $\alpha$ -COOH amino  $\alpha$  NH<sub>3</sub><sup>+</sup> groups [ valid only for neutral amino acid ]
  - (C) Glycine is characterised by two pK<sub>a</sub> values
  - (D) For neutral amino acid the concentration of zwitter ion is maximum at its isoelectric point

**BM0047** 

- 6 Amino acids are synthesised from
  - (A)  $\alpha$ -Halo acids by reaction with NH<sub>3</sub>
  - (B) Aldehydes by reaction with NH<sub>3</sub> and cyanide ion followed by hydrolysis
  - (C) Pyruvic acid is treated with NH<sub>3</sub> followed by addition of H<sub>2</sub>(Ni)
  - (D) Alcohols by reaction with NH<sub>3</sub> and CN<sup>-</sup> ion followed by hydroysis.

**BM0048** 

- Which of the following carbohydrates developes blue colour on treatment with iodine solution? 7
  - (A) Glucose
- (B) Amylose
- (C) Starch
- (D) Fructose

BM0049

- 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.

**BM0050** 

- 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

BM0051

10 Which of the following options are correct:

$$(A) \bigcirc + AgNO_3 \longrightarrow \bigcirc + AgCl$$

- (B) Na extract of sample containing chlorobenzene  $\xrightarrow{+ \text{AgNO}_3}$  white ppt. of AgCl
- (C) Na extract of sample containing chlorobenzene  $\xrightarrow{+ \text{AgNO}_3}$  No ppt. of AgCl

(D) 
$$\longleftrightarrow$$
 + AgNO<sub>3</sub>  $\longrightarrow$  No ppt. of AgCl

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.

BM0053

12 If on a strand of DNA the base sequence is ATTGACGCAT then the sequence transcription on RNA would be -

(A)UAACUGCGUA

(B) AUUCUGCGUA

(C) UAACTGCGUA

(D) TAACTGCGTA

**BM0054** 

- 13 Select the correct statement among following
  - (A) Number of chiral atom in  $\alpha$ -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

BM0055

- 14 The N-base which differenciate DNA with RNA is:
  - (A) Cytosine

(B) Uracil

(C) Adenine

(D) Guanine

BM0056

- 15 Correct statement
  - (A) Nylon-66 is example of addition polymer
  - (B) Alanin having pH 9 at isoelectric point
  - (C) Fructose when reacts with fehling solution reddish brown ppt. formed
  - (D) All of these

**BM0057** 

**16** Match the column:

Column I

Column II

(A) Sucrose

(P) Two acetals

(B) Maltose

(Q) No hemiacetal

(C) Lactose

(R)  $\beta$ -1,4'-glycosidic bond

(D) Cellulose

(S) One of the hydrolysis product is glucose

## 17 Match the column

Column I

Column II

(Component of mixture)

(Reagent)

(A) Crystalline Na<sub>2</sub>CO<sub>3</sub> +

(P) Fehling solution

Sodium citrate + CuSO<sub>4</sub>(aq. sol.)

 $(B) \ \ CuSO_4 + Rochelle \ Salt + NaOH(Aq. \ sol.)$ 

(Q) Nesseler's Reagent

(C)  $10\% \alpha$  - naphthol in alcohol

(R) Bennedict's solution

(D) HgCl + KI + KOH (aq. sol.)

(S) Molisch's Reagent

#### EXERCISE#S-I

#### **Assertion Reason**

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.

**BM0060** 

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.

**BM0061** 

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.

**BM0062** 

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

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

4 The structure of intermediate [X] is

56

5 Select the correct option.

(C) Y is 
$$H \longrightarrow OH$$
 OCH<sub>3</sub>

(D) Z is 
$$HO \xrightarrow{CH_2OH O} H$$
 OCH<sub>3</sub>

**BM0064** 

- 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.

**BM0065** 

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

The monomer  $\bigcirc$  (G = Me or Cl) when treated with Zieglar - Natta catalyst undergo polymerisation in the manner given below -

cis-poly-1,3-butadiene

- 7 The Zieglar-Natta catalyst is
  - (A) TiCl<sub>4</sub>
- (B) R<sub>3</sub>Al
- (C)  $R_3 Al / TiCl_4$  (D)  $R_3 B/TiCl_4$

**BM0066** 

- The polymer obtained when monomeric unit used is CH<sub>2</sub>=C-CH=CH<sub>2</sub> 8
  - (A) Neoprene
- (B) Stilbene
- (C) Styrene
- (D) Chloropicrin

**BM0067** 

- 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

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

Column I

Column II

(B) 
$$HO \longrightarrow CH^{OH} OH$$

(C) 
$$HO \xrightarrow{HO} OH$$

(S) 0.2 %

**BM0069** 

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) β-glycosidic bond
- (S) α-glycosidic bond
- (T) Reducing sugar
- (U) Hemiacetal

#### **12** Match the column:

#### Column I

Column II

(C) 
$$HO CH_2OH O HO CH_2OH OH CH_2O$$

(R) Forms enediol intermediate

(S) β-glycoside bond

#### BM0071

#### 13 Match the column

#### Column I

## (Functional group)

(A) Aldehydic

(B) Phenolic

#### Column II

## (Test used or complex formed during confirmatory test)

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

(Q) 
$$CH - C-O^{-}$$

$$CU \qquad O \qquad O$$

$$CH - C-O^{-}$$

- (D) α-D- Glucopyranose
- (S)  $(ROH)_2Ce(NO_3)_4$  (Red)
- (T) Molisch's Test

14	Match the columi	٠.
1-		

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

BM0073

#### 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) Na <sub>4</sub> [Fe(CN) <sub>5</sub> NOS]	(W) Prussian Blue		
(B) S	$(Q) \text{ Fe } (CNS)_3$	(X) Black		
(C) N and S together	(R) PbS	(Y) Violet		
	$(S) \operatorname{Fe}_{4}[\operatorname{Fe}(\operatorname{CN})_{6}]$	(Z) Blood Red		

**BM0074** 

## Subjective Type:

16 The pKa values for the three acidic group P,Q,R are 4.3, 9.7 and 2.2 respectively

$$\begin{array}{c} \text{(R)} & \text{(P)} \\ \text{HOOC-CH-CH}_2\text{-COOH} \\ \bullet \\ \text{NH}_3 \\ \text{(Q)} \end{array}$$

Calculate the isoelectric point of the amino acid?

BM0075

- 17 How will you separate?
  - (a) Ethane & Ethyne

**BM0076** 

(b) 1-Butyne & 2-Butyne

**BM0077** 

(c) Phenol & Propanol

**BM0078** 

(d) 2-Propanol & Propanone

**BM0079** 

(e) CH<sub>3</sub>COOH & HCOOCH<sub>3</sub>

**BM0080** 

(f) PhOH & PhCOOH

BM0081

(g)  $C_2H_4 \& C_2H_2$ 

**BM0082** 

(h) EtNH<sub>2</sub> & Me<sub>2</sub>NH

**BM0083** 

(i) EtOH & Et -O - Et

- 18 How will you differentiate?
  - (a) Propane & Propene

**BM0085** 

1,1-Dichloroethane & 1,2-Dichloroethane

**BM0086** 

Chloroethane & Chloroethene

**BM0087** 

Pure & Oxidized CHCl<sub>3</sub>

**BM0088** 

p-chlorotoluene & benzylchloride

**BM0089** 

(f) n-propylchloride & isopropylchloride

**BM0090** 

(g) Methanol & ethanol

**BM0091** 

Isobutanol & tert-butanol (h)

**BM0092** 

(i) 2-Pentanol & 3-pentanol

**BM0093** 

(j) O-cresol & benzylalcohol

**BM0094** 

Ethanol & Propanol

**BM0095** 

Propanone & Ethanol (1)

**BM0096** 

(m) HCHO & PhCHO

**BM0097** 

Glucose & Fructose

BM0098

HCOOH & CH3COOH

**BM0099** 

**НСООН & НСНО** 

BM0100

MeNH<sub>2</sub> & Me<sub>2</sub>NH

**BM0101** 

(r) 
$$CH_2NH_2$$
  $CH$ 

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

$$\bigcup_{N-H}^{O}$$

**BM0103** 

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

BM0103

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 & Red P. Give 2-methyl butane. What is structure of 'A'

BM0104

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

BM0105

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

**BM0105** 

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.

**BM0106** 

23 For given compound

- (a) Which glycosidic linkage is present
- (b) Name of the compound
- (c) Products obtained on hydrolysis
- (d) Is it reducing sugar
- (e) Number of moles of  $HIO_4$  consumed
- (f) Is mutarotation possible
- (g) Number of moles of CH<sub>3</sub>COCl consumed per mole of compound.

**BM0107** 

Ε

## 24 For given compound

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

BM0108

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

BM0109

## 26 Calculate isoelectric point of following amino acid

	pKa <sub>1</sub>	pKa <sub>2</sub>	pKa
	(а-СООН)	(α-СООН)	(side chain)
(a) Glycine $\stackrel{\oplus}{NH}_3 - CH_2 - COOH$	2.3	9.6	_
(b) Serine CH <sub>2</sub> – CH – COOH	2.2	9.2	_
$\stackrel{\oplus}{\mathrm{NH}}_3$			
(c) Alanive CH <sub>3</sub> – CH – COOH	2.3	9.7	_
(d) Asparric acid HOOC – CH <sub>2</sub> – CH – COOH NH <sub>3</sub>	2.1	9.8	3.9
(e) Lysine $\stackrel{\oplus}{NH_3}$ -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH-COOH $\stackrel{N}{NH_3}$	2.2	9.0	10.5

# EXERCISE # (J-MAIN)

1.	Which of the follow	ing pairs give positive T	Collen's test?	[J-Main-2004]			
	(1) Glucose, sucrose	<b>)</b>	(2) Glucose, fructo	ose			
	(3) Hexanal, Acetop	henone	(4) Fructose, sucro	ose			
				BM0111			
2.	Two forms of D – g	lucopyranose, are called	1.	[J-Main-2005]			
	(1) Enantiomers	(2) Anomers	(3) Epimers	(4) Diastereomers			
				BM0112			
3.	When benzene sulf	fonic acid and p-nitrop	ohenol are treated w	ith NaHCO <sub>3</sub> , the gases released			
	respectively are			[J-Main-2006]			
	(1) SO <sub>2</sub> , NO <sub>2</sub>	(2) SO <sub>2</sub> , NO	(3) SO <sub>2</sub> , CO <sub>2</sub>	$(4) CO_2, CO_2$			
				BM0113			
4.	Statement-1: Gluc	ose gives a reddish-brov	wn precipitate with Fe	hling's solution.			
	because			[J-Main-2007]			
	Statement-2: Reac	tion of glucose with Feb	nling's solution gives	CuO and gluconic acid.			
	(1) Statement-1 is Tr	rue, Statement-2 is True	; Statement-2 is a corr	rect explanation for Statement-1.			
	(2) Statement-1 is Tr	ue, Statement-2 is True;	Statement-2 is NOT a c	correct explanation for Statement-1.			
	(3) Statement-1 is Tr	rue, Statement-2 is False	<b>e</b> .				
	(4) Statement-1 is Fa	alse, Statement-2 is True	e.				
				BM0114			
5.	Which one of the fo	ollowing bases is <b>not p</b>	resent in DNA?	[J-Main-2014]			
	(1) Cytosine	(2) Thymine	(3) Quinoline	(4) Adenine			
				BM0115			
6.	Which one is classif	fied as a condensation p	oolymer?	[J-Main- 2014]			
	(1) Teflon	(2) Acrylonitrile	(3) Dacron	(4) Neoprene			
				BM0116			
7.	Which of the vitami	ins given below is wate	r soluble?	[J-Main- 2015]			
	(1) Vitamin E	(2) Vitamin K	(3) Vitamin C	(4) Vitamin D			
				BM0117			
8.	Thiol group is prese	ent in :		[J-Main-2016]			
	(1) Methionine	(2) Cytosine	(3) Cystine	(4) Cysteine			
				BM0118			

- 9. The distillation technique most suited for separating glycerol from spent-lye in the soap industry is [J-Main-2016]
  - (1) Distillation under reduced pressure
- (2) Simple distillation

(3) Fractional distillation

(4) Steam distillation

BM0119

- 10. Which of the following statements about low density polythene is FALSE? [J-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.

BM0120

11. Which of the following compounds will behave as a reducing sugar in an aqueous KOH solution [J-Main-2017]

BM0121

- 12. The formation of which of the following polymers involves hydrolysis reaction? [J-Main-2017]
  - (1) Nylon 6
- (2) Bakelite
- (3) Nylon 6, 6
- (4) Terylene

BM0122

**13.** Glucose on prolonged heating with HI gives :

[J-Main-2018]

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

BM0123

**14.** Which of the following statement is not true:-

[J-Main-2018]

- (1) Nylon 6 is an example of step-growth polymerisation
- (2) Chain growth polymerisation involves homopolymerisation only
- (3) Step growth polymerisation requires a bifunctional monomer
- (4) Chain growth polymerisation includes both homopolymerisation and copolymerisation

**BM0124** 

15. The dipeptide, Gln-Gly, on treatment with CH<sub>3</sub>COCl<sub>3</sub> followed by aqueous work work up gives:

(1)

$$\begin{array}{c}
H \\
CONH \\
COOH
\end{array}$$

COOH

 $\begin{array}{c}
H \\
N \\
COOH
\end{array}$ 

COOH

 $\begin{array}{c}
COOH \\
COOH
\end{array}$ 
 $\begin{array}{c}
COOH
\end{array}$ 
 $\begin{array}{c}
COOH
\end{array}$ 

(2) 
$$(CH_2)_2$$
  $H$   $COOH$   $(CH_2)_3$   $H$   $COOH_3$   $H$   $O$ 

**16.** The copolymer formed by addition polymerization of styrene and acrylonitrile in the presence of peroxide is : [J-Main-2018]

(1) 
$$\begin{bmatrix} CN \\ CH-CH_2-CH_2-CH \\ C_6H_5 \end{bmatrix}_{T}$$

$$(2) \begin{bmatrix} C_6H_5 & CN \\ I & I \\ C & -CH-CH_2 \\ CH_3 \end{bmatrix}_{L}$$

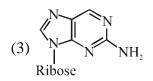
(3) 
$$\begin{bmatrix} C_{6}H_{5} & CN \\ I & I \\ CH_{2}-CH-CH-CH_{2} \end{bmatrix}_{1}$$

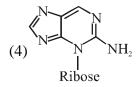
$$(4) \begin{bmatrix} CH_2-CH-CH_2-CH \\ I \\ C_6H_5 \end{bmatrix}_{11}$$

**BM0126** 

17. Which of the following is the correct structure of Adenosine?

[J-Main-2018]





BM0127

18. Among the following, the incorrect statement is:-

[J-Main-2018]

- (1) Cellulose and amylose has 1, 4-glycosidic linkage.
- (2) Lactose contains  $\beta$ -D-galactose and  $\beta$ -D-glucose.
- (3) Maltose and lactose has 1, 4-glycosidic linkage.
- (4) Sucrose and amylose has 1, 2-glycosidic linkage.

BM0128

19. The correct match between items of List-I and List-II is:

[J-Main-2018]

	Litst-I		List-II
(A)	Phenelzine	(P)	Pyrimidine
(B)	Chloroxylenol	(Q)	Furan
(C)	Uracil	(R)	Hydrazine
(D)	Ranitidine	(S)	Phenol

$$(1)(A)-(S),(B)-(R),(C)-(P),(D)-(Q)$$

$$(2)(A)-(R),(B)-(S),(C)-(P),(D)-(Q)$$

$$(3)(A)-(S),(B)-(R),(C)-(Q),(D)-(P)$$

$$(4)(A)-(R),(B)-(S),(C)-(Q),(D)-(P)$$

BM0129

20. The correct sequence of amino acids present in the tripeptide given below is: [J-Main-(Jan)-2019]

$$\begin{array}{c|c} Me & O & Me \\ H_2N & OH \\ \hline OH & H \\ \hline \end{array} \begin{array}{c} OH \\ OH \\ \hline \end{array}$$

(1) Leu - Ser - Thr

(2) Thr - Ser- Leu

(3) Thr - Ser - Val

(4) Val - Ser - Thr

21. Major product of the following reaction is: [J-Main-(Jan)-2019]

$$Cl$$
 $+$ 
 $H_2N$ 
 $O$ 
 $NH_2$ 
 $(1)$  Et<sub>3</sub>N
 $(2)$  Free radical polymerisation

$$(1) \bigcup_{O} \bigcup_{H}^{Cl} \bigcup_{NH_2}^{NH_2}$$

$$(3) \begin{bmatrix} Cl & O \\ & & \\ &$$

$$(2) \xrightarrow{\text{Cl}}_{\text{In}} \\ \text{HN} \xrightarrow{\text{NH}_2}$$

$$(4) \bigcup_{O}^{Cl} \int_{H}^{n} NH_{2}$$

**BM0131** 

22. The major product of the following reaction is: [J-Main-(Jan)-2019]

$$CH_{3}O$$

$$OH$$

$$CH_{3}$$

$$(i) dil. HCl/\Delta$$

$$(ii) (COOH)_{2}/$$
Polymerisation

$$(2) \qquad OCH_3 \qquad O$$

$$(4) = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}_n$$

**BM0132** 

23. Which of the following tests cannot be used for identifying amino acids? [J-Main-(Jan)-2019]

- (1) Biuret test
- (2) Xanthoproteic test (3) Barfoed test
- (4) Ninhydrin test

**BM0133** 

24. The homopolymer formed from 4-hydroxy-butanoic acid is :-

[J-Main-(Jan)-2019]

(1) 
$$\begin{bmatrix} 0 & 0 & 0 \\ -C(CH_2)_3 - O \end{bmatrix}_n$$
 (2)  $\begin{bmatrix} 0 & 0 & 0 \\ -OC(CH_2)_3 - O \end{bmatrix}_n$  (3)  $\begin{bmatrix} 0 & 0 & 0 \\ -C(CH_2)_2 & O \end{bmatrix}_n$  (4)  $\begin{bmatrix} 0 & 0 & 0 \\ -C(CH_2)_2 & O \end{bmatrix}_n$ 

25. Among the following compound which one is found in RNA? [J-Main-(Jan)-2019]

$$(2) \bigvee_{\substack{N \\ N \\ H}}^{NH_2} C$$

$$(3) \bigvee_{N = 0}^{NH}$$

**BM0135** 

26. The polymer obtained from the following reactions is: [J-Main-(Jan)-2019]

$$(1) \begin{bmatrix} O & H \\ -C - (CH_2)_4 - N \end{bmatrix}_n$$

$$(2) \begin{bmatrix} 0 \\ O - (CH_2)_4 - C \end{bmatrix}_n$$

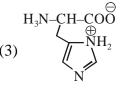
(3) 
$$\begin{bmatrix} O & O & H & H \\ -HNC(CH_2)_4 - C - N & H \end{bmatrix}$$

$$(4) \begin{bmatrix} O \\ -OC(CH_2)_4O \end{bmatrix}_n$$

**BM0136** 

27. The correct structure of histidine in a strongly acidic solution (pH=2) is [J-Main-(Jan)-2019]

$$(2) \begin{array}{c} H_3 N - CH - COO \\ \oplus \\ N H_2 \end{array}$$



**BM0137** 

28. The two monomers for the synthesis of Nylone 6, 6 are : [J-Main-(Jan)-2019]

- (1) HOOC(CH<sub>2</sub>)<sub>6</sub>COOH, H<sub>2</sub>N(CH<sub>2</sub>)<sub>6</sub>NH<sub>2</sub>
- (2)  $HOOC(CH_2)_4COOH$ ,  $H_2N(CH_2)_4NH_2$
- (3)  $HOOC(CH_2)_6COOH$ ,  $H_2N(CH_2)_4NH_2$
- (4) HOOC(CH<sub>2</sub>)<sub>4</sub>COOH, H<sub>2</sub>N(CH<sub>2</sub>)<sub>6</sub>NH<sub>2</sub>

**BM0138** 

29. Maltose on treatment with dilute HCI gives: [J-Main-(April)-2019]

(1) D-Galactose

(2) D-Glucose

(3) D-Glucose and D-Fructose

(4) D-Fructose

BM0139

Ε

**30.** Fructose and glucose can be distinguished by :

[J-Main-(April)-2019]

(1) Fehling's test

(2) Barfoed's test

(3) Benedict's test

(4) Seliwanoff's test

**BM0140** 

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

[J-Main-(April)-2019]

(1) Lys-Asp

(2) Ser-Lys

(3) Gln-Asp

(4) Asp-Gln

BM0141

**32.** Which of the following statements is not true about sucrose?

[J-Main-(April)-2019]

(1) On hydrolysis, it produces glucose and fructose

(2) The glycosidic linkage is present between  $C_1$  of  $\alpha$ -glucose and  $C_1$  of  $\beta$ -fructose

(3) It is also named as invert sugar

(4) It is a non reducing sugar

BM0142

33. Number of stereo centers present in linear and cyclic structures of glucose are respectively:

(1)4 & 5

(2) 5 & 5

[J-Main-(April)-2019]

(3) 4 & 4

(4) 5 & 4

BM0143

**34.** Amylopectin is composed of :

[J-Main-(April)-2019]

(1)  $\alpha$ -D-glucose,  $C_1$ - $C_4$  and  $C_1$ - $C_6$  linkages

(2)  $\alpha$ -D-glucose,  $C_1$ - $C_4$  and  $C_2$ - $C_6$  linkages

(3)  $\beta$ -D-glucose,  $C_1$ - $C_4$  and  $C_2$ - $C_6$  linkages

(4)  $\beta$ -D-Glucose,  $C_1$ - $C_4$  and  $C_1$ - $C_6$  linkages

**BM0144** 

**35.** Which of the following statements is not true about RNA?

[J-Main-(April)-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

BM0145

**36.** Which of the following compounds is a constituent of the polymer

[J-Main-(April)-2019]

$$\bigcup_{\parallel}^{O} HN - C - NH - CH_2 \Big]_{n}$$
?

(1) Formaldehyde

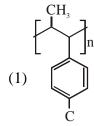
(2) Ammonia

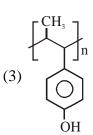
(3) Methylamine

(4) N-Methyl urea

**37.** The major product of the following reaction is:

[J-Main-(April)-2019]





$$(4) \qquad \qquad \bigcap_{\text{CI}} n$$

**BM0147** 

**BM0148** 

**38.** Which of the following is a condensation polymer?

[J-Main-(April)-2019]

- (1) Buna S
- (2) Nylon 6, 6
- (3) Teflon
- (4) Neoprene

[J-Main-(April)-2019]

**39.** The correct name of the following polymer is:



- (1) Polyisoprene
- (2) Polytert-butylene
- (3) Polyisobutane
- (4) Polyisobutylene

BM0149

**40.** Which of the following is a thermosetting polymer?

[J-Main-(April)-2019]

- (1) Buna-N
- (2) PVC
- (3) Bakelite
- (4) Nylon 6

BM0150

41. Which of the following statements is correct-

[J-Main-(Jan)-2020]

- (1) Gluconic acid can form cyclic (acetal/ hemiacetal) structure
- (2) Gluconic acid is a partial oxidation product of glucose
- (3) Gluconic acid is obtained by oxidation of glucose with HNO<sub>3</sub>
- (4) Gluconic acid is a dicarboxylic acid

BM0151

**42.** Match the following :

[J-Main-(Jan)-2020]

- (i) Riboflavin
- (a) Beriberi
- (ii) Thiamine
- (b) Scurvy
- (iii) Pyridoxine
- (c) Cheilosis
- (iv) Ascorbic acid
- (d) Convulsions
- (1) (i)-(c), (ii)-(a), (iii)-(d), (iv)-(b)
- (2) (i)-(c), (ii)-(d), (iii)-(a), (iv)-(b)
- (3) (i)-(d), (ii)-(b), (iii)-(a), (iv)-(c)
- (4) (i)-(a), (ii)-(d), (iii)-(c), (iv)-(b)

BM0152

node06\B0B0-BA\Kota\JEE(Advanced)\Leader\Che\Shee\\Blomolecules`

- 43. Two monomers in maltose are:

[J-Main-(Jan)-2020]

- (1)  $\alpha$ -D-glucose and  $\beta$ -D-glucose
- (2)  $\alpha$ -D-glucose and  $\alpha$ -D-Fructose
- (3)  $\alpha$ -D-glucose and  $\alpha$ -D-glucose
- (4)  $\alpha$ -D-glucose and  $\alpha$ -D-galactose

BM0153

44. A, B and C are three biomolecules. The results of the tests performed on them are given below:

	Molisch's Test	Barfoed Test	Biuret Test
A	Positive	Negative	Negative
В	Positive	Positive	Negative
С	Negative	Negative	Positive

[J-Main-(Jan)-2020]

- A, B and C are respectively:
- (1) A = Glucose, B = Fructose, C = Albumin
- (2) A = Lactose, B = Fructose, C = Alanine
- (3) A = Lactose, B = Glucose, C = Alanine
- (4) A = Lactose, B = Glucose, C = Albumin

Statement-1: p-Hydroxybenzoic acid has a lower boiling point than o-hydroxybenzoic acid. 1 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.

**BM0155** 

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

**BM0156** 

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<sub>3</sub>C≡CH
- (C) CN-
- (D) I-

Column II

- (P) gives precipitate with 2,4-dinitrophenylhydrazine
- (Q) gives precipitate with AgNO<sub>3</sub>
- (R) is a nucleophile
- (S) is involved in cyanohydrin formation

**BM0157** 

4 Cellulose upon acetylation with excess acetic anhydride / H<sub>2</sub>SO<sub>4</sub> (catalytic) gives cellulose triacetate whose structure is [JEE 2008]

$$(C) \begin{array}{c} AcO \\ H \\ H \\ OAc \\ OAc \\ H \\ OAc \\ OAc$$

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

# $(A) \; H_2N - \overset{\ominus}{N}\overset{\ominus}{H_3}\overset{\ominus}{C}l$

(D) 
$$O_2N$$
  $NH - NH_3Br$   $NO_2$ 

#### Column II

- (P) Sodium fusion extract of the compound gives Prussian blue colour with FeSO<sub>4</sub>
- (Q) Gives positive FeCl<sub>3</sub> test
- (R) Gives white precipitate with AgNO<sub>3</sub>
- (S) Reacts with aldehydes to form the corresponding Hydrazone derivative

BM0159

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

- 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

8 The following carbohydrate is

[JEE 2011]

(A) a ketohexose

(B) an aldohexose

(C) an α-furanose

(D) an α-pyranose

BM0162

9 The major product of the following reaction is

[JEE 2011]

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

BM0163

Amongst the compounds given, the one that would form a brilliant coloured dye on treatment with  $NaNO_2$  in dil. HCl followed by addition to an alkaline solution of β-naphthol is -

[JEE 2011]

$$(A) \bigcap^{N(CH_3)_2}$$

$$(D)$$
  $CH_2NH_2$ 

**BM0164** 

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

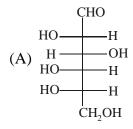
$$X$$
— $(CH_2)_4$ — $X$   $\xrightarrow{(i) Y}$   $\xrightarrow{O}$   $C$   $-(CH_2)_4$   $-C$   $\xrightarrow{O}$   $OH$   $OH$ 

- (A)  $X = COOCH_3$ ,  $Y = H_3 / Ni / heat$
- (B)  $X = CONH_2$ ,  $Y = H_2 / Ni / heat$
- (C)  $X = CONH_2$ ,  $Y = Br_2 / NaOH$
- (D) X = CN,  $Y = H_2 / Ni / heat$

12 The structure of D-(+)-glucose is

[IIT 2011]

The structure of L(–)-glucose is



CHO

СНО

**BM0166** 

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 surgar' is  $-20^{\circ}$
- (D) on reaction with Br<sub>2</sub> water, 'invert sugar' forms saccharic acid as one of the products

**BM0167** 

#### Comprehension: Q.No. 14 to 15

Treatment of compound  $\mathbf{O}$  with  $\mathrm{KMnO_4}$  /  $\mathrm{H^+}$  gave  $\mathbf{P}$ , which on heating with ammonia gave  $\mathbf{Q}$ . The compound  $\mathbf{Q}$  on treatment with  $\mathrm{Br_2}$  / NaOH produced  $\mathbf{R}$ . On strong heating,  $\mathbf{Q}$  gave  $\mathbf{S}$ , which on further treatment with ethyl 2-bromopropanoate in the presence of KOH following by acidification, gave a compound  $\mathbf{T}$ .



14. The compound  $\mathbf{R}$  is:

[JEE 2016]

BM0168

15. The compound T is:

[JEE 2016]

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

BM0169

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

[JEE 2018]

D-glucose

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

$$(A) \begin{array}{c} H \\ HO \\ CH_2OH \\ OH \\ H \\ OH \\ H \end{array} \begin{array}{c} OH \\ HO \\ H \\ H \\ HO \\ H \end{array}$$

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

[JEE 2019]

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

**BM0171** 

**18.** Choose the correct option(s) from the following

[JEE 2019]

- (A) Natural rubber is polyisoprene containing trans alkene units
- (B) Nylon-6 has amide linkages
- (C) Cellulose has only  $\alpha$ -D-glucose units that are joined by glycosidic linkages
- (D) Teflon prepared by heating tetrafluoroethene in presence of a persulphate catalyst at high pressure

## **EXERCISE** # (J-ADVANCE) (SUBJECTIVE)

1 Give the structures of the products in each of the following reactions.

[JEE 2000]

(i) Sucrose  $\xrightarrow{H^+}$  A + B

 $(ii) \xrightarrow{\text{NOH}} C \xrightarrow{\text{Polymerisation}} [-D-]_n$ 

BM0173

2 Aspartame, an artifical sweetener, is a peptide and has the following structure:

[JEE 2001]

$$\begin{array}{c} \operatorname{CH}_2-\operatorname{C}_6\operatorname{H}_5\\ |\\ \operatorname{H}_2\operatorname{N}-\operatorname{CH}-\operatorname{COOH}-\operatorname{CH}-\operatorname{COOCH}_3\\ |\\ \operatorname{CH}_2-\operatorname{COOH} \end{array}$$

- (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?

**BM0174** 

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

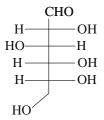
$$H_2N$$
  $NH_2$   $NH_2$   $NH_2$   $COOH$  +  $HOOC$   $COOH$ 

**BM0175** 

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.



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5 Monomer A of a polymer on ozonolysis yields two moles of HCHO and one mole of CH<sub>3</sub>COCHO.

(a) Deduce the structure of A.

[JEE 2005]

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

BM0177

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]

BM0178

7 The substitutes  $\mathbf{R}_1$  and  $\mathbf{R}_2$  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	Н	Н
П	Н	CH <sub>3</sub>
Ш	CH <sub>2</sub> COOH	Н
IV	CH <sub>2</sub> CONH <sub>2</sub>	$(CH_2)_4NH_2$
V	$CH_2CONH_2$	CH <sub>2</sub> CONH <sub>2</sub>
VI	$(CH_2)_4NH_2$	$(CH_2)_4NH_2$
VII	CH <sub>2</sub> COOH	CH <sub>2</sub> CONH <sub>2</sub>
VIII	$\mathrm{CH_2OH}$	$(CH_2)_4NH_2$
IX	$(CH_2)_4NH_2$	CH <sub>3</sub>

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

**BM0180** 

- 9. A tetrapeptide has –COOH group on alanine. This produces glycine (Gly), valine (Val), phenyl alanine (Phe) and alanine (Ala), on complete hydrolysis. For this tetrapeptide, the number of possible sequences (Primary structures) with –NH<sub>2</sub> group attached to a chiral center is [JEE 2013]

  BM0181
- 10. The total number of lone-pairs of electrons in melamine is : [JEE 2013]

BM0182

The total number of <u>distinct naturally occurring amino acids</u> obtained by complete acidic hydrolysis of the peptide shown below is: [JEE 2014]

#### 80

#### ANSWER KEY

DVDD	CICE	$\sim$ T
EXER	CISE-	()-I

1  Alls. (C)  2  Alls. (D)  3  Alls. (C)  4  Alls. (D)  3  Alls. (C)	1	Ans. (C)	2	Ans. (D)	3	<b>Ans.</b> (C)	4	Ans. (B)	5	Ans. (0
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#### **EXERCISE#O-II**

16 Ans. (A) 
$$\rightarrow$$
 P, Q, S; (B)  $\rightarrow$  S; (C)  $\rightarrow$  R, S; (D)  $\rightarrow$  Q,R, S

17 Ans. (A) 
$$\rightarrow$$
 R; (B)  $\rightarrow$  P; (C)  $\rightarrow$  S; (D)  $\rightarrow$  Q

#### **EXERCISE#IS-I**

#### **Assertion Reason**

- 1 Ans. (A) 2 Ans. (A) 3 Ans. (A) 4 Ans. (A) 5 Ans. (D)
- 6 Ans. (B) 7 Ans. (C) 8 Ans. (A) 9 Ans. (C)

#### Match the Column

10 Ans. (A) 
$$\rightarrow$$
 S; (B)  $\rightarrow$  Q; (C)  $\rightarrow$  P; (D)  $\rightarrow$  R

11 Ans. (A) 
$$\rightarrow$$
 Q, S; (B)  $\rightarrow$  Q, R, S; (C)  $\rightarrow$  P, R, T, U (D)  $\rightarrow$  P, S, T, U

12 Ans. (A) 
$$\rightarrow$$
 P, Q, R; (B)  $\rightarrow$  P; (C)  $\rightarrow$  P,S; (D)  $\rightarrow$  P, Q, R

13 Ans. (A) 
$$\rightarrow$$
 Q, R (B)  $\rightarrow$  P, (C)  $\rightarrow$ S; (D)  $\rightarrow$ T

14 Ans. (A)
$$\rightarrow$$
P, Q, R; (B) $\rightarrow$ S; (C) $\rightarrow$ R; (D) $\rightarrow$ P, Q, S

15 Ans. (A) 
$$\rightarrow$$
 S-W (B)  $\rightarrow$  P-Y, R-X (C)  $\rightarrow$  Q-Z

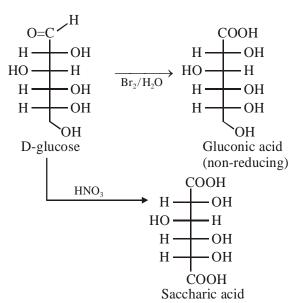
#### Subjective Type:

16 Ans. (3.25)

## **EXERCISE** # (J-MAIN)

1	Ans. (2)	2	Ans. (2)	3	Ans. (4)	4	<b>Ans.</b> (3)	5	<b>Asn.</b> (3)
6	<b>Ans.</b> (3)	7	<b>Ans.</b> (3)	8	Ans. (4)	9	<b>Ans.</b> (1)	10	Ans. (1)
11	<b>Ans.</b> (1)	12	Ans. (1)	13.	Ans. (4)	14.	<b>Ans.</b> (2)	15.	<b>Ans.</b> (1)
16.	<b>Ans.</b> (4)	<b>17.</b>	Ans. (1)	18.	Ans. (4)	19.	<b>Ans.</b> (2)	20.	Ans. (4)
21.	<b>Ans.</b> (4)	22.	<b>Ans.</b> (2)	23.	<b>Ans.</b> (3)	24.	<b>Ans.</b> (1)	25.	Ans. (3)
26.	<b>Ans.</b> (2)	27.	<b>Ans.</b> (1)	28.	<b>Ans.</b> (4)	29.	<b>Ans.</b> (2)	30.	<b>Ans.</b> (4)
31.	<b>Ans.</b> (2)	32.	Ans. (2)	33.	Ans. (1)	34.	<b>Ans.</b> (1)	35.	Ans. (1)
36.	<b>Ans.</b> (1)	<b>37.</b>	Ans. (1)	38.	Ans. (2)	39.	Ans. (4)	40.	Ans. (3)
41.	Ans. (2)								

Sol.



#### 42. Ans. (1)

**Sol.** (i) Riboflavin  $\longrightarrow$  (c) Cheilosis

- (ii) Thiamine → (a) Beriberi
- (iii) Pyridoxin  $\longrightarrow$  (d) Convulsions
- (iv) Ascorbic acid  $\longrightarrow$  (b) Scurvy
- Ans. (3) 43.
- **Sol.** Two monomers in maltose are  $\alpha$ -D-glucose &  $\alpha$ -D-glucose.
- 44. Ans. (4)
- Sol. Alanine does not show Biuret test because Biuret test is used for deduction of peptide linkage & alanine is amino acid.

Albumine is protein so have paptide linkage so it gives positive **Biuret test**.

Positive Barfoed test is shown by monosaccharide but not disaccharide. Positive Molisch's test is shown by glucose.

## EXERCISE # (J-ADVANCE) (OBJECTIVE)

1 Asn. (D) 2 Ans. (A) 
$$\rightarrow$$
 P, S; (B)  $\rightarrow$  Q, R; (C)  $\rightarrow$  P, R; (D)  $\rightarrow$  S

3 Ans. (A) 
$$\rightarrow$$
 P, S; (B)  $\rightarrow$  Q; (C)  $\rightarrow$  Q, R, S; (D)  $\rightarrow$  Q, R

4 **Ans.** (A)

5 Ans. (A) 
$$\rightarrow$$
 R, S; (B)  $\rightarrow$  P, Q; (C)  $\rightarrow$  P, Q, R; (D)  $\rightarrow$  P, S

6 Ans. (B,C)

8 **Ans. (B)** 

9 **Ans.(B)** 

10 **Ans.** (**C**)

11 Ans. (A,B,C,D)

13 **Ans.** (**B,C**)

14 **Ans.** (**A**)

15 **Ans.** (**B**)

16 Ans. (D)

## **EXERCISE** # (J-ADVANCE) (SUBJECTIVE)

2 **Ans.** (i) Amine, carboxylic acid, Amide, Ester

5 **Ans.** (a) 
$$H_{2}C$$
  $H_{3}$   $CH_{2}$   $H_{3}C$   $H_{3}C$   $H_{3}C$   $H_{3}C$   $H_{3}C$   $H_{3}C$   $H_{4}C$   $H_{3}C$   $H_{4}C$   $H_{4}C$   $H_{5}C$   $H_{5}C$ 

- 6 **Ans.** (6)
- 7 **Ans. (4)**
- 8 **Ans. (8)**
- 9. **Asn.** (4)
- 10. Ans. (6)

11 **Ans. (1)**