BIOMOLECULES

CONTENTS

JEE(ADVANCED) SYLLABUS

Concepts: Carbohydrates : Classification; mono- and di-saccharides (glucose and sucrose); Oxidation, reduction, glycoside formation and hydrolysis of sucrose.
Amino acids and peptides : General structure (only primary structure for peptides) and physical properties.

JEE(MAIN) SYLLABUS

General introduction and importance of biomolecules.
Carbohydrates – Classification: aldoses and ketoses; monosaccharides (glucose and fructose), constituent monosaccharides of oligosacchorides (sucrose, lactose, maltose) and polysaccharides (starch, cellulose, glycogen).
Proteins – Elementary Idea of a – amino acids, peptide bond, polypeptides; Proteins: primary, secondary, tertiary and quaternary structure (qualitative idea only), denaturation of proteins, enzymes.
Vitamins – Classification and functions.
Nucleic Acids – Chemical constitution of DNA and RNA. Biological functions of nucleic acids.

BIOMOLECULES

CARBOHYDRATES

1. Concept

Generally, carbohydrates are substances with the general formula $C_x(H_2O)_y$. They are called carbohydrates (hydrates of carbon) because they contain hydrogen and oxygen in the same proportion as in water. However, a number of compounds have been found, which are carbohydrates by chemical behaviour but do not conform to the formula $C_x(H_2O)_y$. E.g : 2-deoxyribose.

(i) carbohydrates are biopolymers of polyhydroxy aldehyde or polyhydroxy ketones.

(ii) monomeric polyhydroxy aldehydes or ketones can also exist in hemiacetal and acetal forms in cyclic structures.

(iii) Almost all of these compounds are chiral and optically active. An exception of this is 1,3-dihydroxypropanone.

(iv) All natural carbohydrates have D-configuration.

2. Classification of Carbohydrates

(A) Classification on the basis of number of hydrolysed products

S.No.	Carbohydrate	No. of units (on hydrolysis)	Examples
1	Monosaccharides	1 or single unit (cannot be hydrolysed)	Glucose, Fructose, Galactose
2	Oligosaccharides	2 to 10 units	Sucrose, Maltose, Lactose
3	Polysaccharides	Many units	Starch, Cellulose, Gums, Resins etc

(B) Classification on the basic of functional groups

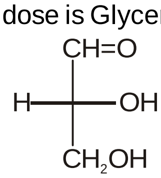
S.No.	Carbohydrate	No. of functional group	Examples
1	Aldose	CH = O Aldehyde | $(CHOH)_n$ | CH_2OH	Glyceraldehyde, Erythrose, Threose, Ribose & 2-Deoxyribose Glucose, Mannose, Allose.
2	Ketose	CH_2OH | C = O Ketone | $(CHOH)_n$ | CH_2OH	n = 0; Ketotriose, n = 1; Ketotetrose, n = 2; Ketopentose, n = 3; Ketohexose

(C) Classification of monosaccharides on the basis of carbon atoms in hydrolysed product.

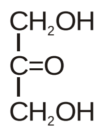
S.No.	Carbon atoms	General term	Aldehyde	Ketone
1	3	Triose	Aldotriose	Ketotriose
2	4	Tetrose	Aldotetrose	Ketotetrose
3	5	Pentose	Aldopentose	Ketopentose
4	6	Hexose	Aldohexose	Ketohexose
5	7	Heptose	Aldoheptose	Ketoheptose

Some facts :

1. Number of carbons in monosaccharides are generally 3 to 7.
2. Simplest aldose is Glyceraldehyde and simplest Ketose is Dihydroxyacetone.



(D-Glyceraldehyde)

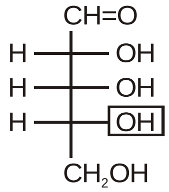


(Dihydroxyacetone)

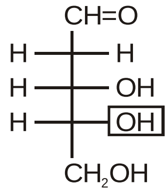
3. Most naturally occuring monosacharides are :

(a) Pentoses E.g. D-Ribose (present in RNA) and 2-Deoxyribose (present in DNA)

(b) Hexoses E.g. D-Glucose, D-Mannose, D-Allose, D-Galactose and D-Fructose



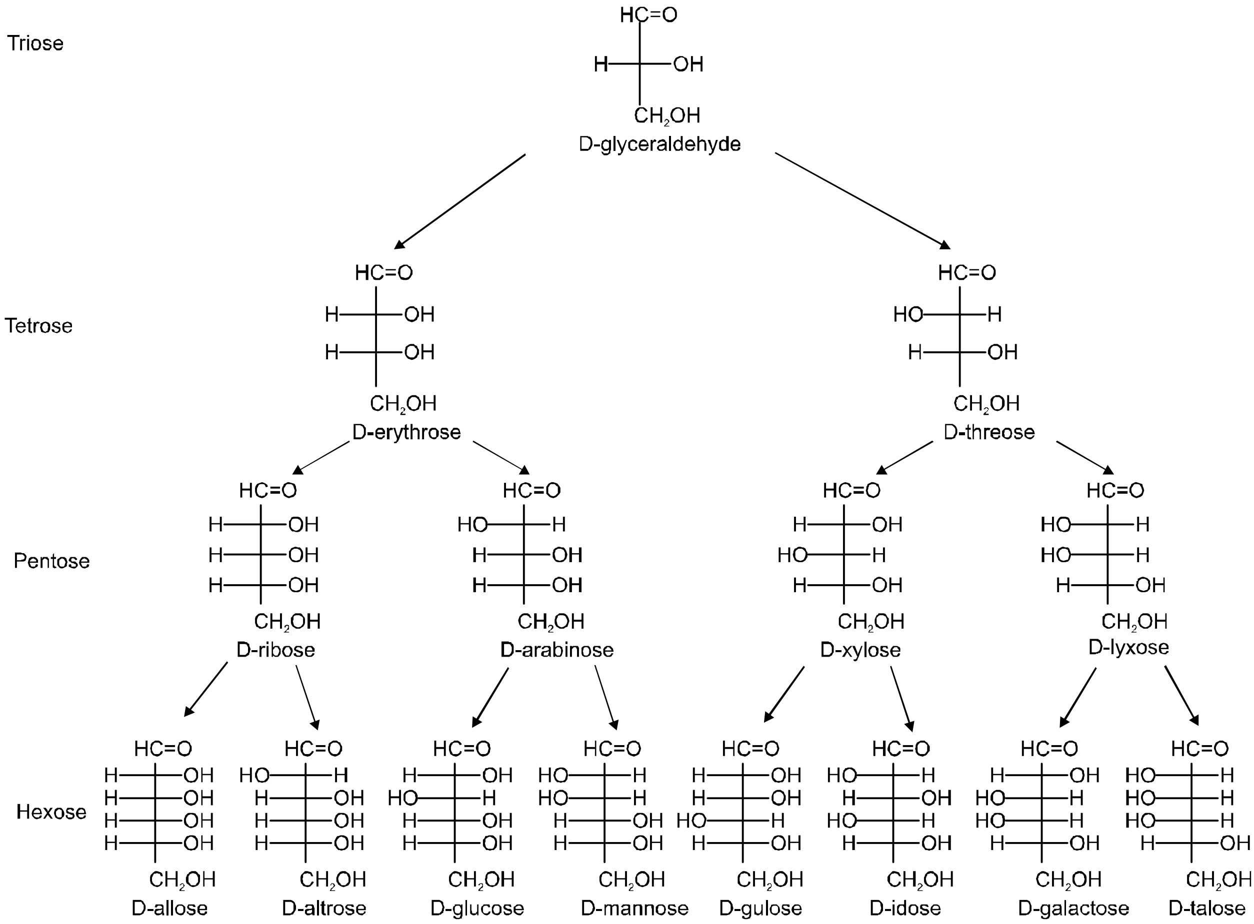
(D-Ribose)



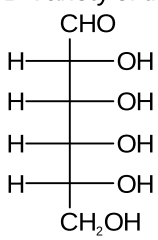
(D-2-Deoxyribose)

3. Stereochemistry of Aldoses :

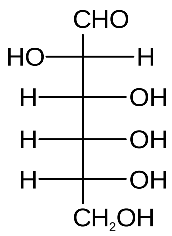
The monosaccharides are chiral and may have D or L configuration. A simple illustration of all 'D' forms is given below.



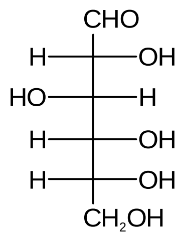
Optical isomers of Aldohexoses : Aldohexoses have four asymmetric carbon atoms, therefore they have sixteen optical isomers out of which 8 are D and 8 are L variety (overall Eight pairs of enantiomers). D-variety of them are as follows



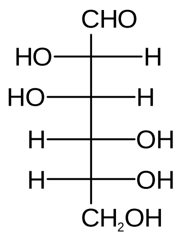
D(+)-allose
(I)



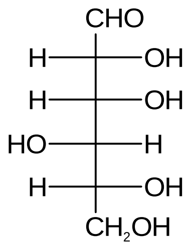
D(+)-altrose
(II)



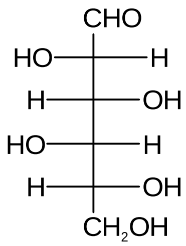
D(+)-glucose
(III)



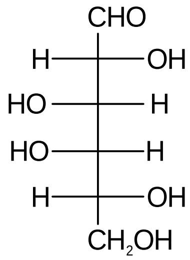
D(+)-mannose
(IV)



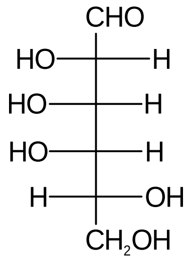
D(–)-gulose
(V)



D(–)-idose
(VI)



D(+)-galactose
(VII)

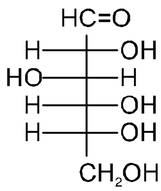
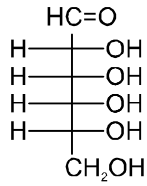
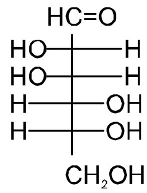
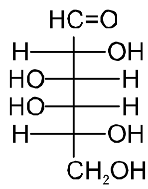
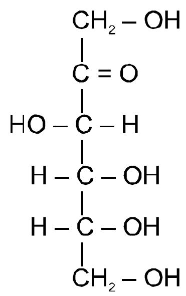


D(+)-talose
(VIII)

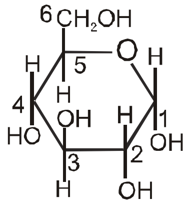
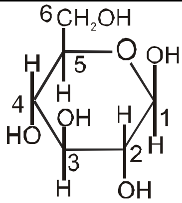
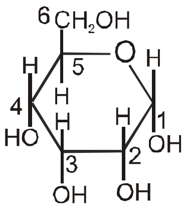
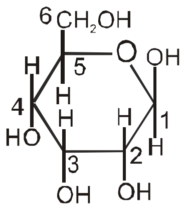
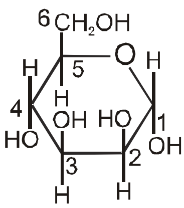
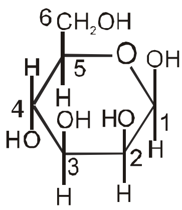
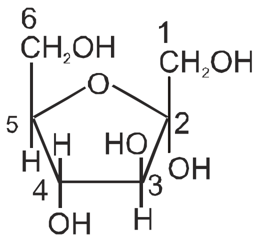
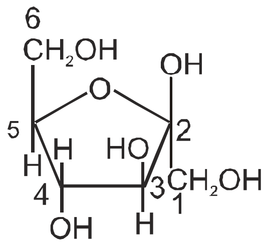
Note : **1.** D-aldohexoses shown above have diastereomeric relationship with each other
2. D-aldohexoses can be either dextro (+) or laevo (-).

4. **Structure of aldohexoses :** All form of Aldose or ketose may exist in open chain form as well as in cyclic pyranose or furanose form.

(i) **Open chain structure of mono saccharides**

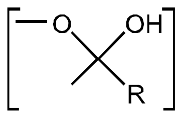
Carbohydrate	Structure	Functional Group	Typical nature
D - Glucose		aldehyde	3rd (L)
D - Allose		aldehyde	No (L)
D - Mannose		aldehyde	2, 3 (L)
D - Galatose		aldehyde	3, 4 (L)
D - Fructose		Ketone	3 (L)

(ii) Cyclic structure of monosaccharides

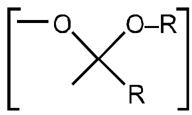
Carbohydrate	Cyclic structure
Glucose	 $\alpha^o = (112^o)$ α- D-glucopyranose  $\alpha^o = (19^o)$ β-D-glucopyranose
Allose	 α- D-Allopyranose  β- D-Allopyranose
Mannose	 α- D-Mannopyranose  β- D-Mannopyranose
Fructose	 **α-fructofuranose**  **β-fructofuranose**

5. Anomers :

Anomers are diastereomers that differ in the configuration at the acetal or hemiacetal C atom of a sugar in its cyclic form (Anomeric carbon: A carbon bonded with two 'O' atoms). For example, α D(+) and β -D(+) glucose are anomers. α-D(–) and β-D(–) fructose are anomers.



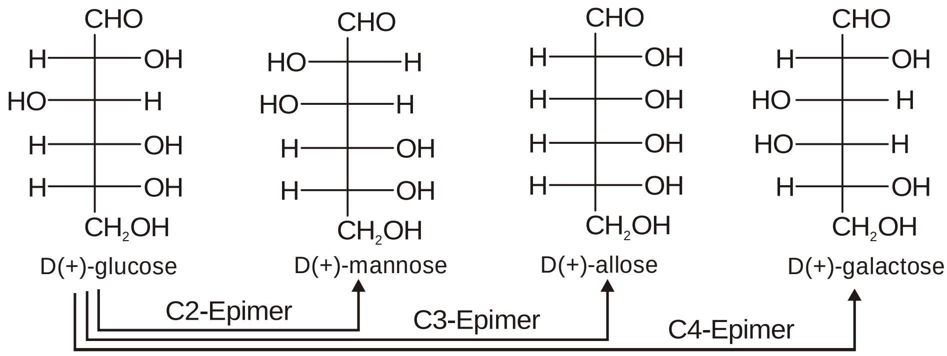
Hemiacetal functional group



Acetal functional group

6. **Epimers :** Diastereomers with more than one stereocentre that differ in the configuration about only one stereocentre (other than anomeric carbon) are called epimers.

i. D-Erythrose and L-threose are epimers.
ii. D-glucose and D-galactose are C-4 epimers and
iii. D-idose and D-talose are C-3 epimers.
iv. D-glucose and D-mannose are C-2 epimers.
v. Epimerisation of glucose at C-2 gives mannose.
vi. Epimerisation of glucose at C-3 gives allose.
vii. Epimerisation of glucose at C-4 gives galactose.



Reducing and non Reducing properties of Sugars :

	(I) Reducing sugars	(II) Non Reducing sugars
1.	Reduces Tollen's reagent, Fehling's solution & Benedicts's solution.	Don't reduce Tollen's, Fehling's & Benedict's solution.
2.	Should have atleast one hemiacetal or hemiketal functional group.	Should have acetal linkage.
Ex.	All Mono and Oligosaccharides except Sucrose	Ex. All Polysaccharides and few Oligosaccharides (Ex. Sucrose)

MONOSACCHARIDES

GLUCOSE

Glucose is the most common monosaccharide. It is known as Dextrose because it occurs in nature principally as the optically active dextrorotatory isomers. It is act as a reducing agent (reduces both Fehling's solution and ammonical silver nitrate solution **; Tollen's reagent**). It is known as **dextrose** and found as grapes, honey, cane sugar, starch and cellulose.

Preparation of Glucose :

(i) By acid hydrolysis of canes sugar (a disaccharide) :

If sucrose is boiled with dil. HCl or H_2SO_4 in alcoholic solution. Glucose & fructose are obtained in equal amount.

$$\underset{\text{Disaccharides Sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_2O/H^+} \underset{\alpha\text{-glucose}}{C_6H_{12}O_6} + \underset{\beta\text{-fructose}}{C_6H_{12}O_6}$$

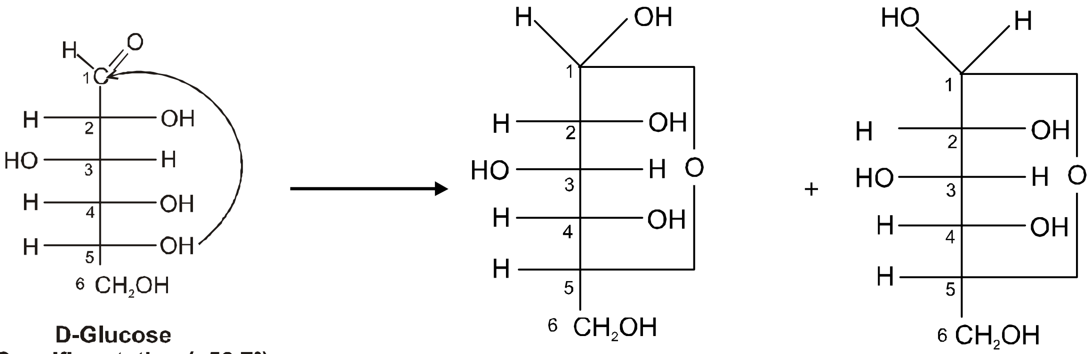
(ii) By enzymatic action over starch : Glucose is obtained by hydrolysis of starch by boiling it with dil. H_2SO_4 at 393 K under pressure.

$$\underset{\substack{\text{Polysaccharides} \\ (C_6H_{10}O_5)_n}}{\text{Starch}} \xrightarrow{\text{Diastase}} \underset{\substack{\text{Disaccharides} \\ (C_{12}H_{22}O_{11})}}{\text{Maltose}} \xrightarrow{\text{Maltase}} \underset{\substack{\text{Monosaccharides} \\ (C_6H_{12}O_6)}}{\text{Glucose}}$$

Structure of Monosaccharides :

Open chain structure (Fisher projection) and Cyclic structure (Haworth projection) :

(1) Despite having aldehyde group , glucose does not give schiff's test & it does not form the hydrogen sulphite (bisulphite) addition product with $NaHSO_3$.
(2) The pentaacetate of glucose does not react with hydroxylamine indicating the absense of free –CHO group.
This behaviour could not be explained by open chain structure. It was proposed that one of –OH group add to CHO group , forms a cyclic structure.
These two cyclic hemiacetal form of glucose differs only in configuration of the hydroxyl group at C1, called anomeric carbon. Such isomers i.e. α-form & β-form, are called anomers.

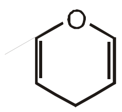


D-Glucose
Specific rotation (+52.7°)

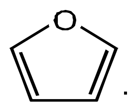
α-D-glucose
Specific rotation (+112°)

β-D-glucose
Specific rotation (+19°)

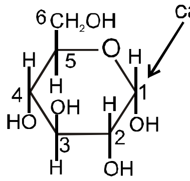
Note : β-form of D-glucose is more stable than α-D-Glucose.
Haworth projection
The six membered cyclic structure of glucose is called pyranose structure (α- or β-), in analogy with pyran. and five membered cyclic structure of monosaccharides is called furanose structure (α or β) in analogy with furan.



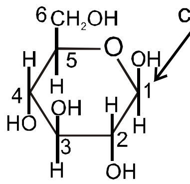
Pyran



Furan

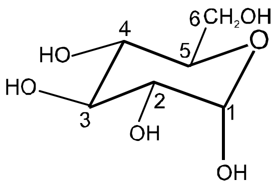


Specific rotation (112°)
α-D-glucose
α-D-glucopyronose

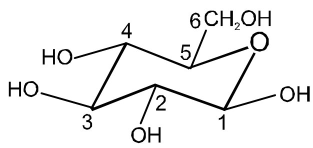


Specific rotation (19°)
β-D-glucose
β-D-glucopyranose

α and β-Glucose are anomer's of each other (i.e change in configuration of 1st carbon atom only)



α-D Glucose

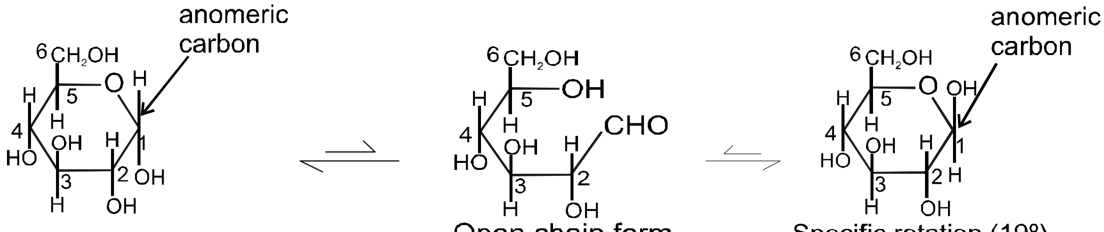


β-D-Glucose

Properties of Anomers : Mutarotation

When one of the pure glucose anomers dissolve in water, an intersting change in the specific rotation is observed. When the α-anomer dissolves, its specific rotation gradually decreases from an initial value of +112º to +52.7º. When the pure β anomer dissolves, its specific rotation gradually increases from +19º to the same value of +52.7º. **This change (mutation) in the specific rotation is called mutarotation**. What is happening to each solution ?

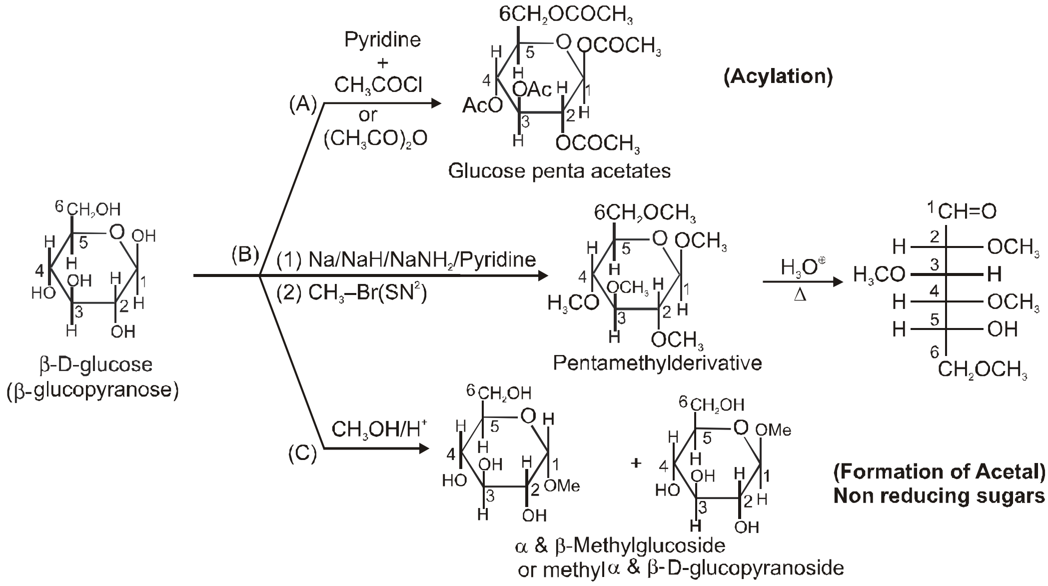
Initially solution with only one anomeric form, undergoes equilibrium to the same mixture of α-and β-forms. The open chain form is in intermediate in the process of equilibrium. For mutarotation atleast one hemiacetal group must be present in the sugar therefore **all reducing sugars will mutarotate.**



Specific rotation (112º) α-D-glucose α-D-glucopyranose | Open chain form of -D-glucose α specific (+ 52.7º) | Specific rotation (19º) β-D-glucose β-D-glucopyranose

Chemical Reactions of Anomers (Glucose)

(1) Reaction due to OH group :



Note : (A) Acylation with acid halide or acetic anhydride gives pentaacetates which confirms the presence of five –OH groups.

(B) After Hydrolysis product of pentamethyl derivatives, aldehyde group and hydroxy of C_5 regenerated hence hydroxy of C_5 is involved in the hemiacetal formation.

(C) (i) Sugars in the form of **acetals** are called **glycosides**. (glucose → glucoside, mannose → mannoside, ribose → riboside, fructose → fructoside etc).

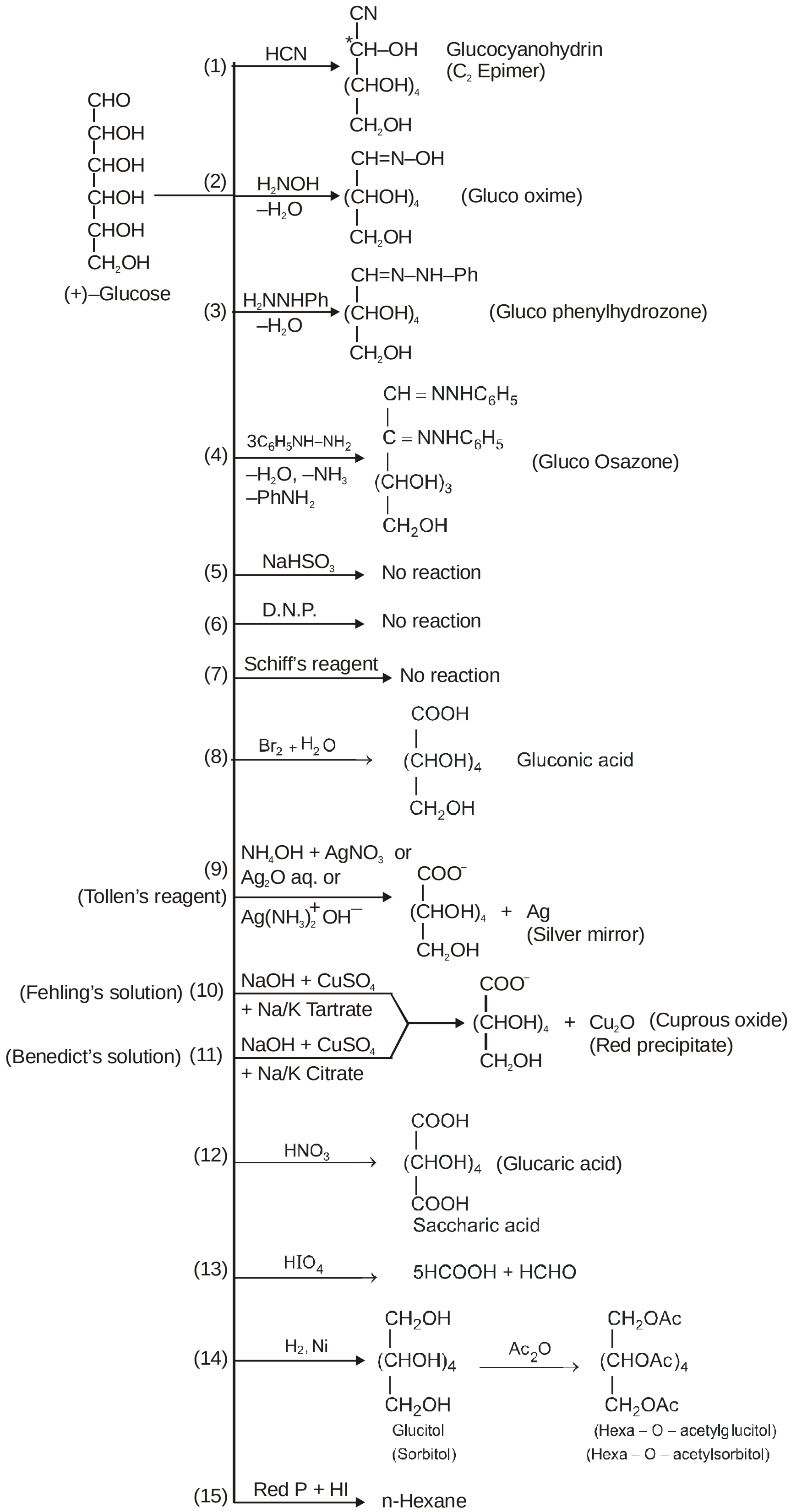
(ii) In the formation of glycosides only one mole of alcohol is required so monosacchardies are already present in the hemiacetal form with one of the hydroxyl group and carbonyl group.

(iii) Glycosides are non-reducing and will not show mutarotation because in neutral and basic condition glycosides are stable (cyclic form cannot open to the free carbonyl compound).

(iv) After acidic hydrolysis of glycosides, product form will have reducing property and also show mutarotation.

(2) Reaction due to aldehyde :

In aqueous solution, α-Anomer or β-Anomer remains in the equilibrium with each other by small amount of open chain forms (0.02%), in which carbonyl group is regenerated and gives various reactions.



FRUCTOSE

Fructose preparation :

(1) By acid hydrolysis of cane sugar.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_2O/H^+} \underset{\alpha\text{-glucose}}{C_6H_{12}O_6} + \underset{\beta\text{-fructose}}{C_6H_{12}O_6}$$

Disaccharides

(2) By enzymatic action of sucrose.

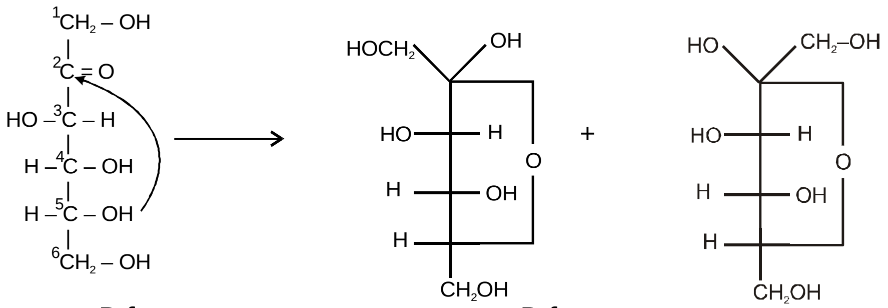
$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{invertase}} \text{Glucose} + \text{Fructose}$$

Note : (i) Glucose & fructose obtained by acid hydrolysis of sucrose can be separated by treating with $Ca(OH)_2$ which forms calcium glucosate & calcium fructosate. Calcium fructosate, being water insoluble, is seperated out easily.

(ii) Fructose is the sweetest monosaccharide.

Structure of fructose :

It also exist in two cyclic forms which are obtained by the addition of –OH at C5 to the ($>C=0$) group.



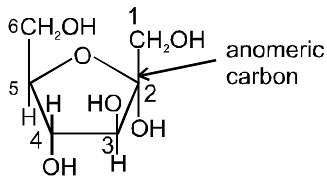
D-fructose Specific Rotation (– 92°)

α-D-fructose Specific Rotation (– 21°)

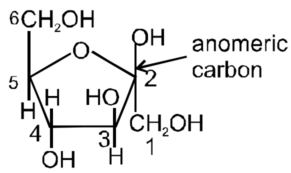
β-D-fructose Specific Rotation (– 133°)

Haworth projection : Fructofuranose

The five membered ring & is named as furanose with analogy to the compound furan.



Specific rotation (-21°)
α-fructose
α-fructofuranose

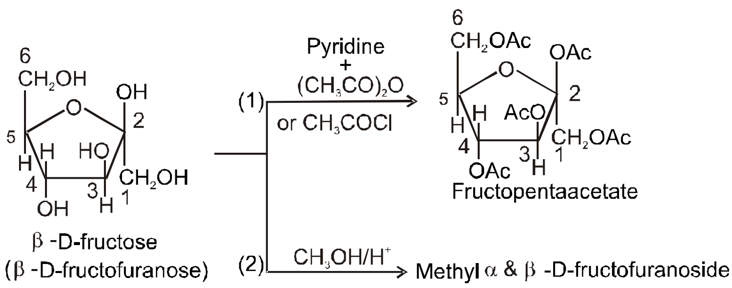


Specific rotation (-133°)
β-fructose
β-fructofuranose

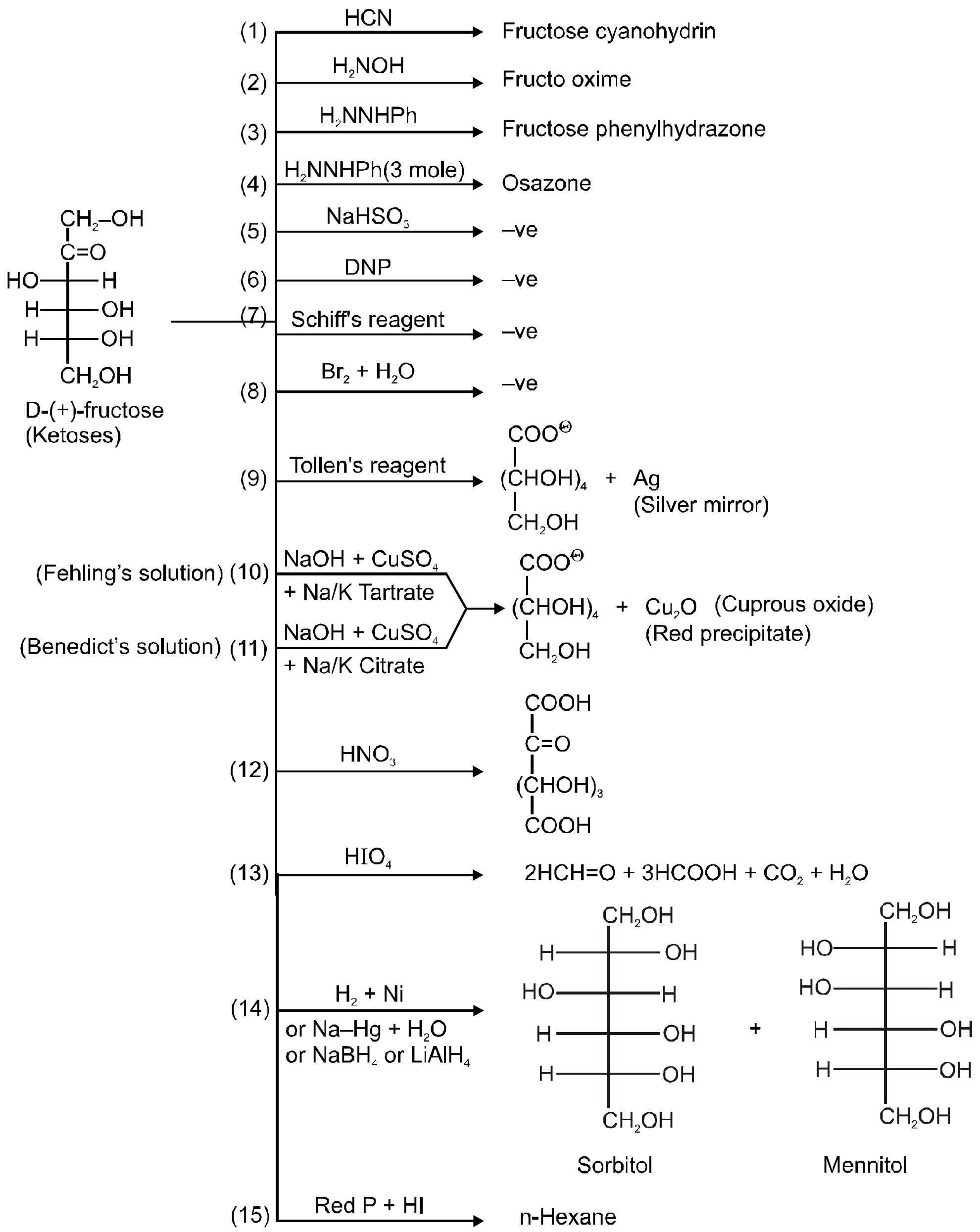
Chemical Reactions of Fructose :

Reaction due to OH group at 2nd carbon :

(1) It forms fructose pentaacetate with acetyl chloride :



(2) Reaction due to keto group :

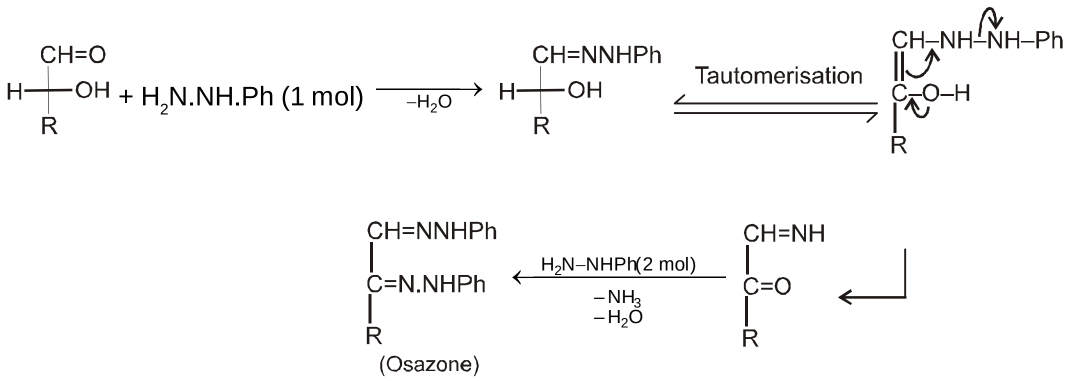


Some Highlights :

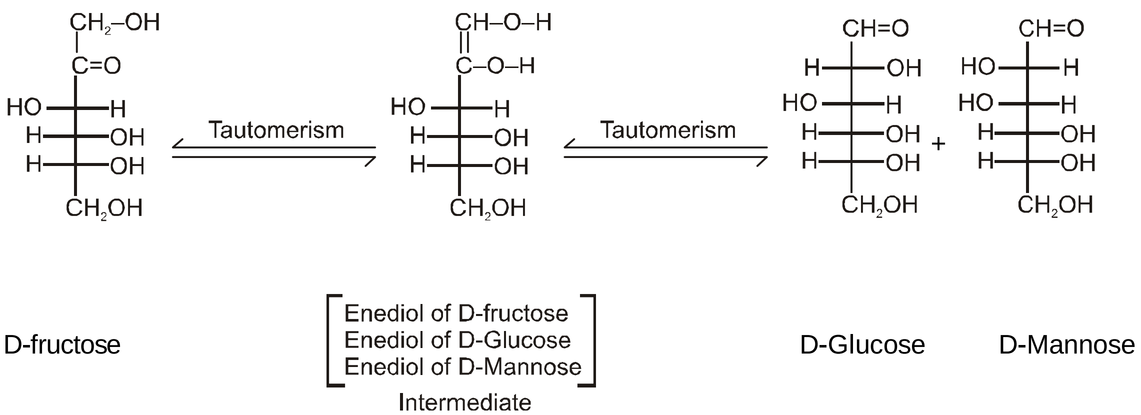
1. Since glucose & fructose (Aldoses/Ketoses) reacts with HCN, H_2NOH, H_2NNHPh which indicates the presence of carbonyl group but they don't react with DNP, $NaHSO_3$ & Schiff's reagent (weak reagents) therefore we can conclude that carbonyl group is not free, but remains in the form of cyclic structures.

2. In the formation of osazone, C_1 & C_2 are only involved so glucose, fructose and C-2 epimers (Glucose & Mannose, Threose and Erythrose) give same osazone.

3. Osazone are crystalline solid having sharp melting point so used for identifying the carbohydrates. In the osazone formation three molecules of NH_2NHPh is overall consumed out of which two molecule react with nucleophilic addition/elimination reaction forming hydrazone whereas one molecule undergoes redox reaction.



4. Both glucose and fructose gives test with Tollen's reagent, Fehling's solution and Benedict's solution because in basic medium, ketoses remains in the form of dynamic equilibrium with Aldoses (C-2 epimers) by the process of **tautomerisation/enediol rearrangement as below**.



5. Only Br_2/H_2O is used for the identification of Aldoses & Ketoses. (Mild oxidising agent like bromine water (Neutral) Oxidises only aldehydic group).

6. Oxidation with HNO_3, gives information that one primary alcohol is present in aldoses and two primary alcohols are present in ketoses.

7. Reduction product with Na/Hg and H_2O gives only one alcohol with aldoses and two alcohols with ketoses (C-2 epimers)

8. Reduction product with Red P & HI, gives n-Hexane which indicates that all the six carbon atoms are linearly arranged.

DISACCHARIDES

Condensation of two monosacharides after loss of water molecule (Glycosidic bond), gives disacharides. Common examples are sucrose, maltose, lactose, cellubiose.

(A) Sucrose : (Cane sugar)

(i) Sucrose is a white crystalline solid, soluble in water.

(ii) When heated above its melting point, it forms a brown substance known as caramel.

(iii) Sucrose is dextrorotatory, its specific rotation being + 66.5°.

(iv) On hydrolysis with dilute acids sucrose yields an equimolecular mixture of D(+)-glucose and D(–)-fructose :

$$\underset{[\alpha] = +66.6°}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{HCl} \underset{\substack{D-\text{glucose} \\ [\alpha] = +52.7°}}{C_6H_{12}O_6} + \underset{\substack{D-\text{fructose} \\ [\alpha] = -92.2°}}{C_6H_{12}O_6}$$

Since D(–)-fructose has a greater specific rotation than D(+)-glucose, the resulting mixture is laevorotatory.

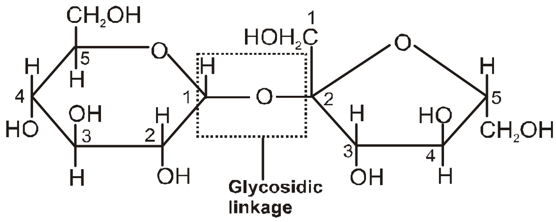
Since the hydrolysis of cane-sugar (sucrose) gives laevorotatory solution in place of original dextrorotatory solution therefore hydrolysis of cane-sugar is also known as the **inversion of cane-sugar or Inversion of sucrose** and the mixture of sugars are known as **invert sugar Ex. D - Glucose & D-Fructose.**

The inversion (i.e., hydrolysis) of cane-sugar may also be effected by the enzyme invertase which is found in yeast.

(v) Sucrose is not a reducing sugar, e.g., it will not reduce Fehling's solution or Tollen's reagnet. It does not form an oxime or an osazone, and does not undergo mutarotation. This indicates that hemiacetal group is not present in the rings.

Sucrose (Cane sugar) $\xrightarrow{H_3O^{\oplus}}$ **α-glucose + β-fructose**

In sucrose two monosaccharides are joined together by an oxide linkage formed by loss of water molecule. Such linkage through oxygen atom is called glycosidic linkage. In sucrose linkage in between C1 of α-glucose and C2 of β-fructose. Since the reducing group of glucose & fructose are involved in glycosidic bond formation, sucrose is non reducing sugar.



$C_1\alpha$–D-glucose + $C_2\beta$–D-fructose

α-D-Glucose β-D-Fructose.

(B) Maltose : (Malt sugar)

Maltose ($C_{12}H_{22}O_{11}$) is produced by the action of malt (which contains the enzyme diastase) on starch :

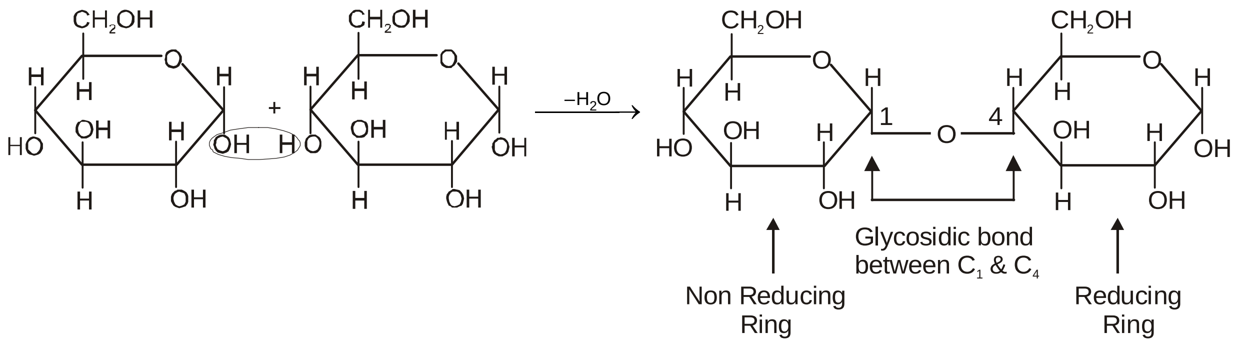
$$C_{12}H_{22}O_{11} \xrightarrow{H_3O^{\oplus}} 2C_2H_{12}O_6 \;\; \alpha\text{-D-Glucose}$$

When it is hydrolysed with dilute acids or by the enzyme maltase, maltose yields two molecules of D (+)-glucose. Maltose is a reducing sugar, e.g., it reduces Fehling's solution or Tollen's reagent; it forms an oxime and an osazone, and undergoes mutarotation. This indicates that at least one hemiacetal group (of the two glucose molecules) is free in maltose.

Maltose (Malt sugar) $\xrightarrow{H_3O^{\oplus}}$ **α-glucose + α-glucose**

Formation of Maltose ($C_{12}H_{22}O_{11}$)

C_1 α–D-Glucose + C_4 α-D-Glucose

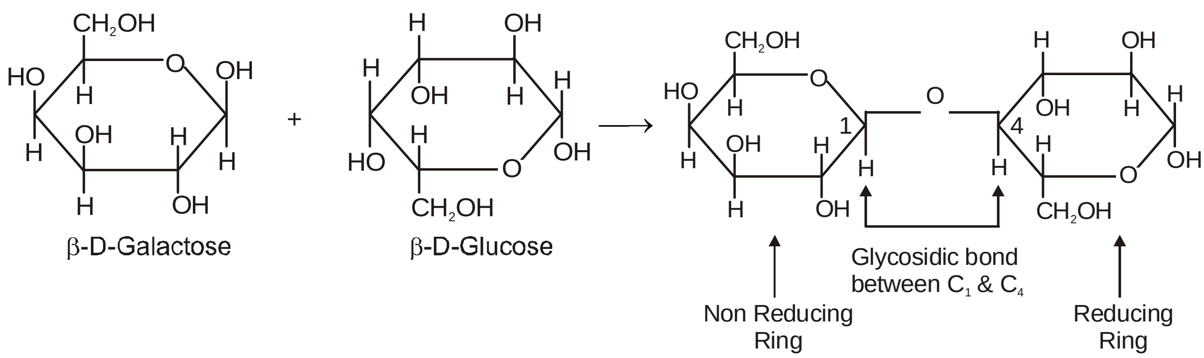


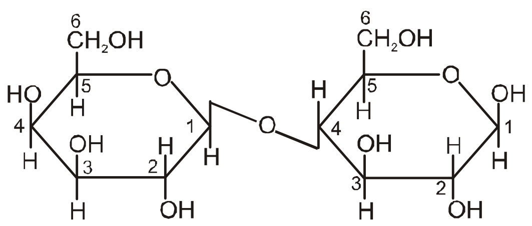
(C) Lactose : (Milk Sugar)

Lactose occurs in the milk of all animals and is dextrorotatory. It is hydrolysed by dilute acids or by the enzyme lactase, to an equimolecular mixture of D(+)-glucose and D(+)-galactose. Lactose is a reducing sugar.

Lactose (Milk sugar) $\xrightarrow{H_3O^{\oplus}}$ β-galactose + β-glucose

Formation of Lactose ($C_{12}H_{22}O_{11}$)





C_1β–D-Galactose + C_4β-D-Glucose

The linkage is between C-1 of Galactose and C-4 of Glucose.

(D) Cellubiose :

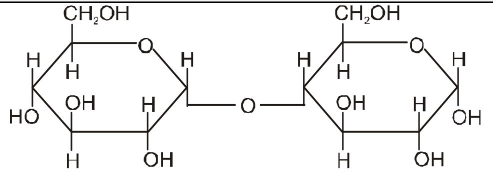
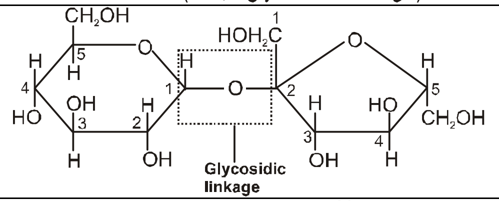
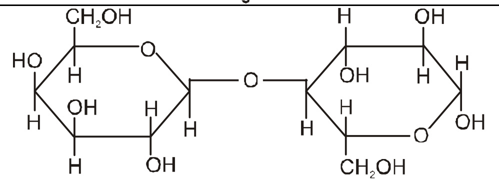
Cellubiose $\xrightarrow{H_3O^{\oplus}}$ β-glucose + β-glucose

β–D-Glucose + β-D-Glucose

C_1 C_4

Pyranose form Pyranose form

DISACCHARIDE

Disaccharide	Structure	Monomeric unit linkage	Properties
Maltose	 Maltose (α-1,4-glycosidic linkage)	D (+) Glucose + D(+) Glucose (α-1, 4-glycosidic linkage)	Produced by action of malt on starch. Undergoes mutarotation.
Sucrose		α-D-glucose + β-D-fructose (α-1,β-2 glycosidic linkage)	White crystalline solid , soluble in water. dextrorotatory specific rotation + 66.5°
Lactose	 Lactose (β-1,4-glucosidic linkage)	D(+) Glucose + D (+) galactose (β-1,4- glycosidic linkage)	dextrorotatory

POLYSACCHARIDES

Polysaccharides : It contains large number of monosaccharide units joined together by glycosidic linkage (acetal bond). They are food storage or structural material.

(A) Starch, $(C_6H_{10}O_5)_n$

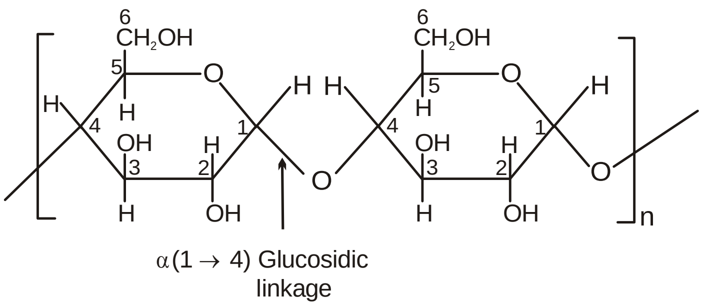
(i) Starch is the main contributor of carbohydrates in our diet. It exists exclusively in plants, stored in the seeds, roots, and fibres as food reserve. Example rice, potato.

(ii) Starch is actually a mixture of two structurally different polysaccharides, Amylose (15-20%) and Amylopectin (80-85%).

(iii) When starch is heated with hot water, it can be separated into its components. The part that is soluble in water is amylose and remaining fraction is amylopectin.

(iv) Both amylose and amylopectin are composed of D-glucose units.

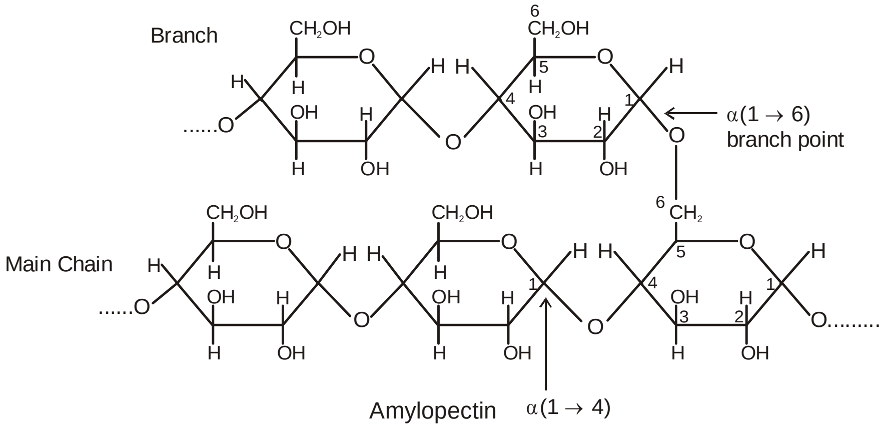
(v) The **amylose** molecule is made up of D-glucose unit joined by α-glycosidic linkages between C-1 of one glucose unit and C-4 of the next glucose unit. The number of D-glucose units in amylose range from 60-300.



1,4-Glycosidic linkage of α-D-Glucose

Amylose

(vi) **Amylopectin** has a branched-chain structure. It is composed of chains of 25 to 30 D-glucose units joined by α-glycosidic linkages between C-1 to one glucose unit and C-4 of the next glucose unit. These chains are in turn connected to each other by 1, 6-linkages.



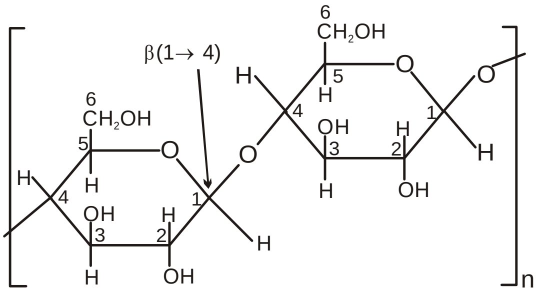
1,4-Glycosidic linkage of α-D-Glucose with Branching at 1, 6

α-amylose soluble in water, and the solution gives a blue colour with iodine. Amylopectin is insoluable in water, is stable in contact with water, and gives a violet colour with iodine.

(B) Glycogen (Animal Storage)

It is also like amylopectin but branching will take place after every 5 to 6 glucose unit. (highly branched)

(C) Cellulose, $(C_6H_{10}O_5)_n$



1,4-Glycosidic linkage of β-D-Glucose

Cellulose

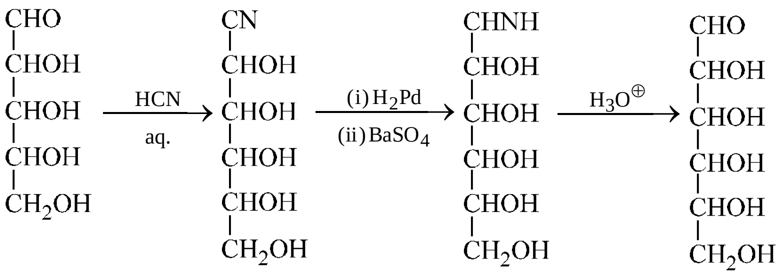
1. Cellulose is linear chain natural polymers of β-D glucose units joined by 1, 4-glycosidic linkage (Natural linear polymers).
2. Cellulose is the main structural material of tree and other plants. Wood is 50% cellulose, while cotton wool is almost pure cellulose.
3. Artificial silk, rayon, is used collectively to cover all synthetic or manufactured fibres from cellulose.
4. The nitrates are prepared by the reaction of cellulose with a mixture of nitric and sulphuric acids, and the degree of 'nitration' depends on the concentrations of the acids and the time of the reaction. Cellulose trinitrate (12.2 – 13.2%N) is known as **gun-cotton** and is used in the manufacture of blasting explosives and smokeless powders.

Starch : (Plant Storage, Polymer of α–D-glucose),
Glycogen : (Animal Storage, Polymer of α–D-glucose),
Cellulose : (Plant Skeleton, Polymer of β–D-glucose)

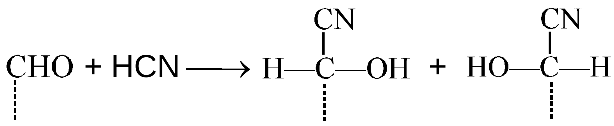
(A) Method of ascending the sugar series:

An aldose may be converted into it's next higher aldose eg. an aldopentose into an aldohexose.

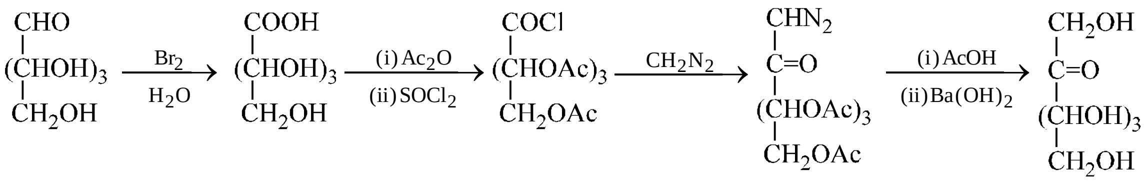
(1) By Kiliani Fischer upgradation:



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)

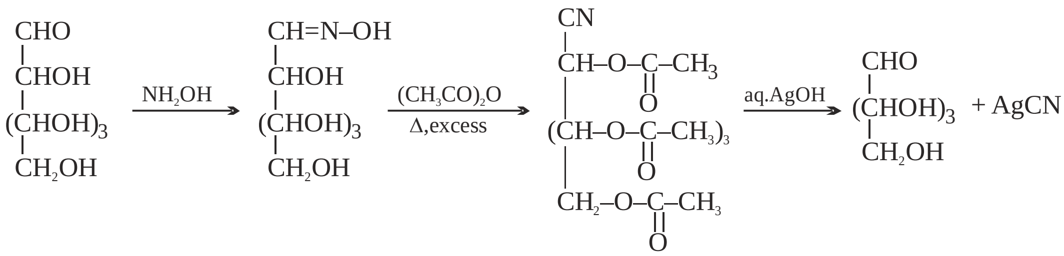


(2) By Wolfrom reaction : Wolfrom have stepped up an aldose to a ketose with one more carbon atom by a modified Arndt-Eister reaction.

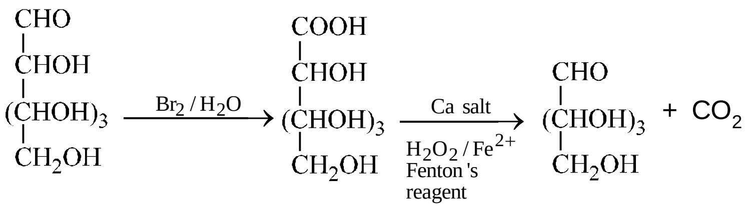


(B) Method of descending the sugar series :

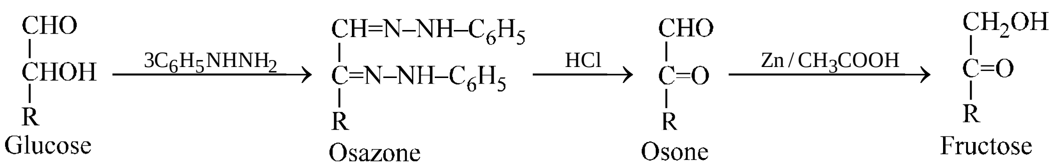
(1) Wohl's method:



(2) Ruff's method :

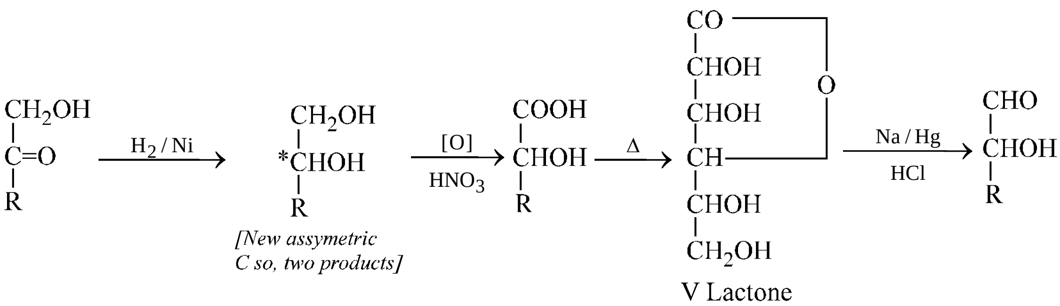


(C) Conversion of an aldose into a ketose :



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

(D) Conversion of a Ketose into an aldose :



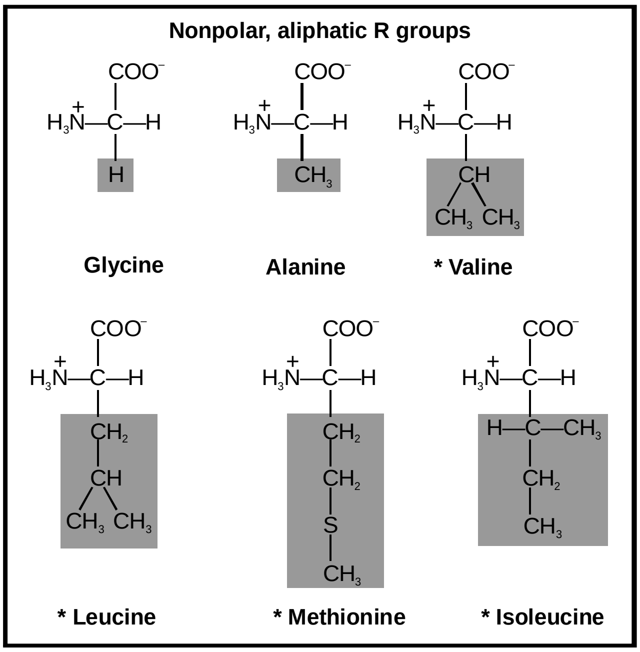
PROTEINS & AMINO ACIDS

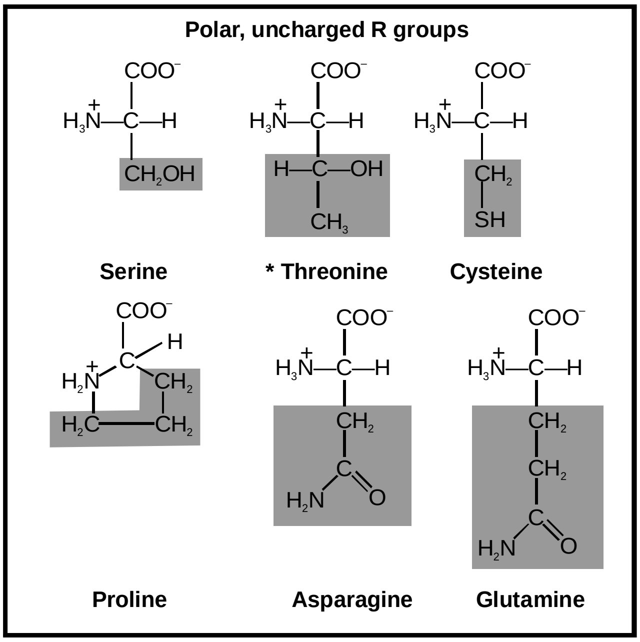
Proteins : Proteins are the most abundant-biomolecules of the living beings. The chief sources of proteins are milk, cheese, pulses, peanuts, fish, meat etc. These are high molecular mass complex, biopolymers of amino acids.

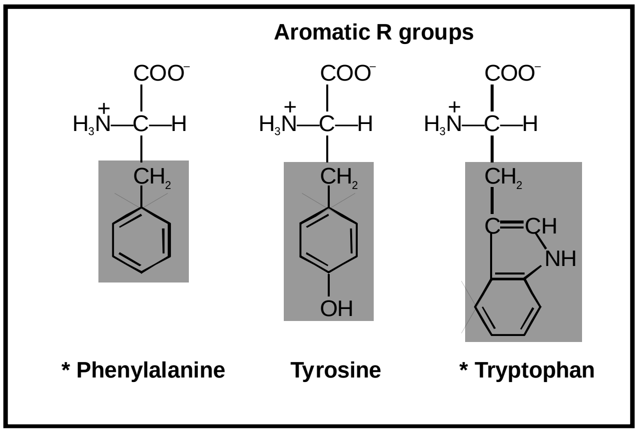
Amino Acids : Each living cell is made up of thousands of different proteins. All natural proteins are polymers of α-(L) amino acids and on partial hydrolysis give peptides of varying molecular masses which upon complete hydrolysis give α-amino acids.

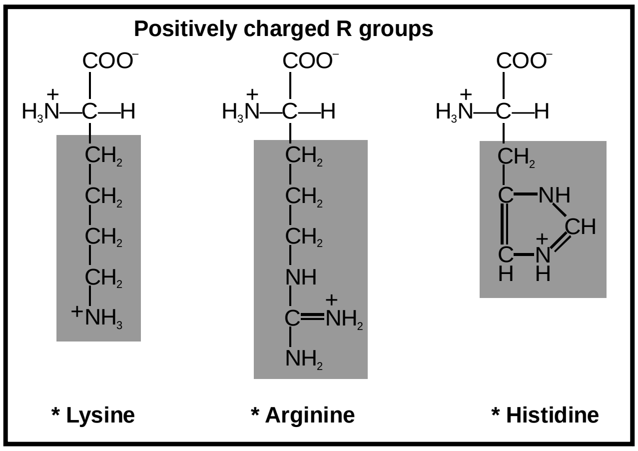
$$\text{Natural proteins} \xrightarrow{\text{Hydrolysis}} \text{Peptides} \xrightarrow{\text{Hydrolysis}} \alpha\text{-amino acids}$$

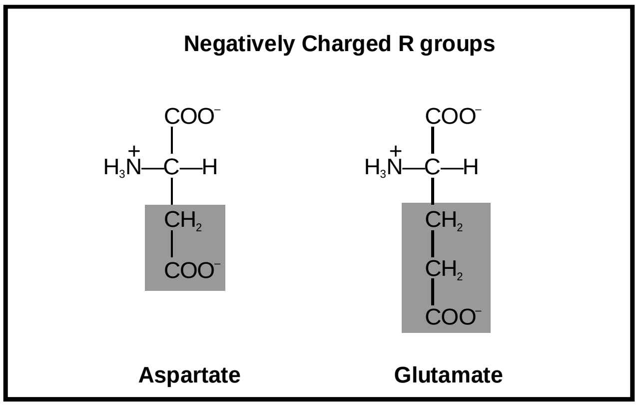
Type of α-amino acids :



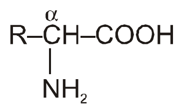




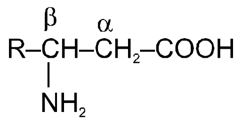




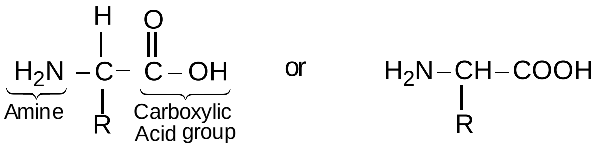
The amino acids contain amino as well as carboxylic acid group. On the basis of position of amino group in the chain, these are named as α, β, γ etc. amino acid.



α-amino acid



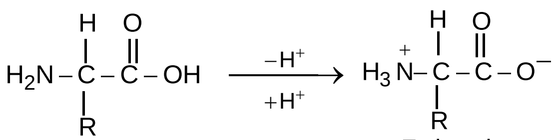
β-amino acid



where, R = alkyl, aryl, or any other group, but never contain unstable, strained cycles or functional groups.

Zwitter ion (Dipolar Nature of Amino acids) :

In a neutral amino acid solution, the –COOH loses a proton and the $-\ddot{N}H_2$ of the same molecule picks up one.The resulting ion is dipolar, charged but overall electrically neutral. This is called Zwitter ion (German, "two ions"). Therefore amino acids are amphoteric.



Zwitter ion

There are around 20 amino acids in the living system.

Classification of Amino Acids

(A) On the basis of synthesis:

(i) Non essential amino acids : 10 amino acids are synthesis in our body and these are said to be **non essential amino acids** (eg. Gly, Ala, Glu, Asp, Pro, Cys, Asn, Tyr, Ser, Gln). **(CAAATS-GGGP)**.

(ii) Essential amino acid : 10 amino acids which are necessarily be present in our diet are called **essential amino acids** (eg. Val, Leu, Ile, Lys, Phe, Thr, Trp, Met, His, Arg). **(PVT-TIM HALL)**

(B) On the basis of functional groups present :

(i) Neutral amino acids : If only one – NH_2 and one – COOH groups are present. **eg.** Glycine, Alanine, Valine, Leucine etc.

(ii) Acidic amino acid : If one basic and two acidic groups are present. Additional acidic functional group must be present in the side chain. **E.g.** Aspartic acid and Glutamic acid.

(iii) Basic amino acid : If two basic and one acidic group is present. Additional basic group must be present in the side chain. **E.g.** Arginine, Lysine & Histidine.

Note :

(i) Amino acids with aromatic chain : E.g. Phenylalanine, Tyrosine, Tryptophan

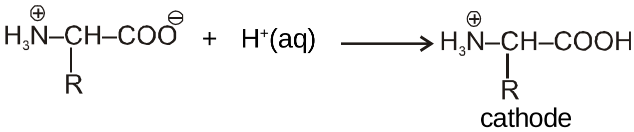
(ii) Amino acids with sulphur : E.g. Cysteine

Isoelectric point of α-amino acids :

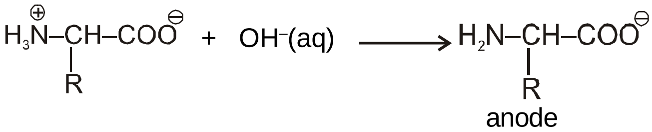
Isoelectric Point (PI) : The pH at which the amino acid shows no tendency to migrate when placed in an electric field is known as its isoelectric point.

Because of amphoteric nature in acidic solution it exist as the +ve ion. Hence it migrate towards cathode while in basic solution it exist as –ve ion and migrates towards anode.

In strongly acidic medium



In strongly basic medium



At some intermediate pH amino acids exist as a neutral dipolar ion i.e. the concentration of the cation and anions are equal and it does not migrate towards either electrode, this pH is called iso electric point of amino acid which is different for different amino acids.

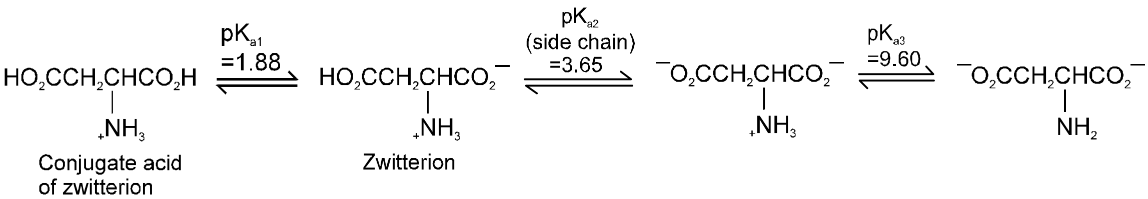
For example :

(i) For neutral amino acid : pH of isoelectric point varies between 5.1 to 6.5. **E.g.** Glycine has pH value 6.0

PI for neutral amino acid is calculated as $\dfrac{pK_{a_1} + pK_{a_2}}{2}$

(ii) For acidic amino acid : Where there are two COOH groups and one NH_2 group then isoelectric pH is around 3. E.g. Aspartic acid.

Aspartic acid :

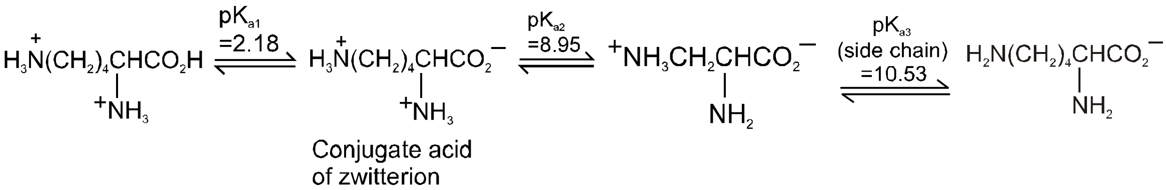


PI for acidic amino acid is calculated as $\dfrac{pK_{a_1} + pK_{a_2}}{2}$

The pI of aspartic acid is the average of pK_{a1} (1.88) and the pK_{a2} of the side chain (3.65) or 2.77.

(iii) For basic amino acid : where there are two NH_2 groups and one COOH group then isoelectric point varies between 7.6 to 10.8. E.g. Lysine (9.8)

Lysine :

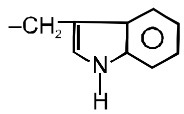
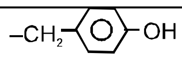
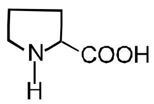
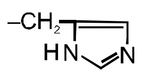


PI for basic amino acid is calculated as $\dfrac{pK_{a_2} + pK_{a_3}}{2}$

The PI of Lysine is the average of pK_{a2} (8.95) and the pK_a of the side chain (10.53) or 9.74.

Note : Amino acid has minimum aqueous solubilities at their isoelectric points.

Amino acids, their symbols and Isoelectric point :

S.No.	Name of the Amino acid	Three letter symbol	One letter code	Side chain (R)	Isoelectric point
		Neutral amino acids			
1.	Glycine	Gly	G	– H	6.0
2.	Alanine	Ala	A	$-CH_3$	6.0
3.	Valine*	Val	V	$-CH-(CH_3)_2$	6.0
4.	Leucine*	Leu	L	$-CH_2-CH-(CH_3)_2$	6.0
5.	Isoleucine*	I leu	I	$-\underset{\displaystyle CH_3}{\underset{\vert}{C}}H-C_2H_5$	6.1
6.	Phenyalanine*	Phe	F	$-CH_2-C_6H_5$ or CH_2Ph	5.5
7.	Cysteine	Cys	C	$-CH_2-SH$	5.1
8.	Methionine*	Met	M	$-CH_2-CH_2-S-CH_3$	5.8
9.	Tryptophan*	Trp	W		5.9
10.	Serine	Ser	S	$-CH_2-OH$	5.7
11.	Asparagine	Asn	N	$-CH_2-CO.NH_2$	5.4
12.	Glutamine	Gln	Q	$-CH_2-CH_2-CO-NH_2$	5.7
13.	Threonine*	Thr	T	$-CH-CH_3$	6.5
14.	Tyrosine	Tyr	Y		5.7
15.	Proline	Pro	P	 (It is complete structure)	6.3
		Acidic amino acids			
16.	Aspartic acid	Asp	D	$-CH_2-COOH$	3.0
17.	Glutamic acid	Glu	E	$-CH_2-CH_2-COOH$	3.2
		Basic amino acids			
18.	Lysine*	Lys	K	$-CH_2-(CH_2)_3-NH_2$	9.8
19.	Arginine*	Arg	R	$-CH_2-(CH_2)_2-NH-\underset{\displaystyle NH}{\underset{\Vert}{C}}-NH_2$	10.8
20.	Histidine*	His	H		7.6

* Essential α -amino acids

(a) General methods of preparation

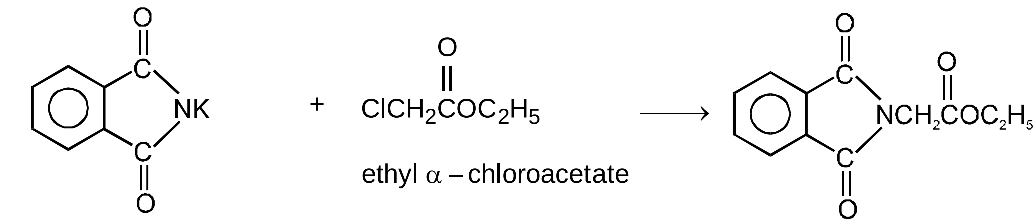
1. Aminolysis of α-halocarboxylic acid

$$\underset{\text{2-Bromo propanoic acid}}{\underset{|\atop Br}{CH_3CHCO_2H}} + \underset{\text{excess}}{2NH_3} \xrightarrow{H_2O} \underset{\text{alanine}}{\underset{|\atop \oplus H_3N}{CH_3CHCO_2^{\ominus}}} + NH_4Br$$

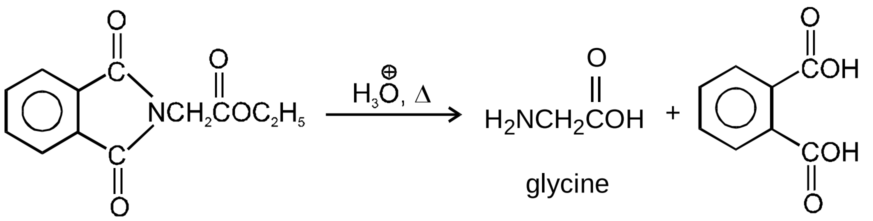
2. By strecker synthesis : Aldehyde reacts with a mixture of NH_4Cl and NaCN to form α-aminonitrile (as an intermediate) which on hydrolysis gives an amino carboxylic acid.

$$CH_3\overset{O\atop ||}{C}H \xrightarrow[NaCN]{NH_4Cl} \underset{2-\text{aminopropanenitrile}}{\underset{|\atop NH_2}{CH_3CHCN}} \xrightarrow[2.\ OH^-]{1.\ H_2O/HCl,\ \Delta} \underset{\text{alanine}}{\underset{|\atop \oplus NH_3}{CH_3CHCO_2^{\ominus}}}$$

3. By Gabriel Synthesis :



N-potassium phthalimide



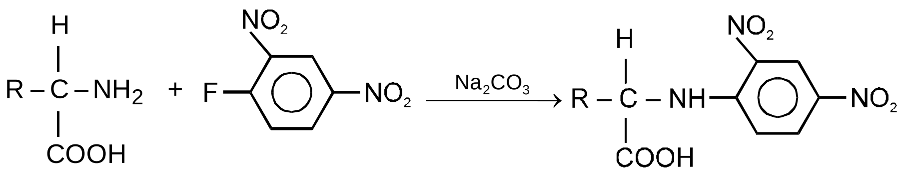
phthalic acid

(b) Chemical reactions :

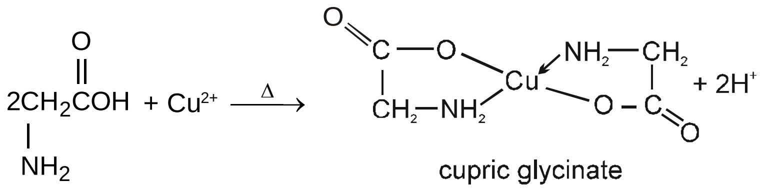
1. Formaldehyde reacts with amino acids to form N-methylene amino acids. In this reaction basic character is lost and thus, free acid can be determined by titration - Sorenson titration method for amino acids.

$$CH_2O + H_2NCH_2\overset{O\atop ||}{C}OH \longrightarrow \underset{N-\text{methylene glycine}}{CH_2 = NCH_2\overset{O\atop ||}{C}OH} + H_2O$$

2. DNFB **(2, 4-dinitrofluorobenzene)** also called **Sanger's reagent** reacts with the free amino group of terminal amino acid in a peptide or protein to form yellow coloured dinitro phenyl amino acid. This is thus, used to determine N-terminal amino acid.



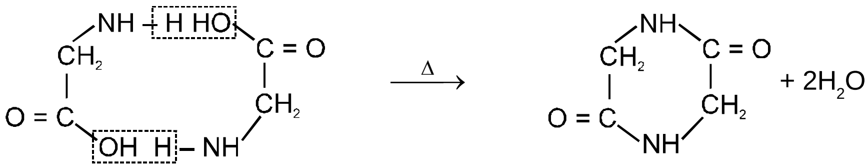
3. Cu^{2+} salts form blue coloured complex with amino acids.



cupric glycinate
(deep blue)

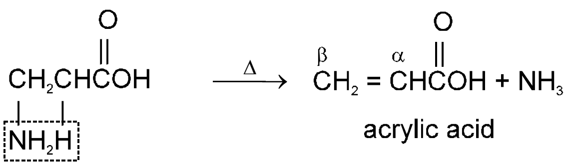
4. **Effect of Heat :**

α-amino acids undergo intermolecular dehydration on heating at about 200°C to give diketopiperazines.



glycine 2,5-diketopiperazine

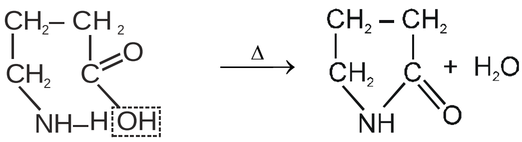
β-amino acids undergo intramolecular deamination on heating to form α, β-unsaturated acids.



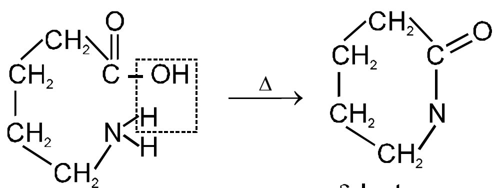
acrylic acid

γ-amino acids and δ-amino acid undergo intramolecular dehyderation to form cyclic amides called.

Lactams.

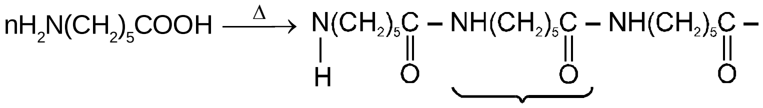


γ amino acid γ–butyrolactam



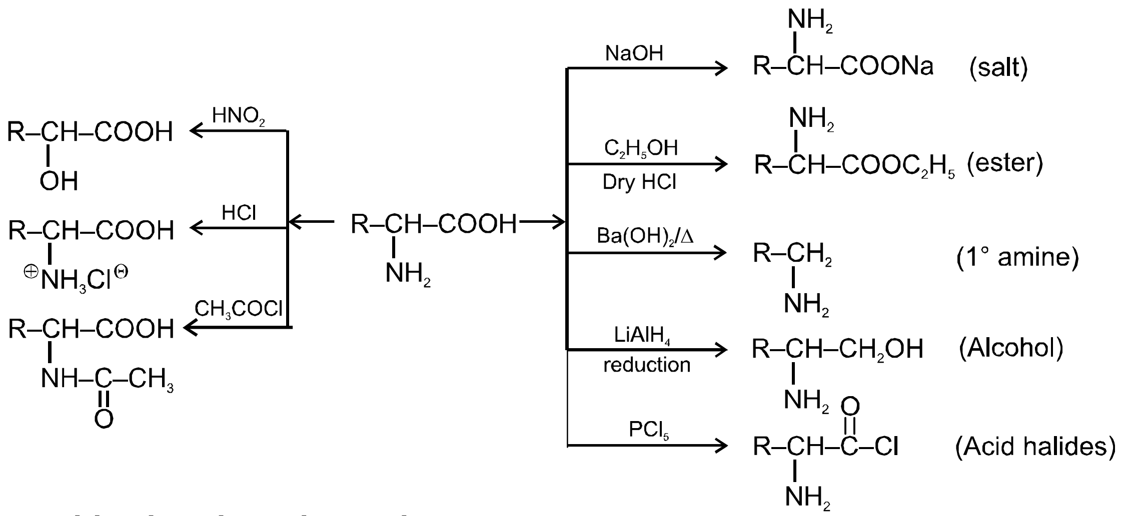
δ-amino acid δ-lactam

In case of ε-amino acid, intramolecular cyclisation would given a seven-membered ring, which is formed with difficulty. Hence, there is intermolecular polymerisation forming nylon-6.



monomer unit
Nylon-6

(c) Other Reactions of α-Amino Acid :

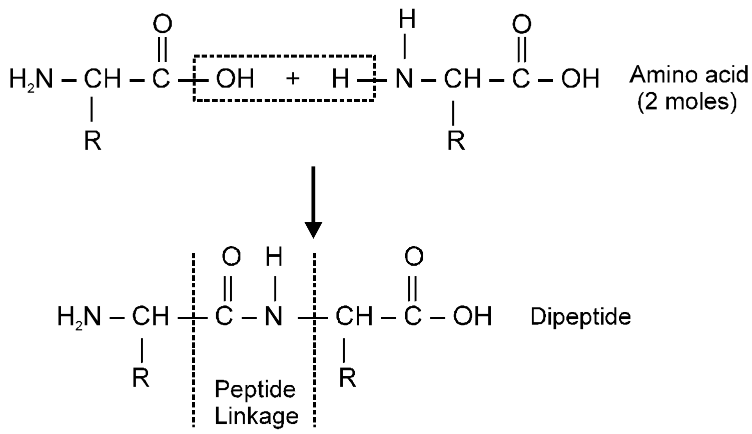


Peptides bonds and Proteins :

Peptides (Proteins) : Peptides are condensation polymers of α-amino acids formed by condensation of amino group of one α-amino acid with the carboxyl group of same or differnet α-amino acid by elimination of water. They are classified as di, tri, tetra, pentapeptides etc. according to two, three, four, five etc molecules of the same or different amino acid combining together. It determines their specific physiological functions in the living organism.

Structure of Proteins (Peptides)

Amino acids are bifunctional molecules with $-NH_2$ group at one end and – COOH at the other. Therefore, –COOH of one molecule and $-NH_2$ of another molecule interact by elimination of H_2O to form an amide-like linkage.



Peptide Linkage : The amino acid unit having free $-NH_2$ groups is called N-terminal end whereas the amino acid unit with free – COOH group is called C-terminal end. The structure is written with N-terminal end to the left and C-terminal end to the right. At N-terminal or C-terminal further bond formation take place and tri, tetra, pentapeptide are formed. $-NH-\underset{}{\overset{R\,|}{CH}}-\overset{O\,||}{C}$ unit repeated in polypeptides.

Polypepties : More than 10 aminoacids join together is called polypeptides which is a linear chain natural polymer.

Naming of polypeptides : Naming of polypeptides starts from –N–terminal residue, and suffix -ine of amino acids is replaced by -yl for all except amino acid of C-terminal residue.

Example : Glycine $\rightarrow$ Glycyl, Alanine $\rightarrow$ Alanyl, Lysine $\rightarrow$ Lysyl

Alanylglycylphenylalanine means Ala-Gly-Phe or A-G-F.

Determining sequence of polypetides by partial hydrolysis :

Q.1 Tripeptides $\xrightarrow{H_3O^+}$ Glycine, Alanine, Valine

Tripeptides $\xrightarrow[\text{Hydrolysis}]{\text{Partial}}$ Gly–Ala, Ala–Val

Write the structure of tripeptide?

Ans. Gly-Ala–Val.

Q.2 Tripeptides $\xrightarrow{H_3O^+}$ Glycine, Valine, Lysine

Tripeptides $\xrightarrow[\text{Hydrolysis}]{\text{Partial}}$ Valine–Lysin & Glycine–Valine

Write the structure of tripeptide?

Ans. Gly-Val-Lys.

PROTEINS

A polypeptide with more than 100 amino acid residues (mol. mass > 10,000) is called a protein but, a few polypeptide with lesser number of amino acid is also known.
Example : Insulin have 51 amino acids.

Classification of Proteins :

(I) On the basis of molecular structure : Proteins have been classified into two parts.

(i) Fibrous proteins (ii) Globular proteins

(i) Fibrous Proteins : When polypeptide chain run parallel and fiber like structure then it is called fibrous protein. In Fibrous protein chain are held together by hydrogen and disulphide bond. These are insoluble in water.

Ex. Keratin, myosin.

(ii) Globular proteins : When polypeptide chain is folded to form spheroidal shape it is called globular protein. Such folding is because of a folding of polypeptides in such a way that lipophilic (fat soluble) part are pushed inward and hydrophilic part is pushed outward. These are soluble in water and sensitive to small change in temperature and pH.

Ex. Albumins in egg, enzyme and some hormones, etc.

(II) On the basis of chemical composition :

(i) Simple proteins : Simple proteins on hydrolysis give only α-aminoacids. For example albumin in the white portion of eggs, glutenin in wheat, oxygenin in rice, keratin in hair, nails horns etc.

(ii) Conjugated Proteins : In conjugated proteins, protein part. is combined with non-protein part. On hydrolysis these give a non protein part in addition to the α-amino acids. This non protein portion is called PROSTHETIC GROUP. It function is to control the biological function of the protein.

Prothetic groups may be carbohydrate, phophate, lipids (ester of higher fatty acids) and so on.

Ex. Casein of milk, haemoglobin of blood are example of congugated proteins.

(iii) Derived Proteins : Degradation products obtained by partial hydrolysis of simple or conjugated proteins with acids, alkalies or enzymes are called derived proteins. For example : proteoses peptones, and polypeptides

Protein $\rightarrow$ Proteoses $\rightarrow$ Peptones $\rightarrow$ Polypeptides

Structure of Proteins :

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

(i) Primary structure of Proteins :

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 that protein. Any change in this primary structure i.e sequence of amino acids creates a different proteins.

Ex. Normal Haemoglobin : –Val – His – Leu – Thr – Pro – Glu –Lys–

Sickle cell anemia Haemoglobin : –Val – His – Leu – Thr – Pro – Val – Lys–

(ii) Secondary structure of Proteins :

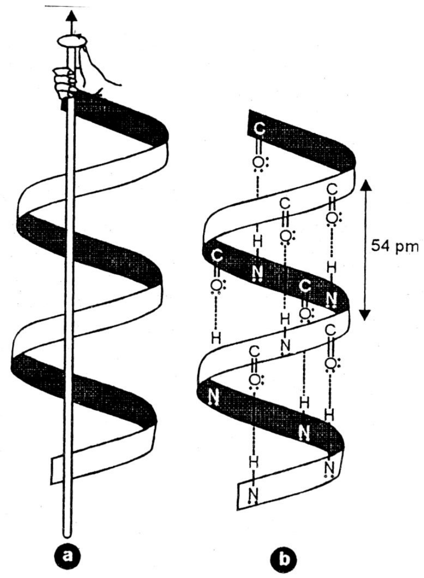
The shape in which a long polypeptide chain can exist is called secondary structure of proteins. The following two different secondary structure are possible.

(a) α-Helix structure

(b) β-pleated sheet structure

(a) α-Helix structure :

In α Helix a polypeptide chain forms all possible H–bonds by twisting into a right handed screw (helix) –NH group of each amino acid residue H–bond to the C=O of an adjacent turn of helix.

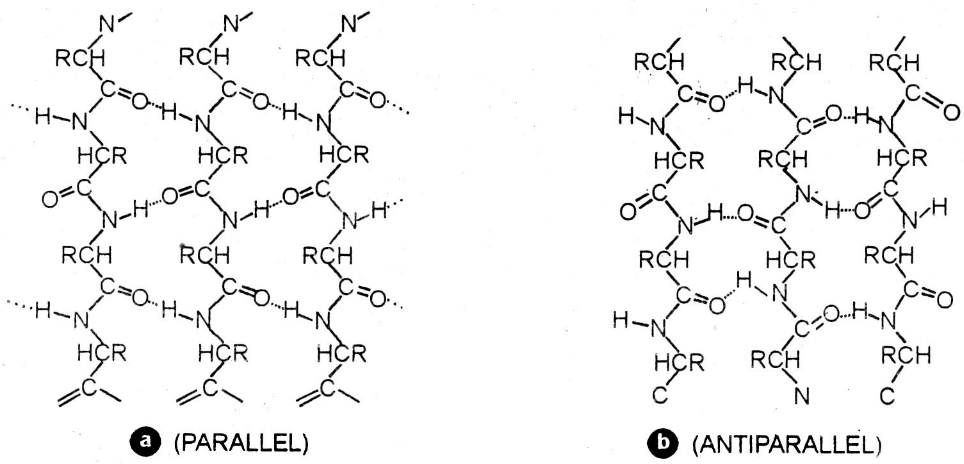


(a) A right handed α-Helix
(b) Hydrogen bonding in α-Helix

(b) β-pleated sheet structure or simply β-structure :

In β structure all peptide chains are stretched out to a nearly maximum extension and then laid side by side which are held together by inter molecular H– bond.

The poly peptide chains can link together in parallel and antiparallel sequence. These are represented as follows :



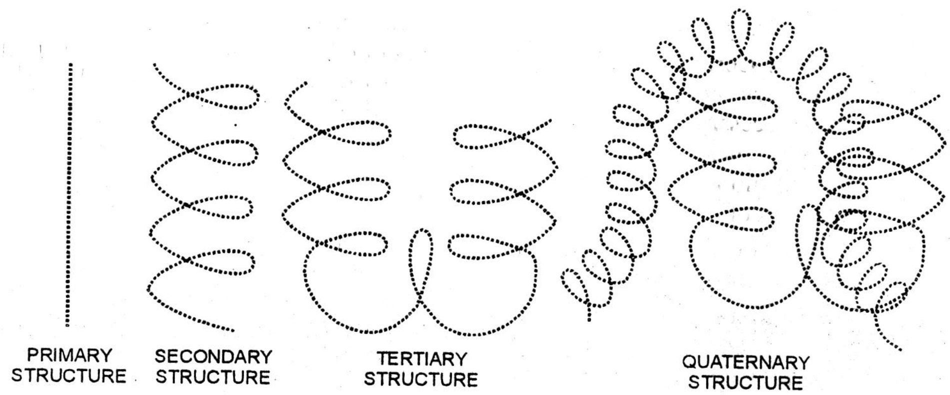
β-Conformation of proteins (a) Parallel (b) Anti-parallel.

(iii)Tertiary structure of proteins :

The tertiary structure of protein represent overall folding of the polypeptide chains i.e further folding of the secondary structure producing a 3D structure. **It gives rise to two major molecular shapes fibrous and globular.**

(iv) Quarternary structure of proteins :

There are certain proteins which are composed of two or more polypeptide chains referred to as sub-units or protomoss. The quarternary structure refers to the determination of the number of sub-units and their arrangement with respect to each other in an aggregate protein molecule.



Diagrammatic representation of four levels of protein structure (two subunits of two types in quaternary structure).

Denaturation of proteins :

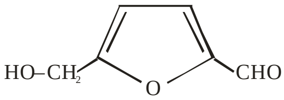
When protein in native form is subjected to a physical change like temperature or pH, the H–bonds are disturbed. As a result globules get unfold and helices get uncoiled therefore proteins loses its activity. During denaturation 2° and 3° structures get destroyed but 1° structure remain the same.
Ex: Coagulation of egg while on boiling and curdling of milk caused by bacteria present in milk.

Renaturation of proteins :

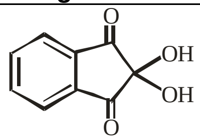
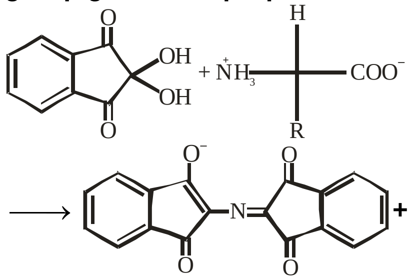
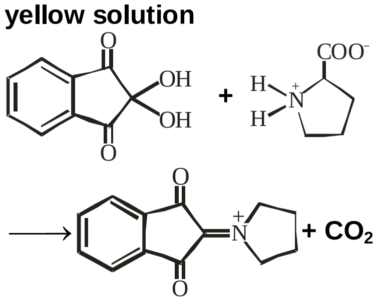
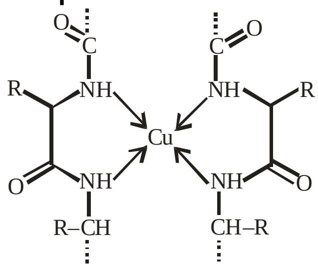
Denaturation may be reversible or irrevisible. Coagulation of egg on boiling and curdling of milk are example of irreversible protein denaturation. But in some cases it may be reversible and this process of reversibility is called renaturation. Hence, When the temperature and pH of a denaturated protein are brought back 3° & 2° structures are restored.

Chemical Tests

Test for Carbohydrates

Test	Reagent	Observations	Reason	Test given By
Molisch's Test	5% solution of α-Napthol in alcohol + Few drops of conc. H_2SO_4	Formation of reddish violet ring at the junction of two liquids	Formation of furfural or furfural derivatives. 	Carbohydrates
Iodine Test	I_2 solution with a little KI	Blue/red/brown colour solution	Colour due to formation of adsorption complex of starch/dextrin/glucogene.	Starch/dextrin/glycogens
Seliwonoff's Test	0.5% Resorcinol in conc. HCl and heat for 5 minutes.	Fiery red colour or coloured solution.	Complex formation.	Fructose gives fiery red solution but glucose, maltose and sucrose gives brown/violet coloured solutions. (Difference between fructose and glucose)
Bial/s Test	Orcinol and a little $FeCl_3$ dissolved in ethanol	Blue green compound formed	Heating pentose with strong acids gives furfural. Which with Bial's reagent gives blue-green compound.	Pentose i.e. Arabinose
Osazone Test	Phenylhydrazine –hydrochloride mixture with anhydrous sodium acetate	Yellow crystals of Osazone	Formation of Yellow crystals of Osazone	Only Glucose, Mannose and Fructose.
Fehling's Solution Test	(i) $CuSO_4.5H_2O$ is water. (ii) Alkaline solution (KOH) of sodium Potassium tartarate	Red/brown ppt. of Cupric oxide	Reducing sugar reduces Cu^{2+} to Cu_2O	Given by Glucose, Fructose, Maltose, Lactose (Not given by Sucrose)
Benedict's Solution Test	1. $CuSO_4,5H_2O$ in water 2. Alkaline solution of sodium citrate	Red/brown ppt. of Cupric oxide	Reducing sugar reduces Cu^{2+} to Cu_2O	Given by Glucose, Fructose, Maltose, Lactose (Not given by Sucrose)
Barfoed's Test	1.Copper acetate solution in water 2. Buffered with few drops of Acetic acid	Red/brown ppt. of Cupric oxide	Reducing sugar reduces Cu^{2+} to Cu_2O	Given by Glucose, Fructose, Maltose, Lactose (for mono-saccharide only)

Test for amino acids and proteins

Test	Reagent	Observation	Test Given By
Ninhydrin Test	 **Ninhydrin hydrate**	**Blue/purple or Yellow solution**	**α-amino acids with primary amino group gives blue/purple solution**  **CO_2(g) + RCHO + H_2O** **α-amino acids with secondary amino group “proline” gives yellow solution**  **+ CO_2 +** **H_2O**
Biuret Test	**(i) Hydrated $CuSO_4$** **(ii) KOH solution** **(iii) Sod. Pot. Tartarate**	**Violet colour solution**	**Tri peptide, Polypeptide and Proteins** **form violet coloured chelate complex in alkaline conditions.**  ***2–peptide bonds are required for the formation of chelates,** **Single amino acids has no peptide bond or dipeptide (gives a negative test)**
Xanthoproteic Test	**Nitrating mixture**	**Yellow solution**	**Aminoacids/proteins with only activated benzene ring “Tyrosine & Tryptophan” gives this test**
Million’s Test	**Nitrating mixture followed by Hg(I) and Hg(II) ions in the solution**	**Red Solution**	**Specific test of amino acid with phenolic groups. “Tyrosine”**
Hopleins cole Test			**Specific test for the “Tryptophan”, the amino acid**

Exercise # 1

✍ **Marked Questions may have for Revision Questions.**

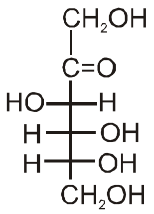
PART - I : SUBJECTIVE QUESTIONS

Section (A) : Carbohydrate

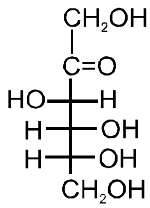
A-1. What are monosaccharides ?

A-2. **(a)** Draw the Fischer projections for the open-chain structures of D-glucose and L-glucose ?

(b) The fischer projection of D-fructose is given below, write the fischer projection of L-fructose.



D-Fructose



D-फ्रुक्टोस

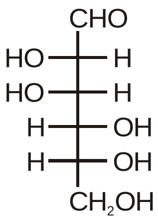
A-3. Give reasons as the evidence in support of cyclic structure of glucose

A-4.✍ What is mutarotation ?

A-5.✍ What do you understand by glycosidic linkage ?

A-6.✍ What are reducing sugars ?

A-7. **(a)** Some reactions of a monosaccharide **U** are given below. Complete them by drawing the structures of the products with correct stereochemistry wherever applicable.



U

(i) **U** $\xrightarrow{NH_2OH}$

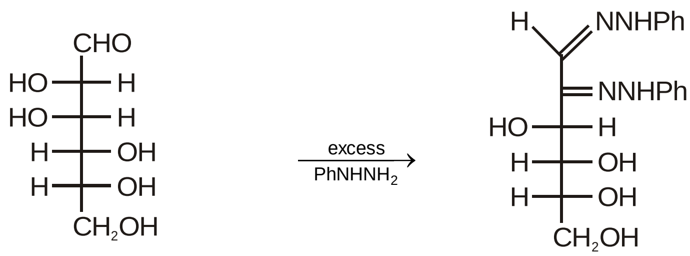
(ii) **U** $\xrightarrow{Br_2/H_2O}$ $(C_6H_{12}O_7)$

(iii) **U** $\xrightarrow{\text{Conc. } HNO_3}$ $(C_6H_{10}O_7)$

(iv) **U** $\xrightarrow{\text{excess } (CH_3CO)_2O}$

(v) **U** $\xrightarrow{NaBH_4}$

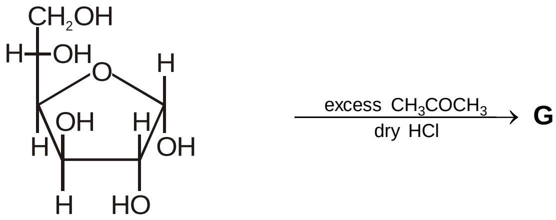
(b) Monosaccharide **U** react with phenylhydrazine in excess to yield a crystalline derivative called osazone.



U **osazone**

Another aldose **V** and ketose **W** also the same osazone as **U** on reaction with excess of phenylhydrazine. Draw the structure of **V** and **W** in the Fischer projection formula.

A-8. Draw the structure of the product **G** in the following reaction.



A-9. What are the hydrolysis products of sucrose ?

A-10. What is the basic structural difference between starch and cellulose ?

A-11. Simple six memebered ring compound (eg. Cyclohexane) are not soluble in water whereas glucose and sucrose are soluble in water. Explain why ?

Section (B) : Amino Acids & Proteins

B-1. Amino acids show amphoteric behaviour . Explain why ?

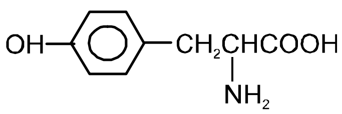
B-2. How will you identify a basic amino acid ?

B-3. Why an amino acid is usually solid at room temperature.

B-4. The melting point and solubility (in H_2O) of amino acids are generally high. explain why ?

B-5. What is the product obtained when glycine hydrochloride reacts with two equivalents of NaOH ? Write the chemical reactions involved.

B-6. Tyrosine is an α –amino carboxylic acid shown below:



Write the most stable structural formula -

(a) In it's cationic form

(b) In it's anionic form

(c) In it's dianionic form

(d) In it's Zwitter ionic form

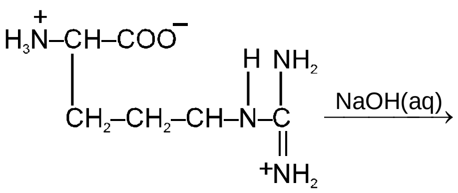
B-7. Complete the following reactions :

(i) $R-\underset{\large NH_2}{\underset{|}{CH}}-COO^- \xrightarrow{HCl(aq)}$

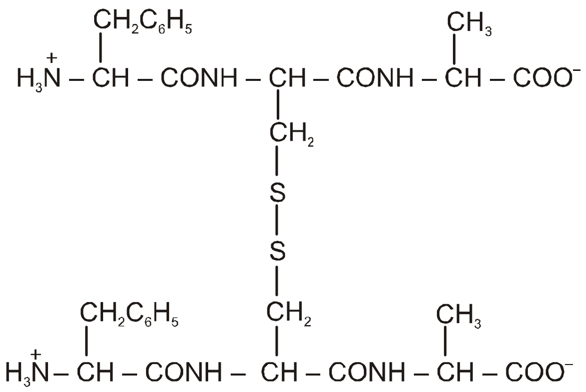
(ii) $R-\underset{\large \overset{+}{N}H_3}{\underset{|}{CH}}-COOH \xrightarrow{NaOH(aq)}$

(iii) $HOOC-CH_2-\underset{\large \overset{+}{N}H_3}{\underset{|}{CH}}-COOH \xrightarrow{NaOH(aq)}$

(iv)

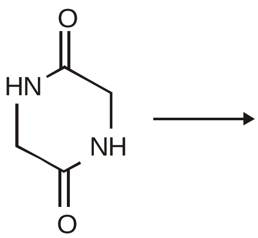


B-8. For the following peptide give the products of complete hydrolysis



B-9. The artificial sweetener aspartame is a methyl ester of synthetic dipeptide Asp-Phe
(i) How many stereoisomers of aspartame are possible ?
(ii) Draw the structure of aspartame.

B-10. Identify the product/s of complete hydrolysis of the compound shown below.

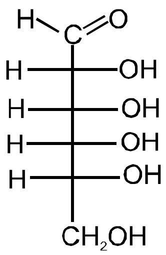


B-11. What is the denaturation of proteins ?

B-12. What do you mean by the following also give example
(a) Non -essential amino acids (b) Essential amino acids

PART-II : OBJECTIVE TYPE QUESTIONS

Section (A) : Carbohydrate

A-1. 

Allose, given monosacharide is a/an ?

(A) Aldopentose (B) Aldohexose (C) Ketopentose (D) Aldoheptose

A-2. The letter D in D-glucose signifies
(A) dextrorotatory (B) mode of synthesis (C) its configuration (D) its diamagnetic nature

A-3. Which of the following monosaccharide is pentose ?
(A) Glucose (B) Fructose (C) Arabinose (D) Galactose

A-4. α-D-glucose and β-D-glucose differ from each other due to the difference in one of the carbon atoms, with respect to its
(A) Number of –OH groups (B) Configuration
(C) Conformation (D) Size of hemiacetal ring

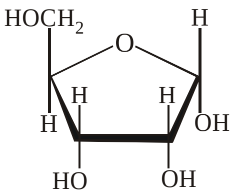
A-5. Glucose when treated with CH_3OH in presence of dry HCl gas gives α- and β-methylglucosides because it contains
(A) an aldehydic group (B) a $-CH_2OH$ group
(C) a cyclic structure (D) five –OH group

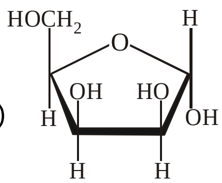
A-6. α-D (+) glucopyranose is example of
(A) acetal (B) ketal (C) hemiacetal (D) hemiketol

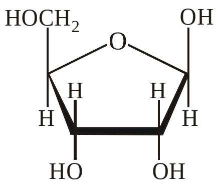
A-7. Which of the following indicates the presence of 5 –OH groups in glucose
(A) Penta-acetyl derivative of glucose (B) Cyanohydrin formation of glucose
(C) Reaction with fehling's solution (D) Reaction with Tollen's reagent

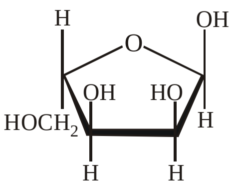
A-8. Which of the following pairs form the same osazone ?
(A) Glucose and fructose (B) Glucose and galactose
(C) Glucose and arabinose (D) Lactose and maltose

A-9. Which of the following represents the anomer of the compound shown ?



(A) 

(B) 

(C) 

(D) None of these

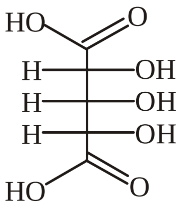
A-10. D-Mannose $\underset{}{\overset{HO^-}{\rightleftharpoons}}$ D-Glucose $\underset{}{\overset{HO^-}{\rightleftharpoons}}$ (A) ;
Product (A) of above reaction is :
(A) D-glucose (B) D-fructose (C) D-talose (D) D-idose

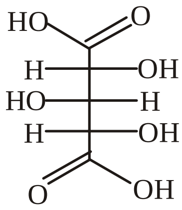
A-11. Which of the following statement is not correct for maltose.

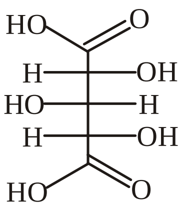
(A) It is a disaccharide (B) It undergoes mutarotation

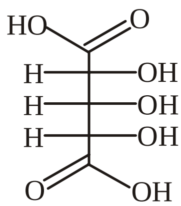
(C) It is a reducing sugar (D) It does not have hemiacetal group.

A-12. D-Ribose when treated with dilute HNO_3 forms.

(A)  , Achiral

(B)  , Chiral

(C)  , Achiral

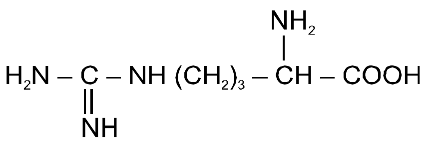
(D)  , Chiral

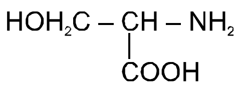
Section (B) : Amino Acids & Proteins

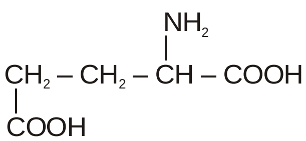
B-1. Which of the following α-amino acids is not optically active ?

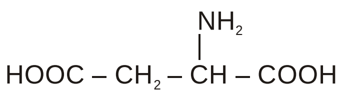
(A) Alanine (B) Glycine (C) Phenylalanine (D) Cysteine

B-2. Which of the following is a basic amino acid?

(A) 

(B) 

(C) 

(D) 

B-3. The three pK_a values of aspartic acid are 1.89, 3.65 and 9.60. The pI of the amino acid is

(A) 2.77 (B) 6.62 (C) 5.74 (D) 7.0

B-4. 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

B-5. Which of following amino acid has lowest iso-electric point ?

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

B-6. $H—C \equiv C—H \xrightarrow[H_2SO_4]{HgSO_4} (A) \xrightarrow[(2)\ H_3O^+]{(1)\ NH_3+HCN} (B)$; Product (B) of given reaction is :

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

B-7. The name of the given dipeptide is

$$H_2N\underset{\underset{CH_3}{|}}{C}HCONHCH_2COOH$$

(A) Glycylglycine (B) Glycylalanine (C) Glycine alanine (D) Alanylglycine

B-8. Peptide linkage is -

(A) $-\overset{\overset{O}{||}}{C}-O-$

(B) $-\overset{\overset{O}{||}}{C}-NH_2$

(C) $-\overset{\overset{O}{||}}{C}-NH-$

(D) $-\overset{\overset{O}{||}}{C}-NH-NH_2$

B-9. The force of attraction between the neighbouring peptide chains is

(A) Vander Waal's force (B) Covalent bond

(C) Hydrogen bond (D) Peptide linkage

B-10. 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

B-11. The N-base which differenciate DNA with RNA is :

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

PART-III : MATCH THE COLUMN

1. Match the column :

Column I (Carbohydrate)	Column II (Properties)
(A) Starch	(P) Mutarotation
(B) Sucrose	(Q) Non reducing sugar
(C) Lactose	(R) β-glycosidic bond
(D) Maltose	(S) α-glycosidic bond
	(T) Reducing sugar
	(U) Hemiacetal

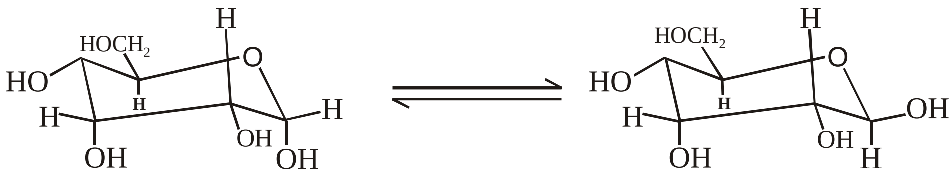
2. Match the column-I with column-II

Column I	Column II
(A) Fructose	(P) Protein
(B) Zwitter ion	(Q) Inversion
(C) Peptide linkage	(R) α-Amino acid
(D) Hydrolysis of cane sugar	(S) Carbohydroates
	(T) Ketose

Exercise # 2

PART-I : ONLY ONE OPTION CORRECT TYPE

1. Which one of the statements concerning the equilibrium shown is true ?



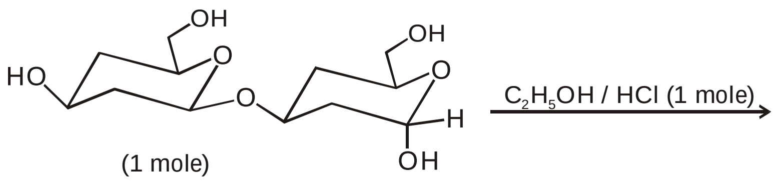
(A) The two structures are enantiomers of each other. They have equal but oppostie optical rotations and recemize slowly at room temperature

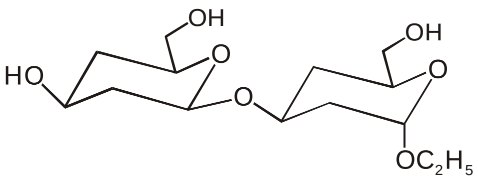
(B) The two structures are enantiomers of each other. They racemize too rapidly at room temperature for their optical rotations to be measured

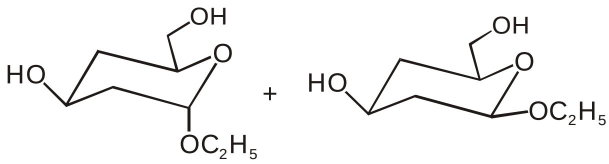
(C) The two structures are diastereomers of each other. Their interconversion is called mutarotation

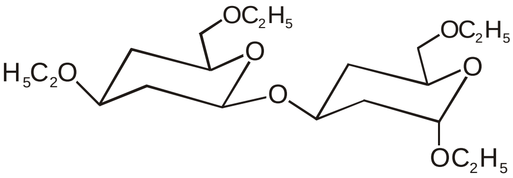
(D) The two structures are diastereomers of each other. Their interconversion does not require breaking and making bonds, only a change in conformation

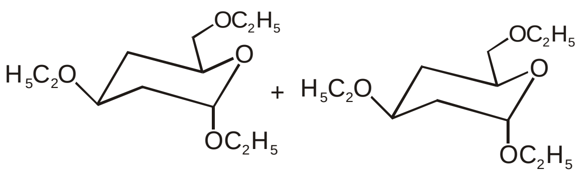
2. Major product of following reaction is :



(A) 

(B) 

(C) 

(D) 

3. D-glucose & D-fructose can be differentiated by :

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

4. 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

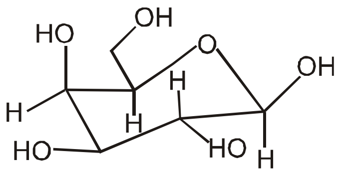
(D) The same configurations at C-3, C-4, C-5 and C-6 but different configuration at C-1 and C-2 which becomes identical by osazone formation.

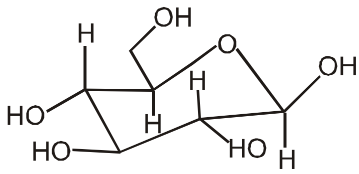
5. $$\text{D(–) –Erythrose} \xrightarrow{NaBH_4} (P)$$

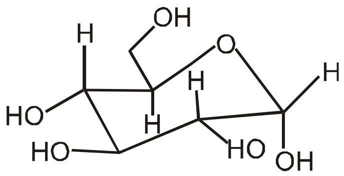
$$\text{D(–) –Threose} \xrightarrow{NaBH_4} (R)$$

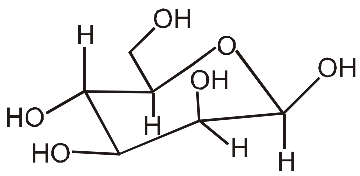
Which of the following statement is correct about P and R ?
(A) Both are optically active
(B) Both are optically inactive
(C) P is optically inactive and R is optically active
(D) Neither P nor R has asymmetric carbon.

6. Which is correct structure of β-D-glucopyranose.

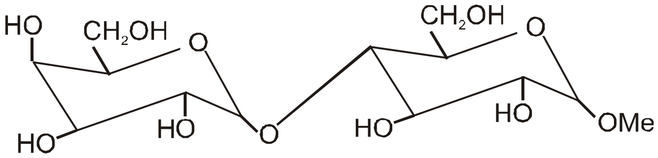
(A) 

(B) 

(C) 

(D) 

7. Ketones do not reduce Tollen's reagents, but fructose with a keto group reduces it. Which one of the following is a correct statement ?
(A) Enolisation of keto group of fructose and transformation into aldehyde group in presence of OH^-, (which is present in Tollen's reagent).
(B) > CHOH group is also oxidised to keto group.
(C) Both statements are correct.
(D) None of the statement is correct.

8. 

On acid hydrolysis of above disaccharide, we get
(A) Two moles of glucose
(B) one mole of glucose
(C) One mole of galactose
(D) one mole of glucose and one mole of galactose

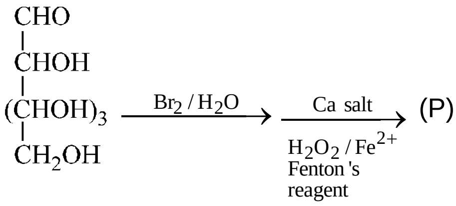
9. Find the pair which is correctly matched
(A) Sucrose : monosaccharide
(B) Fructose : aldose sugar
(C) Glucose : mutarotation
(D) Sucrose : reducing sugar

10. Consider the reaction sequence -

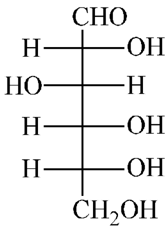
$$\text{Glucose} \xrightarrow[\text{excess}]{PhNHNH_2} P \xrightarrow[\Delta]{H_3O^+} Q \xrightarrow[AcOH]{Zn} R$$

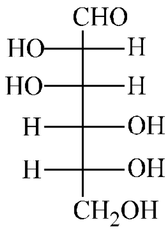
The product R is -
(A) Arbinose (B) Sorbitol (C) Fructose (D) Mannose

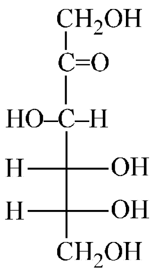
11. Consider the reaction sequence -

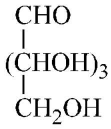


Product (P) is :

(A) 

(B) 

(C) 

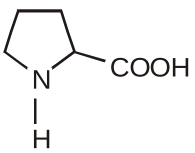
(D) 

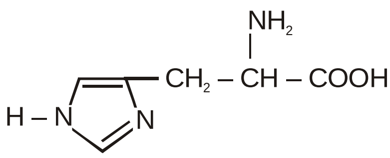
12. Nitrous acid (HNO_2) converts amino acids into hydroxy acids with retention of configuration. Estimation of nitrogen gas evolved in the reaction is the basis of Van slyke estimation of amino acids.

$$R-\underset{}{CH}(NH_2)-COOH \xrightarrow{HNO_2} R-CH(OH)-COOH + N_2\uparrow + H_2O$$

Which of the following amino acids cannot be analysed by Van slyke method?

I – $HS-CH_2-CH(NH_2)-COOH$ (cysteine)

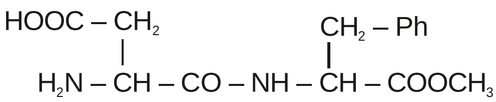
II –  (Proline)

III –  (Histidine)

IV – $CH_3-CH(CH_3)-CH(NH_2)-COOH$ (Valine)

(A) only I (B) only II (C) I and III (D) I, III, IV

13.



(Aspartame)

Aspartame is 160 times as sweet as sucrose and is used as a sugar substitute.
the correct statement (s) about aspartame is (are)

I – It is an ester derivative of dipeptide
II – It can be named as aspartyl phenylalanine methyl ester
III – It is a tripeptide
IV – It is having four functional groups.

(A) I, II (B) I, II, IV (C) II, III, IV (D) only II

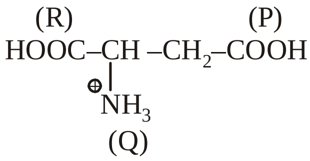
14. What would be the net charge on Glutamic amino acid at pH = 11?
(A) –1 (B) –2 (C) +1 (D) +2

15. α - amino acid when heated with NaOH/CaO forms -
(A) α,β - unsaturated acid (B) α,β - unsaturated amine
(C) Carboxylic acid (D) Amine

PART - II : NUMERICAL TYPE QUESTIONS

1. An octapeptide (Mol. wt. = 516 g) on complete hydrolysis given glycine and alanine (Mol. mass = 89 g). Alanine contributes 41.59% to total weight of hydrolysed product. How many number of alanine unit present in octapeptide.

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



Calculate the isoelectric point of the amino acid ?

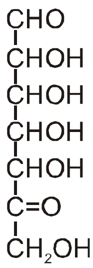
3. For the complex conversion of D-glucose into the corresponding osazone, the minimum number of equivalents of phenyl hydrazine required is :

4. 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) :

5. How many structural tripeptide are possible using alanine,glycine, and tyrosine amino acid?

6. Consider an amylose chain of 4000 glucose unit. At how many cleavage require to lower the average length to 400 units.

7. No of optical isomers possible for



8. How many of the following amino acids have more than one chiral centre?
(I) Glycine (II) Alanine (III) Valine (IV) Cysteine
(V) Leucine (VI) Isoleucine (VII) Serine (VIII) Threonine
(IX) Proline (X) Arginine (XI) Histidine (XII) Glutamic acid
(XIII) Tyrosine

9. How many of the following compounds are aldohexoes
(I) Allose (II) Iodose (III) Talose (IV) xylose
(V) Arabinose (VI) Ribose (VII) Erythrose (VIII) Maltose
(IX) Mannose (X) Galactose

PART - III : ONE OR MORE THAN ONE OPTION CORRECT TYPE

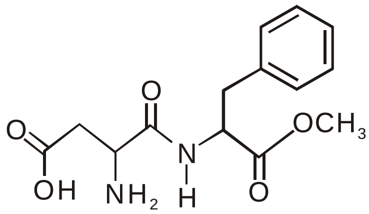
1. Carbohydrates may be :

(A) Sugars
(B) Starch
(C) Polyhydroxy aldehyde/ ketones
(D) Compounds that can be hydrolysed to sugar

2. Select the correct statement :

(A) Poly-saccharides 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) α-D glucose reacts with Ag_2O and excess CH_3I to form tetramethyl ether
(D) D-glucose upon treatment with warm HNO_3 forms D-glucaric acid

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



(A) $PhCH_2–\underset{\displaystyle CO_2H}{\underset{|}{C}}H–NH_2$
(B) $H_2N–\underset{\displaystyle CH_2CO_2H}{\underset{|}{C}}H–CO_2H$
(C) CH_3OH
(D) $CH_3–\underset{\displaystyle CO_2H}{\underset{|}{C}}H–NH_2$

4. Starch molecules are polymer with repeating glucose units. Select the correct statement(s).

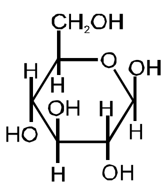
(A) Glucose units are joined through α-glycosidic linkage
(B) The branches of amylopectin are linked to the chain with α-1,6'-glycosidic linkages
(C) The linear linkages of amylopectin are formed by α-1,6'-glycosidic bond
(D) Amylose has an unbranched skeleton of glucose molecules with α-1,4'-glycosidic linkages

5. Amino acids are synthesised from

(A) α-Halo acids by reaction with NH_3
(B) Aldehydes by reaction with NH_3 and cyanide ion followed by hydrolysis
(C) Pyruvic acid is treated with NH_3 followed by addition of H_2(Ni)
(D) Alcohols by reaction with NH_3 and CN^- ion followed by hydroysis.

6. Select the correct statement among following

(A) Number of chiral atom in α-D-glucose is less than D-glucose
(B) D-glucose and D-fructose give same product with HIO_4
(C) D-glucose and D-fructose give same product with H_2NOH
(D) D-glucose and D-fructose form same product with $H_2N–NH–Ph$

7. 

Glucose

The correct statements about above structure of glucose are :

(A) It is a Pyranose form
(B) It is a furanose form
(C) It is a β-anomer
(D) It is a D -sugar

8. Which of the following is /are reducing sugar
(A) Sucrose (B) Glucose (C) Fructose (D) methylmaltoside

9. Which of these are polysaccharides of glucose ?
(A) Starch (B) Cellulose (C) Sucrose (D) Lactose

10. D-glucose & D-fructose can be differentiated by :
(A) Selivanoff's test (B) Furfural test (C) Tollen's test (D) Br_2 / H_2O

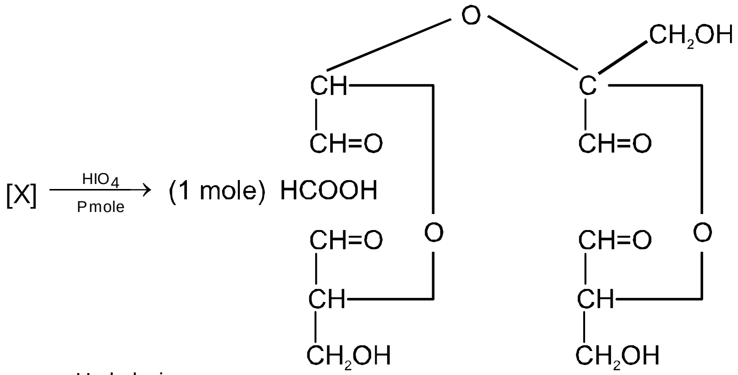
11. The correct statements about peptides are :
(A) A dipeptide has one peptide link between two amino acids.
(B) By convention N-Terminus is kept at left and C- terminus at right in the structure of a peptide
(C) If only one amino group and one carboxylic acid, group are available for reaction, then only one dipeptide can forms.
(D) A polypeptide with more than hunderd amino acid recidues (mol. mass > 10,000) is called a protein

12. Correct statement about peptide linkage in a protein molecule is/are correct ?
(A) It is amide linkage (B) It has partial double bond character.
(C) It is hydrophilic in nature (D) It connects protein molecules through H-bonds.

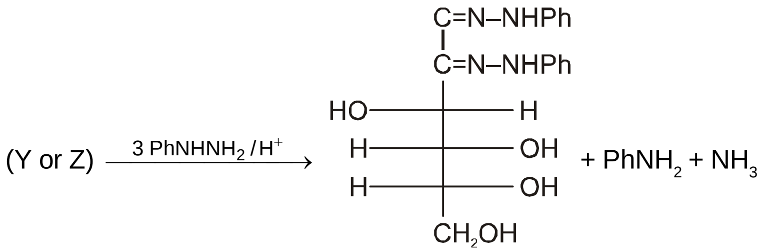
PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

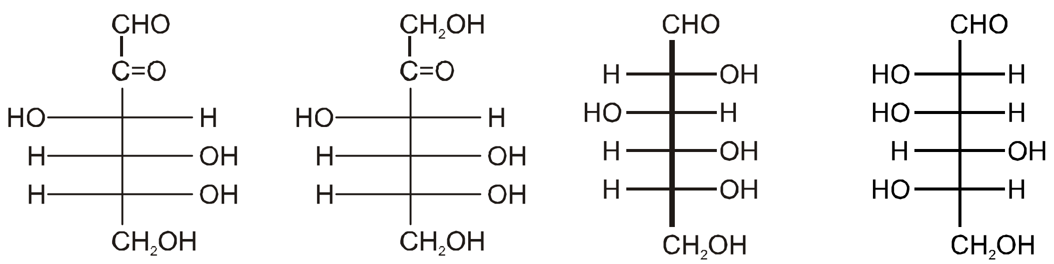
Comprehension # 1



$[X] \xrightarrow{\text{Hydrolysis}} [Y] + [Z]$



1. Compounds Y and Z can be :



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

(A) 1 only (B) 2, 3 (C) 1, 4 (D) 2, 3, 4

2. Number of moles (P) of HIO_4 used per moles of compound X is :

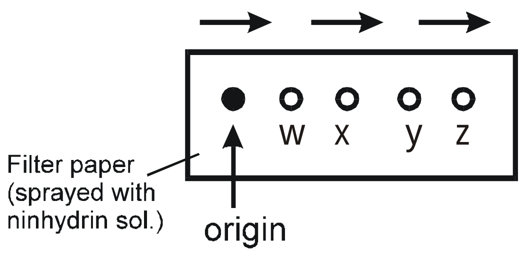
(A) 2 (B) 3 (C) 4 (D) 5

Comprehension # 2

Read the following passage and answer the following questions (3 to 5) :

Paper chromatography is used to separate amino acid.

A drop of solution of amino acid mixture is applied to the bottom of a filterpaper. The edge of paper is dipped in a polar solvent. The solvent moves up and the amino acids adsorb at different points as spots. This technique is based upon polarity of amino acid. The most polar amino acids are those which have charged side chains. The next most polar are those which have side chains which can form hydrogen bonds. The least polar have hydrocarbon side chain. The amino acid with larger alkyl group side chain is less polar. The most polar amino acid is adsorbed on the filter paper (sprayed with ninhydrin) sooner near the origin. The least polar is adsorbed farthest from the origin.



(colour of different amino acids)

3. If the x, y, z, w represent four amino acids, then 'w' is

(A) Alanine (B) Leucine (C) Glutamic acid (D) Glycine

4. z can be

(A) alanine (B) glycine (C) lysine (D) glutamic

5. x can be :

(A) $CH_3-CH(OH)-CH(\overset{\oplus}{N}H_3)-COO^{\ominus}$

(B) $(CH_2)_3CH-CH(\overset{\oplus}{N}H_3)-COO^{\ominus}$

(C) $H_3\overset{\oplus}{N}-(CH_2)_4-CH(\overset{\oplus}{N}H_3)-COO^{\ominus}$

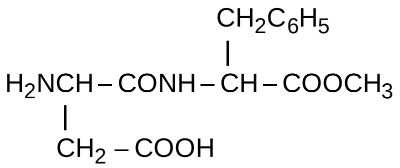
(D) $PhCH_2-CH(\overset{\oplus}{N}H_3)-COO^{\ominus}$

Exercise # 3

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

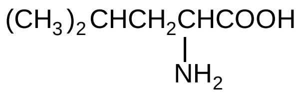
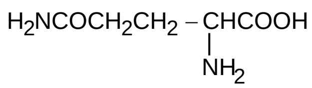
*** Marked Questions may have more than one correct option.**

1. Aspartame, an artificial sweetener, is a peptide and has the following structure : **[JEE-2001, 5/100]**



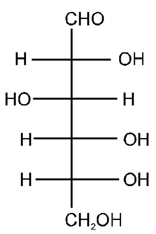
(i) Identify the four functional groups
(ii) Write the zwitter ionic structure
(iii) Write the structures of the amino acids obtained from the hydrolysis of aspartame.
(iv) Which of these two amino acids, is more hydrophobic ?

2. Following two aminoacids leusine and glutamine form dipeptide linkage. What are two possible dipeptides ?

 and  **[JEE-2003, 2/60]**

3. Which of the following pairs give positive Tollen's Test ? **[JEE-2004, 3/84]**
(A) Glucose, sucrose (B) Glucose, fructose
(C) Hexanol, Acetophenone (D) Fructose ,sucrose

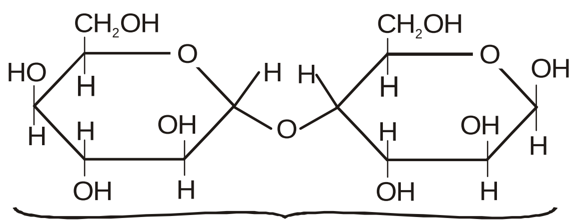
4. The Fischer projection formula of D-glucose is **[JEE 2004, 2/60)]**



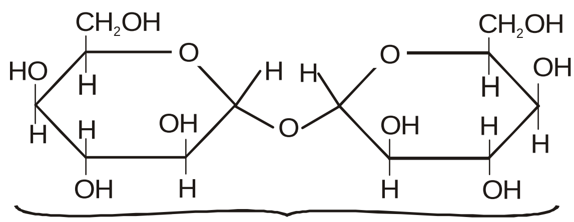
(i) Give Fischer projection formula of L-glucose.
(ii) Give the product of reaction of L-glucose with Tollen's reagent.

5. The two forms of D-Glucopyranose obtained from solution of D-Glucose are known as **[JEE-2005, 3/84]**
(A) Epimers (B) Anomers
(C) Enantiomers (D) Geometrical Isomers

6. Which of the following disaccharide will not reduce tollen's reagent. **[JEE-2005, 2/60]**



P



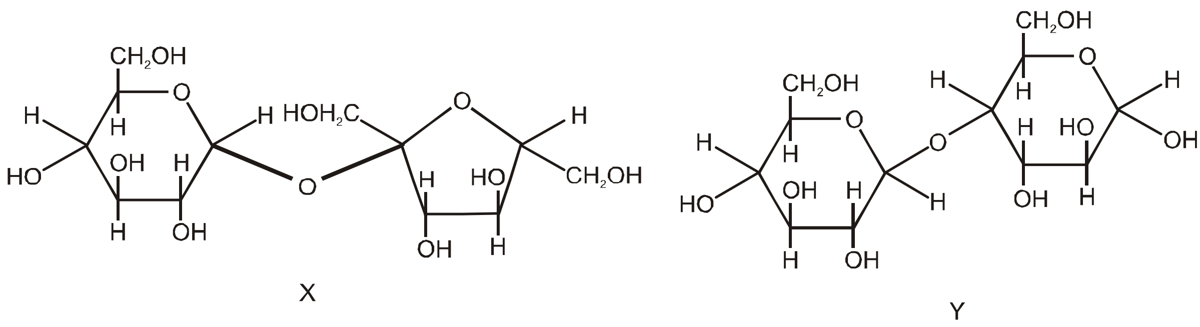
Q

7. Statement-**1 :** Glucose gives a reddish-brown precipitate with Fehling's solution. **[JEE-2007, 3/162]**
because
Statement-2 : Reaction of glucose with Fehling's solution gives CuO and gluconic acid.
(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

8. 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 × 4 matrix given in the ORS. **[JEE 2007]**

	Column I		**Column II**
(A)	Cellulose	(P)	Natural polymer
(B)	Nylon-6, 6	(Q)	Synthetic polymer
(C)	Protein	(R)	amide linkage
(D)	Sucrose	(S)	Glycoside linkage

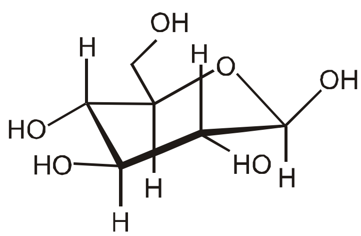
9.* The correct statement(s) about the following sugars **X** and **Y** is(are) : **[JEE 2009, 4/160]**



(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 α and β, respectively.
(D) The glucosidic linkages in **X** and **Y** are β and α, respectively.

10. 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, 4/180]**

11. The following carbohydrate is **[JEE 2011, 3/180]**



(A) a ketohexose (B) an aldohexose (C) an α-furanose (D) an α-pyranose

12. When the following aldohexose exists in its D-configuration, the total number of stereoisomers in its pyranose form is : **[JEE-2012]**

CHO
|
CH_2
|
CHOH
|
CHOH
|
CHOH
|
CH_2OH

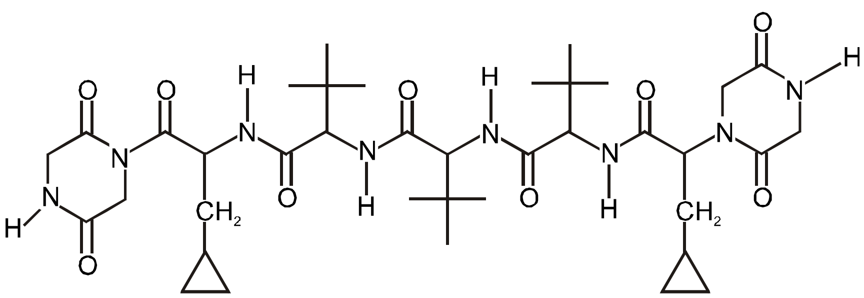
13. The substituents R_1 and R_2 for nine peptides are listed in the table given below. How many of these peptides are positively charged at pH = 7.0 ? **[JEE-2012]**

$$\overset{\oplus}{H_3N}-\underset{H}{\underset{|}{CH}}-CO-NH-\underset{R_1}{\underset{|}{CH}}-CO-NH-\underset{R_2}{\underset{|}{CH}}-CO-NH-\underset{H}{\underset{|}{CH}}-CO\overset{\ominus}{O}$$

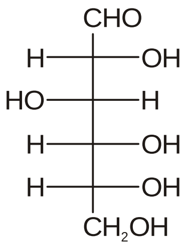
Peptide	R_1	R_2
I	H	H
II	H	CH_3
III	CH_2COOH	H
IV	CH_2CONH_2	$(CH_2)_4NH_2$
V	CH_2CONH_2	CH_2CONH_2
VI	$(CH_2)_4NH_2$	$(CH_2)_4NH_2$
VII	CH_2COOH	CH_2CONH_2
VIII	CH_2OH	$(CH_2)_4NH_2$
IX	$(CH_2)_4NH_2$	CH_3

14. 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_2 group attached to a chiral center is : **[JEE(Advanced)-2013, 4/120]**

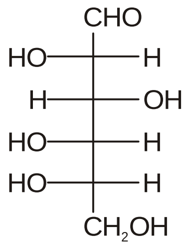
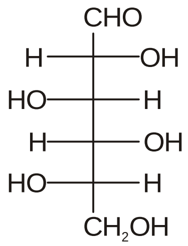
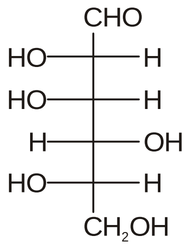
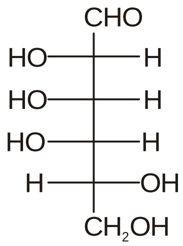
15. The total number of ***<u>distinct naturally occurring amino acids</u>*** obtained by complete acidic hydrolysis of the peptide shown below is **JEE(Advanced)-2014, 4/120]**



16. The structure of D-(+)-glucose is

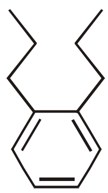


The structure of L-(–)-glucose is **[JEE(Advanced)-2015, 4/120]**

(A)  (B)  (C)  `(D) 

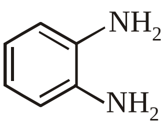
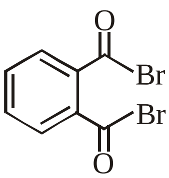
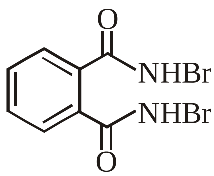
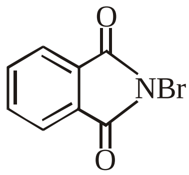
17. For 'invert sugar', the correct statement(s) is (are) : **[JEE(Advanced)-2016, 4/120]**
(Given : specific rotations of (+)-sucrose, (+)-maltose, L-(–)-glucose and L-(+)-fructose in aqueous solution are + 66°, +140°, –52° and + 92°, respectively)
(A) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose
(B) 'invert sugar' is an equimolar mixture of D-(+) glucose and D-(–)-fructose
(C) specific rotation of 'invert sugar' is –20°
(D) on reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the products

Comprehension : Q.No. 18 to 19 **[JEE(Advanced)-2016]**
Treatment of compound **O** with $KMnO_4$ / H^+ gave **P**, which on heating with ammonia gave **Q**. The compound **Q** on treatment with Br_2 / NaOH produced **R**. On strong heating, **Q** gave **S**, which on further treatmenet with ethyl 2-bromopropanoate in the presence of KOH following by acidification, gave a compound **T**.



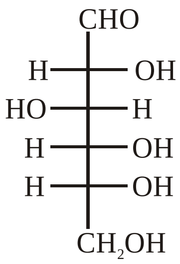
(O)

18. The compound **R** is :

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

19. The compound **T** is :
(A) Glycine (B) Alanine (C) Valine (D) Serine

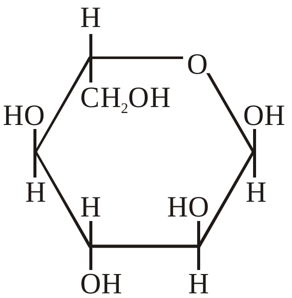
20. The Fischer presentation of D-glucose is given below. **[JEE(Advanced)-2018]**



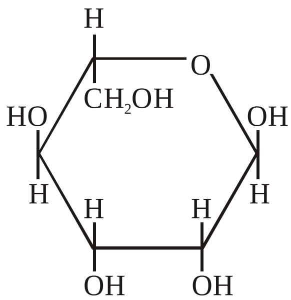
D-glucose

The correct structure(s) of β-L-glucopyranose is (are) :-

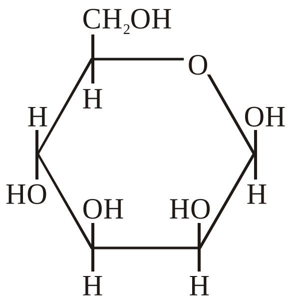
(A)



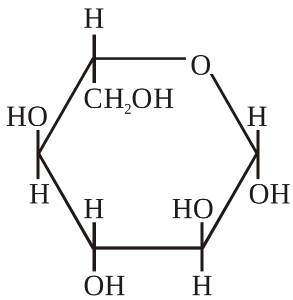
(B)



(C)



(D)



21. Which of the following statement(s) is(are) true ? **[JEE(Advanced)-2019]**

(A) Oxidation of glucose with bromine water gives glutamic acid

(B) The two six-membered cyclic hemiacetal forms of D-(+)-glucose are called anomers

(C) Hydrolysis of sucrose gives dextrorotatory glucose and laevorotatory fructose

(D) Monosaccharides **cannot** be hydrolysed to give polyhydroxy aldehydes and ketones

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A substance forms zwitter ion. It can have functional group. **[AIEEE-2002]**
(1) $-NH_2$, $-COOH$ (2) $-NH_2$, $-SO_3H$ (3) Both (1) and (2) (4) None of these

2. Complete hydrolysis of cellulose gives **[AIEEE-2003]**
(1) D-fructose (2) D-ribose (3) D-glucose (4) L-glucose

3. The pyrimidine bases present in DNA are **[AIEEE-2006]**
(1) cytosine and guanine (2) cytosine and thymine
(3) cytosine and uracil (4) cytosine and adenine

4. The term anomers of glucose refers to **[AIEEE-2006]**
(1) a mixture of (D)–glucose and (L)–glucose
(2) enantiomers of glucose
(3) isomers of glucose that differ in configuration at carbon one (C–1)
(4) isomers of glucose that differ in configurations at carbons one and four (C–1 and C–4)

5. The secondary structure of protein refers to: **[AIEEE-2007, 3/120]**
(1) α-helical backbone. (2) hydrophobic interactions.
(3) sequence of α-amino acids. (4) fixed configuration of the polypeptide backbone.

6. The two functional groups present in a typical carbohydrate are : **[AIEEE-2009, 4/144]**
(1) –CHO and –COOH (2) >C=O and –OH (3) –OH and –CHO (4) –OH and –COOH

7. The presence or absence of hydroxy group on which carbon atom of sugar differentiates RNA and DNA. **[AIEEE-2011, 4/120]**
(1) 1[st] (2) 2[nd] (3) 3[rd] (4) 4[th]

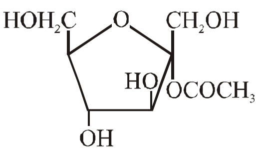
8. Synthesis of each molecule of glucose in photosynthesis involves : **[JEE Main 2013, 4/120]**
(1) 18 molecules of ATP (2) 10 molecules of ATP
(3) 8 molecules of ATP (4) 6 molecules of ATP

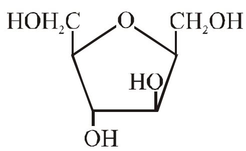
9. Which one of the following bases is not present in DNA ? **[JEE Main 2014, 4/120]**
(1) Quinoline (2) Adenine (3) Cytosine (4) Thymine

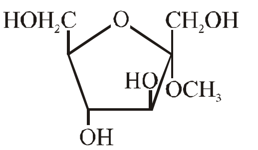
10. Which of the vitamins given below is water soluble ? **[JEE Main 2015, 4/120]**
(1) Vitamin C (2) Vitamin D (3) Vitamin E (4) Vitamin K

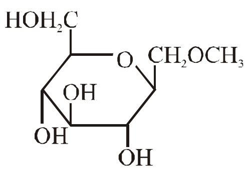
11. Thiol group is present in : **[JEE Main 2016, 4/120]**
(1) Cystine (2) Cysteine (3) Methionine (4) Cytosine

12. Which of the following compounds will behave as a reducing sugar in an aqueous KOH solution **[JEE Main 2017, 4/120]**

(1) 

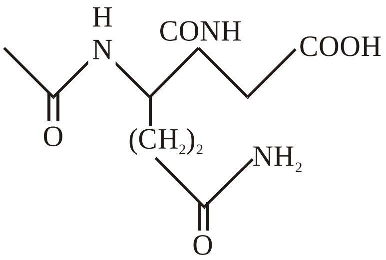
(2) 

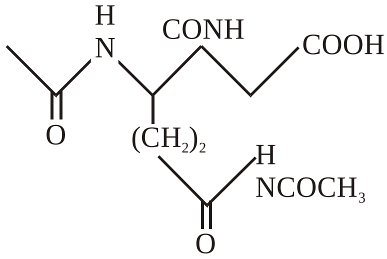
(3) 

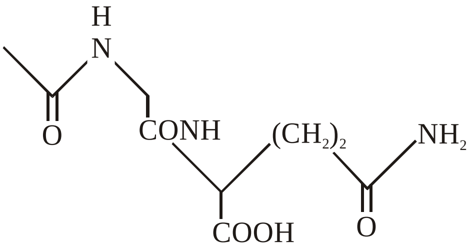
(4) 

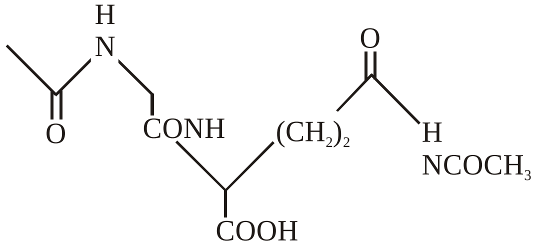
13. Glucose on prolonged heating with HI gives : **[JEE Main 2018, 4/120]**
(1) 1–Hexene (2) Hexanoic acid (3) 6-iodohexanal (4) n-Hexane

14. The dipeptide, Gln-Gly, on treatment with CH_3COCl_3 followed by aqueous work up gives :- **[JEE Main 2018, 4/120]**

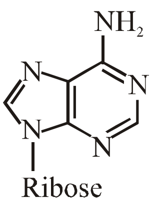
(1) 

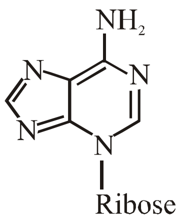
(2) 

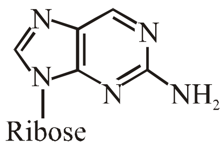
(3) 

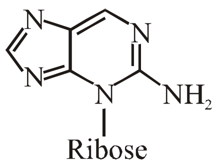
(4) 

15. Which of the following is the correct structure of Adenosine ? **[JEE Main 2018, 4/120]**

(1) 

(2) 

(3) 

(4) 

16. Among the following, the incorrect statement is:- **[JEE Main 2018, 4/120]**

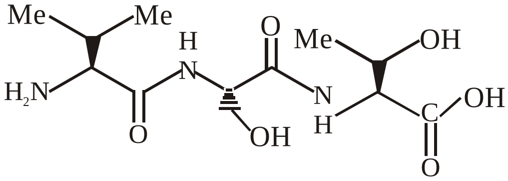
(1) Cellulose and amylose has 1, 4-glycosidic linkage.

(2) Lactose contains β-D-galactose and β-D-glucose.

(3) Maltose and lactose has 1, 4-glycosidic linkage.

(4) Sucrose and amylose has 1, 2-glycosidic linkage.

17. The correct sequence of amino acids present in the tripeptide given below is : **[JEE Main 2019, 4/120]**

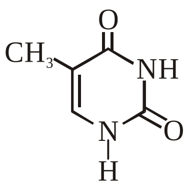
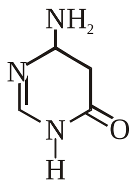
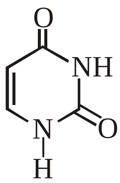
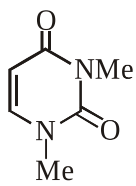


(1) Leu - Ser - Thr (2) Thr - Ser- Leu (3) Thr - Ser - Val (4) Val - Ser - Thr

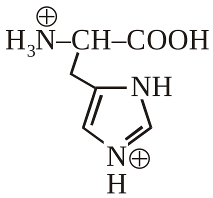
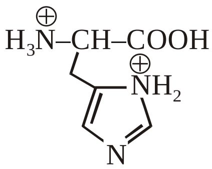
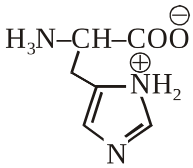
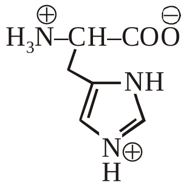
18. Which of the following tests cannot be used for identifying amino acids ? **[JEE Main 2019, 4/120]**

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

19. Among the following compound which one is found in RNA ? **[JEE Main 2019, 4/120]**

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

20. The correct structure of histidine in a strongly acidic solution (pH=2) is **[JEE Main 2019, 4/120]**

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

21. Fructose and glucose can be distinguished by : **[JEE Main 2019, 4/120]**

(1) Fehling's test (2) Barfoed's test (3) Benedict's test (4) Seliwanoff's test

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

[JEE Main 2019, 4/120]

(1) Lys-Asp (2) Ser-Lys (3) Gln-Asp (4) Asp-Gln

23. Which of the following statements is not true about RNA ? **[JEE Main 2019, 4/120]**

(1) It has always double stranded α-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

24. 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
B	Positive	Positive	Negative
C	Negative	Negative	Positive

A, B and C are respectively : **[JEE Main 2020, 4/120]**

(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

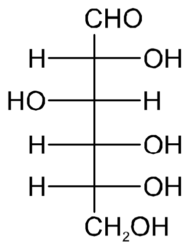
ANSWER KEY

EXERCISE # 1

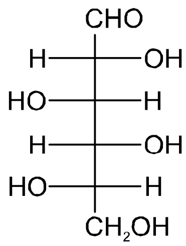
PART - I

A-1. Monosaccharide is a carbohydrate that cannot be hydrolysed further to give simpler unit of polyhydroxy aldehyde or ketone.

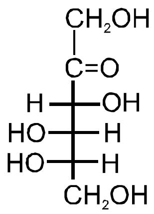
A-2. **(a)** Fischer projections of D-glucose and L-glucose are respectively



D(+)-glucose



L-glucose

(b) 

L-Fructose

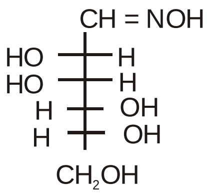
L- Fructose is enantiomer of D-Fructose.

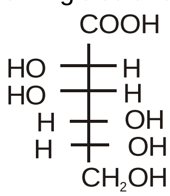
A-3. (i) Though glucose has aldehyde group, it does not give 2,4-DNP test
(ii) It does not form hydrogen sulphite addition product
(iii) The pentacetate of glucose does not react with hydroxyl amine.
Above facts indicate the absence of free –CHO group in glucose.

A-4. The spontaneous change in specific rotation of an optically active compound in solution with time, to an equilibrium value, is called mutarotation

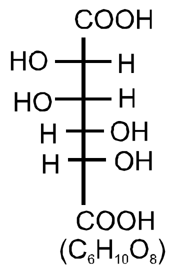
A-5. The oxide linkage between two monosaccharides, formed by loss of a water molecule is called glycosidic linkage.

A-6. Those carbohydrates which reduce fehling's solution and tollen's reagents are called reducing sugars.

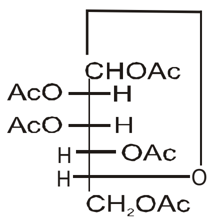
A-7. **(a)** (i) 

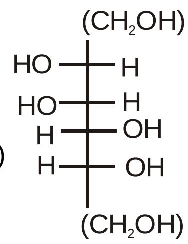
(ii) 

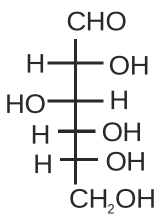
($C_6H_{12}O_7$)

(iii) 

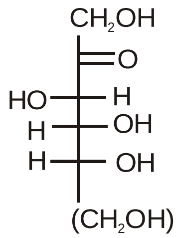
($C_6H_{10}O_8$)

(iv) 

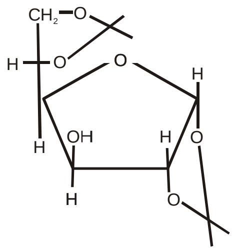
(v) 

(b) 

V



W

A-8. 

A-9. Glucose and fructose

A-10. Starch has (C_1–C_4) α glycosidic linkage between α-D glucose units, cellulose has (C_1–C_4) β glycosidic linkage between β-D glucose units.

A-11. Glucose has five –OH groups and sucrose has eight –OH groups so they can form hydrogen bonding with H_2O molecules, hence soluble in water.

B-1. Due to the presence of both acidic and basic groups in the same molecule. In aqueous solution –COOH group can lose a proton and $-NH_2$ group can accept a proton and forms zwitter ion. In zwitter ionic form amino acids show amphoteric behaviour.

B-2. Number of amino groups is more than the number of carboxylic groups.

B-3. Due to its existence in the form of zwitter ion, there exist a very strong intermolecular attraction which is responsible for high melting point of amino acid.

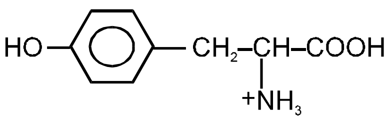
B-4. Amino acids contain two functional groups which can make H-bonds that is the reason why they have high m.p. and solubility in water.

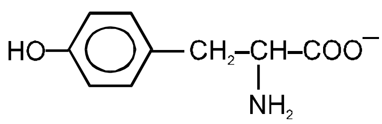
B-5.

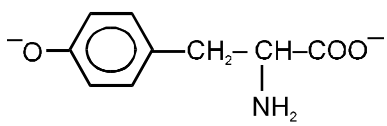
$$Cl^{\ominus}\,H_3\overset{\oplus}{N}-CH_2-\underset{\underset{O}{\|}}{C}-OH + \underset{\text{1st eqv.}}{NaOH} \longrightarrow \overset{\oplus}{N}H_3CH_2\overset{\overset{O}{\|}}{C}O^{\ominus} + H_2O + NaCl$$

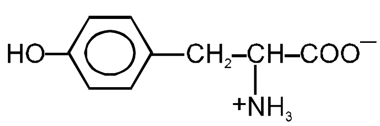
Glycine hydrochloride

$$\overset{\oplus}{N}H_3CH_2\underset{\underset{O}{\|}}{C}-O^{\ominus} + \underset{\text{2nd eqv.}}{NaOH} \longrightarrow H_2N-CH_2-\overset{\overset{O}{\|}}{C}-\overset{\ominus}{O}\,\overset{\oplus}{Na} + H_2O$$

B-6. (a) 

(b) 

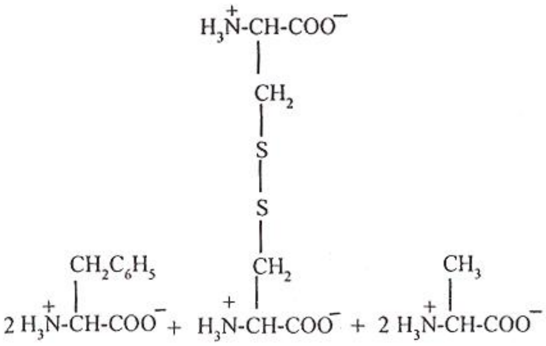
(c) 

(d) 

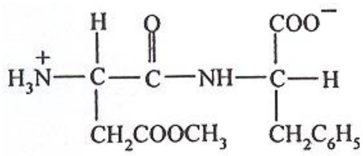
B-7. (i) $R-\underset{\displaystyle COO^-}{CH}-\overset{+}{N}H_3$ (ii) $R-\underset{\displaystyle {}^{+}NH_3}{CH}-COO^-$

(iii) $HOOC-CH_2-\underset{\displaystyle {}^{+}NH_3}{CH}-COO^-$ (iv) $NH_2-\underset{\displaystyle CH_2-CH_2-CH_2-NH-C(NH_2)=\overset{+}{N}H_2}{CH}-COO^-$

B-8.



B-9. (i) 4 (ii)



B-10. H_2HCH_2COOH

B-11. When protein in native form is subjected to a physical change like temperature or pH, the H–bonds are disturbed. As a result globules get unfold and helices get uncoiled therefore proteins loses its activity. During denaturation 2° and 3° structures get destroyed but 1° structure remain the same.
Ex: Coagulation of egg while on boiling and curdling of milk caused by bacteria present in milk.

B-12. (a) The amino acids which can be synthesised in the body - non-essential ex. Glycine, Alanine.
(b) The amino acids which cannot be synthesised and must be obtained through diet. ex. valine, leucine.

PART - II

A-1.	(B)	**A-2.**	(C)	**A-3.**	(C)	**A-4.**	(B)	**A-5.**	(C)
A-6.	(C)	**A-7.**	(A)	**A-8.**	(A)	**A-9.**	(B)	**A-10.**	(B)
A-11.	(D)	**A-12.**	(A)	**B-1.**	(B)	**B-2.**	(A)	**B-3.**	(A)
B-4.	(D)	**B-5.**	(C)	**B-6.**	(B)	**B-7.**	(D)	**B-8.**	(C)
B-9.	(C)	**B-10.**	(A)	**B-11.**	(B)				

PART - III

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

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

EXERCISE # 2

PART - I

1.	(C)	**2.**	(A)	**3.**	(D)	**4.**	(D)	**5.**	(C)
6.	(B)	**7.**	(A)	**8.**	(D)	**9.**	(C)	**10.**	(C)
11.	(D)	**12.**	(B)	**13.**	(B)	**14.**	(B)	**15.**	(D)

PART - II

1.	3	**2.**	3.25	**3.**	3	**4.**	8	**5.**	27
6.	9.	**7.**	$2^4 = 16$	**8.**	3	**9.**	5		

PART - III

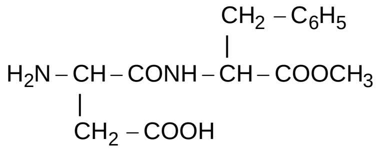
1.	(ABCD)	**2.**	(ABD)	**3.**	(ABC)	**4.**	(ABD)	**5.**	(ABC)
6.	(D)	**7.**	(ACD)	**8.**	(BC)	**9.**	(AB)	**10.**	(ABD)
11.	(ABCD)	**12.**	(ABCD)						

PART - IV

1.	(B)	**2.**	(B)	**3.**	(C)	**4.**	(A)	**5.**	(A)

EXERCISE # 3

PART - I

1. 

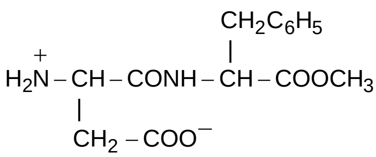
Aspartame (Asparta min e)

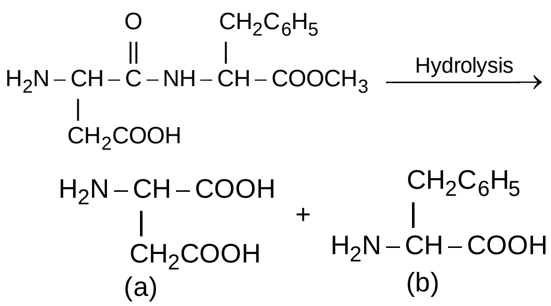
(i) In aspartame four functional groups are present which are

(a) $-NH_2$ (Amine) (b) (– COOH) (Carboxylic acid)

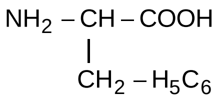
(c) $-\overset{O}{\overset{\|}{C}}-NH-$ (2° amide) (d) $-\overset{O}{\overset{\|}{C}}-O-$ (Ester)

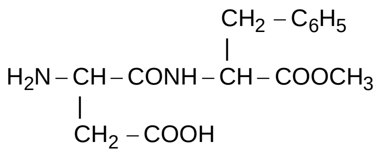
(ii) Zwitter ion structure is givens as below :



(iii) 

Hence on hydrolysis two amino and (a) and (b) are obtained.

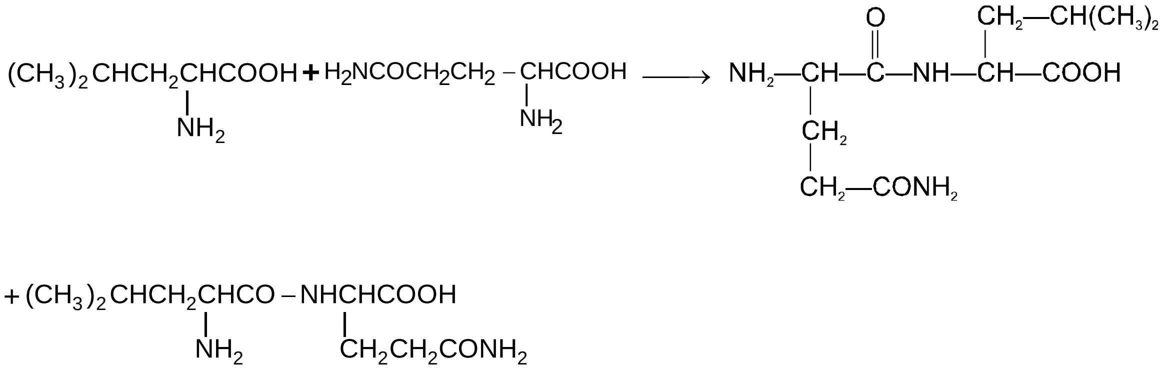
(iv) In above to amino acids  is more hydrophobic due to presence of non-polar C_6H_5–CH_2– or benzyl group.



Aspartame (Asparta min e)

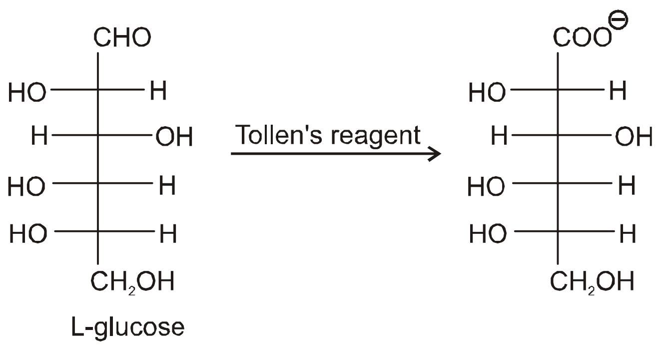
2. Peptide linkage is $-NH-\overset{\overset{\displaystyle O}{\|}}{C}-$ and it is formed by the condensation between $-NH_2$ group and $-COOH$ group as follows

$$-\underset{\underset{\displaystyle O}{\|}}{C}-\boxed{O-H+H}-NH_2 \xrightarrow[-H_2O]{} -\underset{\underset{\displaystyle O}{\|}}{C}-NH-$$



3. (B)

4.



5. (B)

6. P is a reducing sugar as one monosaccharide has free reducing group because glycosidic linkage is (1, 4). Whereas in Q both the reducing groups are involved in glycosidic bond formation

7. (C) **8.** (A) $\rightarrow$ P, S ; (B) $\rightarrow$ Q, R ; (C) $\rightarrow$ P, R ; (D) $\rightarrow$ S

9.*	(BC)	**10.**	6	**11.**	(B)	**12.**	8		
13.	4 [(iv) , (vi), (viii) & (ix)]			**14.**	4	**15.**	1	**16.**	(A)
17.	(BC)	**18.**	(A)	**19.**	(B)	**20.**	(D)	**21.**	(BCD)

PART - II

1.	(3)	**2.**	(3)	**3.**	(2)	**4.**	(3)	**5.**	(4)
6.	(3)	**7.**	(2)	**8.**	(1)	**9.**	(1)	**10.**	(1)
11.	(2)	**12.**	(1)	**13.**	(4)	**14.**	(1)	**15.**	(1)
16.	(4)	**17.**	(4)	**18.**	(3)	**19.**	(3)	**20.**	(1)
21.	(4)	**22.**	(2)	**23.**	(1)	**24.**	(3)		

✍ **Marked Questions may have for Revision Questions.**

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Reliable students.

Self Assessment Test

PART- 1 : PAPER JEE (MAIN) PATTERN

SECTION–I : (Maximum Marks : 80)

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in <u>one of the following categories</u> :

Full Marks	:	+4	If only the bubble corresponding to the correct option is darkened.
Zero Marks	:	0	If none of the bubbles is darkened.
Negative Marks	:	–1	In all other cases

1. Glucose on reduction with Na/Hg and water gives ?
(A) Sorbitol (B) Fructose (C) Saccharic acid (D) Gluconic acid

2. Glucose or fructose is converted into C_2H_5OH in the presence of ?
(A) Diastage (B) Maltase (C) Invertase (D) Zymase

3. Glucose cannot be calassified as ?
(A) Hexose (B) Carbohydrate (C) Aldose (D) Oligosaccharide

4. The commonest disaccharide has the molecular formula :
(A) $C_{10}H_{18}O_9$ (B) $C_{10}H_{20}O_{11}$ (C) $C_{18}H_{22}O_{11}$ (D) $C_{12}H_{22}O_{11}$

5. Strach is changed into disaccharide in presence of ?
(A) Diastase (B) Maltase (C) Lactase (D) Zymase

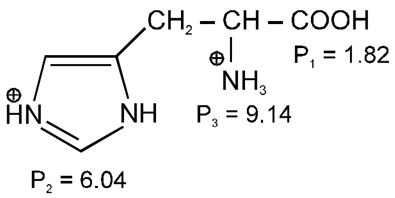
6. How many opticallyactive molecules are possible with structural formula $CH_2OHCHOHCHOHCHOHCHOHCHO$?
(A) 16 (B) 8 (C) 32 (D) 4

7. Which one of the following kinds of bonds are not broken during denaturation of a protein ?
(A) Peptide bond (B) Hydrogen bond (C) Disulphide bond (D) Ionic bond

8. A hexapeptide with the composition Arg, Gly, leu, Pro has proline at both C-terminal and N-terminal position. The partial hydrolysis of the hexapeptide gives
Gly–Pro–Arg, Arg–Pro, Pro–Leu–Gly.
Gly–Pro–Arg, Arg–Pro, Pro–Leu–Gly.
(A) Pro–Gly–Leu–Pro–Arg–Pro (B) Pro–Leu–Gly–Pro–Arg–Pro
(C) Pro–Leu–Gly–Arg–Pro–Pro (D) Pro–Arg–Pro–Leu–Gly–Pro

9. The function of proteins is to act as
(A) Structural materials of animal tissues (B) Enzymes and antibodies
(C) Metabolic regulators (D) All the three above

10. Observe the pKa values (P_1-P_3) of the given amino acid.



Which form of this amino acid will exist in aqueous solution at pH = 8

(A) as dication (B) as monocation (C) as zwitter ion (D) as monoanion

11. Which of the following statements about β-pleated sheet secondary structure of proteins is correct ?

(A) Parallell β-pleated sheet structure is more stable than the antiparallel sheet structure.

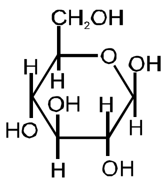
(B) Antiparallel β-pleated sheet structure is more stable than the parallel sheet structure.

(C) Both parallel and antiparallel sheet structures have equal stability.

(D) there is no clear relationship between the two in terms of stability.

12. The two forms of D-Glucopyranose obtained from solution of D-Glucose are known as

(A) Epimers (B) Anomers (C) Enantiomers (D) Geometrical Isomers

13. 

Glucose

The incorrect statements about above structure of glucose is :

(A) It is a Pyranose form (B) It is a furanose form

(C) It is a β-anomer (D) It is a D -sugar

14. Hydrolysis of sucrose into (+) glucose and (-) fructose is known as

(A) Mutarotation (B) Inversion (C) Pyrolysis (D) None of these

15. The term inverted sugar refers to an equimolar mixture of :

(A) D-Glucose and D-galactose (B) D-Glucose and D-fructose

(C) D-Glucose and D-mannose (D) D-Glucose and D-ribose

16_. Glycoside linkage is

(A) an acetal linkage (B) an ether linkage (C) an ester linkage (D) an amide linkage

17. Sucrose on hydrolysis yields a mixture which is

(A) optically inactive (B) dextrorotatory (C) laevorotatory (D) racemic

18. Cellulose on hydrolysis yields

(A) β-D-Fructose (B) α-D-Glucose (C) β-D-Glucose (D) α-D-Fructose

19. Find true and False from the following statements regarding carbohydrates

S_1 : All monosaccharides whether aldoses or ketoses are reducing sugars.

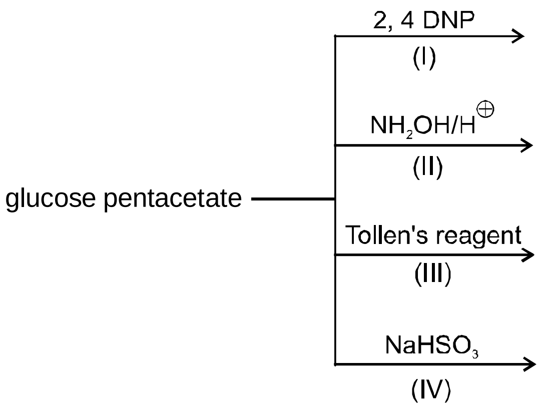
S_2 : Bromine water can be used to differentiate between aldoses and ketoses

S_3 : A pair of diastereomeric aldoses which differ only in configuration at C-2 are anomers.

S_4 : Osazone formation destroys the configuration at C-2 of an aldose, but does not affect the configuration of the rest of the molecule.

(A) TTTT (B) TFTF (C) TTFT (D) FTTT

20. Observe the following laboratory tests for glucose pentacetate and mention +ve or –ve from the code given below.



(A) + + + +   (B) – – – –   (C) + – + –   (D) + + – –

SECTION-II : (Maximum Marks: 20)

- This section contains **FIVE** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.

  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:

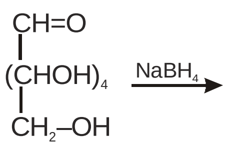
  Full Marks : +4 If ONLY the correct numerical value is entered as answer.

21. How many compound which is given below is isomer of D-glucose

(I) D-Mannose (II) D-fructose (III) D-Idose
(IV) D-Galactose (V) D-Arabinose (VI) D-Ribose
(VII) D-Allose (VIII) D-Maltose (IX) D-Lactose

22. How many tetrapeptides can be formed from the three amino acids

23. Observe the following reaction and and find out that how many number of reactant stereoisomers can be reduced to optically inactive stereoisomers.



24. HIO_4 splits glucose and fructose into formic acid and formaldehyde. Ratio of formic acid and formaldehyde from glucose and fructose are (P) and (Q). Report your answer as P + Q

25. Number of moles of acetic anhydride needed to react completely with maltose?

PART 2 : PAPER JEE (ADVANCED) PATTERN

SECTION-I : (Maximum Marks : 12)

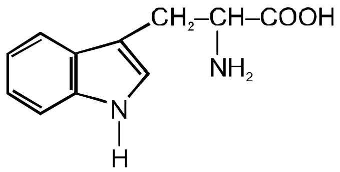
- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

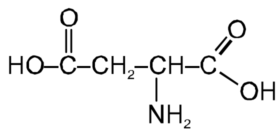
Full Marks	:	+3	If only the bubble corresponding to the correct option is darkened.
Zero Marks	:	0	If none of the bubbles is darkened.
Negative Marks	:	–1	In all other cases

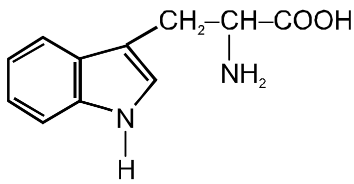
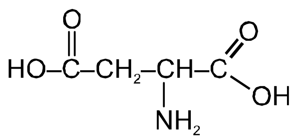
1. Two hexoses form the same osazone. Find the correct statement about these hexoses.
(A) Both of them must be aldoses
(B) They are epimers at C-3
(C) The carbon atoms 1 and 2 in both have the same configuration
(D) The carbon atoms 3, 4 and 5 in both have the same configuration

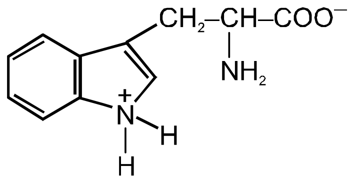
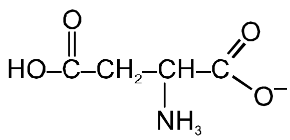
2. Consider following reagent :
I. Br_2 water II. Tollen's reagent III. Fehling's solution
which can be used to make distinction between an aldose and a ketose ?
(A) I, II and III (B) II and III (C) I only (D) II only

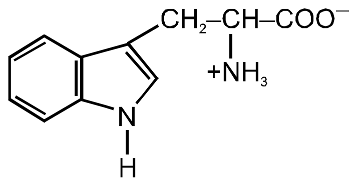
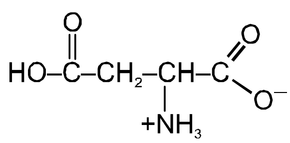
3. Alanine $CH_3-\underset{\displaystyle NH_2}{CH}-C(=O)OH$ in aquous solution is found as $CH_3-\underset{\displaystyle {}^{+}NH_3}{CH}-C(=O)O^-$, then Tryptophan

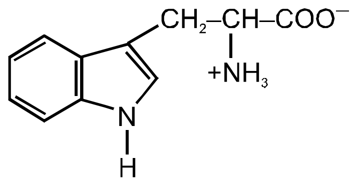
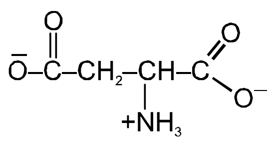


and Aspartic acid  is found in neutral aquous solution as

(A)  and  respectively

(B)  and  respectively

(C)  and  respectively

(D)  and  respectively

4. $CH_3-\underset{NH_2}{\underset{|}{C}}H-COOH \xrightarrow{(X)} CH_3-\underset{NH_2}{\underset{|}{C}}H-CH_2OH$

The reagent (X) can be :

(A) H_2 / Pd/$BaSO_4$/quinoline (B) $NaBH_4$ (C) $LiAlH_4$ (D) CH_3MgI

SECTION-II : (Maximum Marks: 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s).
- For each question, choose the correct option(s) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4	If only (all) the correct option(s) is (are) chosen.
Partial Marks	:	+3	If all the four options are correct but ONLY three options are chosen.
Partial Marks	:	+2	If three or more options are correct but ONLY two options are chosen, both of which are correct options.
Partial Marks	:	+1	If two or more options are correct but ONLY one option is chosen and it is a correct option.
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered).
Negative Marks	:	–1	In all other cases.

- **For Example :** If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –1 marks.

5. The correct statement (s) about starch :

(A) It is a pure single compound.

(B) It is mixture of two polysaccharides of glucose.

(C) It involves the (C_1-C_4) α - glycosidic linkage between two α - D glucose units.

(D) It involves branching by (C_1-C_6) glycosidic linkage.

6. Which of the following pairs is (are) correctly matched ?

(A) α-D (+) glucose and β-D(+) glucose $\rightarrow$ C-2 epimers

(B) Glucose and fructose $\rightarrow$ C-3 epimers

(C) Glucose $\rightarrow$ mutarotation

(D) Sucrose $\rightarrow$ Glucose + fructose

7. The correct structure of glycine at given pH are :

(A) $H_3\overset{\oplus}{N}CH_2-\underset{\underset{O}{\|}}{C}-OH$ at pH = 2.0 (B) $H_3\overset{\oplus}{N}CH_2-\underset{\underset{O}{\|}}{C}-O^{\ominus}$ at pH = 6.0

(C) $H_2NCH_2-\underset{\underset{O}{\|}}{C}-O^{\ominus}$ at pH = 9 (D) $H_2NCH_2-\underset{\underset{O}{\|}}{C}-OH$ at pH = 12

8. The correct statements about anomers are :

(A) Anomers have different stereochemistry at C-1(anomeric carbon).

(B) α-D-glucopyranose and β-D-glucopyranose are anomers.

(C) Both anomers of D-glucopyranose can be crystallised and purified.

(D) When pure α-D-glucopyranose is dissolved in water its optical rotation slowly changes.

9. Which of the following would not givesa positive tollen's test?

(A) α-D-glycopyranose (B) Methyl β-D-glucopyranoside

(C) Sucrose (D) Methyl α-D-ribofuranoside

10. The final product of which of the following reactions furnishes evidence that glucose has unbranched carbon chain :

(A) Glucose $\xrightarrow[\text{2. Red P+HI}]{\text{1.Br}_2\text{,H}_2\text{O}}$ (B) Glucose $\xrightarrow[\text{2. Red P+HI}]{\text{1.NaBH}_4}$

(C) Glucose $\xrightarrow[\text{2. H}_3\text{O}^+ \text{ 3. Red P+HI}]{\text{1.HCN}}$ (D) Glucose $\xrightarrow{\text{CH}_3\text{OH / H}^+}$

11. Which of the following statements are correct with reference to amino acid?

(A) A carboxylic acid that contains an amino group.

(B) Amino acids are the building blocks of peptides and proteins.

(C) An amino acid may exist as a zwitter ion under suitable conditions.

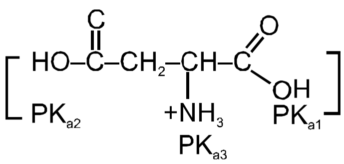
(D) Amino acids are negatively charged in basic medium.

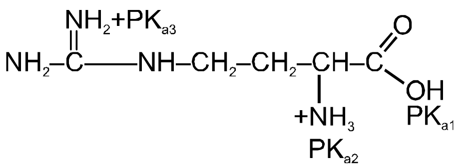
12. On hydrolysis which of the following carbohydrate give only glucose?

(A) Cellulose (B) Lactose (C) Maltose (D) Starch

SECTION-III : (Maximum Marks: 18)

- This section contains **SIX** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.
  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 If ONLY the correct numerical value is entered as answer.
  Zero Marks : 0 In all other cases.

13. For Aspartic acid , the pK_{a_1}, pK_{a_2} and pK_{a_3} are 2,4 and 10 respectively and

for Arginine , the pK_{a_1}, pK_{a_2} and pK_{a_3} are 2, 9 and 13 respectively.

If pI of aspartic acid is x and of arginine is y then x + y is :

14. Allose and Glucose are isomeric structures with similar structural formula but different configurations. If D-Allose and (L) - Glucose differs in configuration along C_i no. of carbons ($C_i = C_1, C_2, C_3, ...$), then $\sum C_i$ is

15. How many isomers are formed when alanine amino acids are heated?

16. Glucose react with phenyl hydrazine and forms osazone. Sum of nitrogen and oxygen atoms in osazone is:

17. In cellulose number of free –OH groups available for acylation. (per monomeric unit)

18. Number of reducing sugar :

(1) Glucose (2) Galactose (3) Maltose (4) Lactose

(5) Sucrose (6) Cellulose (7) Starch (8) Ribose

PART - 3 : OLYMPIAD (PREVIOUS YEARS)

1. Which of the following vitamins are water soluble ? **[NSEC-2001]**
(A) A and E (B) A and E (C) B and C (D) D and E

2. The portions of proteins having the highest mobility are **[NSEC-2003]**
(A) α - helics (B) β -sheets (C) peptide bonds (D) surface side chains.

3. Metal ions are known to interact with amino acid residues of proteins. The amino acid with larger number of metal binding sites are **[NSEC-2003]**
(A) cysteine, alanine (B) methionine, tryptophan
(C) glutamic acid, cysteine (D) arginine, isoleucine.

4. Transport of oxygen is an important function of blood. Partial pressure of O_2 is highest and lowest, respectively in **[NSEC-2003]**
(A) muscles and heart (B) lungs and muscles
(C) heart and lungs (D) muscles and lungs.

5. The boiling point of a glucose solution is higher than that of water because **[NSEC-2004]**
(A) glucose forms extensive hydrogen bonding with water
(B) glucose does not dissociate in water
(C) its vapour pressure is higher than that of water at a given temperature
(D) its vapour pressure is lower than that of water at a given temperature.

6. The structure representing the Zwitter ion form of glycine is **[NSEC-2004]**
(A) NH_2-CH_2-COOH (B) $NH_3^+-CH_2-COOH$ (C) $NH_3^+-CH_2-COO^-$ (D) $NH_2-CH_2-COO^-$

7. Glucose and fructose give the same osazone because **[NSEC-2004]**
(A) both are hexoses and the epimers of each other
(B) C_3,C_4 and C_5 carbon atoms of both have identical configuration
(C) C_1,C_2 and C_3 carbon atoms of both have identical configuration
(D) both are functional isomers of each other, differing only at C_2.

8. The simplest carbohydrate capable of exhibiting optical isomerism is **[NSEC-2005]**
(A) glucose (B) fructose (C) sucrose (D) glyceraldehyde.

9. Secondary structure of proteins can be destabilized by **[NSEC-2005]**
(A) treating it with β-mercaptoethanol (B) treating it with iodoacetate
(C) treating it with 0.001 M KCl (D) heat.

10. Tertiary structure of proteins depends on **[NSEC-2005]**
(A) number and type of amino acids (B) number and sequence of amino acids
(C) type and sequence of amino acids (D) type of amino acids only.

11. The peptide bond in proteins is **[NSEC-2005]**
(A) planar and usually found in a trans conformation.
(B) planar, but rotates to three preferred dihedral angles.
(C) non-polar and fixed in a trans conformation.
(D) non-polar, but rotates to three preferred dihedral angles.

12. Identify the biomolecules which is not a polymer. **[NSEC-2005]**
(A) glycogen (B) sucrose (C) haemoglobin (D) DNA.

13. Test by which starch and cellulose can be distinguished from each other is **[NSEC-2006]**
(A) reducing sugar test (B) analysis of products of hydrolysis
(C) iodine test (D) Molisch test.

14. A positive Biuret test confirms the presence of **[NSEC-2006]**
(A) ester (B) carboxylic acid (C) amide (D) amine.

15. Bonds responsible for the helical structure of proteins are **[NSEC-2006]**
(A) peptide bonds (B) hydrophobic interactions
(C) intermolecular H bonds (D) intramolecular H bonds

16. Glucose and fructose react with phenylhydrazine to give identical yellow osazones because **[NSEC-2006]**
(A) carbon atoms 3,4 and 5 in both have same configuration
(B) both are hexoses
(C) both are reducing sugars
(D) all the above.

17. Which of the following statements is not correct for glycine? **[NSEC-2006]**
(A) It contains amino group. (B) It is a constituent of proteins.
(C) It contains a carboxylate group. (D) It is optically active.

18. Which of the following term is applicable for glucose - galactose pair? **[NSEC-2006]**
(A) isomers (B) epimers (C) anomers (D) none of these.

19. Can the amino group, in the aniline molecule, become meta - directing in an electrophilic substitution reaction? **[NSEC-2006]**
(A) No, it never shows meta directing properties. (B) Yes, in a strongly acidic medium.
(C) Yes, in a strongly alkaline medium. (D) Yes, in a non - polar solvent.

20. Proteins undergo degradation during starvation to act as a carbon source. The final byproduct of this reaction is **[NSEC-2007]**
(A) glucose (B) ammonia (C) ATP (D) amino acid

21. Ultra violet light absorption occurring in protein is due to the presence of **[NSEC-2008]**
(A) Alanine (B) Cysteine (C) Glutamic acid (D) Tryptophan

22. The amino acid prolin allows bending of a polypeptide in secondary structure of protein. This is possible due to **[NSEC-2008]**
(A) Presence of peptide bond (B) Abence of hydrogen bond
(C) Presence of hydrogen bond (D) Steric hindrance

23. Which of the amino acid stabilizes tertiary structure of protein through formation of covalent bond ? **[NSEC-2008]**
(A) Tyrosine (B) Methionine (C) Cysteine (D) Valine

24. A mixture of three amino acids glycine (Gly), lysine (Lys) and glutamic acid (Glu) was separated by ananion exhchange chromatography process. The order of elution of amino acids from the column is **[NSEC-2008]**
(A) Glu, Lys, Gly (B) Lys, Glu, Gly (C) Gly, Lys, Glu (D) Glu, Gly, Lys

25. Enzymatic hydrolysis of starch leads to release of **[NSEC-2008]**
(A) Fructose (B) Mannose (C) Glucose (D) Xylose

26. During alcoholic fermentation of sugars, the enzyme which converts glucose (or fructose) into ethanol is : **[NSEC-2009]**
(A) zymase (B) invertase (C) maltase (D) urease

27. The most likely change occuring in a protein sample when treated with 6 M HCl is – **[NSEC-2009]**
(A) formation of disulphide bond (B) formation of peptide bond
(C) hydrolysis of peptide bond (D) oxidation of disulphide bond

28. The order of the energy released by biological oxidation of equal amounts (moles) of glucose, sucrose and starch is – **[NSEC-2009]**
(A) starch > sucrose > glucose (B) starch > glucose > sucrose
(C) sucrose > glucose > starch (D) glucose > sucrose > starch

29. Precipitation of protein from a solution is generally achieved by using ammonium sulphate solution. This could be a result of – **[NSEC-2009]**
(A) neutralization of the charge of the protein (B) increase in hydrophilicity of the protein
(C) increase in hydrophobicity of the protein (D) formation of salt protein complex

30. Enzymatic breakdown of cellulose will yield monomers of – **[NSEC-2009]**
(A) Galactose (B) Glucose (C) Fructose (D) Ribose

31. The trend of isoelectric point (pI) of the amino acids glycine, lysine and aspartic acid is – **[NSEC-2009]**
(A) glycine > lysine > aspartic acid (B) aspartic acid > lysine > glycine
(C) aspartic acid > glycine > lysine (D) lysine > aspartic acid > glycine

32. The secondary structure of a protein molecule can be promoted by the presence of - **[NSEC-2010]**
(A) Prolin residues (B) Glycine residues (C) Leucine residues (D) Aspartic acid residues

33. Though proteins have a range of molecular weights and different compositions, the percentage of carbon in any protein is **[NSEC-2010]**
(A) 50-55% (B) 40-45% (C) 60-65% (D) 70-75%

34. A nonapeptide in rat on hydrolysis gave the following identifiable tripeptides: **[NSEC-2010]**
Gly-Ala-Phe, Ala-Leu-Val, Gly-Ala-Leu, Phe-Glu-His, and His-Gly-Ala. The sequence of the nonapeptide is
(A) Gly-Ala-Leu-Val-Phe-Glu-His-His-Gly (B) Ala-Phe-Leu-Val-Gly-Leu- Phe-Glu-His
(C) Gly-Ala-Phe-Glu-His-Gly-Ala-Leu-Val (D) Phe- Ala-Leu-Val-Gly-Glu-His-Gly-Ala

35. Denaturation of protein due to change in pH could be due to **[NSEC-2011]**
(A) loss of van der Waal's interaction (B) hydrophobic interaction
(C) Change in ionic interaction (D) Breaking of covalent bonds

36. Two protein molecules with the same average molecular mass (molecular weight) can absorb different amount of ultraviolet radiation due to difference in the content of **[NSEC-2011]**
(A) tyrosine (B) glutamic acid (C) lysine (D) methionine

37. If titration of an amino acid present in the solution yielded pI (isoelectric point) value of 10.80, the amino acid present in the solution may be **[NSEC-2011]**
(A) glycine (B) arginine (C) histidine (D) prolin

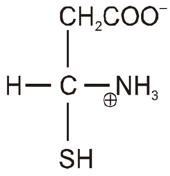
38. Structural features of proteins secreted outside the cells may be stabilised by presence of - **[NSEC-2011]**
(A) hydrogen bond (B) disulfide bond (C) hydrophobic force (D) phospho-diester bond

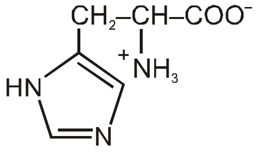
39. α-D(+) glucose and β-D(+) glucose are **[NSEC-2012]**
(A) Enantiomers (B) Geometrical isomers (C) Epimers (D) Anomers

40. Which of the following does not reduce Benedict's solution? **[NSEC-2012]**
(A) Glucose (B) Fructose (C) Sucrose (D) Aldehyde

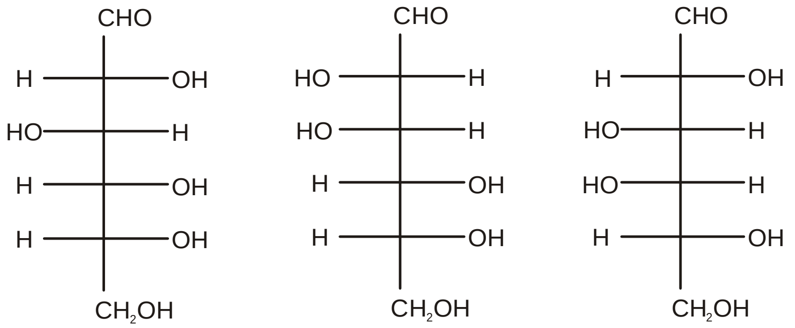
41. The amino acid that cannot be obtained by hydrolysis of protein is **[NSEC-2012]**

(A) $HOOCCH_2CH(\overset{+}{N}H_3)COO^-$

(B) 

(C) 

(D) $\overset{+}{N}H_3\,(CH_2)_4CH(NH_2)COO^-$

42. 

[NSEC-2013]

D-Glucose D-Mannose D-Galactose

The above structures are related to each other as

(A) identical substance
(B) diastereomers
(C) enantiomers
(D) epimers

43. The minimum number of H^+ ions that can be released by an amino acid is : **[NSEC-2013]**

(A) 1 (B) 2 (C) 3 (D) 4

44. Amylose and cellulose are polymers of glucose in which glucose units are joined to each other respectively by linkages of the type **[NSEC-2014]**

(A) α, β (B) β, β (C) β,α (D) $\alpha\beta, \beta$

45. 50g of sucrose is hydrolysed to a mixture of glucose and fructose, Sucrose is dextrorotatory, however the mixture formed is laevorotatory. This is because **[NSEC-2014]**

(A) more amount of β-D-fructose is formed than that of β-D-glucose.
(B) β-D-glucose undergoes inversion of configuration.
(C) β-D-fructose and β-D-glucose undergo inversion to their α-anomers.
(D) laevorotation of β-D-fructose is more than dextrorotation of β-D-glucose.

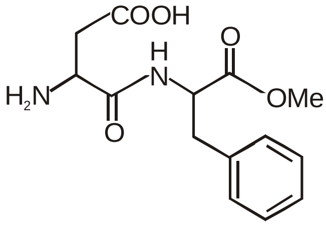
46. The sugars that are porduced on hydrolysis of DNA and RNA are **[NSEC-2014]**

(A) epimers
(B) two different sugars
(C) positional isomers
(D) diasteromers

47. Many protein-based biomaterials, such as waste hair and feathers, can absorb heavy metal ions from wastewater. It has been observed that metal uptake by these materials increases in alkaline condition. The enhanced uptake in alkaline conditions is due to **[NSEC-2015]**

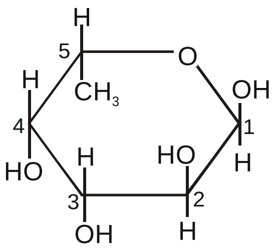
(A) generation of many ligand sites in the protin molecules due to removal of H^+
(B) availability of a high concentration of OH^- ions as ligands
(C) Increased cross-linkages in the protein chains by formation of amide bonds
(D) Increase in solubility of the proteins

48. Aspartame (x) is an artificial sweetening agent and is 200 times sweeler than sugar. It is an ester of the dipeptide of : **[NSEC-2016]**

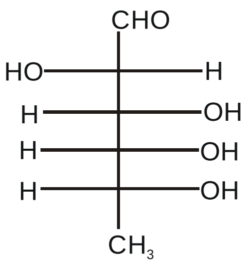


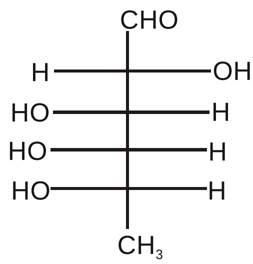
(A) alanine and phyenylalanine
(B) aspartic acid and alanine
(C) phenylalanine and glycine
(D) aspartic acid and phenylalanine

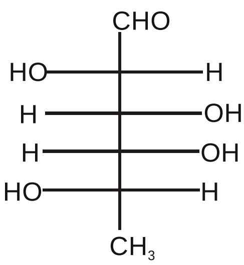
49. L-Fucose with the following planar reprosentation is a sugar component of the determinants of the A, B, O blood group typing **[NSEC-2016]**

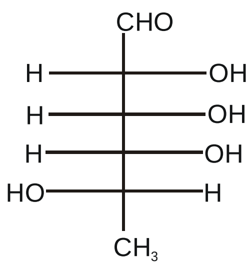


The open chain structure of L-fucose can be represented as

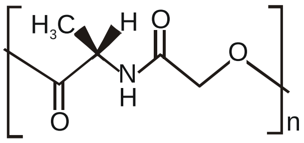
(A)


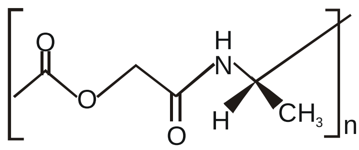
(B)


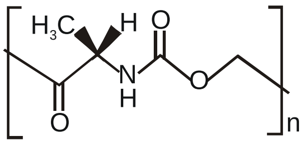
(C)


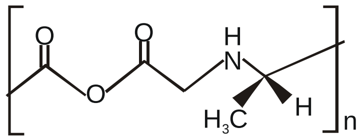
(D)


50. A biodegradable alternating copyolymer of L-alanine and glycolic acid ($HO–CH_2–COOH$) is : **[NSEC-2016]**

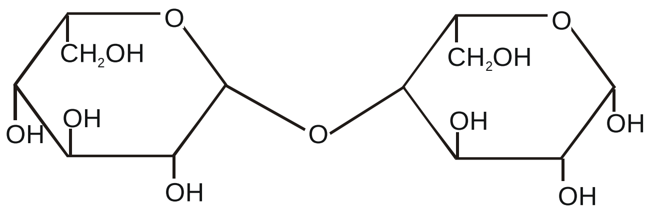
(A) 

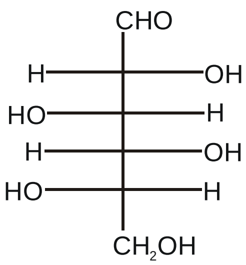
(B) 

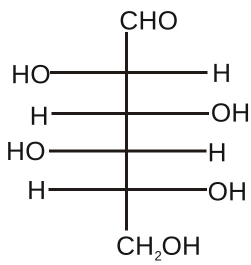
(C) 

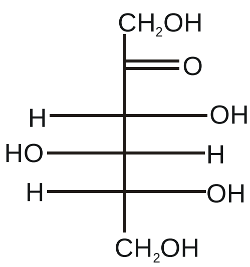
(D) 

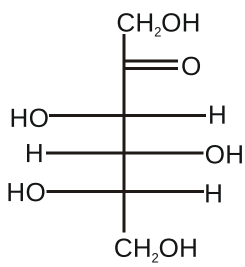
51. The monosaccharide present in the following disaccharide is **[NSEC-2018]**



(A) 

(B) 

(C) 

(D) 

RRP ANSWER KEY

PART- 1

1.	(A)	**2.**	(D)	**3.**	(D)	**4.**	(D)	**5.**	(A)
6.	(A)	**7.**	(A)	**8.**	(B)	**9.**	(D)	**10.**	(C)
11.	(C)	**12.**	(B)	**13.**	(B)	**14.**	(B)	**15.**	(B)
16.	(A)	**17.**	(C)	**18.**	(C)	**19.**	(C)	**20.**	(B)
21.	5	**22.**	81	**23.**	4	**24.**	6.5	**25.**	8

PART- 2

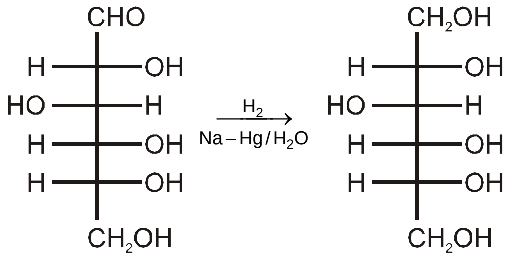
1.	(D)	**2.**	(C)	**3.**	(D)	**4.**	(C)	**5.**	(BCD)
6.	(CD)	**7.**	(ABC)	**8.**	(ABCD)	**9.**	(BCD)	**10.**	(ABC)
11.	(ABCD)	**12.**	(ACD)	**13.**	14	**14.**	2+4+5=11	**15.**	3
16.	8	**17.**	3	**18.**	5				

PART- 3

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

RRP SOLUTIONS

PART - 1

1. 

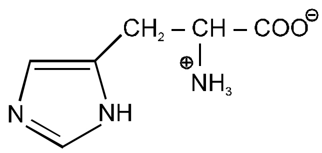
2. $C_6H_{12}O_6 \xrightarrow[3O_2]{\text{Zymase}} C_2H_5OH + 4CO_2 + 3H_2O$

3. Glucose is a monosaccharide where as oligosaceharides are those which have 2-10 monosaccharide units

4. Commonest disaccharide (sucorse) has molecular fomula $C_{12}H_{22}O_{11}$.

5. Starch is hydrolysed by the enzyme diastase (also called β-amylase) to maltose

6. Total no. of optical isomers $=2^4=16$

10. In pH range 6.04 – 9.17 the structure is 

12. α-D-Glucopyranose and β-D-Glucopyranose are anomers.

13. 6 membered ring with oxygen making a center is pyranose form.

14. Hydrolysis of sucrose (dextrorotatory) into (+) glucose and (–) fructose gives overall levorotatory mixture of products, hence the process is known as "inversion of sugar".

15. Inverted sugar is 1 : 1 mixture of glucose and fructose.

16. Glycosidic linkage is an acetal linkage as it connects two (hemiacetal) monosaccharide units.

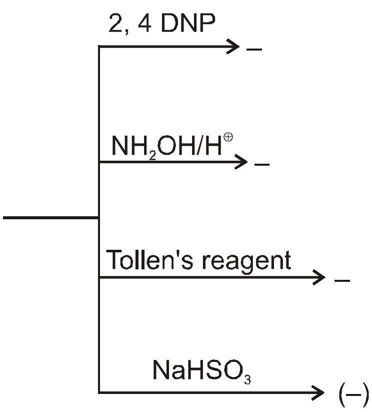
17. Sucrose $\longrightarrow$ Gulcose + Fructose

+ 65º + 52.5º – 90º

the product mixture is overall leavorotatary.

18. Cellulose on hydrolysis yields β–D–glucose, because β–D–glucose units are polymerised in cellulose.

19. S_1, S_2 and S_4 are correct. S_3 is incorrect because anomers are those which have difference in configuration at C-1.

20. glucose pentacetate 

21. (I),(II),(III), (IV) & (VII)

22. $(3)^4 = 81$

24. $P = \frac{5}{1}$, $Q = \frac{3}{2}$; $\frac{5}{1}+\frac{3}{2}$; $\frac{10+3}{2} = \frac{13}{2} = 6.5$

PART - 2

1. In the formation of osazone C–1 and C–2 react with phenyl hydrazine to form phenyl hydrazone. If C–3, C–4, C–5 have same configuration the carbohydrates will form same osazone even if they differ in configuration at C–1 or C–2.

2. Tollen's reagent and fehling's solution can not be used to distinguish between aldose and ketose

4. $CH_3-\underset{}{\overset{NH_2}{\overset{|}{C}}}H-COOH \xrightarrow{LiAlH_4} CH_3-\overset{NH_2}{\overset{|}{C}}H-CH_2OH$. hence X is $LiAlH_4$

5. Starch is the mixture of two polysaccharides - Amylose and amylopectin

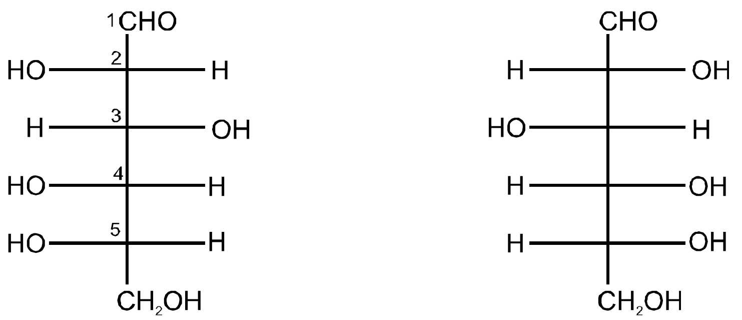
6. Glucose shows mutarotation, sucrose gives glucose and fructose on hydrolysis.

7. At acidic pH, glycine will convert to cation and at basic pH glycine will convert to anion.

8. Cabohydrate having different stereochemistry at C-1 are termed as Anomers, whereas when stereochemistry at any other carbon is different then those carbohydrates are known as epimers.

13. $x = \frac{2+4}{2} = 3$; $y = \frac{9+13}{2} = 11$; $x + y = 14.$

14. D-Allose and L-Glucose differ in configuration along C_2, C_4 and C_5 therefore $\sum C_i = 2 + 4 + 5 = 11.$



L-Glucose D-Allose

PART - 3

27. $-NH-\overset{O}{\overset{||}{C}}- \xrightarrow[H^+]{H_2O} -NH_2 + HO-\overset{O}{\overset{||}{C}}-$

32. It is fact.

34. The sequence of tripeptides are present in 'C' in given order only.

35. pH change brings change in ionic interactions, hence denaturation.

36. In tyrosine lone pair of Oxygen is in conjugation with benzene ring therefore it has different properties in UV light due to non bonding to π^* transition.

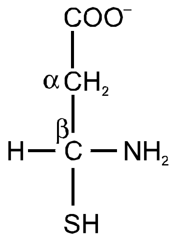
37. Arginine is basic amino acid due to presence of guanidine group and its pI is 10.80.

38. It is fact.

39. α D (+) glucose and β-D(+) glucose are anomers.

40. Sucrose has not any aldehydic group hence does not reduce Benedict solution.

41. Hydrolysis of protein (natural molecules), yields α-aminoacids, but the option (B) is β-aminoacid.



42. All the above structures differs in configuration at one or two stereocentres.

51.