26. BIOMOLECULES AND POLYMERS

1. INTRODUCTION

The study of chemical make-up and structure of living matter and of the chemical changes that takes place within them is called biochemistry.

The various activities of living organisms are regulated by complex organic molecules, such as carbohydrates, lipids, proteins and nucleic acids, called biomolecules.

2. CARBOHYDRATES

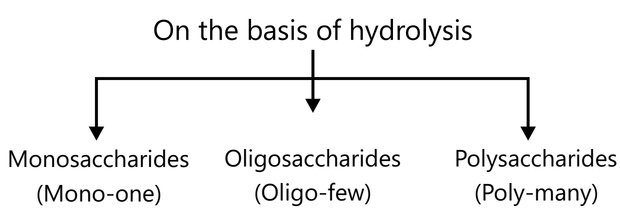
Carbohydrates are principally plants products and are a part of an extremely large group of naturally occuring organic compounds. Cane sugar, glucose, starch and so on are a few examples of carbohydrates. The general formula for carbohydrates is $C_z(H_2O)_y$. Carbohydrates are generally hydrates of carbon, which is where the name was derived. So, carbohydrates on hydrolysis produce polyhydroxy aldehydes or polyhydroxy ketones.

2.1 Classification of Carbohydrates

(a) On the basis of Physical Characteristics

- **(i) Sugar:** Characteristics of sugars are crystalline substances, taste sweet and readily water soluble. Because of their fixed molecular weight, sugars have sharp melting points. A few examples of sugars are glucose, fructose, sucrose, lactose, etc.
- **(ii) Non-Sugars:** Amorphous, Tasteless, waster insoluble substances with variable melting points e.g., Starch.

(b) On the basis of Hydrolysis

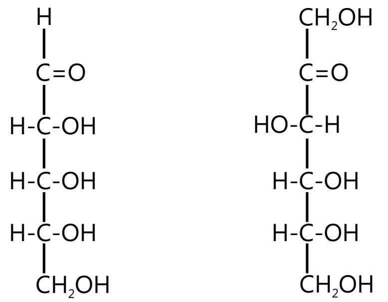


Flowchart 26.1: Classification based on Hydrolysis

Monosaccharaides': A carbohydrate that can be hydrolyzed only once to break down into simpler units of polyhydroxy aldehyde or ketone is called monosaccharide. These include glucose, mannose, etc.

Monosaccharide classification

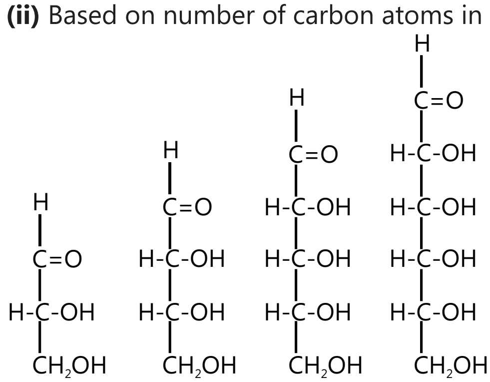
(i) Based on location of $\left(\begin{array}{c} O \\ \| \\ -C- \end{array}\right)$



Aldose Ketone

Aldehyde (-CHO), ketone $\left(\begin{array}{c} O \\ \| \\ -C- \end{array}\right)$

(ii) Based on number of carbon atoms in the chain



Triose Tetrose Pentose Hexose

Can be either aldose or ketose sugar.

Oligosaccharides: Sugars that on hydrolysis produce two or more molecules of monosaccharides are called oligosaccharides. These are further classified as di-, tri- or tetrasaccharides, etc.

- **Disaccharides:** These are sugars that produce two molecules of the same or different monosaccharides on hydrolysis. Examples are sucrose, maltose and lactose. An example for disaccharides is sucrose: $C_{12}H_{22}O_{11}$.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or } H^+]{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or } H^+]{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + 2H_2O \xrightarrow[\text{or } H^+]{\text{Lactase}} \underset{\text{Glucose}}{C_6H_{11}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

- **Trisaccharides:** Sugars that yield three molecules of the same or different monosaccharides on hydrolysis are called trisacchardies. An example of trisaccharides is Raffinose $C_{18}H_{32}O_{16}$

$$\underset{\text{Raffinose}}{C_{18}H_{32}O_{16}} + 2H_2O \longrightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

- **Polysachharides:** On hydrolysis polysaccharides yield large number of monosaccharides units. An example of polysaccharide is starch cellulose.

$$\underset{\text{Strach cellulose}}{\left(C_6H_{10}O_5\right)_n} + nH_2O \rightarrow \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

(c) On basis of test with reagents (like Benedict's solution, Tollen's reagent and Fehling's solution):

(i) Reducing Sugars:

- These have a free aldehyde (-CHO) or ketone $\left(-\overset{\overset{\displaystyle O}{\|}}{C}-\right)$ group.
- These have the ability to reduce the cupric ions (Cu^{2+}; blue) in Fehling's or Benedict's Solution to cuprous ions (Cu^{+}; reddish) that separates out as cuprous oxide (Cu_2O) from the solution.
- Examples include maltose, lactose, melibiose, gentiobiose, cellobiose, mannotriose, rhamnotriose.

(ii) Non-reducing sugars:

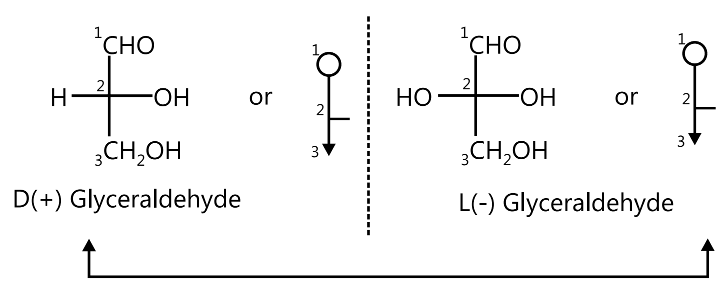
- A free aldehyde or ketonic group is absent.
- No cuprous oxide (Cu_2O) producing chemical reaction takes place.
- Examples are sucrose, trehalose, raffinose, gentiarose, melezitose.

Table 26.1: The common oxidizing agents used to test for the presence of a reducing sugar

Oxidizing Reagent	Benedict's Solution	Fehling's Solution	Tollen's Reagent
Composition	Copper sulfate in alkaline citrate	Copper sulfate in alkaline tartrate	Silver nitrate in aqueous ammonia
Non-reducing sugar	Deep blue	Deep blue	Colorless
Color after reaction with reducing sugar	Brick red precipitate $Cu_2O(s)$	Brick red precipitate $Cu_2O(s)$	Silver mirror forms Ag(s)
Species being reduced (the oxidant)	Cu^{2+} $Cu^{2+}+e^{-} \rightarrow Cu^{+}$	Cu^{2+} $Cu^{2+} + e^{-} \rightarrow Cu^{+}$	$Ag^{\oplus}$ $Ag^{+} + e^{-} \rightarrow Ag(s)$
Species being oxidized (the reductant)	Reducing sugar oxidized to carboxylate	Reducing sugar oxidized to carboxylate	Reducing sugar oxidized to carboxylate

2.2 Classification of Aldols

In the given chemical formulae, symbols D and L refer to the relative configuration of the (–OH) group at the penultimate carbon, where glyceraldehyde is taken as standard. D and L refer to the (–OH) groups that lies on right hand side and left hand, respectively.

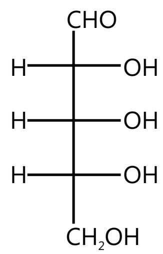


Pair of C-2, Epimer as well as enantiomers

2.3 Epimers

Epimers are essentially diastereomers that contain multiple chiral centers that are absolutely separate from each other in configuration at only one chiral center.

Example:



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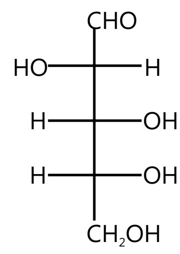
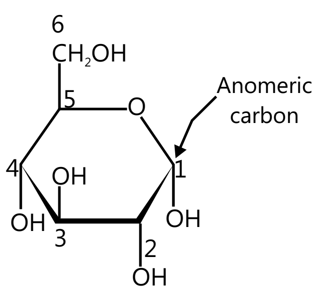


2

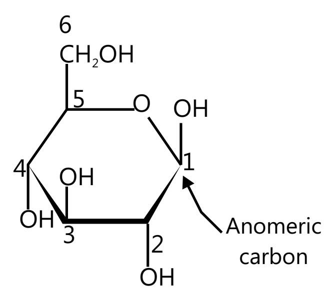
2.4 Anomers

Cyclic monosaccharides or glycosides that are epimers, differing from each other in the configuration of C-1 if they are aldoses or of C-2 if they are ketoses are called anomers. The epimeric carbon in such compounds is known as anomeric carbon or anomeric center.

Example 1: α-D-Glucopyranose and β-D-glucopyranose are anomers.

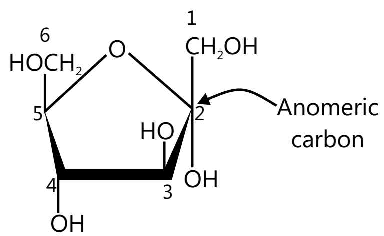


α-D-glucopyranose

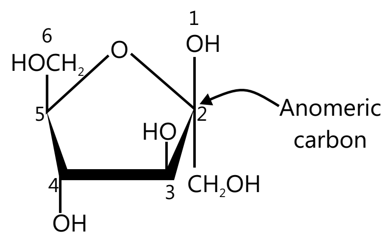


β-D-glucopyranose

Example 2: α-D-Fructofuranose and β-D-fructofuranose are anomers.

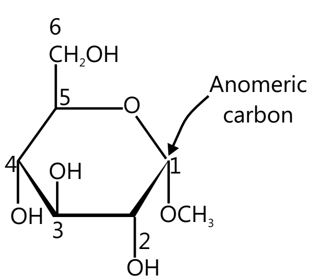


α-D-fructofuranose

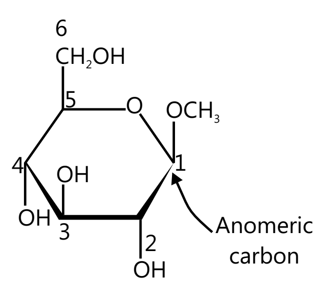


β-D-fructofuranose

Example 3: Methyl α-D-glucopyranoside and methyl β-D-glucopyranoside are anomers.



Merthl α-D-glucopyranoside

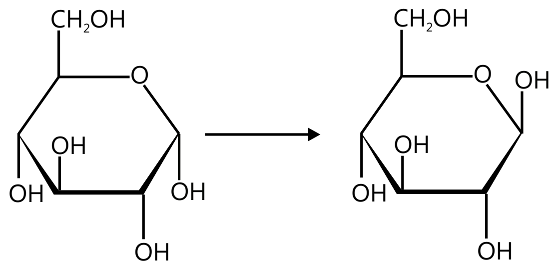


Methyl β-D-glucopyranoside

2.5 Mutarotation

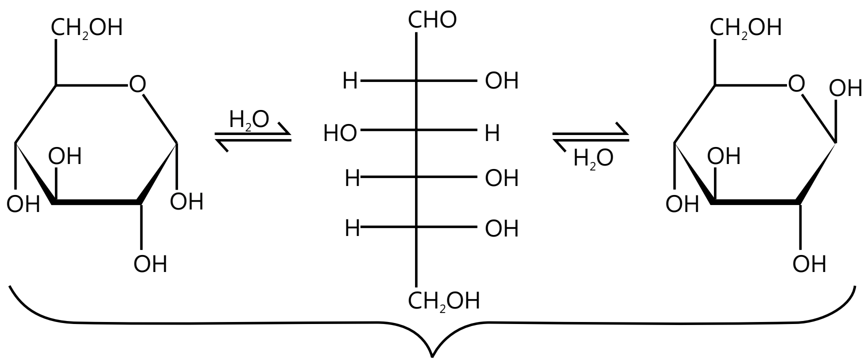
Mutarotation is commonly used in carbohydrate chemistry to describe the change in specific rotation of a chiral compound due to epimerization.

For example, the monosaccharide D-glucose can be found in two cyclic forms, α-D-glucose ($[\alpha]_D^{25}$ = +112) and β-D-glucose ($[\alpha]_D^{25}$ = +18.7), which are epimers and are available as pure compounds.



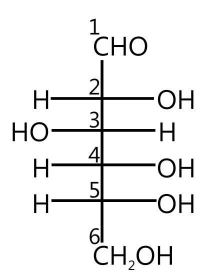
α-D-glucose β-D-glucose

On adding water to one of the cyclic forms of D-glucose, through reversible epimerization it changes to the other via open-chain form, while the specific rotation of the solution gradually changes, until it reaches the equilibrium value +52.7°.

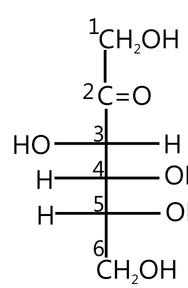


2.6 Representation of Structures of Glucose and Fructose

(a) Open chain structures (Fischer projection):



D (+) Glucose

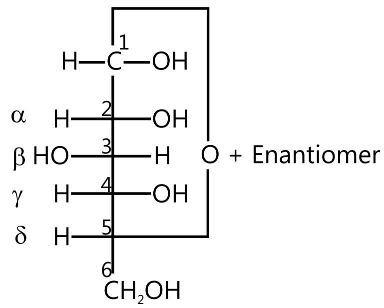


D (-) Fructose

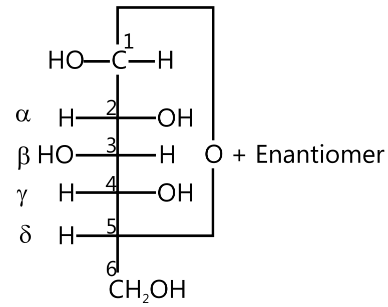
D symbolizes the comparative configuration of C-5 -OH group with relation to D-glyceraldehyde, which these are prepared from. Here, (+) and (–) refer to optical rotation. Naturally, D-glucose is (+) or dextrorotatory but D-fructose is (–) or laevorotatory.

(b) Cyclic structures of glucose: The CHO group of glucose reacts with either C-5 -OH group or with C-4 -OH group to form stable six- and five-membered cyclic rings, respectively, having hemiacetalic linkage. When -CHO group reacts with C-6 -OH group, seven-membered ring is formed, or four-membered ring is formed on reaction with C-3 -OH; both are unstable.

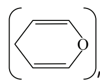
(i) -CHO reaction with C-5 -OH group produces two anomeric glucose: In such a case, a six-membered ring, pyranose, is formed.



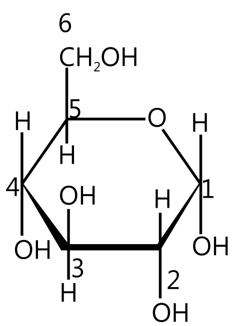
(C-1) (OH) on R.H.S. is called α-glucose
α-D (+) Glucopyranose



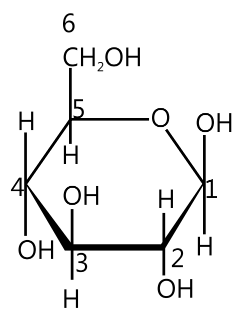
(C-1) (OH) on L.H.S. is called β-glucose
β-D (+) Glucopyranose

Pyranose refers to six-membered ring, like in pyran , or to δ-linkages, since there is hemiacetalic linkage is between C-1 and C-5 δ-C atom. δ-C atom is formed next to the functional group -CHO and β next to the α-C atom and so on.

(ii) Haworth representation: English chemist W. N. Haworth (awarded the Nobel Prize in chemistry for his study of carbohydrate in 1937) established cyclic structure of glucose. Below, R.H.S. shows the -OH group above the plane of the ring in Haworth structures while as per Fischer projection, on the L.H.S., it is shown below the plane of the ring .

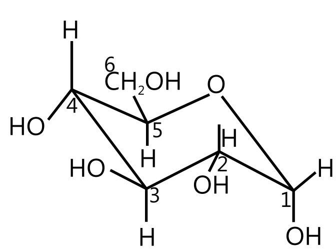


α-D (+) Glucopyranose

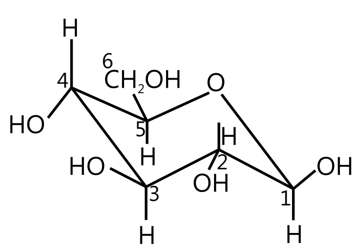


β-D (+) Glucopyranose

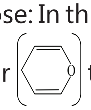
(iii) Chair-form conformation structures: Haworth projection structures are transformed to the chair conformation. The -OH groups present below the plane of the ring in Haworth structures remain below the plane in the chair conformation as well.

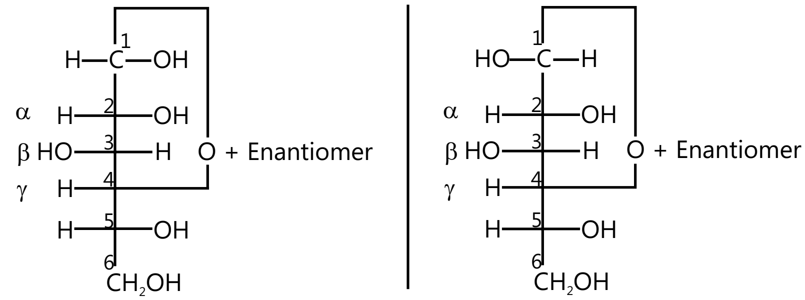


α-D (+) Glucopyranose
(Less stable one OH Group is in axial position)



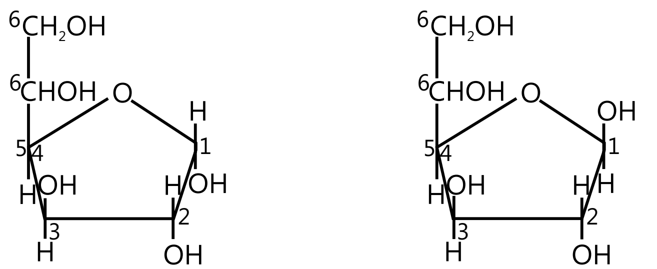
β-D (+) Glucopyranose
(more stable since all OH Groups is in equatorial Position)

(iv) -CHO reaction with C-4 -OH group produces two anomeric glucose: In this case, five-membered ring (furanose) is formed. Furanose refers to five-membered ring, like in furan, or  to γ-linkage, as the hemiacetal linkage is between C-1 and C-4 γ-C atom. Not all carbohydrates exist in equilibrium as six-membered hemiacetal rings; in several compounds, the ring is five-membered, as in fructose. However, glucose naturally occurs only in pyranose form (six-membered), and in small extent in furanose form, which is in equilibrium with five-membered hemiacetal ring,.



β-D(+) Glucopyranose
(C-1) (OH) on L.H.S.

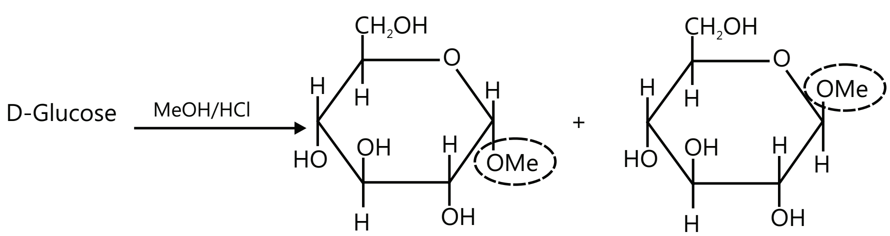
Haworth representation



α-D (+) Glucofuranose   β-D (+) Glucofuranose

Structures of Glucosides

D-Glucose on reaction with MeOH + HCl gives α- and β- D-glucopyranoside.

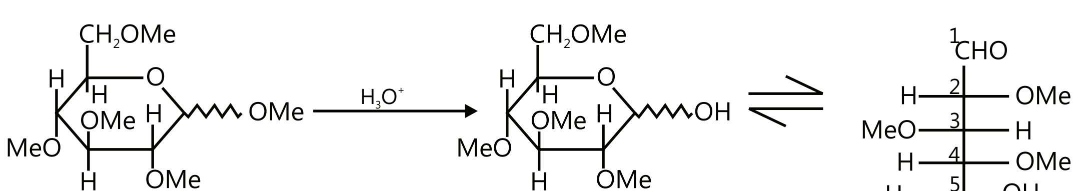


Methyl-α-D (+) glucopyranoside   Methyl-β-D (+) glucopyranoside

Methyl glucoside reacts with an excess of Me_2SO_4/NaOH to produce pentamethyl derivatives. Presence of many electronegative O atoms in the -OH groups of monosaccharides makes them more acidic than alcohols, and all of them exert –I effect on the nearby -OH groups. In aqueous NaOH, the -OH groups get converted to alkoxide ion (RO^-) that reacts with Me_2SO_4 by S_N2 mechanism and forms methyl ether. This process is called exhaustive methylation.

The OMe groups at C-2, C-3, C-4 and C-6 of the pentamethyl derivative are ordinary ether groups. These groups are stable in diluted aqueous acid, since ether groups are cleaved by heating with concentrated HBr or HI.

The OMe groups at C-1 are formed partly of acetal linkage (it is glucosidic) and hence are different from others.



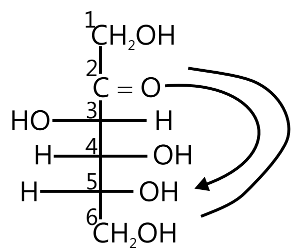
Pentamethyl
derivative
(I)

Hydrolysis of the glycosidic -OMe group occurs when pentamethyl derivatives are treated with dilute aqueous acid to give 2, 3, 4, 6-tetra-O-methyl-D-glucose. (O in the name refers that the Me groups that are attached to O atoms.)

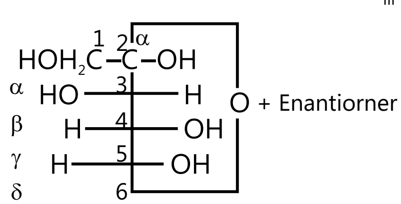
In the open-chain structure, absence of Me group at C-5 because it was originally a part of the cyclic hemiacetal linkage of D-glucose.

Representation of Structure of Fructose

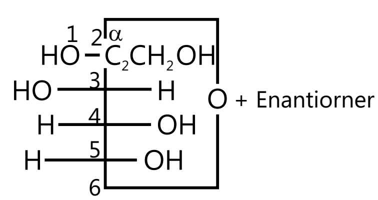
1. Haworth representation



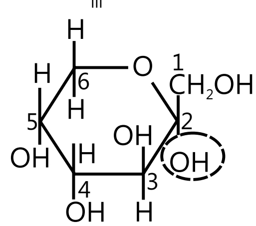
Open chain
Structure
of D(-) fructose



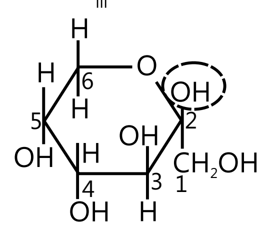
α-D(-) Fructopyranose
(C=O) reacts with C-6 OH
Six-membered pyranose
Ring of δ-linkage
OH group on R.H.S. is α



β-D(-) Fructopyranose
OH group on L.H.S. is β

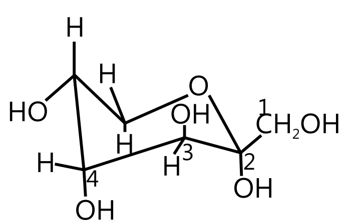


α-D (-) Fructopyranose



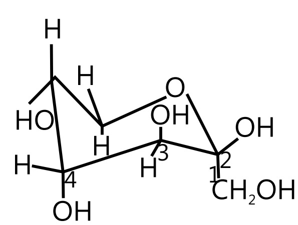
β-D (-) Fructopyranose

2. Chair-form conformational structures



α-D(-) Fructopyranose

More stable, since bulky (CH_2OH) group on equatorial position

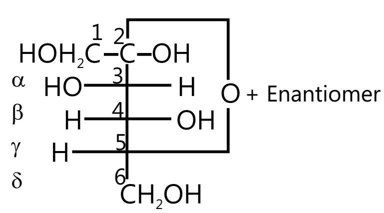


β-D(-) Fructopyranose

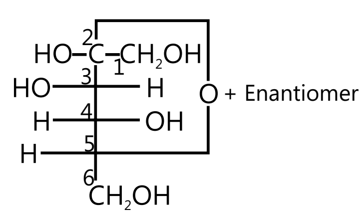
Less stable, since bulky (CH_2OH) group on axial position

3. Fructose occurs in nature in furanose form (five-membered cyclic ring) and in small extent in pyranose form which is in equilibrium with six-membered hemiacetal ring.

It also exists in two cyclic forms that are obtained by the reaction of $\left(\begin{matrix}O\\ \|\\ -C-\end{matrix}\right)$ group with C-5 -OH group.

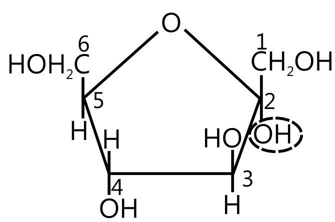


α-D (-) Fructopyranose

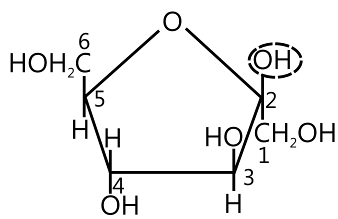


β-D (-) Fructopyranose

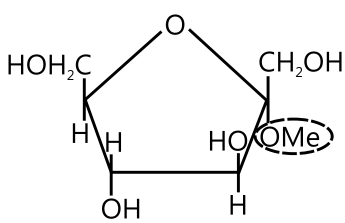
Haworth representation



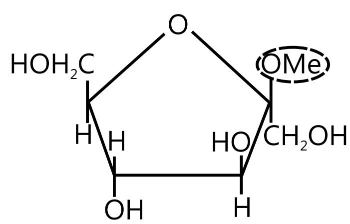
α-D (-) Fructofuranose



β-D (-) Fructofuranose



α-D (-) Fructofuranose



β-D (-) Fructofuranose

2.7 Glucose

Preparation:

(a) From sucrose (cane sugar): Boiling sucrose with diluted HCl or H_2SO_4 in alcoholic solution produces glucose and fructose in equal proportions.

$$\underset{\text{(Sucrose)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^{\oplus}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(b) From starch: Industrially, glucose is manufactured by the hydrolysis of starch by boiling it with dil. H_2SO_4 at 393 K under pressure.

$$\underset{\text{Starch or Gellolose}}{(C_6H_{12}O_5)_n} + nH_2O \xrightarrow[393K;2-3bar]{H^{\oplus}} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

PLANCESS CONCEPTS

(a) **Carbohydrates:** Polyhydroxy aldehydes or ketones with general formula $C_x(H_2O)_y$.

(b) Classification based on hydrolysis:

(i) **Monosaccharides:** Simplest carbohydrates that cannot be hydrolyzed any further.

(ii) **Oligosaccharides:** On hydrolysis gives two to nine units of monosaccharides.

(iii) **Polysaccharides:** On hydrolysis gives many units of monosaccharides.

(c) **Reducing sugar:** Sugars that reduce Fehling's and Tollen's solutions.

(d) **D-L configuration:** Refers to relative configuration of the (–OH) group with respect to glyceraldehydes.

(e) **Epimers:** Have more than one stereocenter but differ in configuration about only stereocenter.

(f) **Anomers:** Differ in configuration about the acetal or hemiacetal carbon.

(g) All anomers are epimers but the reverse is not true.

(h) **Mutarotation:** Change in specific rotation of an optically active compound when dissolved in solution is called mutarotation.

(i) β-D glucose is more stable compared to α-D glucose, since all –OH groups are in equatorial position.

(j) In solution, β-D glucose and α-glucose are both in equilibrium.

(k) Fructose being a polyhydroxy ketone still gives positive test for Tollen's, Benedict's and Fehling's reagent and thus is a reducing sugar.

Vaibhav Krishnan (JEE 2009, AIR 22)

Chemical Reactions: Glucose has one aldehyde group, one primary (—CH_2OH) group and four secondary (—CHOH) hydroxyl groups, and gives the following reactions:

(a) Acetylation of glucose with acetic anhydride forms a penta-acetate, proving the presence of five hydroxyl groups in glucose.

$$OHC-(CHOH)_4-CH_2OH \xrightarrow{(CH_3COO)_2O} OHC-(CHOCOCH_3)_4-CH_2OOCCH_3$$

(b) Glucose reacts with hydroxylamine to form monoxime and adds up a molecule of hydrogen cyanide to form a cyanohydrin.

$$HOH_2C-(CHOH)_4-CHO+HONH_2 \rightarrow \underbrace{HOCH_2-(CHOH)_4-CH=NOH}_{\text{Glucose monoxime}}$$

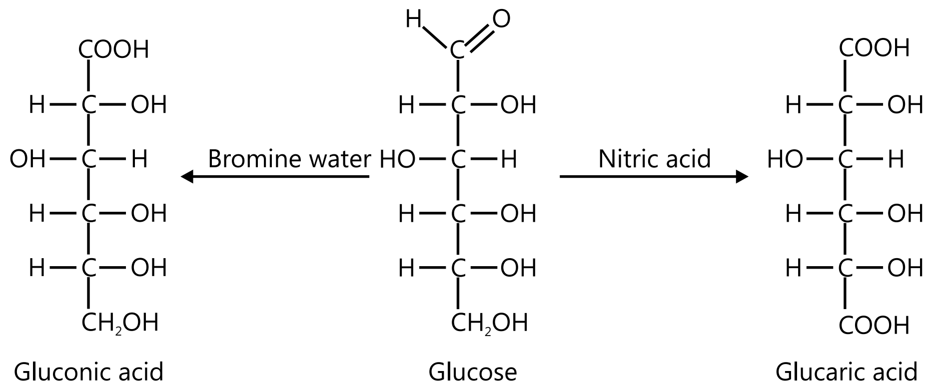
$$HOH_2C-(CHOH)_4-CHO+HCN \longrightarrow \underbrace{HOCH_2-(CHOH)_4-CH(OH)CN}_{\text{Glucose cyanohydrin}}$$

The above reactions validate the occurrence of a carbonyl group in glucose.

(c) Ammonical silver nitrate solution (Tollen's reagent) is a reducing sugar reducing to metallic silver.

Similarly, Fehling's solution is reduced to reddish brown cuprous oxide. On the other hand, it itself gets oxidized to gluconic acid. This proves the presence of an aldehydic group in glucose.

(d) $$HOCH_2-(CHOH)_4-CHO+Ag_2O \longrightarrow \underbrace{HOCH_2-(CHOH)_4-COOH}_{\text{Gluconic acid}}+2Ag$$

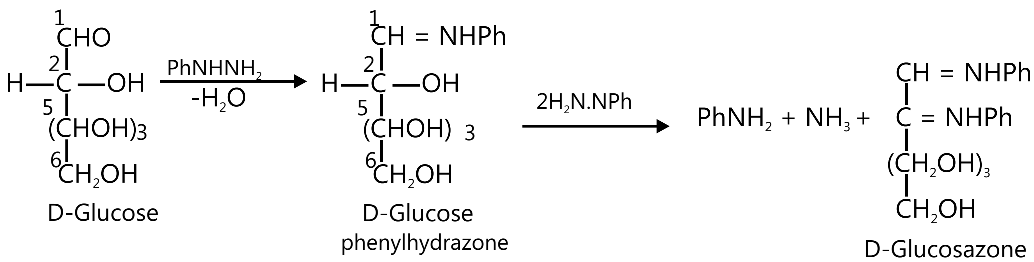


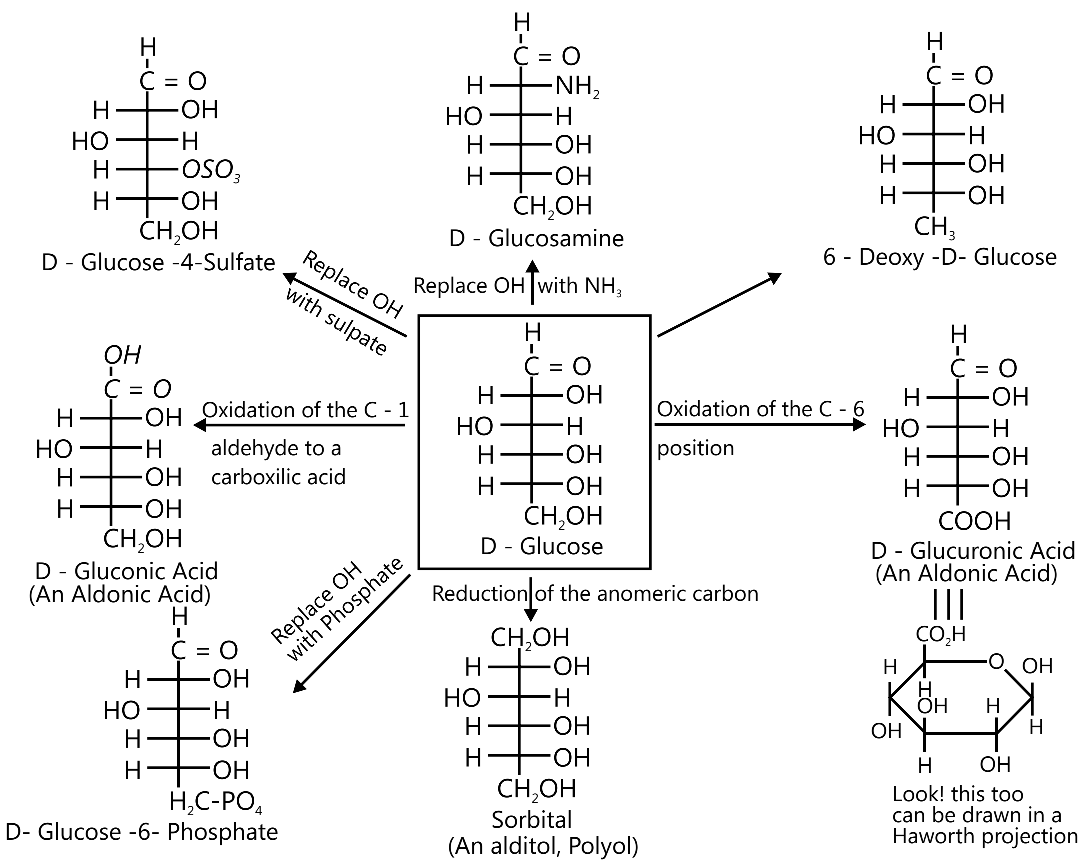
(e) On prolonged heating with HI, glucose forms n-hexane, indicating that all the six carbon atoms in glucose are linked linearly.

$$HOCH_2-(CHOH)_4-CHO \xrightarrow{HI} \underset{\text{n–hexane}}{H_3C-CH_2-CH_2-CH_3}$$

(f) D-Glucose reacts with phenyl hydrazine and gives glucose phenylhydrazone, which is soluble.

Excess use of phenylhydrazine produces, a dihydrazone, called osazone.

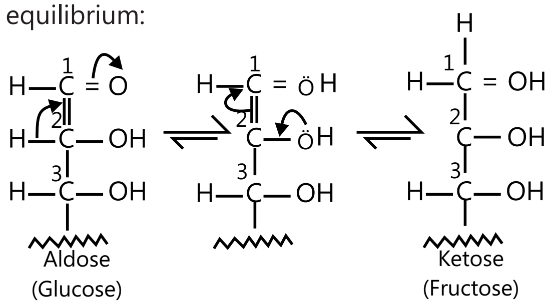




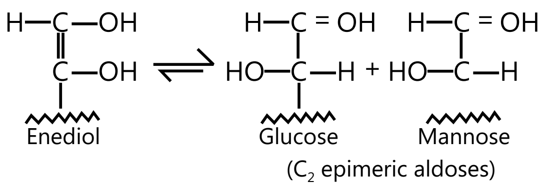
Lobry de bruyn van ekenstein rearrangement reaction

Mechanism

(a) The ketose and aldose tautomerise in $\ddot{O}H$ to a common intermediate enediol, establishing the following equilibrium:



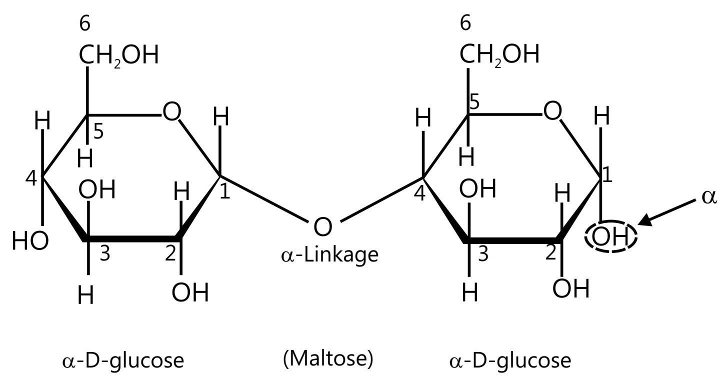
(b) When the aldose reforms from the enediol, H^+ can add to C-2 from either face of the (C=C) to give C_2 aldohexose epimers.



2.8 Some Disaccharides

Maltose: (a) Preparation: Fractional hydrolysis of starch by enzyme diastase.

$$\underset{\text{Starch}}{2(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{\text{Diastase}} \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$



(b) Units: Two units of α-D glucose.

(c) Reducing sugar

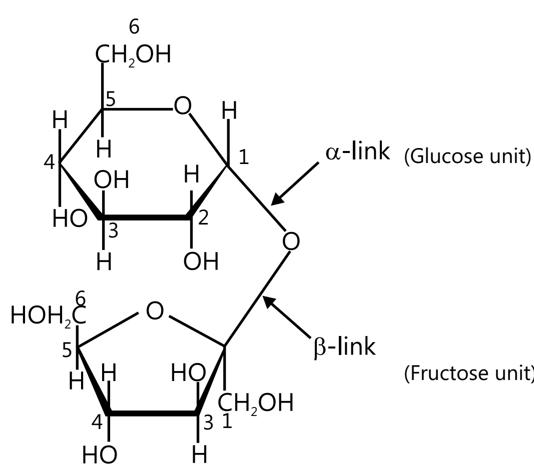
(d) Linkage: α glycosidic linkage between C1 and C4 carbon atoms.

Sucrose: (a) Preparation: Prepared from sugarcane and beetroot

(b) Units: α-D glucose and α-D fructose.

(c) Non-reducing sugar

(d) Linkage: α gylcosidic linkage with reference to glucose and β gylcosidic linkage to fructose, both linked at C1 carbon.



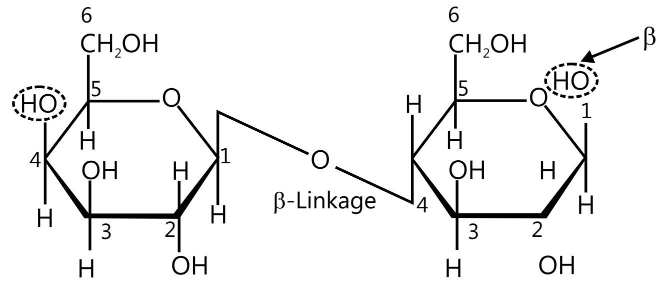
Lactose:

(a) Preparation: Found in milk.

(b) Units: β-D glucose and β-D galactose.

(c) Reducing sugar.

(d) Linkage: β glycosidic linkage.

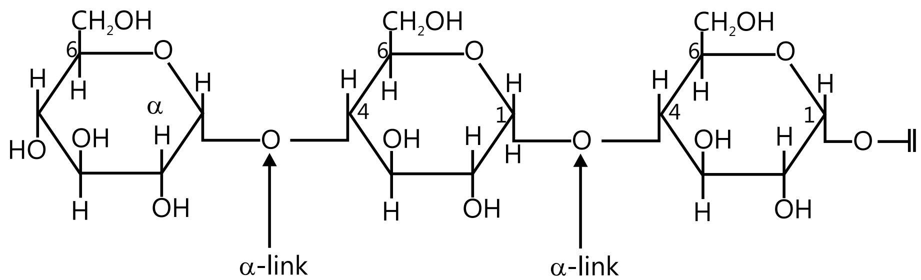


The laevo rotation of fructose (–92.4°) is more than rotation of glucose (+52.5º), so the mixture is laevorotatory. Sucrose hydrolysis brings about a change in the sign of rotation, from dextro (+) to laevo (–) and the product is called invert sugar.

2.9 Polysaccharides

(a) Starch: It is the main storage poly saccharide of plants having general formula $(C_8H_{16}O_5)_n$. The main source is maize, wheat, barley, rice and potatoes. It is a polymer of α-glucose and consists of two components – Amylose and Amylopectin. Amylose is made up of long, unbranched chain of α-D-(+)-glucose linkage. Amylopectin is a branched chain polymer of α-D-glucose units, in which chain is formed by C_1–C_6 glycosidic linkage whereas branching occurs by C_1–C_6 glycosidic linkage.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)n} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$



Amylopectin

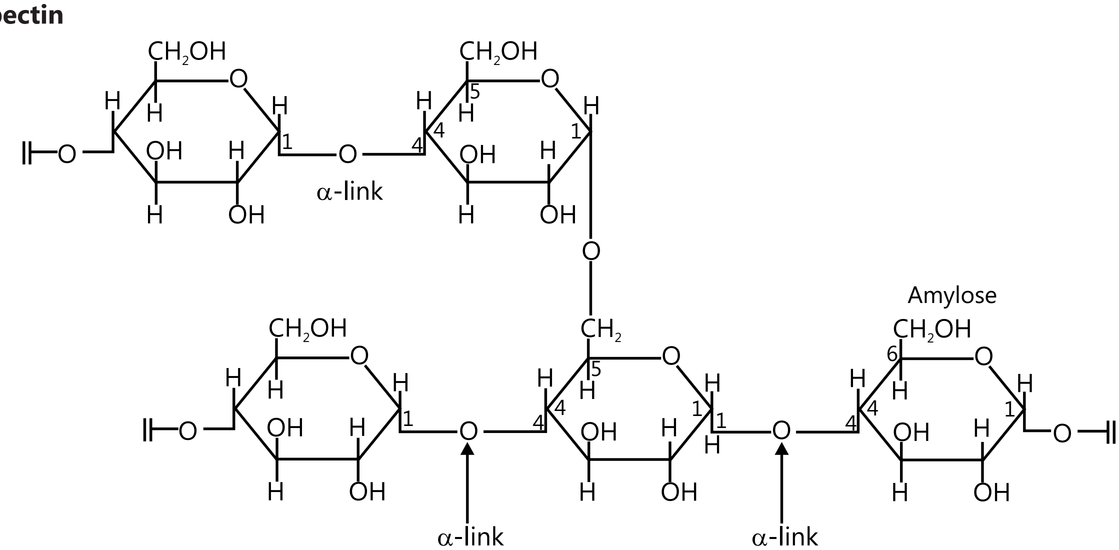


Table 26.2: Difference between Amylose and Amylopectin

S.No.	Amylose	Amylopectin
1.	It is water soluble fraction for starch	It is water insoluble fraction of starch.
2.	It is 20% of starch	It is 80% of starch.
3.	It is straight chain polymer of D-glucose units.	It is branched chain polymer of D glucose units.
4.	Glucose units are joined by α-1, 4 glycosidic linkage	In amylopectin, the glucose units are joined by α-1, 6 glycosidic linkage.
5.	Its molecular mass lies in the range of 10,000–50,000	Its molecular mass is in the range of 50,000–1,00,000.

(b) It occurs exclusively in plants and is a main constituent of cell wall of plant cell. It is a linear polymer of β-D-glucose in which glucose units are linked together by C_1–C_4 glycosidic linkage. It is a non-reducing sugar.

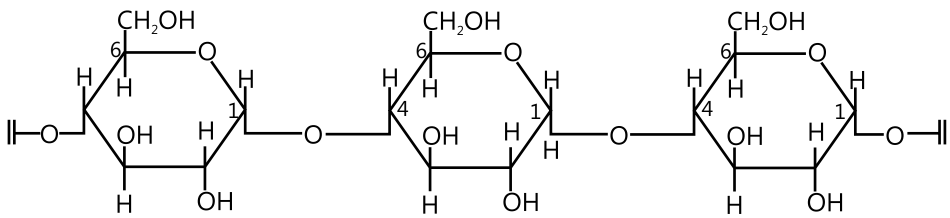


Table 26.3: Relative sweetness of sugar

Sugar	Relative Sweetness	Sugar	Relative Sweetness
Sucrose	100 (standard)	Glucose	74
Lactose	16	Invert sugar	130
Galactose	32	Fructose	173
Maltose	33		

Chemical treatment of cellulose, the most important natural polymer, gives various useful derivatives

- **Rayon:** Cellulose acetate and cellulose xanthate are used as a fibre.
- **Celluloid:** Cellulose dinitrate or pyroxylin, combined with plasticizer and alcohol, is used for the manufacturing of photographic film, spectacle frames, piano keys, etc. It is known as artificial ivory.
- **Explosive:** Cellulose trinitrate is used extensively as a blasting and propellant explosive.
- **Lacquer:** Collodion is used for manufacturing washable cellulose paints.
- **Water proofing:** Solution of cellulose acetate is used to provide anti-shrink property to textile fabric.
- **Methyl cellulose:** is used in fabric sizing, paste and cosmetics. Ethyl cellulose is used for manufacturing of rain coats and plastic films.

PLANCESS CONCEPTS

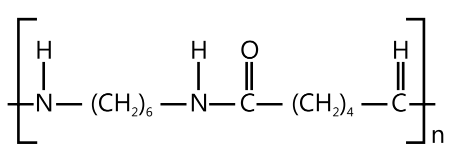
- Both glucose and gluconic acid on oxidation with nitric acid yield a dicarboxylic acid.
- Glucose on heating with HI gives n-hexane.
- D-glucose reacts with phenylhydrazone to give glucose phenylhydrazine and excess use gives osazone. But three molecules per molecule of glucose are used for oxidation while the other two are attached to the molecule.

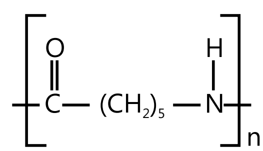
PLANCESS CONCEPTS

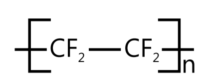
- Glucose when heated with concentrated NaOH, establishes an equilibrium of D-glucose, D mannose and D-fructose.
- Sucrose on hydrolysis changes from Dextrorotatory to Levorotatory and hence is called invert sugar.
- Sucrose is a non-reducing sugar since the hemiacetal hydroxyl groups are linked by glycosidic linkage.
- Sucrose on hydrolysis gives glucose and fructose.
- Maltose is a reducing sugar that on hydrolysis gives two molecules of D-glucose.
- Starch is non-reducing polysaccharides that on hydrolysis give D-glucose.
- Starch is mixture of two polysaccharides: amylose and amylopectin.
- Amylase is straight-chain polysaccharide that is soluble in water and gives blue colour with iodine.
- Amylopectin is a branched chain polysaccharide insoluble in water and doesn't give blue colour with iodine.
- Cellulose is a straight chain polysaccharide comprising of only D-glucose units.
- The difference between starch and cellulose is that starch has α-glycosidic linkage while cellulose has β glycosidic linkage.

Nikhil Khandelwal (JEE 2009, AIR 94)

Illustration 1: Write the names of monomers of the following polymers: **(JEE MAIN)**

(i) 

(ii) 

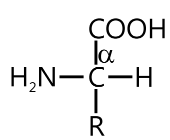
(iii) 

Sol: (i) Hexamethylenediamine, $H_2N—(CH_2)_6—NH_2$ and adipic acid, $HOOC—(CH_2)_4—COOH$

(ii) Caprolactam (iii) Tetrafluoroethene, $F_2C = CF_2$.

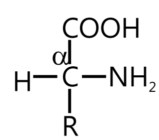
Illustration 2: Describe the term D-and L-configuration used for amino acids with examples. **(JEE ADVANCED)**

Sol: Consider the following configurations (I and II) of a-amino acids



I

L-Amino acid

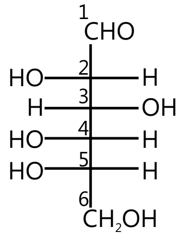


II

D-Amino acid

NH_2 group on the **α**-carbon oriented toward left (as in structure I) is referred to as L-amino acid and NH_2 group oriented toward right (as in structure II) is referred to as D-amino acid.

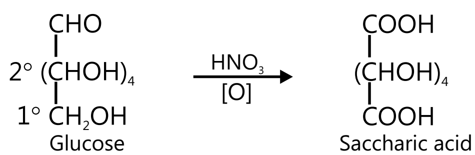
Illustration 3: The letters 'D' or 'L' before the name of a stereoisomer of a compound indicates the correlation of configuration of that particular stereoisomer. This refers to their relation with one of the isomers of glyceraldehyde. Predict whether the following compound has 'D' or 'L' configuration.



Sol: The orientation of the OH group at the penultimate chiral carbon (i.e. last but one or C_5) toward left gives the compound it's L-configuration.

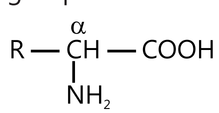
Illustration 4: How will you distinguish 1° and 2° hydroxyl groups present in glucose? Explain with reactions. **(JEE ADVANCED)**

Sol: The –OH group on the terminal carbon atom (i.e. C_6) is called the 1° hydroxyl while the rest of the four remaining OH group present on C_2, C_3, C_4 and C_5 are called 2° hydroxyl groups. While 1° Hydroxyl groups are easily oxidized to give carboxylic acids but 2° hydroxyl groups undergo oxidation only under drastic conditions. For example, glucose on oxidation with HNO_3 gives a dicarboxylic acid, saccharic acid having the same number of carbon atoms as glucose. This indicates that glucose contains one 1° hydroxyl group while the remaining four are 2° hydroxyl groups.



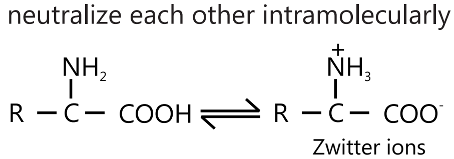
3. AMINO ACIDS

α-Amino Acids: Carboxylic acids in which one α-hydrogen atoms of alkyl group is substituted by amino ($–NH_2$) group are called α-Amino acids. The general formula is

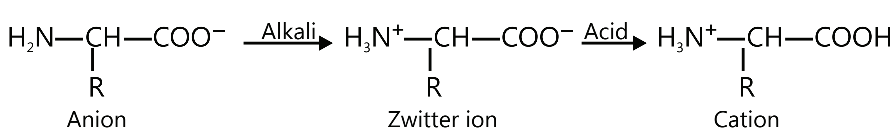


Where R = H or alkyl group

Structure of α-amino acids: The amino acids containing one carboxylic group and one amino group behave like a neutral molecule. This is because in aqueous solutions the acidic carboxylic group and basic amino group neutralize each other intramolecularly to produce an internal salt structure known as zwitter ion or dipolar ions.



However, the neutral zwitter ion (dipolar ions) changes to cation in acidic solution and exist as anion in alkaline medium. Thus amino acids exhibit amphoteric character.



Therefore, amino acid exists as zwitter ion when the solution is neutral or pH-7. The pH at which the structure of an amino acid has no net charge is called its isoelectric point.

Classification of Amino Acids: Based on the relative number of $-NH_2$ and $-COOH$ group, α-amino acids are classified in three main groups

(a) Neutral Amino acids: Amino acids containing one $-NH_2$ group and one $-COOH$ group. For example, glycine, valine, alanine etc.

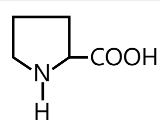
(b) Basic amino acids: These contain one $-COOH$ group and two $-NH_2$ groups, such as lysine and arginine.

(c) Acidic amino acids: Amino acids that containing two $-COOH$ groups and one $-NH_2$ group are called acidic amino acids; for example, aspartic acid and glutamic acid, etc.

Isoelectronic Point: In acidic solution, an amino acid being a positive ion moves toward the cathode in an electric field. On the other hand in alkaline solution, it is available as a negative ion that migrates toward anode. At a specific hydrogen ion concentration (pH), the dipolar ion exists as neutral ion and does not show migration toward any electrode. This pH is termed as the isoelectric point of the amino acid.

The isoelectric point is dependent on other functional groups in the amino acids. Neutral amino acids have the range between pH 5.5 and 6.3. At isoelectric points, the amino acids are least soluble in water. This property is utilized in the separation of various amino acids formed by the hydrolysis of proteins.

Table 26.4: List of 20 naturally occurring α- amino acids

Nature	α-Amino acid	Abbreviation or code	Structure
NEUTRAL			
1.	Glycine	Gly	H_2N-CH_2-COOH
2.	Alanine	Ala	$H_2N-CH-COOH$ | CH_3
3.	Valine	Val	$H_2N-CH-COOH$ | $CH(CH_3)_2$
4.	Proline	Pro	
ACIDIC			
5.	Serine	Ser	$H_2N-CH-COOH$ | CH_2-OH
6.	Aspartic acid	Asp	$H_2N-CH-COOH$ | CH_2-COOH
7.	Glutamic acid	Glu	$H_2N-CH-COOH$ | CH_2-CH_2-COOH
BASIC			
8.	Lysine*	Lys	$H_2N-CH-COOH$ | $CH_2-CH_2CH_2-CH_2NH_2$
9.	Arginine	Arg	$H_2N-CH-COOH$ | $CH_2(CH_2)_2NH-C(=NH)-NH_2$

4. PROTEINS

Proteins are complex nitrogeneous organic substance that occurs in all animals and plants. Proteins are called the most vital chemical substance and are necessary for the normal growth and maintenance of life. Protein serves following functions in our body:

- Proteins promote growth
- Proteins supply essential amino acids to blood.
- Proteins help maintain body tissues.
- Proteins synthesize various enzymes.
- Proteins protect body from infections.

Protein content of food stuffs

Food stuff	% Protein	Food stuff	% Protein
Milk	5	Meat	24-26
Wheat	14	Egg yolk	16
Peas	21	Egg (white)	12.5
Maize	10	Cheese	33

Classification of proteins: Proteins are classified on the basis of two different methods. The first mode of classification, proteins are of two types is based on their shape and functions:

(a) Fibrous proteins (b) Globular proteins

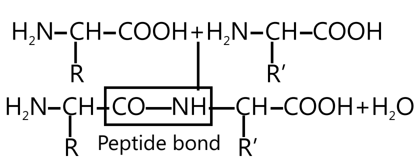
(a) Fibrous proteins: They are thread like molecules that lie side by side to form fibers. They are held together by hydrogen bonds. These are insoluble in water but soluble in concentrated acids and alkalis. A few examples are keratin (present in hair, nails, wood, feathers and horns). Muscles have myosin, silk is composed of fibroin, bones and cartilages have collagen.

(b) Globular proteins: These proteins have molecules folded into compact units that often acquire spheroidal shape. Such proteins are soluble in water, diluted acids and alkalis, such as insulin, haemoglobin, albumin, etc.

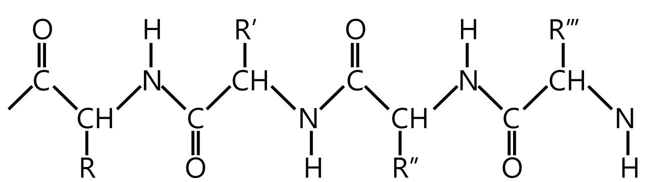
Structure of Proteins: The structure of proteins is quite complex. Study of its structure is carried out under the following headings.

(a) Primary structure of protein: The primary structure of protein refers to its covalent structure, that is, the sequence in which various α-amino acid are arranged in protein or in the polypeptide structure of protein.

The linkage (–CO–NH–) is known as peptide linkage.



The dipeptide still has free amino and carboxyl groups that can react with other molecules of amino acid resulting in polypeptide formation.



C-terminal N-terminal

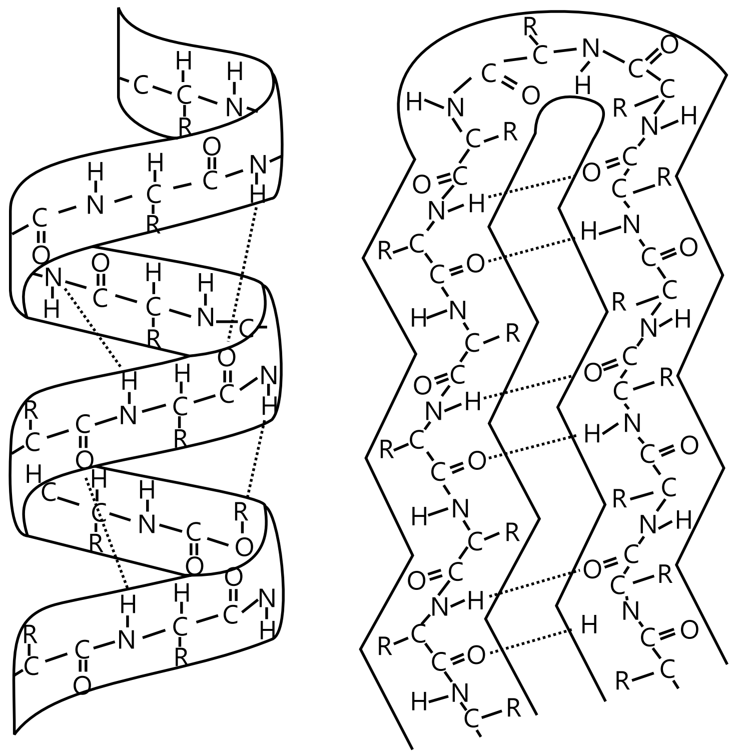
In the polypeptide chain, the free amino end is termed as N–terminal and the free carboxyl end is called C–terminal end.

(b) Secondary structure of protein: This refers to the arrangement of polypeptide chains into a definite three-dimensional structure that protein assumes as a result of hydrogen bonding. Depending upon the size of the R-group of the amino acids in polypeptides, two different types of secondary structure are possible:

(i) α-helix structure (ii) β-Pleated structure

(i) α-Helix structure: This type of secondary structure is possible when the alkyl groups present in amino acids are large and involved in coiling of the polypeptide chains. The intramolecular hydrogen bond between the >C = O group of one amino acid and –NH group of the fourth amino acid stabilizes the helical pattern in right-handed coil and the shape.

(ii) β-Pleated structure: Such secondary structure is acquired when the alkyl groups of amino acids are small. In this kind of structure, the linear polypeptide chains are arranged side by side and are held together by intermolecular hydrogen bond between the $\left(\begin{array}{c} O \\ \| \\ -C- \end{array}\right)$ and –NH group.



α-helix β-pleated sheet

(c) Tertiary structure of protein: The tertiary structure of protein is the most stable shape that a protein assumes under the normal temperature and pH conditions. Attractive forces between the amino acid chains are involved in acquiring tertiary structure,. These attractive forces, like hydrogen bond, disulphide bonds, ionic, chemical and hydrophobic bonds, result in a complex and compact structure of protein. The two important tertiary structures of proteins are fibrous structures and globular structure. Fibrous proteins have largely helical structure and are rigid molecules of rod-like shape. Globular proteins show a polypeptide chain that consists partly of helical sections and partly β-pleated structure and remaining in random coil form. These different segments of secondary structure then fold up to give protein a spherical shape.

(d) Quaternary structure of proteins: The quaternary structure of proteins develops when the polypeptide chains, which may or may not be identical, are held together by hydrogen bonds. It results in the increase of molecular mass of protein greater than 50,000 amu. For example, hemoglobin contains four subunits, two identical α-chains containing 141 amino acids each and the other two identical β-chains containing 161 amino acids each.

(e) Denaturation of proteins: Proteins when subjected to the action of heat, mineral acids or alkali, the water soluble form of globular protein changes to water insoluble fibrous protein resulting in the precipitation or coagulation of protein. This is called denaturation of proteins.

5. NUCLEIC ACIDS

Nucleic acids are vital biomolecules that present in the nuclei of all living cells as nucleoproteins. These are long-chain polymers with a high molecular mass. Also called biopolymer, they have nucleotide as a repeating structural unit (monomer). These play an important role in transmission of the heredity characteristics from one generation to the next and also in the biosynthesis of proteins. Therefore, the genetic information coded in nucleic acid governs the structure of protein during its biosynthesis and hence controls the metabolism in the living system.

Structure of nucleic acids: The nucleic acid is the prosthetic component of nucleoproteins. Nucleic acid on stepwise hydrolysis gives following products as shown in the chart.

Nucleic acid
↓ Hydrolysis
Nucleotides
↓ Hydrolysis
Nucelosides | Phosphoric acid

Nucelosides
↓
Hydrolysis
↓
Pentose sugar Ribose or Deoxyribose | Purine bases (Adenine and guanine) | Pyrimidine bases (Thymine and cytosine) from DNA (Uracil and cytosine) from RNA

Flowchart 26.1: Components of nucleic acid

Difference between DNA and RNA

The main points of difference between the two types of nucleic acids are given in the table.

Table 26.5: Difference between DNA and RNA

	DNA	RNA
1	The pentose sugar present in it is 2- deoxy D(–) ribose.	It has D(–) ribose sugar.
2.	It contains cytosine and thymine as pyrimidine bases.	It contains cytosine and uracil as pyrimidine bases.
3.	DNA is double strand and pairing of bases is present throughout the molecule.	It is a single strand molecule looped back on itself. The pairing of bases in present only in helical part.
4.	It occurs in the molecules of the cell.	It mainly occurs in the cytoplasm of the cell.
5.	It is a very large molecule and the molecular weight varies from 6 million to 16 million amu.	It is a much smaller molecule and its molecular weight ranges from 20 thousand to 40 thousand amu.
6.	It has a characteristic property of replication.	It does not replicate.
7.	DNA controls the heredity character.	RNA only governs the biosynthesis of proteins.

Ribonucleic acids

(a) The pentose sugar in RNA is ribose.

(b) Adenine and guanine represent the purine bases of RNA; the pyrimidine bases are uracil and cytosine.

(c) The thymine in DNA is replaced by uracil in RNA.

(d) RNA is single stranded, but double stranded RNA is present in Rheovirus and wound tumor virus.

(e) There are three major classes of RNA, each with specific functions in protein synthesis

(i) mRNA

- Messenger RNA is produced by DNA; the process is called transcription.
- Messenger RNA encodes the amino acid sequence of a protein in their nucleotide base sequence.
- A triplet of nitrogenous bases specifying an amino acid in mRNA is called codon.

(ii) tRNA

- tRNA is also known as soluble RNA (sRNA) as it is soluble in 1 molar solution of sodium chloride.
- tRNA identifies amino acids in the cytoplasm and transports them to the ribosome.
- Molecules of tRNA are single-stranded and relatively very small.
- Anitcodon is a three-base sequence in a tRNA molecule that forms complementary base pairs with a codon of mRNA.
- All transfer RNA possess the sequence CCA at their three ends; the amino acid is attached to the terminal as residue.

(iii) rRNA

- Ribosomal RNA is found in ribosomes of cell and is also called insoluble RNA.
- The main function of rRNA is to attract provide large surface for spreading of mRNA over ribosome's during translocation process of protein synthesis.

Table 26.6: Types of RNA

Type	Sedimentation Coefficient	Mol. Wt.	Number of nucleotide residues	Percentage of total cell RNA
mRNA	6 to 25	25,000-1000,000	75-3000	2
tRNA	4	23,000-23,000	75-90	16
rRNA	5	35,000	100	
	16	550,000	1500	82
	23	1100,000	3100	

- The relationship between the sequence of amino acids in polypeptide with base sequence of DNA or mRNA is genetic code.
- Genetic code determines the sequence of amino acids in a protein.
- A triplet would code for a given amino acid as long as three bases are present in a particular sequence.
- Later in a cell-free system. Marshall Nirenberg and Philip (1964) were able to show that GUU codes for the amino acid valine.
- The spellings of further codons were discovered by R. Holley. H. Khorana and M. Nirenberg.
- They have been awarded the Nobel Prize in 1968 for researches in genetic code.

Lipids: The term lipids represent a group of biomolecules that are insoluble in water but soluble in organic solvents of low polarity, such as chloroform, toluene, ether, carbon tetrachloride.

(a) They serve as the energy reserve for living cell.

(b) Lipids are classified in three groups:

  (i) Triglyceride ester of higher fatty acids or oils and fats

  (ii) Phospholipids

  (iii) Waxes

PLANCESS CONCEPTS

- Proteins: Complex biopolymers of amino acids. Proteins on hydrolysis give peptides that on hydrolysis give amino acids. Almost all amino acids found in our body is α-amino carboxylic acid.
- Amino acids are generally colorless, water soluble, have high melting point and are crystalline solids.
- In aqueous solutions, carboxylic group loses a proton and the amino group accepts it and thus it exists in form of dipolar ion called zwitter ion.
- At a particular pH, the dipolar ion exists as a neutral ion and does not show migration toward any electrode, and this pH is known as isoelectric point.
- At isoelectric point, the amino acids are least soluble in water and this property is used for separation of various amino acids formed by hydrolysis of proteins.
- –CO–NH– bond in peptide are called the peptide linkage. There is restriction in rotation about the peptide bonds and thus free rotation is not possible.
- Test for protein:

  (i) Biurets' test: the blue color reagent turns violet in presence of protein.

  (ii) Xanthoprotic test: protein + concentrated HNO_3 gives orange color in alkaline solution.

  (iii) Millons test: protein + Million's reagent gives white precipitate that on heating gives red precipitate.

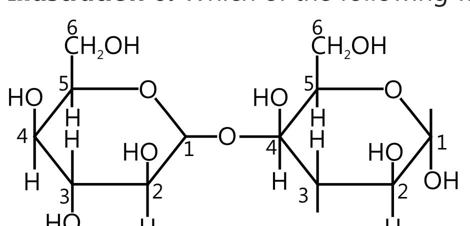
  (iv) Ninhydrin test: proteins or amino acids in presence of Ninhydrin reagent give a colored product.

Saurabh Gupta (JEE 2010, AIR 443)

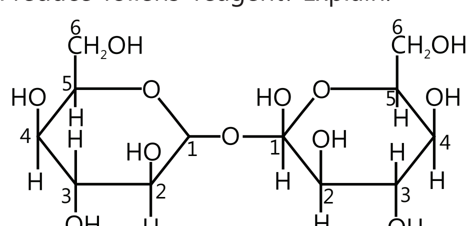
Illustration 5: Two samples of DNA, A and B have melting temperature, T_m 340 K and 350 K, respectively. Can you draw any conclusion from these data regarding their base content? **(JEE MAIN)**

Sol: We know that CG base pair has three H-bonds and AT base pair has two H-bonds; therefore, CG base pair is more stable than AT base pair. Since sample B has higher melting temperature than sample A; therefore, sample B has higher CG content as compared to sample A.

Illustration 6: Which of the following will reduce Tollens' reagent? Explain. **(JEE MAIN)**



(P)



(Q)

Sol: In disaccharide (Q), both the monsaccharides are linked through their reducing centres (C_1); therefore, it is not a reducing disaccharide. In disaccharide (P), the reducing end (C1) of one monosaccharide is linked to non-reducing end (C4) of the other monosaccharide. In other words, reducing end of one monosaccharide is free. Therefore, it is a reducing disaccharide.

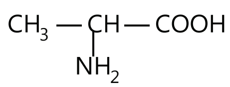
Illustration 7: An optically active amino acid (A) can exist in three form depending upon the pH of the medium. If the molecular formula of (A) is $C_3H_7NO_2$ write. **(JEE ADVANCED)**

(i) Structure of compound (A) in aqueous medium. What are such ions called?

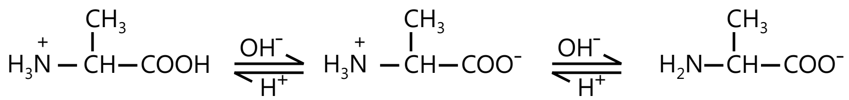
(ii) In which medium will the cationic form of compound (A) exist?

(iii) In alkaline medium, towards which electrode will the compound (A) migrate in electric field?

Sol: An optically active amino acid having the M.F. $C_3H_7NO_2$ is alanine, i.e.



Depending upon the pH of the medium, alanine can exist in the following three forms:



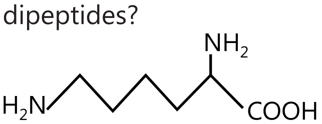
Cationic form(I) (exists in acid medium) | Zwitterion(II) (exists in aqueous medium) | Anionic(III) (exists in basic medium)

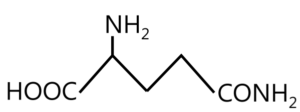
(i) In aqueous medium, the compound (A) exists as a zwitterion (II).

(ii) In acidic medium, it will exist in the cationic form (I).

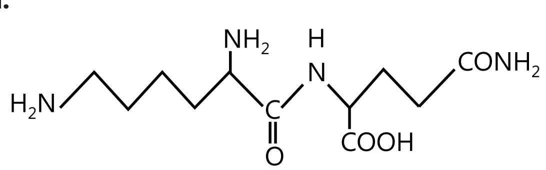
(iii) In alkaline medium, it will exist in the anionic form (III) and will migrate towards anode under the influence of an electric field.

Illustration 8: Following two amino acids, lysine and glutamine form dipeptide linkage. What are the two possible dipeptides?

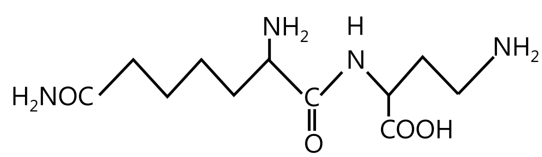




Sol:

(i) 

Lyslglutamine
(Lys-Gln or K-Q)

(ii) 

Glnyllysine
(Gln-Lys or Q-K)

6. POLYMERS

A polymer is a compound of high molecular mass formed by the combining large number of small molecules and the process is called polymerization. The small molecules that constitute the repeating units in a polymer are called monomer units. These large molecules have relative molecular masses in the range $10^4 - 10^6$ amu.

E.g. $\underset{\text{ethene}}{nCH_2 = CH_2} \longrightarrow \underset{\text{polyethene}}{\left[CH_2 - CH_2 -\right]_n}$.

Where n is as high as 10^5. The number of monomer units in a polymer is called the degree of polymerization.

7. CLASSIFICATION OF POLYMERS

(a) On the Basis of Source

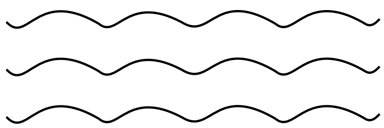
(i) Natural polymers: These polymers are found in plants and animals. Examples are proteins, cellulose, starch, some resin and rubber.

(ii) Semi-synthetic polymers: Cellulose derivatives as cellulose acetate (rayon), cellulose nitrate, etc. are the usual examples of this sub category.

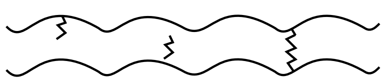
(iii) Synthetic polymers: A variety of synthetic polymers such as plastic (polythene), synthetic fibers (nylon 6,6) and synthetic rubbers (Buna –S) are examples of manmade polymers extensively used in daily life as well as in industry.

(b) On the Basis of Structure: There are three different types based on the structure of the polymers.

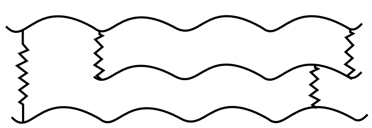
(i) Linear polymers: These polymers consist of long and straight chains. The examples are high density polythene, polyvinyl chloride, etc. These are represented as:



(ii) Branched chain polymers: These polymers contain linear chains having some branches, For example, low density polythene. These are depicted as follows:



(iii) Cross-linked or Network polymers: These are usually formed from bifunctional and trifunctional monomers and contain strong covalent bonds between various linear polymer chains. For example, bakelite, melamine, etc. These polymers are depicted as follows:



(c) On the Basis of Synthesis: These are of two types based on synthesis –

(i) Condensation polymerization: In this, the monomer (same or different) units link with each other by the elimination of a small molecule (for example, water, methyl alcohol) as a byproduct. The polymer formed is known as condensation polymer. Nylon and terylene are the most common examples.

Since the condensation polymerization proceeds by a stepwise intermolecular condensation, it is also known as step polymerization and the polymer formed is known as step growth polymer.

$$n\,H_2N(CH_2)_6NH_2 + n\,HOOC\,(CH_2)_4\,COOH \longrightarrow \underbrace{-\left[NH(CH_2)_6NHCO(CH_2)_6CO\right]_n-}_{\text{Nylon}-6,6} + nH_2O$$

(ii) Addition polymerization: This involves self-addition of several unsaturated molecules of one or two monomers without loss of any small molecule to form a single giant molecule. The polymer formed is known as addition polymer. Polythene is the most common example. However, the addition polymers formed by the polymerization of a single monomeric species is known as homopolymers, for example, polyethene.

$$\underset{\text{Ethene}}{nCH_2 = CH_2} \longrightarrow \underset{\text{Polyethene}}{-(CH_2 - CH_2)_n-}\text{Homopolymer}$$

The polymers made by addition polymerization from two different monomers are termed as copolymers, for example, Buna-S, Buna-N, etc.

(d) On the Basis of Molecular Forces: A large number of polymer applications in different fields depend on their unique mechanical properties like tensile strength, elasticity, toughness, etc. These mechanical properties are governed by intermolecular forces, for example, van der Waals forces and hydrogen bonds.

(i) Elastomer: In these polymers, polymer chains are held together by the weakest intermolecular force. Weak binding forces permit the polymer to be stretched. A few "crosslinks" are introduced in between the chains, which help the polymer to retract to its original position after the force is released as in vulcanized rubber. The examples are Buna-N, neoprene, etc.

(ii) Fibers: In these polymers, polymer chain held together by strong intermolecular forces, like hydrogen bonding. These strong forces also lead to close packing of chains and thus impart crystalline nature. Fibers are the thread-forming solids that possess high tensile strength and high modulus. The examples are polyamides (nylon -6, 6), polyesters (terylene), etc.

(iii) Thermoplastic polymers: These polymers possess intermolecular forces of attraction intermediate between elastomers and fibers. These are the linear or slightly branched long-chain molecules capable of repeatedly softening on heating and hardening on cooling. Some common thermoplastics are polythene, polystyrene, polyvinyls, etc.

(iv) Thermosetting polymers: These polymers are cross linked or heavily branched molecules, which on heating undergo extensive cross linking in molds and again become infusible. These cannot be reused. Some common example are bakelite, urea-formaldelyde resins, etc.

(e) Classification on the Basis of Type of Polymerization: Synthetic polymers have been classified into definite classes in various manners, for example,

(i) All the synthetic polymers may be classified into two groups based on of the type of the process involved during their preparation, viz. condensation or addition polymers involving condensation or addition polymerization processes, respectively, during their synthesis.

(ii) A more rational method of classification is based upon the sequence of synthesis of the polymer (i.e., mode of addition of the monomer units to the growing chain).

According to this method, polymers may be of two types, viz. chain growth polymers and step growth polymers.

- Chain growth polymers (earlier called as addition polymers). These polymers are formed by the successive addition of monomer units to the growing chain having a reactive intermediate (free radical, carbocation or carbanion)

  The most important free radical initiator is benzoyl peroxide.

E.g. $\underset{\text{Benzoylperoxide}}{RCO - O - O - OCR} \xrightarrow{\text{heat}} 2RCO\dot{O} \longrightarrow 2\dot{R} + 2CO_2$

$$\dot{R} + H_2C = CH_2 \xrightarrow{\text{heat}} R - CH_2\dot{C}H_2 \xrightarrow{CH_2=CH_2} R - CH_2 - CH_2 - \dot{C}H_2 \longrightarrow R\left[-CH_2 - CH_2\right]_n-$$

Examples of chain growth polymers

Monomer(s)	**Polymer**
Ethylene	Polyethylene
Propylene	Polypropylene
Tetrafluoroethylene	Polytetrafluoroethylene (PTFE) or Teflon
Vinyl chloride	Polyvinyl chloride (PVC)
Isoprene	Polyisoprene (Natural rubber)
Butadiene	Polybutadiene
Butadiene and styrene	Buna-S

- Step growth polymers (earlier called as condensation polymers). These polymers are formed through a series of independent steps (reactions). Each step involves the condensation (bond formation) between two difunctional units (monomers) leading to the formation of small polymer (say dimer, trimer, tetramer, etc.)

Step 1.	A + B (Monomer, Monomer)	→ A – B (Dimer)
Step 2.	A — B + A	→ A — B —A (Trimer)
Step 3.	A — B + A — B (Dimer, Dimer)	→ A — B — A — B (Tetramer)
Step 4.	A — B — A — B + A — B	→ A — B — A — B — A — B or $(A — B)_3$
Step 5.	$(A — B)_3$	→ $(— A — B —)_n$ (Polymer)

Examples of step growth polymers

Monomers	**Polymers**
Adipic acid hexamethylene diamine	Nylon-66
Terepthalic acid and ethylene glycol	Terylene
Phenol and formaldehyde	Bakelite

(f) Based on the magnitude of molecular forces the polymers may be classified as:

(i) Elastomers

- In which the intermolecular forces of attraction are the weakest. They are amorphous and have high degree of elasticity, for example, Buna-S.

(ii) Fibers

- In which the intermolecular forces of attraction are the strongest like H bonding or dipole-dipole attraction.
- They have high tensile strength, high melting point and low solubility, for example, polyesters, polyacrylonitriles

(iii) Thermoplastics

- In which the intermolecular forces of attraction are in between those of elastomers and fibers
- They are hard at room temperature, soften on heating without any change in mechanical properties of plastic, have little or no cross links, for example, polythene, polyacrylonitrile, Teflon, etc.
- Semi-fluid substances with low molecular weight that once set into particular mold cannot be used again and again.
- This is because of extensive crosslinking between two polymer chains to give a three-dimensional network, for example, bakelite, urea-formaldehyde; melamine formaldehyde etc.

8. MOLECULAR MASS OF POLYMERS

(a) There are two types of average molecular mass of polymers.

(b) Number average molecular mass $\left(\bar{M}n\right)$: It is determined by methods depending upon the number of molecules present in the polymer sample, for example, colligative properties like ΔT_f; ΔT_b, Osmotic pressure

(c) $$\bar{M}n = \frac{N_1M_1 + N_2M_2 + N_3M_3}{N_1 + N_2 + N_3} = \frac{\sum N_1M_1}{\sum N_1}$$

Where N_1, N_2, N_3 are the number of molecules. M_1, M_2, M_3 are the molecular masses.

Weight Average Molecular Mass: It is determined by using the methods depending upon the masses for the individual molecules like light scattering, ultracentrifugation, sedimentation, etc.

$$\bar{M}w = \frac{\sum m_1M_1}{\sum m_1} = \frac{\sum N_1M_1^2}{\sum N_1m_1}$$; *M*– is mass of macromolecule

Example in a polymer sample, 30% molecules have molecular mass 20,000; 40% have molecular mass 30,000 and the rest 30% have 60,000. Calculate the number average and mass average molecular masses.

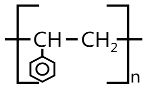
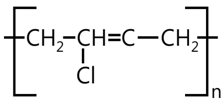
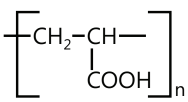
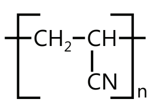
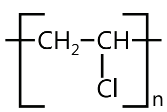
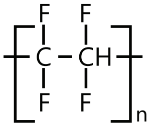
$$\bar{M}n = \frac{30\times 20000 + 40\times 30{,}000 + 30\times 60{,}000}{30+40+30} = \frac{600000+1200000+1800000}{100} = \frac{3600000}{100} = 36000$$

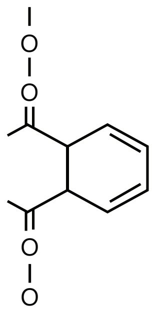
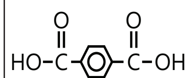
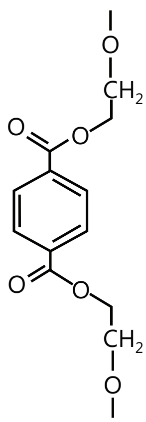
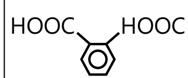
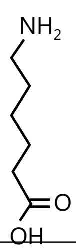
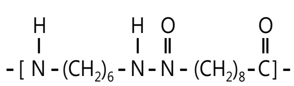
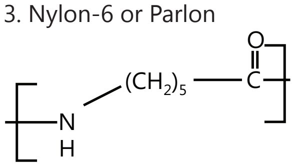
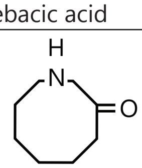
$$\bar{M}w = \frac{30(20000)^2 + 40(30{,}000)^2 + 30(60{,}000)^2}{30\times 20000 + 40\times 30{,}000 + 30\times 60{,}000} = 43{,}333$$

9. VARIOUS TYPES OF POLYMERS

Table 26.7: Types of polymers

Name of the polymer along with abbreviation	**Structure of monomer**	**Natural of polymer**	**Properties**	**Uses**
A. Addition Polymers				
I. Polyolefins				
1. Polymers or polythome $\left[-CH_2-CH_2-\right]$	$CH_2 = CH_2$	(a) Low-density polyethylene (LDPE) in an addition or chain-growth homopolymer. It is a highly branched polymer and is obtained by free-radical polymerization (b) High-density polyethylene (HDPE) is obtained by coordination polymerization. It is a linear addition or chain-growth homopolymer.	Transparent, moderate tensile strength, high toughness. Translucent, chemical inert, growth toughness and tensile strength.	Packing material (plastic films, bags etc.) insulation for electrical wires and cables. Manufacture buckets, tubs, pipes, bottles and toys.
2. Polypropylene or Polypropene $\left[-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_2-\right]$	$CH_3CH{=}CH_2$	Addition homopolymer linear can be obtained by free-radical or Ziegler-Natta polymerization.	Harder and stronger than polythene	Packing of textile and foods, for making liners of bags, heat shrinkable wraps, carpet fibers, ropes, automotive molding, stronger pipes and bottles.

Name of the polymer along with abbreviation	Structure of monomer	Natural of polymer	Properties	Uses
3. Polystyrene or Styron 	$C_6H_5CH=CH_2$	Addition homopolymer, linear chain	Transparent	Plastic toys, household wares, radio and television bodies, refrigerator linings etc.
II Polydienes				
1. Neoprene 	$CH_2=CH-C(Cl)=CH_2$ Chloroprene or 2-Chloro-1, 3-butadiene.	Addition homopolymer	Rubber like, inferior to natural rubber but superior in its stability to serial oxidation and its resistance to oils, gasoline, etc.	Hoses, shoe heels, stoppers etc.
III. Polyacrylates				
1. Poly (methyl methacrylate) Plexigas, Lucise, Acrylite Perspex (PMMA)	$CH_2=C(Cl)-COOCH_3$ Methyl methacrylate	Addition homopolymer	Hard, transparent, excellent light transmission properties, optical clarity better than glass.	Lenses, light covers, light shades, signboards, transparent domes, skylights, aircraft windows, dentures and plastic jewelry.
2. Poly (ethyl acrylate) 	$CH_2=CHCOOC_2H_5$	Addition homopolymer.	Tough, rubber like product.	—
3. Polyacrylonitrile (PAN) 	$CH_2 = CH–CN$ Acrylonitrile	Addition homopolymer.	Hard and has high melting material.	Manufacture of fibers, orlon, acrilon used for making clothes, carpets, blankets.
IV. Polyhalolefines				
1. Polyvinyl chloride (PVC) 	$CH_2=CH–Cl$ Vinyl chloride	Homopolymer, chain growth	Pliable (easily molded)	(i) When plasticized with high-boiling esters used in rain coats, hand bags, shower curtains, upholstery fabrics, shoe soles, vinyl flooring (ii) Good electrical insulators for wires and cables (iii) Making hose pipes.
2.Polytetrafluoro ethylene of Teflon (PTFE) 	$F_2C = CF_2$ Tetrafluoroethylene	Chain growth, homopolymer	Flexible and inert to solvents, boiling acids, even aquaregia, stable up to 598 K.	(i) For making nonstick utensils coating (ii) Making baskets, pump packings, valves, seals, nonlubricated bearings.
Condensation Polymers				
I. Polyesters				

Name of the polymer along with abbreviation	Structure of monomer	Natural of polymer	Properties	Uses
1. Terylene or Dacron 	$HO–CH_2–CH_2–OH$ Ethylene glycol or Ethane-1, 2-diol and  Terephthalic acid or Benzene-1, 4-dicarboxylic acid	Copolymer, linear, step-growth. Thermoplastic, dissolves in suitable solvents and its solutions, on evaporation leaves a tough but non-flexible a film.	For making paints and lacquers.	
2. Glyptal or Alkydresin 	$HO–CH_2–CH_2–OH$ Ethylene glycol and  Phthalic acid or Benzene-1, 2-dicarboxylic acid	Copolymer, linear, step-growth. Thermoplastic, dissolves in suitable solvents and its solutions, on evaporation leaves a tough but non-flexible a film.	For making paints and lacquers.	
II. Polyamides				
Nylon-6,6 	$HO-\overset{O}{\overset{\|}{C}}-(CH_2)_4\overset{O}{\overset{\|}{C}}-OH$ Adipic acid and $H_2N—(CH_2)_4—NH_2$ Hexamethylene diamine	Copolymer, step, growth, linear	High tensile strength, abrasion resistant, somewhat elastic.	(i) Textile fabrics, carpets, bristles for brushes (ii) Substitute for metals in bearings and gears. (iii) Crinked nylon is used for making elastic hosiery.
2. Nylon-610 	$H_2N(CH_2)_6NH_2$ Hexamethylene diamine and $HOOC(CH_2)_8$ COOH Sebacic acid	Copolymer, step- growth, linear	For making points and lacquers.	(i) Textile fabrics, carpets, bristles for brushes (ii) Substitute for metals in bearings and gears. (iii) Crimped nylon is used for making elastic hosiery.
3. Nylon-6 or Parlon 	 E-Caprolactam	Homopolymer, step growth, linear		Mountaineering ropes, tire cords and fabrics
III Formaldehyde resins				

Name of the polymer along with abbreviation	Structure of monomer	Natural of polymer	Properties	Uses
1. Phenol-formaldehyde resin or Bakelite	Phenol and formaldehyde	Copolymer, step growth, highly branched thermosetting polymer		(i) Bakelite with low degree of polymerization is used as binding glue for wooden planks and in varnishes and lacquers (ii) Bakelite with high degree of polymerization is used for making combs and micatable tops, fountain pen barrels, electrical goods (switches and plugs), gramophone records etc.

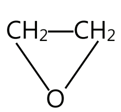
PLANCESS CONCEPTS

- Polymers are product of large number of small molecules, called monomers, chemically bonded to each other.
- The individual large polymer molecules are known as macromolecules.
- Polymers are characterized by the average molecular mass of the chains and the number of repeating units in such polymers is known as the degree of polymerization.
- The physical properties of a polymer are determined by such factors as the flexibility of macromolecules, the sizes and types of group attached to the polymer chains and the magnitude of intermolecular forces.
- Polymers may be linear, branched or cross linked.
- Copolymers are produced from two monomers combined randomly or in a specific manner
- To participate in polymerization, a molecule must be able to react at both ends.
- The principal types of polymerization reaction are chain reaction polymerization (initiation propagation and termination), which is undergone by monomers such as vinyl bromide and step reaction polymerization, which involves reactions between functional group on different monomer molecules like adipic acid and hexamethylene diamine to give nylon 66.

Neeraj Toshniwal (JEE 2009, AIR 21)

Illustration 9: Write the structures of the monomers of the following polymers: **(JEE MAIN)**

(a) $\left(CH_2CH_2—O—CH_2CH_2 \right)_n$ (b) $[= CH(CH_2)_4CH = N(CH_2)_6N =]_n$

Sol: (a) 

Ethylene oxide
(Monomer)

(b) $HO — CH —(CH_2)_4—CH_2 — OH$ and $H_2N—(CH_2)_6—NH_2$

Hexane-1, 6 diol
(Monomer)

Hexamethylenediamine
(Monomer)

Illustration 10: (a) Can a copolymer be formed in both addition and condensation polymerization? Explain.
(b) Can a homopolymer be formed in both addition and condensation polymerization? Explain. **(JEE MAIN)**

Sol: (a) Yes, copolymers can be formed both in addition and condensation, polymerization. For example, Buna-S is an addition copolymer of styrene and 1, 3-butadiene while nylon-6,6, bakelite and polyester are condensation copolymers.
(b) Yes, homopolymers can be formed both in addition and condensation polymerization. For example, polythene, PVC, PMMA, PAN, neoprene, etc. are example of addition homopolymers while nylon-6 is an example of condensation homopolymer.

Illustration 11: How does the presence of benzoquinone inhibit the free radical polymerization of a vinyl derivative? **(JEE ADVANCED)**

Sol: Benzoquinone react with radical of the growing polymer chain (R•) to form a new radical (I) which is extremely uncreative, since it is highly stabilized by resonance. Because of the lack of reactivity of this new radical further growth of the polymer chain is interrupted and hence the reaction stops.

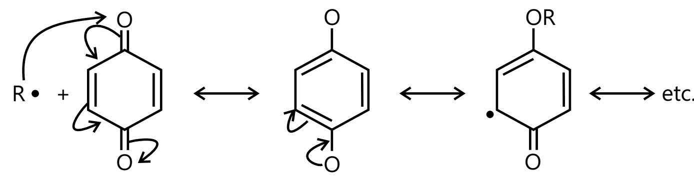
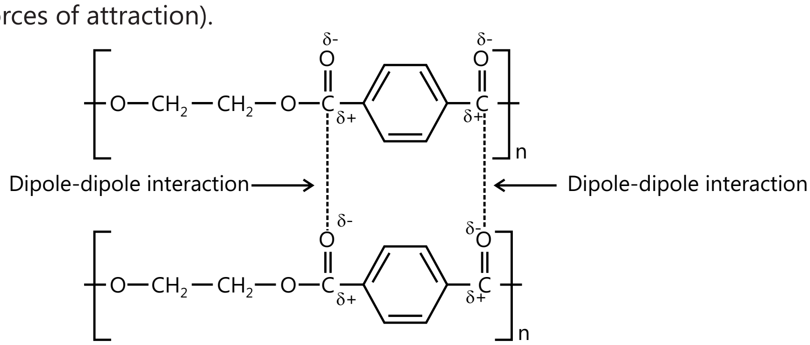


Illustration 12: Differentiate the following pairs of polymers based on the property mentioned against each. **(JEE ADVANCED)**

(i) Novolac and bakelite (structure).
(ii) Buna-S and terylene (intermolecular forces of attraction).

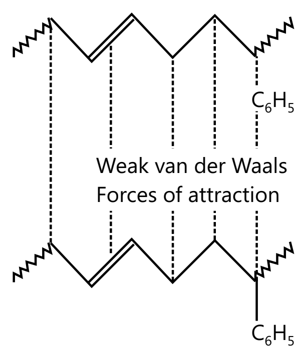
Sol: (i) Novolac is a linear but bakelite is a cross-linked polymer of phenol and formaldehyde.

(ii) Terylene contains ester functional groups that are polar in nature. Therefore, the intermolecular forces of attraction involved in terylene are strong dipole–dipole interaction as shown below:



Terylene polymer chains

Buna-S, on the other hand, does not have polar functional groups. It has only nonpolar hydrocarbon chains and hence has only weak Van Der Waals forces of attraction as shown below:



Buna-S polymer Chains

POINTS TO REMEMBER

- Carbohydrates
  - On the basis of physical characteristics
    - Sugar
    - Non-sugar
  - On the basis of hydrolysis
    - Monosaccharides
    - Oligosaccharides
    - Polysaccharides
  - On the basis of test with reagents
    - Reducing
    - Non-neducing

- Dissachharides
  - Maltose
  - Sucrose
  - Lactose

- Representation Structure
  - Open chain (Fischer Projection)
  - Cyclic structure
    - Haworth
    - Chain form

- Proteins
  - Fibrous Proteins
  - Globular Proteins

- Structure of Protein
  - Primary structure
  - Secondary structure
    - α-helix
    - β-pleated
  - Tertiary structure
  - Quaternary structure

- Amino acids
  - Basic amino acids
  - Neutral amino acids
  - Acidic amino acids

- Polymers
  - On the basis of source.
  - On the basis of structure.
  - On the basis of synthesis.
  - On the basis of molecular force.
  - On the basis of type of polymerization.

Solved Examples

JEE Main/Boards

Example 1: What type of bonding occurs in globular protein?

Sol: Globular protein is spherical in nature and are water soluble. Globular protein may have the following types of bonding: hydrogen bonding, disulphide bridges, ionic or salt bridges, and hydrophobic interactions.

Example 2: What will be the sequence of bases on mRNA molecules synthesized on the following strand of DNA?

TATCTACCTGGA

Sol: The opposite bases bind with the strand i.e. A-T and G-C.

Sequence of bases on mRNA molecule:

DNA strand TAT CTA CCT GGA

m-RNA AUA GAU GGA CCU

Example 3: Name one reducing and one nonreducing disaccharide.

Sol: Reducing sugar has a free aldehydic group which can be easily oxidized and can thus reduce other substances.

Maltose or lactose (reducing)

Sucrose (non-reducing)

Example 4: Explain the functions of nucleic acids.

Sol: Nucleic acids are large biomolecules consisting of RNA and DNA.

Nucleic acids have two important functions:

i) Replication: Due to its unique property of self-replication (process by which a single DNA molecule produces two identical species of itself), it is responsible for maintaining the heredity traits from one generation to another.

ii) Protein synthesis: RNA helps in the biosynthesis of proteins and is, in one way, responsible for the process of learning and memory storage. Furthermore, it sends information and instructions to the cell for the manufacture of specific proteins.

Example 5: Define the terms:

(A) Gene (B) Genetic code

(C) Transcription (D) Translation

(E) Codons

Sol: (A) Gene: A gene is a sequence of base triplets in a strand of DNA helix that factions to code a polypeptide chain. The polypeptide chain ultimately becomes the part of the protein synthesized. Every protein in a cell has the corresponding gene.

(B) Genetic code: The relation between the amino acids and the nucleotide triple is called is genetic code.

(C) Transcription: The way the code on DNA is copied to give the complementary code on RNA is called transcription.

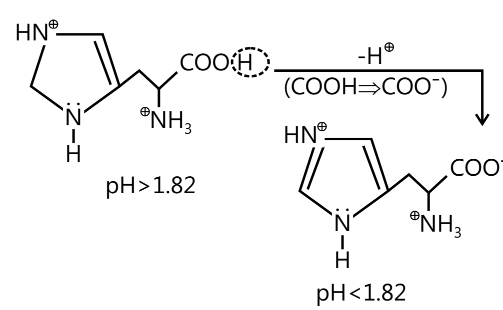
(D) Translation: The way the four-base code in nucleic acid is turned into a 20 unit code needed to specify

The amino acid sequence in proteins during synthesis is called translation.

(E) Codons: The nucleotide bases in RNA function in groups of three (triplets) in coding amino acids. These base triplets are called codons.

Example 6: a. Write the structure of histidine when pH < 1.82 and pH > 1.82.

Sol: a.



Example 7: 'The two strands of DNA are not identical, but are complementary'. Explain this statement.

Sol: DNA consists of two strands of polynucleotides coiled around each other in the form of a double helix. The nucleotides making up each strand of DNA are connected by phosphate ester bonds. This forms the backbone of each DNA strand, from which the bases extend. The bases of one strand of DNA are paired with the bases on the other strand by means of hydrogen bonding. This hydrogen bonding is very specific as the structure of bases permits only one mode of pairing. Adenine pairs only thymine via two hydrogen bonds and guanine pairs with cytosine through three hydrogen bonds. The two strands of DNA are said to be complementary to each other in the sense that the sequence of bases in one strand automatically determines that of the other. These strands are not identical.

Example 8: Which purine and pyrimidine bases are present in DNA and RNA?

Sol: Adenine and guanine (purine base) in DNA and RNA. Cytosine, thymine, and uracil (pyrimidine base)

Example 9: What are the monomers constituting proteins?

Sol: The amino acids such as glycine and alanine are the monomers that constitute proteins.

Example 10: What is the effect of pH on the action of enzyme?

Sol: The low or high pH values can cause denaturation of the protein and hence make enzyme's protein inactive.

JEE Advanced/Boards

Example 1: Complete the following reactions.

(i) $\underset{(A)}{\alpha\text{-D-Glocofuranose}} \xrightarrow[\text{Acetone}/H_2SO_4]{} (B) \xrightarrow[\text{(i) } H^{\oplus}]{\text{(i) } PhCH_2Cl/\overset{\oplus}{O}H} (C)$

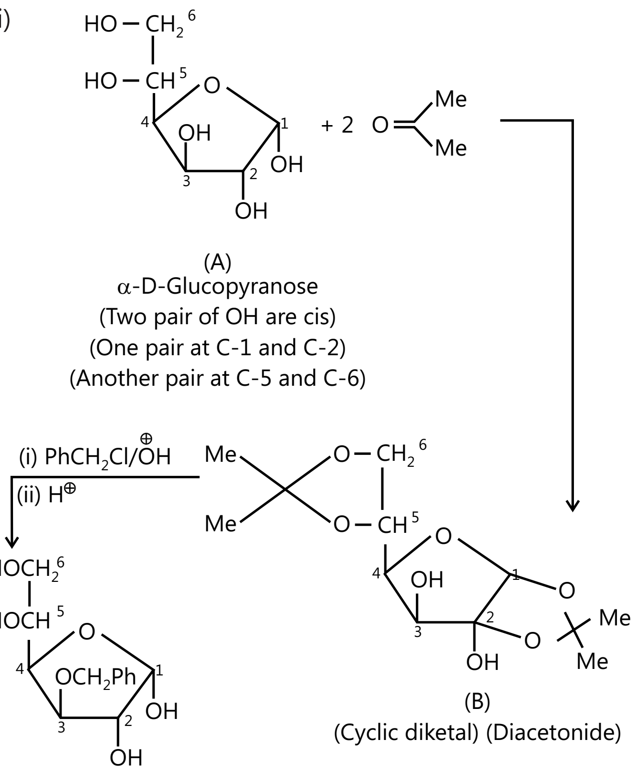
(ii) $\underset{(D)}{\beta\text{-D-Glocofuranose}} \xrightarrow[\text{Acetone}/H^{\oplus}]{} (E) \xrightarrow[\text{(i) } H^{\oplus}]{\text{(i) } PhCH_2Cl/\overset{\oplus}{O}H} (F)$

(iii) $\underset{(G)}{\alpha\text{-D-Glucopyranose}} \xrightarrow[\text{Acetone}/H^{\oplus}]{} (H) \xrightarrow[\text{(i) } H^{\oplus}]{\text{(i) } PhCH_2Cl/\overset{\oplus}{O}H} (F)$

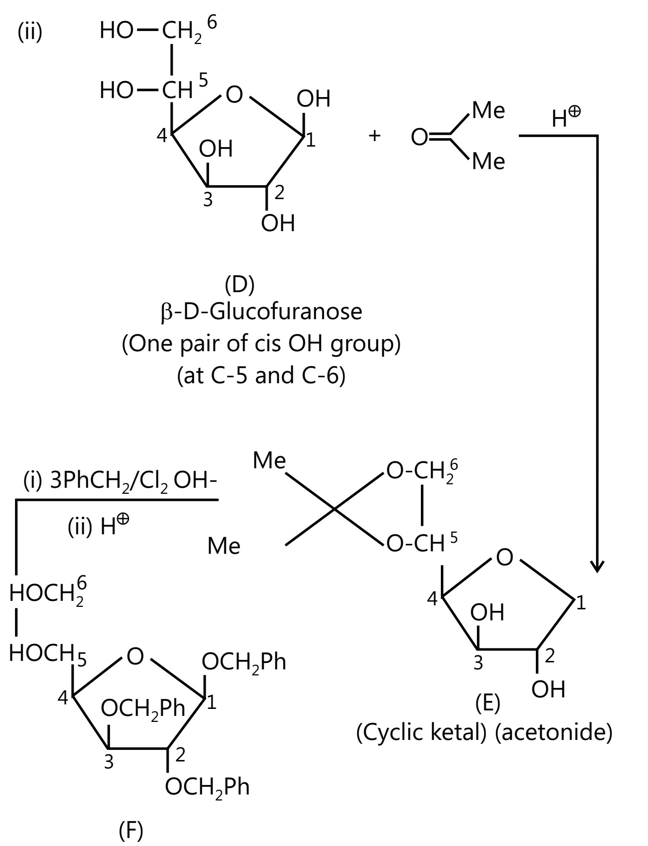
(iv) $\underset{(J)}{\beta\text{-D-Glucopyranose}} \xrightarrow[\text{Acetone}/H^{\oplus}]{} (K)$

Sol: Acetone forms a cyclic ketal called an acetonide with two cis (OH) groups. D-Glucopyranose is in equilibrium with some D-glucofuranose (having two pais of cis OH groups), the formation of diketal shift the equilibrium toward the reaction D-glucofuranose.

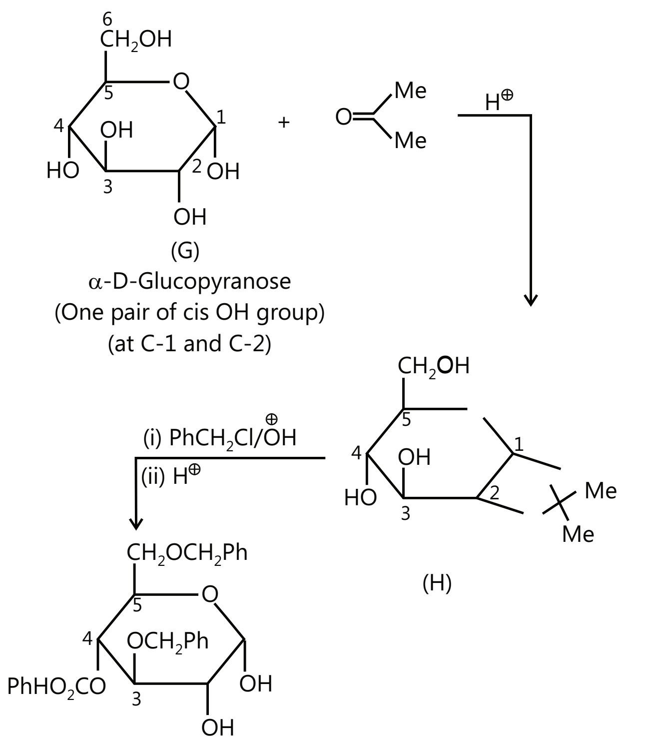
(i)



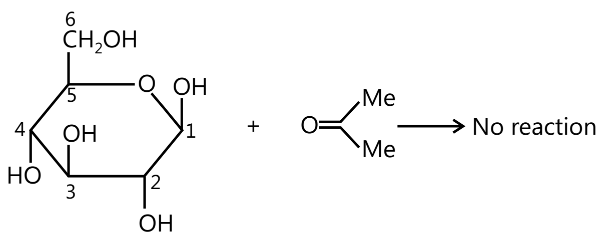
(ii)



(iii)



(iv)



(J)

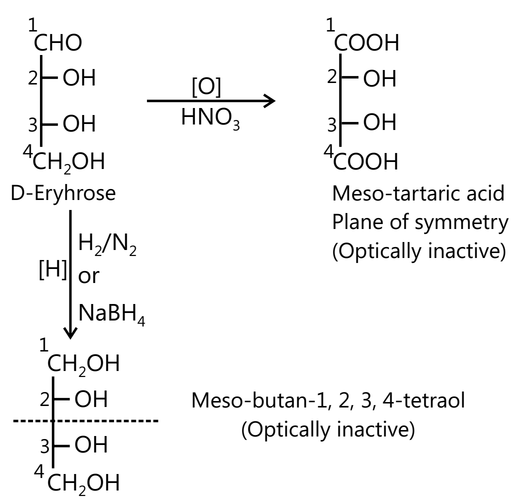
α-D-Glucopyranose

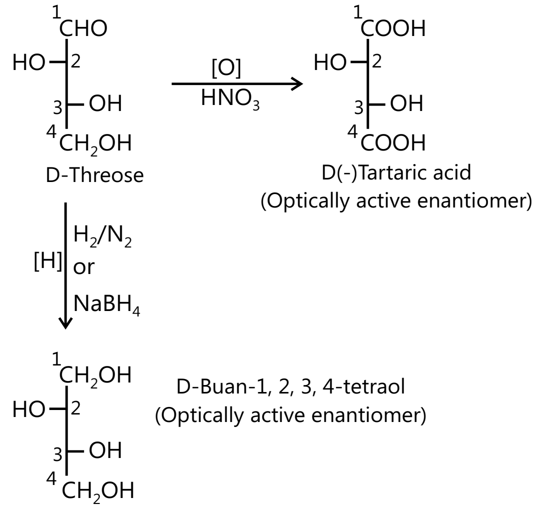
(No pair of cis OH group)

Example 2: Differentiate between D-erythrose and D-threose by

(a) Mild oxidation and (b) Reduction.

Sol:





Example 3: a. Name the smallest aldose that forms cyclic hemiacetal and the functional groups are involved in its formation.

b. What is invert sugar?

c. Calculate the specific rotation of invert sugar.

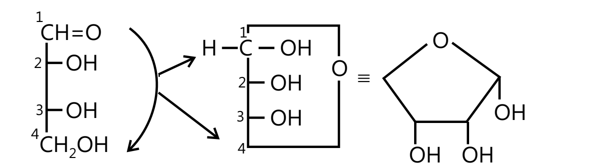
Given, $\alpha|_D$ of D-glucose = 52.7°

$|\alpha|_D$ of D-fructose = –92.4°

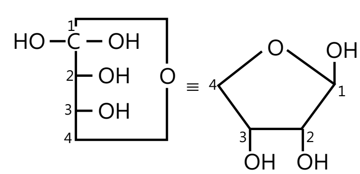
d. Give the mechanism of mutarotation of β-D-glucopyranose in (i) aq. $H^{\oplus}$ and (ii) $OH^{\ominus}$.

e. Why is the mutarotation faster in the presence of 2-pyridinol?

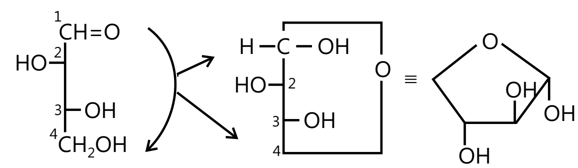
Sol: a.



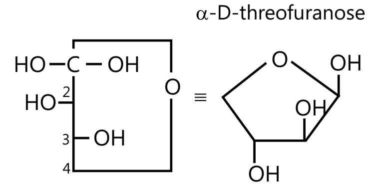
D-Erthrofuranose



β-D-Erthrofuranose



α-D-threofuranose



β-D-threofuranose

b. Equimolar mixture of D-glucose and D-fructose obtained but the hydrolysis of sucrose is called invert sugar. Since the specific rotation of sucrose is positive and after hydrolysis it changes to negative value and this process is called inversion of cane sugar.

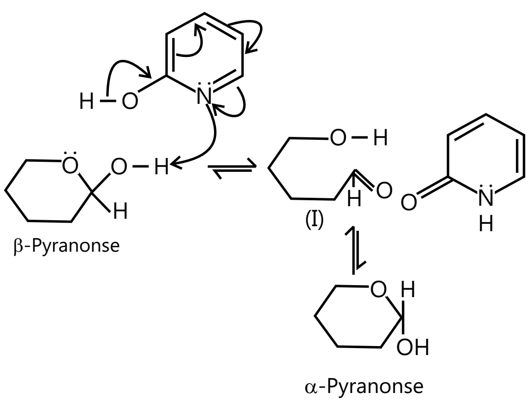
c. The specific rotation is half the sum of specific rotation of glucose and fructose.

Specific rotation of invert sugar = $\frac{1}{2}[+52.7^\circ+(-92.4^\circ)]$ = -19.99°

d. i. In acidic medium:

The smallest aldose is a tetraldose that has four C atoms and an O atom to form a five-membered ring. The CHO group and 1° OH group of tetrose are involved in the formation of ring. Both erythrose and threose form cyclic hemiacetals. The rate depends on the conversion of cyclic hemi- (ii)acetal to open-chain aldehyde (i).

e.2-Pyridinol is an acid-base catalyst [containing both basic ($\ddot{N}$) and acidic (OH) group] that gives H ion to hemiacetalic O atom and simultaneously removes $H^{\oplus}$ ions from the HO– group of the hemiacetal by the formation a cyclic intermediate transition state.



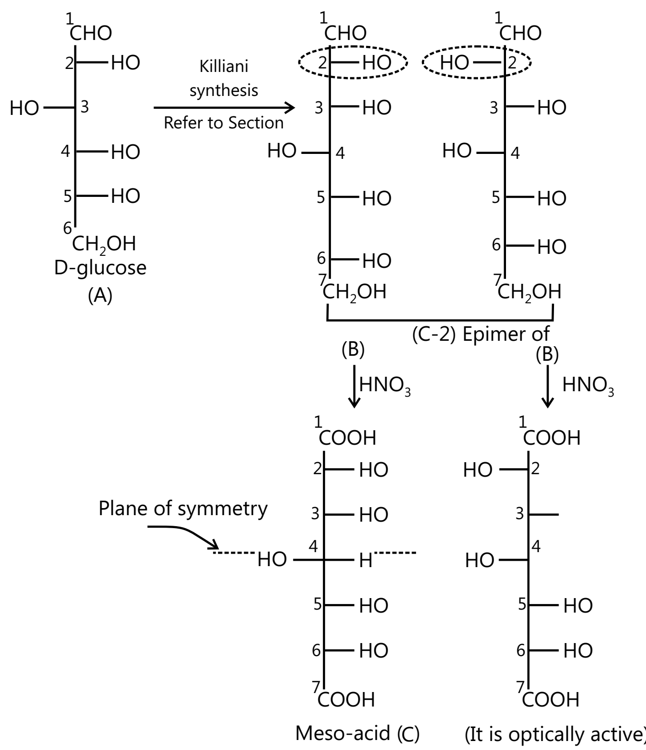
Example 4: Complete the following reactions:

(i) $\underset{(A)}{\text{D - Glucose}} \xrightarrow[\text{synthesis}]{\text{Killiani}} \underset{(B)}{\text{Pair}} \xrightarrow{HNO_3}$ Meso-Heptaldaric acid (C)

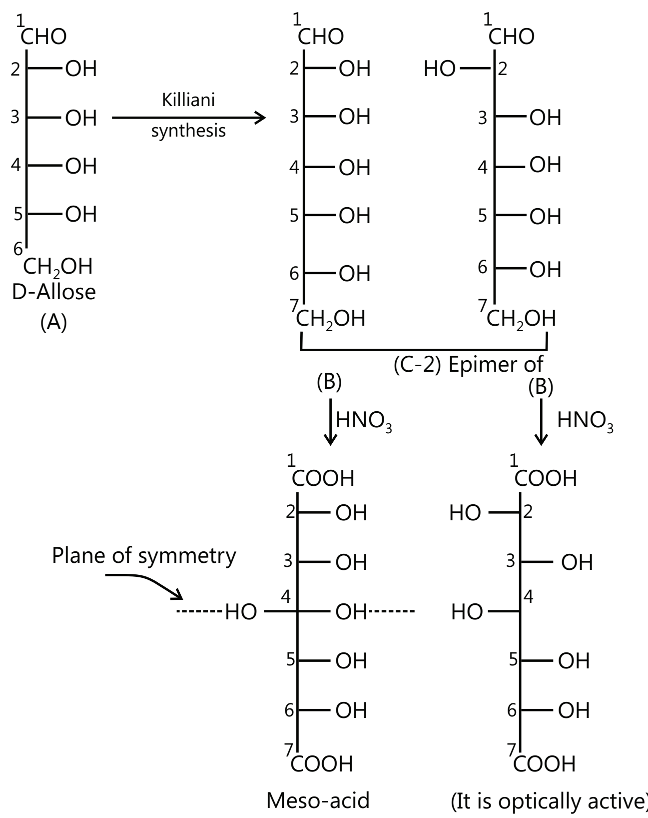
(ii) $\underset{(D)}{\text{D - Allose}} \xrightarrow[\text{synthesis}]{\text{Killiani}} \underset{(B)}{\text{Pair}} \xrightarrow{HNO_3}$ Meso-Heptaldaric acid (F)

Explain whether the acids (C) and (F) are same or different. Which pair out of (B) and (E) gives meso-acids (C) and (F)?

Sol: (i)



(ii)



Although both acids (C) and (F) are heptaldric acid and both are meso (optically inactive) but they are different.

Example 5: a. How is the mixture of aspartic acid (A) histidine (B) and threonine (C) separated by electrophoresis method?

pI (pH at isoelectric point) are given.

pI of (A), (B), and (C) are 2.77, 7.59 and 5.60, respectively.

b. How are they separated by solubility method?

Sol: a. Choose the intermediate pH of 5.60. This is the pI of threonin, which has a zero net charge and does not migrate in the electric field or in the electrophoresis experiment.

Aspartic acid (pI = 2.77) [Refer to solved example No. 8 (d) above] donates an $H^{\oplus}$ and is converted to anion (III), and migrates to the anode. Histidine (pI = 7.59) accepts an $H^{\oplus}$ and is converted to a cation, and migrates to the cathode.

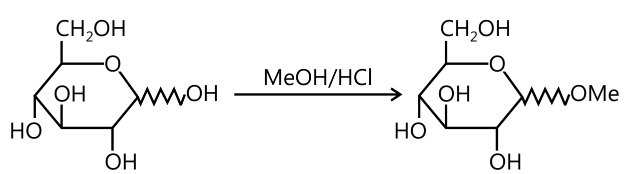
b. At isoelectrical point (pI) the amino acids have least solubility in water and this property is exploited in the separation of different amino acids obtained from the hydrolysis of protein.

To the mixture of three amino acids (A, B and C) set the pH of the solution by adding acid upto 2.77, at which (A) will be least soluble in H_2O and will precipitate out. It is followed by the separation of amino acid (A).

Increase the pH of the remaining solution by adding base upto 5.60, at which amino acid (c) will precipitate out. Similarly, (B) will precipitate out at the pH of 7.59.

Example 6: Convert D-glucopyranose to 2, 3, 4-trimethyl glucopyranoside.

Sol: First convert D-glucose to methyl glucopyranoside with MeOH/HCl. Then CH_2OH is protected by reacting methyl glucopyranoside with $Ph_3C—Cl$ (trityl chloride),

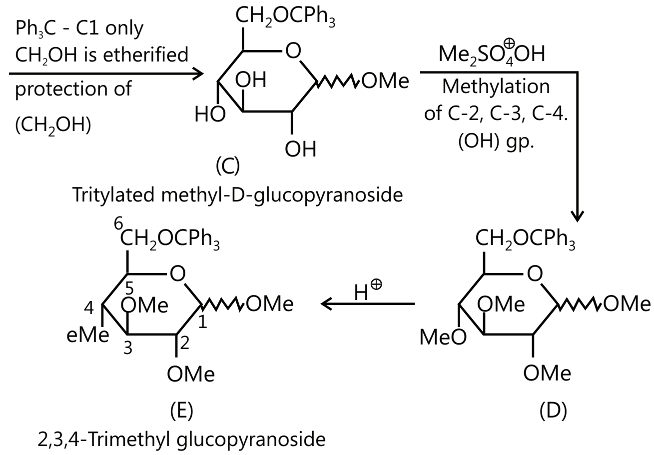


(A) (B)

(α-or β-D-glucopyrnose) Methyl-D-glucopyranoside

Only CH_2OH is etherified giving CH_2OCPh_3 group. The 2° OH groups are sterically hindered and do not react with the bulkyl ($Ph_3C—Cl$) group.

The free OH groups of tritylated methyl glucosides are now methylated with Me_2SO_4/NaOH followed by acidic hydrolysis removes both trityl group and the glycosidic Me group leaving OMe group at C_2, C_3, and C_4 intact. The hydrolysis of $–OCPh_3$, groups proceeds by the formation of stable $Ph_3C^{\oplus}$ (triphenyl methyl carbocation).



Example 7: Write the names and structures of the monomers of the following polymers:

(i) Buna-S (ii) Buna-N (iii) Dacron (iv) Neoprene.

Sol: The names and structures of the monomers are:

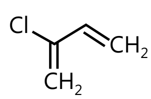
(i) Buna-S:

$$\underset{\text{1,3–Butadiene}}{CH_2 = CH — CH = CH_2} \text{ and } \underset{\text{Styrene}}{C_6H_5 — CH = CH_2}$$

(ii) Buna-N:

$$\underset{\text{1,3–Butadiene}}{CH_2 = CH — CH = CH_2} \text{ and } \underset{\text{Acrylonitrile}}{CH_2 — CH = CN}$$

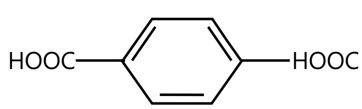
(iii) Neoprene:



Chloropreneor 2 – chloro – 1,3 – butadiene

(iv) Dacron:

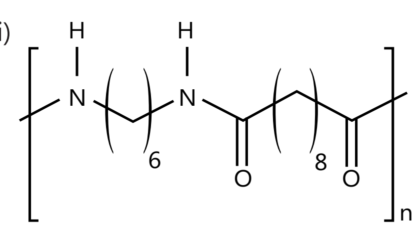
$$\underset{\text{Ethyleneglycol}}{HO — CH_2 — CH_2 — OH} \text{ and}$$

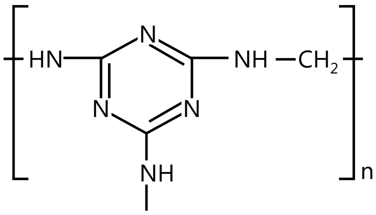


Terephthalic acid

Example 8: Identify the monomer in the following polymeric structures:

(i)

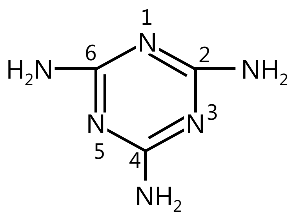


(ii) 

Sol: Monomers are:

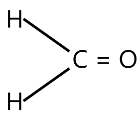
(i) $HOOC—(CH_2)_8—COOH$
Decanoic acid or Sebacic acid

and $H_2N—(CH_2)_6—NH_2$
Hexamthylenediamine

(ii) 

Melamine or
2.4.6.-Triamino-1,3,5-triazine

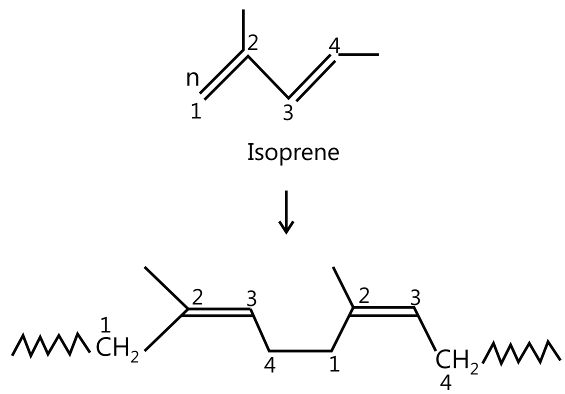
and



Formaldehyde

Example 9: How does the presence of double bonds in rubber molecules influence their structure and reactivity?

Sol: Natural rubber is cis-polyisoprene and is obtained by 1, 4-polymerization of isoprene units. In this polymer, double bonds are located between C_2 and C_3 of each isoprene unit. These cis-double bonds do not allow the polymer chains to come closer for effective interactions and hence intermolecular forces are quite weak. As a result, natural rubber, i.e., cis-polyisoprene has a randomly coiled structure and hence shows elasticity.



cis-Polyisoprene
(Natural rubber)

JEE Main/Boards

Exercise 1

Q.1 What happens when D-glucose in treated with the following reagents?

(i) HI (ii) Bromine water (iii) HNO_3

Q.2 Define the following terms in relation to proteins

(i) Peptide linkage (ii) Denaturation

Q.3 Define the following as related to proteins

(i) Peptide linkage (ii) Primary structure

(iii) Denaturation

Q.4 What are the common types of secondary structure of proteins?

Q.5 How do you explain the amphoteric behavior of amino acids?

Q.6 What is the effect of denaturation on the structure of proteins?

Q.7 Describe the following: (i) Glycosidic linkage

Q.8 Enumerate the reactions of D-glucose which cannot be explained by its open chain structure.

Q.9 What are essential and non-essential amino Acids? Give two examples of each type.

Q.10 List any four vitamins. Mention the chief sources and functions of two of them.

Q.11 (i) What are essential and non-essential amino acids? Give two example of each.

(ii) What is a denatured protein?

Q.12 How are vitamins classified? Name the vitamin responsible for the coagulation of blood.

Q.13 Why are vitamins A and vitamin C essential to us? Give their important sources.

Q.14 Draw open chain structure of aldopentose and aldohexose. How many asymmetric carbons are present in each?

Q.15 (a) Describe the following giving one example: Nucleotide.

(b) List four functions of carbohydrates in living organisms.

Q.16 What type of bonding helps in stabilizing the α-helix structure of proteins?

Q.17 Differentiate between globular and fibrous proteins.

Q.18 (a) Give reasons for the following statements:

(i) Amino acids have comparatively higher melting points than the corresponding haloacids.

(b) What deficiency diseases are caused due to lack to lack of vitamins A, B_1, B_6 and K in human diet?

Q.19 The two strands in DNA are not identical but are complementary. Explain.

Q.20 State difference between the following pair

(i) **α**-helix and **β**-pleated structures.

(ii) Primary and secondary structures of a protein.

Q.21 What are nucleic acids? Mention their two important functions.

Q.22 What is the difference between a nucleoside and a nucleotide?

Q.23 What are reducing and non-reducing sugar? What is the structural feature characterizing reducing sugars?

Q.24 Distinguish between α-glucose and β-glucose.

Q.25 What happens when L-glucose is treated with the following reagents?

(i) HI (ii) Bromine water (iii) HNO_3

Q.26 Write the important structural and functional differences between DNA and RNA.

Q.27 What are the different types of RNA found in the cell?

Q.28 Define the following and give one example of each

(a) Isoelectric point (b) Mutarotation

(c) Enzymes

Q.29 Answer the following queries about proteins?

(i) How are proteins related to amino acid?

(ii) How are oligopeptides different from polypeptides?

(iii) When is a protein said to be denatured?

Q.30 (a) Name the three major classes of carbohydrates and give the distinctive characteristic of each class.

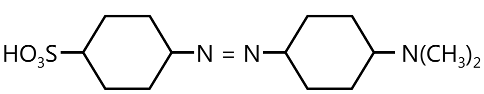
(b) What are nucleotides? Name two classes of nitrogen containing bases found amongst nucleotides.

Exercise 2

Biomolecules

Single Correct Choice Type

Q.1 The chromophore in the dye



is

(A) $-N(CH_3)_2$ (B) $-SO_3H$

(C) $-C_6H_5$ (D) $-N=N-$

Q.2 At the isoelectric point for an amino acid the species present are

(A) $R-\underset{NH_2}{\underset{|}{CH}}-COOH$ (B) $R-\underset{^{+}NH_3}{\underset{|}{CH}}-COOH$

(C) $R-\underset{NH_2}{\underset{|}{CH}}-COO^-$ (D) $R-\underset{^{+}NH_3}{\underset{|}{CH}}-COO^-$

Q.3 Secondary structure of a protein refers to

(A) Mainly denatured proteins and structures of prosthetic groups

(B) Regular folding patterns of contiguous portions of the polypeptide chain

(C) Linear sequence of amino acid residues in the polypeptide chain

(D) None of these

Q.4 The general formula of carbohydrates is:

(A) $C_nH_{2n+1}O$ (B) $C_nH_{2n}O$

(C) $C_n(H_2O)_n$ or $C_x(H_2O)_y$ (D) $C_n(H_2O)_{2n}$

Q.5 Which of the following is a disaccharide?

(A) Sucrose (B) Glucose

(C) Fructose (D) Starch

Q.6 The iron in hemoglobin is bound by

(A) Hydrogen bonds (B) Chelation

(C) Ionic bonds (D) Covalent bonds

Q.7 Anomers have different

(A) Properties (B) Melting points

(C) Specific rotation (D) All of these

Q.8 Peptide bond is

(A) – CO – NH – (B) NH_2 – CO – NH – R

(C) R – CO – NH – R (D) – $CONH_2$

Q.9 Glucose and Fructose are

(A) Tautomers (B) Chain isomers

(C) Functional isomers (D) Geometrical isomers

Q.10 Glucose is

(A) Aldopentose (B) Aldohexose

(C) Ketopentose (D) Ketohexose

Q.11 A substance which can act both as an antiseptic and disinfectant is

(A) Aspirin (B) Chloroxylenol

(C) Bithinal (D) Phenol

Q.12 The reagent used in Ruff's degradation is

(A) Baeyer's reagent (B) Tollen's reagent

(C) Fentons' reagent (D) Benedict's reagent

Q.13 If K_{a1} and K_{a2} are the ionization constants of $H_3N^+CHICOOH$ and $H_3N^+CHICOO^-$, respectively, the pH of the solution at the isoelectric point is

(A) pH = $pK_{a1} + pK_{a2}$ (B) pH = $(pK_{a1} + pK_{a2})^{1/2}$

(C) pH = $(pK_{a1} + pK_{a2})^{1/2}$ (D) pH = $\frac{(pK_{a1} + pK_{a2})}{2}$

Q.14 Coordination polymerization was developed by

(A) Zeigler and Natta (B) Linus Pauling

(C) Beckamann (D) None of these

Q.15 Teflon, polystyrene and neoprene are all

(A) Copolymers (B) Condensation polymers

(C) Homopolymers (D) Monomers

Q.16 Carbohydrates which differ in configuration at the glycoside carbon (i.e. C_1 in aldose and C_2 in ketoses) are called

(A) Anomers (B) Epimers

(C) Diastereomers (D) Enantiomers

Q.17 Choose the correct relationship for α-D-glucose (1) and β-D-glucose (2)

(A) A and B are epimers

(B) A and B are crystal modification

(C) A is a pyranose sugar and B is furanose sugar

(D) A is an aldose and B is a ketose.

Q.18 Natural rubber is a polymer of

(A) Chloroprene (B) Isoprene

(C) 1, 3-Butadiene (d) None

Q.19 Hydrolysis of sucrose is called

(A) Saponification (B) Inversion

(C) Esterification (D) Hydration

Q.20 In vulcanization of rubber

(A) Sulphur reacts to form a new compound

(B) Sulphur cross-links are introduced

(C) Sulphur forms a very thin protective layer over rubber

(D) All statements are correct

Q.21 The simplest amino acid is

(A) Glycine (B) Alanine

(C) Guanine (D) All of the above

Q.22 Which of the following belong to the class of natural polymers?

(A) Proteins (B) Cellulose

(C) Rubber (D) All of the above

Q.23 D-Glucose and β-D glucose differ from each other due to difference in one of carbon with respect to its

(A) Size of hemiacetal ring

(B) Number of —OH groups

(C) Configuration

(D) Conformation

Q.24 Glucose gives the silver mirror test with ammoniacal solution of silver nitrate because it contains

(A) Aldehydes group (B) Ester group

(c) Ketone group (D) Amide group

Q.25 Oligosaccharides contain .... Simple sugar units

(A) 2 to 10 (B) 4 to 8 (C) 6 to 12 (D) 6 to 10

Q.26 A pair of diastereomers that differ only in the configuration about a single carbon atom are called

(A) Anomers (B) Epimers

(C) Conformes (D) Enantiomers

Q.27 Pick out the incorrect statement about ATP.

(A) It is a nucleotide

(B) It contains the purine, adenine

(C) The enzyme-catalysed hydrolysis of ATP to ADP and AMP is accompanied by absorption of energy

(D) Energy is stored in the cell in the form of ATP.

Q.28 Cellulose is a linear polymer of

(A) Glucose (B) Glucose

(C) Fructose (D) None of these

Q.29 Glucose molecule reacts with X number of molecules of phenylhydrazine to yield osazone. The value of X is

(A) Three (B) Two (C) One (D) Four

Q.30 Main structural unit of protein is

(A) Ester linkage (B) Ether linkage

(C) Peptide linkage (D) All the above

Q.31 Which of the following statements is true of proteins?

(A) They catalyse the biochemical reactions

(B) They act as antibodies

(C) They perform all these functions

(D) They perform all these functions

Q.32 Which of the following is a polysaccharide?

(A) Glucose (B) Galactose

(C) Sucrose (D) Pectines

Q.33 Starch can be used as an indicator for the detection of traces of

(A) Glucose in aqueous solution

(B) Proteins in blood

(C) Iodine in aqueous solution

(D) Urea in blood

Q.34 Which of the following statements about ribose in incorrect?

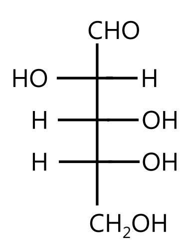
(A) It is polyhydroxy compound

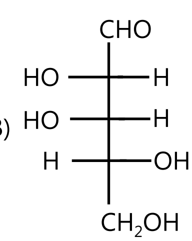
(B) It is an aldehyde sugar

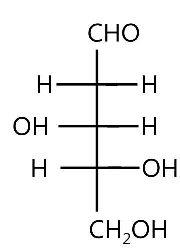
(C) It has six carbon atoms

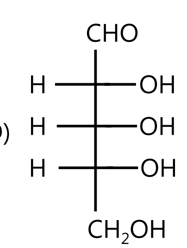
(D) It exhibits optical activity

Q.35 Which of the following is the structure of D-xylose?

(A)


(B)


(C)


(D)


Q.36 Glucose gives the silver mirror test with ammoniacal solution of silver nitrate because it contains the group

(A) Aldehyde (B) Ester

(C) Ketone (D) Amide

Q.37 A condensation polymer among the following is-

(A) Dacron (B) PVC

(C) Polystyrene (D) Teflon

Q.38 Melamine polymer is copolymer of

(A) Melamine and acetaldehyde

(B) Melamine and formaldehyde

(C) Phenol and formaldehyde

(D) None of the above

Q.39 Which one of the following pairs is not correctly matched?

(A) Terylene: Condensation polymer of terephthalic acid and ethylene glycol

(B) Perspex: A homopolymer of methymethacrylate

(C) Teflon: Thermally stable cross-linked polymer of phenol and formaldehyde

(D) Synthetic rubber: A copolymer of butadiene and styrene

Q.40 Orlon is a polymer of-

(A) Styrene (B) Tetrafluoroethylene

(C) Vinyl chloride (D) Acrylonitrile

Q.41 Which one of the following is not an example of chain growth polymer-

(A) Neoprene (B) Buna-S

(C) PMMA (D) Glyptal

Q.42 Ebonite is-

(A) Natural rubber

(B) Synthetic rubber

(C) Highly vulcanized rubber

(D) Polypropene

Q.43 $F_2C = CF_2$ is a monomer of-

(A) Teflon (B) Glyptal (C) Nylon-6 (D) Buna-S

Q.44 P.V.C. is formed by polymerization of-

(A) 1-Chloroethene (B) Ethene

(C) Propene (D) 1-Chloropropene

Q.45 Polyacrylonitrile, characterized by the repeating unit, is made from which of the following monomer?

(A) CH_3CH_2CN (B) $HOCH_2CH_2CH_3$

(C) $CH_3CH = CHCN$ (D) $CH_2 = CHCN$.

Q.46 On the basis of intermolecular forces, polymers are classified as

(A) Elastomers, Fibres, Thermoplastics and Thermosetting

(B) Elastomers, Fibres, Chain growth and Step growth

(C) Addition polymers and Condensation polymers

(D) None of these

Q.47 Which of the following polymers do not involve cross linkages-

(A) Melmac (B) Bakelite

(C) Polythene (D) Vulcanised rubber

Q.48 Ziegler-Natta catalyst is-

(A) $K[KPtCl_3(C_2H_4)]$ (B) $(Ph_3P)_3RhCl$

(C) $Al(C_2H_5)_3 + TiCl_4$ (D) $Fe(C_5H_5)_2$

Q.49 Which one of the following monomers give the polymer neoprene on polymerization?

(A) $CH_2 = CHCl$ (B) $CH_2 = CCl - CH = CH_2$

(C) $CF_2 = CF_2$ (D) $CCl_2 = CCl_2$

Q.50 Which of the following pairs is not correctly matched?

(A) Terylene-condensation polymer of terephthalic acid and ethylene glycol

(B) Teflon-thermally stable cross linked polymer of phenol and formaldehyde

(C) Perspex-a homopolymer of methyl methacrylate

(D) Synthetic rubber –a copolymer of butadiene and styrene

Q.51 Which one of the following is used to make ‘non-stick’ cookware?

(A) PVC

(B) Polystyrene

(C) Polyethylene terephthalate

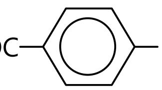
(D) Polytetrafluoroethylene

Q.52 Which compound/set of compounds is used in the manufacture of nylon-66?

(A) $HOOC(CH_2)_4COOH + H_2N(CH_2)_6NH_2$

(B) $CH_2 = CH–CH(CH) = CH_2$

(C) $CH_2 = CH_2$

(D) HOOC–  –COOH + $HOCH_2 – CH_2OH$

Q.53 Teflon, styron and neoprene are all-

(A) Copolymers (B) Condensation polymers

(C) Homopolymers (D) Monomers

Previous Years' Questions

Q.1 Which of the following pairs give positive Tollen's test? ***(2004)***

(A) Glucose, sucrose (B) Glucose, fructose

(C) Hexanal, acetophenone (D) Fructose, sucrose

Q.2 Two forms of D-glucopyranose, are called ***(2005)***

(A) Enantiomers (B) Anomers

(C) Epimers (D) Diastereomers

Read the following questions and answer as per the direction given below:

(a) Statement-I is true; statement-II is true; statement-II is not the correct explanation of statement-I.

(b) Statement-I is true; statement-II is true; statement-II is not the correct explanation of statement-I.

(c) Statement-I is true; statement-II is false.

(d) Statement-I is false; statement-II is true.

Q.3 Statement-I: Glucose gives a reddish-brown precipitate with Fehling's solution.

Statement-II: Reaction of glucose with Fehling's solution gives CuO and gluconic acid. ***(2007)***

Q.4 $\alpha-D-(+)$ - glucose and $\beta-D-(+)$ - glucose are ***(2008)***

(A) Conformers (B) Epimers

(C) Anomers (D) Enantiomers

Q.5 The two functional groups present in a typical carbohydrate are: ***(2009)***

(A) –OH and –COOH (B) –CHO and –COOH

(C) > C = O and –OH (D) –OH and –CHO

Q.6 Buna-N synthetic rubber is a copolymer of: ***(2009)***

(A) $H_2C=CH-\underset{\overset{|}{Cl}}{C}=CH_2$ and $H_2C=CH-CH=CH_2$

(B) $H_2C=CH-CH=CH_2$ and $H_5C_6-CH=CH_2$

(C) $H_2C=CH-CN$ and $H_2C=CH-CH=CH_2$

(D) $H_2C=CH-CN$ and $H_2C=CH-\underset{\underset{CH_3}{|}}{C}=CH_2$

Q.7 Biuret test is not given by ***(2010)***

(A) Carbohydrates (B) Polypeptides

(C) Urea (D) Proteins

Q.8 The polymer containing strong intermolecular forces e.g. hydrogen bonding, is ***(2010)***

(A) Teflon (B) Nylon 6, 6

(C) Polystyrene (D) Natural rubber

Q.9 The presence or absence of hydroxyl group on which carbon atom of sugar differentiates RNA and DNA? ***(2011)***

(A) 2^{nd} (B) 3^{rd} (C) 4^{th} (D) 1^{st}

Q.10 Which one of the following statements is correct? ***(2012)***

(A) All amino acids except lysine are optically active

(B) All amino acids are optically active

(C) All amino acids except glycine are optically active

(D) All amino acids except glutamic acid are optically active

Q.11 Synthesis of each molecule of glucose in photosynthesis involves: ***(2013)***

(A) 18 molecules of ATP (B) 10 molecules of ATP

(C) 8 molecules of ATP (D) 6 molecules of ATP

Q.12 Which one is classified as a condensation polymer? ***(2014)***

(A) Dacron (B) Neoprene

(C) Teflon (D) Acrylonitrile

Q.13 Which one of the following bases is **not** present in DNA? ***(2014)***

(A) Quinoline (B) Adenine

(C) Cytosine (D) Thymine

Q.14 Which polymer is used in the manufacture of paints and lacquers? ***(2015)***

(A) Bakelite (B) Glyptal

(C) Polypropene (D) Poly vinyl chloride

Q.15 Which of the vitamins given below is water soluble? ***(2015)***

(A) Vitamin C (B) Vitamin D

(C) Vitamin E (D) Vitamin K

Q.16 Which of the following statements about low density polythene is FALSE? ***(2016)***

(A) It is a poor conductor of electricity.

(B) Its synthesis required dioxygen or aperoxide initiator as a catalyst.

(C) It is used in the manufacture of buckets, dust-bins etc.

(D) Its synthesis requires high pressure.

Q.17 Which of the following is an anionic detergent? ***(2016)***

(A) Sodium lauryl sulphate

(B) Cetyltrimethyl ammonium bromide

(C) Glyceryl oleate

(D) Sodium stearate

Q.18 Thiol group is present in: ***(2016)***

(A) Cystine (B) Cysteine

(C) Methionine (D) Cytosine

JEE Advanced/Boards

Exercise 1

Q.1 State a use for the enzyme streptokinase in medicine.

Q.2 Why is cellulose in our diet not nourishing?

Q.3 Explain muta-rotation taking D-glucose as an example.

Q.4 Enumerate the structural difference between DNA and RNA. Write down the structure of sugar present in DNA.

Q.5 Answer the following queries about proteins-

(i) How are proteins related to amino acids?

(ii) How are oligopeptides different from polypeptides?

(iii) When is a protein said to be denatured?

Q.6 (a) Define and classify vitamins. Give at least two example of each type.

(b) Define an enzyme and comment on the specificity in action of an enzyme. Illustrate with an example.

Q.7 What are essential and non-essential amino acids? Give two examples of each.

Q.8 (a) Define the following term:

(i) Co-enzymes

Q.9 (a) Answer the following questions briefly

(i) What are any two good sources of vitamin A?

(ii) What are nucleotides?

(b) How are carbohydrates classified?

Q.10 Write two main functions of carbohydrates in plants.

Q.11 What happens when D-glucose is treated with the following reagents?

(i) alk.$KMnO_4$ (ii) $Br_2 + CS_2$ (iii) H_2SO_4

Q.12 Name the four bases present in DNA. Which one of these is not present in RNA?

Q.13 Name two fat soluble vitamins that sources and diseases caused due to their deficiency in diet.

Q.14 State a use for the enzyme streptokinase in medicine.

Q.15 Write the major classes in which the carbohydrates are divided?

Q.16 Aspartame, an artificial sweetener, is a peptide and has the following structures:

$$\begin{array}{l} \quad\quad\quad\ NH_2 \quad\quad\quad\quad CH_2C_6H_5 \\ \quad\quad\quad\ \ | \quad\quad\quad\quad\quad\quad\ | \\ HOOC-CH_2CH-CH-COOCH_3 \end{array}$$

(a) Identify the four functional groups.

(b) Write the zwitter ionic structure

(c) Write the structure of the amino acids obtained from the hydrolysis of aspartame.

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

Q.17 Give the chemical name of vitamin B_{12}.

Q.18 What are the following substances?

(i) Invert sugar (ii) Polypeptides

Q.19 Which forces are responsible for the stability of α-helix? Why is it named as 3.6_{13} helix?

Q.20 What are complementary bases? Draw structure to show hydrogen bonding between adenine and thymine and between guanine and cytosine.

Q.21 Give reasons for the following:

(i) On electrolysis in acidic solution amino acids migrate towards cathode, while in alkaline solution these migrate towards anode.

(ii) The monoamino monocarboxylic acids have two pK values.

Q.22 Glycine exists as a Zwitter ion but anthranilic acid does not comment.

Q.23 Write the difference between DNA and RNA?

Q.24 Explain structure of protein.

Exercise 2

Single Correct Choice Type

Q.1 If the sequence of bases in one strand of DNA is ATGACTGTC, then the sequence of bases in its complementary strand is

(A) TACTGACAG (B) TUCTGUCUG

(C) GUACTUAUG (D) None of these

Q.2 During hydrogenation of oils, higher melting 'vegetable ghee' is formed because

(A) Hydrogen is dissolved in the oil

(B) Hydrogen combines with oxygen of the oil

(C) Ester of unsaturated fatty acids are reduced to those of saturated acids

(D) Hydrogen drives off the impurities from the oil

Q.3 Structurally a biodegradable detergent should contain a

(A) Normal alkyl chain (B) Branched alkyl chain

(C) Phenyl side chain (D) Cyclohexyl side chain

Q.4 Thrust imparted to the rocket is governed by the

(A) Third law of thermodynamics

(B) Gravitational law

(C) Newton's third law

(D) None of these

Q.5 Which of the following represent a bi-liquid propellant?

(A) N_2O_4 + unsymmetrical dimethylhydrazine

(B) N_2O_4 + acrylic rubber

(C) Nitroglycerine + nitrocellulose

(D) Polybutadiene + ammonium perchlorate

Q.6 'Placedo' is often given to patients. It is

(A) An antidepressant

(B) A broad spectrum antibiotic

(C) A sugar pill

(D) A tonic

Q.7 An aldohexose (e.g., glucose) and 2-oxohexose (e.g., fructose) can be distinguished with the help of

(A) Tollen's reagent (B) Fehling's solution

(C) Benedict solution (D) Br_2 / H_2O

Q.8 The open-chain glucose on oxidation with HIO_4 gives

(A) 5 HCOOH + $H_2C = O$

(B) 4 HCOOH + 2 $H_2C = O$

(C) 3 HCOOH + 3 $H_2C = O$

(D) 2 HCOOH + 4 $H_2C = O$

Q.9 Glucose and fructose give the same osazone. One may, therefore, conclude that

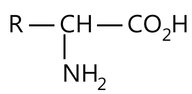
(A) Glucose and fructose have identical structures

(B) Glucose and fructose are anomers

(C) The structure of glucose and fructose have mirror-image relationship

(D) The structure of glucose and fructose differ only in those carbon atoms which take part in osazone formation.

Q.10 For α-amino acid having the structure



Which of the following statements are true?

(a) Water solubility is maximum at a pH when concentration of anions and cations are equal.

(b) They give ninhydrin test

(c) On reacting with nitrous acid give of N_2

(A) All (B) b and c

(C) a and b (D) None of these

Q.11 Bakelite is obtained from phenol and formaldehyde. The initial reaction between the two compounds is an example of

(A) Aromatic electrophilic substitution

(B) Aromatic nucleophilic Substitution

(C) Free radical reaction

(D) Aldol reaction

Q.12 If N_1, N_2, N_3,.......... are number of molecules with molecular masses M_1, M_2, M_3, ... respectively, then average molecular mass is expressed as

(A) $\dfrac{\Sigma N_i M_i^2}{N_i M_i}$ (B) $\dfrac{\Sigma N_i M_i}{\Sigma N_i}$

(C) Both (A) and (B) (D) None of these

Q.13 The ratio of weight average molecular mass to number average molecular mass is called as

(A) Planck's disposal index

(B) Polydiagonal index

(C) Polydispersity index

(D) None of these

Q.14 The best way to prepare polyisobutylene is

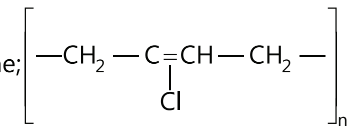
(A) Coordination polymerization

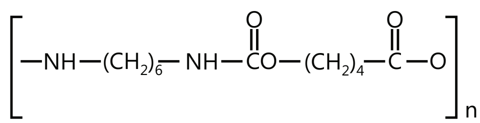
(B) Free radial polymerization

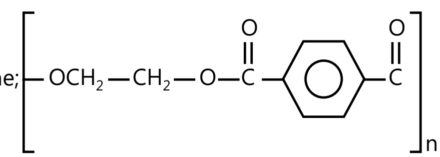
(C) Cationic polymerization

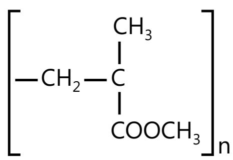
(D) Anionic polymerization

Q.15 Which of the following is not correctly matched?

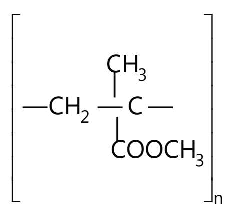
(A) Neoprene;


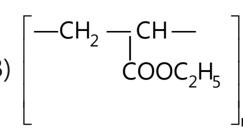
(B) Nylon-6;


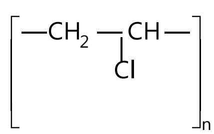
(C) Terylene;


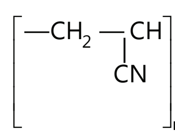
(D) PMMA;


Q.16 Acrilan is a hard, horny and a high melting material. Which of the following represent its structure?

(A)


(B)


(C)


(D)


Q.17 Which of the following statement/s is (are) correct?

(A) Vinyon is a copolymer of vinyl chloride and vinyl acetate

(B) Saran is copolymer of vinyl chloride and vinylidene chloride

(C) Butyl rubber is a copolymer of isobutylene and isoprene

(D) All are correct

Q.18 Plexiglass (perspex) is

(A) Polyacrylonitrile (B) Polyethylacrylate

(C) Polystyrene (D) Polymethylmethacrylate

Multiple Correct Choice Type

Q.19 Which of the following statement (s) is (are) true?

(A) All amino acids contain one chiral centre

(B) Some amino acids contain one, while some contain more chiral center or even no chiral center

(C) All amino acids found in proteins have L configuration

(D) All amino acids found in proteins have 1° amino group

Q.20 Pick out correct statements.

(A) In an electrolysis experiment, amino acids migrate at the isoelectric point towards electrodes

(B) p-aminobenzensulphonic acid is a dipolar ion: while p-aminobenzoic acid is not

(C) Sulphanilic acid is soluble in base, but not in acid

(D) $H_3\overset{\oplus}{N}CH_2COOH$(pka = 2.4) is more acidic than RCH_2COOH (pKa = 4–5)

Q.21 Which of the following statements is/ are correct?

(A) Polyethylene contains double bonds

(B) The monomer used to make Teflon is C_2F_4

(C) Condensation polymers are known as copolymers

(D) A denatured protein could have the same primary structure as the active protein.

Assertion Reasoning Type

Questions 22-29

Each of the questions given below consists of two statements, an assertion (A) and reason (R). Select the number corresponding to the appropriate alternative as follows

(A) If both assertion and reason are true and reason is the correct explanation of assertion.

(B) If both assertion and reason are true but reason is not the correct explanation of assertion.

(C) If assertion is true but reason is false.

(D) If both assertion and reason are false.

Q.22 Assertion: The enzyme amylase hydrolyses starch to maltose.

Reason: Starch is polymer containing glycosidic linkages.

Q.23 Assertion: A solution of sucrose in water is dextrorotatory but on hydrolysis in the presence of small amount of dil. HCl, it becomes laevorotatory.

Reason: Sucrose on hydrolysis gives unequal amounts of glucose and fructose as a result of which change in sign of rotation is observed.

Q.24 Assertion: Each turn of the α-helix structure of protein forms α 13 membered ring the containing 3.6 amino acids.

Reason: α-helix is a secondary of protein which gets stabilized via hydrogen bonding and disulphide linkages.

Q.25 Assertion: Styrene is more reactive than propylene towards cationic polymerization.

Reason: The carbocation resulting from styrene is more stable than that resulting from propylene.

Q.26 Assertion: Natural rubber is all cis-polyisoprene.

Reason: trans-Polyisoprene cannot be formed.

Q.27 Assertion: PMMA is used for making lenses and light covers.

Reason: It has excellent light transmission properties.

Q.28 Assertion: Polyvinyl alcohol is obtained by polymerization of vinyl alcohol

Reason: Polyvinyl alcohol is prepared by hydrolysis of polyvinyl acetate.

Q.29 Assertion: Nylon-6 is obtained by polymerization of caprolactum

Reason: It is a polyamide.

Comprehension Type

Paragraph 1: The utility of the polymers in various fields is due to their mechanical properties like tensile strength, elasticity, toughness etc.

These properties mainly depend upon intermolecular forces like van der Waal’s forces and hydrogen bonding operating in polymer molecules. Polymers have been classified on this basis, e.g.,

(A) Elastomers (B) Fibers

(C) Thermoplastics (D) Thermosetting

Q.30 The molecular forces of attraction are weakest in

(A) Elastomers (B) Fibers

(C) Thermoplastics (D) Thermosetting polymers

Q.31 Which of the following have usually a linear structure?

(A) Thermoplastics (B) Thermosetting polymers

(C) Polyethylene (D) Nylon-66

Q.32 Which of the following is hard?

(A) Elastomer (B) Fibre

(C) Thermoplastic (D) Thermosetting polymers

Paragraph 2: A natural elastomer polymer when with sulphur got stiff and resistant to action of common solvents and wear & tear.

Q.33 The natural polymer is:

(A) Rubber (B) Cellulose (C) Silk (D) Starch

Q.34 Heating of polymer with sulphur is called:

(A) Galvanisation (B) Saponification

(C) Vulcanization (D) None of these

Match the Columns

Q.35 Match list I with list II and select the correct answer using the codes given below the lists.

	List I		List II
I.	Nucleic acids	(p)	D.N.A.
II.	Uracil	(q)	Hormones
III.	Thymine	(r)	Polynucleotides
IV.	Double-helix structure	(s)	R.N.A.

(A) I → s, II → r, III → p, IV → p

(B) I → r, II → s, III → p, IV → p

(C) I → r, II → p, III → s, IV → p

(D) None of these

Q.36

	List I		List II
I.	Pepsin	(p)	Genetic material
II.	Nucleic acid	(q)	Sex hormone
III.	Ascorbic acid	(r)	Vitamin C
IV.	Testosterone	(s)	Digestive enzyme

(A) I → s, II → p, III → r, IV → q

(B) I → s, II → p, III → q, IV → r

(C) I → s, II → p, III → r, IV → q

(D) None of these

Q.37 Match list I with list II and select the correct answer using the codes given below the lists.

	List I		List II
	(Polymer)		**(Polymerizing units)**
I.	Bakelite	(p)	Butadiene and styrene
II.	Dacron	(q)	Phenol and methanal
III.	Nylon-66	(r)	1, 2-dihydroxyethane and dimethylterephthalate
IV.	Buna-S	(s)	Urea and methanol
		(t)	1, 6-hexanedioic acid and 1, 6-dimino hexane

(A) I → s, II → r, III → t, IV → p

(B) I → q, II → r, III → t, IV → p

(C) I → t, II → q, III → r, IV → p

(D) None of these

Q.38 Match list I with list II and select the correct answer using the codes given below the lists.

	List I		List II
I.	Phenol + formaldehyde.	(p)	Synthec rubber
II.	Terephthalic acid	(q)	Bakelite + ethylene glycol
III.	Caprolactam	(r)	Nylon-6
IV.	Butadiene+styrene	(s)	terylene

(A) I → q, II → r, III → s, IV → p

(B) I → r, II → p, III → q, IV → s

(C) I → q, II → s, III → r, IV → p

(D) None of these

Q.39 Match list-I (Monomer) with list-II (Polymer) and select the correct answer using the codes given below the lists:

	List I		List II
I.	Hexamethylenediamine	(p)	Bakelite
II.	Phenol	(q)	Dacron
III.	Phthalic acid	(r)	Glyptal
IV.	Terephtalic acid	(s)	Melamine
		(t)	Nylon 6, 6

(A) I → t, II → p, III → q, IV → r

(B) I → t, II → p, III → r, IV → q

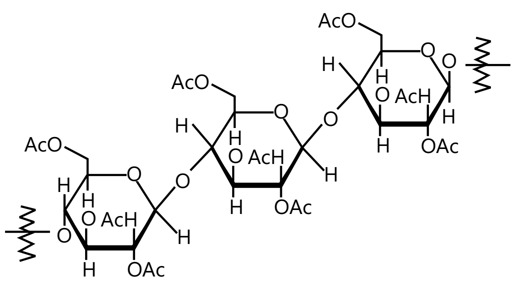
(C) I → s, II → r, III → p, IV → q

(D) I → s, II → r, III → p, IV → q

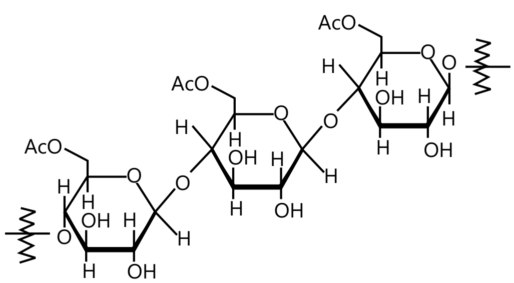
Previous Years' Questions

Q.1 Cellulose upon acetylation with excess acetic anhydride/H_2SO_4 (catalytic) gives cellulose triacetate whose structure is ***(2008)***

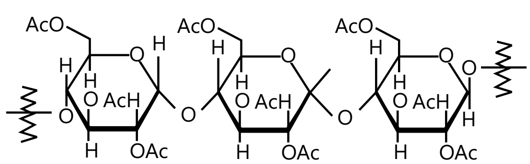
(A)



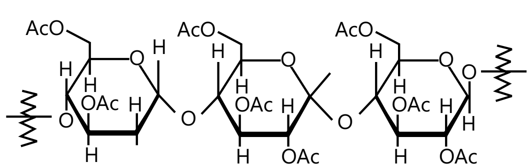
(B)



(C)



(D)

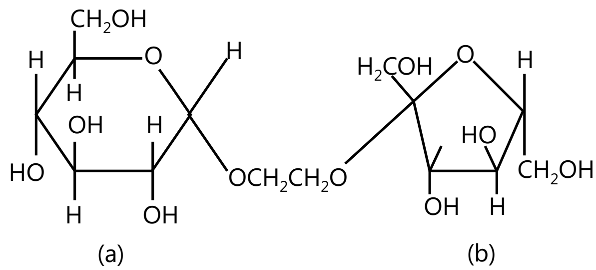


Q.2 Among cellulose, poly (vinyl chloride), nylon and natural rubber, the polymer in which the intermolecular force of attraction is weakest is ***(2012)***

(A) Nylon (B) Poly (vinyl chloride)

(C) Cellulose (D) Natural rubber

Q.3 The correct statement about the following disaccharide is ***(2012)***



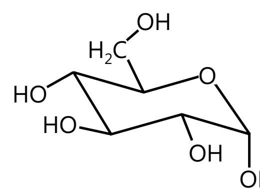
(A) Ring (a) is pyranose with α-glycosidic link

(B) Ring (a) is furanose with α-glycosidic link

(C) Ring (b) is furanose with α-glycosidic link

(D) Ring (b) is pyranose with β-glycosidic link

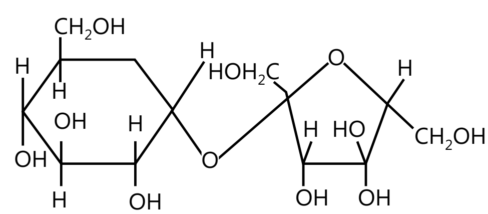
Q.4 The following carbohydrate is ***(2011)***



(A) A ketohexose (B) An aldohexose

(C) An α-furanose (D) An α-pyranose

Q.5 The correct statement (s) about the following sugars X and Y is (are): ***(2011)***



X

(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 linkage in X and Y are α and β respectively

(D) The glucosidic linkage in X and Y are β and α, respectively

Q.6 For 'invert sugar', the correct statement(s) is (are) (Given: specific rotations of (+)-sucrose, (+)-maltose, L-(-)-glucose and L-(+)-fructose in aqueous solution are $+66°, +140°, -52°$ and $+92°$, respectively.) ***(2016)***

(A) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose

(B) 'invert sugar' is an equimolar mixture of D-(+)-glucose and D-(-)-fructose

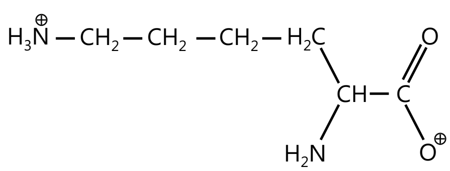
(C) Specific rotation of 'invert sugar' is $-20°$

(D) On reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the products

Q.7 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. ***(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

Q.8 The total number of basic group in the following form of lysine is ***(2010)***



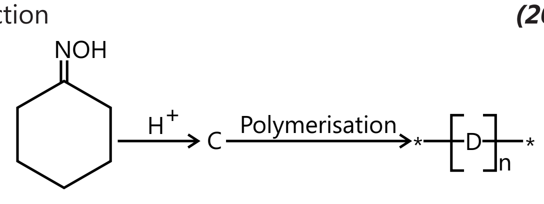
Q.9 A decapeptide (Mol. Wt. 796) on complete hydrolysis gives glycine (Mol. Wt. 75), alanine and phenylalanine. Glycine contributes 47.0 % to the total weight of the hydrolysed products. The number of glycine units present in the decapeptide is ***(2011)***

Q.10 Write the structure of alanine at pH = 2 and pH = 10. ***(2000)***

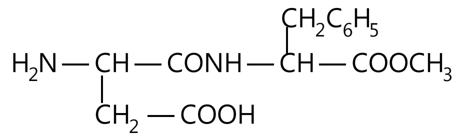
Q.11 Give the structure of the products in the following reaction ***(2000)***

$$\text{Sucrose} \xrightarrow{H^+} A + B$$

Q.12 Give the structure of the products in the following reaction ***(2000)***



Q.13 Aspartame, an artificial sweetener, is a peptide and has the following structure ***(2001)***



(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 the two amino acids in more hydrophobic?

Q.14 Name the heterogenous catalyst used in the polymerization of ethylene. ***(2003)***

Q.15 Statement-I: Glucose gives a reddish-brown precipitate with Fehling's solution. ***(2007)***

Statement-II: Reaction of glucose with Fehling's solution gives CuO and gluconic acid.

(A) Statement-I is True, statement-II is True; statement-II is a correct explanation for statement-I

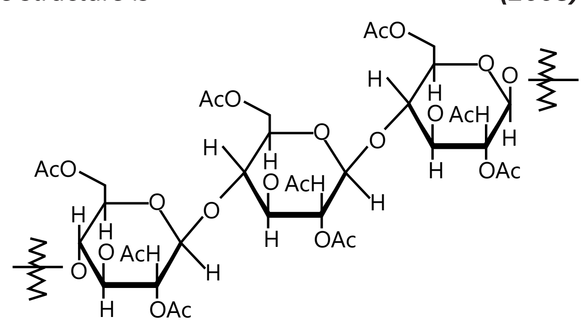
(B) Statement-I is True, statement-II is True; statement-II is NOT a correct explanation for statement-I

(C) Statement-I is True, statement-II is False

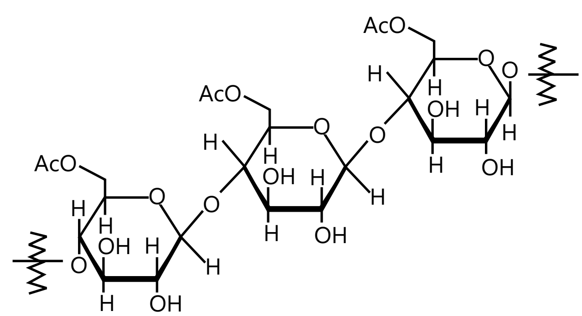
(D) Statement-I is False, statement-II is True

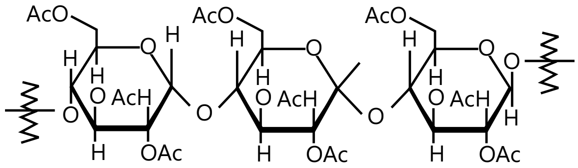
Q.16 Cellulose upon acetylation with excess acetic anhydride / H_2SO_4 (catalytic) gives cellulose triacetate whose structure is ***(2008)***

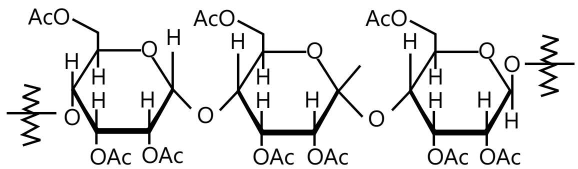
(A)



(B)



(C) 

(D) 

Q.17 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? ***(2012)***

$$H_3\overset{\oplus}{N}-\underset{H}{CH}-CO-NH-\underset{R_1}{CH}-CO-NH-\underset{R_2}{CH}-CO-NH-\underset{H}{CH}-CO\overset{\ominus}{O}$$

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

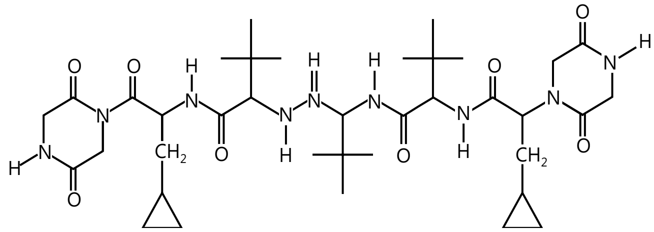
Q.18 When the following aldohexose exists in its D-configuration, the total number of stereoisomers in its pyranose form is ***(2012)***

$$CHO-CH_2-CHOH-CHOH-CH_2OH$$

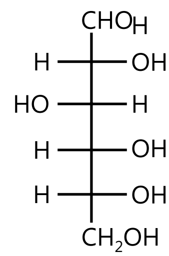
Q.19 A tetrapeptide has –COOH group on alanine. This produces glycine (Gly), valine (Val), phenyl alanine (Phe) and alanine (Ala), on complete hydrolysis. For this tetrapeptide, the number of possible sequences (primary structures) with $-NH_2$ group attached to a chiral center is ***(2013)***

Q.20 The total number of lone-pairs of electrons in melamine is ***(2013)***

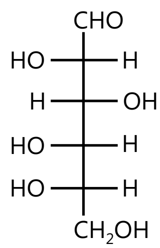
Q.21 The total number of distinct naturally occurring amino acids obtained by complete acidic hydrolysis of the peptide shown below is ***(2014)***

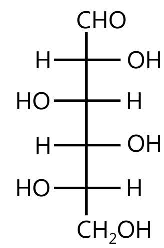


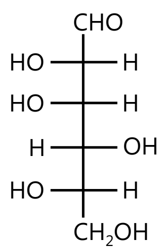
Q.22 The structure of D-(+)-glucose is ***(2015)***

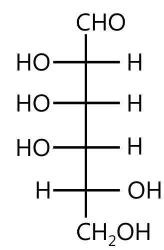


The structure of L-(–)-glucose is

(A) 

(B) 

(C) 

(D) 

Q.23 Under hydrolytic conditions, the compounds used for preparation of linear polymer and for chain termination, respectively, are ***(2015)***

(A) CH_3SiCl_3 and $Si(CH_3)_4$

(B) $(CH_3)_2SiCl_2$ and $(CH_3)_3SiCl$

(C) $(CH_3)_2SiCl_2$ and CH_3SiCl_3

(D) $SiCl_4$ and $(CH_3)_3SiCl$

Q.24 On complete hydrogenation, natural rubber produces ***(2016)***

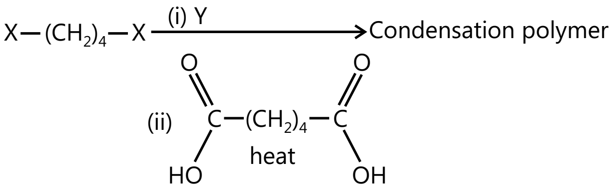
(A) Ethylene-propylene copolymer

(B) Vulcanised rubber

(C) Polypropylene

(D) Polybutylene

Q.25 The correct functional group X and the reagent/reaction conditions Y in the following schemes are ***(2011)***



(A) X = $COOCH_3$, Y = H_2/Ni/heat

(B) X = $CONH_2$, Y = H_2/Ni/heat

(C) X = $CONH_2$, Y = Br_2/NaOH

(D) –X = CN, Y = H_2/Ni/heat

PlancEssential Questions

JEE Main/Boards

Exercise 1

Q.5 Q.14 Q.18 (i)
Q.23 Q.24

Exercise 2

Q.1 Q.11 Q.20
Q.27 Q.33 Q.39
Q.43 Q.38 Q.40
Q.48 Q.51

Previous Years' Questions

Q.3

JEE Advanced/Boards

Exercise 1

Q.1 Q.11 (a) Q.14
Q.22 Q.25

Exercise 2

Q.2 Q.8 Q.19
Q.13 Q.15 Q.27

Previous Years' Questions

Q.1 Q.5 Q.12
Q.13

Answer Key

JEE Main/Boards

Exercise 2

Single Correct Choice Type

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

Q.25 A	**Q.26** B	**Q.27** C	**Q.28** B	**Q.29** A	**Q.30** C
Q.31 D	**Q.32** D	**Q.33** C	**Q.34** C	**Q.35** C	**Q.36** A
Q.37 A	**Q.38** B	**Q.39** C	**Q.40** D	**Q.41** D	**Q.42** C
Q.43 A	**Q.44** A	**Q.45** D	**Q.46** A	**Q.47** C	**Q.48** C
Q.49 B	**Q.50** B	**Q.51** D	**Q.52** A	**Q.53** C	

Previous Years' Questions

Q.1 B	**Q.2** B	**Q.3** C	**Q.4** C	**Q.5** C	**Q.6** C
Q.7 A	**Q.8** B	**Q.9** A	**Q.10** C	**Q.11** A	**Q.12** A
Q.13 A	**Q.14** B	**Q.15** A	**Q.16** C	**Q.17** A	**Q.18** B

JEE Advanced/Boards

Exercise 2

Single Correct Choice Type

Q.1 A	**Q.2** C	**Q.3** D	**Q.4** C	**Q.5** A	**Q.6** C
Q.7 D	**Q.8** A	**Q.9** D	**Q.10** B	**Q.11** A	**Q.12** A
Q.13 C	**Q.14** C	**Q.15** B	**Q.16** D	**Q.17** D	**Q.18** D

Multiple Correct Choice Type

Q.19 B, C	**Q.20** B, C, D	**Q.21** B, C, D

Assertion Reasoning Type

Q.22 A	**Q.23** C	**Q.24** C	**Q.25** C	**Q.26** C	**Q.27** A
Q.28 D	**Q.29** B				

Comprehension Type

Paragraph 1:	**Q.30** A	**Q.31** A	**Q.32** D
Paragraph 2:	**Q.33** A	**Q.34** C	

Match the Columns

Q.35 B	**Q.36** C	**Q.37** B	**Q.38** C	**Q.39** B

Previous Years' Questions

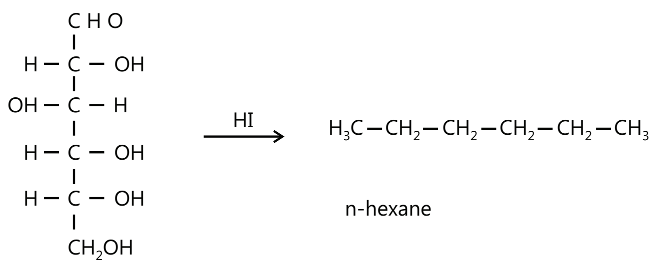
Q.1 A	**Q.2** B	**Q.3** A	**Q.4** B	**Q.5** B, C	**Q.6** B,C
Q.7 A $\rightarrow$ p, s; B $\rightarrow$ q, r; C $\rightarrow$ p, r; D $\rightarrow$ s		**Q.8** 2	**Q.9** 6	**Q.15** C	**Q.16** A
Q.17 D	**Q.18** 8	**Q.19** 4	**Q.20** 6	**Q.21** 1	**Q.22** A
Q.23 B	**Q.24** A	**Q.25** C, D			

Solutions

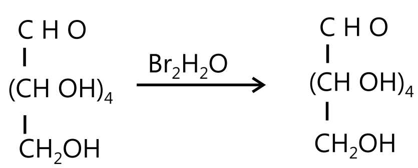
JEE Main/Boards

Exercise 1

Sol 1: (i)

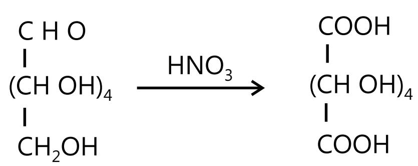


(ii)



D-Gluconic Acid

(iii)



Glucaric acid

Sol 2: (i) Peptide Linkage: The linkage $(-CO-NH-)$ is known as peptide linkage. This linkage is found in the primary structure of proteins.

(ii) Denaturation – when the proteins are sulgected to the action of heat, mineral acids or alkali, the water soluble form of globular protein changes to water insoluble fibrous protein resulting in the precipitation or coagulation of protein, called denaturation of proteins.

Sol 3: (i) Peptide Linkage: The linkage $(-CO-NH-)$ is known as peptide linkage. This linkage is found in the primary structure of proteins.

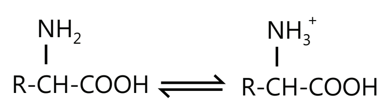
(ii) The primary structure of proteins refer to its covalent structure, i.e sequence in which various $\alpha-$amino acids are arranged in protein or in the polypeptide structure of protein.

(iii) Denaturation – when the proteins are subjected to the action of heat, mineral acids or alkali, the water soluble form of globular protein changes to water insoluble fibrous protein resulting in the precipitation or coagulation of protein, called denaturation of proteins.

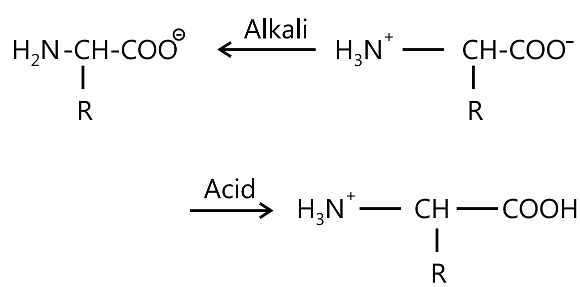
Sol 4: (i) α – Helix structure: This structure is acquired when the alkyl groups in amino acids are large and are involved in the coiling of the polypeptide chain. This is stabilized by the intermolecular hydrogen bond between the $>C=O$ group of one amino acid and $-NH$ group of the fourth amino acid.

(ii) β – pleatedstructure: This structure is acquired when the alkyl group are small in this structure. Linear polypeptide chains are arranged side by side and stabilised by intermolecular hydrogen bond between $>C=O$ and $-NH$ group.

Sol 5: The amino acids containing one carboxylic group and one amino group behave like a neutral molecule. This is due to the formation of a zurtter ion structure.



This zwitter ion changes to cation in acidic solution and anion in alkaline medium. making it amphoteric in nature.



Sol 6: Due to denaturation, water soluble form of globular protein changes to water insoluble fibrous protein, resulting in the precipitation or coagulation of protein.

Sol 7: (i) A glycosidic linkage is a type of covalent bond that joins a carbohydrate molecule to another group which may or may not be another carbohydrate.

Sol 8: (i)Glucose does not undergo certain reactions of aldehydes, for ex reaction with $NaHSO_3$ schiff's test etc.

(ii) Reaction of glucose with NH_2OH

(iii) Mutarotation of α and β glucose

(iv) Formation of two isomeric methyl glycosides when treated with methanol.

Sol 9: Essential amino acids: Amino acids which cannot by synthesized by the body and therefore needs to taken through external diet. For ex. Phenylalanine, valine

Non-Essential amino acids: - These amino acids can by synthesized by the body and therefore. need not be supplied by an external diet. For ex. Alanine, aspartic acid.

Sol 10: (i) Vitamin A: Chief source orange, ripe yellow fruits, leafy vegetables, carrots, pumpkin Function. helps in vision, gene transcription, bone metabolism, antioxidant, activity.

(ii) Vitamin B: Chief source pork, oatmeal, brown rise, potatoes, eggs

Function. growth, regulation of apetite Functioning of heart, muscles and nervous system.

(iii) Vitamin D

(iv) Vitamin K

Sol 11: (i) Refer solution 9.

(ii) Refer solution 2.

Sol 12: Vitamin are classified into two groups.

Depending upon their solubility in water or fat.

(i) Fat soluble Vitamin: Vitamin which are soluble in fats and oils, but insoluble in water. for ex. Vitamin A,P,E and K

(ii) Water soluble vitamins: Vitamins which are soluble in water. For ex B group vitamins and vitamin C.

Vitamin K is responsible for coagulation of blood.

Sol 13: Function of vitamin A

(i) Vision

(ii) Gene transcription

(iii) Immune function

(iv) Bone metabolism

(v) Antioxidant activity

Deficiency causes night blindness.

Source: Liver, orange, carrots, pumpkin

Vitamin C

Function: Highly effective antioxidant

Lessen oxidative stress

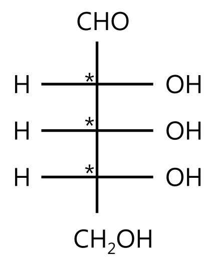
Natural antihistamine

Functioning of immune system

Deficiency causes scurvy, bleeding gums

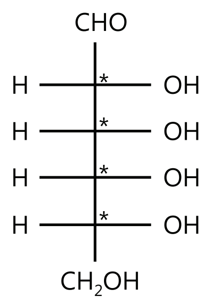
Sources: Virus fruits, amla, green leafy vegetable

Sol 14: Aldopentose



Asymmetric carbons are 3

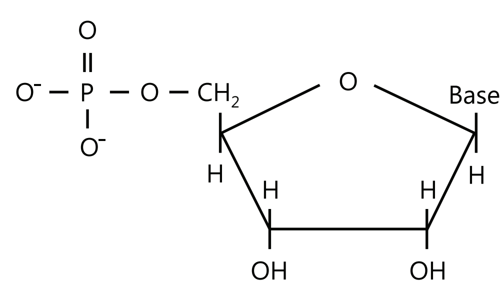
Aldohexose



Asymmetric carbons are 4

Sol 15: Nucleotides are organic molecules that serves as the monomers. Or subunits of nucleic acids like DNA or RNA

For E.g.



(b) (i) As a source of energy (more than 50–80% of energy in the diet is supplied by carbohydrates)

(ii) Protein sparing action: As carbohydrates are mainly used for energy need of body, proteins are spared for tissue building and repairing.

(iii) Essential for fat oxidation

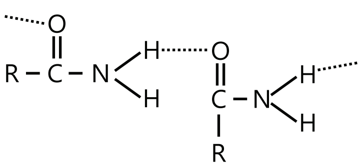
(iv) Gastro intestinal function.

Sol 16: α Helix structure is stabilized by the intra molecular hydrogen bond between the $>C=O$ group of one amino acid and $-NH$ group of the fourth amino acid.

Sol 17: Fibrous proteins have largely helical structure and are rigid molecules of rod like shape. Globular proteins, on the other hand have a polypeptide chain which consist partly of helical section and partly β pleated structure and Remaining random coil form.

Sol 18: (i) Amino acids have very strong intermolecular forces due to highly effective hydrogen bonding between

$>C=O$ and $-NH$ groups.



(ii) Vitamin A Night blindness Vitamin B_1 Beri Beri Vitamin B_6 Convulsions

Vitamin K increasing blood clotting time

Sol 19: In DNA, two nucleic acid chains are wound about each other held together by hydrogen bonds between pair of bases. The two strands are complementary to each other because the hydrogen bonds are formed between specific pair of bases. Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

Sol 20: (i) $\alpha-$Helix

(a) Alkyl groups in amino Acids are large.

(b)Polypeptide chains are coiled leading to right handed helical coil

(c)Stablised by intermolecular H – bonding between groups on one amino acid and –NH group of 4 amino acid.

$\beta-$Helix

(a) Alkyl groups in amino acids are small

(b) Polypeptide chains are arranged side by side

(c) Stabilized by intermolecular H-Bonding between the $>C=O$ and $-NH$ group.

(ii) (a) Primary Structure: This structure refer to its covalent structure which various sequence in which various $\alpha-$amino acids are arranged in protein or in the polypeptide structure of protein.

(b) Secondary Structure: This refers to the arrangement of polypeptide chains into a defined three dimension structure which protein assumes as a result of hydrogen bonding.

Sol 21: The particles in nucleus of the cell, responsible for heredity, are called chromosomes, which are made up of proteins, and another type of biomolecules called nucleic acids.

Function:

(i) Nucleic acid serves as chemical basis of heredity and may be regards regarded as reserve of genetic information.

(ii) Protein synthesis in cells.

Sol 22: Nucleoside:

(a) Consist of a nitrogenous base covalently attached to a sugar (ribose or deoxyribose) but without the phosphate group.

Nucleoside = sugar + base

(b) Used as antiviral or anticancer agents

(c) E.g. Cytidine, uridine, adenosine

Nucleotide:

(a) Consists of a nitrogenous base, a sugar (ribose or deoxyribose) and one to three phosphate groups.

(b) Nucleotide sugar + base + phosphate

(c) Malfunctioning nucleotides are one of the main causes of cancer.

E.g. S-uridine monophosphate

Sol 23: Reducing sugar: sugar that contain aldehyde group that are oxidized to carboxylic acids are classified as reducing sugar.

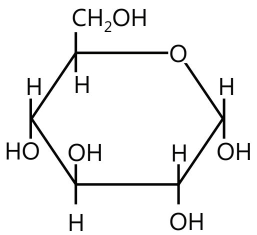
For e.g. Sucrose act as reducing agents.

Non reducing sugar: they cannot act as a reducing group due to absence of an aldehydic group.

Reducing sugars must either contain aldehyde group or in is capable of forming one in solution through isomerism.

Sol 24: α glucose

(a)

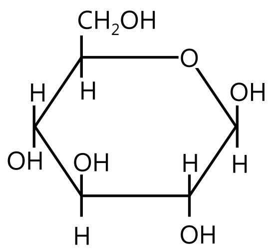


(b) $-OH$ group lies below the ring on carbon

(c) α glucose folds up into a helix.

β glucose

(a)



(b) $-OH$ group lies above the ring on carbon

(c) β glucose folds up into a pleated sheet.

Sol 25: Refer solution 1.

Same reaction as D-Glucose, only structural difference is in the configuration of atoms around different carbons.

Sol 26: Refer text pg. 15

Sol 27: Different types:

(i) mRVA

(ii) fRNA

(iii) rRNA

Sol 28: (i) This pH at which the structure of amino acid has no net charge is called it's isoelectronic point for ex. Aspartic acid hs isoelectric point of 2.77

(ii) Mutarotation is the change in the optical rotation that occurs by epimerization (change in equilibrium between two epimers, when the corresponding stereocentres interconvert) for ex. $\beta-D$ glucose.

With specific rotation of +18.7°, when dissolved in water undergo mutarotation and attains a final specific rotation of 52.5^0

(iii) An enzyme is a substance produced by a living organism which acts as a catalyst to bring about a specific biochemical reaction for ex. Streptokinase

Sol 29: Refer theory.

Sol 30: (a) Refer text Pg. 2

(b) A nucleotide is an organic molecule made up of nucleotide base, a five carbon sugar and at least one phosphate group.

The two classes are

(i) Purine: contains adenine and guanine

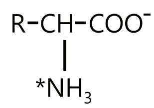
(ii) Pyrimidine: contains cytosine, thymine and uracil.

Exercise 2

Single Correct Choice Type

Sol 1: (D) Chromophore is the colouring agent, which is diazo group (–N = N -)

Sol 2: (D) Zwitter ion is present



Sol 3: (C) This is secondary structure of a protein

Sol 4: (C) General formula of carbohydrates:

$C_n(H_2O)_n$ or $C_x(H_2O)_y$

Sol 5: (A) Rest are all monosaccharide except sucrose.

Sol 6: (B) Iron is bonded by co-ordination ring formation (chelation)

Sol 7: (C) Anomers have different specific relation.

Sol 8: (A) Amide linkage $(-CO-NH-)$ is called peptide bond

Sol 9: (C) Glucose is a hydroxyl aldehyde whereas Fructose is a ketone.

Sol 10: (B) Glucose is a hydroxy aldehyde with 6 carbon or aldehexose.

Sol 11: (D) Phenol acts both as an antiseptic and disinfectant.

Sol 12: (C) Fenton's reagent (H_2O_2 + Fe) converts D -glucose (6 carbon) to D arabinose (5 carbon)

Sol 13: (D) At isoelectronic point.

$$pH = \frac{pk_{a1} + pk_{a2}}{2}$$

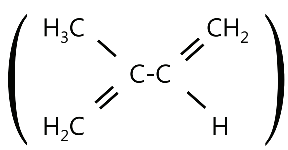
Sol 14: (A) Zeigler and Natta developed zeigler Natta Catalysts $(Al(C_2H_5)_3 + TiCl_3)$ which are used for coordination polymerization.

Sol 15: (C) Teflon is homopolymer of tetraflourethylene. Polystyrene is a homopolymer of styrene. Neoprene is a homopolymer of chloroprene.

Sol 16: (A) Anomer have different configurations at Glycosidic carbon and hence different specific rotation.

Sol 17: (A) They are called epimers.

Sol 18: (B) Natural rubber is polymer of isoprene



Sol 19: (B) It is called inversion as sucrose, which is dextrorotatory gives a laevorotatory mixture on dilution.

Sol 20: (B) Sulphur cross links are present in vulcanised rubber.

Sol 21: (A) Glycine $(H_2N - CH_2 - COOH)$ is the simplest amino acid.

Sol 22: (D) All of these are natural polymers.

Sol 23: (C) They differ in configuration of CI

Sol 24: (A) Aldehydic group gives silver mirror test with tollen's reagent.

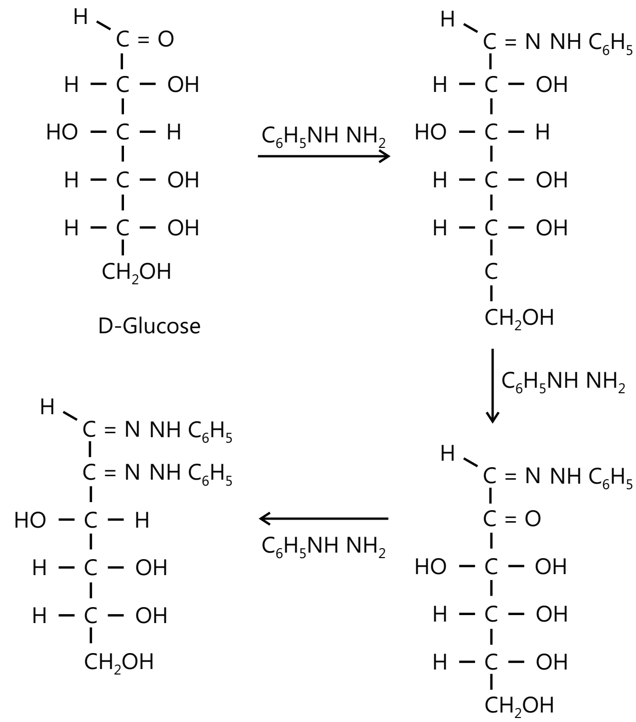
Sol 25: (A) This is definition of oligosaccharides.

Sol 26: (B) This is definition of epimer.

Sol 27: (C) Energy is evolved with ATP is hydrolysed to ADP and AMP. Rest are correct.

Sol 28: (B) Cellulose is a linear polymer of β glucose.

Sol 29: (A)



3 molecules of phenylhydrazine is used.

Sol 30: (C) Main structural unit is peptide linkage $(-CO-NH-)$

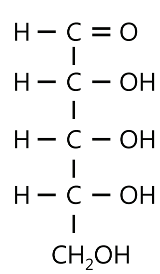
Sol 31: (D) All these are function of the proteins

Sol 32: (D) Glucose and galactose are monosaccharide while sucrose is disaccharide.

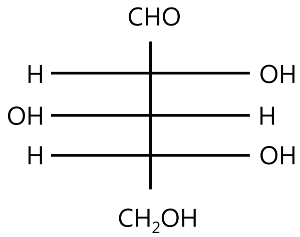
Sol 33: (C) Starch on reaction with iodine gives blue colour which serves as a test for presence of I_2

Sol 34: (C) Ribose has five carbon atoms, rest all options are correct.

Ribose



Sol 35: (C) D – xylose is a diastereomer of ribose with formula.



Sol 36: (A) Glucose gives the silver mirror test with ammoniacal solution of silver nitrate because it contains the group Aldehyde.

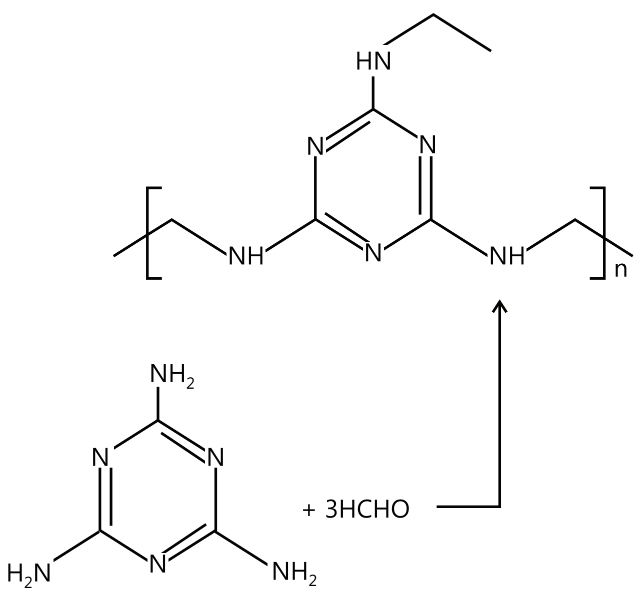
Sol 37: (A) Dacron is a copolymer of ethylene glycol and terephthalic acid.

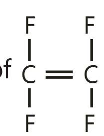
PVC is a polymer of : Vinyl chloride

Polystyrene is a polymer of styrene

Teflon is a polymer of tetraflouroethylene

Sol 38: (B) Melamine resin:



Sol 39: (C) Teflon is a polymer of 

Sol 40: (D) Acrylonitrile n $H_2C = C - C \equiv N \rightarrow$

$(HC = C - C = N)_n$

Sol 41: (D) Glyptal is a condensation polymer.

Sol 42: (C) Highly vulcanised rubber is called ebonite.

Sol 43: (A) Teflon is a polymer of $F_2C = CF_2$

$$nCF_2 = CF_2 \rightarrow \left(\underset{F}{\overset{F}{C}}-\underset{F}{\overset{F}{C}}\right)_n$$

Sol 44: (A) $H_3C - \overset{Cl}{CH_2} \longrightarrow \left(H_2C - \overset{Cl}{CH}\right)_n$ PVC

Sol 45: (D) Polyacrylonitrile is a polymer of acrylonitrile ($CH_2 = CHCN$)

Sol 46: (A) This is the classification based on inter molecular forces.

Sol 47: (C) Polyethene involves linear linkage between chains $(CH_2 - CH_2)_n$

Sol 48: (C) Al $(C_2H_5)_3$ + $TiCl_4$ is Zieglar – Nata catalyst

Sol 49: (B) Neoprene is a polymer of chloroprene

$$CH_2=\underset{Cl}{C}-CH=CH_2 \longrightarrow \left[CH_2-CH=\underset{Cl}{C}-CH_2\right]$$

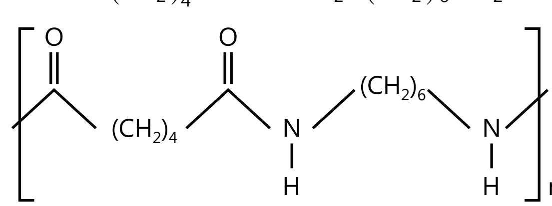
Sol 50: (B) Teflon is a polymer of $CH_2 = CF_2$.

Sol 51: (D) Polytetraflouroethylene or Teflon $\left(\underset{F}{\overset{F}{C}}-\underset{F}{\overset{F}{C}}\right)_n$

is used because of its being a thermoplastic polymer.

Sol 52: (A)

$$nHOOC(CH_2)_4COOH + nH_2N(CH_2)_6NH_2 \rightarrow$$



Sol 53: (C) They are made from a single compound i.e. they contain a single repeating unit.

Previous Years' Questions

Sol 1: (B) Both glucose and fructose are reducing sugars, reduces Tollen's reagent to metallic silver.

Sol 2: (B) "α" and "β" cyclic hemiacetals of D-glucose having difference in configuration at C-1 only are called anomers.

Sol 3: (C) Statement I is Correct: Presence of -CHO group in glucose is tested by Fehling solution test where a reddish-brown precipitate of Cu_2O is formed.

Hence, statement II is incorrect.

Sol 4: (C) $\alpha-D(+)$ glucose and $\beta-D(+)$ glucose are anomers.

Sol 5: (C) Carbohydrates are polyhydroxy carbonyl compounds.

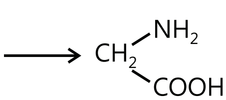
Sol 6: (C) Buna-N synthetic rubber is a copolymer of acrylonitrile (ACN) and butadiene.

Sol 7: (A) It is a test characteristic of amide linkage. Urea also has amide linkage like proteins.

Sol 8: (B) Nylon 6,6 is a polymer of adipic acid and hexamethylene diamine

$$\left(\overset{O}{\overset{\|}{C}} - (CH_2)_4 - \overset{O}{\overset{\|}{C}} - NH - (CH_2)_6 - NH \right)_n$$

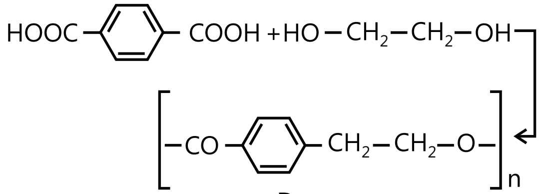
Sol 9: (A) In RNA, the sugar is $\beta-D$ -Ribose, where as in DNA the Sugar is $\beta-D-2$ - deoxy Ribose.

Sol 10: (C) Glycine 

Sol 11: (A) Fact

$6CO_2+12NADPH+18ATP \rightarrow C_6H_{12}O_6+12NADP+18ADP$

Sol 12: (A) Dacron is polyester formed by condensation polymerisation of terephthalic acid and ethylene glycol



Dacron

Acrylonitrile, Neoprene and Teflon are addition polymers of acrylonitrile, isoprene and tetrafluoro ethylene respectively.

Sol 13: (A) DNA contains ATGC bases

A – Adenine

T – Thymine

G – Guanine

C – Cytocine

So quinoline is not present.

Sol 14: (B) Glyptal is used in the manufacture of paints and lacquers.

Sol 15: (A) Vitamin B and C are water soluble and Vitamin A, D, E and K are water insoluble.

Sol 16: (C) Low density polythene is not used in the manufacturing of buckets, dust-bins etc. because buckets, dustbins are manufactured by high density polythene.

Sol 17: (A)

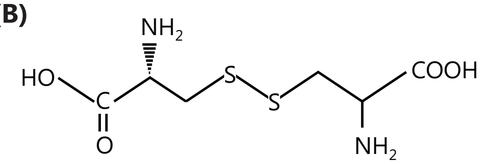
Sodium lauryl sulphate = detergent, anionic

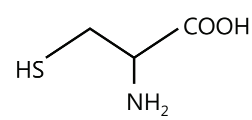
Cetyltrimethyl ammonium bromide = detergent, cationic

Glyceryl oleate = detergent, non-ionic

Sodium stearate = soap, anionic

Sol 18: (B)

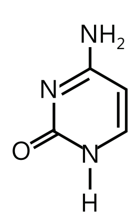
Cystine 

Cysteine 

Thiol group (SH) is present in cysteine.

Methionine $CH_3-S-CH_2-CH_2-\underset{NH_2}{\underset{|}{C}} \quad H-\overset{O}{\overset{\|}{C}}-OH$

Cytosine



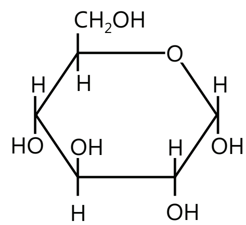
JEE Advanced/Boards

Exercise 1

Sol 1: Streptokinase is used as a medicine for blood clots.

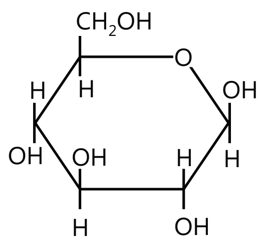
Sol 2: Cellulose in our diet is not nourishing as because, it is a complex from of carbohydrate, and no mammal makes the necessary enzyme to break down cellulose.

Sol 3: Mutarotation is the change in the optical rotation that occurs by epimerization (that is the change in he equilibrium between two epimers, when the corresponding stereo centers interconvert epimers of D-glucose



α – D – (+) – Glycopyranose

θ = +112°C



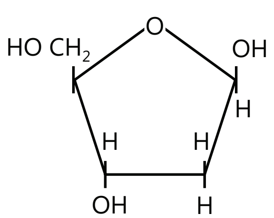
β – D – (+) – Glycopyranose

θ = 19°C

When either of these forms of D-glucose is dissolved in water and allowed to stand, a gradual change in specific rotation occurs the specific rotation of the α form falls and that of the β form rises until a constant values of 53° is obtained.

Sol 4: For differences, refer text.

Sugar: 2 – deoxy D(–)ribose



Sol 5: (i) Proteins are polymer of α–amino acids and they are connected to each other by peptide bond or peptide linkage.

(ii) A polypeptide is a single linear chain of amino acids whereas an oligopeptide is a polypeptide less then

30-50 amino acids long.

(iii) Refer Exercise I, Q.6

Sol 6: A vitamin is an organic compound required by an organism as a vital nutrients in limited amounts.

(a) Two types Fat Soluble Vitamins: Vitamins which are soluble in fat and oil, but insoluble in water for E.g. Vitamin A,D,E And K

(b) Water Soluble Vitamin: Vitamins which are soluble in water, for Ex. B group vitamins and vitamins C

(b) Refer theory part.

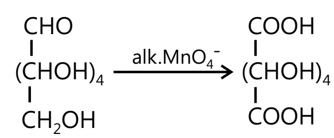
Sol 7: (a) (i) A coenzyme is a substance that works with an enzyme to initiate or aid the function of enzyme. They can not function on their own and require the presence of an enzyme.

Sol 8: (a) (i) Oranges, carrots, pumpkins

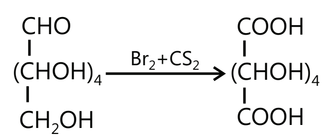
Sol 9: (i) Cellular Respiration: Like other organisms, plants store corbohydrates and burn them for energy.

(ii) Mechanical Strength: Certain carbohydrats, like cellulose helps plants in enhancing mechanical strength.

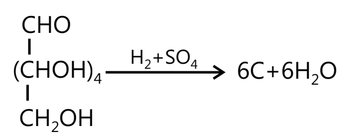
Sol 10: (i)

(i) 

Saccharic acid

(ii) 

Gluconic acid

(iii) 

Sol 11: (i) Adenine (ii) Thymine (iii) Cystosine (iv) Guanine

Thymine is not present in RNA.

Sol 12: Two fat soluble vitamin are vitamin A and D.

Vitamin A: Deficiency disease night blindness.

Sources: (i) Carrots (ii) Liver (iii) Pumpkin (iv) Orange

Vitamin D: Deficiency disease: Rickets sources.

(i) Sunlight (chief source)

(ii) Some mushrooms

Sol 13: Refer theory.

Sol 14: Refer Exercise I, two (ii)

Sol 15: (a) Functional group

(i) Carboxylic acid (ii) Amine

Amide Ester

(b) $${}^{-}OOC\text{-}CH_2\text{-}\overset{NH_3^+}{\overset{|}{CH}}\text{-}CONH\text{-}\overset{CH_2C_6C_5}{\overset{|}{CH}}\text{-}COO\ CH_3$$

(c) (i) $$HOOC\text{-}CH_2\overset{NH_2}{\overset{|}{CH}}\text{-}COOH$$

(ii) $$H_2N\text{-}\overset{CH_2\,C_6\,H_5}{\overset{|}{CH}}\text{-}COOH$$

(d) (ii) is more hydrophobic as (i) is more polar due to presence of 2 COOH groups,

Helping, (i) to make hydrogen bonds with water, increasing its hydrophilicity

Sol 16: α – (5, 6 –dimenthylbenzimidazolyl)

Cobamidcyanide more commonly called cobalmin.

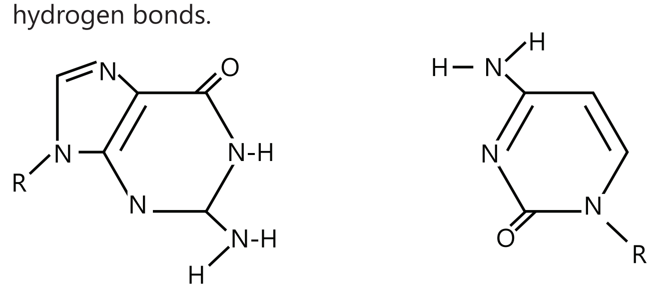
Sol 17: (a) A mixture of equal parts of glucose and fructose resulting from the hydrolysis of sucrose is called invert sugar.

(b) Polypeptide is a linear organic polymer consisting of a large number of amino acid residues bonded together in a chain, forming part of (or the whole of) a protein molecule.

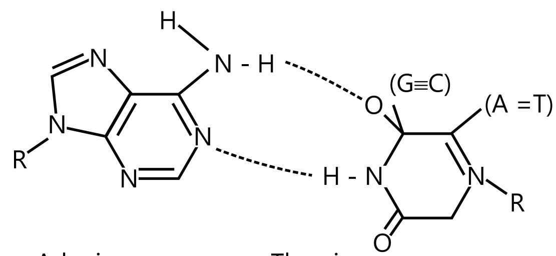
Sol 18: Intramolecular Hydrogen bonding is between C=O group of one amino acid and –HN group of fourth amino acid stabilises α–helix structure.

In 3.6_{13}–Helix, 3.6 is the number of residues per turn and 13 is the number of atoms in the hydrogen bonded loop.

Sol 19: Complementary bases are specific pairs that join up the two strands of double stranded DNA Via hydrogen bonds.



Guanine Cytosine



Adenine Thymine

Sol 20: (i) In acidic medium,

$$\underset{COO^-}{\underset{|}{R\text{-}CH\text{-}NH_3^+}} \xrightarrow{H^+} \underset{COOH}{\underset{|}{R\text{-}CH\text{-}NH_3^+}}$$

Since this is a positively charged ion (cation), they migrate towards the cathode.

In basic medium,

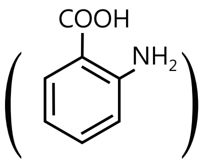
$$\underset{COO}{\underset{|}{R\text{-}CH\text{-}NH_3^+}} \xrightarrow{OH^+} \underset{COO^-}{\underset{|}{R\text{-}CH\text{-}NH_2}}$$

Since this is an anion (negatively charged), they migrate towards the anode.

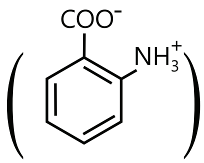
(ii)Monoamino carboxylic acids exits as zwitter ions and exhibit two different k_a values and hence two pk_a values.

$$\underset{NH_3^+}{\underset{|}{R\text{-}CH\text{-}COOH}} \xleftarrow{PK_{a1}} \underset{NH_3^+}{\underset{|}{R\text{-}CH\text{-}COO^-}} \xrightarrow{Pk_{a2}} \underset{NH_2}{\underset{|}{R\text{-}COO^-}}$$

Sol 21: Glycine ($H_2N - CH_2 - COOH$) exists as zwitter ion ($H_3N - CH_2 - COO^-$) as it contains both acid and amino group on the same α – Carbon

Anthranilic acid 

Cannot exist as zwitter ion, because

The resulting zwitter ion 

is highly destabilised by the strong +I And no m-effect of NH_3^+ group.

Sol 22: Refer theory Part.

Sol 23: Refer theory Part.

Sol 24: Refer theory Part.

Exercise 2

Biomolecules

Single Correct Choice Type

Sol 1: (A) In complementary strand, complementary bases will be present, that is according to pairing (A = T) and (C = G). Now

DNA strand.

```
A  T  G  A  C  T  G  T  C
II II III II III II III II III
T  A  C  T  G  A  C  A  G
```

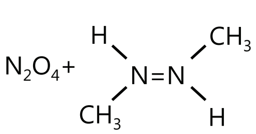
Complementary strand

Sol 2: (C) Saturated acids have high melting point due to low bond polarity

Sol 3: (D) Biodegradable detergent should contain a cyclohexyl side chain.

Sol 4: (C) The gases ejected by the rocket exert an equal and opposite thrust on the rocket.

Sol 5: (A)



(unsymmetrical dimethyl hydrazine)

Is used as bi liquid propellant in rocket fuels.

Sol 6: (C) In 'placebo', a group of patients is given an actual medicine, while the other group is given an ordinary sugar pill. The ordinary pill is called placebo.

Sol 7: (D)

$$\begin{array}{c} CHO \\ | \\ (CHOH)_2 \\ | \\ CH_2OH \end{array} \xrightarrow{Br_2,\ H_2O} \begin{array}{c} COOH \\ | \\ (CHOH)_2 \\ | \\ CH_2OH \end{array}$$

Glucose

Fructose does not undergo any reaction.

Sol 8: (A)

$$\begin{array}{c} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow{HIO_4} 5HCOOH + H_2C{=}O$$

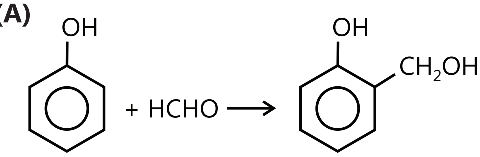
Sol 9: (D) This is correct.

Sol 10: (B) Amino acids give minhydrin test as they are primary amines.

With HNO_2,

$$\underset{\displaystyle R\,CHCOOH}{\overset{\displaystyle NH_2}{|}} \xrightarrow{HNO_2} R\,CH_2COOH + N_2$$

Sol 11: (A)



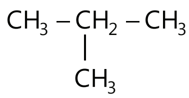
This is an electrophilic substitution.

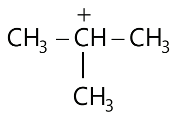
Sol 12: (A) Average molecular mass = $\dfrac{\Sigma N_i M:^2}{\Sigma N_i M:}$

Sol 13: (C) Polydispersity index

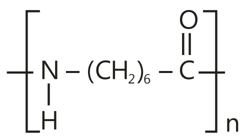
$$= \frac{\text{Weight Average Molecular Mass}}{\text{Number Average Molecular Mass}} = \frac{\dfrac{\Sigma N_i M_i^2}{\Sigma N_i M_i}}{\dfrac{\Sigma N_i M_i}{\Sigma N_i}}$$

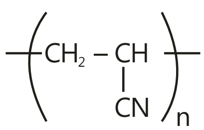
$$= \frac{\Sigma N_i \times \Sigma N_i M_i^2}{(\Sigma N_i M_i)^2}$$

Sol 14: (C) Isobutane 

We see then its cation  is very stable,

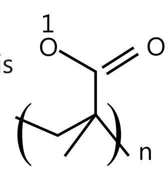
as it is tertiary, therefore the best way to polymer it is by cationic polymerization.

Sol 15: (B) Nylon-6 : 

Sol 16: (D) Acrilan 

Sol 17: (D) They are all correct.

Sol 18: (D) Commercial name for polymethylmethacrylate, is plexiglass (orperpox)



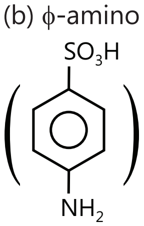
Multiple Correct Choice Type

Sol 19: (B, C) Self explanatory.

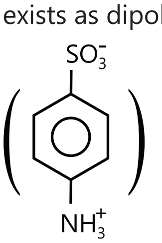
Sol 20: (B, C, D)

(a) At isoelectric point, amino acid solution is neutral.

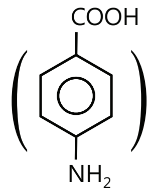
(b) ϕ-amino benzesulphonic acid



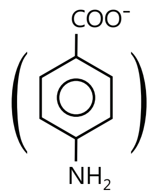
exists as dipolar ion



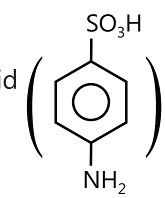
Due to very high acidity of $-SO_3H$ group and stabilisation of resulting dipolar ion due to charge distribution. In p – aminobenzoic acid

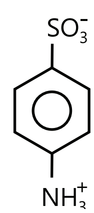


the resulting dipolar ion



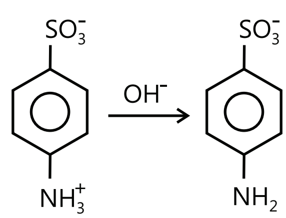
Does not exist as relatively low acidity of –COOH group and less stablisation of dipolar ion, as negative charge is distributed between only 20 atoms.

(c) Sulphanilic acid 

Exists as dipolar ion, 

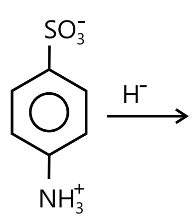
Which is an insoluble salt.

Now in base,



Reacts with base as OH^- is more basic than $^-NH_2$ group.

In acid,

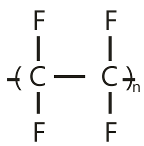
 No Reaction

No reaction, as H^+ is less acidic than $^-SO_3H$ group.

(d) Since pK_a of $H_3N^+CH_2COOH$ is less than pK_a of RCH_2COOH, it is more acidic

Sol 21: (B, C, D) Polyethylene contains single bonds only.

Polyethylene : $\left(CH_2 - CH_2\right)_n$

Teflon : 

(C) and (D) are correct

Assertion Reasoning Type

Sol 22: (A) Strach $\xrightarrow[\text{Amylase}]{}$ Maltose

Starch contains glycosidic linkage which are broken down by amylase.

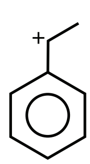
Sol 23: (C) On hydrolysis, sucrose (θ = 66.47°) gives equal amount of glucose (θ = 52.5°) and fructose (–92.4°). Thus total specific rotation of mixture is –39.9° which makes it laevorotatory, whereas the initial solution was dextrorotatory.

$$\underset{\theta = 66.47^0}{\text{Sucrose}} \rightarrow \underset{\theta = 52.5^0}{\text{Glucose}} + \underset{\theta = -92.4^0}{\text{Fructose}}$$

Sol 24: (C) A is correct

R is wrong as α –Helix is stabilised via intramolecular hydrogen bonding between –CO of one amino acid and –NH group of fourth amino acid

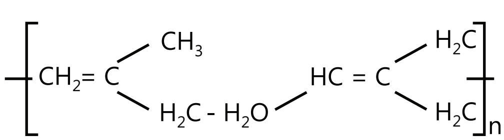
Sol 25: (C)

Carbocation form styrene 

Carbocation from propylene $CH_3\text{-}\overset{+}{H}C\text{-}CH_3$ (ii)

(i) is more than (ii) as it is resonance stabilised through conjugation with benzene ring.

Sol 26: (C) Natural rubber is all cis-polyisoprene.

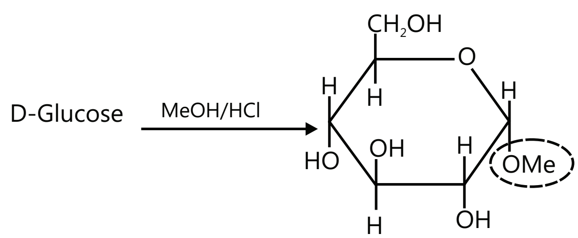


Trans-Polyisoprene can be formed but is generally not found naturally.

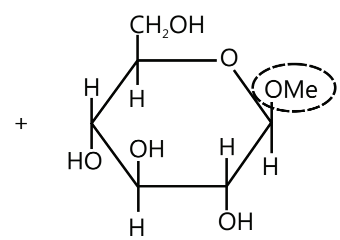
Sol 27: (A) PMMA (Poly (Methyl methacrylate) has excellent light transmission properties as it is transparent and thus used for making lanses end light covers.

Sol 28: (D) Vinyl alcohol, $H_2C = CH - OH$ is unstable

and converts to $H_3C - \overset{\overset{\displaystyle O}{\|}}{C}H$. Therefore, poly vinyl alcohol is prepared by hydrolysis on polyvinyl acetate.

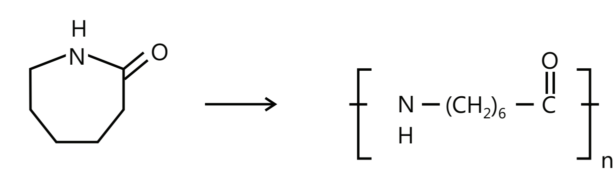


Methyl-α-D (+)
glucopyranoside



Methyl-β-D (+)
glucopyranoside

Sol29: (B) It is a polyamide



Caprolactum

Nylon-6

Comprehension Type

Paragraph 1:

Sol 30: (A) Elastomers have weakest forces of attraction e.g. rubber.

Sol 31: (A) Thermoplastics usually have a linear structure which allows them to be repeatedly softened (or hardened) by an increase (decrease) in temperature.

Sol 32: (D) Thermosetting polymers are hard due to three dimensional network of bonds.

Paragraph 2:

Sol 33: (A) Rubber on reaction with sulphur forms vulcanized rubber which is shift and resistant to action of common solvents and wear and tear.

Sol 34: (C) This process is called vulcanisation.

Match the Columns

Sol 35: (B) Nucleic acids are polynucheotides uracil is found only in RNA.

Thymine is found only in DNA, DNA has double helix structure.

Sol 36: (C) Pepsin is a digestive enzyme Nucleic acid contains genetic material Ascorbic acid is chemical name for vitamin C. Testosterone is a sex hormone.

Sol 37: (B) Bakelite is copolymer of phenol and methanol dacron is copolymer of 1, 2-dihydroxyethane and dimethylterephthalate.

Nylon-66 is a copolymer of 1, 6-hexanedioic acid and 1, 6-diaminol hexane.

(o) Buna-S is copolymer of butadiene and styrene.

Sol 38: (C)

Polymer	Monomer
Bakelite	Phenol and formaldehyde
Terylene	Terephthalic acid and ethylene glycol
Nylon-6	Caprolactam
Synthetic rubber	Butadiene and styrene

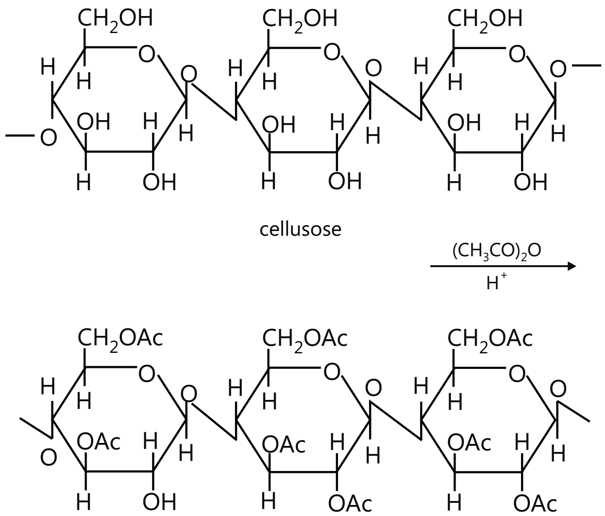
Sol 39: (B)

Polymer	Monomer
Nylon-66	Hexamethylene diamine + adipic acid
Bakelite	Phenol and formaldehyde
Glyptal	Phthalic acid and ethylene glycol
Dacron	Terephthalic acid and ethylene glycol.

Previous Years' Questions

Sol 1: (A) Cellulose is biopolymer of

β -D –glucopyranose as:



Tri-acetylated cellulose

Sol 2: (B) Cellulose and nylons have H-bonding type of intermolecular attraction while poly (vinyl chloride) is polar. Natural rubber is hydrocarbon and has the weakest intermolecular force of attraction, ie, van der Waals' force of attraction.

Sol 3: (A) The six-membered cyclic ether is known as pyranose while the five membered cyclic ether is known as furanose. Hence, ring (a) is a pyranose and it has ether linkage at α-Position that is known as α- glycosidic linkage in carbohydrate chemistry.

Sol 4: (B) Here, the –OH of hemiacetal group is equatorial therefore, it is a β -pyranose of an aldohexose.

Sol 5: (B, C) X is acetal, has no free hemiacetal, hence a non-reducing sugar while Y has a free hemiacetal group, it is reducing sugar. Also, glucosidic linkage of X is 'α' while that of Y is β -linkage.

Sol 6: (B, C)

(A) False (B) Factual

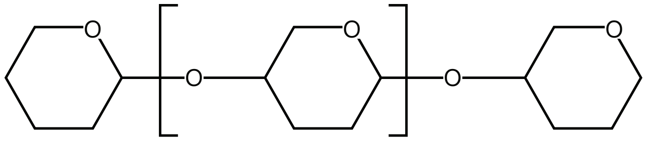
(C) $\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Invertase}]{H^+} \underset{\text{D-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-Fructose}}{C_6H_{12}O_6}$

Net specific Rotation of an equimolar mixture of

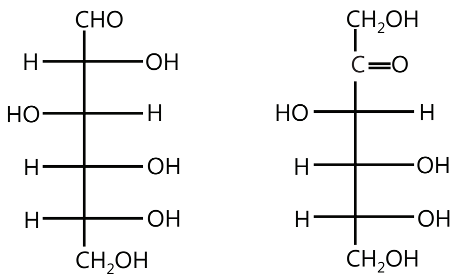
$$\text{Invert} = \frac{52-92}{2} = \frac{-40}{2} = -20$$

Sol 7: A $\rightarrow$ p, s; B $\rightarrow$ q, r; C $\rightarrow$ p, r; D $\rightarrow$ s

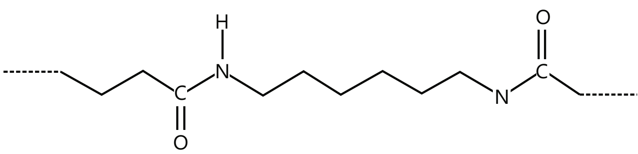
(A) Cellulose



(Glycoside linkage)

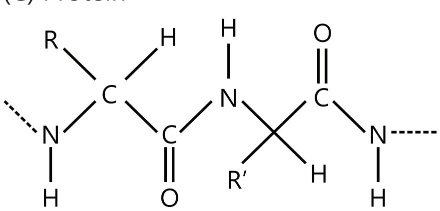


(B) Nylon 6, 6



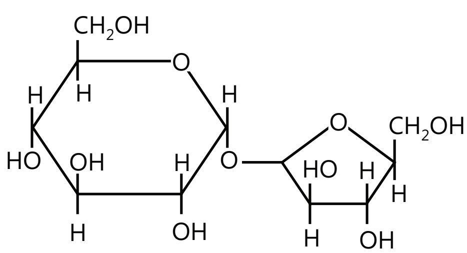
(Amide linkage)

(C) Protein



(Amide linkage)

(D) Sucrose



(Glycoside linkage)

Sol 8: –COO⁻ and $-NH_2$ are basic groups in lysine.

Sol 9: A decapeptide has nine peptide (amide) linkage as -

Therefore, on hydrolysis, it will absorb nine water molecules.

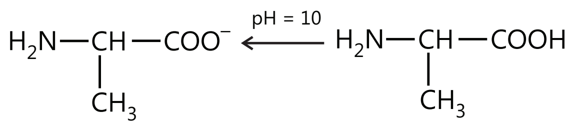
Hence, total mass of hydrolysis product

$= 796 + 18 \times 9 = 958$

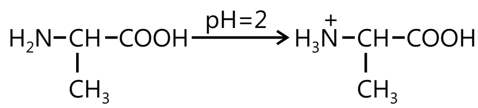
$\Rightarrow$ Mass of glycine in hydrolysis product $= \dfrac{958 \times 47}{100} = 450$

$\Rightarrow$ Number of glycine molecule in one molecule of decapeptide $= \dfrac{450}{75} = 6$

Sol 10:



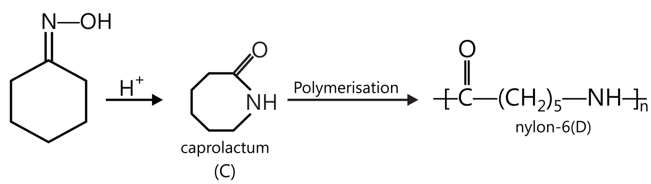
alanine



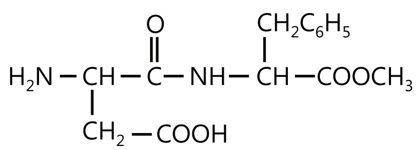
Alanine

Sol 11: Sucrose $\xrightarrow[H_2O]{H^+}$ D-glucose + D –fructose

Sol 12:



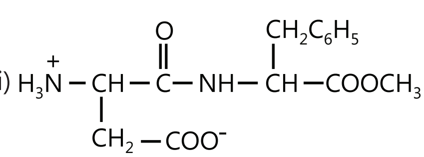
Sol 13:



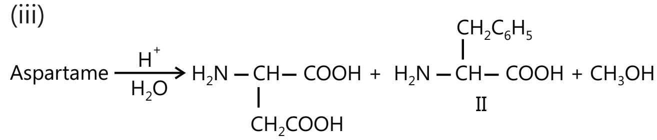
aspartame

(i) Aspartame has amine, acid, amide and ester groups.

(ii)



(iii)



(iv) II is more hydrophobic due to presence of phenyl group.

Sol 14: Zeigler-Natta catalyst, which is a mixture of triethylaluminium "$(C_2H_5)_3Al$" and $TiCl_4$, is used as heterogeneous catalyst in polymerization of ethylene.

Sol 15: (C)

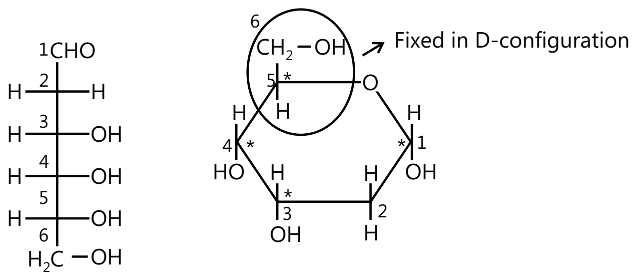
$$C_6H_{12}O_6 + \text{Fehling solution} \longrightarrow (C_6H_{11}O_7)^- + \underset{\text{(Red ppt.)}}{Cu_2O\downarrow}$$

Sol 16: (A) As in cellulose $\beta\,1-4$ glycosidic linkage is present.

Sol 17: (D) Peptides with isoelectric point (pI) > 7, would exist as cation in neutral solution (pH = 7).

IV, VI, VIII and IX

Sol 18:



Hence total number of stereoisomers in pyranose form of D-configuration $= 2^3 = 8$

Sol 19: Because –COOH group of tetrapeptide is intact on alanine, its NH_2 must be participating in condensation.

$\therefore$ Alanine is at one terminus, – – –A.

To fill the 3 blanks, possible options are:

(i) When NH_2 group attached to non chiral carbon

G	V	P
G	P	V

(ii) When NH_2 group attached to chiral carbon

V	G	P	P	V	G
V	P	G	P	G	V

where, Glycine (G)

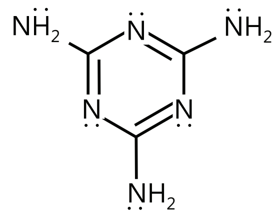
Valine (V)

Phenyl alanine (P)

Alanine (A)

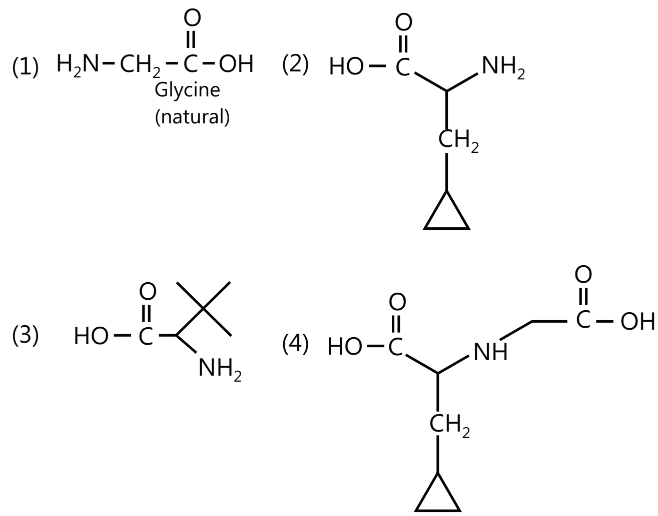
So the number of possible sequence are 4.

Sol 20: lone pairs



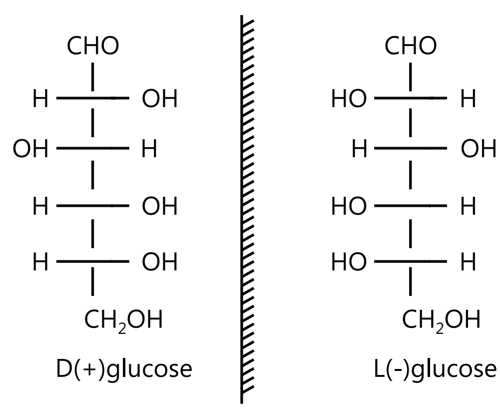
Melamine

Sol 21: This peptide on complete hydrolysis produced 4 distinct amino acids which are given below:

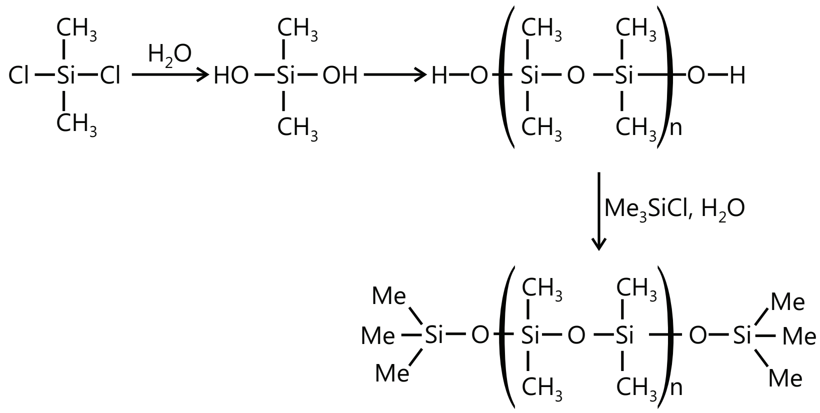


Only glycine is naturally occurring amino acid.

Sol 22: (A)



Sol 23: (B)



Sol 24: (A)

$$n\,CH_2=\underset{\displaystyle CH_3}{\underset{|}{C}}-CH=CH_2 \longrightarrow \left(CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}=CH_2\right)_n$$

Natural Rubber

Sol 25: (C, D)

(a) When X = $COOCH_3$

$$CH_3OOC-(CH_2)_4-COOCH_3 \xrightarrow[\text{heat}]{H_2/Ni} HOCH_2-(CH_2)_4-CH_2OH+2CH_3OH \xrightarrow[\text{heat}]{HOOC-(CH_2)_4-COOH}$$

$$\left[O-(CH_2)_6-\overset{\overset{\displaystyle O}{\|}}{O}-C-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}\right]_n$$

Ester, condensation polymer

(b) When X = $CONH_2$

$$H_2NOC-(CH_2)_4-CONH_2 \xrightarrow[\text{heat}]{H_2/Ni} H_2N-(CH_2)_6-NH_2 \xrightarrow[\text{heat}]{HOOC-(CH_2)_4-COOH}$$

$$\left[HN-(CH_2)_6-NH-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}\right]_n$$

Nylon, condensation polymer

(c) $H_2NOC-(CH_2)_4-CONH_2 \xrightarrow[NaOH]{Br_2} H_2N-(CH_2)_4-NH_2 \xrightarrow[\text{heat}]{HOOC-(CH_2)_4-COOH}$

Hofmann's bromamide reaction

$$\left[HN-(CH_2)_4-NH-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}\right]_n$$

Nylon, condensation polymer

(d) When X = $CONH_2$

$$NC-(CH_2)_4-CN \xrightarrow[\text{heat}]{H_2/Ni} H_2N-(CH_2)_6-NH_2 \xrightarrow[\text{heat}]{HOOC-(CH_2)_4-COOH}$$

$$\left[HN-(CH_2)_6-NH-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}\right]_n$$

Nylon, condensation polymer