Chapter–14

Biomolecules

basic concepts

1. **Biomolecules:** Macromolecules which are naturally occurring in biological systems are called biomolecules. Examples: polysaccharides (starch, cellulose, etc.), proteins, enzymes, vitamins, hormones, etc.
2. **Carbohydrates:** These are optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis, *e.g.*, glucose, sucrose, cellulose, starch, etc.
3. **Classification of carbohydrates:**
   - (*a*) **Monosaccharides:** The simple carbohydrates that cannot be broken further into smaller units on hydrolysis, *e.g.*, glucose and fructose, ribose, etc.
   - (*b*) **Oligosaccharides:** These are the carbohydrates which on hydrolysis give two to ten units of monosaccharides, *e.g.*, sucrose, maltose, raffinose, stachyose, etc.
   - (*c*) **Polysaccharides:** These are the carbohydrates which produce a large number of monosaccharide units on hydrolysis, *e.g.*, starch, cellulose, etc.

   Importance of carbohydrates:
   - (*i*) Carbohydrates act as biofuel to provide energy for functioning of living systems.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2832\ kJ$$

   - (*ii*) Carbohydrates are used as storage molecules as starch in plants and glycogen in animals.
   - (*iii*) D-Ribose and 2-Deoxy-D-ribose are present in RNA and DNA, respectively.
   - (*iv*) Cellulose acts as structural material of cell walls of bacteria and plants.
   - (*v*) Carbohydrates provide raw material for many important industries like textiles, paper, lacquers and breweries.
4. (*i*) **Reducing sugars:** Those carbohydrates which contain free aldehydic or ketonic group and reduce Fehling's solution and Tollens' reagent are called reducing sugars, *e.g.*, all monosaccharides, maltose and lactose.

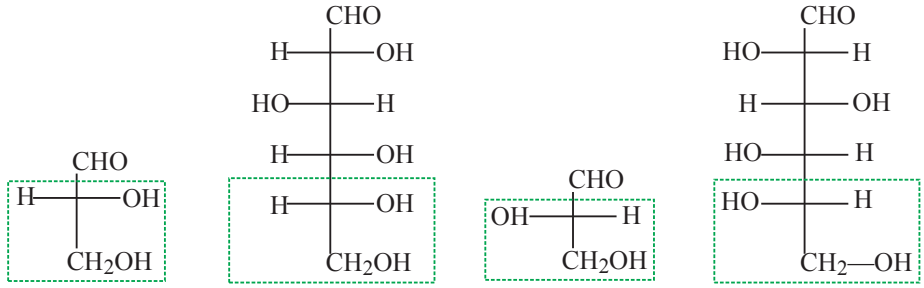
   (*ii*) **Non-reducing sugars:** Those sugars which do not have free aldehydic or ketonic group and do not reduce Fehling's solution or Tollens' reagent are called non-reducing sugars, *e.g.*, sucrose.
5. **Preparation of Glucose**
   - (*a*) **From sucrose:**

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

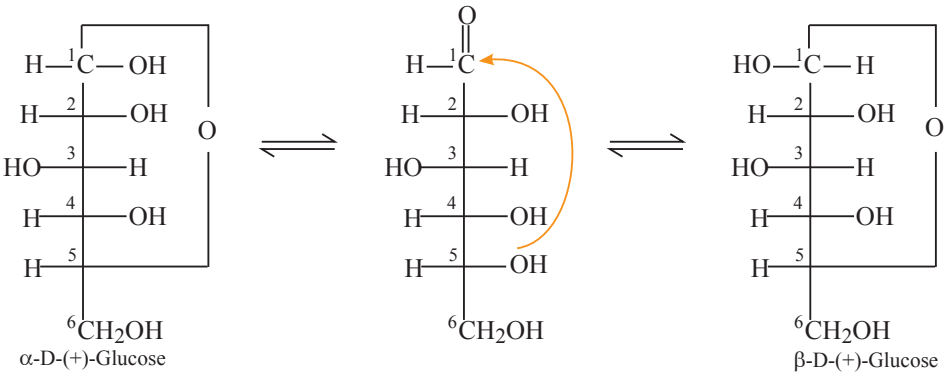
(*b*) From starch: Commercially, glucose is obtained by hydrolysis of starch by boiling it with dil. H_2SO_4 at 393 K under pressure.

$$\underset{\text{Starch or cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[393K;\ 2-3\ atm]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

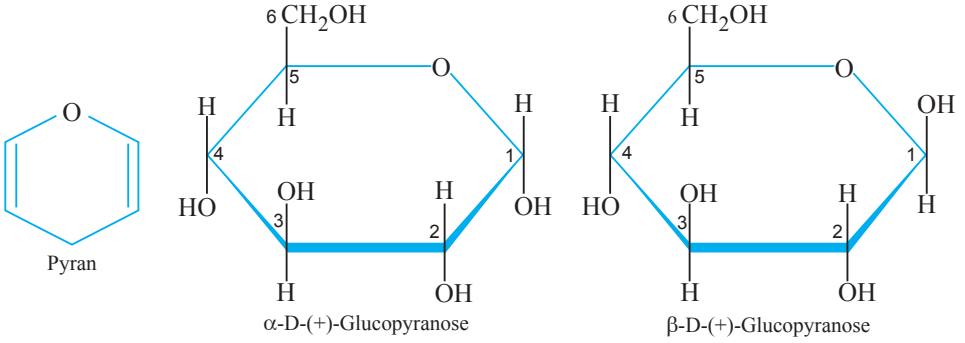
6. (*a*) Structure of Glucose: Glucose is a six carbon straight chain aldose which has one aldehydic group (—CHO), one primary hydroxyl group (—CH_2OH) and four secondary hydroxyl groups (—CHOH). If the —OH group attached to C-5 is on the right side, the glucose is assigned D–configuration; if the —OH group attached to C-5 is on the left side, it is assigned L–configuration. The (+) and (–) signs represent the optical rotation as dextro and laevo, respectively and have no relationship with D and L configuration.



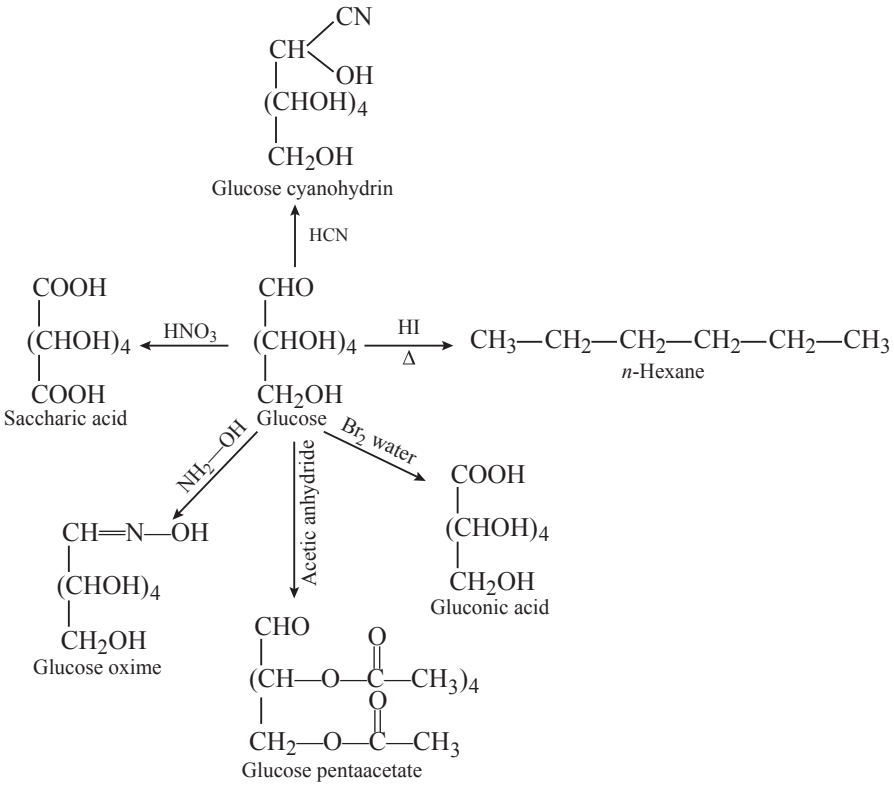
(*b*) Cyclic structure of glucose: The glucose has been shown to possess cyclic structure represented as follows:



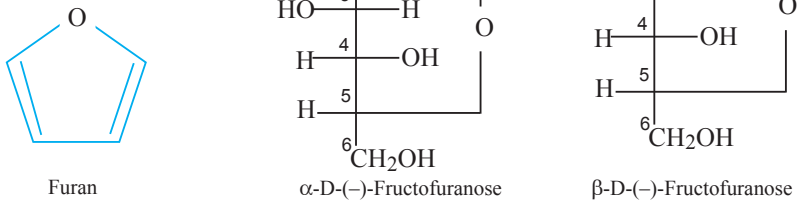
Haworth Structures



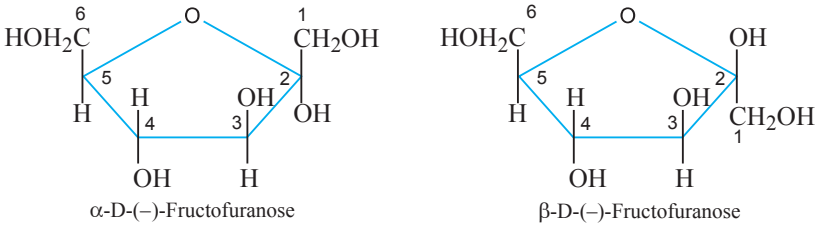
7. Reactions of Glucose



8. Structure of Fructose: Fructose is a ketohexose and has the molecular formula $C_6H_{12}O_6$. It belongs to D-series and is a laevorotatory compound.



The cyclic structures of two anomers of fructose are represented by Haworth structures as given below.

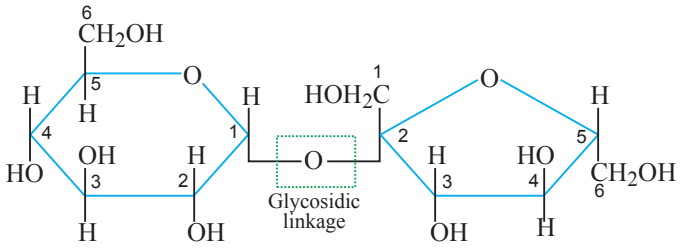


9. Disaccharides: The sugar which on hydrolysis gives two units of monosaccharides is called disaccharide. Disaccharides are crystalline solids and are soluble in water. Sucrose, maltose and lactose are disaccharides.

Hydrolysis of sucrose is called inversion of cane sugar. Sucrose is a disaccharide because on hydrolysis, it produces two monosaccharides namely D-(+)-glucose and D-(–)-fructose.

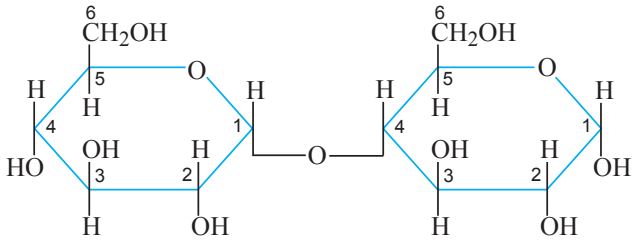
$$\underset{\substack{\text{Sucrose}\\(\text{disaccharide})}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\substack{\text{D-(+)-Glucose}\\(\text{monosaccharide})}}{C_6H_{12}O_6} + \underset{\substack{\text{D-(–)-Fructose}\\(\text{monosaccharide})}}{C_6H_{12}O_6}$$

(*a*) Ring structure of a sucrose molecule: A sucrose molecule is composed of α-glucose and β-fructose units.



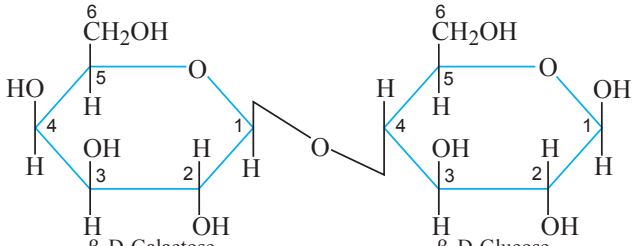
Sucrose

(*b*) Ring structure of a maltose molecule: A maltose molecule is composed of two α-D-glucose units in which C-1 of one glucose (I) is linked to C-4 of another glucose unit (II).



Maltose

(*c*) Ring structure of a lactose molecule: A lactose molecule is composed of β-D-galactose and β-D-glucose units.

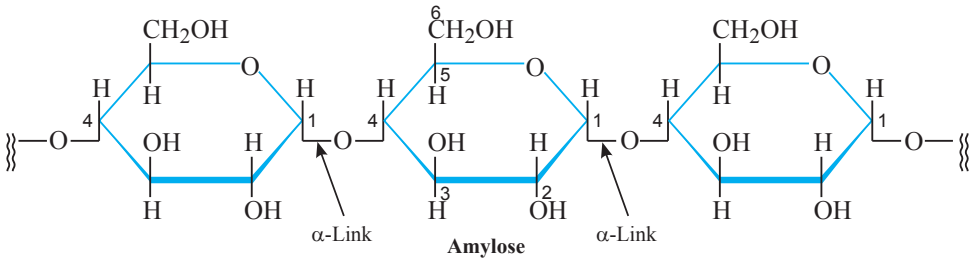


Lactose

10. Polysaccharides: Polysaccharides are the carbohydrates which yield a large number of monosaccharide molecules upon hydrolysis. Starch, cellulose and glycogen are examples of polysaccharides.

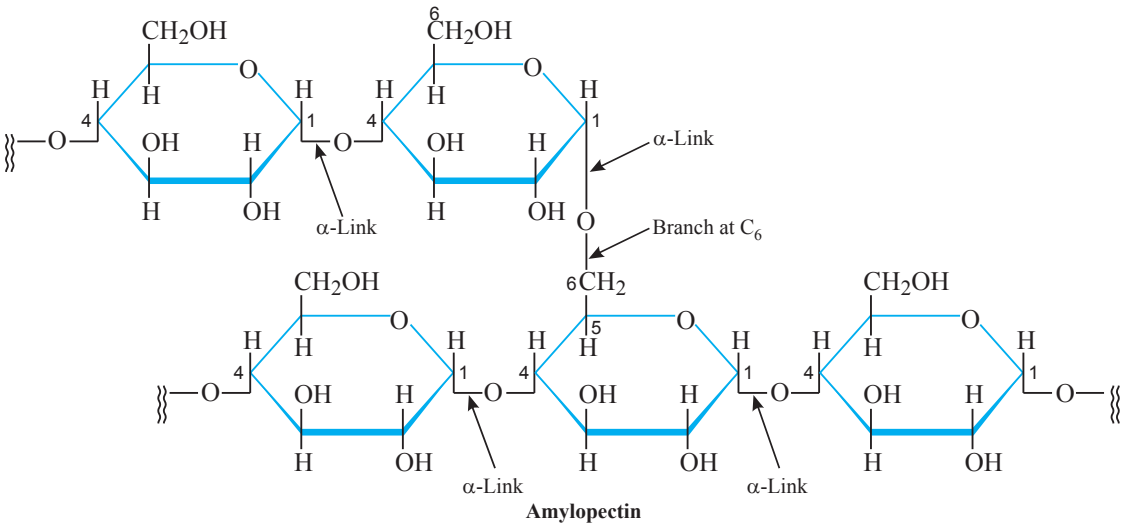
(*a*) Starch: The fundamental unit of starch is α-D-glucose.

Structure of starch: Starch is a polymer of α-glucose and consists of two components—amylose and amylopectin. Amylose is a long unbranched chain with 200–1000 α-D-(+)-glucose units held by C1–C4 glycosidic linkage.



Amylose

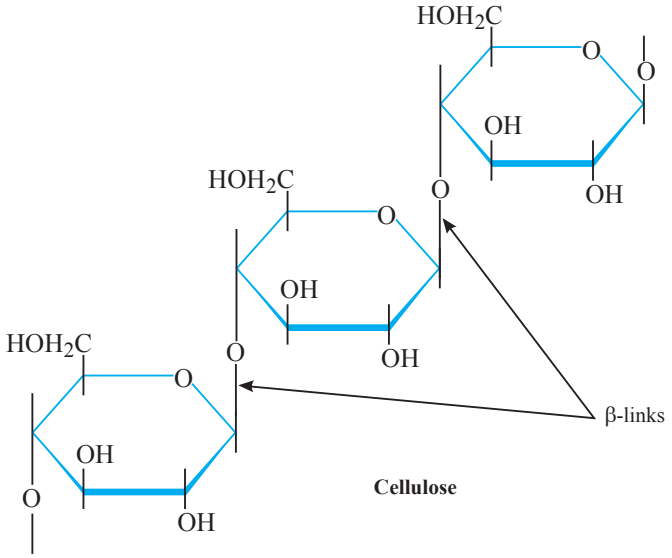
Amylopectin is a branched chain polymer of α-D-glucose units in which the chain is formed by C1–C4 glycosidic linkage, whereas branching occurs by C1–C6 glycosidic linkage.



Amylopectin

***(b)* Cellulose:** Cellulose is a polysaccharide. The fundamental structural unit of cellulose is β-D-glucose.

Structure of cellulose: Cellulose is a linear polymer of β-D-glucose which are joined by glycosidic linkage between C1 of one glucose unit and C4 of the next glucose unit.



Cellulose

11. Amino acids: Those compounds, whose molecule contains both the carboxylic acid group and the amino group are called amino acids. There are twenty amino acids which form protein. The amino acids which are synthesised in body are known as non-essential amino acids, *e.g.*, glycine, alanine. Those amino acids which cannot be synthesised in body and must be obtained through diet are known as essential amino acids, *e.g.*, valine, lysine.

Amino acids have also been classified as neutral, acidic and basic amino acids. Amino acids like glycine, valine, etc. which contain one —NH_2 and one —COOH group are called neutral amino acids. Those amino acids such as aspartic acid, glutamic acid, etc. which contain one —NH_2 group and two —COOH groups are called acidic amino acids and amino acids such as lysine, histidine, etc., which contain two —NH_2 groups and one —COOH group are called basic amino acids.

12. Proteins are complex nitrogenous organic molecules which are essential for growth and maintenance of body.

Chemically, proteins are the polymers of α-amino acids which are linked by peptide bonds ($-\overset{\overset{O}{\|}}{C}-NH-$) .

(*a*) Types of proteins based on molecular shape:

(*i*) Fibrous proteins: They have thread-like molecules which tend to lie side by side to form fibres, *e.g.*, keratin, collagen, myosin, fibroin, etc. In such proteins, the molecules are held together by hydrogen and disulphide bonds. They are insoluble in water. They are the chief structural materials of animal tissues.

(*ii*) Globular proteins: They have molecules which are folded into compact units that often form spheroidal shapes. The area of contact between molecules are small and inter-molecular forces are comparatively weak, *e.g.*, insulin, thyroglobulin, albumin, haemoglobin and fibrinogen. In clotting of blood, fibrinogen gets converted into fibrous protein, fibrin.

(*b*) Structure of Proteins: There are four levels at which the structure of proteins are studied. These are primary, secondary, tertiary and quarternary levels.

(*i*) Primary structure of proteins: The sequence in which various amino acids are arranged in a protein is called its primary structure. Any change in the sequence of amino acids creates different protein which alters biological functions.

(*ii*) Secondary structure of proteins: It refers to shape in which a long polypeptide chain exists. A protein may assume α-helix structure or β-pleated sheet structure. The α-helix structure results due to regular coiling of polypeptide chain which is stabilised by intramolecular hydrogen bonding. Keratin in hair, nails, wool and myosin in nucleus have α-helix structure. In β-pleated sheet structure, all peptide chains are stretched to nearly maximum extension and then arranged side by side and held together by intermolecular hydrogen bonding. Silk has β-pleated sheet structure.

(*iii*) Tertiary structure of proteins: The tertiary structure of proteins represents overall folding of the polypeptide chain, *i.e.*, further folding of the secondary structure. It gives rise to two major molecular shapes, *viz*., fibrous and globular. The main forces which stabilise 2° and 3° structures of proteins are hydrogen bonds, disulphide linkages, van der Waals forces and electrostatic force of attraction.

(*iv*) Quaternary structure: Some of the proteins are composed of two or more polypeptide chains referred to as sub-units. The spatial arrangement of these subunits with respect to each other is known as quaternary structure.

(*c*) Denaturation of Proteins: When a protein in its native form is subjected to a change, such as change in temperature or change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. This is called denaturation of protein. During denaturation, 2° and 3° structures are destroyed but 1° structure remains intact, *e.g.*, coagulation of egg while on boiling, curdling of milk, etc.

13. **(*a*) Enzymes:** Enzymes are essential biological catalysts which are required to catalyse biological reactions, *e.g.*, maltose, lactose, invertase, etc. Almost all the enzymes are globular proteins.

(*b*) Oxidoreductase enzymes: Enzymes which catalyse the oxidation of one substrate with simultaneous reduction of another substrate.

(*c*) Phenylketonuria: Disease caused by deficiency of the enzyme phenylalanine hydroxylase.

(*d*) Albinism: Disease caused due to deficiency of an enzyme tyrosinase.

(*e*) Streptokinase: Enzyme which dissolves the blood clot formed in coronary artery which leads to heart trouble.

14. **Nucleic Acids:** Nucleic acids are long chain polymers of nucleotides. They play an important role in transmission of hereditary characteristics and biosynthesis of proteins.

Types of nucleic acids: There are two types of nucleic acids. These are DNA and RNA.

(*a*) Constituents of nucleic acids:

(*i*) Pentose sugar (*ii*) Phosphoric acid (*iii*) Nitrogenous bases.

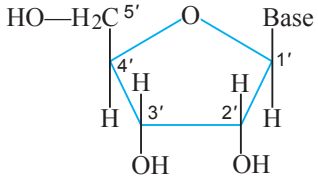
In DNA, β-D-2-deoxyribose sugar is present while in RNA β-D-ribose sugar is present.

Nitrogen containing bases: There are two types of nitrogen containing bases found in nucleic acids. These are pyrimidines and purines.

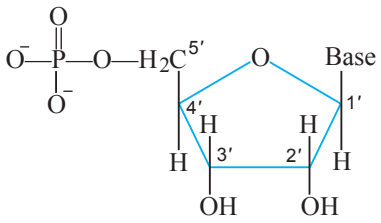
Pyrimidines: There are three bases derived from pyrimidines. These are cytosine (C), thymine (T) and uracil (U). In DNA, T is present but in RNA, U is present.

Purines: There are two bases derived from purine. These are adenine (A) and guanine (G).

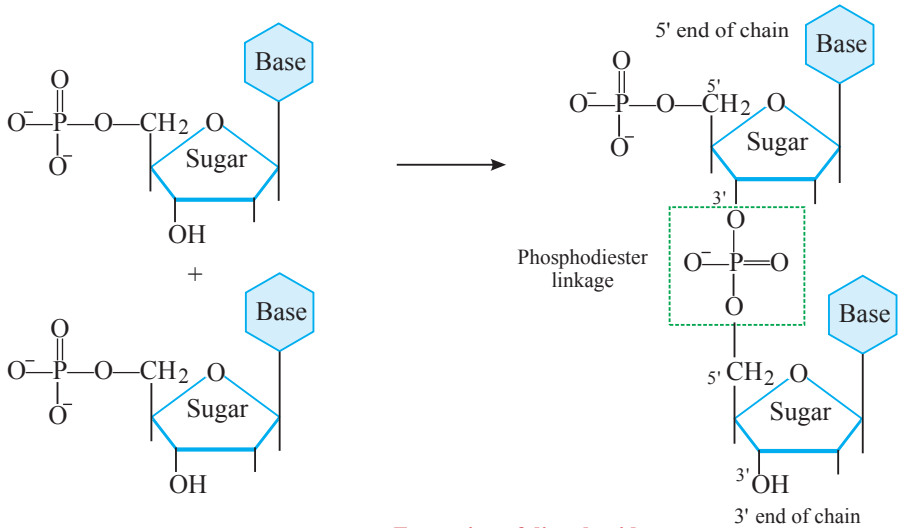
Nucleoside: A unit formed by the attachment of a base to 1′-position of sugar is known as nucleoside.



Nucleotide: When nucleoside is linked to phosphoric acid at 5′-position of sugar moiety, the unit obtained is called nucleotide.



Nucleotides are joined together by phosphodiester linkage between 5′ and 3′ carbon atoms of the pentose sugar.



Formation of dinucleotide

(*b*) Deoxyribonucleic acid (DNA): It contains a pentose sugar deoxyribose, and adenine, guanine, thymine and cytosine bases. A phosphate group is present at C-5 of the sugar unit. The repeating units, deoxyribonucleotides, are linked by phosphate group. Thus, they are the biopolymers of deoxyribonucleotides and have double helix structure of polynucleotides. The two strands of DNA are said to be complementary to each other. Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine. They are responsible for genetic characteristics and for sending information and instruction in the cell for the synthesis of specific protein.

(*c*) Ribonucleic acid (RNA): It contains ribose sugar, bases from pyrimidine bases—uracil and cytosine, and two bases from purine base—adenine and guanine. A phosphate group is present at C-5 of the sugar unit. The repeating units, ribonucleotides, are linked by phosphate group. They are the polymers of ribonucleotide and have a single helix structure. RNA is associated with the process of learning and memory storage, and helps in biosynthesis of protein.

15. Functions of Nucleic Acids: Two main functions of nucleic acids are:

(*a*) Replication or heredity transfer: The double helix of DNA is the storehouse of the genetic information of the organism which is contained in the sequence of bases A, T, C, G on the strands of DNA. The process by which a DNA molecule produces two identical molecules of itself in the nucleus of the cell is called replication.

(*b*) **Protein synthesis:** This is brought about in two steps:

(*i*) **Transcription:** Copying of sequence of bases from the DNA strand onto the RNA molecule is called transcription. During transcription, the double helix of the DNA partially unwinds and one of the two DNA strands serves as a template for the synthesis of RNA strand called messenger RNA (*m*RNA) which is complementary to a segment of the DNA chain.

(*ii*) **Translation:** This is the process in which *m*RNA directs protein synthesis in the cytoplasm of cell with involvement of transfer RNA (*t*RNA) and ribosomal particles (*r*RNA protein complexes).

16. (*a*) **Codon:** The sequence of nucleotides in *m*RNA molecules are read in a serial order in sets of three (triplet) at a time. Each triplet is called a codon. It specifies one amino acid. The *m*RNA codon recognises the amino acids through *t*RNAs which carry specific amino acids.

(*b*) **Gene:** The sequence of bases or nucleotides in the DNA molecule which regulates the synthesis of a specific protein is called a gene. Every protein in the cell has a corresponding gene. The relationship between a nucleotide triplet (codon) and the amino acid is called genetic code.

(*c*) **Mutation:** The chemical change in the sequence of bases in the DNA molecule can lead to synthesis of protein with an altered amino acid sequence is called mutation. This is brought about spontaneously by exposure to UV-rays, X-rays and chemicals.

17. Vitamins: Vitamins are generally regarded as organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism.

Vitamins are classified into two groups depending upon their solubility in fat or water:

(*i*) **Fat-soluble vitamins:** Vitamins A, D, E and K are soluble in fat and oils but insoluble in water. They are stored in liver and adipose tissues.

(*ii*) **Water-soluble vitamins:** Vitamins belonging to group B and vitamin C are soluble in water. They must be supplied regularly in diet because they are readily excreted in urine and cannot be stored (except vitamin B_{12}) in our body.

Table 14.1: Some Important Vitamins, their Sources and their Deficiency Diseases

S. No.	Name of Vitamins	Sources	Deficiency Diseases
1.	Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye), night blindness
2.	Vitamin B_1 (Thiamine)	Yeast, milk, green vegetables and cereals	Beri-beri (loss of appetite, retarded growth)
3.	Vitamin B_2 (Riboflavin)	Milk, egg white, liver, kidney	Cheilosis (fissuring at corners of mouth and lips), digestive disorders and burning sensation of the skin.
4.	Vitamin B_6 (Pyridoxine)	Yeast, milk, egg yolk, cereals and grams	Convulsions
5.	Vitamin B_{12}	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
6.	Vitamin C (Ascorbic acid)	Citrus fruits, *amla* and green leafy vegetables.	Scurvy (bleeding gums)
7.	Vitamin D	Exposure to sunlight, fish and egg yolk	Rickets (bone deformities in children) and osteomalacia (soft bones and joint pain in adults)
8.	Vitamin E	Vegetable oils like wheat germ oil, sunflower oil, etc.	Increased fragility of RBCs and muscular weakness
9.	Vitamin K	Green leafy vegetables	Increased blood clotting time

18. Hormones: Hormones are molecules that act as intercellular messengers. These are produced by endocrine glands in the body and are released directly in the blood stream. From here these are transported to the site of their action.

Functions of hormones:

(*i*) They help to maintain the balance of biological activities in the body. For example, insulin keeps the blood glucose level within the range, epinephrine and norepinephrine mediate response to external stimuli, growth hormones and sex hormones play role in growth and development.

(*ii*) The hormones released by gonads are responsible for development of secondary sexual characters.

(*iii*) Adrenal cortex release glucocorticoids and mineralocorticoids. The glucocorticoids control the carbohydrate metabolism, modulate inflammatory reactions and are involved in reactions to stress. The mineralocorticoids control the level of excretion of water and salt by the kidney.

NCERT Textbook Questions

NCERT Intext Questions

Q. 1. Glucose or sucrose are soluble in water but cyclohexane or benzene (simple six-membered ring compounds) are insoluble in water. Explain.

Ans. Glucose contains five —OH groups and sucrose (molecular mass = 342) contains eight —OH groups. These —OH groups form hydrogen bonds with water. Because of this extensive intermolecular hydrogen-bonding, glucose and sucrose are soluble in water.

On the other hand, benzene (molecular mass = 78) and cyclohexane (molecular mass = 84) are simple molecules having low molecular masses. Even then they are insoluble in water as these compounds do not contain —OH groups and hence do not form hydrogen bonds with water.

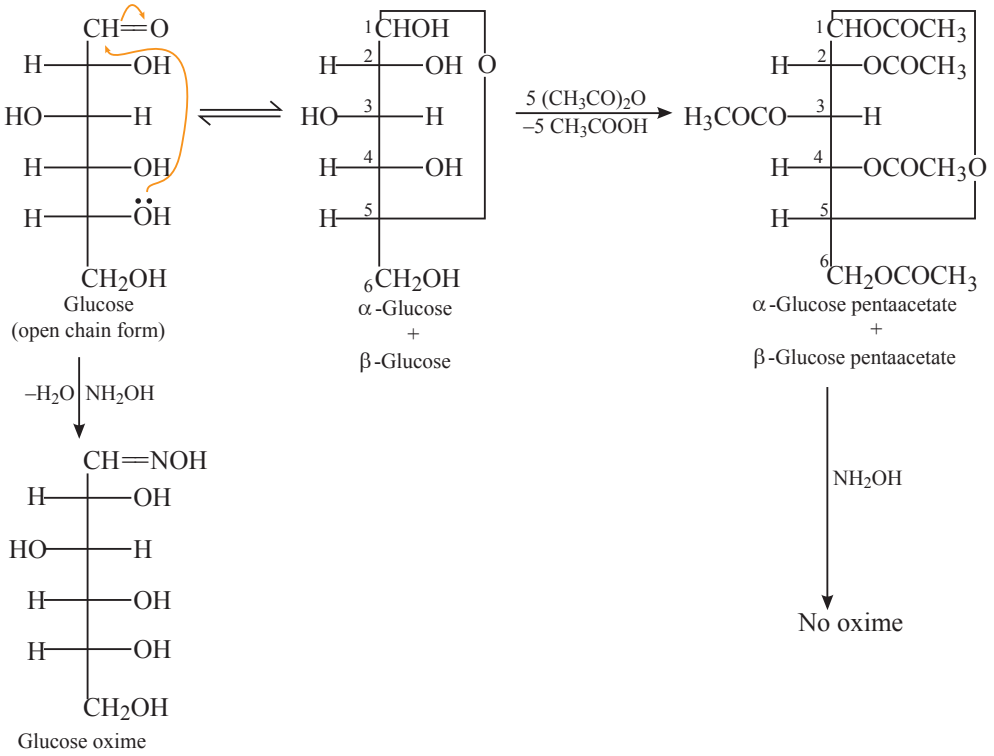
Q. 2. What are the expected products of hydrolysis of lactose? ***[CBSE 2019 (56/2/3)]***

Ans. On hydrolysis, lactose gives two molecules of monosaccharides, *i.e.*, one molecule of D-(+)-glucose and one molecule of D-(+)-galactose.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or Lactase}]{H_3O^+} \underset{\text{D-(+)-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-(+)-Galactose}}{C_6H_{12}O_6}$$

Q. 3. How do you explain the absence of aldehyde group in the pentaacetate of D-glucose? ***[CBSE 2020 (56/3/3)]***

Ans. The cyclic hemiacetal form of glucose contains an —OH group at C-1 which gets hydrolysed in the aqueous solution to produce the open chain aldehydic form which then reacts with NH_2OH to form the corresponding oxime. Therefore, glucose contains an aldehydic group. On the other hand, when glucose is reacted with acetic anhydride, the —OH group at C-1, along with the four other —OH groups at C-2, C-3, C-4 and C-6 form a pentaacetate. As the pentaacetate of glucose does not contain a free —OH group at C-1, it cannot get hydrolysed in aqueous solution to produce the open chain aldehydic form and thus glucose pentaacetate does not react with NH_2OH to form glucose oxime.



Q. 4. The melting points and solubility in water of amino acids are generally higher than that of the corresponding halo acids. Explain.

Ans. The amino acids exist as zwitter ions, $H_3\overset{+}{N}$—CHR—COO^-. Because of this dipolar salt-like character, they have strong dipole–dipole attractions. So, their melting points are higher than halo acids which do not have salt-like character. Moreover, due to this salt-like character, they interact strongly with H_2O. Thus, solubility in water of amino acids is higher than that of the corresponding halo acids which do not have salt-like character.

Q. 5. Where does the water present in the egg go after boiling the egg?

Ans. On boiling the egg, the proteins undergo denaturation and the water present in the egg gets absorbed or adsorbed in the denaturated proteins probably through H-bonding.

Q. 6. Why cannot vitamin C be stored in our body?

Ans. Vitamin C is soluble in water, hence, it is readily excreted in urine and thus cannot be stored in the body.

Q. 7. What products would be formed when a nucleotide from DNA containing thymine is hydrolysed?

Ans. Besides thymine, the two products are 2-deoxy-D-ribose and phosphoric acid.

Q. 8. When RNA is hydrolysed, there is no relationship among the quantities of different bases obtained. What does this fact suggest about the structure of RNA? ***[HOTS]***

Ans. A DNA molecule has two strands in which the four complementary bases pair each other, *viz*., cytosine (C) always pairs with guanine (G) while thymine (T) always pairs with adenine (A). Therefore, when a DNA molecule is hydrolysed, the molar amounts of cytosine is always equal to that of guanine and that of adenine is always equal to that of thymine. RNA also contains four bases, the first three are same as in DNA but the fourth one is uracil (U).

As in RNA, there is no relationship between the quantities of four bases (C, G, A and U) obtained, therefore, the base-pairing principle, *viz*., A pairs with U and C pairs with G is not followed. So, unlike DNA, RNA has a single strand.

NCERT Textbook Exercises

Q. 1. What are monosaccharides?

Ans. Monosaccharides are carbohydrates which cannot be further hydrolysed to simpler molecules. The general formula is $(CH_2O)_n$ where $n = 3 - 7$.

Q. 2. What are reducing sugars?

Ans. Carbohydrates which reduce Fehling's solution to red precipitate of Cu_2O or Tollens' reagent to metallic Ag are called reducing sugars. All monosaccharides (both aldoses and ketoses) and disaccharides except sucrose are reducing sugars.

Q. 3. Write two main functions of carbohydrates in plants.

Ans. (*i*) **Structural material for cell walls:** The polysaccharide, cellulose acts as the chief structural material of the cell walls.

(*ii*) **Reserve food material:** The polysaccharide, starch is the major reserve food material in the plants.

Q. 4. Classify the following into monosaccharides and disaccharides: Ribose, 2-deoxyribose, maltose, galactose, fructose and lactose.

Ans. **Monosaccharides:** Ribose, 2-deoxyribose, galactose and fructose.

Disaccharides: Maltose and lactose.

Q. 5. What do you understand by the term glycosidic linkage?

Ans. The linkage between two monosaccharide units in a oligosaccharide or a polysaccharide through oxygen atom is called glycosidic linkage.

Q. 6. What is glycogen? How is it different from starch? ***[CBSE (F) 2012]***

Ans. Glycogen is a polymer of α–D–glucose. The carbohydrates are stored in animal body as glycogen. Starch is also a polymer of α–D–glucose and consist of two components amylose and amylopectin. Amylose is linear chain polymer of α–D–glucose. Both glycogen and amylopectin are branched chain polymers of α–D–glucose but glycogen is more highly branched than amylopectin. Starch is the main storage polysaccharide of plants.

Q. 7. What are the hydrolysis products of (*i*) sucrose (*ii*) lactose? **[*CBSE (AI) 2010, 2013, 2014*]**

Ans. Both sucrose and lactose are disaccharides. Sucrose on hydrolysis gives one molecule each of glucose and fructose. Lactose on hydrolysis gives one molecule each of glucose and galactose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or Invertase}]{H_3O^+} \underset{\text{D-(+)-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-(–)-Fructose}}{C_6H_{12}O_6}$$

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or Lactase}]{H_3O^+} \underset{\text{D-(+)-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-(+)-Galactose}}{C_6H_{12}O_6}$$

Q. 8. What is the basic structural difference between starch and cellulose? **[*CBSE 2019 (56/2/2)*]**

OR

Starch and cellulose both contain glucose units as monomer, yet they are structurally different. Explain. **[*CBSE 2020 (56/1/2)*]**

Ans. Starch consists of amylose and amylopectin.

Amylose is a long unbranched chain with α-D(+)-glucose units that are held together with C1–C4 glycosidic linkage. Amylopectin is a highly branched chain polymer of α-D-glucose units in which glycosidic linkage is present between C1–C4 atoms and branching occurs through C1–C6 glycosidic linkage. For figures refer to Basic Concept Point 10(*a*).

Cellulose is a straight chain polysaccharide composed only of β-D-glucose units which are joined by glycosidic linkage between C1 of one glucose units and C4 of next glucose units. For figure refer to Basic Concepts Point 10(*b*).

Q. 9. What happens when D-glucose is treated with the following reagents? **[*CBSE 2019 (56/5/2)*]**

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

Ans. Refer to Basic Concepts Point 7.

Q. 10. Enumerate the reactions of D-glucose which cannot be explained by its open chain structure.

Ans. The following reactions cannot be explained by its open chain structure proposed by Baeyer:

(*i*) Despite having an aldehydic group, glucose does not give Schiff's test and it does not react with sodium bisulphite and ammonia.

(*ii*) The pentaacetate of glucose does not react with hydroxylamine indicating absence of —CHO group.

(*iii*) When D-glucose is treated with methyl alcohol in presence of dry hydrogen chloride gas, it gives two isomeric mono methyl derivatives known as α-D-glucoside and methyl β-D-glucoside. These glucosides does not reduce Fehling's solution and also do not react with hydrogen cyanide or hydroxylamine indicating the absence of free —CHO group.

Q. 11. What are essential and non-essential amino acids? Give two examples of each type.

[*CBSE Delhi 2010*]

Ans. α-Amino acids which are required for health and growth of human beings but are not synthesised by the human body are known as essential amino acids. Examples: valine, leucine, phenylalanine, etc. On the other hand, α-amino acids which are needed for health and growth of human beings and are synthesised by the human body are called non-essential amino acids. Examples: glycine, alanine, aspartic acid, etc.

Q. 12. Define the following terms as related to proteins:

(*i*) Peptide linkage **(*ii*) Primary structure** **(*iii*) Denaturation**

[*CBSE (AI) 2014; 2019 (56/5/2)*]

Ans. (*i*) A **peptide linkage** is an amide ($\underset{\|}{\overset{O}{}}$—C—NH—) linkage formed between —COOH group of one α-amino acid and —NH_2 group of other α-amino acid by loss of a water molecule.

(*ii*) The specific sequence in which various α-amino acids present in a protein are linked to one another is called its **primary structure**. Any change in its primary structure creates a new protein.

(*iii*) When a protein in its native form is subjected to a change, such as change in temperature or change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. This is called **denaturation of protein**. During denaturation, 2° and 3° structures are destroyed but 1° structure remains intact, *e.g.*, coagulation of egg while on boiling, curdling of milk, etc.

Q. 13. What are common types of secondary structure of proteins?

Ans. The conformation which the polypeptide chains assume as a result of hydrogen bonding is known as the secondary structure of the proteins. The two types of secondary structures are α-helix and β-pleated sheet structure.

Q. 14. What type of bonding helps in stabilising the α-helix structure of proteins?

Ans. The α-helix structure of proteins is stabilised by intramolecular H-bonding between C—O of one amino acid residue and the N—H of the fourth amino acid residue in the chain.

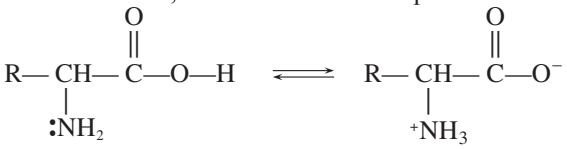
Q. 15. Differentiate between globular and fibrous proteins. ***[CBSE 2019 (56/5/2), 2020 (56/5/1)]***

Ans. Refer to Basic Concepts Point 12(*a*).

Q. 16. How do you explain the amphoteric behaviour of amino acids?

Ans. Amino acids contain both acidic (carboxyl group) and basic (amino group) groups in the same molecule. In aqueous solution, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as zwitter ion. This is neutral but contains both positive and negative charges.

In zwitter ionic form, amino acids show amphoteric behaviour as they react with both acids and bases.



Q. 17. What are enzymes?

Ans. Enzymes are biological catalysts. Each biological system requires a different enzyme. So, as compared to conventional catalysts, enzymes are specific and efficient in their action. They are required in only small quantity and work at optimum temperature (310 K) and pH (7.4) under 1 atmospheric pressure. Chemically, they are globular proteins. However, some enzymes are also associated with some non-protein components called the co-factors for their activity. Cofactors are of two types:

(*i*) Inorganic ions such as Zn^{2+}, Mg^{2+}, Mn^{2+}, Fe^{2+}, Cu^{2+}, Co^{2+}, etc.

(*ii*) Organic molecules: These are of two types:

(*a*) Coenzymes: These are usually derived from vitamins such as thymine, riboflavin, niacin, etc. They are loosely held to the protein and can be easily separated by dialysis.

(*b*) Prosthetic group: They are also derived from vitamins such as biotin but are tightly held to the protein molecule by covalent bonds. They can be separated only by careful hydrolysis.

Q. 18. What is the effect of denaturation on the structure of proteins?

Ans. During denaturation, 2° and 3° structures of proteins are destroyed but 1° structure remains intact. Due to denaturation, the globular proteins (soluble in H_2O) are converted into fibrous proteins (insoluble in H_2O) and their biological activity is lost. For example, boiled egg which contains coagulated proteins cannot be hatched.

Q. 19. How are vitamins classified? Name the vitamin responsible for the coagulation of blood.

Ans. Vitamins are classified into two groups depending upon their solubility in water or fat.

(*i*) Water-soluble vitamins: These include vitamin B-complex (B_1, B_2, B_5, *i.e.*, nicotinic acid, B_6, B_{12}, pantothenic acid, biotin, *i.e.*, vitamin H and folic acid) and vitamin C.

(*ii*) Fat-soluble vitamins: These include vitamin A, D, E and K. These are stored in liver and adipose tissues (fat storing tissues).

Vitamin K is responsible for coagulation of blood.

Q. 20. Why are vitamin A and vitamin C essential to us? Give their important sources.

Ans. Vitamin A is essential for us because its deficiency can cause xerophthalmia (hardening of cornea of eye) and night blindness.

Sources: Carrots, fish liver oil, butter and milk.

Vitamin C: Vitamin C is essential for us because its deficiency causes scurvy (bleeding gums) and pyorrhea (loosening and bleeding of teeth).

Sources: *Amla*, citrus fruits and green leafy vegetables.

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

Ans. Nucleic acids are biomolecules which are found in the nuclei of all living cells in the form of nucleoproteins or chromosomes (proteins containing nucleic acids as the prosthetic group).

These are of two types: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The two main functions of nucleic acids are:

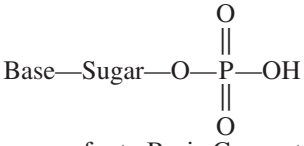
(*i*) DNA is responsible for transmission of hereditary effects from one generation to another. This is because of the unique property of replication during cell division and the transfer of two identical DNA strands to the daughter cells.

(*ii*) DNA and RNA are responsible for synthesis of all proteins essential for the growth and maintenance of our body. Actually, the proteins are synthesised by various RNA molecules (*r*RNA, *m*RNA and *t*RNA) in the cell but the message for the synthesis of a particular protein is present in DNA.

Q. 22. What is the difference between a nucleoside and a nucleotide? ***[CBSE Delhi 2010; (F) 2013]***

Ans. A nucleoside is formed when 1-position of pyrimidine (cytosine, thymine or uracil) or 9-position of purine (guanine or adenine) base is connected to C-1 of sugar (ribose or deoxyribose) by a β-linkage. Hence, in general, nucleosides may be represented as: Sugar–Base.

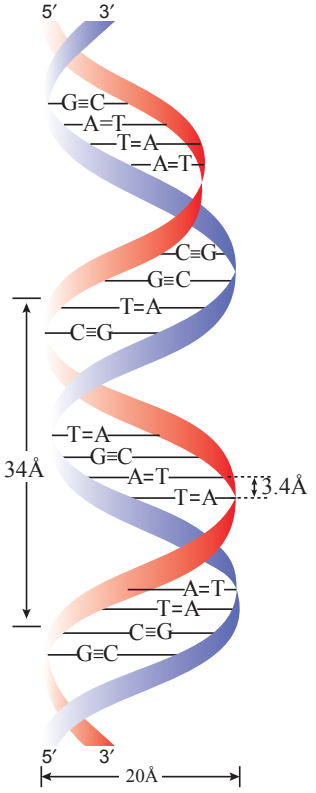
A nucleotide contains all the three basic compounds of nucleic acids, *i.e.*, a phosphoric acid group, a pentose sugar and a nitrogenous base. These are obtained by esterification of C'_5 — OH group of the pentose sugar by phosphoric acid. Thus, in general, a nucleotide is represented as:



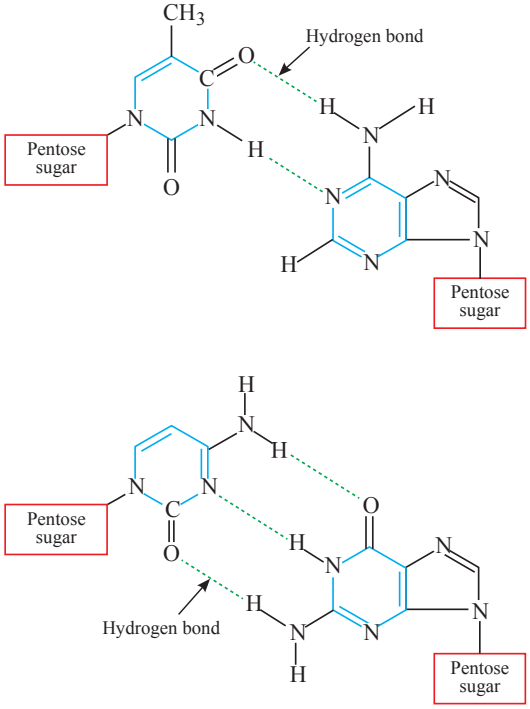
For figures refer to Basic Concepts Point 14(*a*).

Q. 23. The two strands in DNA are not identical but are complementary. Explain. ***[CBSE 2020 (56/1/2)]***

Ans. The two strands in DNA molecule are held together through hydrogen bonds between purine base of one strand and pyrimidine base of the other and vice versa. Because of different sizes and geometries of the base, the only possible pairing in DNA are G (guanine) and C (cytosine) through three H-bonds (*i.e.*, C≡G) and between A (adenine) and T (thymine) through two H-bonds (*i.e.*, A = T). Due to this base-pairing principle, the sequence of bases in one strand automatically fixes the sequence of bases in the other strand. Thus, the two strands are not identical but are complementary.



(a) The double strand helix structure for DNA



(b) Base pair in DNA

Q. 24. Write the important structural and functional differences between DNA and RNA.

Ans.

	DNA	RNA
Structural differences		
(*i*)	The sugar present in DNA is 2-deoxy-D-(–)-ribose.	The sugar present in RNA is D-(–)-ribose.
(*ii*)	DNA contains cytosine and thymine as pyrimidine bases.	RNA contains cytosine and uracil as pyrimidine bases.
(*iii*)	DNA has a double stranded α-helix structure.	RNA has a single stranded α-helix structure.
(*iv*)	DNA molecules are very large; their molecular mass may vary from $6 \times 10^6 - 16 \times 10^6$ u.	RNA molecules are much smaller with molecular mass ranging from 20,000 to 40,000 u.
Functional differences		
(*i*)	DNA has unique property of replication.	RNA usually does not replicate.
(*ii*)	DNA controls the transmission of hereditary effects.	RNA controls the synthesis of proteins.

Q. 25. What are the different types of RNA found in the cell? ***[CBSE Delhi 2013]***

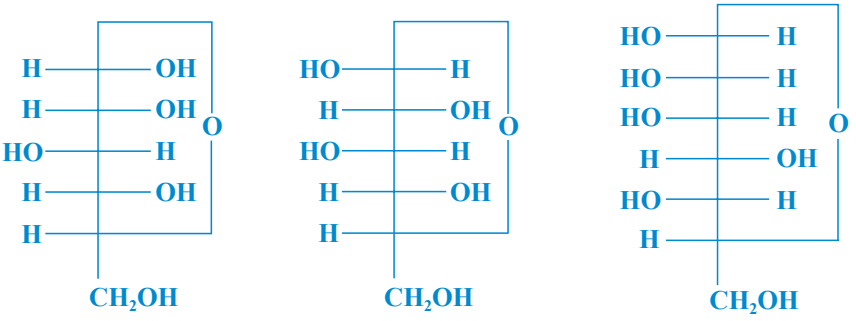
Ans. There are three types of RNAs:

(*i*) Ribosomal RNA (*r*RNA) (*ii*) Messenger RNA (*m*RNA) (*iii*) Transfer RNA (*t*RNA)

Multiple Choice Questions [1 mark]

Choose and write the correct option(s) in the following questions.

1. Three cyclic structures of monosaccharides are given below which of these are anomers. ***[NCERT Exemplar]***

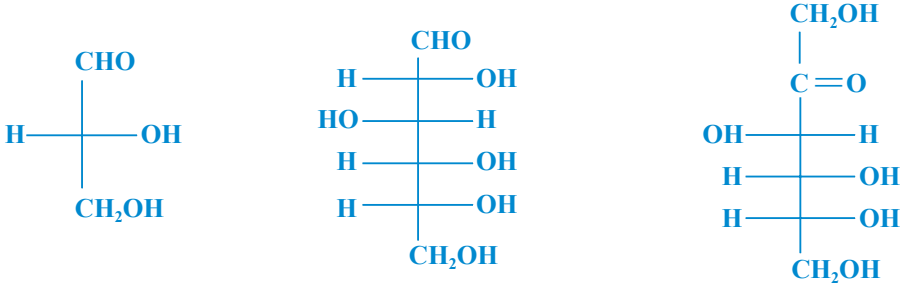


(I) **(II)** **(III)**

(*a*) I and II (*b*) II and III

(*c*) I and III (*d*) III is anomer of I and II

2. Optical rotations of some compounds along with their structures are given below which of them have D configuration. ***[NCERT Exemplar]***



(+) rotation **(+) rotation** **(–) rotation**

(I) **(II)** **(III)**

(*a*) I, II, III (*b*) II, III (*c*) I, II (*d*) III

3. Which of the following statements is not true about glucose? [*NCERT Exemplar*]

(*a*) It is an aldohexose.
(*b*) On heating with HI it forms n-hexane.
(*c*) It is present in furanose form.
(*d*) It does not give 2,4-DNP test.

4. Which of the following reactions of glucose can be explained only by its cyclic structure? [*NCERT Exemplar*]

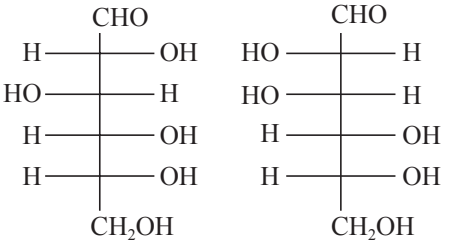
(*a*) Glucose forms pentaacetate.
(*b*) Glucose reacts with hydroxylamine to form an oxime.
(*c*) Pentaacetate of glucose does not react with hydroxylamine.
(*d*) Glucose is oxidised by nitric acid to gluconic acid.

5. Which of the following reaction confirms the presence of carbonyl group (> C═O) in glucose?

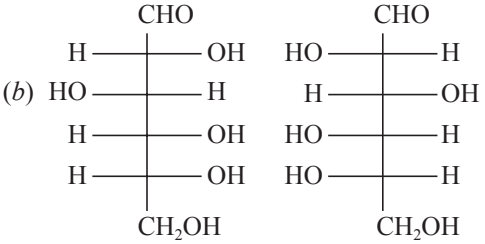
(*a*) Reaction with HI
(*b*) Reaction with hydroxylamine
(*c*) Reaction with HCN
(*d*) Both (*b*) and (*c*)

6. Which of the following pairs represents anomers? [*NCERT Exemplar*]

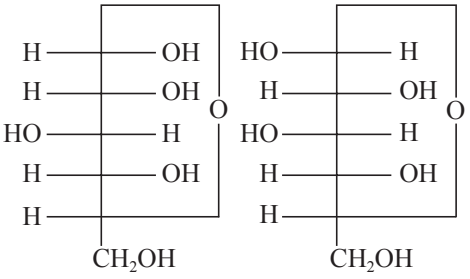
(*a*)



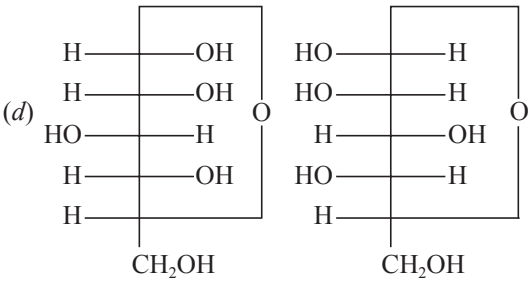
(*b*)



(*c*)



(*d*)



7. Fructose reduces Tollens' reagent due to

(*a*) Primary alcoholic group
(*b*) Asymmetric carbons
(*c*) Secondary alcoholic groups
(*d*) Enolisation of fructose followed by conversion to aldehyde by base

8. Carbohydrates are classified on the basis of their behaviour on hydrolysis and also as reducing or non-reducing sugar. Sucrose is a _____. [*NCERT Exemplar*]

(*a*) monosaccharide
(*b*) disaccharide
(*c*) reducing sugar
(*d*) non-reducing sugar

9. Amylopectin is insoluble in water and constitutes about

(*a*) 15–20% of starch (*b*) 20–40% of starch (*c*) 50–70% of starch (*d*) 80–85% of starch

10. Cellulose is not digestible by human beings due to absence of cellulose hydrolysing enzyme called

(*a*) cellulase (*b*) invertase (*c*) zymase (*d*) urease

11. Glycogen is a branched chain polymer of α-D-glucose units in which chain is formed by C1—C4 glycosidic linkage whereas branching occurs by the formation of C1—C6 glycosidic linkage. Structure of glycogen is similar to _____. [*NCERT Exemplar*]

(*a*) Amylose (*b*) Amylopectin (*c*) Cellulose (*d*) Glucose

12. Which of the following polymer is stored in the liver of animals? [*NCERT Exemplar*]

(*a*) Amylose (*b*) Cellulose (*c*) Amylopectin (*d*) Glycogen

13. Which of the following naturally occurring α– aminoacids is optically inactive?

(*a*) Glycine (*b*) Alanine (*c*) Leucine (*d*) Valine

14. Each polypeptide in a protein has aminoacids linked with each other in a specific sequence. This sequence of amino acids is said to be _____. [*NCERT Exemplar*]

(*a*) primary structure of proteins. (*b*) secondary structure of proteins.
(*c*) tertiary structure of proteins. (*d*) quaternary structure of proteins.

15. Proteins can be classified into two types on the basis of their molecular shape *i.e.*, fibrous proteins and globular proteins. Examples of globular proteins are : [*NCERT Exemplar*]

(*a*) Insulin (*b*) Keratin (*c*) Albumin (*d*) Myosin

16. Proteins are found to have two different types of secondary structures viz. α-helix and β-pleated sheet structure. α-helix structure of protein is stabilised by : [*NCERT Exemplar*]

(*a*) Peptide bonds (*b*) van der Waals forces (*c*) Hydrogen bonds (*d*) Dipole-dipole interactions

17. Which of the following B group vitamins can be stored in our body? [*NCERT Exemplar*]

(*a*) Vitamin B_1 (*b*) Vitamin B_2 (*c*) Vitamin B_6 (*d*) Vitamin B_{12}

18. Which of the following acids is a vitamin? [*NCERT Exemplar*]

(*a*) Aspartic acid (*b*) Ascorbic acid (*c*) Adipic acid (*d*) Saccharic acid

19. Nucleic acids are the polymers of _____. [*NCERT Exemplar*]

(*a*) nucleosides (*b*) nucleotides (*c*) bases (*d*) sugars

20. Dinucleotide is obtained by joining two nucleotides together by phosphodiester linkage. Between which carbon atoms of pentose sugars of nucleotides are these linkages present? [*NCERT Exemplar*]

(*a*) 5′ and 3′ (*b*) 1′ and 5′ (*c*) 5′ and 5′ (*d*) 3′ and 3′

21. DNA and RNA contain four bases each. Which of the following bases is not present in RNA? [*NCERT Exemplar*]

(*a*) Adenine (*b*) Uracil (*c*) Thymine (*d*) Cytosine

22. The presence or absence of hydroxyl group on which carbon atom of sugar differentiate RNA and DNA

(*a*) 2nd (*b*) 4th (*c*) 3rd (*d*) 1st

23. Which one is the complementary base of cytosine in one strand to that in other strand of DNA? [*CBSE 2020 (56/4/3)*]

(*a*) Adenine (*b*) Guanine (*c*) Thymine (*d*) Uracil

Answers

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

Assertion-Reason Questions

In the following questions, two statements are given—one labeled Assertion (A) and the other labeled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(*a*) ***Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).***

(*b*) ***Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).***

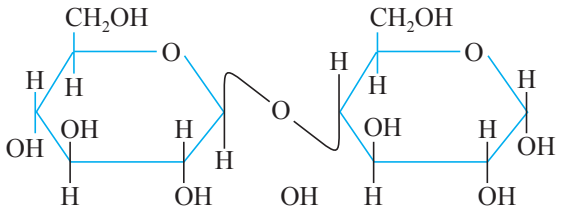
(*c*) ***Assertion (A) is correct, but Reason (R) is incorrect statement.***

(*d*) ***Assertion (A) is incorrect, but Reason (R) is correct statement.***

1. Assertion (*A*) : Deoxyribose, $C_5H_{10}O_4$ is a carbohydrate.
Reason (*R*) : Carbohydrates are hydrates of carbon so compounds which follow $C_x(H_2O)_y$ formula are carbohydrates.

2. Assertion (*A*) : D (+) – Glucose is dextrorotatory in nature.
Reason (*R*) : 'D' represents its dextrorotatory nature.

3. **Assertion** (*A*) : Reducing sugars undergo mutarotation.
   Reason (*R*) : During mutarotation, one pure anomer is converted into an equilibrium mixture of two anomers.
4. **Assertion** (*A*) : Sucrose is a non-reducing sugar.
   Reason (*R*) : In sucrose, the aldehydic group of glucose and ketonic group of fructose are not free.
5. **Assertion** (*A*) : A solution of sucrose in water is dextrorotary but on hydrolysis in presence of little hydrochloric acid, it becomes laevoratory.
   Reason (*R*) : Sucrose on hydrolysis gives unequal amounts of glucose and fructose as a result of which change in sign of rotation is observed.
6. **Assertion** (*A*) : β-glycosidic linkage is present in maltose,



   Reason (*R*) : Maltose is composed of two glucose units in which C1 of one glucose unit is linked to C4 of another glucose unit.
7. **Assertion** (*A*) : All naturally occurring α-aminoacids except glycine are optically active.
   Reason (*R*) : Most naturally occurring amino acids have L-configuration.
8. **Assertion** (*A*) : Glycine must be taken through diet.
   Reason (*R*) : It is a non-essential amino acid.
9. **Assertion** (*A*) : Proteins are made up of α-amino acids.
   Reason (*R*) : During denaturation, secondary and tertiary structures of proteins are destroyed.
10. **Assertion** (*A*) : In presence of enzyme, substrate molecule can be attacked by the reagent effectively.
    Reason (*R*) : Active sites of enzymes hold the substrate molecule in a suitable position.
11. **Assertion** (*A*) : Vitamin D can be stored in our body.
    Reason (*R*) : Vitamin D is fat soluble vitamin.

Answers

1. (*c*) **2.** (*c*) **3.** (*a*) **4.** (*a*) **5.** (*c*) **6.** (*d*) **7.** (*b*) **8.** (*d*) **9.** (*b*) **10.** (*a*) **11.** (*a*)

Passage-based/Case-based Questions

Read the given passages and answer the questions that follow.

PASSAGE–1

The most abundant biomolecules of the living system are proteins. They are polymers of α-amino acids connected to each other by peptide linkage. Amino acids contain amino (—NH_2) and carboxyl (—COOH) group. Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule. They behave like salts rather than simple amines or carboxylic acids. In aqueous solution, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as zwitter ion.

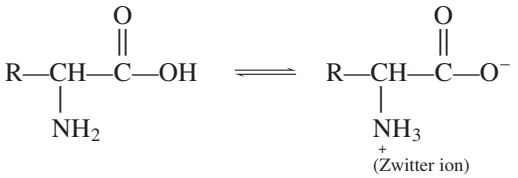
The amino acids, which can be synthesised in the body, are known as non-essential amino acids. On the other hand, those which cannot be synthesised in the body and must be obtained through diet, are known as essential amino acids.

1. The K_a and K_b values of α-amino acid are very low. Why?

Ans. In α-amino acids the acidic group is $-\overset{+}{N}H_3$, instead of —COOH group as in carboxylic acids and basic group is $-COO^-$ instead of $-NH_2$ group as in amines. That is why they have low values of K_a and K_b.

2. Draw the structure of zwitter ion.

Ans.



3. Name the alpha amino acid which is optically inactive.

Ans. Glycine

4. 4. Name two essential amino acids.

Ans. Valine, Leucine

5. Give any two properties of amino acids.

Ans. (*i*) Amino acids are water soluble.

(*ii*) They have high melting point.

PASSAGE–2

Carbohydrates, proteins, nucleic acids, etc. form the basis of life and are responsible for the growth and maintenance of living systems. Therefore, they are referred to as biomolecules. Carbohydrates are widely distributed in nature. Carbohydrates are optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis. Glucose, fructose, sucrose, starch, cellulose, etc. are some naturally occurring carbohydrates. They act as the major source of energy for animals and human beings.

Monosaccharides are the simple carbohydrates that cannot be broken further into smaller units on hydrolysis, *e.g.*, glucose and fructose, ribose, etc. Oligosaccharides are the carbohydrates which on hydrolysis give two to ten units of monosaccharides, *e.g.*, sucrose, maltose, raffinose, stachyose, etc. Polysaccharides are the carbohydrates which produce a large number of monosaccharide units on hydrolysis, *e.g.*, starch, cellulose, etc.

1. Which carbohydrate provides instant energy to the body?

Ans. Glucose

2. Which disaccharide is found only in animals and not in plants?

Ans. Lactose

3. Which carbohydrate is the main constituent of plant cell wall?

Ans. Cellulose

4. Write the name of two monosaccharides obtained on hydrolysis of lactose sugar.

Ans. D-(+)-Glucose and D-(+)-Galactose

5. Which one of the following is a polysaccharide?

Starch, Maltose, Fructose, Glucose

Ans. Starch

Very Short Answer Questions [1 mark]

Q. 1. Why are carbohydrates generally optically active?

Ans. Carbohydrates have chiral or asymmetric carbon atom.

Q. 2. What happens when glucose is treated with bromine water? *[CBSE (F) 2010]*

Ans. When glucose is treated with bromine water it forms gluconic acid.

$$HOCH_2—(CHOH)_4—CHO \xrightarrow{Br_2/H_2O} \underset{\text{Gluconic acid}}{HOCH_2—(CHOH)_4—COOH}$$

Q. 3. What happens when glucose reacts with nitric acid? [*CBSE (F) 2010*]

Ans. Glucose gets oxidised to succinic acid

$$HOCH_2—(CHOH)_4—CHO \xrightarrow{HNO_3} \underset{\text{Succinic acid}}{HOOC—(CHOH)_4—COOH}$$

Q. 4. Write a reaction which shows that all the carbon atoms in glucose are linked in a straight chain. [*CBSE (AI) 2012*]

Ans. On prolonged heating with HI, glucose gives *n*-hexane.

$$\begin{array}{l}CHO\\|\\(CHOH)_4\\|\\CH_2OH\end{array} \xrightarrow[\Delta]{HI} \underset{n\text{-Hexane}}{CH_3CH_2CH_2CH_2CH_2CH_3}$$

Q. 5. Which component of starch is a branched polymer of α-glucose and insoluble in water? [*CBSE Delhi 2014*]

Ans. Amylopectin

Q. 6. Which of the two components of starch is water soluble? [*CBSE Delhi 2014*]

Ans. Amylose is water soluble whereas amylopectin is water insoluble component.

Q. 7. Name two α-amino acids which form a dipeptide which is 100 times more sweet than cane sugar. [*NCERT Exemplar*]

Ans. Aspartic acid and phenylalanine.

Q. 8. What type of bonding helps in stabilising the α-helix structure of proteins? [*CBSE Delhi 2013*]

Ans. The α-helix structure of proteins is stabilised by intramolecular H-bonding between C═O of one amino acid residue and the N—H of the fourth amino acid residue in the chain.

Q. 9. How do you explain the presence of five —OH groups in glucose molecule? [*NCERT Exemplar*] [*HOTS*]

Ans. Glucose gives pentaacetate derivative on acetylation with acetic anhydride. This confirms the presence of five —OH groups.

$$\underset{\text{Glucose}}{\begin{array}{l}CHO\\|\\(CHOH)_4\\|\\CH_2OH\end{array}} \xrightarrow{(CH_3CO)_2O} \underset{\text{Glucose pentaacetate}}{\begin{array}{l}CHO\quad\ O\\|\quad\ \ ||\\(CH—O—C—CH_3)_4\\|\\CH_2—O—C—CH_3\\\quad\quad\ ||\\\quad\quad\ O\end{array}}$$

Q. 10. What are biocatalysts? Give an example. [*CBSE (F) 2014*]

Ans. Enzymes are termed as biocatalysts as they catalyse numerous reactions that occur in the bodies of animals and plants to maintain life process *e.g.*, invertase, pepsin, urease.

Q. 11. What are three types of RNA molecules which perform different functions? [*CBSE Delhi 2013*]

Ans. There are three types of RNAs:

(*i*) Ribosomal RNA (*r*RNA) (*ii*) Messenger RNA (*m*RNA)

(*iii*) Transfer RNA (*t*RNA)

Short Answer Questions–I [2 marks]

Q. 1. Write the reactions involved when D-glucose is treated with the following reagents:

(*i*) HCN **(*ii*) Br_2 water** [*CBSE (F) 2013*]

Ans. (*i*) HCN (*ii*) Br_2 water

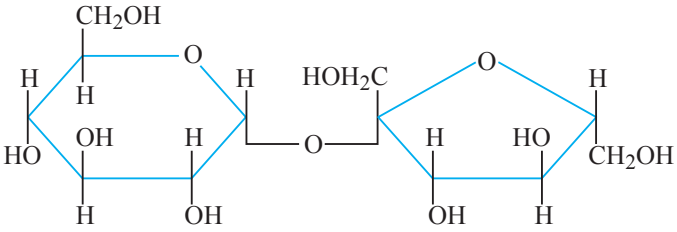
$$\underset{\text{D-Glucose}}{\begin{array}{l}CHO\\|\\(CHOH)_4\\|\\CH_2OH\end{array}} \xrightarrow{HCN} \underset{\text{Glucose cyanohydrin}}{\begin{array}{l}CH(CN)(OH)\\|\\(CHOH)_4\\|\\CH_2OH\end{array}}$$

$$\underset{\text{D-Glucose}}{\begin{array}{l}CHO\\|\\(CHOH)_4\\|\\CH_2OH\end{array}} \xrightarrow{Br_2\text{ water}} \underset{\text{Gluconic acid}}{\begin{array}{l}COOH\\|\\(CHOH)_4\\|\\CH_2OH\end{array}}$$

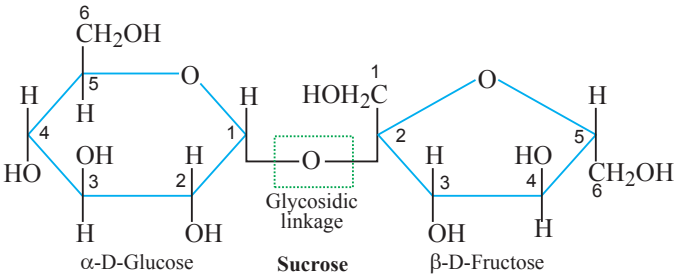
Q. 2. How do you explain the presence of an aldehydic group in a glucose molecule? [*NCERT Exemplar*]

Ans. Glucose reacts with hydroxylamine to form a monoxime and adds one molecule of hydrogen cyanide to give cyanohydrin so it contains a carbonyl group which can be an aldehyde or a ketone. On mild oxidation with bromine water, glucose gives gluconic acid which is a six carbon carboxylic acid. This indicates that carbonyl group present in glucose is an aldehydic group.

Q. 3. Label the glucose and fructose units in the following disaccharide and identify anomeric carbon atoms in these units. Is the sugar reducing in nature? Explain. [*NCERT Exemplar*] [*HOTS*]

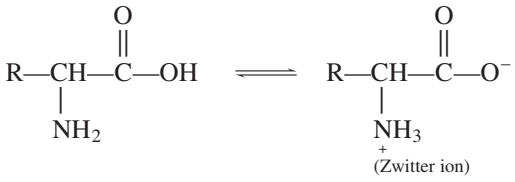


Ans. C-1 of glucose unit and C-2 of fructose unit are anomeric carbon atoms in the given disaccharide. The disaccharide is non-reducing sugar because —OH groups attached to anomeric carbon atoms are involved in the formation of glycosidic bond.



Q. 4. Amino acids behave like salts rather than simple amines or carboxylic acids. Explain. [*NCERT Exemplar*]

Ans. In aqueous solution, the carboxyl group loses a proton and amino group accepts a proton to form a zwitter ion.



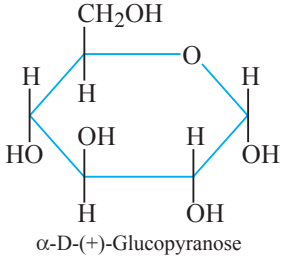
Q. 5. Explain what is meant by the following:

(*i*) peptide linkage

(*ii*) pyranose structure of glucose. [*CBSE (AI) 2011; (F) 2011*]

Ans. (*i*) Refer to NCERT Textbook Exercises, Q. 12(*i*).

(*ii*) The six-membered cyclic structure of glucose is called pyranose structure (α- or β-), in analogy with heterocylic compound pyran.



Q. 6. Describe what you understand by primary structure and secondary structure of proteins.

[CBSE Delhi 2011; (F) 2011]

Ans. **Primary structure:** The specific sequence in which the various α-amino acids present in a protein are linked to one another is called its primary structure. Any change in the primary structure creates a different protein.

Secondary structure: The conformation which the polypeptide chain assumes as a result of hydrogen bonding is known as secondary structure. The two types of secondary structures are α-helix and β-pleated sheet structures.

In α-helix structure, the polypeptide chain forms all the possible hydrogen bonds by twisting into a right-handed screw (helix) with the —NH group of each amino acid residue hydrogen bonded to the $>C=O$ groups of an adjacent turn of the helix. In β-pleated structure, all peptide chains are stretched out to nearly maximum extension and then laid side by side and are held together by hydrogen bonds.

Q. 7. (*i*) What type of linkage is present in nucleic acids?

(*ii*) Give one example each for fibrous protein and globular protein. *[CBSE Central 2016]*

Ans. (*i*) Phosphodiester linkage.

(*ii*) **Fibrous protein:** Myosin, keratin, collagen, etc.

Globular protein: Insulin, haemoglobin, etc.

Q. 8. Name the bases present in RNA. Which one of these is not present in DNA?

[CBSE Delhi 2011, 2020 (56/3/3)]

Ans. The bases present in RNA are adenine (A), guanine (G), cytosine (C) and uracil (U). Uracil is not present in DNA.

Q. 9. If one strand of a DNA has the sequence —ATGCTTCA—, what is the sequence of the bases in the complementary strand?

Ans. As we know that in DNA molecule, adenine (A) always pairs with thymine (T) and cytosine (C) always pairs with guanine (G). Thus,

Sequence of bases in one strand: A T G C T T C A

Sequence of bases in the complementary strand: T A C G A A G T

Short Answer Questions–II [3 marks]

Q. 1. Define the following terms: *[CBSE (AI) 2014]*

(*i*) Glycosidic linkage *[CBSE 2020 (56/3/2)]*

(*ii*) Invert sugar **(*iii*) Oligosaccharides**

Ans. (*i*) The linkage between two monosaccharides through oxygen atom in an oligosaccharide or a polysaccharide is known as glycosidic linkage.

(*ii*) Sucrose is dextrorotatory (+ 66.5°) but after hydrolysis it gives an equimolar mixture of D-(+)-glucose and D-(–)-fructose, which is laevorotatory. This change of specific rotation from dextrorotation to laevorotation is called inversion of sugar and the mixture obtained is called invert sugar.

(*iii*) Carbohydrates which on hydrolysis give two to ten molecules of monosaccharides are called oligosaccharides *e.g.*, sucrose.

Q. 2. (*i*) Which of the following biomolecules is insoluble in water? Justify.
Insulin, Haemoglobin, Keratin.

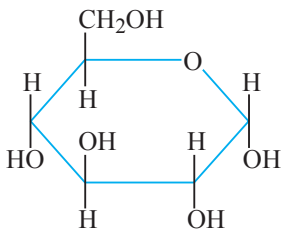
(*ii*) Draw the Haworth structure for α-D-Glucopyranose.

(*iii*) Write chemical reaction to show that glucose contains aldehyde as carbonyl group.

[CBSE Sample Paper 2015]

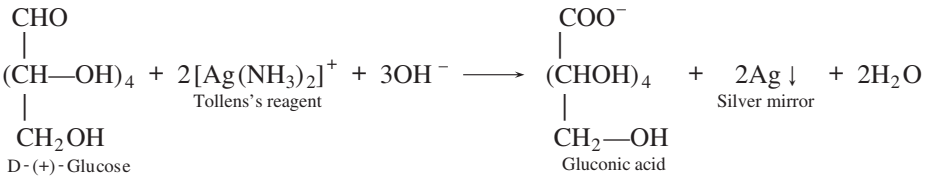
Ans. (*i*) Keratin being a fibrous protein insoluble in water.

(*ii*)



α-D-(+)-Glucopyranose

(*iii*) Glucose reduces Tollens' reagent to metallic silver.



Q. 3. **(*i*) Give one structural difference between amylose and amylopectin**

(*ii*) Name the protein and its shape present in oxygen carrier in human body.

(*iii*) Name two fat storing tissues in human body. **[*CBSE Sample Paper 2014*]**

Ans. (*i*) Amylose is a long unbranched chain polymer of α-D(+) glucose.

Amylopectin is a branched chain polymer of α-D glucose.

(*ii*) Globular protein and its shape is spherical.

(*iii*) Liver and adipose tissue.

Q. 4. **(*i*) A non-reducing disaccharide 'A' on hydrolysis with dilute acid gives an equimolar mixture of D-(+)-glucose and D-(–)-fructose.**

Identify A. What is the mixture of D-(+)-glucose and D-(–)-fructose known as? Name the linkage that holds the two units in the disaccharide.

(*ii*) α-amino acids have relatively higher melting points than the corresponding halo acids. Explain. **[*CBSE Sample Paper 2016*] [*HOTS*]**

Ans. (*i*)
- A = $C_{12}H_{22}O_{11}$ (sucrose).
- Invert sugar.
- Glycosidic linkage.

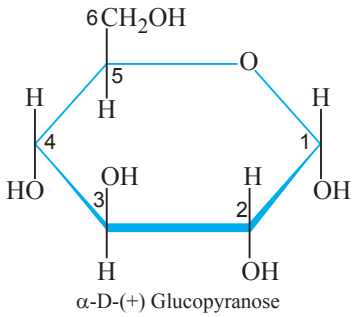
(*ii*) α-Amino acids act as zwitter ions, ($H_3\overset{+}{N}$—CHR—COO^-) or dipolar ions. Due to this dipolar salt-like structure, they have strong dipole-dipole interactions. Therefore, their melting points are higher than the corresponding halo acids which do not exist as zwitter ions.

Q. 5. **(*i*) Draw the pyranose structure of glucose.**

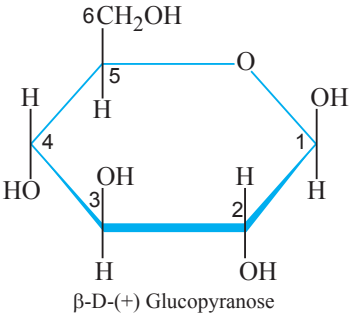
(*ii*) What type of linkage is present in proteins?

(*iii*) Give one example each for water-soluble vitamins and fat-soluble vitamins. **[*CBSE (F) 2016*]**

Ans. (*i*)



α-D-(+) Glucopyranose



β-D-(+) Glucopyranose

(*ii*) Peptide linkage ()

(*iii*) Vitamin C and B group vitamins are water soluble vitamins.

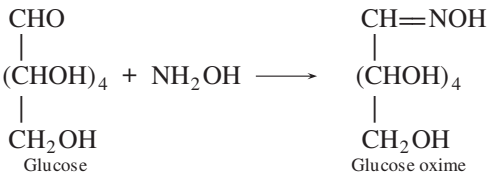
Vitamins A, D, E and K are fat soluble vitamins.

Q. 6. **(*i*) Write the product obtained when D-glucose reacts with H_2N—OH.**

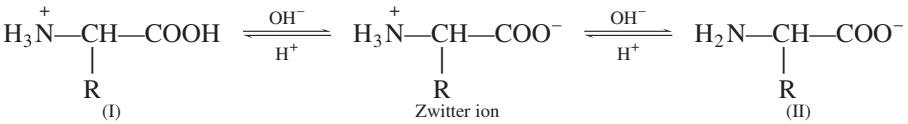
(*ii*) Amino acids show amphoteric behaviour. Why?

(*iii*) Why cannot vitamin C be stored in our body? **[*CBSE Patna 2015*]**

Ans. (*i*)



(*ii*) In aqueous solution, amino acids exist as a zwitter ion. In zwitter ionic form, amino acids show amphoteric behaviour as they react both with acids and bases.



In acidic medium COO^- ion of the zwitter ion accepts a proton to form the cation (I) while in basic medium $\overset{+}{N}H_3$ loses a proton to form the cation (II).

(*iii*) As vitamin C is water soluble, therefore, it is readily excreted in urine and hence cannot be stored in the body.

Long Answer Question [5 marks]

Q. 1. (*i*) (*a*) What is the difference between native protein and denatured protein?

(*b*) Which one of the following is a disaccharide?

Glucose, Lactose, Amylose, Fructose

(*c*) Write the name of the vitamin responsible for the coagulation of blood. [*CBSE 2019 (56/4/3)*]

(*ii*) Define the following terms:

(*a*) Native protein [*CBSE 2020 (56/3/2)*]

(*b*) Nucleotide [*CBSE 2019 (56/2/2)*]

Ans. (*i*) (*a*) Protein found in a biological system with unique three-dimensional structure and biological activity is called native protein.

When a protein in its native form is subjected to change such as change in temperature, change in pH, its 2° and 3° structures are destroyed and it loses its biological activity. The protein thus formed is called denatured protein.

(*b*) Lactose

(*c*) Vitamin K.

(*ii*) (*a*) Protein found in biological system with unique three dimensional structure and biological activity is called native protein.

(*b*) A unit formed by the combination of nitrogenous base , pentose sugar and phosphate.

Self-Assessment Test

Time allowed: 1 hour **Max. marks: 30**

Choose and write the correct answer for each of the following. (3 × 1 = 3)

1. Which of the following is laevorotatory?

(*a*) Glucose (*b*) Sucrose (*c*) Fructose (*d*) None of these

2. Amino acids are best represented as:

(*a*) dipolar ions (*b*) isoelectric ions (*c*) amphoteric ions (*d*) zwitter ions

3. Which one of the following is a peptide hormone?

(*a*) Testosterone (*b*) Glucagon (*c*) Adrenaline (*d*) Thyroxine

In the following questions, two statements are given—one labeled Assertion (A) and the other labeled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(*a*) *Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).*

(*b*) *Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).*

(*c*) *Assertion (A) is correct, but Reason (R) is incorrect statement.*

(*d*) *Assertion (A) is incorrect, but Reason (R) is correct statement.* (3 × 1 = 3)

4. **Assertion (*A*) :** The pyrimidine base uracil is present in RNA.
   Reason (*R*) : RNA controls the synthesis of proteins.

5. **Assertion (*A*) :** Enzymes are globular proteins.
   Reason (*R*) : Enzymes are regenerated during reactions.

6. **Assertion (*A*) :** Maltose is a reducing sugar, one molecule of which gives two molecules of D-glucose on hydrolysis.
   Reason (*R*) : Maltose has a 1, 4 β-glycosidic linkage.

Answer the following questions:

7. What are anomers? Give one example. (1)

8. What type of protein is present in keratin. **[*CBSE 2020 (56/4/3)*]** (1)

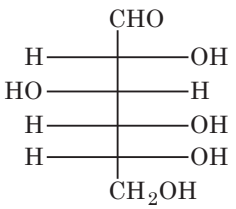
9. Which forces are responsible for the stability of α-helix? Why is it named as 3.6_{13} helix? (2)

10. Write the reactions showing the presence of following in the open structure of glucose:
    (*i*) five —OH groups (*ii*) a carbonyl group **[*CBSE 2020 (56/4/3)*]** (2)

11. Define enzymes. How do enzymes differ from ordinary chemical catalysts? (2)

12. What is essentially the difference between α-form of glucose and β-form of glucose?
    [*CBSE Delhi 2011*] (2)

13. The Fischer projection of D-Glucose is given alongside.
    (*i*) Give the Fischer projection of L-Glucose.
    (*ii*) What happens when L-Glucose is treated with Tollens' reagent? (2)



14. Define the following terms:
    (*i*) Polysaccharides (*ii*) Amino acids (*iii*) Enzymes **[*CBSE (F) 2014*]** (3)

15. (*i*) Name the three major classes of carbohydrates and give an example of each of these classes.
    (*ii*) What type of linkage is responsible for the primary structure of proteins?
    (*iii*) Name the location where protein synthesis occurs in our body. (3)

16. (*i*) Write about the following on protein synthesis:
    (*a*) Name the location where protein synthesis occurs.
    (*b*) How do 64 codons code for only 20 amino acids?
    (*c*) Which of the two bases of the codon are more important for coding? (3)
    (*ii*) What deficiency diseases are caused due to lack of vitamins A, B_1, B_6 and K in human diet?

17. (*i*) Comment on the specificity of enzyme action. What is the most important reason for their specificity?
    (*ii*) (*a*) What are the products of hydrolysis of maltose?
    (*b*) Name the vitamin whose deficiency causes pernicious anaemia.
    [*CBSE 2019 (56/2/2)*] (3)

Answers

1. (*c*) **2.** (*d*) **3.** (*b*) **4.** (*c*) **5.** (*a*) **6.** (*c*)