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.
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:**

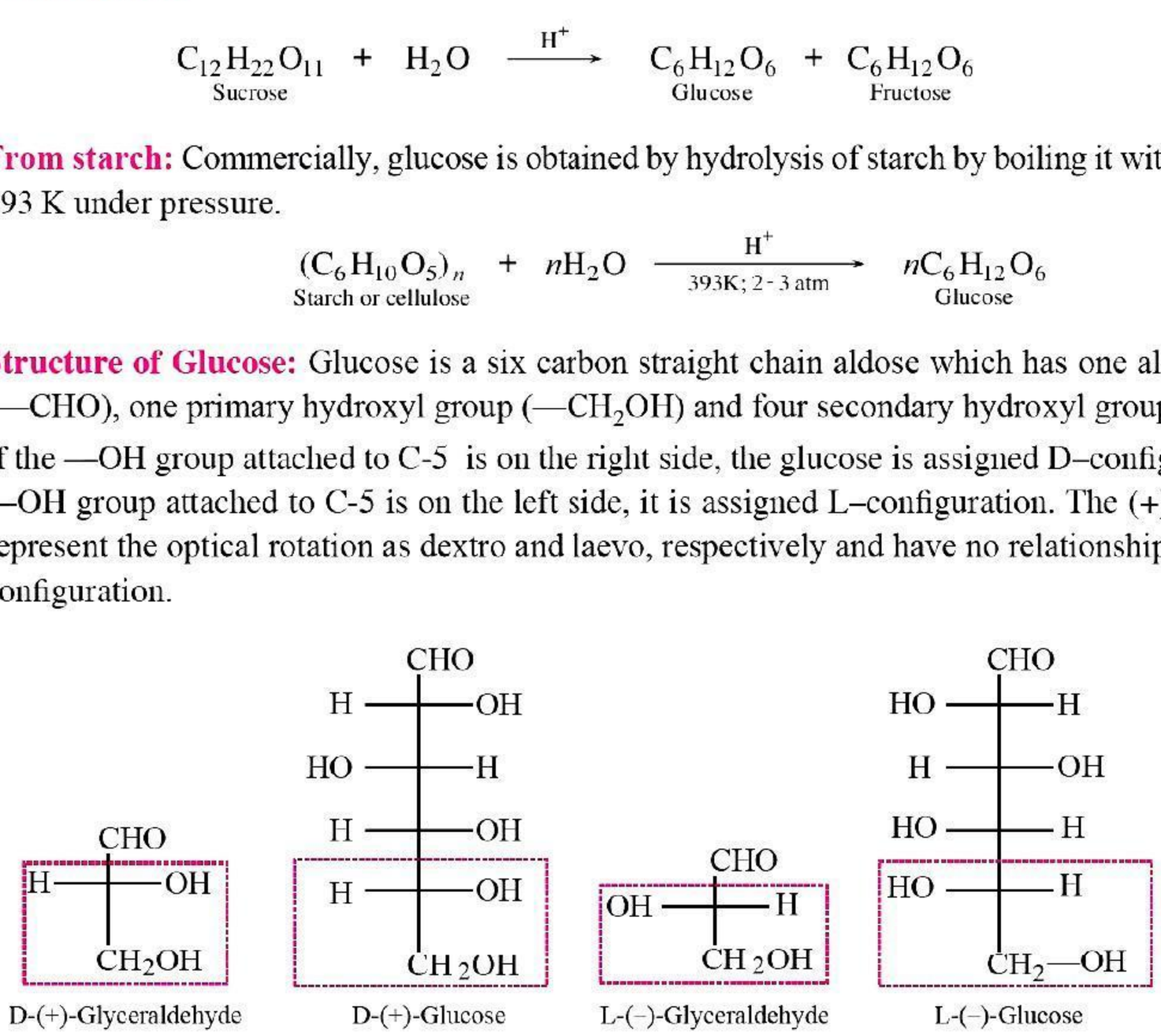
$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

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

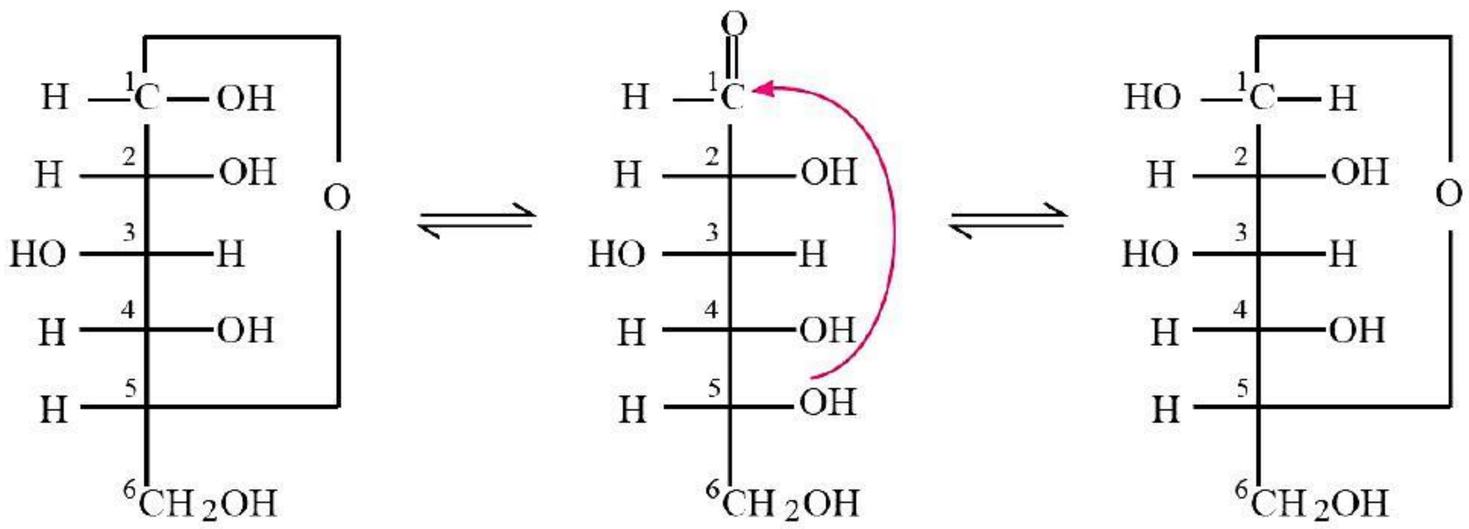
$$\underset{\text{Starch or cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[393K;\ 2-3\ atm]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

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).

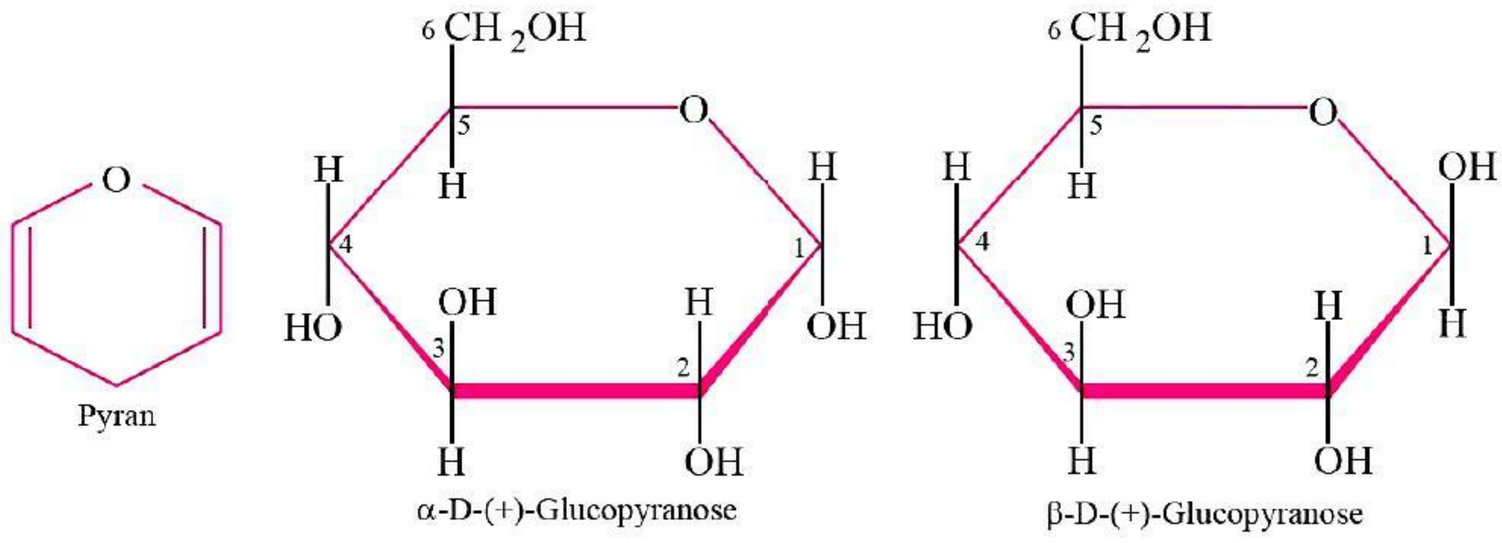
   If the —OH group attached to C-5 is on the right side, the glucose is assigned D–configuration; if the —OH group attached to C-5 is on the left side, it is assigned L–configuration. The (+) and (–) signs represent the optical rotation as dextro and laevo, respectively and have no relationship with D and L configuration.



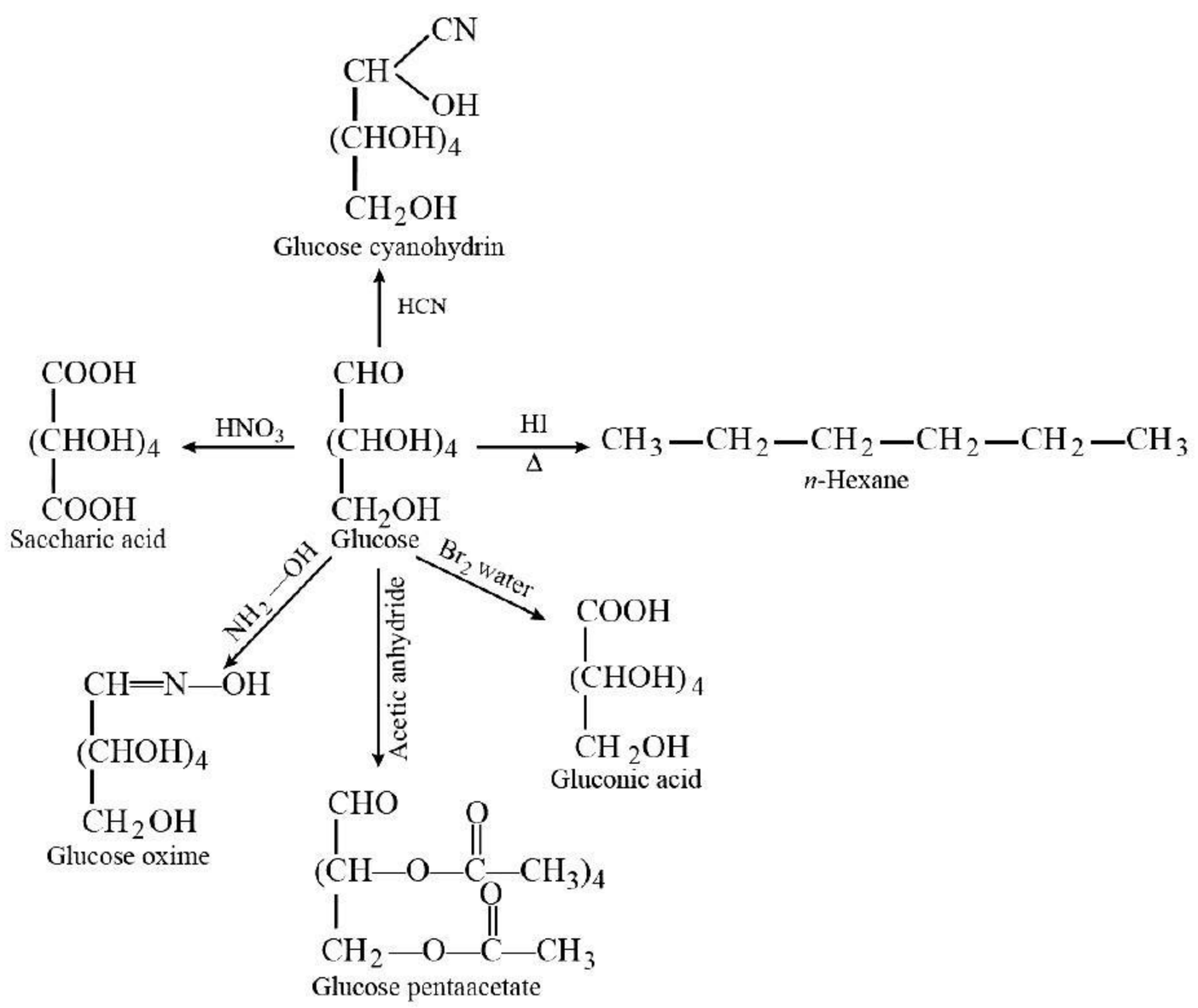
(*b*) Cyclic structure of glucose: The glucose has been shown to possess cyclic structure represented as follows:



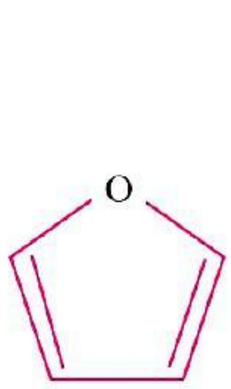
Haworth Structures



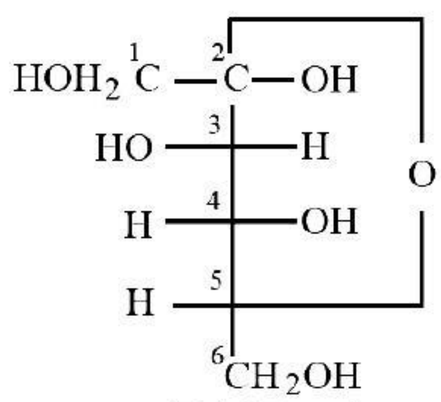
7. Reactions of Glucose



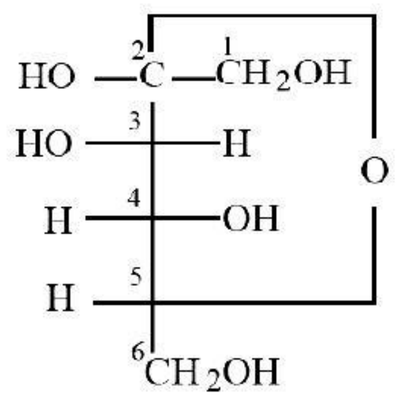
8. **Structure of Fructose:** Fructose is a ketohexose and has the molecular formula $C_6H_{12}O_6$. It belongs to D-series and is a laevorotatory compound.



Furan

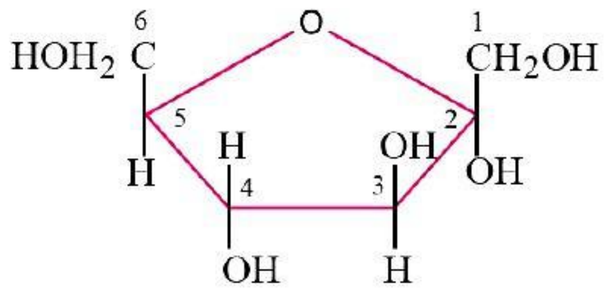


α-D-(–)-Fructofuranose

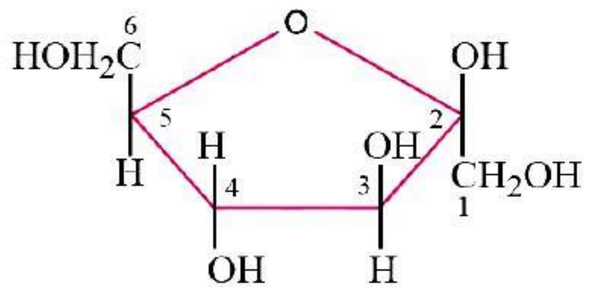


β-D-(–)-Fructofuranose

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



α-D-(–)-Fructofuranose



β-D-(–)-Fructofuranose

9. **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.

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

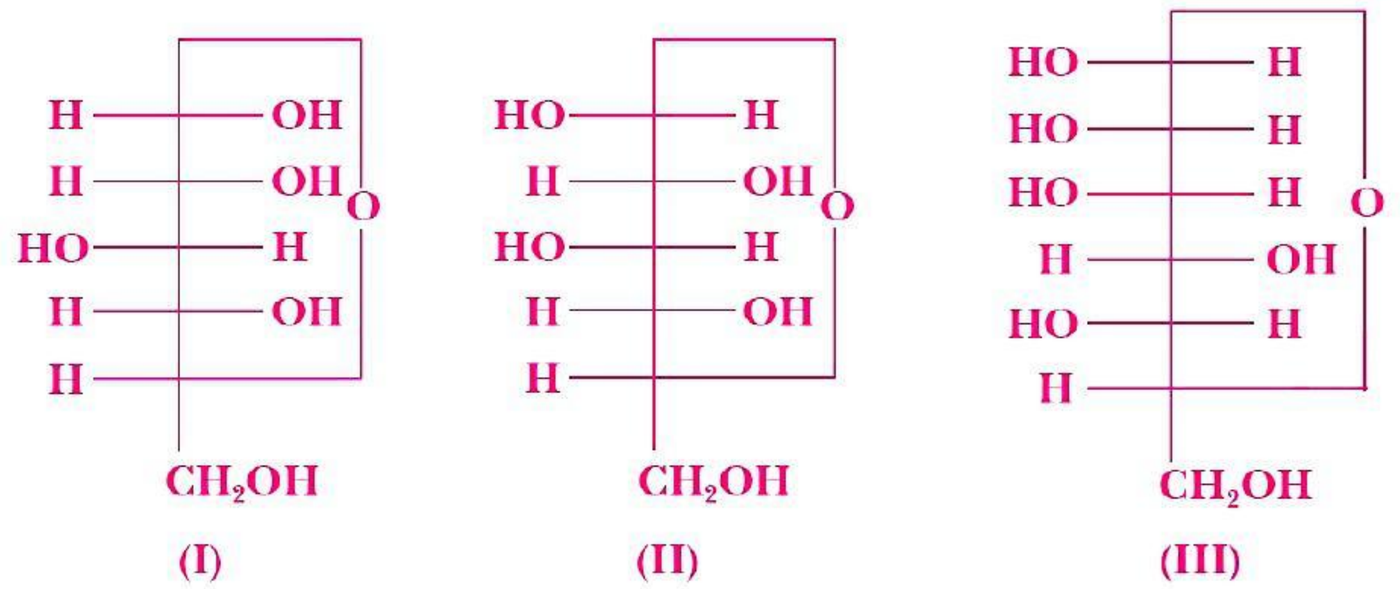
    Chemically, proteins are the polymers of α-amino acids which are linked by peptide bonds $\left(-\overset{\overset{O}{\|}}{C}-NH-\right)$.

    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.

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

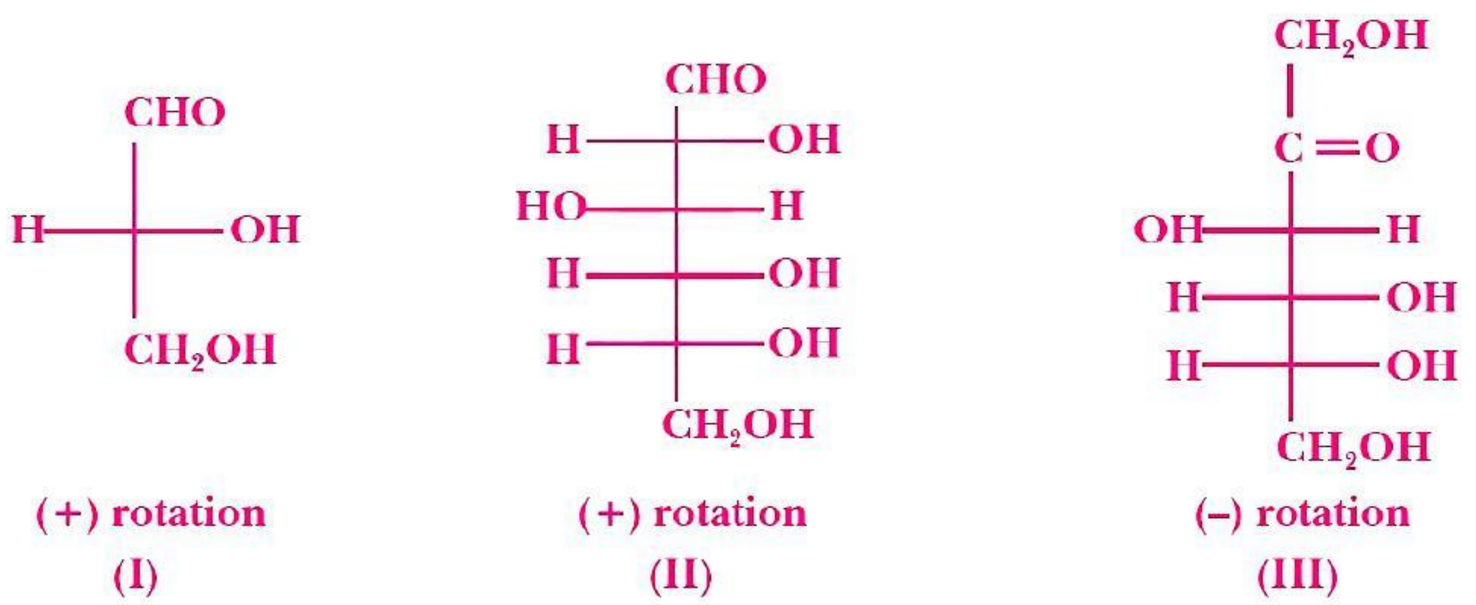
1. Three cyclic structures of monosaccharides are given below which of these are anomers. [*NCERT Exemplar*]



(*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*]



(*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.

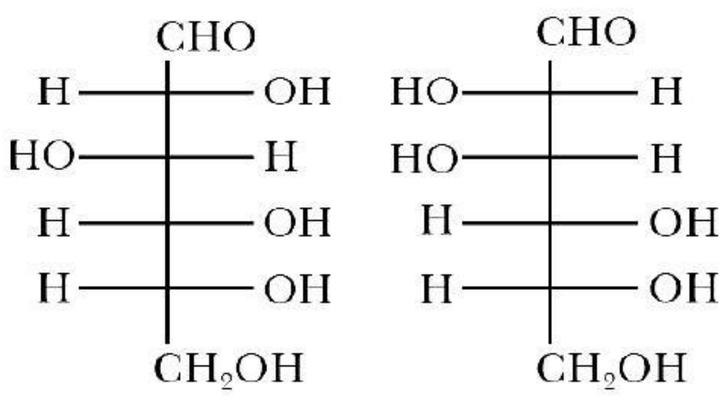
5. Which of the following reaction confirms the presence of carbonyl group (> C═O) in glucose?

(*a*) Reaction with HI (*b*) Reaction with hydroxylamine

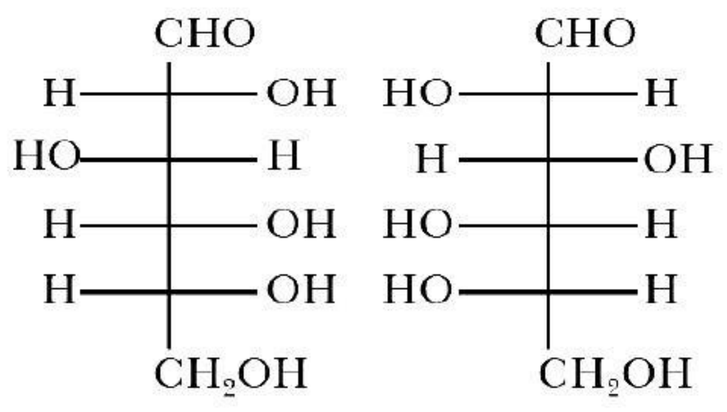
(*c*) Reaction with HCN (*d*) Both (*b*) and (*c*)

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

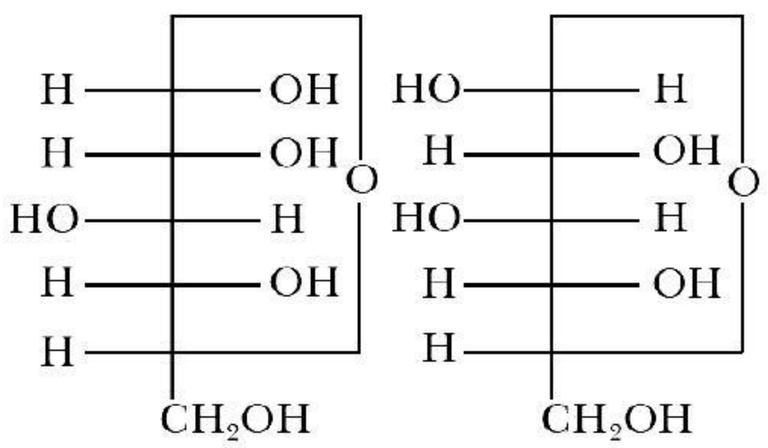
(*a*)



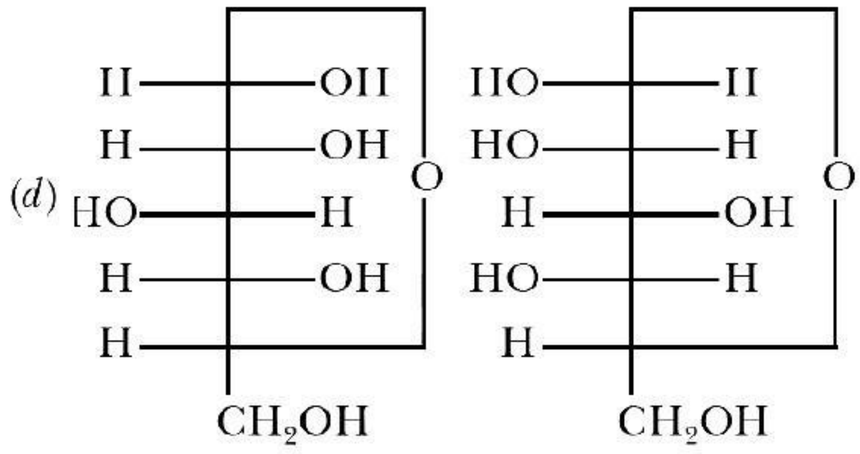
(*b*)



(*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 _____.

(*a*) monosaccharide (*b*) disaccharide (*c*) reducing sugar (*d*) polysaccharide

9. Which of the following naturally occurring α-aminoacids is optically inactive?

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

10. 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.

11. 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:

(*a*) Insulin (*b*) Keratin (*c*) Albumin (*d*) both (*a*) and (*c*)

12. 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

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

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

14. 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′

15. 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

16. 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

17. 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

18. Glucose cannot be classified as:

(*a*) carbohydrate (*b*) aldose (*c*) oligosaccharide (*d*) hexose

19. Which one is the formula of a disaccharide?

(*a*) $C_{12}H_{22}O_{11}$ (*b*) $C_6H_{12}O_6$ (*c*) $C_{18}H_{22}O_{11}$ (*d*) $C_{10}H_{20}O_{10}$

20. Which of the following is an example of aldopentose?

(*a*) Erythrose (*b*) Ribose (*c*) Fructose (*d*) Dihydroxy acetone

21. Which of the following is an example of aldohexose?

(*a*) Sucrose (*b*) Glucose (*c*) Fructose (*d*) Lactose

22. On oxidation with nitric acid, glucose yields

(*a*) monocarboxylic acid(*b*) dicarboxylic acid (*c*) tricarboxylic acid (*d*) none of these

23. Which of the following is laevorotatory?

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

24. Amino acids are best represented as :

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

25. The main structural feature of protein is :

(*a*) ether linkage (*b*) ester linkage (*c*) peptide linkage (*d*) all the three above

26. Which of the following is not a protein?

(*a*) Wool (*b*) Nail (*c*) Hair (*d*) DNA

27. Glucose reacts with acetic anhydride to form :

(*a*) monoacetate (*b*) tetracetate (*c*) pentaacetate (*d*) hexaacetate

28. Which substance is not present in nucleic acid?

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

29. In DNA the complimentary bases are :

(*a*) Uracil and Adenine : Guanine and Cytosine

(*b*) Adenine and Thymine : Guanine and Cytosine

(*c*) Adenine and Thymine : Guanine and Uracil

(*d*) Adenine and Guanine : Thymine and Cytosine

30. The acid showing salt like character in aqueous solution is :

(*a*) acetic acid (*b*) benzoic acid (*c*) formic acid (*d*) amino acid

31. Which of the following is correct about hydrogen bonding in nucleotide?

(*a*) A—T; G—C (*b*) A—G; T—C (*c*) G—T; A—C (*d*) A—A; T—T

32. A nucleoside consists of :

(*a*) base and sugar (*b*) base and phosphate

(*c*) sugar and phosphate (*d*) base, sugar and phosphate

33. The RNA responsible for the specific sequence of amino acids in protein is :

(*a*) *m*RNA (*b*) *t*RNA (*c*) ribosomal RNA (*d*) both (*a*) and (*b*)

34. Which of the following statements is correct?

(*a*) All amino acids are optically active.

(*b*) All amino acids except glycine are optically active.

(*c*) All amino acids except glutamic acid are optically active.

(*d*) All amino acids except lysine are optically active.

35. Which of the following compound is a protein?

(*a*) Penicillin (*b*) Orlon (*c*) Keratin (*d*) Savlon

36. Which of the following is a monosaccharide?

(*a*) Lactose (*b*) Maltose (*c*) Fructose (*d*) Cellulose

37. Amino acids are:

(*a*) Acidic (*b*) Alkaline (*c*) Amphoteric (*d*) Neutral

38. Which of the following is a natural polymer?

(*a*) Protein (*b*) Teflon (*c*) Nylon (*d*) Terylene

39. Which amino acid has phenolic–OH group as its backbone?

(*a*) Glycine (*b*) Leucine (*c*) Tyrosine (*d*) Serine

40. Which base is present in RNA but not in DNA?

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

41. The simplest amino acid is

(*a*) Alanine (*b*) Tyrosine (*c*) Asparagine (*d*) Glycine

42. Which of the following is a non-reducing sugar?

(*a*) Sucrose (*b*) Glucose (*c*) Maltose (*d*) Lactose

43. On oxidation with a mild oxidising agent like Br_2/H_2O, the glucose is oxidized to

(*a*) saccharic acid (*b*) glucaric acid (*c*) gluconic acid (*d*) valeric acid

44. During acetylation of glucose it needs how many moles of acetic anhydride?

(*a*) 3 (*b*) 5 (*c*) 4 (*d*) 1

45. Which reagent is used to convert glucose into saccharic acid?

(*a*) Br_2/H_2O (*b*) Nitric acid

(*c*) Alkaline solution of iodine (*d*) Ammonium hydroxide

46. The general formula of carbohydrates is

(*a*) $C_nH_{2n+1}O$ (*b*) $C_nH_{2n}O$ (*c*) $C_x(H_2O)_y$ (*d*) $C_n(H_2,O)_{2n}$

47. Which one of the following is not correct?

(*a*) D (–) Fructose exist in furanose structure

(*b*) D (+) Glucose exists in pyranose structure

(*c*) In sucrose the two monosaccharides are held together by peptide linkage

(*d*) Maltose is a reducing sugar

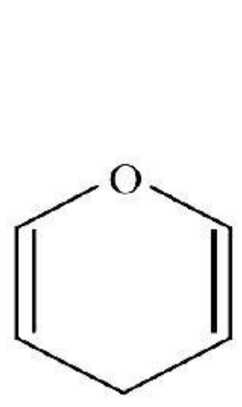
48. Glucose does not react with

(*a*) NH_2OH (*b*) $NaHSO_3$ (*c*) $C_6H_5NHNH_2$ (*d*) HCN

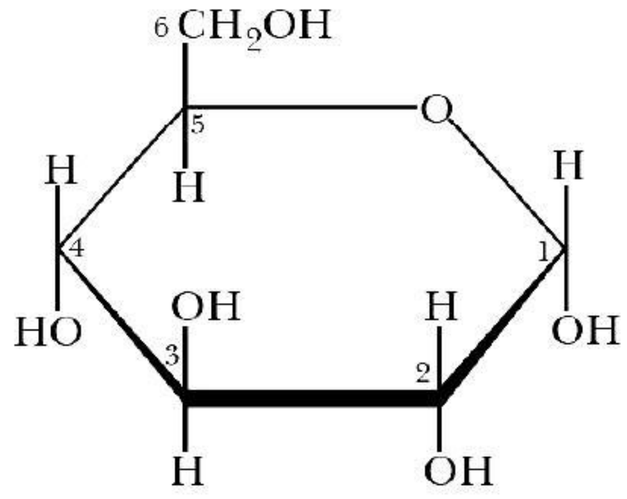
49. The anomeric carbon in D (+) glucose is

(*a*) C-1 carbon (*b*) C-2 carbon (*c*) C-5 carbon (*d*) C-6 carbon

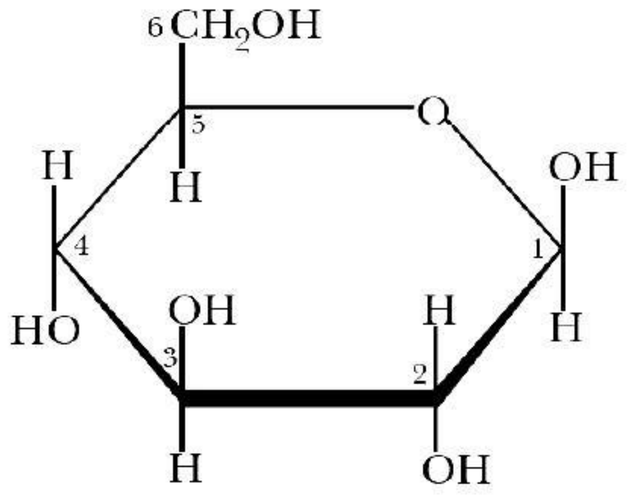
50. How many C-atoms are there is a pyranose ring?



Pyran



α-D-(+)-Glucopyranose



β-D-(+)-Glucopyranose

(*a*) 3 (*b*) 5 (*c*) 6 (*d*) 7

51. Amino acids generally exist in the form of Zwitter ions. This means they contain

(*a*) Basic $-NH_2$ group and acidic —COOH group

(*b*) The basic $-\overset{+}{N}H_3$ group and acidic $-COO^-$ group

(*c*) Basic $-NH_2$ and acidic $-H^+$ group

(*d*) Basic $-COO^-$ group and acidic $-NH_3$ group

52. Denaturation of protein leads to loss of its biological activity by

(*a*) formation of amino acids

(*b*) loss of primary structure

(*c*) loss of both primary and secondary structure

(*d*) loss of both secondary and tertiary structures

53. Mark the wrong statement about denaturation of proteins.

(*a*) The primary structure of the protein does not change.

(*b*) Globular proteins are converted into fibrous proteins.

(*c*) Fibrous proteins are converted into globular proteins.

(*d*) The biological activity of the protein is destroyed.

54. α-D (+) glucose and β-D (+) – glucose are

(*a*) Enantiomers (*b*) Geometrical isomers (*c*) Anomers (*d*) Epimers

55. Which of the following is called non-sugars?

(*a*) Monosaccharide (*b*) Disaccharide (*c*) Trisaccharide (*d*) Polysaccharide

56. Glucose is prepared from

(*a*) Sucrose (*b*) Maltose (*c*) Lactose (*d*) Cellulose

57. In D(+) glucose,

(*a*) 'D' represents configuration and (+) represents dextrorotatory nature

(*b*) 'D' represents dextrorotatory nature and (+) represents configuration

(*c*) 'D' represents configuration and (+) represents laevorotatory nature

(*d*) 'D' represents laevorotatory nature and (+) represents configuration

58. Which of the following is a basic amino acid?

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

59. Which of the following gives rise to fibrous and globular proteins?

(*a*) Primary structure of proteins (*b*) Secondary structure of proteins

(*c*) Tertiary structure of proteins (*d*) Quaternary structure of proteins

60. The product formed when glucose reacts with HI is

(*a*) Gluconic acid (*b*) *n*-hexane (*c*) saccharic acid (*d*) cyanohydrin

61. Which of the following does not confirm the presence of carbonyl group in glucose?

(*a*) Reaction with hydroxylamine (*b*) Reaction with hydrogen cyanide

(*c*) Reaction with acetic anhydride (*d*) Reaction with bromine water

62. Furan is a

(*a*) five membered cyclic compound with one oxygen and four carbon atoms.

(*b*) cyclic organic compound with one oxygen atom and five carbon atoms in the ring.

(*c*) five membered cyclic compound with one carbon and four oxygen atoms.

(*d*) cyclic organic compound with one carbon atom and five oxygen atoms in the ring.

63. Amide group is present in

(*a*) Carbohydrates (*b*) Proteins (*c*) Lipids (*d*) Vitamins

64. Glucose gives silver mirror with Tollen's reagent. It shows the presence of

(*a*) An acidic group (*b*) An alcoholic group (*c*) A ketonic group (*d*) An aldehydic group

65. The main force(*s*) which stabilise the 2° and 3° structures of proteins is/are

(*a*) hydrogen bonds (*b*) disulphide linkages (*c*) van der Waals (*d*) all of these

66. The segment of DNA which acts as the instruction manual for the synthesis of protein is

(*a*) ribose (*b*) gene (*c*) nucleoside (*d*) nucleotide

67. Glycosidic linkage is an;

(*a*) amide linkage (*b*) ether linkage (*c*) ester linkage (*d*) acetyle linkage

68. The functional group which is formed in amino acid is

(*a*) –COOH (*b*) $-NH_2$ (c) $-CH_3$ (*d*) both (*a*) and (*b*)

69. By which bond the polypeptide chains are held together in fibrous protein?

(*a*) Covalent bond (*b*) Hydrogen bond (*c*) Disaulphide bond (*d*) Both (*b*) and (*c*)

70. Which of the following base is not present in DNA?

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

71. A carbohydrate must contain :

(*a*) 2 carbon atoms (*b*) 3 carbon atoms (*c*) 4 carbon atoms (*d*) 6 carbon atoms

72. Glucose contains :

(*a*) One —CHO group (*b*) five —OH groups

(*c*) one primary alcoholic group (*d*) all are correct

73. Amino acids are the end products in the digestion of :

(*a*) cellulose (*b*) lecithin (*c*) nucleic acid (*d*) albumin

74. The helical structure of protein is established by :

(*a*) Peptide bonds (*b*) Dipeptide bonds (*c*) Hydrogen bonds (*d*) Van der Waals forces

75. Which of the following is not an amino acid?

(*a*) Glycine (*b*) Alanine (*c*) Histidine (*d*) Benzidine

76. The letter D in carbohydrates signifies :

(*a*) mode of synthesis (*b*) its configuration (*c*) dextrorotatory (*d*) diamagnetic nature

77. Which parts of amino acids molecules are linked through hydrogen bonds in the secondary structure of proteins?

(*a*) NH_2 group (*b*) COOH group

(*c*) —C— and —NH— groups (*d*) None of the above
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78. An α-helix is a structural feature of

(*a*) Sucrose (*b*) Polypeptides (*c*) Nucleotides (*d*) Starch

79. Which one is the complementary base of cytosine in one strand to that in other strand of DNA?

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

80. The function of DNA is

(*a*) To synthesise DNA (*b*) To synthesise the necessary protein

(*c*) To carry the hereditary information (*d*) All are correct

Answers

1. (*a*)	**2.** (*a*)	**3.** (*c*)	**4.** (*c*)	**5.** (*d*)	**6.** (*c*)	**7.** (*d*)	**8.** (*b*)
9. (*a*)	**10.** (*a*)	**11.** (*d*)	**12.** (*c*)	**13.** (*b*)	**14.** (*a*)	**15.** (*c*)	**16.** (*a*)
17. (*b*)	**18.** (*c*)	**19.** (*a*)	**20.** (*b*)	**21.** (*b*)	**22.** (*b*)	**23.** (*c*)	**24.** (*d*)
25. (*c*)	**26.** (*d*)	**27.** (*c*)	**28.** (*d*)	**29.** (*b*)	**30.** (*d*)	**31.** (*a*)	**32.** (*a*)
33. (*d*)	**34.** (*b*)	**35.** (*c*)	**36.** (*c*)	**37.** (*c*)	**38.** (*a*)	**39.** (*c*)	**40.** (*a*)
41. (*d*)	**42.** (*a*)	**43.** (*c*)	**44.** (*b*)	**45.** (*b*)	**46.** (*c*)	**47.** (*c*)	**48.** (*b*)
49. (*a*)	**50.** (*b*)	**51.** (*a*)	**52.** (*d*)	**53.** (*c*)	**54.** (*c*)	**55.** (*d*)	**56.** (*a*)
57. (*a*)	**58.** (*d*)	**59.** (*c*)	**60.** (*b*)	**61.** (*c*)	**62.** (*a*)	**63.** (*b*)	**64.** (*d*)
65. (*d*)	**66.** (*b*)	**67.** (*b*)	**68.** (*d*)	**69.** (*d*)	**70.** (*d*)	**71.** (*b*)	**72.** (*d*)
73. (*d*)	**74.** (*c*)	**75.** (*d*)	**76.** (*b*)	**77.** (*c*)	**78.** (*b*)	**79.** (*b*)	**80.** (*c*)

CASE-BASED QUESTIONS

1. Read the given passage and answer the questions that follow. ***[CBSE Question Bank]***

Adenosine triphosphate (ATP) is the energy-carrying molecule found in the cells of all living things. ATP captures chemical energy obtained from the breakdown of food molecules and releases it to fuel other cellular processes. ATP is a nucleotide that consists of three main structures: the nitrogenous base, adenine; the sugar, ribose; and a chain of three phosphate groups bound to ribose. The phosphate tail of ATP is the actual power source which the cell taps. Available energy is contained in the bonds between the phosphates and is released when they are broken, which occurs through the addition of a water molecule (a process called hydrolysis). Usually only the outer phosphate is removed from ATP to yield energy; when this occurs ATP is converted to adenosine diphosphate (ADP), the form of the nucleotide having only two phosphates.

The importance of ATP (adenosine triphosphate) as the main source of chemical energy in living matter and its involvement in cellular processes has long been recognized. The primary mechanism whereby higher organisms, including humans, generate ATP is through mitochondrial oxidative phosphorylation. For the majority of organs, the main metabolic fuel is glucose, which in the presence of oxygen undergoes complete combustion to CO_2 and H_2O:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6O_2 + 6H_2O + \text{energy}$$

The free energy (ΔG) liberated in this exergonic (ΔG is negative) reaction is partially trapped as ATP in two consecutive processes: glycolysis (cytosol) and oxidative phosphorylation (mitochondria). The first produces 2 mol of ATP per mol of glucose, and the second 36 mol of ATP per mol of glucose. Thus, oxidative phosphorylation yields 17-18 times as much useful energy in the form of ATP as can be obtained from the same amount of glucose by glycolysis alone.

The efficiency of glucose metabolism is the ratio of amount of energy produced when 1 mol of glucose oxidised in cell to the enthalpy of combustion of glucose. The energy lost in the process is in the form of heat. This heat is responsible for keeping us warm.

(**Source:** *Ereciińska, M., & Silver, I.A. (1989). ATP and Brain Function. Journal of Cerebral Blood Flow & Metabolism, 9(1), 2–19. https://doi.org/10.1038/jcbfm.1989.2 and https://www.britannica.com/science/adenosine-triphosphate*)

The following questions are multiple choice questions. Choose the most appropriate answer:

(*i*) Cellular oxidation of glucose is a:

(*a*) spontaneous and endothermic process

(*b*) non spontaneous and exothermic process

(*c*) non spontaneous and endothermic process

(*d*) spontaneous and exothermic process

(*ii*) What is the efficiency of glucose metabolism if 1 mole of glucose gives 38 ATP energy? (Given: The enthalpy of combustion of glucose is 686 k cal, 1 ATP = 7.3 k cal)

(*a*) 100% (*b*) 38% (*c*) 62% (*d*) 80%

(*iii*) Which of the following statement is true?

(*a*) ATP is a nucleoside made up of nitrogenous base adenine and ribose sugar .

(*b*) ATP consists the nitrogenous base, adenine and the sugar, deoxyribose.

(*c*) ATP is a nucleotide which contains a chain of three phosphate groups bound to ribose sugar.

(*d*) The nitrogenous base of ATP is the actual power source.

(*iv*) Nearly 95% of the energy released during cellular respiration is due to:

(*a*) glycolysis occurring in cytosol

(*b*) oxidative phosphorylation occurring in cytosol

(*c*) glycolysis in occurring mitochondria

(*d*) oxidative phosphorylation occurring in mitochondria

(*v*) **Which of the following statements is correct:**

(*a*) ATP is a nucleotide which has three phosphate groups while ADP is a nucleoside which three phosphate groups.

(*b*) ADP contains a nitrogenous bases adenine, ribose sugar and two phosphate groups bound to ribose.

(*c*) ADP is the main source of chemical energy in living matter.

(*d*) ATP and ADP are nucleosides which differ in number of phosphate groups.

Answers

(*i*) (*d*)

(*ii*) (*b*)

(Glucose catabolism yields a TOTAL of 38 ATP. 38 ATP × 7.3 kcal/mol ATP = 262 kcal. Glucose has 686 kcal. Thus the efficiency of glucose metabolism is 262/686 × 100 = 38%.)

(*iii*) (*c*) (*iv*) (*d*) (*v*) (*b*)

2. Read the given passage and answer the questions that follow. ***[CBSE Question Bank]***

EVIDENCE FOR THE FIBROUS NATURE OF DNA

The basic chemical formula of DNA is now well established. As shown in Figure 1 it consists of a very long chain, the backbone of which is made up of alternate sugar and phosphate groups, joined together in regular 3′-5′ phosphate di-ester linkages. To each sugar is attached a nitrogenous base, only four different kinds of which are commonly found in DNA. Two of these---adenine and guanine--- are purines, and the other two thymine and cytosine-are pyrimidines. A fifth base, 5-methyl cytosine, occurs in smaller amounts in certain organisms, and a sixth, 5-hydroxy-methyl-cytosine, is found instead of cytosine in the T even phages. It should be noted that the chain is unbranched, a consequence of the regular internucleotide linkage. On the other hand the sequence of the different nucleotides is, as far as can be ascertained, completely irregular. Thus, DNA has some features which are regular, and some which are irregular. A similar conception of the DNA molecule as a long thin fiber is obtained from physicochemical analysis involving sedimentation, diffusion, light scattering, and viscosity measurements. These techniques indicate that DNA is a very asymmetrical structure approximately 20 A° wide and many thousands of angstroms long. Estimates of its molecular weight currently center between 5×10^6 and 10^7 (approximately 3×10^4 nucleotides). Surprisingly each of these measurements tend to suggest that the DNA is relatively rigid, a puzzling finding in view of the large number of single bonds (5 per nucleotide) in the phosphate-sugar back bone. Recently these indirect inferences have been confirmed by electron microscopy.

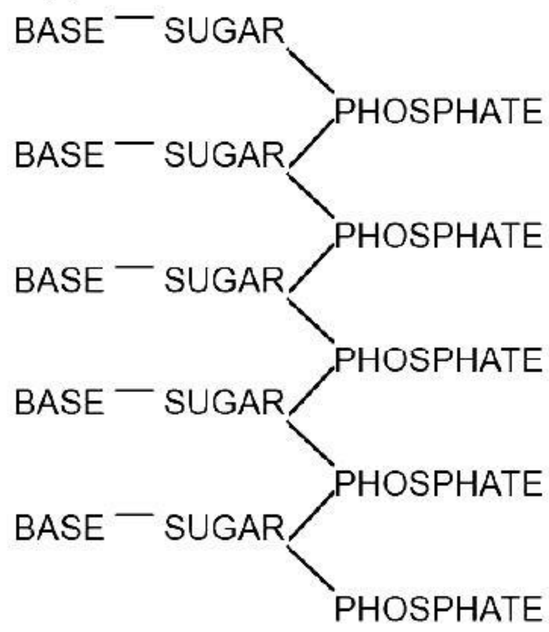


Figure 1: Chemical formula (diagrammatic) of a single chain of deoxyribonucleic acid

(**Source:** *Watson, J. D., & Crick, F. H. (1953, January). The structure of DNA. In Cold Spring Harbor symposia on quantitative biology (Vol. 18, pp. 123-131). Cold Spring Harbor Laboratory Press.*)

The following questions are multiple choice questions. Choose the most appropriate answer:

(*i*) Purines present in DNA are:

(*a*) adenine and thymine (*b*) guanine and thymine
(*c*) cytosine and thymine (*d*) adenine and guanine

(*ii*) DNA molecule has _____ internucleotide linkage and _____ sequence of the different nucleotides

(*a*) regular, regular (*b*) regular, irregular
(c) irregular, regular (*d*) irregular, irregular

(*iii*) DNA has a _____ backbone.

(*a*) phosphate-purine (*b*) pyrimidines-sugar
(*c*) phosphate-sugar (*d*) purine-pyrimidine

(*iv*) Out of the four different kinds of nitrogenous bases which are commonly found in DNA, _____ has been replaced in some organisms.

(*a*) adenine (*b*) guanine (*c*) cytosine (*d*) thymine

Answers

(*i*) (*d*) (*ii*) (*b*) (*iii*) (*c*) (*iv*) (*c*)

ASSERTION-REASON QUESTIONS

In the following questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason 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. ***[CBSE 2020 (56/1/1)]***
   Reason (R) : Sucrose has glycosidic linkage.
5. **Assertion (A) :** Sucrose is a non-reducing sugar. ***[CBSE 2020 (56/1/3)]***
   Reason (R) : Reducing groups of glucose and fructose are involved in glycosidic bond formation.
6. **Assertion (A) :** Albumin is a globular protein. ***[CBSE 2020 (56/2/1)]***
   Reason (R) : Polypeptide chain coils around to give a straight chain.
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.

Answers

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

HINTS/SOLUTIONS OF SELECTED MCQS

3. (*c*) Glucose is an aldohexose since it consists of six carbon atoms and an aldehyde group. It is present in the pyranose form and not in the furanose form.
Its cyclic structure is a six-membered ring similar to the organic compound pyran.

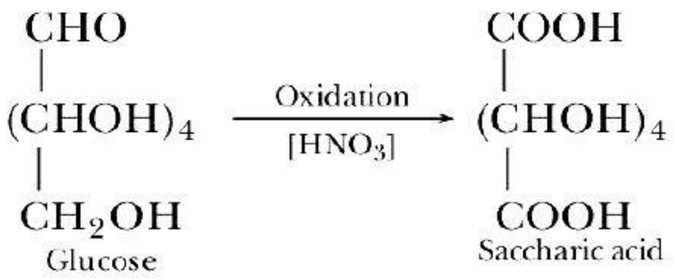
18. (*c*) Glucose is a monosaccharide.

19. (*a*) It is sucrose which is a disaccharide. On hydrolysis, it gives glucose and fructose.

20. (*b*) Ribose is an example of aldopentose. It is a five carbon sugar with an aldehyde carbonyl.

21. (*b*) Aldohexoses are glucose, mannose, galactose, etc. Glucose is a carbohydrate compound consisting of six carbon atoms and an aldehyde group and so they are referred to as aldehexose.

22. (*b*) On oxidation, glucose yields dicarboxylic acid (saccharic acid).



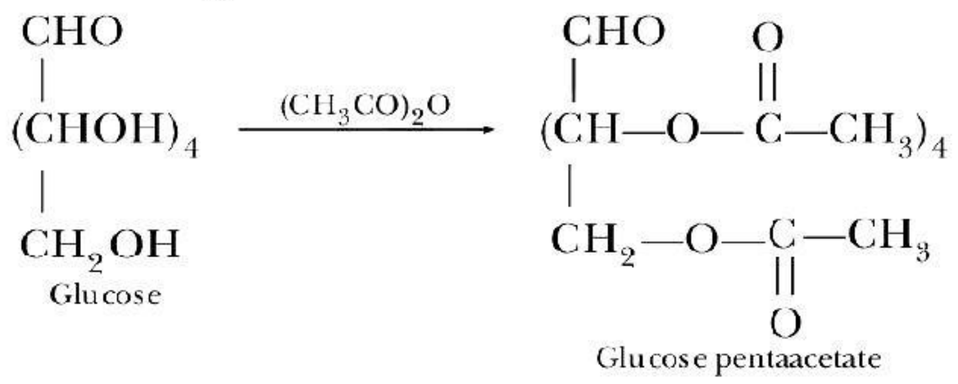
23. (*c*) Fructose belongs to D-series and is a laevorotatory compound. It is appropriately written as D-(–)-fructose. It is also called, levulose, after its laevorotatory property of rotating plane polarised light to the left.

24. (*d*) In aqueous solution of amino acids, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as zwitter ion. In zwitter ionic form, amino acids show amphoteric behaviour as they react both with acids and bases.

25. (*c*) Peptide linkage is an amide formed between –COOH group and $-NH_2$ group.

26. (*d*) DNA is a type of nucleic acid.

27. (*c*)



28. (*d*) Insulin is a protein while rest are the purines and pyrimidine bases present in nucleic acids.

29. (*b*) Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

30. (*d*) 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.

31. (*a*) Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

32. (*a*) A unit formed by the attachment of a base to 1′ position of sugar is known as nucleoside.

33. (*d*) 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.

35. (*c*) Keratin is a fibrous protein present in hair, wool, silk, etc.

36. (*c*) Fructose is a ketohexose and a natural monosaccharide found in fruits, honey and vegetables.

37. (*c*) In zwitter ionic form, amino acids show amphoteric behaviour as they react both with acids and bases.

38. (*a*) Protein is a natural polymer of α-amino acids linked by peptide bonds.

39. (*c*) Tyrosine or 4-hydroxyphenylalanine is a non-essential amino acid with a polar side group.

40. (*a*) In RNA, thymine is replaced by uracil.

41. (*d*) Glycine (The structure of glycine is $H_2N-\underset{H}{\overset{H}{C}}-COOH$, simplest amino acid.

glycine

42. (*a*) Sucrose (It does not have free ketone or aldehyde groups since the reducing groups of glucose and fructose are involved in glycosidic bond formation)

43. (*c*) $\underset{\underset{CH_2OH}{|}}{\overset{\overset{CHO}{|}}{(CHOH)_4}} \xrightarrow{Br_2/H_2O} \underset{\underset{CH_2OH}{|}}{\overset{\overset{COOH}{|}}{(CHOH)_4}}$

Gluconic acid

44. (*b*) Acetylation of glucose with acetic anhydride gives glucose pentaacetate which confirms the presence of five –OH groups.

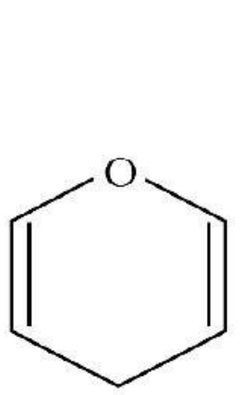
45. (*b*) $CHO-(CHOH)_4-HOCH_2 \xrightarrow{HNO_3} \underset{\text{Saccharic acid}}{HOOC-(CHOH)_4-COOH}$

46. (*c*) Most of carbohydrates have a general formula, $C_x(H_2O)_y$. For example, the molecular formula of glucose ($C_6H_{12}O_6$) fits into this general formula, $C_6(H_2O)_6$.

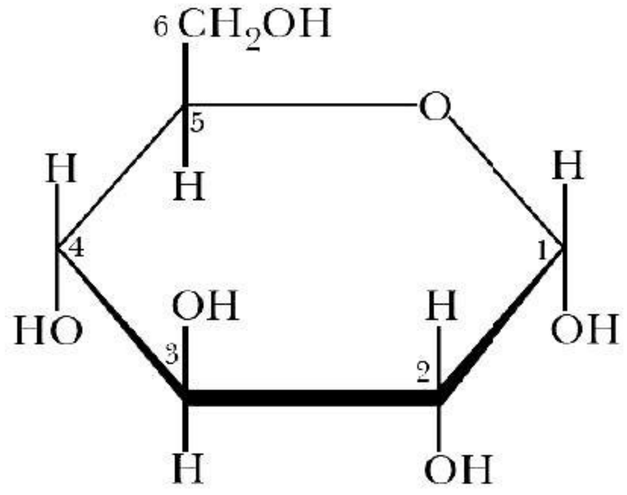
47. (*c*) In sucrose the two monosaccharides are held together by glycosidic linkage.

49. (*a*) Anomers differ from each other in the configuration of C-1and the carbon is known as anomeric carbon

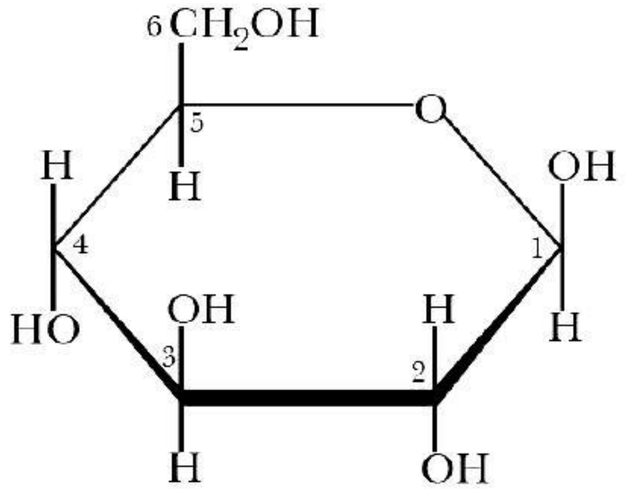
50. (*b*)



Pyran



α-D-(+)-Glucopyranose



β-D-(+)-Glucopyranose

51. (*a*) In amino acids, there is presence of both acidic (carboxyl group) and basic (amino group) in the same molecule. In aqueous solution of amino acids, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as zwitter ion.

52. (*d*) During denaturation secondary and tertiary structures are destroyed but primary structure remains intact.

53. (*c*) When a protein in its native form, is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and converts to fibrous protein.

54. (*c*) α-D(+) glucose and β-D(+)-glucose differ from each other in the configuration of C-1 and are called as anomers.

55. (*d*) Polysaccharides are not sweet in taste thus are called non-sugars.

56. (*a*) When sucrose is boiled with dilute HCl or H_2SO_4 in alcoholic solution, glucose and fructose are obtained in equal amounts.

57. (*a*) In D(+) glucose, 'D' represents configuration which means –OH group lies on right hand side in the structure. (+) represents dextrorotatory nature which means it rotates the plane of a polarized light ray to the right.

58. (*d*) There are three amino acids that have basic side chains at neutral pH. These are Arginine, lysine and histidine. They contains more number of amino than carboxyl group.

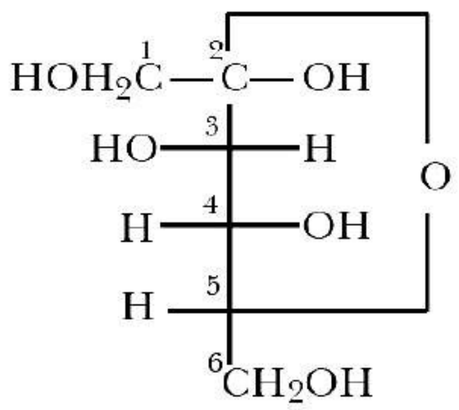
59. (*c*) The tertiary structure of proteins represents overall folding of the polypeptide chains *i.e.*, further folding of the secondary structure. It gives rise to two major molecular shapes viz. fibrous and globular.

60. (*b*) $\begin{matrix}CHO\\|\\(CHOH)_4\\|\\CH_2OH\end{matrix} \xrightarrow[\Delta]{HI} \underset{n\text{-Hexane}}{CH_3CH_2CH_2CH_2CH_2CH_3}$

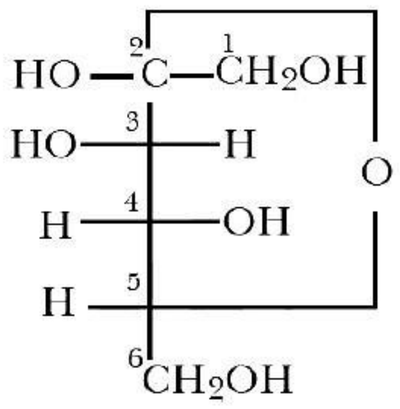
61. (*c*) Acetylation of glucose with acetic anhydride gives glucose pentaacetate which confirms the presence of five –OH groups.

62. (*a*)

Furan



α-D-(–)-Fructofuranose



β-D-(–)-Fructofuranose

63. (*b*) In proteins, polymers of α-amino acids are connected to each other by peptide bond (–CO–NH–.)

64. (*d*) Aldehydes reduce Tollens reagent.

65. (*d*) The main forces which stabilise the 2° and 3° structures of proteins are hydrogen bonds, disulphide linkages, van der Waals and electrostatic forces of attraction.

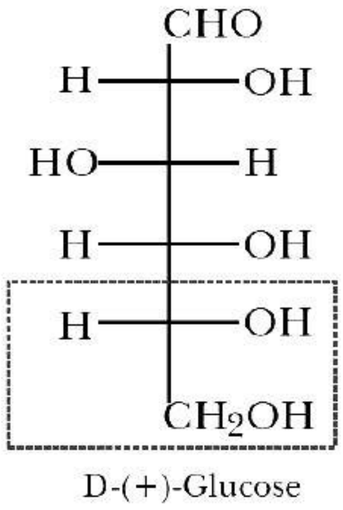
69. (*d*) When the polypeptide chains run parallel and are held together by hydrogen and disulphide bonds, then fibrous protein is formed.

70. (*d*) DNA contains four bases viz. adenine (A), guanine (G), cytosine (C) and thymine (T)

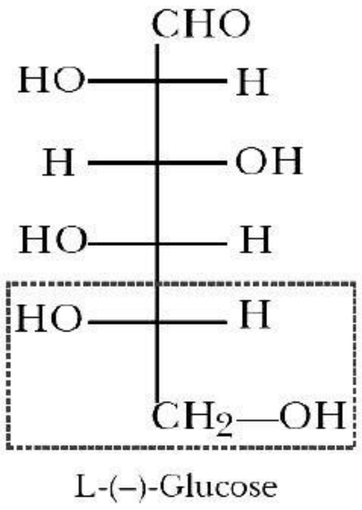
71. (*b*) The simplest carbohydrate with 3 carbon atoms is glyceraldehyde, $C_3H_6O_3$.

72. (*d*) **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.



D-(+)-Glucose



L-(–)-Glucose

73. (*d*) The amino acids are the end products of the digestion of proteins. So, the correct option is albumin.

74. (*c*) α-Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the –NH group of each amino acid residue hydrogen bonded to the CO of an adjacent turn of the helix.

75. (*d*) Benzidine is not an amino acid it is an aromatic amine.