DAY THIRTY FOUR

Biomolecules

Learning & Revision for the Day

- Carbohydrates
- Proteins
- Enzymes
- Vitamins
- Nucleic Acids

Biomolecules are the complex lifeless organic chemical substances. These build up living organisms and are required for their growth and maintenance. Carbohydrates, proteins, nucleic acids, lipids etc., are the examples of biomolecules. These biomolecules interact with each other and constitute the molecular logic of life processes. Vitamins and mineral salts also play an important role in functions of organisms.

Carbohydrates

- Carbohydrates are optically active polyhydroxy aldehydes or ketones or substances which produce such units on hydrolysis. Most of them have general formula $C_x(H_2O)_y$. But all the compounds which fits into this formula may not be considered as carbohydrate, e.g. CH_3COOH.
- Carbohydrates are also known as **saccharides** and classified according to their behaviour towards hydrolysis.

Carbohydrates

Depending upon the units produced after hydrolysis

Monosaccharides	**Oligosaccharides**	**Polysaccharides**
Simplest saccharides which cannot be hydrolysed to smaller molecules.	(*Oligos*-few) Yield 2-10 monosaccharides on hydrolysis.	Hydrolysed to yield large number of monosaccharides.
Crystalline solids, soluble in water and sweet in taste and collectively called sugars.		Amorphous solids, insoluble in water and tasteless and thus are called **non-sugars**.
Except-sucrose, all are reducing-sugars.		All polysaccharides are non-reducing sugars.

- On the basis of functional group present, monosaccharides are classified as follows:
  (i) **Aldose** mainly contains aldehyde group along with hydroxyl group, e.g. glucose, galactose.
  (ii) **Ketose** mainly contains ketone group along with hydroxyl (—OH) group, e.g. fructose.

Monosaccharides

A carbohydrate that cannot be hydrolysed further to give simpler units is called **monosaccharide**, e.g. glucose, fructose, galactose are hexose while ribose and arabinose are pentose. All monosaccharides are reducing sugars.

Glucose can be prepared by sucrose and starch. The reactions are as follows:

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

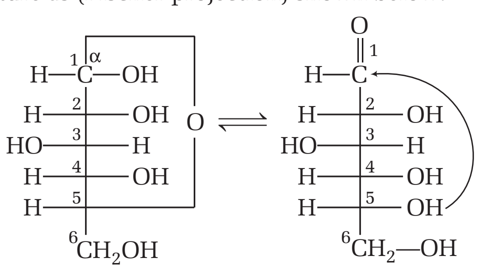
(ii) $\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[\text{393 K, 2-3atm}]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$

Some important properties of glucose are as follows:

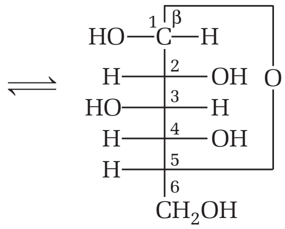
- Glucose is an aldohexose and is also known as dextrose (Grape sugar). It is the monomer of starch and glucose.
- On prolonged heating with HI, it forms *n*-hexane, suggesting that all the six carbon atoms are linked in a straight chain.
- Glucose reacts with hydroxylamine to form an oxime and adds a molecule of hydrogen cyanide to give cyanohydrin. These reactions confirm the presence of carbonyl group $>C=O$ in glucose.
- Glucose get oxidised to six carbon carboxylic acid on reaction with a mild oxidising agent like bromine water. This indicates that the carbonyl group is present as an aldehyde group.
- Acetylation of glucose with acetic anhydride gives glucose penta-acetate which confirms the presence of five —OH groups.
- On oxidation with nitric acid, glucose as well as gluconic acid both yield a dicarboxylic acid (saccharic acid). This indicates the presence of primary alcoholic group.
- When glucose is warmed with excess of phenyl hydrazine, crystalline product, glucosazone is formed.

Structure and Isomerism

- Glucose forms a six membered ring in which —OH at C-5 is involved in ring formation. This explains the absence of —CHO group and also existence of glucose in two cyclic forms which are in equilibrium with open structure as (Fischer projection) shown below:

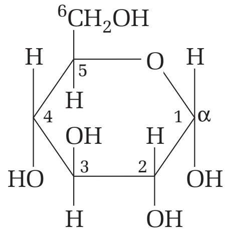


α-D-(+)-glucose

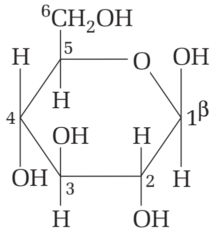


β-D-(+)-glucose

- The cyclic structure of glucose is more correctly represented by **Haworth structure** as given below:

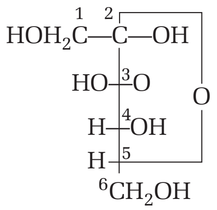


α-D-(+)-glucopyranose

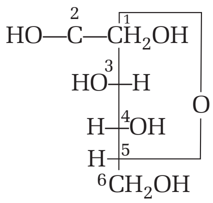


β-D-(+)-glucopyranose

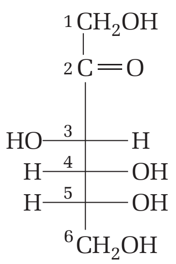
- α and β-D-glucose have different configuration at anomeric (C-1) carbon atom, hence are called **anomers**.
- While the pair of diastereomeric aldoses, e.g. glucose and mannose that differ only in configuration about C-2 are called epimers. Glucose and galactose differ in configuration at C-4 are called C-4-epimers.
- Fructose is a functional isomer of glucose and has ketone group. It is obtained along with glucose by the hydrolysis of disaccharide, sucrose. It exists in two cyclic forms which are obtained by the addition of —OH at C-5 to the $>C=O$ group. The ring formed is a five membered ring and is named as furanose.



α-D-(–)-fructofuranose

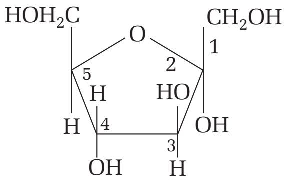


β-D-(–)-fructofuranose

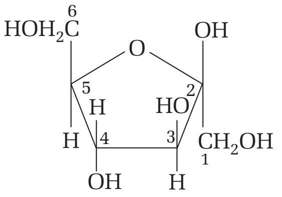


D-(–)-fructose (open structure)

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



α-D-(–)-fructofuranose



β-D-(–)-fructofuranose

Oligosaccharides

The carbohydrates that yield two to ten monosaccharide units on hydrolysis are known as oligosaccharides. These are further classified as disaccharides, trisaccharides, tetrasaccharides etc., on the basis of number of monosaccharides units obtained on their hydrolysis. e.g. disaccharides : sucrose, maltose, lactose etc.; trisaccharides : raffinose; tetrasaccharides : stachyose.

- Except sucrose all other disaccharides are reducing in nature and hence, are called reducing sugars.
- In disaccharides, the two monosaccharide units are joined together by an oxide linkage formed by the loss of a water molecule, this linkage is known as **glycosidic linkage**.

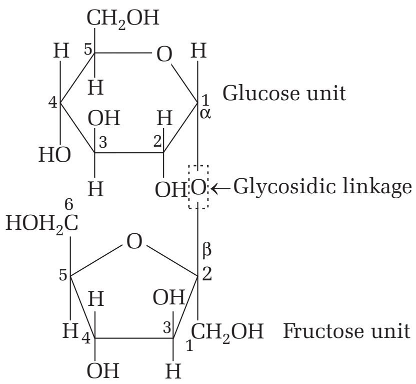
Various types of disaccharides are as follows:

1. Sucrose

Sucrose is non-reducing due to absence of free aldehyde or ketone group. It is cane sugar or table sugar.

- Sucrose (which is dextrorotatory) is also known as invert sugar. Because on hydrolysis (+) sucrose gets inverted to give a mixture of D-(+) -glucose and D-(–)-fructose.
- In sucrose, free aldehyde or ketone group is absent. It is shown by the facts that it does not form osazone, does not exist in anomeric forms and also does not show mutarotation.

Structure of sucrose is as follows:

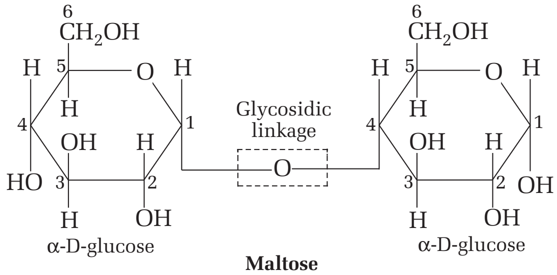


2. Maltose ($C_{12}H_{22}O_{11}$)

It is obtained by partial hydrolysis of starch by diastase enzyme present in malt, i.e. sprouted barley seeds (hence, named maltose or malt sugar).

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

- It is a white crystalline solid (with melting point 160° – 165°C), soluble in water and dextrorotatory. When it is hydrolysed with dilute acid or by enzyme maltase, yields two molecules of D-(+) -glucose. Hence, maltose is a condensation product of two α-D-glucose units.



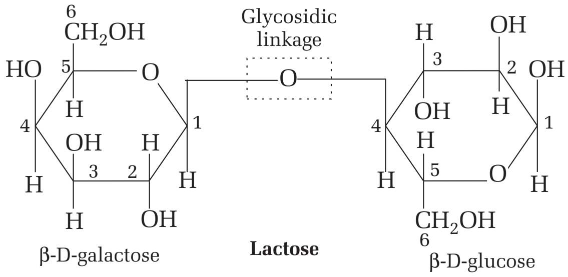
Maltose

- Maltose is a reducing sugar. It reduces Fehling's solution, Tollen's reagent, it forms an oxime and an osazone and undergoes mutarotation. This indicates that at least one aldehyde group is free in maltose.

3. Lactose ($C_{12}H_{22}O_{11}$)

It occurs in the milk of all animals (milk-sugar). It is a white crystalline solid (with melting point 203°C), soluble in water and is dextrorotatory.

- It is hydrolysed by dilute acid or enzyme lactose, to an equimolar mixture of D-(+)-glucose and D-(+)-galactose.
- Lactose is a reducing sugar, forms an oxime and osazone and also undergoes mutarotation.
- It gets hydrolysed by emulsin also, an enzyme which specifically hydrolyses β - glycosidic linkage.



Lactose

Polysaccharides

- Carbohydrates which yield a large number of monosaccharide units on hydrolysis are called polysaccharides. e.g. starch, cellulose, glycogen, gums arabic (acidic) etc.

- Polysaccharides are not sweet in taste, hence they are also called non-sugars.
- Moreover, all polysaccharides are non-reducing due to absence of free —CHO or >CO group.

Some of the important polysaccharides are as follows:

(i) **Starch** is the main storage polysaccharides of plants. It is a polymer of α-D-glucose units and consists of two components-amylose (water soluble) and amylopectin (water insoluble).

(ii) **Cellulose** is a predominant constituent of cell wall of plant cells. It is a straight chain polysaccharide composed only of β-D-glucose units which are joined together by β-1,4-glycosidic linkage, i.e. between C-1 of one glucose and C-4 of the next glucose unit. Cellulose is not digestible by humans due to the absence of enzyme cellulase in digestive system.

(iii) **Glycogen** is the carbohydrate (a condensation polymer of α-D-glucose) which is stored in animal body. When the body needs glucose, enzymes break the glycogen down to glucose.

Proteins

Proteins are large biomolecules that occur in every living organism.

Proteins are polymers of amino acids (the compounds which have both the acid and amino group).

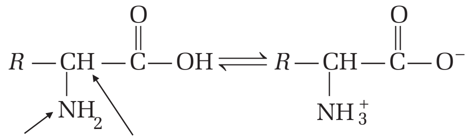
Amino Acids

The total number of amino acids that have been found in proteins are twenty.

On the basis of their synthesis, amino acids are divided into two classes:

1. **Essential amino acids** are the amino acids which cannot be synthesised in the body and must be obtained through diet. e.g. valine, leucine, lysine, isoleucine, arginine etc.
2. **Non-essential amino acids** are the amino acids which can be synthesised in the body. e.g. glycine, alanine, glutamic acid, aspartic acid etc.

   Amino acids behave like salts rather than simple amines or carboxylic acids. This is due to the presence of both acidic and basic groups in the same molecule.



(N-terminal) (C-terminal)

(*Zwitter ion*) or dipolar ion (neutral)

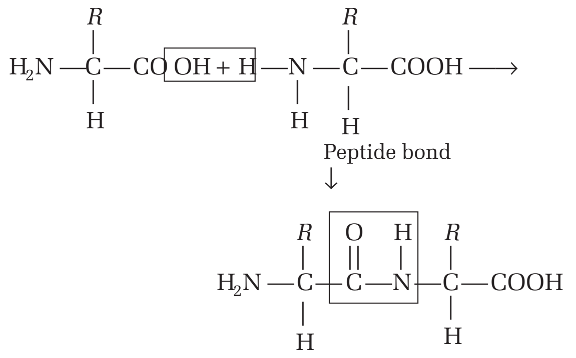
- At a certain pH of the medium, called the isoelectric point of an amino acid, the structure behaves as a dipolar ion or *Zwitter* ion and does not migrate to any electrode on passing current.
- Proteins give biuret test, Millon's test, Ninhydrin test.

Peptides and Peptide Linkage

The basic structural unit protein is α-amino acid.

- Amino acids may be joined together by an amide linkage called peptide linkage (—CO—NH—).

  e.g.



Dipeptide molecule

- The molecule derived from two amino acids containing a single peptide linkage is called a dipeptide, that derived from three amino acids is termed as a tripeptide. The peptides having 2-10 amino acid residues are called oligopeptides while those with greater than 10 amino acid residues are called polypeptides.
- Polypeptide with molecular weight greater than 10,000 u is termed as a protein.

Classification of Proteins

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

1. **Fibrous Proteins** Polypeptide chains form fibre like structure, e.g. keratin and myosin etc.
2. **Globular Proteins** This structure results when the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water, e.g. insulin and albumins.

Structural Levels of Proteins

Structure and shape of proteins are of four different levels. These are as follows:

(i) **Primary structure** of protein involves the polypeptide that has amino acids linked in specific sequence change in this structure gives a different protein.

(ii) **Secondary structure** of proteins involves the linking of polypeptide chains by hydrogen bonds. They are found to exist in two different types of structures *viz*, α-helix and β-pleated sheet structure.

(iii) **Tertiary structure** of proteins represents overall folding of the polypeptide chains. It involves the polypeptide bonds, hydrogen bonds, disulphide linkages, van der Waals' forces and electrostatic forces of attraction. It gives rise to two major molecular shapes *viz*, fibrous and globular.

(iv) **Quarternary structure** of proteins are composed of two or more polypeptide chains referred to as subunits. The spatial arrangement of these subunits with respect to each other is known as quarternary structure.

Denaturation of Proteins

Disturbance of hydrogen bonds either by acids or alcohols or heat, results in unfolding of globules. Thus, helix get uncoiled and protein loses its biological activity due to change in temperature or pH. During denaturation, secondary and tertiary structures of proteins are destroyed while primary structures remains intact.

Enzymes

- Enzymes are globular protein bodies, which are biological catalysts. Enzyme inhibitors reduce the activity of a particular enzyme. These are mostly inorganic ions or complex organic molecules.
- Almost all the enzymes are globular proteins. These are very specific for a particular reaction and for particular substrate.
- Congenital and albinism diseases are caused by the deficiency of the enzymes phenyl ketone urea and tryosinase respectively.

Vitamins

- 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, are termed as vitamins.
- Provitamins are the biologically inactive compounds that have almost same structure as vitamins and can be converted easily into active vitamins. e.g. β-carotene is a provitamin for vitamin A.

Various types of vitamins are as follows:

(i) **Fat or oil soluble vitamins**, e.g. A D, E and K.

(ii) **Water soluble vitamins,** e.g. B group vitamins and vitamin C.

Some Important Vitamins, Their Sources and Their Deficiency Diseases

Name of Vitamin	Sources	Deficiency Diseases
Vitamin-A (Retinol)	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye), night blindness,
Vitamin-B_1 (Thiamine)	Yeast, milk, green vegetables	Beri-beri (loss of appetite)
Vitamin-B_2 (Riboflavin)	Milk, egg white, liver, kidney	Cheilosis (fissuring at corners of mouth and lips)
Vitamin-B_6 (Pyridoxine)	Yeast, milk, egg yolk, cereals	Convulsions, nervousness
Vitamin-B_{12} (Cyanocobalamine)	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
Vitamin-C (Ascorbic acid)	Citrus fruit , amla and green leafy vegetables	Scurvy (bleeding gums)
Vitamin-D	Exposure to sunlight, fish and egg yolk	Rickets and osteomalacia
Vitamin-E	Wheat, germ oil, sunflower oil	Increased fragility of RBC and muscular weakness
Vitamin-K	Green leafy vegetables	Increased blood clotting time.

Nucleic Acids

- These are responsible in the biosynthesis of proteins.
- These are biological polymers. They function as the chemical carriers of cell's genetic information.
- These are mainly of two types the deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

1. DNA (Deoxyribonucleic Acid)

- DNA is the polymer of nucleotide.
- It is a genetic material.
- It has double helical structure.
- Nucleotide has deoxyribose sugar, phosphate and nitrogenous base.
- Nucleoside has deoxyribose sugar and nitrogenous base. A unit formed by the attachment of a base to 1′ position of sugar is known as nucleoside.
- In nucleosides, the sugar carbons are numbered as 1′, 2′, 3′ etc., in order to distinguish these from the bases. When nucleoside is linked to phosphoric acid at 5′-position of sugar moiety, we get a nucleotide.
- Nucleotides are joined together by phosphodiester linkage between 5′ and 3′ carbon.

- DNA contains four bases *viz* adenine (A), guanine (G), cytosine (C) and thymine (T). Here, adenine and guanine are called purines whereas, thymine and cytosine are called pyrimidine.
- DNA has $A=T, C\equiv G$

2. RNA (Ribonucleic Acid)

- It is also a polymer of nucleotide units but here, the nucleotide unit contains ribose sugar instead of deoxyribose sugar.
- RNA has adenine (A), guanine (G), cytosine (C) and uracil (U) instead of thymine (T).
- RNA molecules are of three types. These are messenger RNA (*m*RNA), ribosomal RNA (*r*RNA) and transfer RNA (*t*RNA). They perform different functions.

Biological Functions of Nucleic Acids

- DNA has an ability of self duplication during cell division and identical DNA strand are transferred to daughter cell. In this way DNA is responsible for maintaining the identity of different species of organisms over million of years.
- RNA molecules synthesised various types of proteins in the cell but the message for the synthesis of a particular type of protein is present in DNA.
- Genetic messages are encoded in DNA while RNA translated the encoded messages from DNA and thus helps in protein formation.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Which of the following biomolecules contains a non-transition metal ion?
(a) Haemoglobin (b) Chlorophyll
(c) Insulin (d) Vitamin B_{12}

2 Which of the following monosaccharides is a pentose?
(a) Glucose (b) Fructose
(c) Arabinose (d) Galactose

3 D-glucose contains
(a) 50% each of α-D-glucose and β-D-glucose
(b) 64% of α-D-glucose and 36% of β-D-glucose
(c) 36% of α-D-glucose and 64% of β-D-glucose
(d) 33% of each α-D-glucose and β-D-glucose

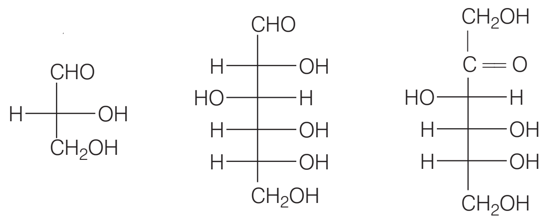
4 Glucose on prolonged heating with HI gives → JEE Main 2018
(a) *n*-hexane (b) 1-hexene
(c) hexanoic acid (d) 6-iodohexanal

5 The two form of D-glucopyranose obtained from the solution of D-glucose are called
(a) isomer (b) anomer
(c) epimer (d) enantiomer

6 The reagent which forms crystalline osazone derivative when treated with glucose, is
(a) Fehling's solution (b) phenyl hydrazine
(c) Benedict's solution (d) hydroxylamine

7 The reaction with sugars are carried out in neutral or acid medium and not in alkaline medium because in alkaline medium sugars undergoes
(a) decomposition (b) racemisation
(c) inversion (d) rearrangement

8 Optical rotations of some compounds along with their structures are given below which of them have D configuration.



(+) rotation I (+) rotation II (–) rotation III

(a) I, II and III (b) II and III (c) I and II (d) Only III

9 Which of the following pairs give positive Tollen's test?
(a) Glucose, sucrose (b) Glucose, fructose
(c) Hexanal, acetophenone (d) Fructose, sucrose

10 The beta and alpha glucose have different specific rotations. When either is dissolved in water, their rotation changes until the same fixed value results. This is called
(a) epimerisation (b) racemisation
(c) anomerisation (d) mutarotation

11 Which of the following statement is not true about glucose?
(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

12 The term invert sugar refers to an equimolar mixture of
(a) D-glucose and D-galactose
(b) D-glucose and D-fructose
(c) D-glucose and D-mannose
(d) D-glucose and D-ribose

13 Biuret test is not given by → AIEEE 2010
(a) carbohydrates (b) polypeptides
(c) urea (d) proteins

14 Which one of the following statements is correct? ➞ AIEEE 2012

(a) All amino acids except lysine are optically active
(b) All amino acids are optically active
(c) All amino acids except glycine are optically active
(d) All amino acids except glutamic acids are optically active

15 The bond that determines the secondary structure of proteins is

(a) coordinate bond (b) covalent bond
(c) hydrogen bond (d) ionic bond

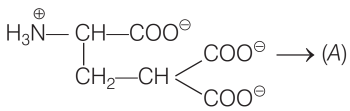
16 Which of the following compounds can be detected by Molisch's test? ➞ AIEEE 2012

(a) Nitro compounds (b) Sugars
(c) Amines (d) Primary alcohols

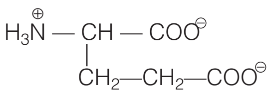
17 The secondary structure of a protein refers to

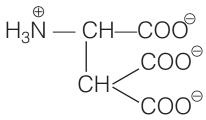
(a) α-helical backbone
(b) hydrophobic interaction
(c) sequence of α-amino acids
(d) fixed configuration of the polypeptide back bone

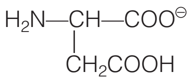
18 Following amino acid has been found in protein prothrombin, but remained undetected due to formation of another common acid (*A*).

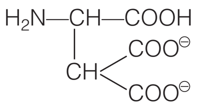


Identify '*A*'

(a) 

(b) 

(c) 

(d) 

19 On heating with conc. HNO_3 proteins give yellow colour. This test is called

(a) oxidising test (b) xanthoproteic test
(c) Hoppe's test (d) acid-base test

20 Enzyme trypsin converts

(a) proteins into α-amino acids
(b) starch into sugar
(c) glucose into glycogen
(d) α-amino acids into proteins

21 Which of the following enzymes hydrolyses triglycerides into fatty acids and glycerol?

(a) Amylase (b) Maltase (c) Lipase (d) Pepsin

22 Match the following enzymes with the reactions they catalyse.

Enzymes	Reactions
A. Invertase	1. Conversion of glucose into ethanol
B. Maltase	2. Hydrolysis of maltose into glucose
C. Pepsin	3. Hydrolysis of cane suger
D. Zymase	4. Hydrolysis of proteins into amino acids

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	3	2	4	1
(c)	1	4	2	3	(d)	4	2	3	1

23 Which of the vitamins given below is water soluble? ➞ JEE Main 2015

(a) Vitamin C (b) Vitamin D
(c) Vitamin E (d) Vitamin K

24 The vitamin which is water soluble and antioxidant is

(a) Vitamin E (b) Vitamin D
(c) Vitamin C (d) Vitamin B_1

25 Identify the vitamin whose deficiency in our blood decreases reproductive power?

(a) Vitamin E (b) Vitamin D
(c) Vitamin A (d) Vitamin C

26 The chemical name of vitamin B_1 is

(a) ascorbic acid (b) riboflavin
(c) pyridoxine (d) thiamine

27 Which of the following is a fat soluble vitamin?

(a) Vitamin A (b) Riboflavin
(c) Pyridoxine (d) Thiamine

28 Adenosine is an example of

(a) nucleotide (b) nucleoside
(c) purine base (d) pyrimidine base

29 The base adenine occurs in

(a) Only DNA (b) Only RNA
(c) Both DNA and RNA (d) protein

30 The presence or absence of hydroxy group on which carbon atom of sugar differentiates RNA and DNA? ➞ AIEEE 2011

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

31 Which one of the following bases is not present in DNA? ➞ JEE Main 2014

(a) Quinoline (b) Adenine (c) Cytosine (d) Thymine

Direction (Q.Nos. 32 and 33) *In the following questions. Assertion (A) followed by Reason (R) is given choose the correct answer out of the following choices.*

(a) Assertion and Reason both are correct statements and Reason is the correct explanation of the Assertion
(b) Assertion and Reason both are correct statements but Reason is not the correct explanation of the Assertion
(c) Assertion is correct and Reason is incorrect
(d) Both Assertion and Reason are incorrect

32 **Assertion** (A) All naturally occurring α-amino acids except glycine are optically active.

Reason (R) Most naturally occurring amino acids have L-configuration.

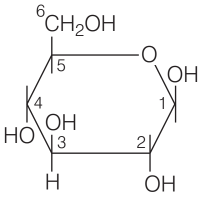
33 **Assertion** (A) Vitamin D can be stored in our body.

Reason (R) Vitamin D is fat soluble vitamin.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 In the following structure, anomeric carbon is



(a) 1 (b) 2 (c) 3 (d) 4

2 How can you say that glucose is cyclic compound?

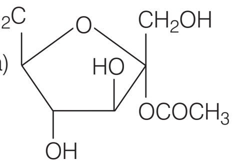
(a) Glucose undergoes Tollen's reaction
(b) Glucose reacts with phenyl hydrazine
(c) Glucose fails to react with sodium hydrogen sulphate
(d) Glucose react with nitric acid

3 Which of the following reaction establishes difference between glucose and fructose?

(a) Tollen's reagent reaction (b) Phenyl hydrazine
(c) P/HI (d) Conc.HNO_3

4 Which of the following compounds will behave as a reducing sugar in an aqueous KOH solution?

→ JEE Main 2016

(a)


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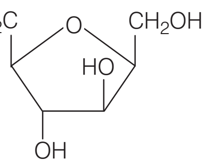

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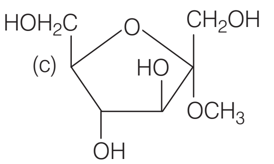
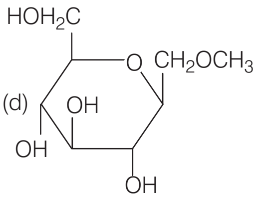
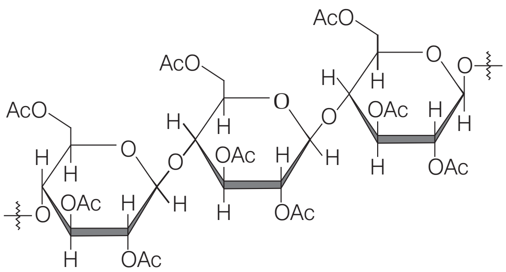
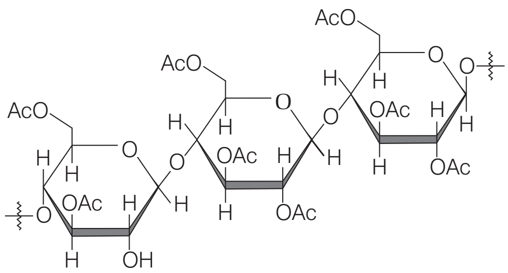
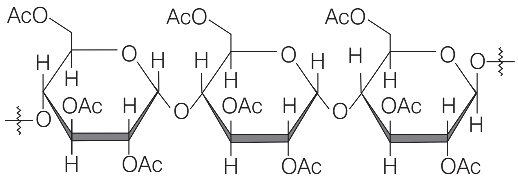


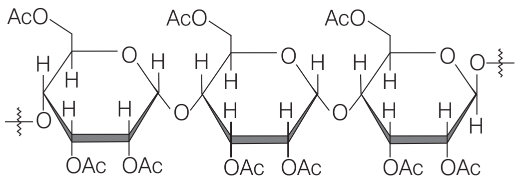
(d)


5 Cellulose upon acetylation with excess acetic anhydride / H_2SO_4 (catalytic) gives cellulose triacetate whose structure is

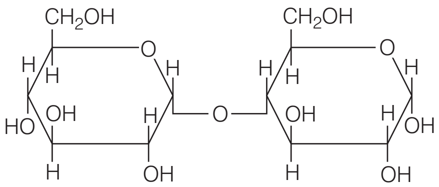
(a)


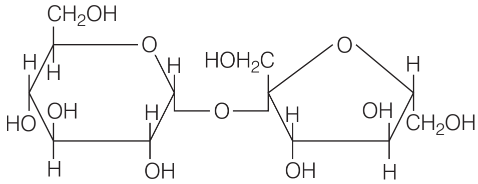
(b)


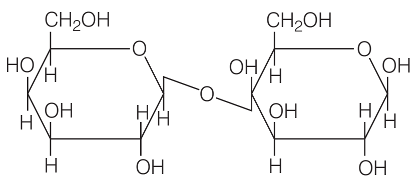
(c)


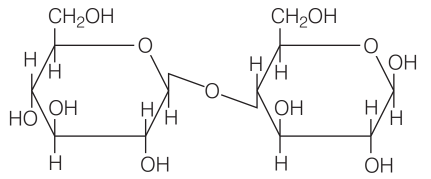
(d)


6 In disaccharides, if the reducing groups of monosaccharides, i.e. aldehydic or ketonic groups are bonded, these are non-reducing sugars. Which of the following disaccharide is a non-reducing sugar?

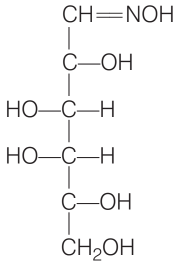
(a)


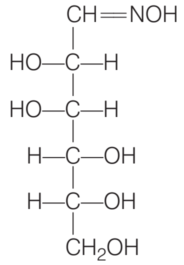
(b)


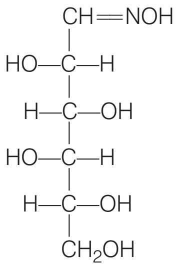
(c)


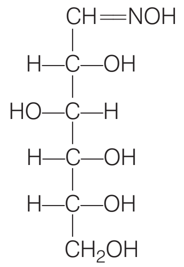
(d) 

7 D-(+)-glucose reacts with hydroxyl amine and yields an oxime. The structure of the oxime would be.

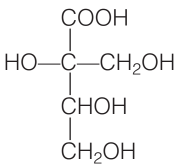
(a) 

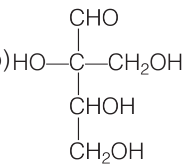
(b) 

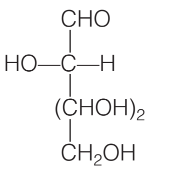
(c) 

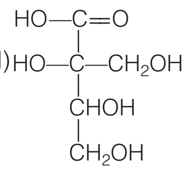
(d) 

8 Compound *A*, $C_5H_{10}O_5$ gives a tetra acetate with Ac_2O and oxidation of '*A*' with Br_2 / H_2O gives an acid, $C_5H_{10}O_6$. Reduction of '*A*' with HI gives *iso*-pentane. What is the possible structure of *A*?

(a) 

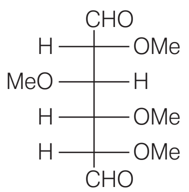
(b) 

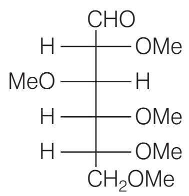
(c) 

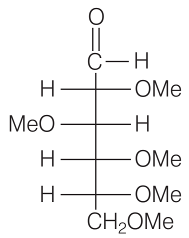
(d) 

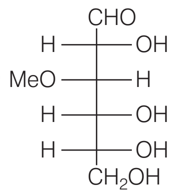
9 The final product of the reaction is

$$\text{D (glucose)} \xrightarrow[\text{HCl}]{\text{EtSH}} ? \xrightarrow[\text{NaOH}]{\text{Me}_2\text{SO}_4} ? \xrightarrow[\text{CdCO}_3]{\text{HgCl}_2} ?$$

(a) 

(b) 

(c) 

(d) 

10 A sugar is classified as a D-isomer if the hydroxyl group

(a) on the chiral carbon nearest to the carbonyl point in the left
(b) on the chiral carbon nearest to the carbonyl point on the right
(c) on the chiral carbon farthest from the carbonyl point to the left
(d) on the chiral carbon farthest from the carbonyl point to the right

11 Consider the following reagents.

I. Br_2 water
II. Tollen's reagent
III. Fehling's solution

Which can be used to make distinction between an aldose and a ketose?

(a) I, II and III
(b) Both II and III
(c) Only I
(d) Only II

12 The type of bond that is most important in maintaining secondary structure of a protein in

(a) disulphide bridges
(b) hydrogen bonding within the backbone
(c) hydrogen bonding between *R* groups
(d) salt bridges

13 When a monosaccharide forms a cyclic hemiacetal, the carbon atom that contained the carbonyl group is identified at the anomeric carbon atom because

(a) the carbonyl group is drawn to the right
(b) the carbonyl group is drawn to the left
(c) its substituents can assume α or β-position
(d) it forms bond to an —O*R* and an —O*R′*

14 The backbone of a nucleic acid molecule consists of

(a) alternating sugar and phosphate groups linked by phosphate ester bonds
(b) alternating sugar and nitrogen base groups linked by amide bonds
(c) alternating nitrogen bases and phosphate groups linked by amide bonds and strengthened by hydrogen bonds
(d) sugar molecules bonded from the C-3 of one molecule to the C-5 of the other by glycosidic linkages

15 Which of the following statements about enzymes are true?

I. Enzymes lack in nucleophilic groups.

II. Pepsin is proteolytic enzyme.

III. Enzymes catalyse chemical reactions enhances the rate of reaction by lowering the activation energy.

IV. Enzymes are highly specific both in binding chiral substrates and in catalysing their reactions.

(a) Both I and II

(b) Both I and III

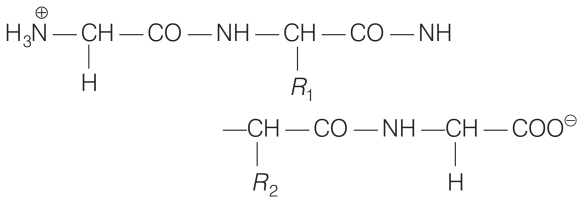
(c) Both I and IV

(d) II, III and IV

16 A decapeptide (mol. wt. 796) on complete hydrolysis gives glycine (mol. wt. 75), alanine and phenylalanine. Glycine contributes 47% to the total weight of the hydrolysed products. The number of glycine units present in the decapeptide is → AIEEE 2011

(a) 3 (b) 4
(c) 5 (d) 6

17 The substituents R_1 and R_2 for nine peptides are listed in the table given below. How many of these peptides are positively charged at pH = 7.0? → AIEEE 2012



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

(a) 2 (b) 4 (c) 6 (d) 8

ANSWERS

SESSION 1	**1** (b)	**2** (c)	**3** (c)	**4** (a)	**5** (b)	**6** (b)	**7** (d)	**8** (a)	**9** (b)	**10** (d)
	11 (c)	**12** (b)	**13** (a)	**14** (c)	**15** (c)	**16** (b)	**17** (d)	**18** (a)	**19** (b)	**20** (a)
	21 (c)	**22** (b)	**23** (a)	**24** (c)	**25** (a)	**26** (d)	**27** (a)	**28** (b)	**29** (c)	**30** (b)
	31 (a)	**32** (b)	**33** (a)							
SESSION 2	**1** (a)	**2** (c)	**3** (d)	**4** (a)	**5** (a)	**6** (b)	**7** (d)	**8** (c)	**9** (b)	**10** (d)
	11 (c)	**12** (b)	**13** (c)	**14** (a)	**15** (d)	**16.** (d)	**17.** (b)			

Hints and Explanations

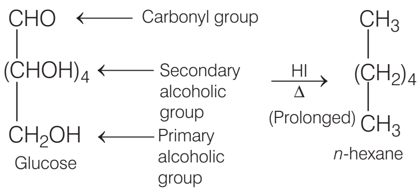
SESSION 1

1 Chlorophyll is a biomolecules that contains magnesium ion (non-transition metal) that is held at the centre of porphyrin ring in the chlorophyll.

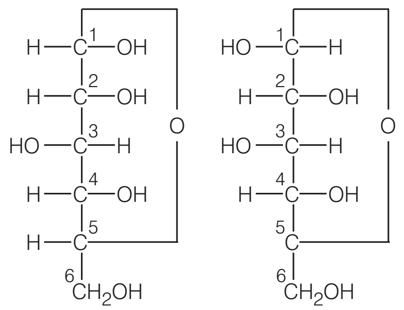
2 Arabinose a monosaccharide is a pentose sugar.

3 D-glucose contains 36% of α-D-glucose and 64% of β-D-glucose.

4 HI is a strong reducing agent. It reduces both primary and secondary alcoholic groups of glucose along with the carbonyl group to produce *n*-hexane as

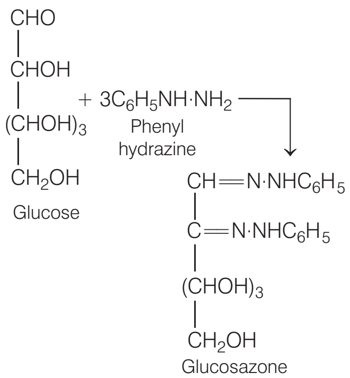


5 Two forms of D-glucopyranose are α and β. These are called **anomers** because they only differ at C_1-configuration.



α-D (+)-glucopyranose β-D (+)-glucopyranose

6



7 In alkaline medium, sugars undergoes rearrangement.

8 In all the three structures (I, II and III), the configuration of OH at lowest assymmetric carbon is towards right and hence, all have D-configuration.

9 Glucose and fructose give positive Tollen's test as they reducing sugar because of the presence of free (— CHO) group.

10 The beta and alpha glucose have different specific rotations. When either is dissolved in water, their rotation changes until the same fixed value results. This is called mutarotation.

11 The cyclic structure of glucose is represented by Haworth projection as a pyranose ring and not in furanose form. Pyranose derived from word pyran which means six membered cyclic ether.

12 D-(+)-sucrose (invert sugar) is an equimolar mixture of D-(+)-glucose and D-(–)-fructose. It is called invert sugar due to the fact that on hydrolysis there is a change in the sign of rotation from positive to negative.

13 Biuret test is characteristically given by the compound having $-\overset{\overset{\large O}{\|}}{C}-NH-$ functional group.

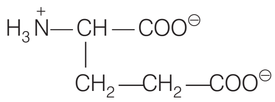
14 The correct statement is that all amino acids except glycine are optically active. In glycine there is no chiral carbon hence, it is optically inactive.

15 The secondary structure of protein refers to the shape in which long polypeptide chains are held together by means of hydrogen bonding.

16 Carbohydrates (e.g. sugar) can be detected by Molisch's test.

17 Secondary structure involves α-helical and β-pleated sheet like structures. α-helix is formed when the chain of α-amino acid coils as a right handed screw where in β-plated sheet the chains are held together by a large number of H-bonds. Hence, correct statement is (d).

18 Another common acid is



19 Xanthoproteic test involves heating of a protein with conc. HNO_3 which gives yellow colour.

20 Trypsin converts proteins into α-amino acids.

21 Lipase enzyme hydrolyses triglycerides into fatty acids and glycerol.

22 A $\rightarrow$ 3; B $\rightarrow$ 2; C $\rightarrow$ 4; D $\rightarrow$ 1

23 Vitamin B and C are water soluble while vitamin A,D,E and K are fat soluble or water insoluble.

24 Vitamin C is water soluble. It also acts as an antioxidant.

25 Deficiency of vitamin E in human being decreases reproductive power.

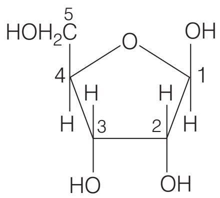
26 The chemical name of vitamin B_1 is thiamine.

27 Vitamin A, D, E and K are fat soluble while all others are water soluble.

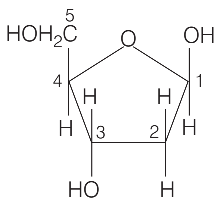
28 Adenosine is a nucleoside while adenosine triphosphate is a nucleotide.

20 Adenine is a purine base which is common in DNA and RNA.

30



β-D-ribose (sugar base) used in RNA; at 2nd carbon —OH group is present



β-D-deoxyribose (sugar base) used in DNA; at 2nd carbon —OH group is missing

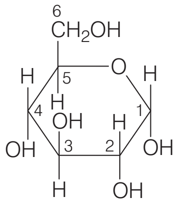
31 Quinoline is an alkaloid and is not present in DNA. DNA has four nitrogen bases in adenine, guanine, cytosine and thymine.

32 **Correct explanation** All α- amino acids except glycine contains at least one chiral carbon.

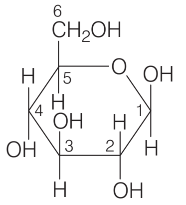
33 Vitamin D is fat soluble, i.e. water insoluble and hence, can be stored in the body.

SESSION 2

1 In the given structure, anomeric carbon is 1, the Haworth structure showing 2 anomers are given below:



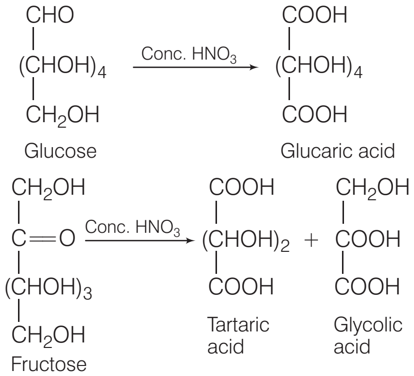
α-D-(+)-glucopyranose



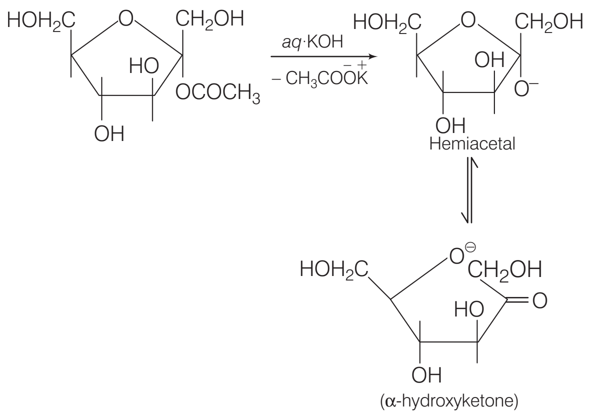
β-D(+)-glucopyranose

2 Aldehydic group reacts with hydrogen sulphate to form bisulphite addition product. But in case of glucose, it fails to react with sodium hydrogen sulphate as the aldehydic group is not free this shows that glucose is cyclic compound.

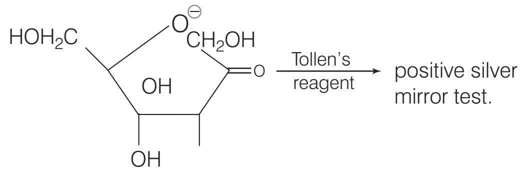
3



4 Sugars that have free aldehyde, a ketone, a hemiacetal or a hemiketal group is able to reduce an oxidising agent. These sugars are classified as reducing sugars.



Hemiacetal can be easily reduced by oxidising agent such as Tollen's reagent.

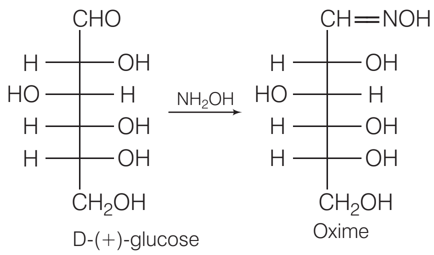


(Reducing sugar)

5 Cellulose is a straight chain polysaccharide composed of D-glucose units, which are joined by β-glycosidic linkages between C - 1 of one glucose and C - 4 of the next glucose. In each unit, only three hydroxy groups are free to form acetate, that's why it is called cellulose triacetate. Whose structure is shown in option (a).

6 The structure given in option (b) is of sucrose which is a non-reducing sugar.

7



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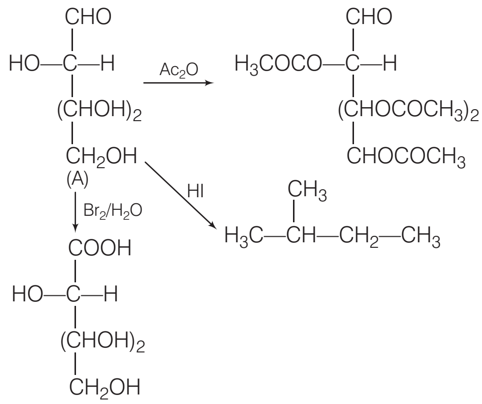

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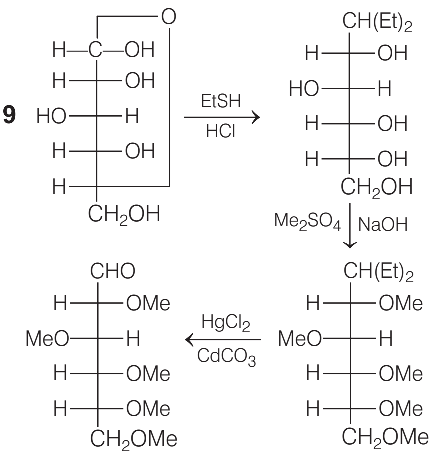
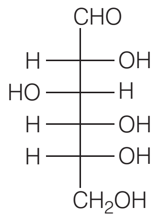
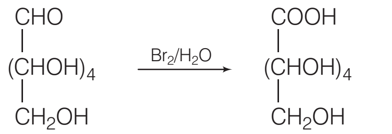


10 A sugar is classified as a D-isomer if the hydroxyl group on the chiral carbon farthest from the carbonyl point to the right. e.g.

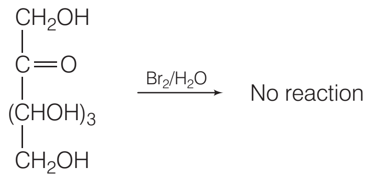


D-glucose

11



Glucose (Aldose) Gluconic acid

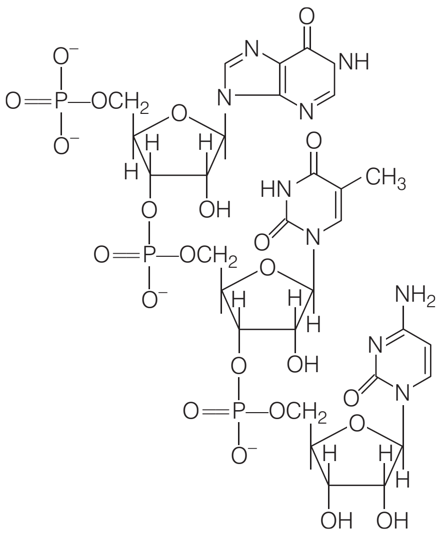


(Ketose)

12 The secondary structure of protein refers to the shape in which long polypeptide chains are held together by means of H-bonding within the backbone.

13 When monosaccharide forms a cyclic hemiacetal the carbon atom that contained the carbonyl group is identified at the anomeric carbon because its substitutents can assume α or β-position.

14 The backbone of nucleic acid molecule consists of an alternating sugar and phosphate groups linked by phosphate ester bond.



15 Enzymes are globular protein bodies which are biological catalyst. Enzyme catalyse chemical reaction enhances the rate by lowering the activation energy. These are highly specific both in binding chiral substrates and in catalysing their reactions. Pepsin is an example of proteolytic enzyme.

16 The number of glycine units present in the decapeptide is 6. Given, molecular mass of decapeptide = 796. Since, it gives glycine, alanine, phenylalanine on hydrolysis. Thus, it needs 9 molecule of water for hydrolysis.

The mass of product

$$= 796 + 18 \times 9 = 958$$

So, the contribution by glycine

$$= \frac{47}{100} \times 958$$

$\therefore$ Number of glycine unit $= \frac{450}{75} = 6$

17 The amino acid remain completely in *Zwitter* ionic form at its isoelectric point. Amino acids with additional acidic group have their isoelectric pH less than 7.0 and increasing pH above isoelectric point makes them anionic. On the other hand, amino acids with additional basic group have their isoelectric pH greater than 7.0 and decreasing pH below isoelectric point (by adding acid solution) makes them cationic. The given peptide with followings R_1 and R_2 are basic, will remain protonated (cationic) at pH = 7.0.

Peptide	R_1	R_2
IV	CH_2CONH_2	$(CH_2)_4NH_2$
VI	$(CH_2)_4NH_2$	$(CH_2)_4NH_2$
VIII	CH_2OH	$(CH_2)_4NH_2$
IX	$(CH_2)_4NH_2$	CH_3