Chapter 2

Biomolecules

Solutions (Set-1)

SECTION - A

School/Board Exam. Type Questions

Very Short Answer Type Questions :

1. What is 'ash' analysis?

Sol. Ash analysis is a technique with the help of which inorganic elements and compounds present in living organisms can be known.

2. Name two secondary metabolites useful for human welfare.

Sol. Rubber and scent.

3. How is deoxyribose derived from ribose?

Sol. The ribose sugar undergoes deoxygenation (removal of oxygen) to produce deoxyribose.

4. Why is sucrose a non-reducing sugar?

Sol. In sucrose, both aldehyde group of glucose and ketone group of fructose are linked during formation of glycosidic bond, thus, there is no free aldehyde or ketone group.

5. Name a heteropolysaccharide responsible for the toughness of cartilage.

Sol. Hyaluronic acid.

6. What is a phosphodiester bond?

Sol. Bonds formed on either side between the phosphate and hydroxyl groups of sugars of a DNA molecule forms the phosphodiester bond

7. Name a carrier protein that transports glucose into cells..

Sol. GLUT-4

8. What is the value of blood concentration of glucose in a normal healthy individual?

Sol. 4.5 - 5.0 mM

9. Name the test performed for the detection of sugar in urine.

Sol. Benedict's test

10. What is the fate of pyruvic acid under aerobic conditions?

Sol. Pyruvic acid gets converted into acetyl CoA, which in turn is oxidised to CO_2 and H_2O.

Short Answer Type Questions :

11. How can we say that a metabolic reaction is exothermic or endothermic?

Sol. If the energy level difference between substrate (S) and product (P) is such that P is at a lower level than 'S' the reaction is said to be exothermic, whereas when substrate (S) is at lower level than product (P), the reaction is endothermic.

12. Why is the tertiary structure of proteins necessary for many biological activities?

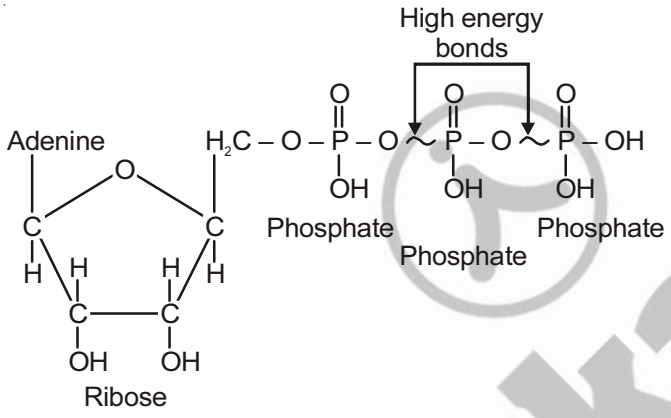
Sol. Tertiary structure is absolutely necessary for the many biological activities of proteins as for example in proteins such as enzymes, the tertiary structure brings distant amino acid side chains closer forming the active site, the site to which a substrate gets attached.

13. How can a competitive inhibitor stop the synthesis of folic acid in bacteria?

Sol. Bacteria synthesizes folic acid from p-aminobenzoic acid. Folic acid is required for bacterial growth. When competitive inhibitor like sulphanilamide binds with the enzyme, the synthesis of folic acid is inhibited.

14. Draw the structure of ATP molecule. Label the high energy bonds.

Sol.



15. What are anabolic and catabolic pathways?

Sol. When a complex structure is formed from simpler structures for example, formation of cholesterol from acetic acid, this metabolic pathway is known as an anabolic pathway. Anabolic pathways consume energy.

Metabolic pathways also lead to the formation of simpler structures from a complex structures for example, glucose gets converted into lactic acid. This is known as catabolic pathway, it releases energy.

16. Explain the transition state structure in a metabolic reaction.

Sol. When substrate binds to the active site of enzyme a new structure of the substrate is formed called the transition state structure. This complex formation lasts only for a short time.

17. How does pH affect the enzyme activity?

Sol. For every enzyme, there is an optimum pH where its action is maximum. A rise or fall in pH reduces enzyme activity.

18. What is meant by turnover of biomolecules?

Sol. Turnover of biomolecules means that they are constantly being changed into some other biomolecules and also being made from some other biomolecules.

19. What are fatty acids? Give two examples.

Sol. A fatty acid molecule is an unbranched chain of carbon atoms having a carboxylic group attached to R-group. The R-group could be a methyl ($–CH_3$) or ethyl ($–C_2H_5$) or higher number of $–CH_2$ groups (1 carbon to 19 carbons).

Example - Palmitic acid has 16 carbons including carboxyl carbon.

Arachidonic acid has 20 carbon atoms including the carboxyl atom.

20. Why are lipids included under acid insoluble fraction?

Sol. Lipids have molecular weights that do not exceed 800 Da but are included under acid insoluble fraction because when a tissue is grinded, cell membrane and other membranes containing lipids are broken into pieces which form vesicles which are not water soluble. These vesicles get separated along with the acid insoluble pool.

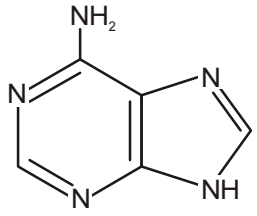
21. Draw the structures of

(i) Adenine

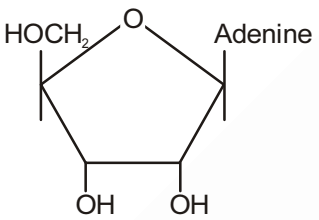
(ii) Adenosine

(iii) Adenylic acid

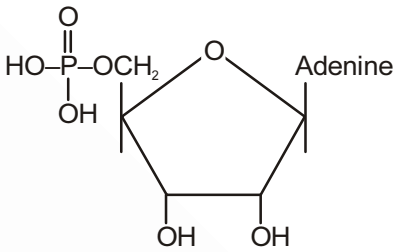
Sol.



Adenine (Purine)



Adenosine



Adenylic acid

22. Explain how metal ions influence the action of enzymes.

Sol. A number of enzymes require metal ions for their activity which form coordination bonds with side chains at the active site and at the same time form one or more coordination bonds with the substrate, for example, zinc is a co-factor for the proteolytic enzyme carboxypeptidase.

23. Explain the terms monoglyceride, diglyceride and triglyceride.

Sol. Neutral or true fats may be **monoglyceride** if there is only one molecule of fatty acid attached to a glycerol molecule. If the number of fatty acids attached to a glycerol happens to be two, it is called **diglyceride**, or **triglyceride**, if the number of fatty acids is three.

24. What is β-pleated sheet organisations in a protein?

Sol. When two or more polypeptide chains are held together by intermolecular hydrogen bonds, the structure is described as β-pleated sheet. It represents the secondary structure of proteins.

25. What is the function of ATP in cell metabolism?

Sol. ATP or adenosine triphosphate is found in all living cells. It usually obtains energy during respiration. The second and third phosphate molecule in an ATP are attached by high energy bonds. Breakdown of these bonds liberates energy to perform the various cellular activities.

26. What are glycolipids?

Sol. Glycolipids contain fatty acids, alcohol sphingosine and sugar (galactose). The sugar molecule replaces one fatty acid molecule. The glycolipids are present in myelin sheath of nerve fibres and on outer surfaces of cell membranes of chloroplast.

27. Why can the lipids be not considered as macromolecules?

Sol. The molecular weight of lipids are below 800 daltons. These do not form polymers. Hence, lipids are not strictly macromolecules, although they remain in acid insoluble pool.

28. What is cholesterol?

Sol. Cholesterol is a compound lipid. It is composed of four fused carbon rings. Cholesterol is the most abundant steroid in the animal tissues. It is an essential component of animal plasma membrane.

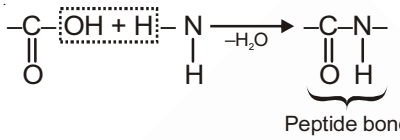
29. Differentiate between lyases and ligases.

Sol.

Lyases	Ligases
These enzymes catalyse the cleavage of specific covalent bonds and removal of specific group(s) without the use of water.	These enzymes catalyse covalent bonding of two substrates to form a large molecule. They catalyse joining of C–O, C–S, C–N, P–O etc. bonds.
Example - Aldolase	Example - PEP carboxylase

30. Explain the formation of peptide bond.

Sol. Two amino acids join through the formation of a peptide bond. The bond is formed between amino group of one amino acid and carboxylic group of the other with the loss of one water molecule.



Long Answer Type Questions :

31. Briefly explain how the chemical composition of living tissue is analysed.

Sol. By performing a chemical analysis, the various biomolecules that are found in living tissues can be studied. When a living tissue is grinded in trichloroacetic acid (Cl_3CCOOH) using a mortar and a pestle, a thick slurry is obtained. This slurry when strained through cheese cloth or cotton gives us two fractions, one is the filtrate which is called **acid soluble pool** and the other fraction is called acid insoluble pool where compounds like proteins, nucleic acids, polysaccharides etc. are found.

However, inorganic elements and compounds present in the living organisms can also be known with the help of a technique called 'ash analysis'. A small amount of a living tissue is weighed and dried. All the water evaporates. The remaining material gives dry weight and when this tissue is fully burnt, the carbon compounds are oxidised to gaseous forms like CO_2, water vapour and are removed and the remnant is called 'ash'. This ash contains many inorganic elements like calcium and magnesium etc.

32. Name any five secondary metabolites and explain how they are useful for human welfare.

Sol. (i) Gums : Natural gums are polysaccharides. They are used in the food industry as thickening agents and gelling agents.

(ii) Codeine : It is an alkaloid obtained from poppy plant. It is used to treat mild to moderate pain and to relieve cough.

(iii) Lemon grass oil : It is an essential oil. It is used in food flavouring and perfumery.

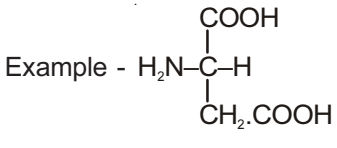
(iv) Anthocyanins : They are pigments which are present in all tissues of higher plants. They can be used as pH indicators as their colour changes with pH.

(v) Rubber : It is an elastic hydrocarbon polymer produced by some plants called rubber trees.

33. (i) Classify amino acids on the basis of comparative number of amino and carboxyl group.
(ii) What are aromatic amino acids?

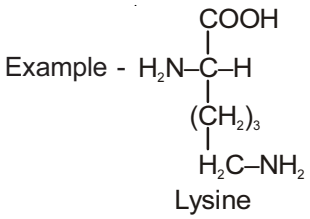
Sol. (i) Based on the number of carboxyl and amino groups, amino acids are classified as –

(a) Acidic amino acids : The amino acids have an extra carboxylic group.

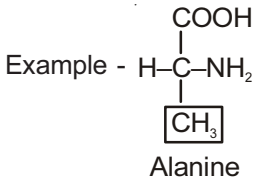


Aspartic acid

(b) Basic amino acids : They have an additional amino group.

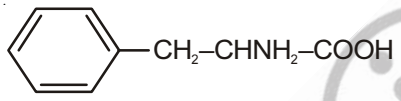


(c) Neutral amino acids : Amino acids have one amino group and one carboxylic group.



(ii) **Aromatic amino acids** : Amino acids which possess cyclic structure with a straight chain bearing carboxylic and amino group.

Example - Phenylalanine



34. Describe the structure of B-DNA molecule.

Sol. ❖ The β-DNA molecule exists as a double helix. It has two unbranched polynucleotide strands. Each polynucleotide strand/chain consists of a sequence of nucleotides linked together by phosphodiester bonds. The polynucleotide strands are antiparallel, *i.e.*, run in the opposite direction.

❖ The two strands are not coiled upon each other but the double strand is coiled upon itself around a common axis like spiral staircase with base pairs forming steps while the backbones of the two strands form railings. The backbone is formed of sugar and phosphate.

❖ The nitrogen bases are projected more or less perpendicular to the sugar phosphate backbone but face inside.

❖ The base-pairing is specific. Adenine is always paired with thymine and guanine is always paired with cytosine. Thus, all base-pairs consist of one purine and one pyrimidine. Once the sequences of bases in one strand of a DNA double helix is known, the sequence of bases in the other strand is also known because of the specific base pairing. The two strands of a DNA double helix are thus said to be complementary (not identical). This is known as complementary base pairing.

❖ The two polynucleotide strands are held together in their helical structure by **hydrogen bonding** between bases in opposing strands. Adenine and thymine form two hydrogen bonds. Guanine and cytosine form three hydrogen bond.

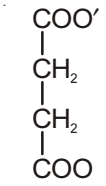
❖ One end of the strand is called **5′ end** where the fifth carbon of the pentose sugar is free and the other end is called **3′ end** where the third carbon of pentose sugar is free.

❖ At each base pair the strand turns 36°. One full turn of the helical strand (360°) would involve **ten base pairs** *i.e.*, one turn of 360° of the helical strand has about 10 nucleotide on each strand of DNA. The base-pairs in DNA are stacked 3.4 Å apart. Thus pitch of the DNA is 34 Å as ten base pairs occupy a distance of about 34 Å.

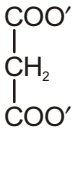
35. How does a competitive inhibitor inhibit enzyme activity? Give two examples.

Sol. Competitive inhibitors are chemicals that closely resemble the substrates in their molecular structure. A competitive inhibitor competes with the substrate for binding to the active site of the enzyme and gets bound to it. Thus, it prevents the enzyme from participating in catalytic change of the substrate into product.

Example - Inhibition of the enzyme succinic dehydrogenase by the inhibitor malonate which closely resembles the substrate succinate in structure.

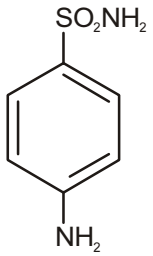


Succinate

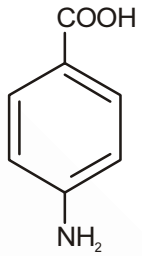


Malonate

Some sulpha drugs like sulphanilamide compete with the enzyme (PABA). This binding of inhibitor to the enzyme prevents the synthesis of folic acid in bacteria.



Sulphanilamide



36. Explain the dynamic state of body constituents.

Sol. ❖ Living organisms contain thousands of organic compounds or biomolecules that are present in certain concentrations (expressed as mole/cells or moles/litre etc.) All these biomolecules have a **turn over** which means they are constantly being changed into some other biomolecules and also made from some other biomolecules. Through chemical reactions, breaking and making occurs constantly in living organisms. Together all these chemicals reactions are called **metabolism**.

❖ Biomolecules get transformed due to metabolic reactions that occur in a living cell/organism.

❖ A few examples of metabolic transformations are : removal of CO_2 from amino acids making an amino acid (contain –COOH and $–NH_2$) into an amine (contain NH_2 only as functional group), removal of amino acid in a nucleotide base; hydrolysis (cleavage of a bond by the addition of element of water, yielding two or more products) of a glycosidic bond in a disaccharide such as **lactose**, yields two monosaccharides molecules namely **glucose** and **galactose**.

❖ Metabolites are converted into each other in series of linked reaction called **metabolic pathways**. These pathways resemble the automobile traffic in a city. They are either linear or circular and criss-cross each other *i.e.,* there are traffic junctions.

❖ Flow of metabolites through metabolic pathway has a definite rate and direction like automobile traffic. This metabolic flow is called the **dynamic state of body constituents**.

❖ In healthy conditions, this interlinked metabolic traffic is very smooth and without a single reported mishap.

37. Explain briefly 'the living state'.

Sol. ❖ In a living organism tens and thousands of metabolites or biomolecules are present at concentrations characteristic of each of them for example, glucose is 4.5-5.0 mM in blood, hormones in nanograms/ml.

❖ The most important fact of biological systems is that all living organisms exist in a **steady state**. Steady state is a non-equilibrium state in which all the biomolecules remain at constant concentration. These biomolecules are in a **metabolic flux**.

❖ Metabolic flux is the rate of turn over of molecules through a metabolic pathway. Flux (the act of flowing) is regulated by the enzymes involved in a pathway within cells. Regulation of flux is vital for all metabolic pathways to regulate the metabolic activity under different conditions.

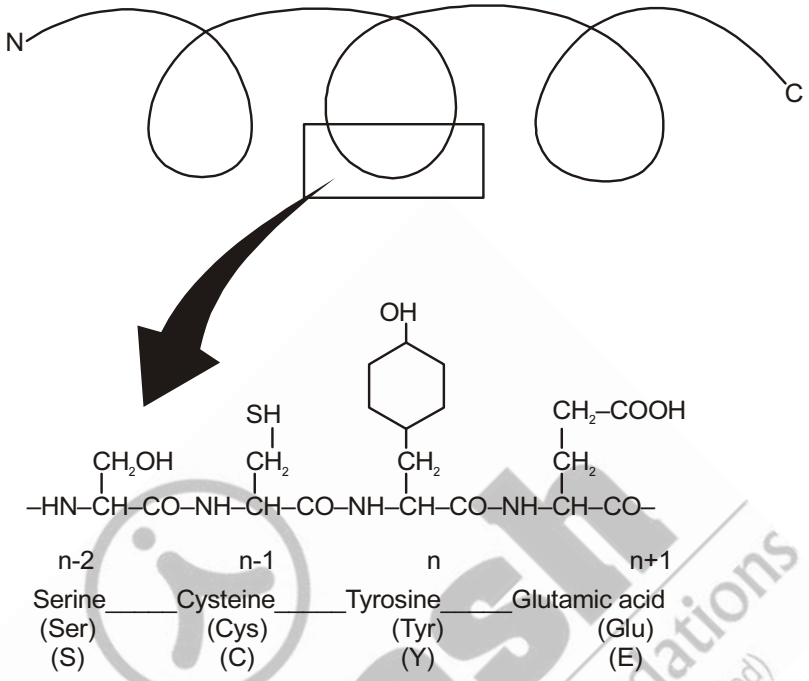
❖ Any chemical or physical process moves spontaneously to equilibrium but at equilibrium no work can be done. Living organisms cannot afford to reach equilibrium as they work continuously. Therefore, **the living state is a non-equilibrium steady-state to be able to perform work**.

❖ Living process is a constant effort to prevent attaining equilibrium. This is done by energy input (absorption of energy). Metabolism provides a mechanism for the production of energy. Hence the living state and metabolism are synonymous. Without metabolism there cannot be a living state.

38. Explain the primary and secondary structures of proteins.

Sol. Primary structure

The sequence in which amino acids are arranged in a polypeptide chain of a protein is called its primary structure. It gives the positional information of amino acids in a protein *i.e.*, which is the first amino acid, which is the second, and so on.

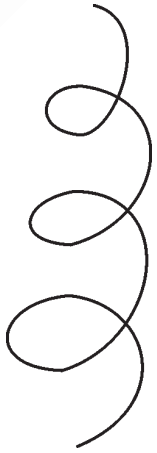


Primary structure of a portion of a hypothetical protein. N and C refer to the two terminal of every protein. Single letter codes and three letter abbreviations for amino acids are also indicated.

- ❖ In this chains of amino acids which constitute protein, the amino acid present at the left end is the first amino acid, whereas the one at the right end is the last amino acid of the protein.
- ❖ The first amino acid is known as **N-terminal** amino acid and the last is known as **C-terminal** amino acid.

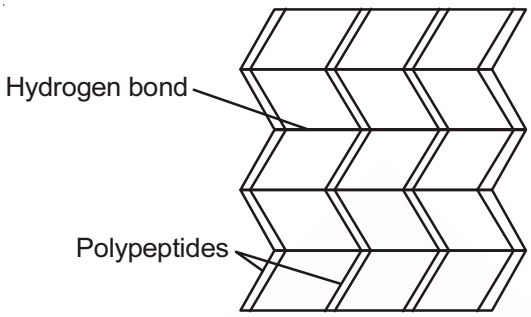
Secondary structure

- ❖ A protein thread does not exist throughout as an extended rigid rod. Some portion of the protein thread are folded in the form of a helix (similar to a revolving staircase). In this, there is interaction between every fourth amino acid by the formation of intramolecular hydrogen bond, the polypeptide gets a helical shape (α-helix) *e.g.*, keratin protein present in hair. The intramolecular hydrogen bond is a bond formed between the hydrogen atom and the highly electronegative atom such as nitrogen, oxygen and fluorine of the same molecule.
- ❖ In proteins, only right-handed helices are observed.



❖ When two or more polypeptide chains are held together by intermolecular hydrogen bonds, the structure is described as **β-pleated sheet**. The intermolecular hydrogen bond is the bond formed between the hydrogen atom of the molecule and the highly electronegative atom (such as nitrogen, oxygen, fluorine) of the other molecule.

Example - **Fibroin** protein of silk



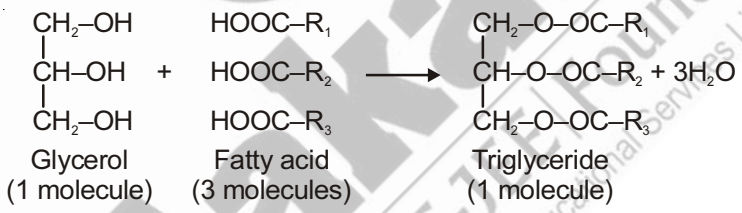
β-pleated

39. (i) What are neutral fats?

(ii) Explain the structure of a triglyceride.

Sol. (i) Neutral fats are esters of fatty acid with glycerol. They are also called glycerides. and consist of one molecule of glycerol and one to three molecules of the same or different long chain fatty acids.

(ii) In a triglyceride, 3 molecules of fatty acids are attached to one molecule of glycerol.



40. What are polysaccharides? Why does starch give a characteristic blue colour with iodine?

Sol. Polysaccharides are polymers or chains of monosaccharides and are macromolecules. They are threads (literally a cotton thread) containing different monosaccharides as building blocks and are branched or unbranched. The right end of a polysaccharide is reducing end while the left end is named as non-reducing ends. They can be

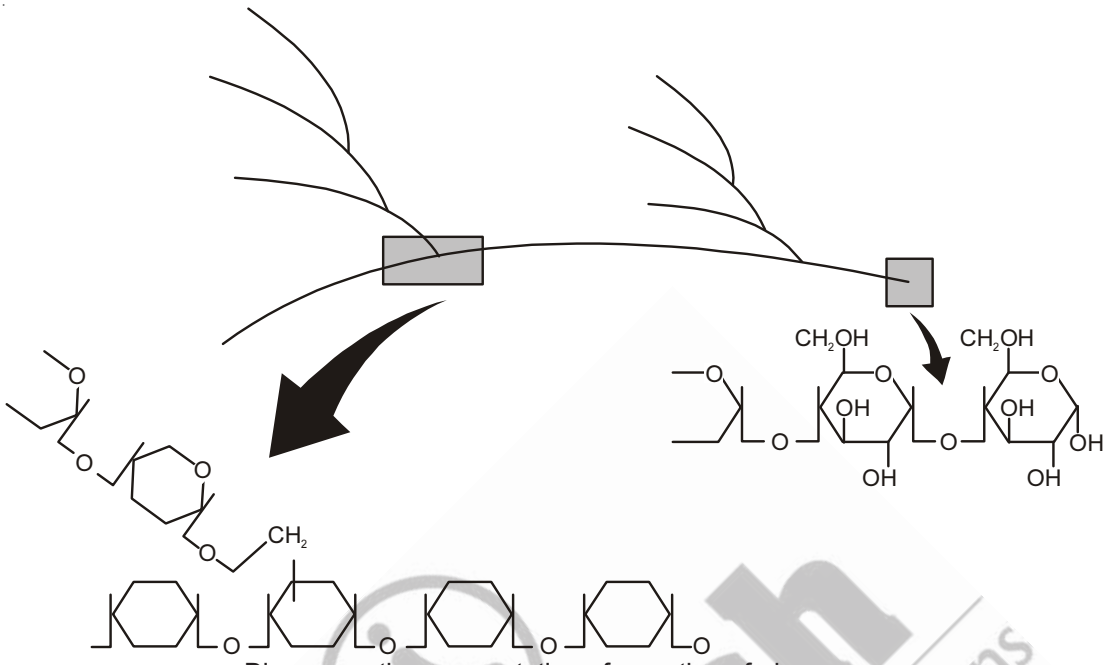
(i) Homopolysaccharides : Homopolysaccharides consist of only one type of monosaccharide monomer. Starch and glycogen both are polymers of glucose and serve as a storage form in plants and animals respectively.

Starch form helical secondary structure *i.e.*, the chain of glucose molecules folds in the form of a helix. Starch gives a characteristic blue colour with iodine (I_2) molecules due to the ability of the latter to occupy a position in the interior of a helical coil of glucose unit.

In plants cellulose serves as structural elements in plant cell wall. Paper made from plant pulp is cellulose. Cotton fibre is cellulose.

Inulin is a polymer of fructose. It is a storage polysaccharide of roots and tubes of dahlia and related plants. Inulin is not metabolised in human body and is readily filtered through the kidney. It is therefore used in testing of kidney function.

Chitin : It is the second most abundance organic substance. In chitin the basic unit is a nitrogen containing glucose derivative known as N-acetyl glucosamine. Chitin is present in the exoskeletons of arthropods.



Diagrammatic representation of a portion of glycogen

(ii) Heteropolysaccharides : Heteropolysaccharides consists of more than one type of monosaccharide monomer. They are more complex polysaccharides. Some of the heteropolysaccharides are :

(a) Peptidoglycan : In peptidoglycan, the heteropolysaccharide chains are made up of two alternate amino-sugar molecules *i.e.*, N-acetyl glucosamine and N-acetyl muramic acid.

(b) Hyaluronic acid : It is a heteropolymer composed of D-glucuronic acid (a carboxylic acid) and D-N-acetyl glucosamine (a monosaccharide derivative of glucose).

Hyaluronic acid accounts for the toughness and flexibility of cartilage and tendon.

41. Differentiate between enzyme and inorganic catalysts.

Sol. Differences between enzymes and inorganic catalysts are listed in table

Enzymes	Inorganic catalysts
(i) Almost all enzymes are proteins and have a complex molecular organisation.	(i) They are usually small and simple molecules like nickel, platinum etc.
(ii) They occur in living cells.	(ii) They do not occur in living cells.
(iii) An enzyme catalyses only a specific reactions.	(iii) They are not specific for any one reaction and can catalyse a number of reactions.
(iv) They get damaged at high temperatures (above 40°C).	(iv) They work efficiently at high temperatures and pressures.
(v) They are highly efficient.	(v) They are less efficient.

42. Discuss the mechanism of enzyme action.

Sol. All enzymes have active site where the substrate binds. The binding of the substrate causes a lowering of the activation energy and the reaction proceeds at a faster rate. When the substrate binds to the enzyme, a new structure is formed called transition-state structure. The catalytic cycle of an enzymes involves :

(i) The binding of the substrate to the active site of the enzyme.

(ii) The binding of the substrate induces the enzyme to alter its shape and fit more tightly around the substrate.

(iii) The active site of the enzyme that is in close proximity of the substrate breaks the chemical bonds of the substrate and an enzyme-product complex is formed.

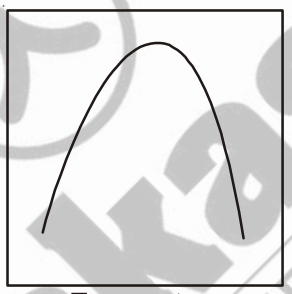
(iv) The enzyme releases the product formed in the reaction and the free enzyme is ready to take up another molecule of the substrate.

43. Explain how different factors affect the enzymatic activity.

Sol. Enzymes are proteins with tertiary structures. Any change in the tertiary structure would affect the activity/ action of enzymes. Factors which can affect the enzyme action are as follows :

(i) Temperature

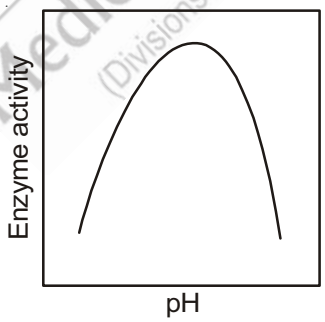
- ❖ Enzymes generally function in a narrow range of temperature.
- ❖ The temperature at which the enzyme shows its highest activity is known as its **optimum temperature**.
- ❖ Enzyme activity declines both below and above the optimum temperature.
- ❖ Low temperature preserves the enzyme in a temporarily inactive state and when the temperature is raised to normal they regain their lost activity.
- ❖ High temperature destroys enzymes by causing their denaturation. At higher temperatures, the kinetic activity of molecules in an enzyme becomes strong enough to break the weak hydrogen bonds that maintain the tertiary structure of the enzyme resulting in the loss of its catalytic activity. This change in structure is called **denaturation** of enzyme or protein. Once the enzyme protein is denatured it remains inactive even if the temperature is then brought down.



Effect of change in : Temperature

(ii) Hydrogen ion concentration (pH)

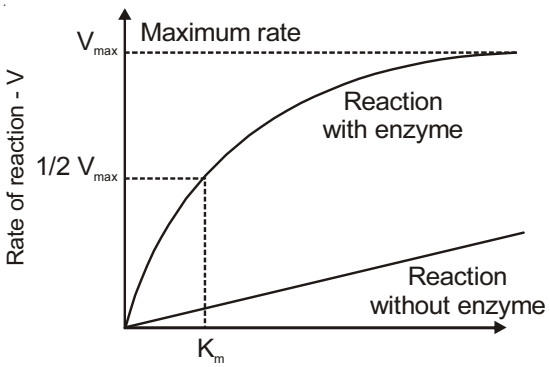
Every enzyme has an optimum pH when it is most effective. A rise or fall in pH reduces enzyme activity. Some enzymes act best in an acid medium, others in an alkaline medium. For every enzyme there is an optimum pH where its action is maximum.



Effect of change in : pH

(iii) Concentration of substrate

Increase in substrate concentration, increases the velocity of the enzymatic reaction. The reaction ultimately reaches a maximum velocity (V_{max}) which is not exceeded by any further rise in concentration of the substrate. This is because, at this stage the enzyme molecules become fully saturated and no active site is left free to bind additional substrate molecules.



Effect of substrate concentration on reaction velocity with or without enzyme, calculation of maximum velocity and K_m value

44. Discuss any five classes of enzymes.

Sol. Five classes of enzyme

(i) Oxidoreductases / dehydrogenases

Enzymes which catalyse oxidation-reduction reactions involving transfer of electrons/H^+ from one molecule to another. In these reactions one compound is oxidised and other is reduced.

Example - dehydrogenase, oxidases, reductases, catalase, peroxidase.

$$S_{reduced} + S'_{oxidised} \rightarrow S_{oxidised} + S'_{reduced}$$

$$\text{Alcohol + NAD} \xrightarrow{\text{alcohol dehydrogenase}} \text{Aldehyde + } NADH_2$$

(ii) Transferases

These enzymes catalyse the transfer of specific groups other than hydrogen from one substrate to another.

Example - Transaminase (transfers amino group), Kinase (catalyse the phosphorylation of substrate by transferring phosphate group usually from ATP).

$$S - G + S' \rightarrow S + S' - G$$

$$\text{Glucose + ATP} \xrightarrow{\text{glucohexokinase}} \text{Glucose 6 phosphate + ADP}$$

(iii) Hydrolases

These enzymes catalyse the breakdown of larger molecules into smaller molecules with the addition of water. They catalyse hydrolysis of ester, ether, peptide, glycosidic, C–C, C-halide or P–N bonds.

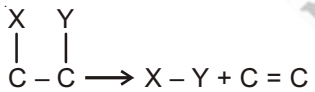
Example - Proteases, amylases, lipases, maltase, nucleases and other digestive enzymes.

$$\text{Sucrose + } H_2O \xrightarrow{\text{sucrase/invertase}} \text{Glucose + fructose}$$

(iv) Lyases

These enzymes catalyse the cleavage of substrate into two parts, without the use of water or removal of groups without hydrolysis. A double bond is formed at the place of removal of group.

Example - Aldolase, decarboxylase, carbonic anhydrase etc.

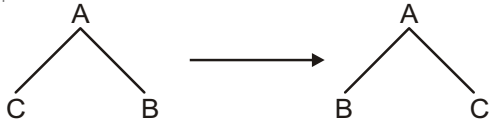


$$\text{Fructose 1, 6, diphosphate} \xrightarrow{\text{aldolase}} \text{Dihydroxy acetone phosphate + glyceraldehyde phosphate}$$

(v) Isomerases

These enzymes catalyse the rearrangement of molecular structure to form isomers. Isomers are molecules or molecular compounds that are similar in that they have the same molecular formula however have different arrangements of the atoms or group of atoms involved. They catalyse inter-conversion of optical, geometric or positional isomers.

Example -



$$\text{Glucose-6-phosphate} \underset{}{\overset{\text{isomerase}}{\rightleftharpoons}} \text{fructose 6-phosphate}$$

45. Discuss a comparison of elements present in non-living and living matter.

Sol. A comparison of elements present in non-living and living matter*

Element	% Weight of Earth's crust	% Weight of Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	Very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	Negligible

* Adapted from CNR Rao, *Understanding Chemistry*, Universities Press, Hyderabad.

SECTION - B

Model Test Paper

Very Short Answer Type Questions :

1. What is inulin?

Sol. Inulin is a polymer of fructose and is a storage homopolysaccharide of roots and tubers of dahlia and related plants.

2. What is abrin?

Sol. Abrin a secondary metabolite is a toxin.

3. Why is glucose a reducing sugar?

Sol. Glucose is a reducing sugar as it has free aldehyde group which can reduce Cu^{2+} ions to Cu^{+} ions and give positive Benedict's and Fehling's test.

4. Name the amino acid that has hydroxyl methyl as R-group.

Sol. Serine

5. What are N-terminal and C-terminal amino acids?

Sol. In the chain of amino acids, the first amino acid is known as N-terminal and the last is known as C-terminal amino acid.

6. Which is the most abundant steroid in the animal tissue?

Sol. Cholesterol

7. What is turnover number?

Sol. The number of substrate molecules changed per minute by an enzyme is called turn-over number.

8. Which is the most abundant protein on earth?

Sol. RubisCO.

Short Answer Type Questions :

9. How the sugar-phosphate backbone is formed in a DNA molecule?

Sol. The sugar phosphate backbone is formed when a phosphate moiety links the 3′ carbon of sugar of one nucleotide to the 5′ carbon sugar of the succeeding nucleotide by means of phosphodiester bonds.

10. What are fats and oils?

Sol. Triglycerides that have high melting points and remain solids at room temperature are known as fats. Triglycerides that have low melting point remain as liquids are known as oils.

11. Give a test for proteins.

Sol. Protein rich seeds are grinded with water to make protein solution. Million's reagent is added and heated to boiling. Formation of red colour, indicates the presence of protein.

12. What are the constituents of acid soluble pool?

Sol. The acid soluble pool contains chemicals with small molecular mass of 18-800 daltons and include amino acids, sugars and nucleotide.

13. How can carotenoids contribute to photosynthesis?

Sol. Carotenoids are secondary metabolites and these pigments are found in plants and in some photosynthetic bacteria. They transfer some of the light energy which they absorb to chlorophyll.

14. Why one end of the strand of DNA is called 5′ and the other 3′?

Sol. At the 5′ end, the fifth carbon of the pentose is free and at the 3′ end, the third carbon of pentose sugar is free.

15. Why biomolecules are in a metabolic flux?

Sol. Biomolecules are in a metabolic flux in order to maintain the steady state of living organisms. Steady state is a non-equilibrium state in which all the biomolecules try to maintain constant concentration.

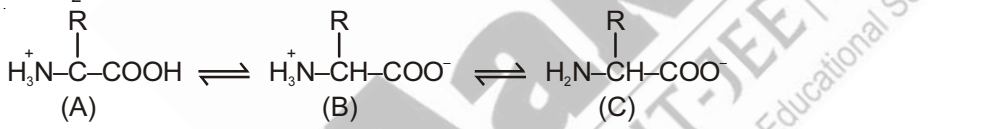
Short Answer Type Questions :

16. Explain the technique to study the inorganic compounds/elements of a living tissue.

Sol. Inorganic compounds/elements of a living tissue can be analysed by a technique called ash analysis. A small amount of a living tissue is weighed and dried. When this dried tissue is fully burnt, the carbon compounds are oxidised to gaseous form and the remnant ash contains many inorganic elements.

17. What happens to the structure of amino acids in solutions of different pH?

Sol. In solutions of different pHs, amino acids exist as ionized species *i.e.*, zwitter ions due to the ionizable nature of NH_2 and COOH groups.

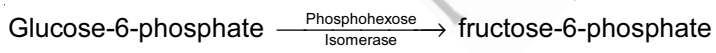


18. What is denaturation of a protein?

Sol. At higher temperature, the kinetic activity of molecules of enzyme become strong enough to break the weak hydrogen bonds that maintain the tertiary structure of the protein like enzymes resulting in the loss of its catalytic activity. This change in structure of protein is known as denaturation.

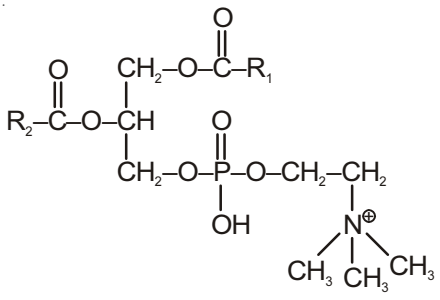
19. What are isomerases? Give one example.

Sol. Isomerases are enzymes that catalyse the rearrangement of molecular structure to form isomers.



20. What is lecithin? Give its structural formula.

Sol. Lecithin is a phospholipid.



Structure of lecithin

21. Differentiate between essential and non-essential amino acids.

Sol.

Essential Amino Acids	Non-essential Amino Acids
(a) These amino acids cannot be synthesised in our body.	(a) These amino acids can be synthesised in our body.
(b) They are obtained from dietary proteins.	(b) They need not be present in the diet.
Example - Tryptophan, valine.	Example - Alanine, glycine.

Long Answer Type Questions :

22. What are the different classes of enzymes? Explain any two with the type of reaction they catalyse.

Sol. There are six classes of enzymes. These are :

Class 1 : Oxidoreductases

Class 2 : Transferases

Class 3 : Hydrolases

Class 4 : Lyases

Class 5 : Isomerases

Class 6 : Ligases

Oxidoreductases are enzymes that catalyse the transfer of electron or proton (H^+) from one substrate to another.

Example - Catalase, Peroxidase, Alcohol dehydrogenase

$S_{reduced} + S'_{oxidised} \rightarrow S_{oxidised} + S'_{reduced}$

Transferases are enzymes that catalyse the transfer of specific groups other than hydrogen from one substrate to another.

$S–G + S' \rightarrow S + S'–G$

Example - Transaminase (transfers amino group), Kinase (transfer a phosphate from ATP)

23. Describe the structures exhibited by keratin and haemoglobin.

Sol. Keratin is a protein which exhibits secondary structure

A protein thread does not exist throughout as an extended rigid rod. Some portion of the protein thread are folded in the form of a helix (similar to a revolving staircase). In this, there is interaction between every fourth amino acid by the formation of intramolecular hydrogen bond, the polypeptide gets a helical shape (α-helix) *e.g.*, keratin protein present in hair. The intramolecular hydrogen bond is a bond formed between the hydrogen atom and the highly electronegative atom such as nitrogen, oxygen and fluorine of the same molecule.

Haemoglobin is a protein that exhibits quaternary structure

Quaternary structure is formed when a protein has more than one subunits or polypeptide chains. Each polypeptide have a primary, secondary or tertiary structure of its own. The way in which these individual folded polypeptides are arranged with respect to each other (*e.g.*, linear string of spheres, arranged one up on each other in the form of a cube or plate etc.) gives the architecture of the quaternary structure of a protein.

Haemoglobin has four helical polypeptide chains, two α-chains and two β-chains.

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Solutions (Set-2)

Objective Type Questions

(How to Analyse Chemical Composition?, Primary and Secondary Metabolites, Carbohydrates)

1. Which of the following is not strictly a biomacromolecule?

   (1) Proteins (2) Lipids

   (3) Polysaccharides (4) Nucleic acid

Sol. Answer (2)

The molecular weight of lipids does not exceed 800 Da but they are obtained in the acid insoluble fraction.

2. A secondary metabolite that acts as a toxin is

   (1) Carotenoids (2) Curcumin

   (3) Abrin (4) Monoterpenes

Sol. Answer (3)

Carotenoid – Pigment

Curcumin – Drug

Monoterpenes – Terpenoids

3. A secondary metabolite that is alkaloid in nature is

   (1) Codeine (2) Anthocyanin

   (3) Gum (4) Abrin

Sol. Answer (1)

Anthocyanin – Pigment

Gum – Polymeric substance

Abrin – Toxin

4. Peptidoglycan present in bacterial cell envelop is

   (1) Made up of cellulose

   (2) A heteropolymer

   (3) An oligosaccharide

   (4) A homopolymer

Sol. Answer (2)

Peptidoglycan is a heteropolysaccharide made up of two alternate amino sugar molecules i.e., N-acetyl glucosamine (NAG) and N-acetyl muramic acid. (NAM)

(Proteins, Lipids)

5. The most abundant protein in animal world is

(1) Chitin (2) Collagen (3) Peptidoglycan (4) Hyaluronic acid

Sol. Answer (2)

Chitin, peptidoglycans and hyaluronic acid are polysaccharides not proteins.

6. The amino acids in a protein are held together by

(1) Glycosidic bond (2) Phosphodiester bond (3) Peptide bond (4) Hydrogen bond

Sol. Answer (3)

Glycosidic bond : Are formed between the two monosaccharides (sugar molecule).

Phosphodiester bond : This bond is formed in nucleic acid i.e. DNA or RNA, between the phosphate and hydroxyl group of sugar.

7. A protein found in silk which exhibits β pleated structure is

(1) Fibroin (2) Haemoglobin (3) Enzyme (4) α-Keratin

Sol. Answer (1)

Haemoglobin $\rightarrow$ Quaternary structure (human blood)

Enzymes $\rightarrow$ Tertiary structure (for optimal activity)

α-Keratin $\rightarrow$ Secondary structure

8. An example of protein with quaternary structure is

(1) Myoglobin (2) Haemoglobin (3) Keratin (4) All of these

Sol. Answer (2)

Myoglobin : Tertiary structure

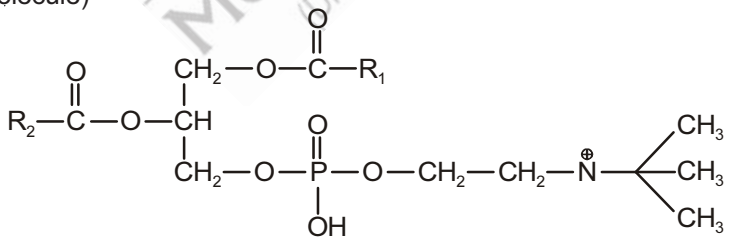
Keratin : Secondary structure

9. Lecithin is a

(1) Type of wax (2) Phospholipid (3) Oil (4) Simple fatty acid

Sol. Answer (2)

Lecithin is made up of a molecule of glycerol, a phosphate group, 2 fatty acid molecules, choline (N-containing alcohol molecule)



Lecithin

10. Lipids that insulate the nerve fibres are

(1) Lecithin (2) Cholesterol (3) Suberin (4) Glycolipids

Sol. Answer (4)

The glycolipids are present in myelin sheath of nerve fibres.

11. The primary precursor for the production of cholesterol in our body is

(1) Acetic acid (2) Citric acid (3) Ethyl alcohol (4) Methanol

Sol. Answer (1)

In biosynthetic pathway or anabolic pathway, the acetic acid is converted into cholesterol in liver.

(Nucleic Acid)

12. The pentose sugar present in RNA is

(1) Galactose (2) Sucrose (3) Ribose (4) Fructose

Sol. Answer (3)

Ribose is a monosaccharide sugar present in RNA.

Deoxyribose is a derived monosaccharide sugar present in DNA.

13. A nucleoside is composed of

(1) Sugar + Nitrogenous base (2) Sugar + Phosphate

(3) Nitrogenous base + Phosphate (4) Purine + Pyrimidine

Sol. Answer (1)

Nucleoside = Sugar + Nitrogenous base

Nucleotide = Sugar + Nitrogenous base + Phosphate

14. In B-DNA, one full turn of the helical strand contains

(1) 11 base pairs (2) 8 base pairs (3) 10 base pairs (4) 9 base pairs

Sol. Answer (3)

A form $\rightarrow$ 11 base pairs

B form $\rightarrow$ 10 base pairs

C form $\rightarrow$ 9 base pairs

D form $\rightarrow$ 8 base pairs

15. In a DNA molecule, adenine of one strand base pairs with ___ on the other strand

(1) Guanine (2) Thymine (3) Cytosine (4) Both (1) & (3)

Sol. Answer (2)

In DNA, $A = T$, $C \equiv G$

16. In B-DNA, the rise per base pair would be

(1) 4.3 Å (2) 2.4 Å (3) 3.4 Å (4) 4.2 Å

Sol. Answer (3)

In B-DNA, the rise per base pair would be 3.4 Å.

17. The nitrogenous bases of the two strands of DNA are joined by

(1) Phosphodiester bond (2) Hydrogen bond (3) Glycosidic bond (4) Peptide bond

Sol. Answer (2)

Hydrogen bond : The bond formed between two polynucleotide strands of DNA.

Glycosidic bond : Formed between the two monosaccharides (sugar).

Peptide bond : Formed between 2 amino acids.

Phosphodiester bond : Bond formed in nucleic acid *i.e.* DNA or RNA, between the phosphate and hydroxyl group of sugar.

18. The genetic material of Tobacco mosaic virus is

(1) RNA (2) DNA (3) Protein (4) NADPH

Sol. Answer (1)

The genetic material of TMV is ssRNA.

19. The double helix model of DNA was proposed by

(1) Berzelius (2) Watson and Crick (3) Griffith (4) Robert Brown

Sol. Answer (2)

The double helix model of DNA was proposed by Watson and Crick.

20. In the 5′ end of a DNA molecule

(1) The fifth carbon of pyrimidine base is free (2) The fifth carbon of purine base is free

(3) The fifth carbon of pentose sugar is free (4) Both (1) & (3)

Sol. Answer (3)

One end of the strand is called 5′ end where the fifth carbon of the pentose sugar is free and the other is called 3′ end where the third carbon of pentose sugar is free.

21. The pitch of the B-DNA is

(1) 36 Å (2) 3.4 Å (3) 34 Å (4) 3.6 Å

Sol. Answer (3)

In B-DNA, one turn of helical strand has 10 nucleotides.

The base pairs of DNA are stacked 3.4 Å part.

$\therefore$ Pitch of the DNA = 3.4 Å × 10 = 34 Å

22. In DNA, uracil is replaced by

(1) Thymine (2) Thiamine (3) Cytosine (4) Adenine

Sol. Answer (1)

In DNA, thymine is present.

In RNA, uracil is present.

(Amino Acid and Dynamic State of Body Constituents–Concept of Metabolism)

23. In glycine, the R group is replaced by

(1) A methyl group (2) Hydroxy methyl (3) A carboxylic group (4) A hydrogen atom

Sol. Answer (4)

Glycine is a simplest amino acid in which R-group is replaced by hydrogen.

24. Zwitterions are ionized species of

(1) Acidic amino acids (2) Basic amino acids

(3) Neutral amino acids (4) All of these

Sol. Answer (4)

Since amino acid can carry both +ve and –ve charges simultaneously, hence they are termed as **Zwitterions.**

25. Non-essential amino acids

(1) Must be obtained from food (2) Are synthesized in our body

(3) Are not needed in our diet (4) Both (2) & (3)

Sol. Answer (4)

Non-essential amino acids are synthesised in our body, so there is no need to take them our diet.

26. Metabolic flux is regulated by

(1) Enzymes (2) Sugars (3) Phospholipids (4) Sterols

Sol. Answer (1)

Metabolic flux is the rate of turn over of molecules through a metabolic pathway.

(The Living State, Enzymes)

27. Proteins which catalyse biochemical reactions in the living world are known as

(1) Enzymes (2) Hormones (3) Antibodies (4) Receptor

Sol. Answer (1)

Almost all enzymes are proteins which catalyse the biochemical reactions.

Hormones can be steroid and amino-acid derivative also.

Antibodies are glycoproteins.

Receptors are associated with sensory reception.

28. Ribozymes are _____ that behave like enzymes

(1) Proteins (2) Ribonucleic acids (3) Oligosaccharide (4) Simple lipids

Sol. Answer (2)

Ribozymes are RNA molecules which act as enzymes.

29. The most abundant enzyme in the biosphere is

(1) Collagen (2) RuBisCO (3) Trypsin (4) Insulin

Sol. Answer (2)

Ribulose bisphosphate carboxylase-oxygenase (RuBisCO) is the most abundant protein in the whole of the biosphere.

30. What is the fate of pyruvic acid under anaerobic conditions in our body?

(1) It gets converted into methyl alcohol

(2) It gets converted into acetyl CoA

(3) It gets converted into lactic acid

(4) It gets converted into glycogen

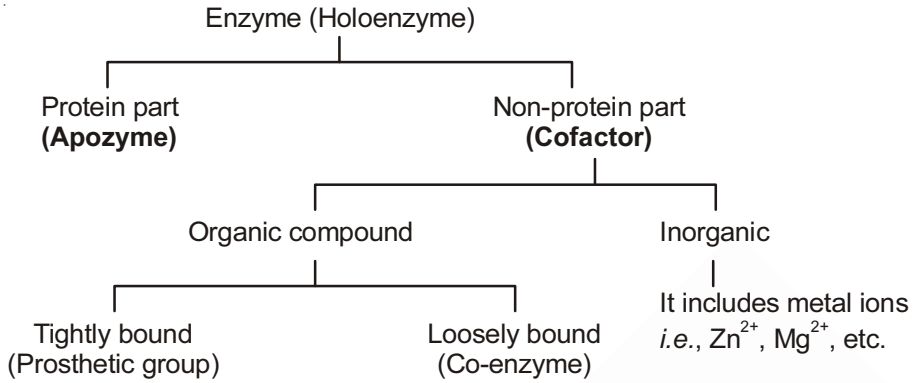
Sol. Answer (3)

Under anaerobic conditions, the glucose is converted into lactic acid in muscles.

31. Organic compounds that are tightly bound to apoenzyme are called

(1) Prosthetic group (2) Apoenzyme (3) Metal ions (4) Co-enzymes

Sol. Answer (1)



32. Growth of bacterial pathogens can be controlled by compound(s)

(1) p-amino benzoic acid (2) Malonate (3) Sulphanilamide (4) All of these

Sol. Answer (3)

Sulpha drugs are derivatives of sulphanilamide, which inhibit the synthesis of folic acid in bacteria by competing with p-amino benzoic acid (PABA) required for the synthesis of folic acid by folic acid synthetase.

33. Non-protein part of enzyme is known as

(1) Apoenzyme (2) Cofactor (3) Inorganic catalyst (4) Active site

Sol. Answer (2)

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