Question 1:

What are macromolecules? Give examples.

Answer

Macromolecules are large complex molecules that occur in colloidal state in intercellular fluid. They are formed by the polymerization of low molecular weight micromolecules.

Polysaccharides, proteins, and nucleic acids are common examples of macromolecules.

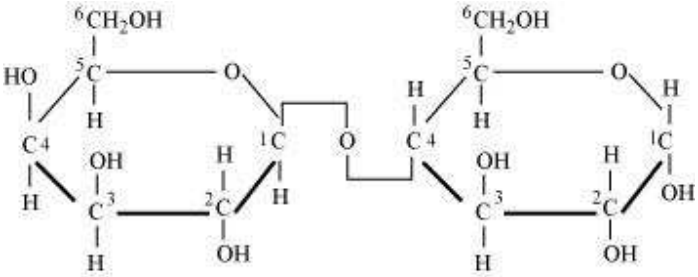
Question 2:

Illustrate a glycosidic, peptide and a phospho-diester bond.

Answer

(a)

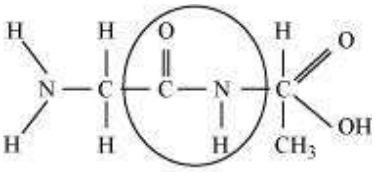
Glycosidic bond is formed normally between carbon atoms, 1 and 4, of neighbouring monosaccharide units.



Glycosidic bond

(b)

Peptide bond is a covalent bond that joins the two amino acids by – NH – CO linkage.



Peptide bond

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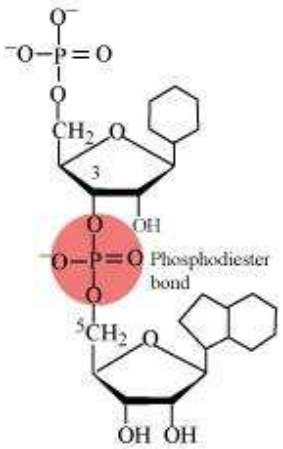
(c)

Phosphodiester bond is a strong covalent bond between phosphate and two sugar groups. Such bonds form the sugar phosphate backbone of nucleic acids.



Question 3:

What is meant by tertiary structure of proteins?

Answer

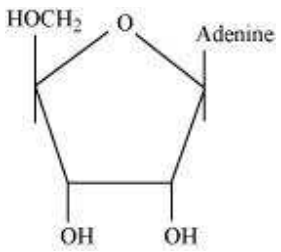
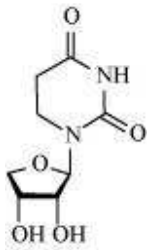
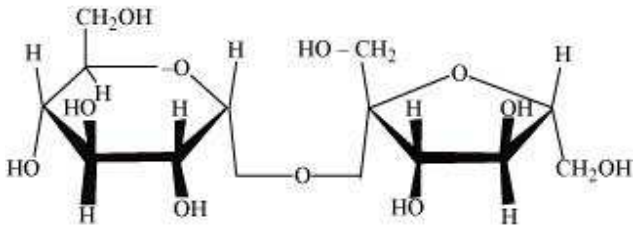
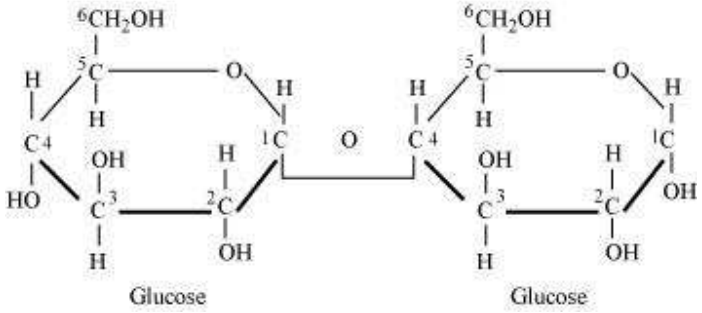
The helical polypeptide chain undergoes coiling and folding to form a complex three-dimensional shape referred to as tertiary structure of proteins. These coils and folds are arranged to hide the non-polar amino acid chains and to expose the polar side chains. The tertiary structure is held together by the weak bonds formed between various parts of the polypeptide chain.

Question 4:

Find and write down structures of 10 interesting small molecular weight biomolecules. Find if there is any industry which manufactures the compounds by isolation. Find out who are the buyers.

Answer

(a)

	Molecule	Structure
1.	Adenosine	
2.	Thymidine	
3.	Sucrose	
4.	Maltose	

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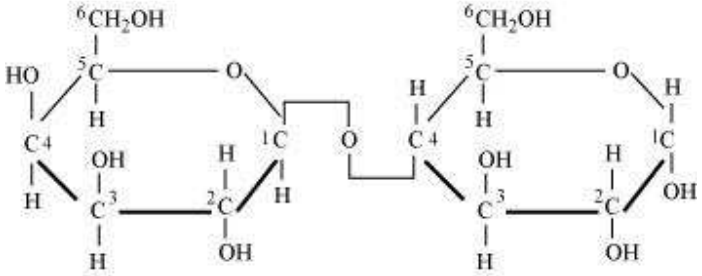
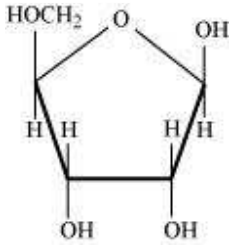
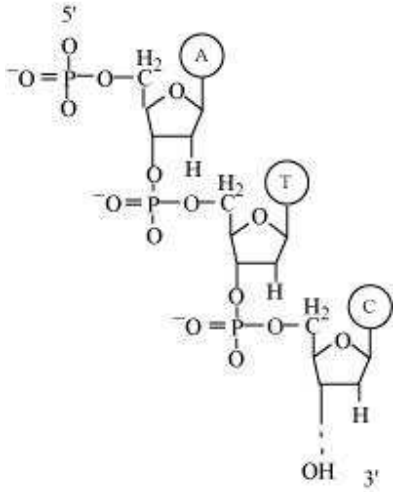
5.	Lactose	
6.	Ribose	
7.	DNA	

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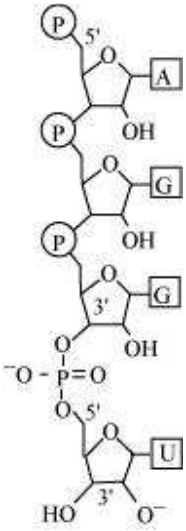
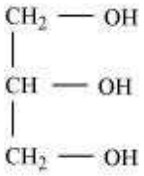
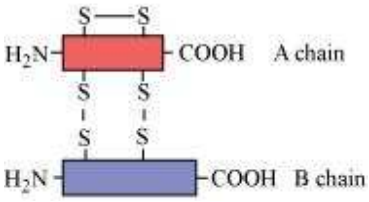
8.	RNA	
9.	Glycerol	
10.	Insulin	

(b)

	Compound	Manufacturer	Buyer
1.	Starch products	Kosha Impex (P) Ltd.	Research laboratories, educational institutes, and other industries, which use biomolecules as a precursor for making other products.
2.	Liquid glucose	Marudhar apparels	

3.	Various enzymes such as amylase, protease, cellulase	Map (India) Ltd	

Question 5:

Proteins have primary structure. If you are given a method to know which amino acid is at either of the two termini (ends) of a protein, can you connect this information to purity or homogeneity of a protein?

Answer

Yes, if we are given a method to know the sequence of proteins, we can connect this information to the purity of a protein. It is known that an accurate sequence of a certain amino acid is very important for the functioning of a protein. If there is any change in the sequence, it would alter its structure, thereby altering the function. If we are provided with a method to know the sequence of an unknown protein, then using this information, we can determine its structure and compare it with any of the known correct protein sequence. Any change in the sequence can be linked to the purity or homogeneity of a protein.

For example, any one change in the sequence of haemoglobin can alter the normal haemoglobin structure to an abnormal structure that can cause sickle cell anaemia.

Question 6:

Find out and make a list of proteins used as therapeutic agents. Find other applications of proteins (e.g., cosmetics, etc.)

Answer

Proteins used as therapeutic agents are as follows:

1. Thrombin and fibrinogen – They help in blood clotting.
2. Antigen (antibody) – It helps in blood transfusion.
3. Insulin – It helps in maintaining blood glucose level in the body.
4. Renin – It helps in osmoregulation.

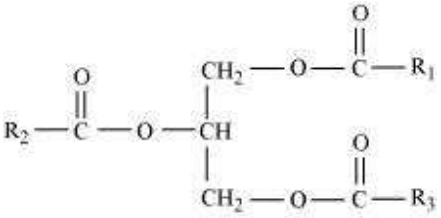
Proteins are also commonly used in the manufacture of cosmetics, toxins, and as biological buffers.

Question 7:

Explain the composition of triglyceride.

Answer

Triglyceride is a glyceride, which is formed from a single molecule of glycerol, esterified with three fatty acids. It is mainly present in vegetable oils and animal fat.



Structure of triglyceride

The general chemical formula of triglyceride is $R_2COO-CH_2CH(-OOCR_1)CH_2-OOCR_3$, where R_1, R_2, and R_3 are fatty acids. These three fatty acids can be same or different.

Question 8:

Can you describe what happens when milk is converted into curd or yoghurt from your understanding of proteins.

Answer

Proteins are macromolecules formed by the polymerization of amino acids. Structurally, proteins are divided into four levels.

(a) Primary structure – It is the linear sequence of amino acids in a polypeptide chain.

(b) Secondary structure – The polypeptide chain is coiled to form a three-dimensional structure.

(c) Tertiary structure – The helical polypeptide chain is further coiled and folded to form a complex structure.

(d) Quaternary structure – More than one polypeptide chains assemble to form the quaternary structure.

Milk has many globular proteins. When milk is converted into curd or yoghurt, these complex proteins get denatured, thus converting globular proteins into fibrous proteins. Therefore, by the process of denaturation, the secondary and tertiary structures of proteins are destroyed.

Question 9:

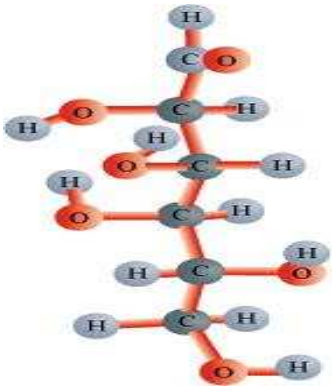
Can you attempt building models of biomolecules using commercially available atomic models (Ball and Stick models).

Answer

Ball and stick models are 3-D molecular models that can be used to describe the structure of biomolecules.

In ball and stick model, the atoms are represented as balls whereas the bonds that hold the atoms are represented by the sticks. Double and triple bonds are represented by springs that form curved connections between the balls. The size and colour of various atoms are different and are depicted by the relative size of the balls.

It is the most fundamental and common model of representing biomolecular structures.



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In the above ball and stick model of D-glucose, the oxygen atoms are represented by red balls, hydrogen atoms by blue balls, while carbon atoms are represented by grey balls.

Question 10:

Attempt titrating an amino acid against a weak base and discover the number of dissociating (ionizable) functional groups in the amino acid.

Answer

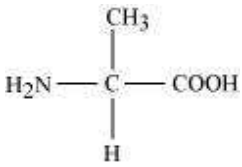
Titrating a neutral or basic amino acid against a weak base will dissociate only one functional group, whereas titration between acidic amino acid and a weak acid will dissociate two or more functional groups.

Question 11:

Draw the structure of the amino acid, alanine.

Answer

Structure of alanine



Question 12:

What are gums made of? Is Fevicol different?

Answer

Gums are hetero-polysaccharides. They are made from two or more different types of monosaccharides. On the other hand, fevicol is polyvinyl alcohol (PVA) glue. It is not a polysaccharide.

Question 13:

Find out a qualitative test for proteins, fats and oils, amino acids and test any fruit juice, saliva, sweat and urine for them.

Answer

(a) Test for protein

Biuret's test – If Biuret's reagent is added to protein, then the colour of the reagent changes from light blue to purple.

(b) Test for fats and oils

Grease or solubility test

(c) Test for amino acid

Ninhydrin test – If Ninhydrin reagent is added to the solution, then the colourless solution changes to pink, blue, or purple, depending on the amino acid.

Item		**Name of the test**	**Procedure**	**Result**	**Inference**
1.	Fruit juice	Biuret's test	Fruit juice + Biuret's reagent	Colour changes from light blue to purple	Protein is present.
		Grease test	To a brown paper, add a few drops of fruit juice.	No translucent spot	Fats and oils are absent or are in negligible amounts.
		Ninhydrin test	Fruit juice + Ninhydrin reagent + boil for 5 minutes	Colourless solution changes to pink, blue, or purple colour	Amino acids are present.
2.	Saliva	Biuret's	Saliva + Biuret's	Colour changes from	Proteins are

		test	reagent	light blue to purple	present.
		Grease test	On a brown paper, add a drop of saliva.	No translucent spot	Fats/oils are absent.
		Ninhydrin test	Saliva + Ninhydrin reagent + boil for 5 minutes	Colourless solution changes to pink, blue, or purple colour	Amino acids are present.
3.	Sweat	Biuret's test	Sweat + Biuret's reagent	No colour change	Proteins are absent.
		Solubility test	Sweat + Water	Oily appearance	Fats/oil may be present.
		Ninhydrin test	Sweat + Ninhydrin reagent + boil for 5 minutes	No colour change, solution remains colourless	Amino acids are absent.
4.	Urine	Biuret's test	Few drops of urine + Biuret's reagent	Colour changes from light blue to purple	Proteins are present.
		Solubility test	Few drops of urine + Water	Little bit of oily appearance	Fats may or may not be present.
		Ninhydrin test	Few drops of urine +	Colourless solution changes to pink,	Amino acids are present.

			Ninhydrin reagent + boil for 5 minutes	blue, or purple colour depending on the type of amino acid	

Question 14:

Find out how much cellulose is made by all the plants in the biosphere and compare it with how much of paper is manufactured by man and hence what is the consumption of plant material by man annually. What a loss of vegetation!

Answer

Approximately, 100 billion tonnes of cellulose are made per year by all the plants in the biosphere and it takes 17 full grown trees to make one ton of paper. Trees are also used to fulfil the other requirements of man such as for timber, food, medicines, etc. Hence, it is difficult to calculate the annual consumption of plant material by man.

Question 15:

Describe the important properties of enzymes.

Answer

Properties of enzymes

(1) Enzymes are complex macromolecules with high molecular weight.

(2) They catalyze biochemical reactions in a cell. They help in the breakdown of large molecules into smaller molecules or bring together two smaller molecules to form a larger molecule.

(3) Enzymes do not start a reaction. However, they help in accelerating it.

(4) Enzymes affect the rate of biochemical reaction and not the direction.

(5) Most of the enzymes have high turnover number. Turnover number of an enzyme is the number of molecules of a substance that is acted upon by an enzyme per minute. High turnover number of enzymes increases the efficiency of reaction.

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(6) Enzymes are specific in action.

(7) Enzymatic activity decreases with increase in temperature.

(8) They show maximum activity at an optimum pH of 6 – 8.

(9) The velocity of enzyme increases with increase in substrate concentration and then, ultimately reaches maximum velocity.

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Chapter-9

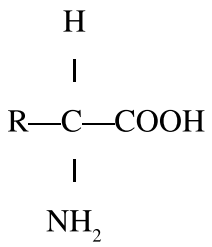
BIOMOLECULES

POINTS TO REMEMBER

Biomolecules : All the carbon compounds that we get from living tissues.

Micromolecules : Molecules which have molecular weights less than one thousand dalton.

Amino acids : Organic compounds containing an amino group and one carboxyl group (acid group) and both these groups are attached to the same carbon atom called **α carbon**.



- Twenty types of amino acids.
- Based on number of amino and carboxyl groups, amino acids can be :
- Phenylalanine, Tryptophan and Tyrosine are aromatic (give smell) amino acids.

Amino Acids

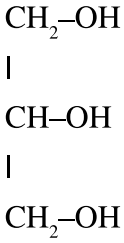
Acidic	**Basic**	**Neutral**
e.g., glutamic acid	*e.g.,* lysine	*e.g.,* valine

Lipids :

- Water insoluble, containing C, H, O.
- Fats on hydrolysis yield fatty acids.
- Fatty acid has a carboxyl group attached to an R group (contains 1 to 19 carbons).
- **Fatty Acids : Saturated :** With single bonds in carbon chain. *e.g.,* Palmitic acid, butyric acid.

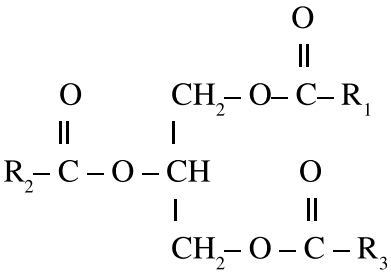
  Unsaturated : With one or more double bonds. *e.g.,* oleic acid, linoleic acid.

• **Glycerol :** A simple lipid, is trihydroxy propane.



• Some lipids have fatty acids esterified with glycerol.

• They can be monoglycerides, diglycerides and triglycerides.



Triglyceride (R_1, R_2, R_3 are fatty acids.)

• **Phospholipids** are compound lipids with phosphorus and a phosphorylated organic compound *e.g.,* Lecithin.

Nitrogen bases

Carbon compounds with heterocyclic rings)

Purine : Adenine, Guanine. **Pyrimidine :** Cytosine, Uracil, Thymine.

Nucleoside : Nitrogenous base + Sugar *e.g.,* Adenosine, guanosine.

Nucleotide : Nitrogenous base + Sugar + Phosphate group. *e.g.,* Adenylic acid, thymidylic acid.

Nucleic acid : Polymer of nucleotides - DNA and RNA.

Biomacromolecules : Biomolecules with molecular weights in the range of ten thousand daltons and above; found in acid insoluble fraction.

Lipids are not strictly macromolecules as their molecular weights do not exceed 800 Da but form a part of the acid insoluble pool.

Proteins :

- Are polymers of aminoacids linked by peptide bond.
- Is a heteropolymer.
- For functions of proteins refer Table 9.5, Page no. 147, NCERT, Text Book of Biology for Class XI.

Structure of Proteins

(a) **Primary structure :** Is found in the form of linear sequence of amino acids. First amino acid is called N-terminal amino acid and last amino acid is called C-terminal amino acid.

(b) **Secondary structure :** Polypeptide chain undergoes folding or coiling which is stabilized by hydrogen bonding. Right handed helices are observed. *e.g.,* fibrous protein in hair, nails.

(c) **Tertiary structure :** Long protein chain is folded upon itself like a hollow wollen ball. Gives a 3-dimensional view of protein, *e.g.,* myosin.

(d) **Quaternary structure :** Two or more polypeptides with their foldings and coilings are arranged with respect to each other. *e.g.,* Human haemoglobin molecule has 4 peptide chains - $2 \propto$ and 2β subunits.

Polysaccharides : Are long chain of sugars.

(a) **Starch :** Store house of energy in plant tissues. Forms helical secondary structures.

(b) **Cellulose :** Polymer of glucose.

(c) **Glycogen :** Is a branched homopolymer, found as storage polysaccharide in animals.

(d) Insulin : Is a polymer of fructose.

(e) **Chitin :** Chemically modified sugar (amino-sugars) N-acetyl galactosamine. Form exoskeleton of arthropods.

Anabolic pathways : Lead to formation of more complex structure from a simpler structure with the consumption of energy. *e.g.,* Protein from amino acids.

Catabolic pathway : Lead to formation of simpler structure from a complex structure. *e.g.,* Glucose $\rightarrow$ Lactic Acid.

Bonds linking monomers in a polymer

Peptide bond – formed between the carboxyl (–COOH) group of one amino acid and the amino ($–NH_2$) group of the next amino acid with the climation of water moeity.

Glycosidic bond – bond formed between two carbon atoms of two adjacent monosaccharides.

Phosphodiester bond - bond formed in mucleic acids where in a phosphate moiety links the 3-carbon of one sugar of one nucleotide to the 5' - carbon of the sugar of the succeeding nucleotide.

Enzymes : Are biocatalysts.

- Almost all enzymes are proteins.
- Ribozymes - Nucleic acids that behave like enzymes.
- Has primary, secondary and tertiary structure.
- Active site of an enzyme is a crevice or pocket into which substrate fits.
- Enzymes get damaged at high temperatures.
- Enzymes isolated from thermophilic organisms (live under high temperatures) are thermostable.
- Enzymes accelerate the reactions many folds.
- Enzymes lower the activation energy of reactions. (Fig. 9.6, Page no. 156, NCERT Text Book of Biology for Class XI).
- $E + S \rightleftharpoons ES \rightarrow EP \rightarrow E + P$

  where E = Enzyme, S = Substrate, P = Product.

Factors affecting enzyme activity :

(a) **Temperature :** Show highest activity at optimum temperature. Activity declines above and below the optimum value.

(b) **pH :** Enzymes function in a narrow range of pH. Highest activity at optimum pH. (Fig. 9.7, Page no. 157, NCERT, Text Book of Biology for Class XI)

(c) **Concentration of substrate :** The velocity of enzymatic reaction rises with increase in substrate concentration till it reaches maximum velocity (V_{max}). Further increase of substrate does not increase the rate

of reaction as no free enzyme molecules are available to bind with additional substrate.

Enzyme inhibition : When the binding of a chemical shuts off enzyme activity, the process is called inhibition and chemical is called **inhibitor.**

Competitive inhibition : Inhibitor closely resembles the substrate in its molecular structure and inhibits the enzyme activity. *E.g.,* inhibition of succinic dehydrogenase by malonate. (Actual substrate is succinic acid)

Classification of enzymes :

1. **Oxidoreductase/dehydrogenases :** Catalyse oxidoreduction between 2 substrates.
2. **Transferases :** Catalyse transfer of a group between a pair of substrates.
3. **Hydrolases :** Catalyse hydrolysis of ester, ether, peptide, glycosidic, C-C, P-N bonds.
4. **Lyases :** Catalyse removal of groups from substrates by mechanisms other than hydrolysis. Leave double bonds.
5. **Isomerases :** Catalyse inter-conversion of optical, geometric or positional isomers.
6. **Ligases :** Catalyse linking together of 2 compounds.

Cofactors : Non-protein constituents bound to the enzyme to make it catalytically active. Protein portion of enzyme is called **apoenzyme.**

1. **Cofactors : • Prosthetic groups :** are organic compounds tightly bound to apoenzyme. *e.g.,* haem in perox, dase and catalase.
2. **• Co-enzymes :** Organic compounds which has transient association with enzyme. *e.g.,* NAD, NADP. (Contain vitamin Niacin)
3. **• Metal ions :** Required for enzyme activity. Form coordination bond with side chains at active site and with substrate. *e.g.,* zinc is a co-factor for enzyme carboxypeptidase.

Nucleic acids : Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

DNA structure (Watson and Crick Model) : DNA is a right handed, double helix of two polynucleotide chains, having a major and minor groove. The two chains are antiparallel, and held together by hydrogen bonds (two between A and T and three between C and G). The backbone is formed by sugar-phosphate-sugar chain. The nitrogen bases are projected more or less perpendicular to this backbone and face inside. The pitch is 34A°. At each step of ascent, the strand

turns36°. The rise per base pair is 3.4A°, so one full turn involves ten base pairs.

QUESTIONS

Very Short Answer Questions (1 mark each)

1. Why do oils generally remain in liquid state even in winters ?

2. Name an element found in proteins but not in lipids and carbohydrates.

3. What is the difference between RNA and DNA in terms of nitrogenous base?

4. What does an enzyme do in terms of energy requirement of a reaction ?

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

6. Name the protein which form the intercellular ground substance.

Short Answer Questions-II (2 marks each)

7. Why are aminoacids also known as substituted methane ?

8. Amino acids exist as zwitter ions. Give its structure. Why is it formed ?

9. Why do starch give blue black colour with iodine ?

10. Why are starch and glycogen more suitable than glucose as a storage product?

11. What would happed when salivary amylase which acts on starch in mouth and in stomach ?

12. Differentiate between homopolysaccharides and heterosaccharides

13. Why do physicians recommend vegetable oils rich in polyunsaturated fat for persons suffering from cardiovascular diseases?

14. Why does the shelf life of fruits and vegetables increase in a refrigerator?

Short Answer Questions-I (3 marks each)

15. Explain the structure of proteins.

16. (a) What is an enzyme ?

(b) Give an example of co-enzyme.

(c) Distinguish between apoenzyme and co-enzyme.

17. Explain Watson-Crick model on DNA structure.

18. Explain peptide bond, glycosidic bond and phosphodiester bond.

19. Explain competitive inhibition along with an example.

Long Answer Questions (5 marks each)

20. List the 6 classes of enzymes alongwith their functions.

ANSWERS

Very Short Answers (1 mark each)

1. Oils are unsaturated lipids, hence have lower melting points.

2. Nitrogen.

3. RNA has uracil instead of thymine.

4. Lowers the activation energy of reaction.

5. Are the energy currency of cell.

6. Collagen.

Short Answers-II (2 marks each)

7. The α-carbon has 4 substituted groups occupying the 4 valency positions : -H, -COOH, $-NH_2$ and -R group.

8.

$$NH_2 - \underset{}{\overset{\overset{R}{|}}{CH}} - COO^-$$

Due to ionizable nature of $-NH_2$ and –COOH groups.

9. Starch forms helical secondary structures which can hold I_2.

10. Occupy lesser space as less bulky and can hydrolysed to glucose when required.

11. In mouth, salivary amylase changes starch into maltose. Action of amylase stops in stomach as it cannot act in an acidic medium.

12.

	Homopolysaccharides	Heteropolysaccharides
a)	Constituted of single type of monosaccharide units	Constituted by two or more type of monosaccharide unit and their derivatives
b)	e.g., starch, glycogen, cellulose	e.g., Peptidoglycans, chiten

13. Polyunsaturated oils contain fatty acids having one or more double bonds which does not clog arteries due to high proportion of polyunsaturated fatty acids

14. Low temperature prevents growth of food spoiling micro organisms and also inhibits the action of enzymes present in the food, because enzymes are inactivated at low temperature.

Short Answers-I (3 marks each)

15. Refer 'Points to Remember'.

16. (a) Are biocatalysts.

(b) NADP, NAD

(c) The enzymes which work only in the presence of co-factors are known as apoenzymes.

An organic non-protein cofactor which is easily separable from the apoenzyme is called co-enzyme.

17. Refer 'Points to Remember'.

18. Refer Page no. 151, NCERT, Text Book of Biology for Class XI.

19. Refer 'Points to Remember'.

Long Answers (5 marks each)

20. Refer Page no. 158., NCERT, Text Book of Biology for Class XI.