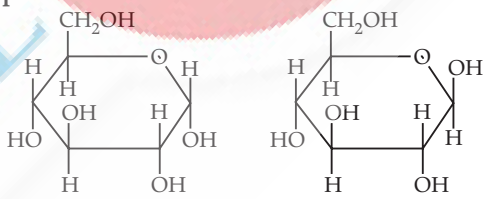
10 CHAPTER

Biomolecules

Level - 1 CORE SUBJECTIVE QUESTIONS

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (B) is correct
   Explanation: Starch contains only a glucose, sucrose contains α-D-glucose and β-D-fructose glucose, maltose contains α-D-glucose and cellulose is a polymer of β-D-glucose.
2. Option (B) is correct
   Explanation: DNA mode up of three components i.e. a sugar molecules, a nitrogenous base and a phosphate group.
3. Option (D) is correct
   Explanation: Vitamin K is essential for blood clotting because it helps in the liver to produce proteins called clotting factors.
4. Option (A) is correct
   Explanation: The linear sequence of amino acids constitutes a protein's primary structure.
5. Option (B) is correct
   Explanation : The functional groups of glucose that interact to form a cyclic hamiacetal and lead to the pyranose structure are the aldehyde (—CHO) and the hydroxyl (—OH) on the fifth Carbon (C_5) of glucose.
6. Option (C) is correct
   Explanation : Ascorbic acid is found naturally in citrus fruits, berries, Kiwi and it represent vitamin C, green vegetable.
7. Option (C) is correct
   Explanation: An α-helix is a secondary structure of proteins that is formed when a polypeptide chain twists into a right handed, screw like shape.
8. Option (C) is correct
   Explanation: A glycosidic linkage is a type of ether bond that joins a carbohydrate molecule to another carbohydrate molecule. In amylose C_1 carbon of one glucose take part in glycosidic linkage by C_4 carbon of other glucose unit, and that linkage is $C_1 - C_4$ α-linkage.
9. Option (A) is correct
   Explanation: Starch and maltose give only glucose on hydrolysis.
10. Option (D) is correct
    Explanation: Vitamins B and C are water soluble while vitamins A, D, E and K are fat soluble.
11. Option (B) is correct
    Explanation: An α-helix is a secondary structure of proteins in which polypeptide chain twists into a right handed, screw like shape.
12. Option (A) is correct
    Explanation:



13. Option (D) is correct
    Explanation: Cyano cabalamin (Vitamin B_{12}) deficiency leads to disease pernicious anaemia.
14. Option (A) is correct
    Explanation: The hydrolysis of sucrose is an acidic process that produces glucose and fractose.
15. Option (A) is correct
    Explanation: This represent linear structure of protein.

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (D) is correct
   Explanation: Assertion is false. Uracil is not found in DNA; it is present in RNA instead. In DNA, thymine replaces uracil.
   Reason is true.
2. Option (C) is correct
   Explanation: Assertion is true. Fructose can act as a reducing sugar because, in alkaline medium, it is converted into glucose and mannose (aldoses) via Lobry de Bruyn–van Ekenstein transformation, and these can reduce Fehling's and Tollen's reagents.
   Reason is false. Fructose does reduce these reagents (indirectly after isomerisation).
3. Option (C) is correct
   Explanation: Assertion is true. Peptide bonds are amide linkages between the –COOH group of one

α-amino acid and the $–NH_2$ group of another.

Reason is false. A tetrapeptide has 4 amino acids but only 3 peptide bonds.

4. Option (A) is correct

Explanation: 'D' (+) is dextrorotatory but D represent the relative configuration with glyceraldehyde where as (+) sign represent the dextro rotatory nature of compound.

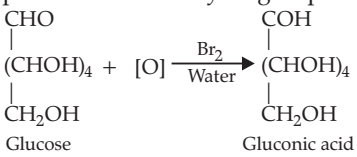
VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Preservation of fruits by adding sugar/salt protects against bacterial action. Through osmosis, a bacterium on canned fruit loses water, shrivels and dies.

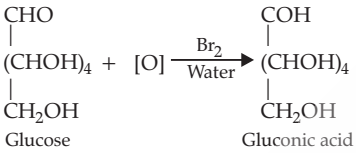
2. (i) Haemoglobin: Iron

(ii) Vitamin B-12: Cobalt

3. The carbonyl group present in glucose is aldehyde and the C_1 atom. Glucose gets oxidised to six-carbon carboxylic acid (gluconic acid) with COOH group at the C_1 atom on reaction with a mild oxidising agent like bromine water. This indicates that the carbonyl group is present as an aldehydic group.



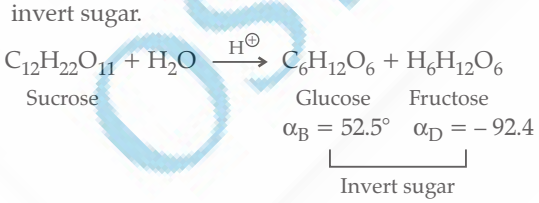
4. (i)



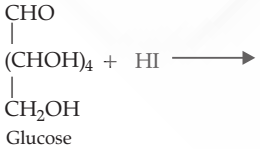
(ii) Thymine is present in DNA and uracil is present in RNA.

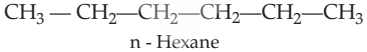
5. (i) Denaturation of protein is a physical change that occurs when a protein loses its secondary and teritary structures due to external stress. This process can be caused by strong acids or bases, heat, alcohol or inorganic salts. Denaturation result in the loss of a protein's biological activity.

(ii) The dextrorotatory sucrose when hydrolysed by boiling with mineral acid produces an equal number of molecules of dextrorotoar glucose having specific rotation + 52.5° and laevorotory fructose having specific rotation of – 92.4°. The resulting mixture is laevoratory and termed as invert sugar.

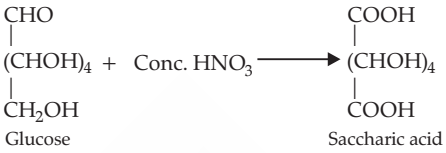


6. (i) Glucose reaction with HI

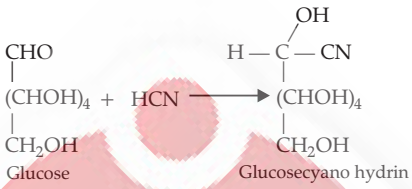




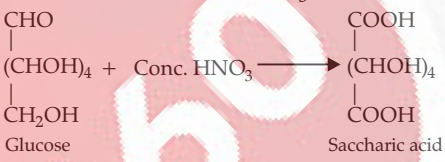
(ii) Glucose reaction with conc. HNO_3



7. (i)



(ii) Glucose reaction with HNO_3



8. Monsaccharides: Glucose and galactose, diasaccharides lactose and maltose.

9.

S.No.	DNA	RNA
1.	DNA is double stranded	RNA is usually single stranded
2.	The sugar in DNA is deoxyribose	The sugar in RNA is ribose

10. (i) When glucose is heated with HI it gives n-hexane which suggest that all the carbon are forming straight chain structure in glucose

Glucose + HI → n-Hexane

(ii) Peptide linkage

11.(i) Peptide linkage form between amino acids while glycosidic linkage form between monosaccharides.

(ii) The main difference between a nucleoside and nucleotide is that a nucleotide has an additional phosphate group attached to it while a nucleoside does not.

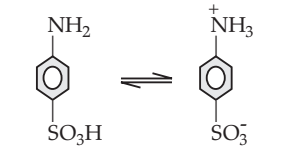
Nucleotide = Nitrogeneous base + five carbon sugar + phosphate group.

Nucleoside = Nitrogenous base + Five carbon sugar

12. (i) In the animal body carbohydrates are stored as glycogen in the liver and muscles.

(ii) The difference between cellulose and starch is that starch is a branched polymer while cellulose is a linear polymer

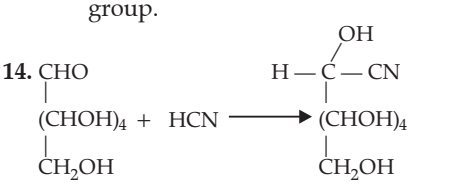
13. (i)



Sulphanilic acid Zwitter acid

(ii) The activating group of $—NH_2$ group can be controlled by acetylation which replaces one hydrogen of the $—NH_2$ group with a $—COCH_3$ group.

14.



Glucose Glucosecyano hydrin

This reaction confirms the presence of a carbonyl group in glucose.

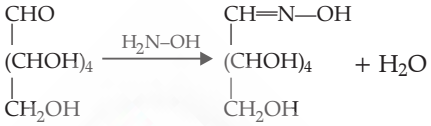
15. (i) Two bases which are common to both DNA and RNA are Adenine and Guanine.

(ii) (1) Vitamin D

(2) Vitamin B_{12}

16. (i) Amino acids show amphoteric behaviour because they can act as both acids and bases in aqueous solution.

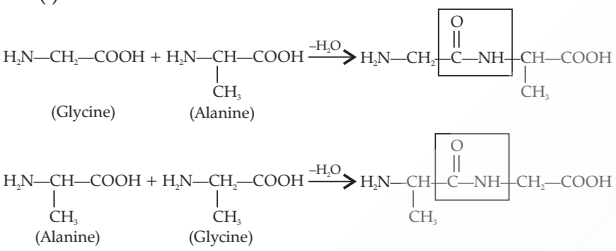
(ii) When D-glucose is treated with hydroxylamine it forms an oxime



Glucose Glucoxime

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. (i)



(Glycine) (Alanine)

(Alanine) (Glycine)

(ii) (1) Keratin is a fibrous protein. Fibre–like structure is formed. Such proteins are generally insoluble in water.

(2) Insulin is a globular protein. This structure results when the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water.

2. (i) Essential aminoacids are aminoacids that our body cannot produce on its own and must be obtained from food.

(ii) A peptide bond (—CONH—) is an amide covalent bond which is formed by the condensation of two α–amino acids.

(iii) Denaturation is a physical change that occurs when a protein loses its secondary and teritary structures due to external stress. This process can be caused by strong acids or bases, heat, alcohol or inorganic salts. Denaturation result in the loss of a protein's biological activity.

3. (i) A peptide bond (—CONH—) is an amide covalent bond which is formed by the condensation two α–amino acids.

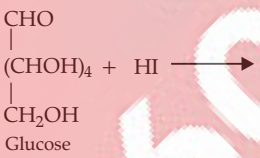
(ii) Hydrogen bonds hold the two strands of a DNA double helix together.

(iii) Starch is a polysaccharide carbohydrate.

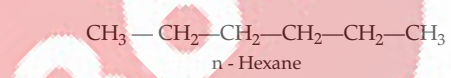
(iv) Water soluble vitamin vitamin C

Fat soluble vitamin vitamin A

4. (i) Glucose reaction with HI

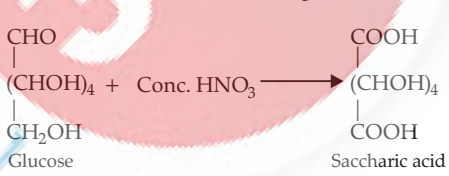


Glucose



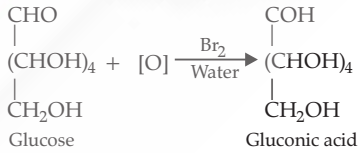
n - Hexane

(ii) Glucose reaction with HNO_3



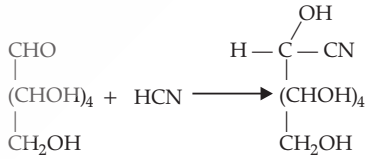
Glucose Saccharic acid

(iii)



Glucose Gluconic acid

(iv)



Glucose Glucosecyano hydrin

5. (i) Pentaacetate of glucose does not react with hydroxylamine because it lacks a free aldehyde group.

(ii) Amino acids behave like salts because they have both acidic and basic group in the same molecule.

(iii) Water soluble vitamins must be taken regularly in the diet because they are not stored in the body and are eliminated in Urine.

(iv) Cytosine forms hydrogen bond with guanine while adenine forms hydrogen bond with thymine. As a result the two strands are complementary to each other.

6. (i) (1) Lactose $\xrightarrow{\text{Hydrolysis}}$ Glucose + Galactose
(1 mole) (1 mole)

(2) Maltose $\xrightarrow{\text{Hydrolysis}}$ Glucose
(2 mole)

(ii) Starch used 1, 4 and 1, 6 linkage and branched structure while cellulose has a rigid, elongated structure and uses 1, 4 β linkage.

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i) (1) Cellulose
β – D (+) Glucose
(2) C – 1 of one unit of glucose is linked to C – 4 of another unit of glucose. These units are linked to each other by glycosidic linkages.
(3) Haworth structure of – D (+) – Glucose.

(ii) Maltose
Silver mirror will be observed as Tollen's reagent is reduced by maltose due to the presence of free aldehyde group.

(iii) Sucrose is dextrorotatory, but on hydrolysis it produces a mixture of α-D-(+) Glucose and β-D-(–) Fructose. Since, the laevorotation of fructose is more than the dextrorotation of α-glucose, so overall mixture becomes laevorotatory, hence inversion is observed.

2. (i) (1) Glucose does not give 2, 4-DNP test.
(2) Glucose does not give schiff's test.
(3) The pentaacetate of glucose does not react with hydroxylamine.

(ii)

Reducing Sugars	Non-reducing Sugars
These are carbohydrates that can act as reducing agents due to the presence of free aldehyde groups of free ketone groups.	These are carbohydrates that cannot act as reducing agents due to the absence of free aldehyde groups or free ketone groups.

(iii) Polysaccharides are carbohydrates which yield a large number of monosaccharide units on hydrolysis. These units are joined together by glycosidic linkages. These are the most commonly encountered carbohydrates in nature. They mainly act as the food storage or structural materials.

Level - 2 ADVANCED COMPETENCY FOCUSED QUESTIONS

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (B) is correct
Explanation: Because it has more basic group i.e. —NH_2 as compared to acidic group i.e. —COOH group.

2. Option (A) is correct
Explanation: Glucose strips used by diabetic patients contain enzymes like glucose oxidise, which catalyse the oxidation of glucose present in a blood sample to gluconic acid. During this process, hydrogen peroxide is also produced, which reacts with a colour indicator, causing the strip to change colour. This colour change is proportional to the amount of glucose present, allowing for a quick estimate of blood sugar levels.

3. Option (C) is correct
Explanation: Glucose is a simple carbohydrate (monosaccharide) that is easily and rapidly absorbed into the bloodstream. During intense physical activity like marathons, the body needs instant energy, and glucose serves this purpose effectively by entering the bloodstream quickly, undergoing glycolysis and cellular respiration, and releasing ATP (energy) that fuels muscle activity. This is why glucose-based energy drinks are popular among athletes for quick energy replenishment.

4. Option (C) is correct
Explanation: Lactase is the enzyme responsible for breaking down lactose, the sugar found in milk, into glucose and galactose. People with lactose intolerance have low or no lactase production in the small intestine. This leads to indigestion, bloating, and gas when they consume dairy products.

5. Option (D) is correct
Explanation: Keratin is a fibrous protein, which means it has elongated, thread-like structure. It is found in hair, nails, skin, and feathers, and provides strength and structural support. Unlike globular proteins, fibrous proteins are insoluble in water and not enzymatic in function.

6. Option (C) is correct
Explanation: Aspartame is an artificial sweetener used in diet sodas and sugar-free products. It is a dipeptide, meaning it is made up of aspartic acid and phenylalanine. These are two amino acids linked together to form a compound that is about 200 times sweeter than sucrose.

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (D) is correct
Explanation: Assertion is false. They are essential nutrients, but they do not burn or reduce body fat. Reason is true. Vitamins A and K dissolve in fats and are stored in body fat and the liver.

2. Option (A) is correct

Explanation: Glucose exist in cyclic structure which is known as pyranose form. In pyranose form CHO group of glucose is not in free form that's why $NaHSO_3$ does not give addition reaction with glucose.

3. Option (A) is correct
Explanation: Assertion is true. Lactose intolerance occurs when the body lacks lactase, an enzyme needed to digest lactose, the sugar found in milk.
Reason is also true. Lactase breaks down lactose into glucose and galactose, which can then be absorbed by the body.

4. Option (A) is correct
Explanation: Assertion is true. Enzymes show substrate specificity because their active sites have a specific shape and structure that matches only particular substrates (like a lock and key).
Reason is also true. The 3D structure of the enzyme's active site allows it to bind only to specific molecules and catalyse specific reactions.

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Glucose oxidase catalyses the oxidation of glucose to gluconic acid and hydrogen peroxide. The reaction causes a colour change on the strip, indicating glucose concentration in blood.
2. Lactose intolerance occurs due to a deficiency of the enzyme lactase, which is needed to hydrolyse lactose into glucose and galactose. Without this enzyme, lactose remains undigested, leading to bloating and discomfort.
3. Glucose is easily absorbed into the bloodstream and provides immediate energy through cellular respiration, helping maintain stamina and prevent fatigue.
4. Keratin is a fibrous protein with strong disulfide bonds, giving it mechanical strength and durability. This structure helps in strengthening and smoothing hair strands.
5. Aspartame is a low-calorie artificial sweetener made from amino acids. It is much sweeter than sucrose, so a smaller quantity is needed, making it suitable for calorie-conscious consumers.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. At pH 7, glutamic acid carries an extra negative charge and moves towards the positive electrode - it is responsible for spot D.
At pH 7, glycine carries one of each type of charge, so it is attracted equally to both electrodes and does not move - it is responsible for spot E.
At pH 7, lysine carries an extra positive charge, and hence moves towards the negative electrode - it is responsible for spot F.
2. Proteins are made up of long chains of amino acids folded into specific three-dimensional structures held together by hydrogen bonds, ionic bonds, and disulfide linkages. When exposed to high temperatures, these bonds are disrupted, causing the protein to lose its specific shape and functionality — a process known as denaturation.
Real-life applications:
Cooking: In foods like eggs, the clear liquid albumin (a protein) becomes white and solid when heated due to protein denaturation.
Fever: High body temperatures during a fever can denature enzymes in the human body, affecting metabolic processes. This is one reason very high fevers can be dangerous.
So, denaturation alters the structure and function of proteins, making it crucial in both culinary and biological contexts.
4. Glucose exists in two cyclic forms in solution: α-glucose and β-glucose, which differ in the configuration of the hydroxyl group at the anomeric carbon (C1). These two forms interconvert through the open-chain form in a process known as mutarotation, leading to an equilibrium mixture.
Impact on sweetness and food behaviour:
Sweetness Variation: α- and β-anomers have slightly different levels of sweetness. The mutarotation causes a dynamic balance of sweetness perception in foods containing glucose.
Texture and Crystallisation: Mutarotation affects how glucose interacts with other ingredients and its crystallisation behaviour. In candies or syrups, this influences the smoothness and shelf life of the product.
Stability in Processing: During food processing (especially heating), the interconversion can affect reaction rates, such as in caramelisation or Maillard reactions, altering the flavour and colour.

CASE BASED QUESTIONS (4 Mark)

1. (i) Reducing sugars are carbohydrates that reduce Fehling's solution and Tollen's reagnet e.g. glucose.
(ii) Monosaccharide-Fructose and Galactose
Diasaccharides -Sucrose and Lactose
(iii) (a) Glycogen in known animal starch. Glycogen is called animal starch because it stores glucose in animals.

OR

(b) (1) The isomers of glucose that differ only in the configuration of the hydroxyl group at C_1 in their cyclic forms are called anomers.

(2) The presence of an aldehyde group is detected when glucose react with bromine water.

2. (i) Essential amino acids are the amino acids that cannot be synthesised by the human body and must be obtained through the diet.

(ii) The Zwitterionic form of amino acids is a state in which the amino acid molecule has an equal number of positively and negatively charged functional groups, resulting in overall net charge of zero.

(iii) (a) (1) Fibrous protein: Keratin
Globular protein: Insulin

(2) Peptide bond holds together monomer unit of proteins.

OR

(b) (1) The structural feature that characterises a reducing sugar is the presence of a free aldehyde or ketone group.

(2) The main structural difference between a nucleoside and a nucleotide is that a nucleotide has one or more phosphate group while a nucleoside does not.

3. (i) Vitamin B_6 is also known as pyridoxine.

(ii) Vitamin K deficiency can cause increased blood clotting time.

(iii) (a) Vitamin A deficiency causes Xerophthalmia. Sources of vitamin A are fish oil and carrots

OR

(b) Vitamin C cannot be stored in body because it is water soluble vitamin and is excreted in urine. Scurvy is a disease caused by deficiency of vitamin C.

4. (i) Two functions of DNA are:

(1) DNA carries the genetic code

(2) It transmits genetic information from one generation to next.

(ii) When a nucleotide from DNA containing adenine is hydrolysed the products are adenine 2-deoxy ribose and phosphoric acid.

(iii) (a) Nucleic acids are chemical compounds that are found in nature and are made up of nucleotides. The main difference between a nucleoside and a nucleotide is that a nucleotide has a phosphate group attached while a nucleoside does not.

OR

(b) One similarity between DNA and RNA is that they both have four bases L: adenine guanine cytosine and either thymine or uracil.

The difference is that DNA contains thymine while RNA contains uracil.

5. (i) Pentaacetate of glucose does not react with hydroxylamine because it lacks a free aldehyde group.

(ii) Vitamin C cannot be stored in our body because it is water soluble vitamin and is excreted in urine.

(iii) (a) (1) A peptide bond (—CONH—) is an amide covalent bond which is formed by the condensation two α–amino acids.

(2) Denaturation is a physical change that occurs when a protein loses its secondary and teritary structures due to external stress. This process can be caused by strong acids or bases, heat, alcohol or inorganic salts. Denaturation result in the loss of a protein's biological activity.

OR

(b) (1) Anomers are stereo isomers of sugars that differ only in the configuration of hydroxyl group at C_1 position. They are not mirror image of each other.

(2) When two monosaccharides are joined together by an oxide linkage formed by loss of water molecule such linkage between two monosaccharide units is called glycosidic linkage.

6. (i) Peptide linkage form between amino acids while glycosidic linkage form between monasaccharides.

(ii) Amino acid which cannot be produced by our body so they must be supplied in the human diet.

(iii) (a) The two most common types of secondary structure in proteins are alpha helix and beta pleated sheets.

The main forces which stabilise the secondary and tertiary structures of proteins are hydrogen bonds, disulphide linkage vander Waals and electrostatic forces of attraction.

OR

(b) Denaturation of protein is an irrevesible change in which protein get precipitated when they are heated with alcohol concentrated in organic acids or by salt. During this process biological activity of protein is lost. Example. boiling of an egg.

During denaturation, the secondary and tertiary structures of a protein are destroyed.

7. (i) The linkage that connects monsaccharides units in polysaccharides is a glycosidic linkage.

(ii) When sucrose is hydrolysed it produces an equimolar mixture of glucose and fructose

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

(iii) (a)

S.No.	Amylose	Amylopectin
1.	It is a linear polymer of α-D-glucose.	It is a branched chain polymer of α-D-glucose units.
2.	In amylose C_1 of one glucose unit is attached to C_4 of other glucose through α-glycosidic linkage.	It contain $C_1 - C_4$ α-glycosidic linkage as well as $C_1 - C_6$ α- glycosidic linkage.

OR

(b) (1) Reducing sugars are carbohydrates that reduce Fehling's solution and Tollen's reagent e.g. glucose.

(2) Sucrose is a dextrorotatory on hydrolysis. It produce a mixture of glucose and fructose having specific rotation +52.5° and –92.4°. Thus, the respectively net result and mixture become laevorotatory.

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i) Enzymes are biological macromolecules, mostly proteins, that act as catalysts in biochemical reactions. Some enzymes may also be RNA-based (ribozymes), but most digestive enzymes are proteinaceous in nature.

(ii) Enzymes accelerate biochemical reactions by lowering the activation energy required for the reaction to occur. They do not undergo permanent change themselves and can be reused. In digestion, enzymes help breakdown large food molecules into smaller, absorbable units.

(iii) Enzymes are highly specific due to the unique 3D structure of their active sites, which only fit specific substrate molecules (like a lock and key).

Temperature affects enzyme activity by altering their structure:

(1) Moderate increase in temperature generally increases activity.

(2) High temperatures can denature enzymes by disrupting hydrogen bonds, leading to loss of function.

(3) Low temperatures slow down enzyme action but don't denature them.

(iv) Two examples of digestive enzymes and their substrates are:

(1) Amylase – Acts on starch to break it down into maltose and glucose.

(2) Pepsin – Acts on proteins in the stomach to break them into peptides.

2. (i) Denaturation of proteins refers to the disruption of the native 3D structure of a protein, caused by physical or chemical agents such as heat, pH changes, or chemicals. Although the primary structure remains intact, the secondary and tertiary structures unfold, leading to loss of biological function.

(ii) Protein structure is classified into four levels:

(1) **Primary structure:** Linear sequence of amino acids.

(2) **Secondary structure:** Local folding into α-helix or β-pleated sheets due to hydrogen bonding.

(3) **Tertiary structure:** 3D folding due to interactions between R-groups (e.g., ionic, hydrogen bonds, disulphide bridges).

(4) **Quaternary structure:** Arrangement of two or more polypeptide chains (e.g., haemoglobin has 4 sub-units).

(iii) Haemoglobin, a globular protein, transports oxygen from the lungs to tissues and carries carbon dioxide back to the lungs for exhalation. It's essential for respiration.

(iv) Proteins are crucial for:

(1) Growth and development of muscles, tissues, and enzymes.

(2) Repairing cells and making new ones.

(3) Supporting immune function through antibodies.

3. (i)

Feature	DNA (Deoxyribonucleic Acid)	RNA (Ribonucleic Acid)
Sugar	Deoxyribose	Ribose
Bases	A, T, G, C	A, U, G, C (Uracil replaces Thymine)
Structure	Double-stranded helix	Single-stranded
Function	Carries genetic blueprint for heredity	Helps in protein synthesis (mRNA, tRNA, rRNA)
Stability	More stable due to double helix	Less stable, short-lived

(ii) Nucleotides are the basic building blocks of nucleic acids. Each nucleotide consists of:

(1) A nitrogenous base (Adenine, Guanine, Cytosine, Thymine or Uracil)

(2) A pentose sugar (deoxyribose in DNA, ribose in RNA)

(3) A phosphate group

They are formed by linking a base to a sugar (nucleoside), followed by attachment of a phosphate group to form a nucleotide.

(iii) Hydrogen bonds between complementary base pairs (A=T with 2 H-bonds, G≡C with 3 H-bonds) hold the two strands of DNA together. These bonds, although individually weak, collectively provide significant stability and specificity to the double helix.

(iv) **Production of human insulin:** Genes coding for insulin are inserted into bacteria like E. coli. These genetically modified bacteria produce recombinant human insulin, which is then purified and used to treat diabetic patients.

4. (i) Artificial sweeteners are synthetic sugar substitutes that provide a sweet taste like sugar but contain little to no calories. They are often used in diet foods and beverages to reduce sugar intake without compromising taste.

(ii) **Structure:** Artificial sweeteners have different chemical structures than glucose or sucrose, and many are not carbohydrates.

Function: Unlike natural sugars, they are not metabolised to release energy or raise blood glucose levels significantly. They bind to sweet taste receptors on the tongue but pass through the digestive system mostly unchanged.

(iii) Two examples of artificial sweeteners and their applications are:

(1) **Aspartame**

Application: Used in diet sodas, sugar-free chewing gum, and low-calorie desserts.

It is 180–200 times sweeter than sugar and provides negligible calories in small amounts

(2) **Saccharin**

Application: Used in sugar-free tablets, toothpaste, and diabetic-friendly foods. It is 300–700 times sweeter than sugar and was one of the first artificial sweeteners discovered.

(iv) Artificial sweeteners are considered safe because they do not raise blood glucose levels, making them ideal for people with diabetes. Since they aren't metabolised like glucose, they help diabetic patients manage sugar intake while still enjoying sweet-tasting foods.