

Unit 5: Enzymes

Short Questions

SHORT ANSWER QUESTIONS EXERCISE

Q1. Define enzyme and co-factor.

Ans. Enzymes

Enzymes are three-dimensional globular proteins, that speedup specific chemical reactions by lowering the required activation energy.

Co-factor

The additional non-protein chemical components used by enzymes, to aid in catalysis are called co-factors. For example, metal ions, prosthetic groups and coenzymes.

Q2. Differentiate between co-enzyme and prosthetic group.

Co-enzyme	Prosthetic Groups
- When the cofactor is a non-protein organic molecule and is loosely attached (hydrogen bond) with enzyme, it is called coenzyme. - Coenzymes participate in enzyme-catalysed reactions, often by transporting electrons (hydrogen atoms); from one enzyme to another. - Many vitamins (e.g., niacin and riboflavin) function as coenzymes.	- Some cofactors form covalent bonds with enzyme and are known as prosthetic groups. - Prosthetic group may be an organic compound e.g., hematin also known as heme, is a part of hemoglobin and myoglobin, it acts as prosthetic group in enzymes like catalyses and peroxidases.

Q3. What do you mean by hydrolases? Give two examples.

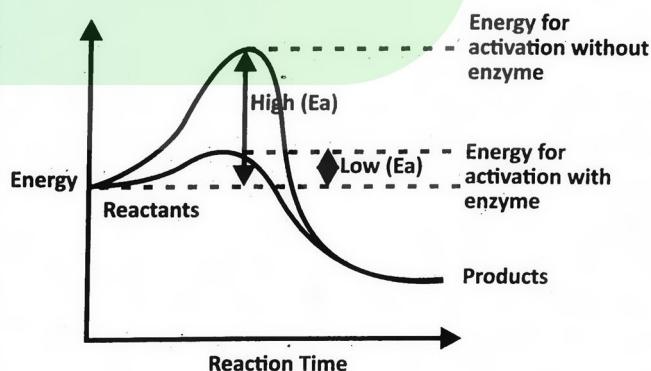
Ans. Hydrolases

These enzymes catalyse hydrolysis reactions. They break their substrates into monomers by adding water.

For example; **lipase** (hydrolyze lipids into fatty acids and glycerol), **amylase** (catalyse the hydrolysis of starch to maltose), **peptidase**, and other digestive enzymes catalyse the hydrolysis of food molecules.

Q4. What is meant by activation energy?

Ans. The speed of a chemical reaction depends on the amount of activation energy required to initiate it. Activation energy is the energy which works to **destabilize existing chemical bonds**. Enzymes bring reactants together in correct orientation or required for new bonds to form and speed up the rate of reactions.



Q5. Define feedback inhibition.

Ans. Feedback inhibition is the phenomenon where the product of a process controls the process itself, often-times limiting the production of more products.

For example, when a cell has a greater number of ATP than its requirement, ATP itself acts as a non-competitive inhibitor and blocks the enzyme that catalyses ATP synthesis.

Q6. Give examples of competitive and non-competitive inhibitors.

Ans. Competitive Inhibitors: The enzyme **succinic dehydrogenase** catalyses the oxidation of succinic acid to fumaric acid. Malonic acid has structural similarity with substrate (succinic acid). So, both of them compete for active site of enzyme. Malonic acid is selected by active site and thus blocks it. Competitive inhibitors are used as antibiotics to kill bacteria.

Non-Competitive Inhibitors: Two substrates i.e. succinic acid and CoA react to form succinyl-CoA. This reaction is catalysed by enzyme succinyl-CoA

synthetase. After its formation, the product i.e., succinyl CoA acts as non-competitive inhibitors and binds with enzyme. Thus enzyme is inhibited and no more succinyl-CoA is produced.

Q7. What is optimum pH? Give optimum pH of three human enzymes.

Ans. Every enzyme works its best at a specific pH, called its **optimum pH**. For example, **pepsin** is active in acidic medium (low pH) while trypsin shows its optimum activity in alkaline medium (high pH). Optimum pH of pepsin is 1.5 – 1.6, salivary amylase is 4.6 – 5.2 and of trypsin is 7.8 – 8.7.

SLO BASED SHORT QUESTION ANSWERS

Enzymes

Q8. How do enzymes speed up specific chemical reactions? Write the rates at which they catalyze reactions.

Ans. Enzymes are specific proteins that speed up specific chemical reactions by lowering the required activation energy, but are unaltered themselves in the process. Enzymes are also known as biocatalysts. **Rates** of enzyme-catalysed reactions may be 10^3 to 10^8 times greater than the rates of corresponding uncatalyzed reactions.

Q9. Compare the time to complete the reaction with and without using enzymes.

Ans. A reaction that is catalysed by an enzyme and is completed in 30 minutes, would take one year to get completed without being catalysed by enzyme. Thus, we can say that without enzymes there would have been no life at all.

Q10. Where enzymes are synthesized? What happens after their synthesis?

Ans. All enzymes are synthesized inside cells by ribosomes. After their synthesis,

either they stay and work inside cell or they are secreted out to work at other sites.

- Inside cell, many enzymes are **dissolved in cytoplasm**; for example, the enzymes of glycolysis.
- Many are tightly **bound to membranes** of certain organelles, for example, the enzyme of Calvin cycle and Krebs cycle.
- Some enzymes are **integral part of ribosomes**; for example, the enzymes of protein synthesis.

Q11. Define active site. Describe its regions.

Ans. There is a small cleft or depression on the surface of globular enzyme molecule. It consists of only a few amino acids. This site is known as active site. It is the location at which catalysis occurs.

Regions: Active site has two distinct regions i.e., binding site and catalytic site.

- **Binding site:** Substrate molecule fits into binding site by weak chemical forces, such as hydrogen bonds.
- **Catalytic site** catalyses the reaction and substrate is transformed into products.

Cofactors and Coenzymes

★Q12. How apoenzyme differs from holoenzyme?

Ans. The protein part of enzyme is called **apoenzyme** and complete enzyme including co-factor is called **holoenzyme**.

Q13. How does metal ions are used as co-factors by enzymes?

Ans. **Metal ions**

- Many enzymes use metal ions, such as Ca^{+2} , Mg^{+2} , Mn^{+2} , Cu^{+2} and Zn^{+2} as their cofactors. These metal ions change the non-functional active sites of enzymes into functional sites.
- The attachment of a cofactor also changes the shape of enzyme and allows it to combine with substrate.

★Q14. Some enzymes may prove harmful. Justify?

Ans. Some enzymes may prove harmful, if become **active at wrong place**. For example; pepsin is a protein digesting enzyme. It can destroy protein-made structures present inside cells where it is synthesized. That is why it is produced in inactive form (pepsinogen) and is secreted out of cells. When it reaches its target site of action, it is activated (pepsin).

★Q15. Can trace elements be used as co-factors?

Ans. Many trace elements such as **molybdenum** and **manganese**, which are

necessary for our health, are used by enzymes as cofactors.

Q16. The most important co-enzyme in cell is NAD^+ , comment. / Describe the role of NAD^+ as co-enzyme.

Ans. The most important coenzyme in cell is the hydrogen acceptor nicotinamide adenine dinucleotide (NAD^+). When NAD^+ acquires a hydrogen atom from an enzyme, it reduces to NADH . The electron of hydrogen atom contains energy that NADH molecule carries.

For example, when food is oxidized in cell, enzymes draw electrons from food molecules and transfer them to NAD^+ , which reduces to NADH .

Q17. How complex metabolic pathways in a cell are regulated by enzymes? / Describe the behaviour of enzymes in regulating complex reactions/metabolic pathways?

Ans. In complex metabolic pathways e.g., respiration, photosynthesis, protein synthesis etc., many enzymes act in a sequence and regulate the steps of pathway. The successive enzymes controlling these steps are present together along with their cofactors. The products from one enzyme's catalysis serve as substrate for the enzyme of next step and are transformed into next products. The series goes on and finally end products are formed that inhibit (through feedback) the first enzyme.

Mechanism of Enzyme Action

Q18. Different between lock and key model and induced fit model of enzyme action.

Ans.

Lock and Key Model	Induced Fit Model
• In 1894 a German chemist Emil Fischer proposed lock-and-key model. • According to this model, "as a specific key can open only a specific lock, in the same manner a specific enzyme can transform only one specific substrate into products".	• American biochemist Daniel Koshland in 1958 presented induced fit model. • According to this model, "when a substrate combines with the binding site of an enzyme it induces change in enzyme structure. • This model postulates that active site is not a rigid structure and is capable of going

- This model postulates that **active site** is a **rigid structure** and there is no modification or flexibility in it before, during or after the enzyme action.

under modification and flexibility, before the enzyme action (catalysis) starts.

Factors Affecting the Rate of Enzyme Action

Q19. Define optimum temperature. What happens when the temperature falls below the optimum temperature?

Ans. Optimum Temperature: Every enzyme works at its maximum rate at a specific temperature called its **optimum temperature**. The optimum temperature for human enzymes is 37°C .

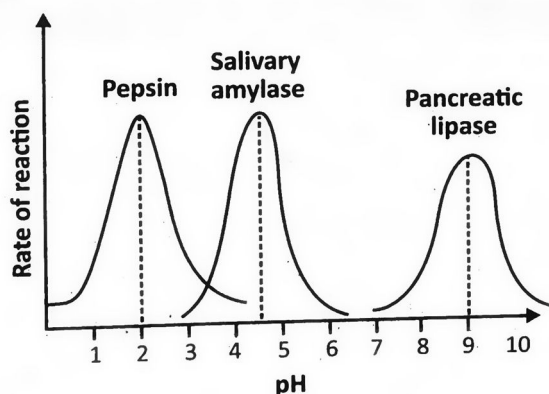
At Low Temperature: When temperature fall below optimum temperature, the bonds that determine enzymes shape become **less flexible**. They do not permit the induced change in active sites that is necessary for enzyme action and so reaction rate is slow.

Q20. If the temperature is raised above optimum temperature, what are its consequences?

Ans. When temperature is raised well above optimum temperature, the heat energy increases the vibrations of atoms of enzyme molecules. When **vibrations** become **too violent**, bonds cannot hold polypeptide chains in the proper position and globular structure of enzyme is lost. This phenomenon is known as **denaturation of enzyme**. It results in a rapid decrease in the rate of enzyme action and it may be blocked completely.

Q21. Draw a graph showing the effect of pH on pepsin, salivary amylase and pancreatic lipase.

Ans.



Q22. How does reaction rate proceeds on adding more enzymes at unlimited and limited substrate concentration?

Ans. The overall rate of enzyme-controlled reactions depends directly on the amount of enzyme present at a specific time (if substrate concentration is unlimited). When enzyme concentration increases, there are more enzyme molecules and more active sites. So, more substrate molecules bind with new active sites and are transformed into products. If enzyme concentration goes on increasing but substrate concentration remains the same, no more substrate molecules will be remaining to attach with enzymes. So, the rate of reaction stays constant and does not increase further.

Q23. What is the effect of substrate concentration on reaction rate?

Ans. If there are enzyme molecules with vacant active sites, an increase in substrate concentration will increase the rate of reaction. If enzyme concentration is kept constant and the amount of substrate is increased, a point is reached where any further increase in substrate does not increase the rate of reaction any more.

Enzyme Inhibition

Q24. Differentiate between inhibitor and inhibition?

Ans.

Inhibitor	Inhibition
A chemical that interferes and blocks active site, hence blocking an enzyme's activity is called an inhibitor.	Inhibitors attach with enzymes but are not transformed into products and thus block active sites temporarily or permanently. This phenomenon is known as enzyme inhibition.

★Q24. How does cyanide act as irreversible inhibitor?

Ans. The poison cyanide is an irreversible enzyme inhibitor that combines with copper

and iron in the active site of enzyme cytochrome oxidase and blocks cellular respiration.

Q25. Differentiate between reversible and irreversible inhibitors?

Ans.

Reversible	Irreversible
- Reversible inhibitors make weak bonds i.e. hydrogen bonds with enzyme. - Such inhibitors can be released and the inhibition caused by them can be neutralized by increasing the concentration of substrate. For example, malonate is a reversible inhibitor. It temporarily slows down the reaction by blocking the enzyme succinate dehydrogenase, which is involved in cellular respiration. This inhibition can be reversed when malonate is removed.	- Irreversible inhibitors make covalent bonds with enzyme. - Such inhibitors cannot be released by dilution or dialysis or by increasing the concentration of substrate. For example, penicillin permanently disables the enzyme responsible for building bacterial cell walls.

Q26. Describe three significances of enzyme inhibition?

Ans. **Significance of Enzyme inhibition**

- Many drugs work as **inhibitors**. For example, antibiotics inhibit the enzymes of bacteria, while cancer drugs may inhibit enzymes involved in cell division.
- Enzyme inhibitors are used to manage various **medical conditions**. For example, some inhibitors of enzymes involved in blood clotting are used as anticoagulants.
- Some toxins and poisons inhibit important enzymes in the body. Understanding how these inhibitors affect enzymes can be critical in **treating cases of poisoning**.

Classification of Enzymes

Q27. Name the classes of enzyme on the basis of reactions?

Ans. The classes of enzymes on the basis of reactions:

- Oxidoreductases
- Transferases

3. Hydrolases

5. Isomerases

4. Lyases

6. Ligases

Q28. Compare oxidoreductases with transferases.

Ans.

Oxidoreductases	Transferases
- These enzymes catalyse the oxidation / reduction of their substrates. They add or remove H^+ ions or electrons from substrates. - For example, cytochrome oxidase catalyses the oxidation of cytochrome.	- The enzymes of this class catalyse the transfer of a specific functional group (e.g., methyl, acyl, amino, or phosphate) from one substrate to another. - For example, hexokinase transfers phosphate group from ATP to glucose.

Q29. Differentiate between hydrolases and isomerases?

Ans.

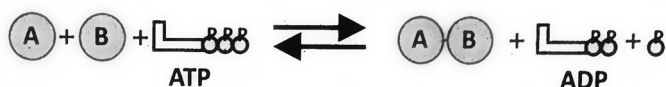
Hydrolases	Isomerases
- These enzymes catalyse hydrolysis reactions. They break their substrates into monomers by adding water. - For example; lipase, amylase, peptidase, and other digestive enzymes catalyse the hydrolysis of food molecules.	- These enzymes catalyse the intra-molecular rearrangement i.e., one isomer is converted into another. - For example, hexose isomerase converts glucose to fructose.

Q30. How lyases differ from ligases?

Ans.

Lyases	Ligases
- These enzymes catalyse non-hydrolytic addition or removal of groups (e.g., CO₂, NH₂ etc.) from substrates. - For example, pyruvate decarboxylase removes CO₂ from pyruvic acid.	- These enzymes catalyse the reactions in which two molecules join by forming new C-C, C-N, C-O, or C-S bonds, using energy from ATP. - For example, polymerase enzymes (DNA polymerase, RNA polymerase) join monomers by using ATP.

Q31. Name the enzyme of the reaction. Write its sub-classes?



Ans. Enzyme: Ligases

Subclasses

- (i) C-C ligases (ii) C-O ligases
(iii) C-N ligases

Q32. How nucleases differ from lipases?

Ans.

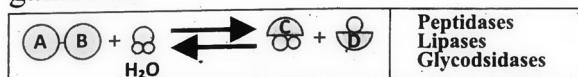
Lipases	Nucleases
- These enzymes act upon lipids and catalyse their breakdown. - For example, pancreatic lipase hydrolyses lipids into fatty acids and glycerol.	- These enzymes act upon nucleic acids and catalyse their breakdown. - For example, RNAase, DNAase ATPase are responsible for the breakdown of RNA, DNA and ATP respectively.

Q33. What are Carbohydrases? Give examples.

Ans. Carbohydrases: These enzymes act upon bigger carbohydrates and break them into smaller units.

For example

- Amylase** acts upon starch or glycogen and breaks them into maltose.
- Cellulase** breaks cellulose into cellobiose (a disaccharide) or glucose.
- Maltase** breaks down maltose into glucose.
- Sucrase** breaks sucrose into glucose and fructose.
- Lactase** breaks lactose into glucose and galactose.



Q34. Illustrate the role of proteases in metabolism with examples?

Ans. Proteases: This group included the enzymes which catalyse the **breakdown** of proteins.

For example, pepsin and trypsin enzymes catalyse the breakdown of large polypeptides into smaller polypeptides.

- **Aminopeptidases** further breakdown small polypeptides into dipeptides.
- **Erypsin** breaks dipeptides into amino acids.

Q35. Give sub-classes of oxidoreductases and transferases?

Ans.

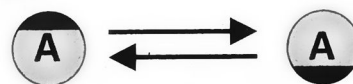
Enzymes	Sub-Classes
Oxidoreductases	Dehydrogenases Oxidases Reductases
Transferases	Phospho-transferases Amino-transferases Acyl-transferases

Q36. Write down the sub-classes of hydrolases and lyases?

Ans.

Enzymes	Sub-Classes
Hydrolases	Peptidases Lipases Glycosidases
Lyases	Decarboxylases Aldolases Synthases

Q37. Identify the enzyme and writes its sub-classes?



Ans.

Enzyme	Reaction Type	Sub-Classes
Isomerases		Epimerases Mutases Cis trans isomerases

LONG QUESTIONS (EXERCISE)

Q1. Describe the structure of enzyme, explaining the role and component parts of the active site of an enzyme.

Ans. See Q1. of theory.

Q2. Differentiate among the three types of co-factors, by giving examples.

Ans. See Q2. of theory.

Q3. Explain the mechanism of enzyme action through induced Fit Model, comparing it with Lock and Key Model.

Ans. See Q4. of theory.

Q4. Define activation energy and explain through graph how an enzyme speeds up a reaction by lowering activation energy.

Ans. See Q3. of theory.

Q5. Describe the effect of temperature on the rate of enzyme action.

Ans. See Q5. of theory.

Q6. Compare the optimum temperatures of enzymes of human and thermophilic bacteria.

Ans. See Q5. of theory

Q7. Describe how the concentration of enzyme affects the rate of enzyme action.

Ans. See Q7. of theory.

Q8. Explain the effect of substrate concentration on the rate of enzyme action.

Ans. See Q8. of theory.

Q9. Describe enzymatic inhibition, its types and its significance.

Ans. See Q9. of theory.

Q10. Categorize inhibitors into competitive and non-competitive inhibitors.

Ans. See Q9. of theory.

Q11. Explain feedback inhibition.

Ans. See Q10. of theory.

Q12. Classify enzymes on the basis of the reactions catalysed.

Ans. See Q11. of theory.

Q13. Give examples of enzymes' naming according to substrates.

Ans. See Q12. of theory.

INQUISITIVE QUESTIONS

Q1. Does physical exercise involve anabolic processes, catabolic processes, or both? Give evidence for your answer.

Ans. Yes, physical exercise involves both anabolic and catabolic processes.

Evidence for Catabolism

During exercise, energy is required for muscle contraction, our cells breakdown glucose aerobically to form ATP. Doing exercise is the evidence that we are continuously being provided with energy, which is brought by catabolism of glucose.

Evidence for anabolism

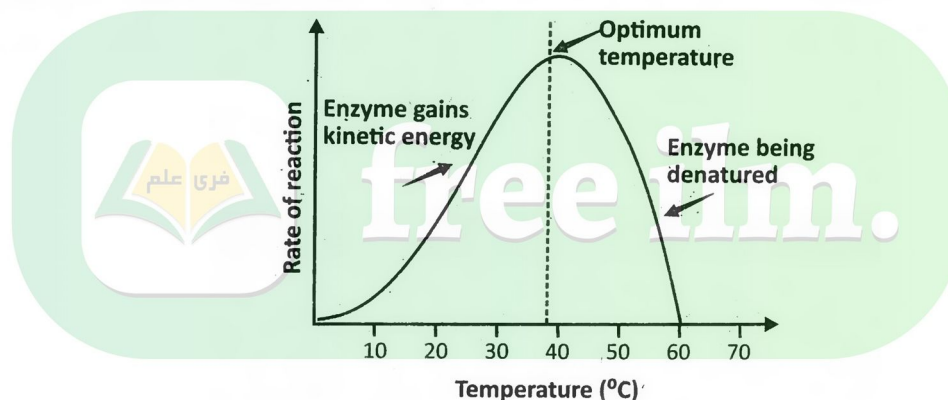
In doing physical exercise daily, we gain muscle mass, which is an anabolic process providing the evidence of muscle repair and growth.

Q2. If a chemical reaction could occur without an enzyme, why is it important to have one?

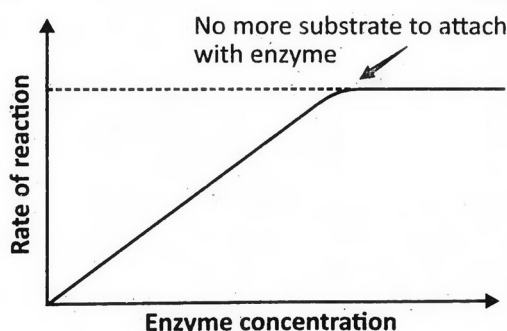
Ans. A reaction that is **catalysed** by an enzyme and is completed in **30 minutes**, would take **one year** to get completed without being catalysed by enzyme. Thus, we can say that without enzymes there would have been no life at all.

Q3. Construct and interpret graphs based on data about the effect of temperature, enzyme concentration and substrate concentration on the rate of enzyme action.

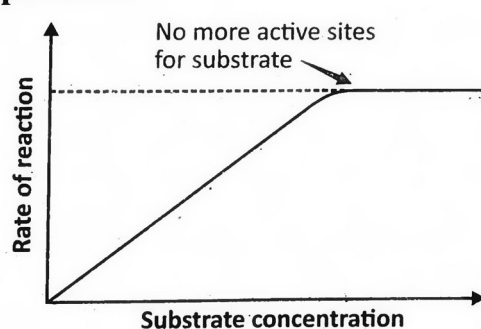
Ans.



Effect of temperature



Effect of enzyme concentration



Effect of substrate concentration

Q4. Identify the competitive and non-competitive inhibitors from a list of chemical used in daily life.

Ans.

Competitive Inhibitors	Non-Competitive Inhibitors
• Malonic Acid • Sulfa drug • Anti-biotics	• Aspirin • Cyanide • Succinyl CoA