7 CHAPTER

ENZYMES

7.1 METABOLISM AND ITS TYPES

LONG ANSWER QUESTIONS

Q.2 Describe metabolism and its types. (K.B)

Ans:

METABOLISM

Definition:

Metabolism is the sum of all **chemical reactions** that occur within an organism to sustain life.

Types of Metabolism:

There are two sub-sets of metabolism i.e., **catabolism** and **anabolism**.

1. **Catabolism**

   It involves the **breakdown of complex molecules** into simpler ones, releasing energy in the process.

   For Example:

   - **Cellular respiration** i.e., oxidation of food (glucose) into CO_2 and H_2O to get energy.
   - **Lipolysis** i.e., break-down of lipids (fats) into **fatty acids** and **glycerol**, which can be used for energy production.

2. **Anabolism**

   Anabolism involves **building up complex molecules** from simpler ones. This process consumes energy.

   For Example:

   - **Photosynthesis** i.e., conversion of carbon dioxide and water into glucose and oxygen using sunlight.
   - **Protein synthesis** i.e., formation of proteins from amino acids, which are vital for cell structure and function.

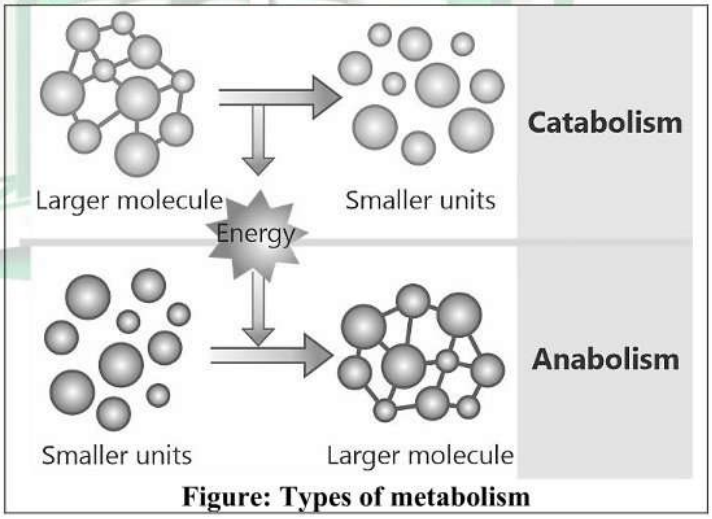

Figure: Types of metabolism

7.2 ENZYMES

LONG ANSWER QUESTIONS

Q.1 Describe the characteristics of enzymes. (K.B)

Ans:

CHARACTERISTICS OF ENZYMES

Definition:

Enzymes are **biological catalysts** that speed up chemical reactions in living organisms without being consumed in the process.

Characteristics of Enzymes:

1. **Chemical Nature of Enzymes**
   - Enzymes are predominantly **proteins**.

- Typically, they contain 100 to 1,000 amino acids.

Ribozyme:

- Some RNA molecules also act as enzymes. Such RNA is called **ribozyme**.
- Ribozymes are primarily found in **ribosome**.
- They are also found in specific **viruses** and **bacteria**.

2. **Globular Structure**
   - Enzymes possess a **three-dimensional globular** structure.
   - This structure allows them to form active sites that can bind specifically to substrates.
3. **Specificity of Enzymes**
   - Enzymes are highly **specific** to the reactions they catalyse.
   - They are also very specific for the nature of substrate.

Example:

The enzyme **amylase** specifically catalyses the breakdown of starch into simple sugars.

4. **Intracellular and Extracellular Enzymes**

Enzymes can be classified based on the **location** where they function.

Intracellular Enzymes:

Intracellular enzymes operate **within cells** e.g., enzymes of cellular respiration.

Extracellular Enzymes:

Extracellular enzymes are secreted **outside** the cells to catalyse reactions e.g., enzymes secreted by the cells of **stomach** walls into stomach cavity for the digestion of food.

5. **Cofactors of Enzymes**

Many enzymes require additional **non-protein molecules** to be fully active. Such non-protein molecules are called **cofactors**.

Groups of Cofactors:

There are two main groups of cofactors. i.e., inorganic cofactors and organic cofactors.

1. **Inorganic Cofactors**
   Inorganic cofactors include **metal ions** like **iron** and **magnesium** ions.
2. **Organic Cofactors**
   The organic cofactors are of two types.
   a) **Prosthetic groups** tightly bind with the enzymes. Example are certain **vitamins** (e.g., biotin) and the **haem** group.
   b) **Coenzymes** loosely bind to the enzyme and may be released during the reaction. Examples include many **vitamins** and **nucleotides** (NAD and NADP).

6. **Enzyme Actions in Complex Metabolic Reactions**
   - Enzymes often function in **pathways**.
   - Multiple enzymes work in a sequence to carry out a series of reactions.
   - Each enzyme in the pathway catalyses a specific step.
   - After speeding up the reaction, the product is passed on to the next enzyme for further reaction.

Q.2 Write down the uses of enzymes. (K.B)

Ans:

USES OF ENZYMES

Use of Enzymes in Different Industries:

Enzymes have extensive applications in various **industries**. For example:

1. **Food Industry**
   - Enzymes that break starch into simple **sugars** are used in production of **white bread**, **buns**, and **rolls**.
   - Enzymes are also used for the production of **cheese**.
2. **Paper Industry**
   Enzymes degrade starch to lower its **viscosity** that aid in making **paper**.

3. **Biological Detergent**
   - **Protease** enzymes are used for the removal of **protein stains** from clothes.
   - **Amylase** enzymes are used in **dish washing** to remove resistant **starch residues**.
4. **Fermentation Industry**
   Enzymes degrade starch and proteins to produce simple sugar, amino acids and peptides that are used by **yeast** for **fermentation**.

SHORT ANSWER QUESTIONS

Q.1 Define metabolism. **(K.B)**

Ans:

METABOLISM

Metabolism is the **sum of all chemical reactions** that occur within an organism to sustain life.

Types of Metabolism:

There are two sub-sets of metabolism i.e., **catabolism** and **anabolism**.

Q.2 Differentiate between catabolism and anabolism. **(K.B)**

Ans:

DIFFERENTIATION

The difference between catabolism and anabolism is as follows:

Catabolism	Anabolism
It involves the **breakdown** of complex molecules into simpler ones.	It involves **building up** complex molecules from simpler ones.
Energy	
Energy is **released** in catabolism.	Energy is **utilized** in anabolism.
Example	
• Respiration • Digestion • Lipolysis	• Photosynthesis • Protein synthesis • Glucose condensation to glycogen

Q.3 What are enzymes? **(K.B)**

Ans:

ENZYMES

Enzymes are **biological catalysts** that **speed up** chemical reactions in living organisms without being consumed in the process.

OR

Enzymes are proteins except **ribozymes** that catalyze (i.e., speed up) biochemical reactions and are not changed during the reaction.

Q.4 What is the role of enzymes in metabolism? **(K.B)**

Ans:

ENZYMES AND METABOLISM

Usually, energy is released in **catabolism** and it is utilized in **anabolism**. During metabolism, chemicals are transformed from one form to other by enzymes. Enzyme are important for metabolism because they act as biocatalyst and speed up and regular **metabolic pathway**.

Q.5 Differentiate between intracellular and extracellular enzyme. **(A.B)**

Ans:

DIFFERENTIATION

Intracellular Enzyme	Extracellular Enzyme
DEFINITION	
The enzymes which remain **inside the cells** to speed up the reactions.	Enzymes that are made inside the cells but allowed to **go out of the cells** to do their work outside.
EXAMPLE	
Enzyme of glycolysis working in cytoplasm	**Pepsin enzyme** working in the stomach cavity.

Q.6 What are the characteristics of Enzymes? (K.B)

Ans:

ENZYME CHARACTERISTICS

Enzyme having following characteristics:

Enzymes are Proteins:

- Enzymes are predominantly **proteins**.
- Typically, they contain 100 to 1,000 amino acids.

Enzymes Increase Rate of Reaction:

Enzymes **speed up** the reactions millions of times faster as compared to non-catalyzed reaction.

Enzymes are Specific:

Enzymes are **highly specific** to the reactions they catalyse. They are also very specific for the nature of substrate.

Q.7 Give the examples of co-factors. (K.B)

Ans:

DEFINITION

Many enzymes require a **non-protein helper** molecule called co-factor, for their proper working.

Types:

There are three types:

i. **Activator:** e.g. zinc, iron, magnesium ions.
ii. **Prosthetic group:** e.g. Haem group.
iii. **Coenzyme:** Coenzyme A and NAD.

Q.8 Why are enzymes are required in small amounts? (U.B)

Ans:

REQUIRED IN SMALL AMOUNT

Enzymes are not changed in chemical reaction. So, they can be used **over and over again**. Thus, a very small quantity of an enzyme is capable of catalyzing a huge amount of substrate.

Q.9 What is the difference between cofactors and co-enzymes? (K.B)

Ans:

DIFFERENTIATION

The difference between cofactors and co-enzymes is as follows:

Cofactor	Coenzyme
DEFINITION	
Many enzymes require an additional **non-protein** component for their proper functioning called co-factor.	When the co-factor is a **loosely attached** organic molecule, it is called co-enzyme.
EXAMPLE	
• **Organic** – Haem group • **Inorganic** – Metal ions like iron	• **NAD** (Nicotinamide adenine dinucleotide) • Coenzyme A • Vitamin A, C

Q.10 Define cofactor. Write its types. (K.B)

Ans:

COFACTORS

Many enzymes require additional **non-protein** molecules to be fully active. Such non-protein molecules are called cofactors.

Groups of Cofactors:

There are two main groups of cofactors. i.e., inorganic cofactors and organic cofactors.

1. **Inorganic Cofactors**
   Inorganic cofactors include **metal ions** like **iron** and **magnesium ions**.
2. **Organic Cofactors**
   The organic cofactors are of two types.
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   b) **Coenzymes** loosely bind to the enzyme and may be released during the reaction. Examples include many **vitamins** and **nucleotides** (NAD and NADP).

Q.11 What is the role of enzymes in food industry? (K.B)

Ans:

ENZYMES IN FOOD INDUSTRY

Enzymes that break **starch** into **simple sugars** are used in production of **white bread**, **buns**, and **rolls**. Enzymes are also used for the production of **cheese**.

Q.12 Write down the uses of enzymes in detergent industry. (K.B)

Ans:

ENZYMES IN DETERGENT INDUSTRY

Protease enzymes are used for the removal of **protein stains** from clothes. Amylase enzymes are used in **dish washing** to remove resistant **starch residues**.

MULTIPLE CHOICE QUESTIONS

1. The term metabolism is derived from the Greek word means: (K.B)

(A) Split (B) To change
(C) Division (D) Break

2. Which of the following is not true about enzymes? (K.B)

(A) They act as biocatalysts (B) Enzymes speed up biochemical reactions
(C) They lower the activation energy (D) Enzymes are consumed in the reaction

3. Chemically enzymes are: (K.B)

(A) Proteins (B) Carbohydrates
(C) Lipids (D) Fats

4. To which group of molecules enzymes belong? (K.B)

(A) Carbohydrates (B) Proteins
(C) Nucleic acids (D) Lipids

5. The molecules on which enzymes act are called: (K.B)

(A) Substrates (B) Coenzymes
(C) Proteins (D) Enzyme substrates complexes

6. The catalytic region of enzyme is called: (K.B)

(A) Cofactor (B) Coenzyme
(C) Prosthetic group (D) Active site

7. If organic cofactors are tightly bound to enzyme, they are called: (U.B)

(A) Coenzymes (B) Prosthetic groups
(C) Cofactors (D) Vitamins

8. If organic cofactors are loosely attached with enzyme, they are called: (U.B)

(A) Coenzymes (B) Prosthetic groups
(C) Both A and B (D) None of these

9. Which one is an organic cofactor? (K.B)

(A) Flavin (B) Haem
(C) Both A and B (D) Cu^{2+}

10. Which of these is a prosthetic group? (K.B)

(A) NAD (B) FAD
(C) Coenzyme A (D) Vitamin C

11. The nature of ribozyme is: (K.B)

(A) RNA (B) Protein
(C) DNA (D) Amino acids

12. In stomach, pepsin is activated, from pepsinogen, by: (K.B)

(A) Mucous (B) HCl
(C) Brain signals (D) Food

13. Example of extracellular enzyme is? (K.B)

(A) Pepsin (B) Trypsin
(C) Both A and B (D) None of these

14. In the process of respiration, glucose molecule is a: (U.B)

(A) Product (B) Substrate
(C) Enzyme (D) By-product

15. In paper industry, enzymes break starch to lower its: (K.B)

(A) Strength (B) Viscosity
(C) Weight (D) Melting temperature

16. The residues which are removed by enzyme amylase is of: (K.B)

(A) Starch (B) Proteins
(C) Oil (D) Lipids

17. The highest metabolic rate in animals is of: (K.B)

(A) Lion (B) Humming birds
(C) Snake (D) Tiger

7.3 MECHANISM OF ENZYME ACTION

LONG ANSWER QUESTIONS

Q.1 Explain the mechanism of enzyme action in detail. (K.B)

OR

Compare the Lock-and-Key and Induced Fit models of enzyme action.

Ans:

MECHANISM OF ENZYME ACTION

Active Site:

An enzyme has one or more **pockets** or **clefts** on its surface called **active sites**. The active sites are directly involved in **catalysis**.

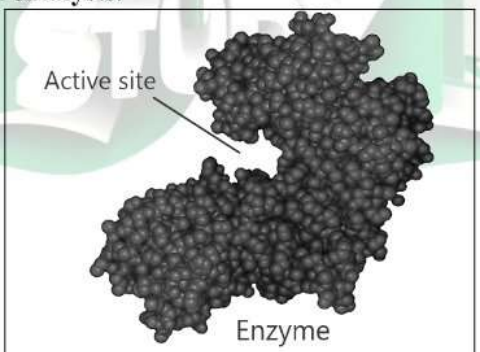


Figure: Active site of enzyme

Mechanism of Enzyme Action:

Two models have been proposed to explain the mechanism of enzyme action.

1. **Lock and Key Model of Enzyme Action**

   This model was proposed by a German chemist **Emil Fischer** in 1894.

   Explanation:

   - According to it, the active site of enzyme has a **fixed structure**.
   - The substrate molecule fits precisely into it to form an **enzyme-substrate complex**.
   - The enzyme **catalyzes** the reaction and substrate is transformed into products.
   - Then, the **product** is released from the enzyme.

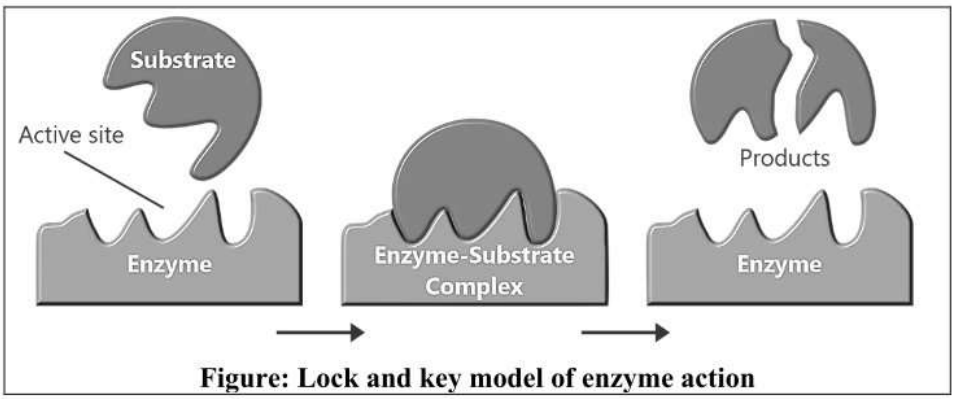


Figure: Lock and key model of enzyme action

2. **Induced Fit Model**

This model was proposed by an American biologist **Daniel Koshland** in 1958.

Explanation:

- According to this model, the active site of enzyme is **not rigid**.
- When substrate interacts with the enzyme, its active site is **reshaped** to perform its function

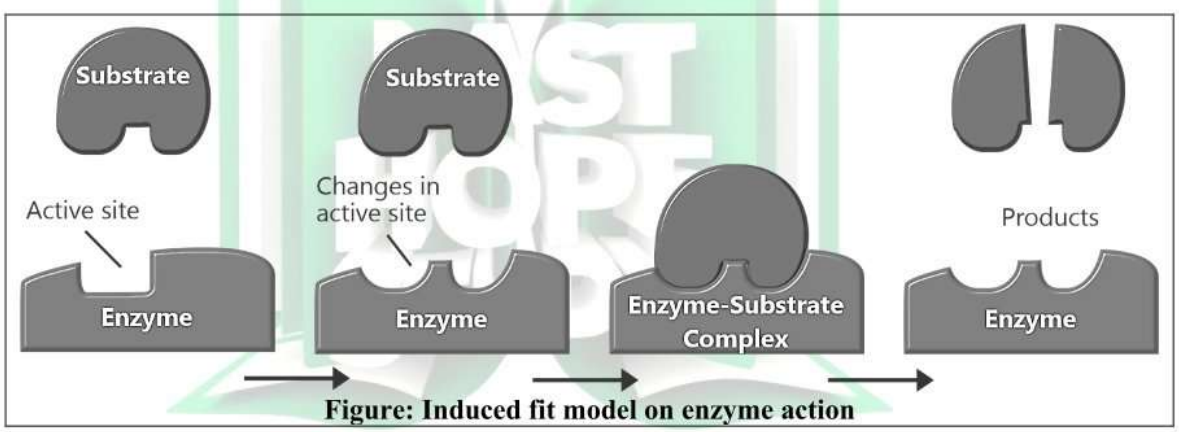


Figure: Induced fit model on enzyme action

7.4 FACTORS THAT AFFECT THE ACTIVITY OF ENZYMES

LONG ANSWER QUESTIONS

Q.1 Briefly describe the factors that affect the activity of enzymes. (K.B + U.B)

Ans: **FACTORS AFFECTING THE ACTIVITY OF ENZYMES**

Enzymes are **sensitive** to their environment. The activity of an enzyme is affected by the following factors:

1. **Temperature**

Optimum Temperature:

Each enzyme works at **maximum rate** at a specific temperature called **optimum temperature**. The optimum temperature for most of the **human enzymes** is 37°C.

Increase in Temperature:

- When temperature **rises** to a certain limit, the heat adds in the movement of molecules.
- So, the rate of enzyme action increases.

Denaturation:

- When temperature is raised well above the optimum temperature, **heat breaks** the bonds in enzyme molecule.

- In this way the globular structure of enzyme is **lost**.
- This is called **denaturation** of enzyme.
- It results in a **rapid decrease** in the rate of enzyme action.

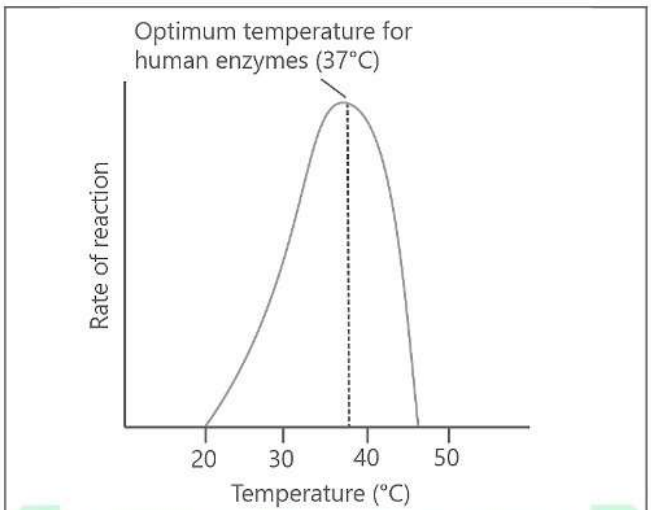


Figure: Effect of temperature on enzyme activity

2. pH

Enzymes are sensitive to **hydrogen ion concentration** (pH) of the fluid in which they work.

Optimum pH:

Enzymes show maximum activity at a **specific pH**, called their optimum PH.

Change in pH:

- Change in pH can affect the **ionization** of the amino acids at the active site of enzyme.
- It slows down enzyme activity or **blocks** it completely.
- Different enzymes have different optimum pH values.

Examples:

- **Pepsin** (working in stomach) works in **acidic medium** (pH 1.5 to 2.0).
- **Trypsin** (working in small intestine) works in **alkaline medium** (7 to 8).

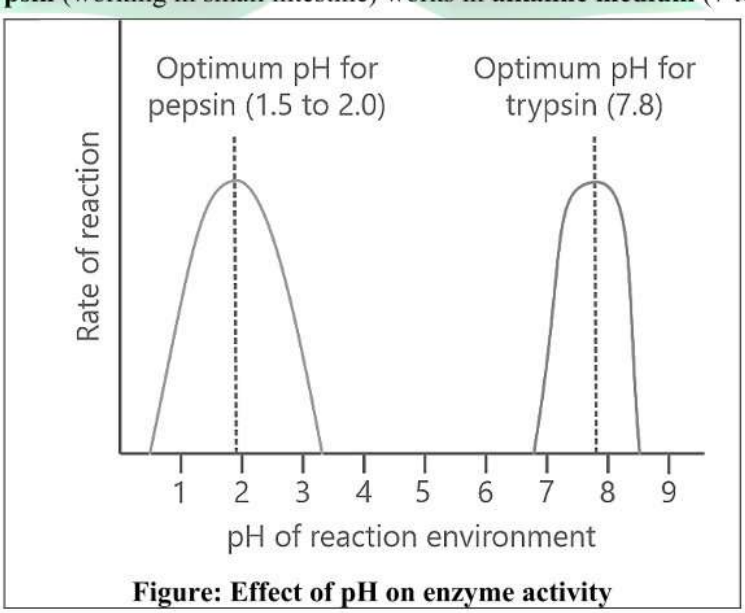


Figure: Effect of pH on enzyme activity

3. **Substrate Concentration**

An increase in substrate concentration increases the rate of reaction.

Saturation:

- At high substrate concentration, all active sites of the enzymes are **occupied**.
- In this condition, any more substrate molecules do not find free active sites.
- This state is called **saturation** of active sites and reaction rate does not increase.

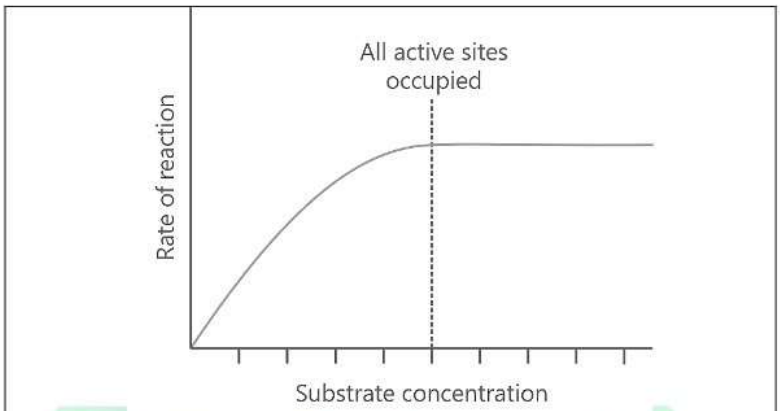


Figure: Effect of substrate concentration on enzyme activity

7.5 ENZYME INHIBITION

LONG ANSWER QUESTIONS

Q.1 Explain the concept of enzyme inhibition. (K.B)

Ans:

ENZYME INHIBITION

Definition:

Certain substances, called **enzyme inhibitors**, bind to enzyme and decrease its activity. This phenomenon is known as **enzyme inhibition**.

Types of Enzyme Inhibition:

1. **Competitive Inhibition**
   - Some inhibitors **resemble** the enzyme's substrate.
   - They **compete** with the substrate to attach to the active site of enzyme.
   - When the inhibitor is attached to the active site, it blocks it and does not allow the substrate to attach.

   Examples:
   - Examples of competitive inhibitors are **antibiotics**.
   - The antibiotic molecules compete with the substrates of **bacterial enzymes**.
   - They attach to bacterial enzymes and inhibit them.
2. **Non-Competitive Inhibition**
   - Some enzyme inhibitors do not have **similarity** to the substrate.
   - They do not attach to the active site of enzyme.
   - Rather, they attach to some other location of enzyme
   - This **attachment** changes the overall shape of enzyme and also the shape of active site.
   - So, this changed active site does not fit substrate and enzyme is inhibited.

   Examples:

   Heavy metals like **mercury** and **certain drugs** used in cancer therapy.

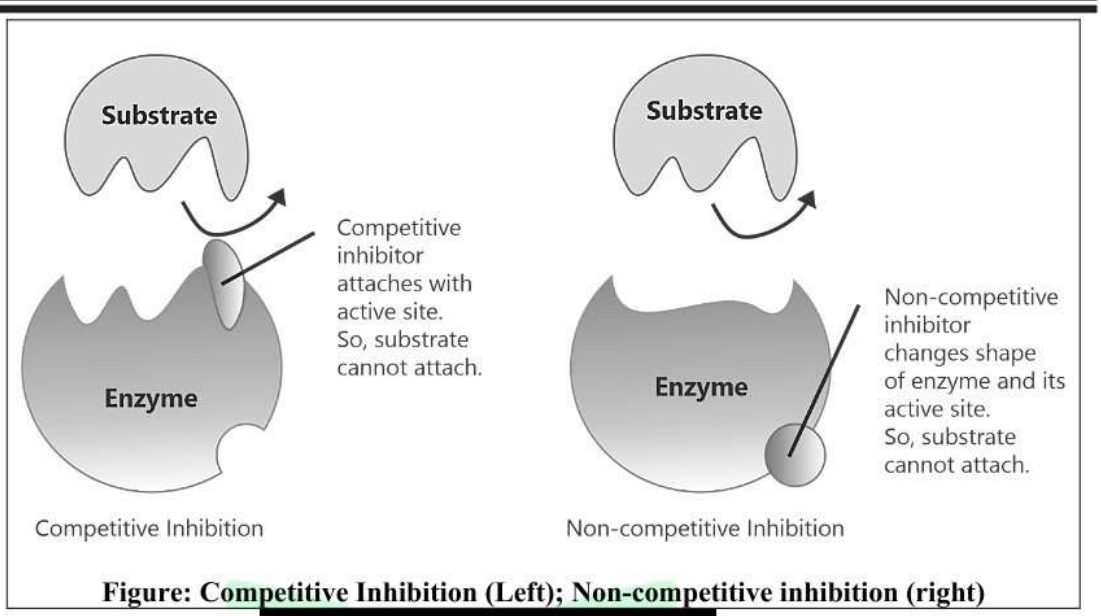


Figure: Competitive Inhibition (Left); Non-competitive inhibition (right)

SHORT ANSWER QUESTIONS

Q.1 Define active site. (K.B)

Ans:

ACTIVE SITE

An enzyme has one or more **pockets** or **clefts** on its surface called **active sites**. The active sites are directly involved in **catalysis**.

Size of Active Site:

The active site is usually a very **small portion** of the enzyme which is a **charge bearing cavity** having a specific shape.

Q.2 Explain lock and key model of enzyme action. (K.B)

Ans:

LOCK AND KEY MODEL

This model was proposed by a German chemist **Emil Fischer** in 1894.

Explanation:

- According to it, the active site of enzyme has a **fixed structure**.
- The substrate molecule fits precisely into it to form an **enzyme-substrate complex**.
- The enzyme catalyzes the reaction and substrate is transformed into **products**.
- Then, the product is released from the enzyme.

Q.3 What induced-fit model explains about enzyme action. (K.B)

Ans:

INDUCED FIT MODEL

This model was proposed by an American biologist **Daniel Koshland** in 1958.

Explanation:

- According to this model, the active site of enzyme is **not rigid**.
- When substrate interacts with the enzyme, its active site is **reshaped** to perform its function

Q.4 How enzyme-substrate and enzyme-product complexes are formed? (U.B)

Ans:

ES AND EP COMPLEX

ES Complex Formation:

Specific substrate molecule **temporarily binds** to the active site of enzyme to form Enzyme Substrate (ES) complex.

EP Complex Formation:

- Once the ES complex has formed, enzyme catalyzes the reaction to convert the substrate in to product, thus converting the ES complex to **Enzyme Product (EP) Complex**.

- Finally, EP complex breaks up into products and enzyme.
- The enzyme molecule remains **unchanged** at the end of the reaction and is available again if needed for same reaction again.

Q.5 Name the factors affecting the enzyme activity. (K.B)

Ans: The activity of an enzyme is affected by the following conditions:

- pH
- Temperature
- Substrate concentration

Q.6 What happens to enzyme when it is heated up to 100°C? (U.B)

Ans:

DENATURATION

If temperature is increased above **optimum temperature** such as 100°C, then a decrease in rate of reaction occurs due to **denaturation** i.e., breakdown at high temperature. Therefore, enzyme lost its activity.

Q.7 Which protein digesting enzyme functions in acidic medium? (U.B)

Ans:

PROTEIN DIGESTING ENZYME

Pepsin is a protein digesting enzyme it works in acidic medium.

pH:

Optimum pH for pepsin enzyme pepsin in **stomach** is about 1.5 – 2.0.

Q.8 What is denaturation? How enzyme is denatured? (K.B)

Ans:

ENZYME DENATURATION

Definition:

Denaturation is the **destruction of enzyme molecule** by either extreme rise in temperature or changes in the pH.

Denaturation of Enzyme:

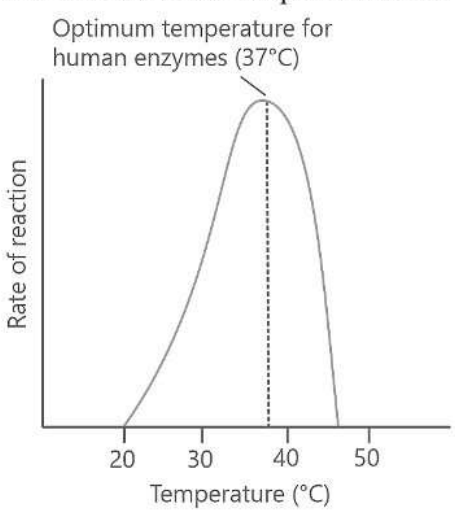
- When temperature is raised well above the optimum temperature, **heat breaks the bonds** in enzyme molecule.
- In this way the **globular structure** of enzyme is lost.
- This is called **denaturation** of enzyme.
- It results in a rapid decrease in the rate of enzyme action.

Q.9 Give a graphical representation of effect of temperature on the enzyme activity? (A.B)

Ans:

EFFECT OF TEMPERATURE

The following graph shows how increase in temperature effects the activity of enzymes.



Q.10 Explain the concept of enzyme saturation. (K.B)

Ans:

SATURATION

Saturation of Active sites:

- At high substrate concentration, all active sites of the enzymes are **occupied**.
- In this condition, any more substrate molecules do not find free active sites.
- This state is called **saturation of active sites** and reaction rate does not increase.

Q.11 How enzyme becomes inactive? (K.B)

Ans:

ENZYME INACTIVATION

At very **low temperature**, enzyme remain **inactive** due to fall in available activation energy. They will regain their catalytic activity when normal temperatures are restored.

Q.12 Define enzyme inhibition. (K.B)

Ans:

ENZYME INHIBITION

Certain substances, called **enzyme inhibitors**, bind to enzyme and decrease its activity. This phenomenon is known as enzyme inhibition.

Q.13 What are inhibitors? Give examples. (K.B)

Ans:

INHIBITORS

Definition:

The **chemical substance** which reacts with enzyme in place of substrate but does not convert to products, thus inhibiting the enzyme action, is called **inhibitor**.

Examples of Inhibitors:

External factors responsible for enzyme inhibition are:

- Poisons
- Cyanide
- Antibiotics
- Some drugs
- Accumulated products

Q.14 What are competitive inhibitors? How they work? (U.B)

Ans:

COMPETITIVE INHIBITORS

The molecules which **occupy the active site** due to their similarity in structure and shape to substrate, and thus inhibits the enzyme activity are called **competitive inhibitors**.

Working of Competitive Inhibitors:

- They **compete with the substrate** to attach to the active site of enzyme.
- When the inhibitor is attached to the active site, it blocks it and does not allow the substrate to attach.

Examples:

- Examples of competitive inhibitors are **antibiotics**.
- The antibiotic molecules compete with the substrates of **bacterial enzymes**.
- They attach to bacterial enzymes and inhibit them.

Q.15 What non-competitive inhibitors do to the enzyme? (K.B)

Ans:

EFFECT OF NON-COMPETITIVE INHIBITORS

The **structure** and **shape** of non-competitive inhibitors do not resemble the substrate molecules so they do not occupy the active site, but binds at allosteric site.

Effect on Enzyme:

- They do not attach to the active site of enzyme.
- Rather, they attach to some other **location** of enzyme
- This attachment changes the overall shape of enzyme and also the shape of active site.
- So, this changed active site does not fit substrate and enzyme is inhibited.

Examples:

Heavy metals like **mercury** and **certain drugs** used in cancer therapy.

MULTIPLE CHOICE QUESTIONS

1. The optimum temperature for the maximum working speed of human enzymes is: (K.B)
(A) 36°C (B) 38°C
(C) 37°C (D) 50°C

2. When there is an increase in temperature, the rate of enzyme catalyzed reactions: (A.B)
(A) Increases (B) Decreases
(C) Remains constant (D) All of these

3. Optimum pH for pepsin is (K.B)
(A) 1.0 - 1.5 (B) 1.5 – 2.0
(C) 3.5 (D) 7.8

4. Optimum pH for trypsin is (K.B)
(A) 6.1 (B) 7.8
(C) 8.0 (D) 9.5

5. Enzyme-product complex is formed when enzyme is attached with: (U.B)
(A) Active site (B) Substrate
(C) Products (D) Cofactors

6. The small of portion of enzyme where substrate binds is called as: (K.B)
(A) Inhibitor site (B) Active site
(C) Allosteric site (D) Substrate-binding site

7. When there is not enough energy, the enzyme is said to be: (U.B)
(A) Denatured (B) Inactivated
(C) Resting (D) Destroyed

8. When adding more substrate causes no effect on the rate of reaction, it is: (K.B)
(A) Inactivation (B) Denaturation
(C) Destruction (D) Saturation

9. pH is defined as the concentration of _____ ions in a medium. (K.B)
(A) Nitrogen (B) Oxygen
(C) Hydrogen (D) Carbon

10. Inhibitors block the active site of enzymes: (K.B)
(A) Temporary (B) Permanent
(C) Both A and B (D) Never

11. Example of enzyme inhibitor is: (U.B)
(A) Glucose (B) Bacteria
(C) Cyanide (D) All of these

12. Types of enzyme inhibition are: (K.B)
(A) Two (B) Three
(C) Four (D) None

13. Competitive inhibitors have their similarity with substrates in terms of: (K.B)
(A) Size (B) Structure only
(C) Shape only (D) Shape and Structure

14. Competitive inhibitors: (K.B)
(A) Are converted to real products (B) Are converted to wrong products
(C) Are not converted to the products (D) Are converted to harmful products

15. Non-competitive inhibitors bind with enzyme at: (U.B)
(A) Active site (B) Substrate site
(C) Binding site (D) Somewhere other than active site

16. The inhibitors that change the shape of enzyme are: (K.B)
(A) Competitive (B) Non-competitive
(C) All inhibitors (D) Both A and B

TEXTBOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

11. Primarily, all enzymes are;
(A) Nucleic acids (B) Proteins
(C) Carbohydrates (D) Lipids

12. Which best defines an enzyme?
(A) A chemical that breaks down food (B) A hormone that regulates metabolism
(C) A protein that speeds up reactions (D) A molecule that stores energy

13. What can happen if an enzyme is exposed to temperature that is higher than its optimal temperature?
(A) Enzyme activity rate will increase
(B) Enzyme's shape will change, potentially reducing its activity
(C) Enzyme will speed up the reaction and remain stable
(D) Enzyme will become a substrate itself

14. Enzymes are specific in their action because:
(A) Their active sites fit specific substrates (B) They are always proteins
(C) They are consumed in reactions (D) They work only at high temperatures

15. Prosthetic groups are;
(A) Required by all enzymes (B) Proteins in nature
(C) Loosely attached with enzymes (D) Tightly bound to enzyme

16. How does increasing temperature affect enzyme activity?
(A) Increases activity to a point (B) Always decreases activity
(C) Makes enzymes non-functional (D) No effect on enzyme

17. How does competitive inhibitor affect enzyme action?
(A) Attaches with the substrate (B) Changes enzyme shape
(C) Attaches and blocks the active site (D) Blocks the cofactors

18. An enzyme works best at a pH of 7.4. It is placed in an acidic solution with a pH of 4.0. How will this affect the enzyme?
(A) The active site will be modified, reducing substrate binding
(B) The enzyme will catalyse reactions faster due to increased H^+ ions
(C) The enzyme will gain additional active sites
(D) The substrate will become inactive in an acidic environment

19. What is TRUE according to the induced fit model of enzyme action?
(A) Enzyme's active site changes shape to bind the substrate
(B) Substrate must fit the enzyme perfectly before binding
(C) No shape changes occur during binding
(D) Enzyme is inactivated during the process

20. What is true about the optimum pH values of the following enzymes of digestive system?
(A) Pepsin works at low pH while trypsin works at high pH
(B) Both work at high pH
(C) Both work at low pH
(D) Pepsin works at high pH while trypsin works at low pH

SHORT ANSWER QUESTIONS

Q.1 Define metabolism. Differentiate between catabolism and anabolism.

Ans:

METABOLISM

Definition:

Metabolism is the sum of all **chemical reactions** that occur within an organism to sustain life.

Types of Metabolism:

There are two sub-sets of metabolism i.e., **catabolism** and **anabolism**.

Catabolism	Anabolism
It involves the **breakdown** of complex molecules into simpler ones.	It involves **building up** complex molecules from simpler ones.
Energy	
Energy is **released** in catabolism.	Energy is **utilized** in anabolism.
Example	
• Respiration • Digestion • Lipolysis	• Photosynthesis • Protein synthesis • Glucose condensation to glycogen

Q.2 Which type of metabolism demands input of energy? Give an example.

Ans:

METABOLISM

Type of Metabolism:

Anabolism is the type of metabolism that demands an input of energy.

Example:

Photosynthesis, where carbon dioxide and water are converted into glucose using sunlight.

Q.3 Define an enzyme. What is its role in metabolism?

Ans:

ENZYME

Definition:

Enzymes are **biological catalysts** that **speed up** chemical reactions in living organisms without being consumed in the process.

Role of Enzyme in Metabolism:

- Usually, energy is released in **catabolism** and it is utilized in **anabolism**.
- During metabolism, chemicals are transformed from one form to other by enzymes.
- Enzyme are important for metabolism because they act as biocatalyst and speed up and regular **metabolic pathway**.

Q.4 What is the active site of enzyme? State its importance in enzyme specificity.

Ans:

ACTIVE SITE

Definition:

An enzyme has one or more **pockets** or **clefts** on its surface called **active sites**. The active sites are directly involved in **catalysis**.

Importance:

The active site has a **unique shape** and **chemical properties** that match only specific substrates, ensuring that each enzyme catalyzes a particular reaction.

Q.5 Provide an example of a specific enzyme-substrate pair.

Ans:

ENZYME-SUBSTRATE PAIRS

Enzyme	Substrate
Amylase	Starch
Protease	Proteins
Lipase	Lipids

Q.6 How does pH affect enzyme activity?

Ans:

AFFECT OF PH

Enzymes are sensitive to **hydrogen ion concentration** (pH) of the fluid in which they work.

Optimum pH:

Enzymes show maximum activity at a **specific pH**, called their optimum PH.

Change in pH:

- Change in pH can affect the **ionization** of the amino acids at the active site of enzyme.
- It slows down enzyme activity or **blocks** it completely.
- Different enzymes have different optimum pH values.

Examples:

Pepsin (working in stomach) works in **acidic medium** (pH 1.5 to 2.0).

Q.7 Provide two examples of enzymes that operate optimally at specific pH.

Ans:

ENZYMES AND PH

Enzyme	Optimum pH
Pepsin	1.5 – 2.0
Trypsin	7.8

Q.8 What do you mean by optimum temperature and pH?

Ans:

OPTIMUM TEMPERATURE AND PH

Optimum Temperature:

Each enzyme works at **maximum rate** at a specific temperature called **optimum temperature**.

Example:

The optimum temperature for most of the **human enzymes** is 37°C.

Optimum pH:

Enzymes show maximum activity at a **specific pH**, called their optimum PH.

Example:

Trypsin (working in small intestine) works in **alkaline medium** (7.8).

Q.9 Which type of enzyme inhibitors inhibit the enzymes without attaching to the active site?

Ans:

ENZYME INHIBITORS

Enzyme inhibitors that inhibit enzymes without attaching to the active site are called **non-competitive inhibitors**.

Working:

- They attach to a location other than the active site, causing a change in the enzyme's overall shape, including the active site.
- This prevents the substrate from fitting into the active site, thus inhibiting the enzyme's activity.

Example:

Heavy metals like mercury and drugs used in cancer therapy act as non-competitive inhibitors.

Q.10 Differentiate between competitive and non-competitive inhibition.

Ans:

DIFFERENTIATION

A comparison between competitive inhibition and non-competitive inhibition is given below:

Competitive Inhibition	Non-Competitive Inhibition
SIMILARITY	
Inhibitors resemble the substrate.	Inhibitors do not resemble the substrate.
ATTACHMENT SITE	
Inhibitors attach to the active site of the enzyme, competing with the substrate.	Inhibitors attach to a different location on the enzyme, not the active site.
EFFECT ON ACTIVE SITE	
Blocks the active site, preventing the substrate from attaching.	Changes the overall shape of the enzyme, including the active site, making it unsuitable for the substrate.
EXAMPLES	
Antibiotics, which compete with the substrates of bacterial enzymes.	Heavy metals like mercury and certain cancer therapy drugs.

EXTENSIVE ANSWER QUESTIONS

Q.1 Describe the characteristics of enzymes.
See Q.No.1 of topic 7.2

Q.2 Describe how temperature extremes can inhibit enzyme activity and lead to enzyme denaturation.
Consult Q.No.1 of topic 7.4

Q.3 How does pH affect enzyme activity?
Consult Q.No.1 of topic 7.4

Q.4 Briefly describe the factors that affect the activity of enzymes.
See Q.No.1 of topic 7.4

Q.5 Compare the Lock-and-Key and Induced Fit models of enzyme action.
See Q.No.1 of topic 7.3

EXTRA CONCEPTUAL MCQs

1. Which of the following best describes the role of enzymes in chemical reactions? (K.B)
(A) They increase the temperature of reactions (B) They act as substrates
(C) They speed up reactions (D) They permanently change during reactions

2. What is the term for the specific area where a substrate binds on an enzyme? (U.B)
(A) Catalytic site (B) Active site
(C) Binding site (D) Allosteric site

3. Which model describes the enzyme-substrate interaction where the enzyme changes shape to fit the substrate? (K.B)
(A) Lock-and-Key Model (B) Induced Fit Model
(C) Substrate Theory Model (D) Active Site Model

4. Enzyme activity can be inhibited by molecules that bind to the: (U.B)
(A) Substrate (B) Active site
(C) Product (D) All of these

5. Which of the following factors affects enzyme activity? (K.B)
(A) Temperature (B) pH level
(C) Substrate concentration (D) All of these

6. In competitive inhibition, an inhibitor: (K.B)
(A) Changes the shape of the enzyme (B) Binds to the active site
(C) Binds to the allosteric site (D) Increases the reaction rate

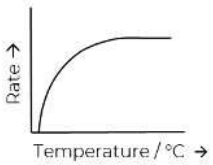
7. What happens to an enzyme after it catalyzes a reaction? (U.B)
(A) It is used up (B) It is unchanged
(C) It becomes a substrate (D) It becomes inactive permanently

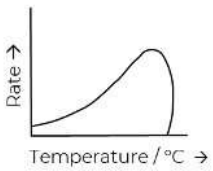
8. Enzymes that break down proteins are known as: (K.B)
(A) Lipases (B) Proteases
(C) Amylases (D) Nucleases

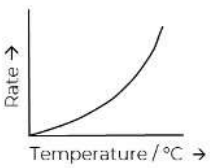
9. Which statement is true regarding enzyme specificity? (K.B)
(A) Enzymes can bind to any substrate
(B) Enzymes are specific to particular substrates
(C) Enzymes change their shape to fit any substrate
(D) Enzymes function best at very high temperatures

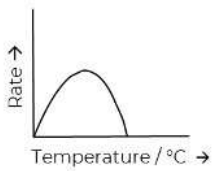
10. Lock and key hypothesis of enzyme action supports that:
(A) Active sites are flexible (B) Active sites are rigid
(C) Active site efficiency increases (D) Active site can change its shape

11. Which graph shows how temperature affects the rate of an enzyme-controlled reaction?

(A) 

(B) 

(C) 

(D) 

12. What is true about cofactors?

(A) Break hydrogen bond in proteins
(B) Help facilitate enzyme activity
(C) Increase activation energy
(D) Are composed of proteins

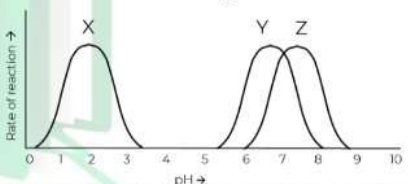
13. Change in pH can alter the active site by affecting the:

(A) Ionization of amino acids
(B) Shape of substrate
(C) Ionization of cofactor
(D) Ionization of coenzymes

14. The catalytic region on enzyme recognizes and binds the substrate and carries the reaction. This region is called as:

(A) Cofactor
(B) Activator
(C) Inhibitor
(D) Active site

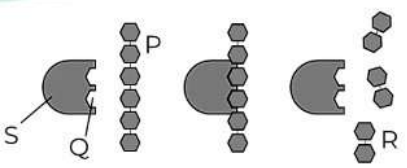
15. The graph shows the activity of three digestive enzymes at different pH levels. Which statement is correct?



(A) Enzyme X and Y are both active at pH 7
(B) Enzyme X and Z are both active at pH 4
(C) Enzyme Y and Z are both active at pH 4
(D) Enzyme Y and Z are both active at pH 7

16. The diagram shows an amylase molecule catalyzing the breakdown of a starch molecule. Which are the labelled parts P, Q, R and S?

	Enzyme	Product	Substrate	Active site
(A)	P	Q	R	S
(B)	R	S	P	Q
(C)	S	P	Q	R
(D)	S	R	P	Q



STUDENT LEARNING OUTCOMES (SLOs)

SHORT ANSWER QUESTIONS

Q.12 How enzymes are named?

Ans:

NAMING OF ENZYME

Enzymes are commonly named by adding a suffix "ase" to the root name of the substrate molecule on why they act.

Example:

Lipase catalyzes the hydrolysis of the substrate lipid.

Q.13 Provide an example of a catabolic process and explain its significance in producing energy.

Ans:

CATABOLIC PROCESS

Example:

A good example of catabolic process is cellular respiration, where glucose and oxygen are used to make energy which makes ATP.

Significance:

This process is important as it is the major process that provides energy to the body for its functions.

Q.14 What is meant by specificity of an enzyme? Give an example.

Ans:

SPECIFICITY OF ENZYME

Specificity:

Enzymes are very specific in their actions. Each enzyme works on a specific substrate because of its unique "active site".

Example:

The enzyme lactase in the small intestine breaks down lactose into glucose and galactose, but it does not work on other sugars like sucrose.

Q.15 What role does the active site of an enzyme play?

Ans:

ROLE OF ACTIVE SITE

Definition:

Active site is a part or region of enzyme where a substrate molecule binds.

Role of Active Site:

The active site of an enzyme is a specific region that precisely fits with a certain molecule called the substrate, similar to how a hand, fits into a glove. This perfect match means the enzyme only works with specific substrates, showing how precise enzymes are.

Q.16 Differentiate between the "lock-and-key" and "induced-fit" models of enzyme-substrate interaction. Who proposed these models?

Ans:

DIFFERENTIATION

The following table gives a comparison between lock-and-key model and induced-fit model of enzyme.

Lock and Key Model	Induced Fit Model
DISCOVERY	
The lock-and-key model was proposed by Emil Fischer in 1894.	Induced fit model was proposed by Daniel Koshland in 1958.
EXPLANATION	
• It suggests that enzymes and substrates fit together perfectly like a key in a lock. • This model explains the specificity of the enzyme, which is due to the exact shape of the active site that binds to a specific substrate.	• According to this model, the enzyme's active site is not rigid. • When the substrate binds to the active site, the enzyme adjusts its shape, which allows it to fit around the substrate precisely, like a glove adjusting to a hand. • This process enhances the efficiency of the enzyme.

Q.17 "Enzyme speeds up a biochemical reaction". Justify this statement with an example.

Ans:

ENZYME SPEEDS-UP A REACTION

Enzyme:

Enzyme acts as a biocatalyst that speeds-up a biochemical reaction, millions time faster.

Uncatalyzed Reaction:

Without an enzyme, turning CO_2 and H_2O into H_2CO_3 (carbonic acid) is very slow, making only about 200 molecules in an hour.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Enzyme-catalyzed Reaction:

When the enzyme carbonic anhydrase helps, the reaction happens much faster. It can make about 600,000 molecules every second. That is almost 10 million times faster than without the enzyme

Q.18 What is the primary purpose of enzyme inhibition in cellular processes?

Ans: **ROLE OF ENZYME INHIBITION**

Explanation:

- Enzyme inhibition plays a crucial role in regulating the production of substances within cells.
- By slowing down enzymes, cells can maintain a balance, which is key for staying healthy and responsive to changes inside or outside the cell.

Q.8 Why enzymes are called biological catalysts?

Ans: **ENZYMES**

Enzymes are biologically active globular proteins made by living cells, which tremendously speed up the biochemical reactions. As they work to speed up only biochemical reactions, they are called as biological catalysts.

Q.9 What happens to an enzyme when it is frozen below 0°C?

Ans: **ENZYME BELOW 0°C**

At temperature below 0°C, an enzyme becomes inactive due to fall in available activation energy. But it can regain its catalytic activity when normal temperature is restored.

Q.10 Why are enzymes specific and why can't each one speed up many different reactions?

Ans: **SPECIFICITY OF ENZYMES**

Enzymes are specific in their action. It means one enzyme can act only on particular substrate. It cannot act on any other substance.

Reason of Specificity:

This is because the shape of active site is very unique that makes only the specific substrate to bind.

Examples:

The examples of specificity of enzymes are.

a) **Proteases:** break up proteins into amino acid.
b) **Lipase:** breaks down only lipids.
c) **Amylase:** acts on starch.

Q.11 According to induced fit model, the active site is flexible. Does it mean that any substrate can attach with this flexible active site? If not, then explain.

Ans: **FLEXIBILITY OF ACTIVE SITE**

No, the induced fit model does not mean that any substrate can attach to the flexible active site of an enzyme.

Induced-Fit Model:

The induced fit model proposes that the active site of an enzyme is not rigidly fixed, but rather can undergo conformational changes to accommodate the binding of a specific substrate.

Flexibility of Active Site:

The flexibility of the active site allows the enzyme to adapt its shape to achieve the perfect orientation to bind with its specific substrate. But the active site still maintains a certain degree of structural specificity and the specificity to its original substrate.

Q.12 How cell regulates its reactions by using inhibitors? (K.B)

Ans: **CELL'S REGULATION**

Inhibitors may block or damage active site temporarily or permanently. Generally, enzyme activity may be temporarily inhibited by accumulated products within the cell to regulate the rate of reaction.

Q.13 What is allosteric site? (K.B)

Ans: **ALLOSTERIC SITE**

The structure and shape of non-competitive inhibitors do not resemble the substrate molecules so they do not occupy the active site

These inhibitors may attach to enzyme surface at a point other than active site called allosteric site.

MULTIPLE CHOICE QUESTIONS

14. Dehydrogenases are the enzymes that remove ____ from a molecule.
(A) Oxygen (B) Hydrogen
(C) Phosphate (D) Electron

15. The pH inside a lysosome is:
(A) 2.0 (B) 4.5
(C) 4.8 (D) 7.5

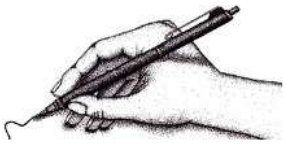
16. The optimum pH of salivary amylase is:
(A) 4.1 (B) 6.8
(C) 5.0 (D) 8.0

17. Which of the following vitamins act as coenzyme?
(A) Riboflavin (B) Thiamine
(C) Folic acid (D) All of these

18. Enzymes function optimally:
(A) At a specific pH (B) At their specific temperatures
(C) In any pH condition (D) Both A and B

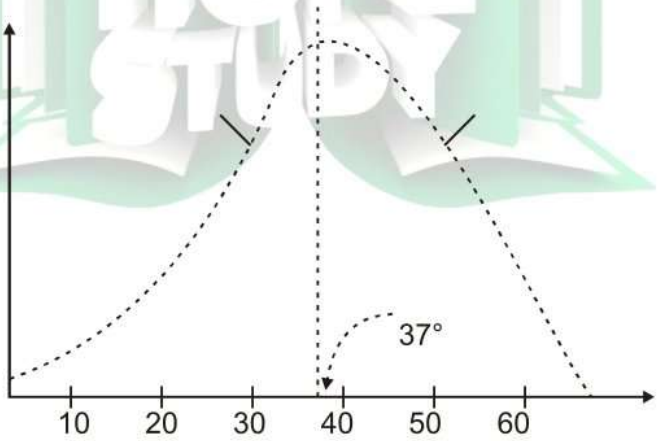
ASSIGNMENT

LET'S DRAW AND LABEL



(A) Effects of Temperature on Enzymes Activity
Instructions:

- Draw the x and y axis using scale.
- Draw the curve as shown in figure.
- Now mark the labels as giving in book.



Terms to Know	
Activation energy	The energy required for a chemical reaction to occur, which involves breaking and forming chemical bonds in the reactants.
Active site	A small cleft or depression on the surface of enzyme molecule; location at which catalysis occurs.
Anabolism	A form of metabolism in which smaller and simpler compounds are used to generate large and complex compounds.
Catabolism	The metabolic processes that involve the breakdown of larger molecules into smaller ones.
Coenzymes	Cofactors, which are non-protein organic molecules, loosely attached with enzyme; participate in enzyme catalysed reactions.
Cofactor	Non-protein component of enzyme; participate in enzyme catalysed reactions.
Enzymes	Biological catalysts made of proteins that catalyse (i.e. speed up) biochemical reactions without themselves being changed.
Inhibitor	Chemical that interferes and blocks an enzyme's activity.
Metabolism	The sum of all chemical reactions taking place within a cell in order to maintain life.
Non-competitive Inhibitor	Inhibitor that has no structural similarity to substrate; it binds the enzyme outside the active site and alters the shape of enzyme.
Substrate	The molecules that undergo a chemical reactions catalysed by enzymes.

Answer Key

TOPIC 7.2

1	B	**2**	D	**3**	A	**4**	B	**5**	A
6	D	**7**	B	**8**	A	**9**	C	**10**	B
11	A	**12**	B	**13**	C	**14**	B	**15**	B
16	A	**17**	B						

TOPIC 7.5

1	C	**2**	A	**3**	B	**4**	B	**5**	B
6	B	**7**	B	**8**	D	**9**	C	**10**	C
11	C	**12**	A	**13**	D	**14**	C	**15**	D
				16	B				

TEXTBOOK EXERCISE

1	B	**2**	C	**3**	B	**4**	A	**5**	D
6	A	**7**	C	**8**	A	**9**	A	**10**	A

EXTRA CONCEPTUAL MCQs

1	C	**2**	B	**3**	B	**4**	B	**5**	D
6	B	**7**	B	**8**	B	**9**	B	**10**	B
11	B	**12**	B	**13**	A	**14**	D	**15**	D
				16	D				

SLOs MCQs

1	B	**2**	C	**3**	B	**4**	D	**5**	D