CHAPTER 6 · BIOLOGY

ENZYMES

Complete Solved Exercise — Multiple Choice, Short & Detailed Answers

5	5	3
MCQs Solved	Short Answers	Detailed Answers

Every question answered, explained, and referenced for quick revision.

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A. Select the Correct Answers

1 **Primarily, all enzymes are:**

a) Nucleic acids

✔ **b) Proteins**

c) Carbohydrates

d) Lipids

Why: Enzymes are globular proteins built from chains of amino acids folded into a specific 3-D shape. (A few RNA molecules called ribozymes can also catalyze reactions, but the overwhelming majority of enzymes are proteins.)

2 **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.

Why: An enzyme is a biological catalyst — a protein that increases the rate of a specific biochemical reaction without itself being permanently changed or used up in the process.

3 **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.

Why: Every enzyme has a unique, precisely shaped active site whose contours and chemical groups match only one substrate (or a small group of closely related substrates) — like a lock accepting only its matching key.

4 **Prosthetic groups are:**

a) Required by all enzymes.

b) Proteins in nature.

c) Loosely attached with enzymes.

✔ **d) Tightly bound to enzyme.**

Why: A prosthetic group is a non-protein cofactor that is permanently and tightly (often covalently) bound to the enzyme molecule — unlike a coenzyme, which attaches loosely and temporarily.

5 **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 changes shape to bind to active site.

c) No shape changes occur in active site or substrate.

d) Substrate attaches the enzyme at a site other than active site.

Why: The induced fit model (Koshland) proposes that the active site is flexible, not rigid. When the substrate approaches, the active site slightly changes/moulds its shape to achieve a snug, optimal fit around the substrate.

B. Short Answers

1 Define metabolism. Differentiate between catabolism and anabolism.

Metabolism is the sum total of all the chemical (biochemical) reactions that occur inside a living organism to maintain life — including the breakdown of nutrients and the building of body components.

Catabolism	Anabolism
Breakdown of complex molecules into simpler ones	Synthesis of complex molecules from simpler ones
Releases energy (exergonic)	Requires/uses energy (endergonic)
Example: Cellular respiration — glucose broken down to CO_2 + H_2O + ATP	Example: Protein synthesis — amino acids joined to form proteins

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

Anabolism demands an input of energy, since it builds larger, more complex molecules from smaller ones.
Example: Photosynthesis in plants, where light energy is used to build glucose from carbon dioxide and water; or protein synthesis, where ATP energy is used to join amino acids into polypeptide chains.

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

An **enzyme** is a specialized, globular protein that acts as a biological catalyst, speeding up the rate of a specific biochemical reaction without being consumed or permanently altered itself.

Role in metabolism: Enzymes catalyze virtually every catabolic and anabolic reaction in the cell. By lowering the activation energy needed, they allow reactions that would otherwise be far too slow to proceed rapidly at normal body temperature, and they allow the cell to precisely regulate the speed and direction of its metabolic pathways.

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

The **active site** is a small, specially shaped pocket or groove on the surface of an enzyme where the substrate binds and the chemical reaction actually takes place.

Importance: The active site has a unique three-dimensional shape and chemical environment that is complementary to only one particular substrate (or a small family of similar substrates). This structural match is exactly what makes each enzyme highly specific — it can only bind and act on the substrate(s) that fit its active site.

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

Sucrase — Sucrose: the enzyme sucrase acts specifically on the substrate sucrose, breaking it down into glucose and fructose. (Other valid examples: *Catalase — Hydrogen peroxide*, or *Amylase — Starch*.)

C. Answers in Detail

1 Describe the characteristics of enzymes.

- **Proteinaceous nature:** Most enzymes are globular proteins (a few, called ribozymes, are RNA).
- **Biological catalysts:** They speed up reactions without being permanently changed or consumed, so they can be used again and again.
- **High specificity:** Each enzyme acts on a particular substrate or type of reaction, due to the unique shape of its active site.
- **Effective in small amounts:** A small quantity of enzyme can catalyze the conversion of a large amount of substrate.
- **Lower activation energy:** Enzymes speed reactions by reducing the energy barrier needed to start the reaction.
- **Sensitive to temperature and pH:** Each enzyme has an optimum temperature and pH; extremes cause denaturation and loss of activity.
- **Reversible action:** Many enzymes can catalyze a reaction in either the forward or reverse direction, depending on conditions.
- **Require cofactors in some cases:** Certain enzymes need non-protein helpers — coenzymes, prosthetic groups, or metal-ion activators — to function.
- **Subject to regulation:** Enzyme activity can be controlled by activators, inhibitors, and feedback mechanisms to regulate metabolism.
- **Named systematically:** Enzyme names usually end in "-ase" and often indicate the substrate they act on (e.g., sucrase, lipase).

2 Describe the factors that affect the activity of enzymes.

- **Temperature:** Activity rises with temperature up to an optimum (often near body temperature); beyond this, the enzyme's protein structure denatures and activity drops sharply.
- **pH:** Every enzyme has an optimum pH range; too acidic or too alkaline conditions disrupt the active site's shape and denature the enzyme.
- **Substrate concentration:** Increasing substrate concentration increases the reaction rate until all active sites are occupied (saturation), after which the rate levels off at a maximum (V_{max}).
- **Enzyme concentration:** Increasing the amount of enzyme increases the reaction rate, provided substrate is not limiting.
- **Presence of inhibitors:** Competitive inhibitors block the active site directly; non-competitive inhibitors bind elsewhere and distort the active site — both reduce enzyme activity.
- **Presence of activators/cofactors:** Certain ions or coenzymes are required to activate some enzymes; their absence lowers or stops activity.
- **Product concentration:** A build-up of reaction products can slow down or inhibit further enzyme activity (product/feedback inhibition).

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

Lock-and-Key Model	Induced Fit Model
Proposed by Emil Fischer	Proposed by Daniel Koshland
Active site has a fixed, rigid shape	Active site is flexible and can change shape
Substrate fits perfectly into the active site, exactly like a key fitting a lock, without any change in shape	The active site moulds itself around the substrate as it binds, changing shape slightly for an optimal fit
Assumes substrate and active site are already perfectly complementary	Assumes the initial fit is only approximate; binding induces the precise fit
Simpler model, but does not explain some enzyme behaviours	More accurate/modern model, better explains enzyme flexibility and catalysis