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VCE Biology ¾
Proteins, Protein Export & Enzymes [1.4]
Homework Solutions

Homework Outline:

Compulsory Questions	Pg 2 – Pg 14

Section A: Compulsory Questions (32 Marks)

Sub-Section [1.4.1]: Define and Compare Primary, Secondary, Tertiary and Quaternary Structures of Proteins

Question 1

Definitions:

a. Primary structure.

The linear sequence, number and type of amino acids in the polypeptide chain of a protein.

b. Secondary structure.

The level of protein structure where the polypeptide chain begins to form alpha helix structures, beta pleated sheets or random coils, due to hydrogen bonding occurring between non-adjacent peptide bonds.

c. Tertiary structure.

The functional 3D shape of the polypeptide, composed of folding at the secondary level. Primarily formed by the interactions between the *R* groups of amino acids.

d. Quaternary structure.

The level of protein structure where multiple polypeptide chains are bonded together, or non protein prosthetic groups are included in the structure to form a fully functional protein.

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Question 2 (1 mark)

A proteome is defined as:

A. The sum of all of the functional proteins that an individual organism produces.

B. Primitive, simple form of protein.

C. The kinds of proteins produced by prokaryotic organisms.

D. The kinds of proteins produced by eukaryotic organisms.

Proteome includes all the proteins produced by an organism, not just some of the proteins produced.

Question 3 (1 mark)

The bonds linking amino acids together are called:

A. Peptide bonds.

B. Hydrogen bonds.

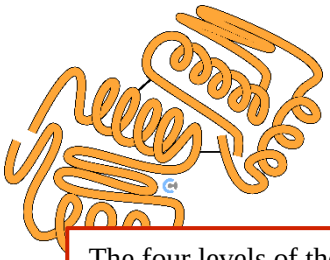
C. Intermolecular bonds.

D. Covalent bonds.

Although hydrogen bonds are present within a single amino acid, they do not hold separate amino acids together when they undergo condensation polymerisation.

Question 4 (1 mark)

The following diagram is of a functional protein.



The highest level of hierarchical structure for the

A. Primary.

B. Secondary.

C. Tertiary.

D. Quaternary.

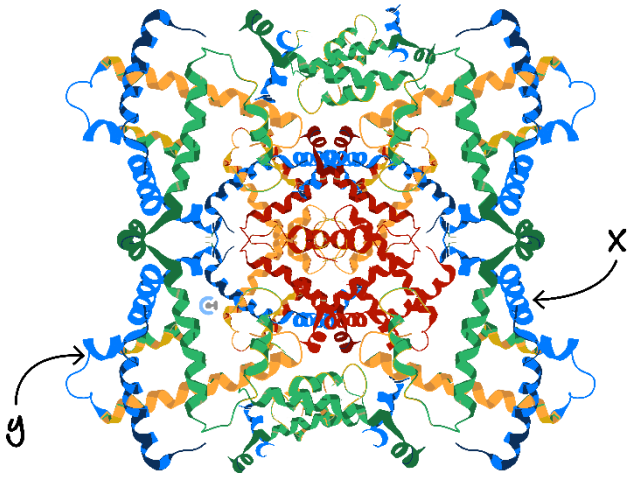
The four levels of the hierarchical structure for proteins are:

- Primary: The amino acid order.
- Secondary: The coiling (α helix) and folding (β sheets) caused by the local amino acid *R* groups.
- Tertiary: The overall three-dimensional shape of a single polypeptide as a result of folding and cross bonds (disulphide bridges).
- Quaternary: More than one polypeptide can be held together by chemical bonds forming a functional protein.

This functional protein is working at the quaternary level.

Question 5 (5 marks)

The diagram below shows a transmembrane protein, found in the cell membranes of mice.
There are two secondary structures labelled as ***X*** and ***Y***.



a. Give one function of a transmembrane protein. (1 mark)

Worked solution
Any of cell recognition, signalling, transport, structural support or enzyme.
Mark allocation: 1 mark
- 1 mark for any of the functions given above.

b. Name the structures labelled ***X*** and ***Y***. (2 marks)

Worked solution
X: Alpha helix
Y: Beta pleated sheet

Mark allocation: 2 marks
- 1 mark for identifying the alpha helix.
- 1 mark for identifying the beta pleated sheet.

c. The protein also displays a tertiary structure. Explain how the tertiary structure would be related to the function of the protein. (2 marks)

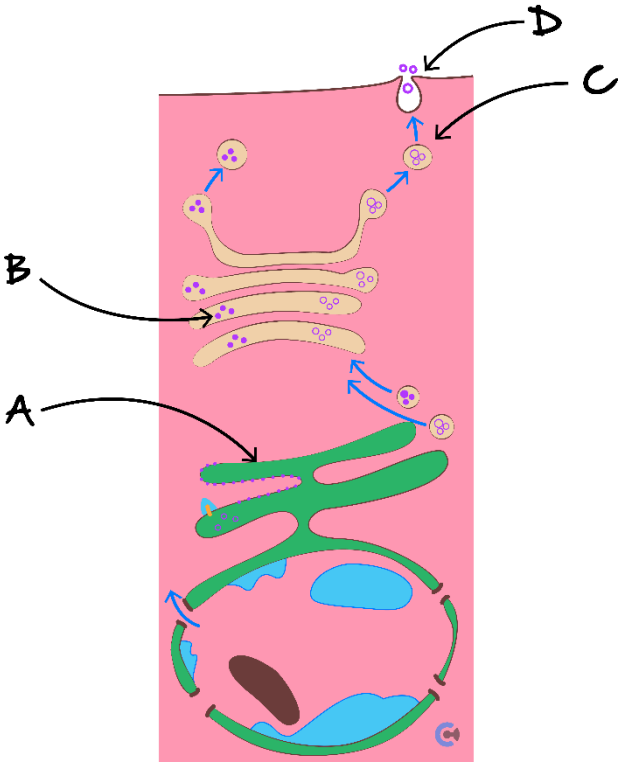
Worked solution
The tertiary level of bonding produces a specific three-dimensional shape. This shape enables the protein to form a structure that is complementary to its target molecule.

Mark allocation: 2 marks
- 1 mark for recognising that the tertiary level of bonding produces a specific three-dimensional shape.
- 1 mark for explaining that a specific shape relates to a specific function.

Sub-Section [1.4.2]: Identify and Describe the Roles of Ribosomes, Rough Endoplasmic Reticulum and Golgi Apparatus in the Transport and Export of Proteins from a Cell

Question 6 (6 marks)

The diagram below shows the production and export of a protein from a cell.



a. Name the final **cellular process** shown at point *D* in the diagram. (1 mark)

Worked solution
Exocytosis
Mark allocation: 1 mark
- 1 mark for exocytosis.

b. Identify the organelles labelled *A*, *B*, and *C* in the diagram. (2 marks)

Worked solution
A: Rough endoplasmic reticulum
B: Golgi apparatus
C: Vesicle
Mark allocation: 2 marks
- 2 marks for all three correct terms.
- 1 mark for two correct terms.
- 0 marks for one or no correct terms.

c. Describe the process shown in the diagram for exporting a protein from a cell. (3 marks)

Worked solution

A protein is synthesised at the rough endoplasmic reticulum by translation. After synthesis at the attached ribosome, the protein enters the membrane of the rough endoplasmic reticulum and folds into its secondary and tertiary structure. Vesicles transport the protein to the Golgi apparatus for further packaging and modification. Another vesicle then transports the protein to the cell membrane and fuses with it to release the protein from the cell.

Mark allocation: 3 marks

- 1 mark for referencing rough endoplasmic reticulum, protein synthesis or translation.
- 1 mark for explaining that the protein is packaged and modified at the Golgi apparatus.
- 1 mark for explaining that the vesicle transports the protein to the cell membrane.

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Sub-Section [1.4.3]: Explain the Lock-And-Key Model, the Induced Fit Model and why Enzymes are Specific and only Catalyse One Reaction.

Question 7

Definitions:

a. Lock and key.

A model for enzyme function where the active site is perfectly complementary to the shape of the substrate, and remains unchanged throughout.

b. Induced fit.

A model of enzyme function where the active site's shape changes slightly to suit the substrate, before returning to its original configuration after the reaction is complete.

c. Catalyst.

A substance that increases the rate of reaction without being consumed.

d. Substrate.

The reactant of an enzyme-catalysed reaction.

e. Active site.

The part of an enzyme to which the substrate binds for a reaction to be catalysed.

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Question 8 (1 mark)

Enzymes catalyse biochemical reactions by:

A. Providing energy to speed up the rate of reaction.

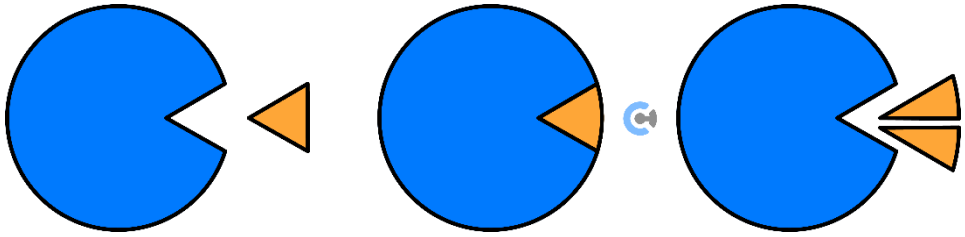
B. Lowering the energy of activation for a reaction.

C. Changing the direction of equilibrium.

D. Changing endergonic into exergonic reactions.

Enzymes reduce the activation energy needed to start the reaction, therefore the reaction can proceed at a faster rate.

Question 9 (1 mark)



The diagram above best depicts the:

A. Interaction between an enzyme and a substrate.

B. Interaction between an antigen and an antibody.

C. Interaction between a receptor and a signalling molecule.

D. Action on a non-competitive drug to slow down metabolism.

Many molecular interactions in Unit 3 Biology can be learnt by using two-dimensional shapes to depict the interaction. Antibodies have two complementary antigen-binding sites per molecule. Receptors and signalling molecules could appear as illustrated but the signalling molecule does not change in the manner depicted in the diagram. Non-competitive drugs would bind to a position on the enzyme, causing a change in the shape of the enzyme active site. An enzyme has an active site that the substrate binds to, causing a structural change in the substrate, changing it into a product. The enzyme is then reusable.

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Question 10 (3 marks)

The equation below describes a reaction that occurs in the liver cells of humans. The enzyme catalase breaks down the toxin hydrogen peroxide into water and oxygen.

$$\underset{\text{hydrogen peroxide}}{2H_2O_2} \xrightarrow{\text{catalase}} \underset{\text{water}}{2H_2O} + \underset{\text{oxygen}}{O_2}$$

a. What is the substrate in the reaction? (1 mark)

Worked solution
Hydrogen peroxide (or $2H_2O_2$)
Mark allocation: 1 mark
- 1 mark for correctly recognising the substrate hydrogen peroxide.

b. Can the enzyme catalase catalyse other reactions in the liver cells?
Explain your answer. (2 marks)

Worked solution
No. Enzymes only catalyse one type of reaction because their specifically shaped active sites can only bond to specific substrates.
Mark allocation: 2 marks
- 1 mark for referencing the specific shape of active site.
- 1 mark for explaining that only specific substrates are complementary to active sites.

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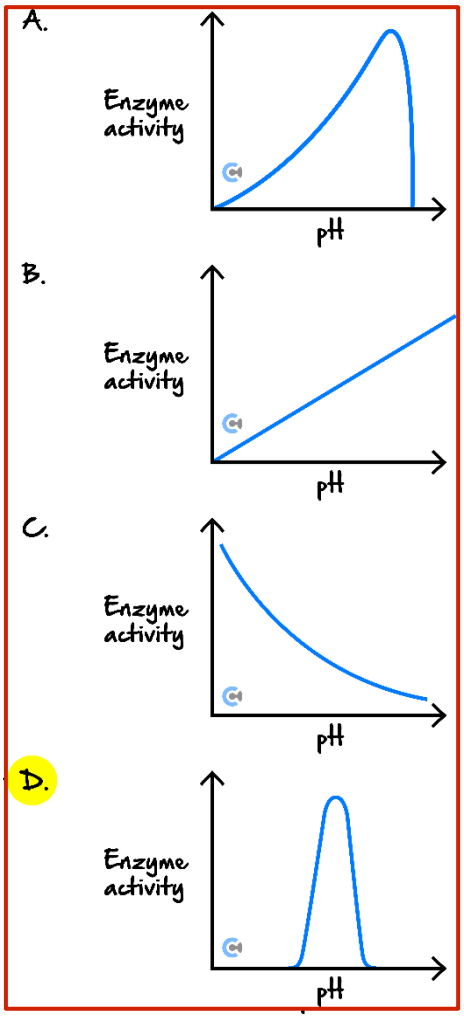
Sub-Section [1.4.4]: Explain how Enzymes Change/Denature in Different pH and at Different Temperatures

Question 11 (1 mark)

Which of the graphs below shows how enzyme activity changes with pH?



Each enzyme has an optimum pH at which it functions best. As you move away from this specific pH, the enzyme rapidly denatures as is shown in graph D.

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Question 12 (1 mark)

Laundry powder is sometimes advertised as containing powerful enzymes that break down dirt. These enzymes are called extremozymes. They come from some species of bacteria and archaea. The following table gives the optimal functioning of enzymes from some of these species.

Species	Enzyme	Optimal Temperature (°C)	Optimal pH
Psychrobacter sp.	*J*	10-30	7.0-9.0
Pseudomonas sp.	*K*	40	10.0
Methanococcus sp.	*L*	120	5.0-8.0
Cystofilobasidium sp.	*M*	40-42	5.0

Given this information and your knowledge of enzyme function, the best enzyme to add to the laundry powder would be:

A. Enzyme *J*.

B. Enzyme *K*.

C. Enzyme *L*.

D. Enzyme *M*.

Using the information given below, answer the following questions.

The enzyme lactase digests lactose.

$$\text{lactose} \xrightarrow{\text{lactase}} \text{glucose} + \text{galactose}$$

Two test tubes were set up using 5 *mL* of lactose syrup and 0.5 *mL* of lactase. Test tube **one** was incubated at 37°C, while test tube **two** was incubated at 15°C. Both tubes were incubated for 10 minutes.

Question 13 (1 mark)

At the end of 10 minutes, the amount of glucose produced in test tube **two** when compared to test tube **one** would be:

A. Lower as the enzyme's active site would have denatured at this temperature.

B. Equal as lowering the temperature does not affect the digestion of lactose.

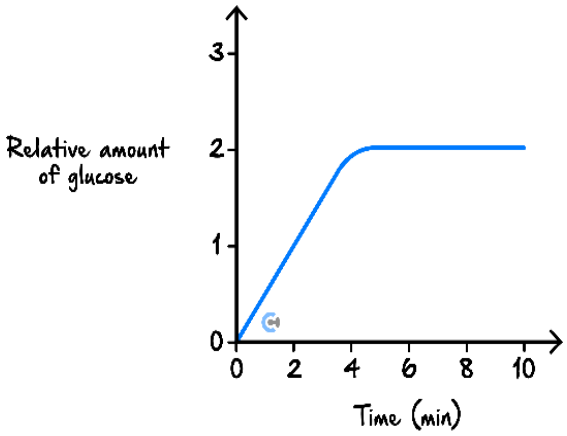
C. Lower as there would be fewer collisions between the substrate and the enzyme.

D. Equal as the two test tubes contained the same amount of lactose and lactase enzyme.

Question 14 (1 mark)

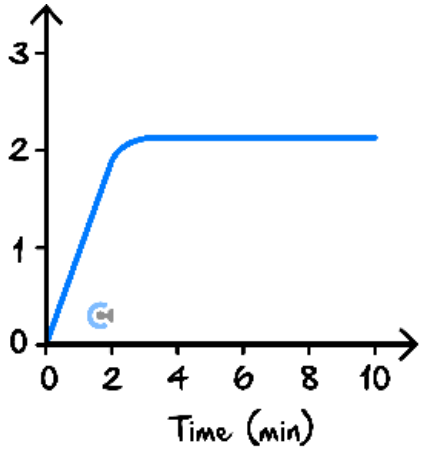
In another experiment, test tube **three** was compared with test tube **four**. Each tube contained 5 mL of lactose syrup. Tube **three** contained 0.5 mL of lactase and tube **four** contained 0.25 mL of lactase. The two tubes were incubated at 15°C and monitored for 10 minutes.

The result for test tube **three** is shown below.

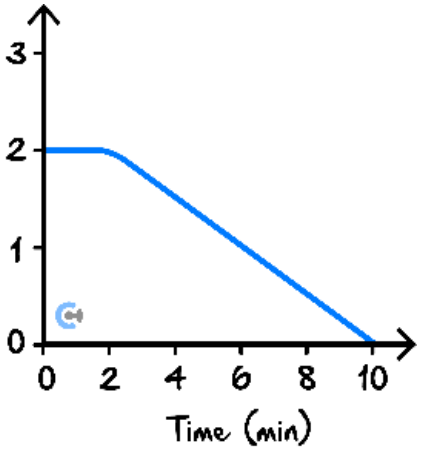


The graph of results for tube **four** would resemble:

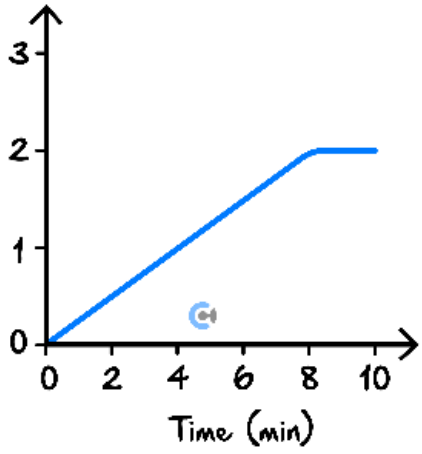
A.



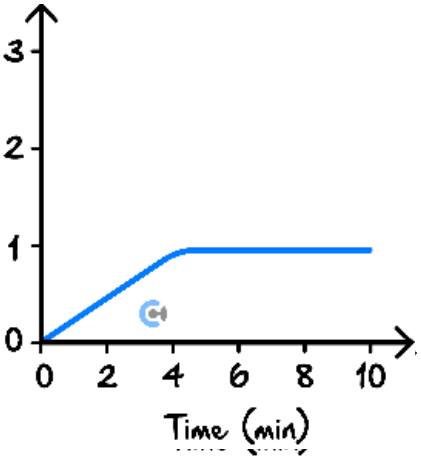
B.



C.



D.

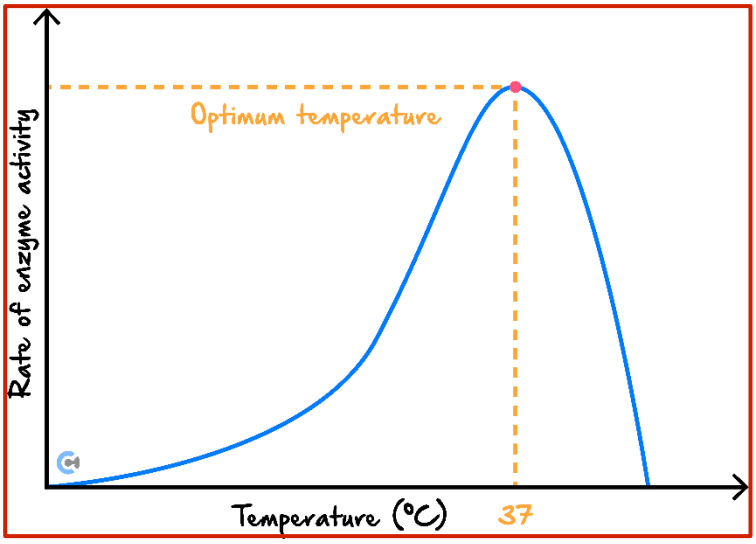


Mark allocation: 2 marks
- 1 mark for a gradual slope increasing up to optimum temperature.
- 1 mark for steep decline above 40°C.

Question 15 (6 marks)

a. The average human body temperature is 37°C, which is the optimum temperature for catalase.

Complete the graph below to show the rate of catalase-controlled reactions at temperatures above and below 37°C. (2 marks)



b. Explain what happens to the enzyme if the body temperature is over 40°C for an extended period. (2 marks)

Worked solution
The enzyme becomes denatured because the heat energy causes bonds in the tertiary level of the protein structure to break. This causes the active sites of the enzymes to lose their shape and they then cannot bind to the substrate.
Mark allocation: 2 marks
- 1 mark for recognising that the enzyme denatures due to heat energy.
- 1 mark for stating that the active site shape changes and is unable to bind to the substrate.

c. State the likely optimal pH for this enzyme, and describe how pH can impact enzyme function. (2 marks)

The likely optimal pH for catalase is around pH 7, as it functions best in neutral conditions. The pH impacts enzyme function by affecting the ionic bonds in the enzyme's structure, which can alter the shape of the active site and lead to reduced activity or denaturation at extreme pH levels.

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Sub-Section [1.4.5]: Explain function of Competitive and Non-Competitive Enzyme Inhibitors and how they affect Rate of Reaction, and how they may/may not be Overcome

Question 16

Definitions:

a. Competitive Inhibitor.

A molecule that hinders enzyme function and prevents it from catalysing a reaction by blocking the active site.

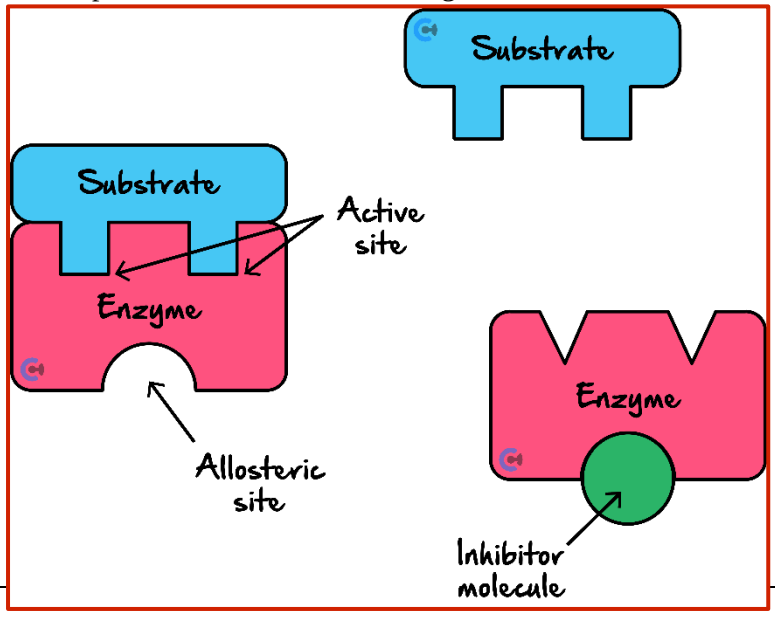
b. Non-competitive inhibitor.

A molecule that hinders enzyme function and prevents it from catalysing a reaction by binding to it (not at the active site) and causing a change in the active site shape.

Question 17 (3 marks)

Catalase activity in humans can be affected by toxins that act as non-competitive inhibitors.

In the space below, draw labelled diagrams to show the action of non-competitive inhibitors on catalase.



Mark allocation: 3 marks

- 1 mark for correct labels of enzyme, substrate, and inhibitor.
- 1 mark for enzyme and substrate binding or showing enzyme and substrate having complementary shapes.
- 1 mark for showing the changing shape of the active site and the substrate being unable to bind.

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