

Enzymes

Mark Scheme



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1. Enzymes are biological molecules that are essential for life. Answer each of the following multiple-choice questions relating to cell transport processes.

a) Which graph shows the effect of temperature on the activity of an enzyme?

C – is the only correct answer.	1 mark
	Total: 1 mark

b) A piece of bread begins to taste sweet when it is mixed with saliva and chewed for several minutes. Which substance in saliva causes this change?

B – is the only correct answer.	1 mark
	Total: 1 mark

c) The diagram shows the human digestive system. Which structure does **not** secrete digestive enzymes?

A – is the only correct answer.	1 mark
	Total: 1 mark

d) Enzymes are biological molecules. What type of biological molecules are enzymes?

D – is the only correct answer.	1 mark
	Total: 1 mark

e) Amylase is a carbohydrase enzyme. What would be the products when amylase breaks down its substrate.

A – is the only correct answer.	1 mark
	Total: 1 mark

f) The figure below shows two different food molecules before and after they have been digested by enzymes in the ileum. Which **two** structures show the products of lipid digestion.

F – is the only correct answer.	1 mark
	Total: 1 mark

g) The figure of the graph below shows the effect of different pH values on the rate of reaction of three different enzymes. What does the figure of the graph show?

C – is the only correct answer.	1 mark
	Total: 1 mark

h) What is the main substrate broken down by the enzyme lipase?

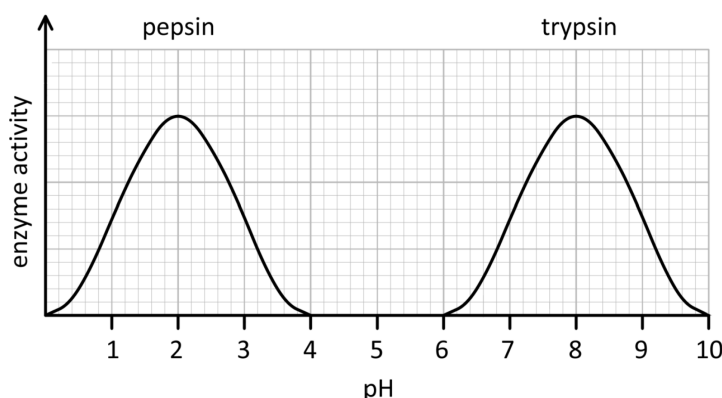
B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 8 marks)

2. The enzymes trypsin and pepsin are protease enzymes.

A student conducted an experiment to examine how enzyme activity is affected by pH.

The results of their investigation is shown in the figure below.



- a) Enzymes are biologically molecules. What are enzymes?

Enzymes are biological catalysts	1 mark
Made of protein.	1 mark
	Total: 2 marks

- b) Describe the trend in the figure above for the enzyme trypsin.

Use information from the figure to support your answer.

A description to include the following:	
The graph shows that the activity of trypsin is highly dependent on pH.	1 mark
Trypsin exhibits very low activity at pH values below 6.	1 mark
As the pH increases from 6 to around 8, the enzyme activity rapidly increases. The enzyme reaches its optimal activity, as indicated by the peak of the curve, at a pH of approximately 8.	1 mark
Above pH 8, the enzyme activity gradually decreases, becoming very low again at pH values above 10.	1 mark
	Total: 3 marks

- c) Identify the optimum pH for pepsin.

pH 2	1 mark
	Total: 1 mark

- d) Explain why there is no pepsin activity at pH 5.

An explanation to include:	
Pepsins active site has been denatured.	1 mark
This means the active site has changed shape.	1 mark
The substrates cannot bind to the active site therefore no products are formed.	1 mark
Accept no enzyme substrate complexes are formed.	
	Total: 3 marks

(Total for Question 2 is 9 marks)

3. A group of students investigated two enzymes, enzyme X and Y which are found in the digestive system.

a) Enzyme X is a protease enzyme.

State the substrate and products of a protease enzyme.

Substrate: protein or proteins.	1 mark
Product: amino acids.	1 mark
	Total: 2 marks

The students say that their results show enzyme X is a protease enzyme and is found in the stomach.

b) Explain whether the students results back up their claim?

An explanation that <u>links</u> the following:	
Yes the results back up the claim.	
pH of the stomach is 1.5 and the optimum pH of enzyme X is close to this.	1 mark
An enzyme that works in the stomach would be adapted for this low pH and only protease enzymes function in the stomach.	1 mark
	Total: 2 marks

c) Enzymes which are present in the mouth are denatured when they are swallowed into the stomach.

i. State what is meant by the term “denatured”.

The active site of the enzyme has changed shape.	1 mark
Therefore substrate molecules cannot bind to the active site.	1 mark
Accept no enzyme substrate complexes form.	
	Total: 2 marks

ii. Explain why a denatured enzyme does not function.

Substrate molecules cannot bind to the active site.	1 mark
No product molecules are formed.	1 mark
	Total: 2 marks

(Total for Question 3 is 8 marks)

4. Maltase is an enzyme that breaks down carbohydrates.

a) State the substrate and product of maltase.

Substrate: maltose.	1 mark
Product: glucose.	1 mark
	Total: 2 marks

b) Identify where maltase is produced in the digestive system.

The ileum or small intestine.	1 mark
	Total: 1 mark

- c) Explain how maltase breaks down carbohydrates, your answer should include correct references to the 'lock and key' model of enzyme action.

An explanation to include the following:	
Maltose is the substrate for the enzyme maltase.	1 mark
Maltase has an active site whose shape is complementary to the shape of maltose.	1 mark
The 'lock and key' model states that the substrate (maltose) has a shape that is complementary to the shape of the enzyme's active site (maltase).	1 mark
The substrate (maltose) fits into the active site of the enzyme (maltase), forming an enzyme-substrate complex.	1 mark
	Total: 3 marks

A student investigated the effect of temperature on the activity of maltase.

The student used the following method:

- Set up the apparatus as shown in the figure above.
 - After 5 minutes, pour the maltose solution into the maltase solution and mix well.
 - Remove some of the maltose-maltase mixture and add it to some Benedict's solution in a water bath.
 - Record the colour of the maltose-maltase mixture after it has been added to the Benedict's solution.
 - Repeat steps 3 and 4 every 2 minutes until the Benedict's solution remains a blue colour.
 - Repeat steps 1 to 5 using water at different temperatures.
- d) Identify **two** control variables the student used in the investigation.

Any <u>two</u> of the following:	
Concentration of maltase solution.	1 mark
Volume of maltase solution.	1 mark
The water bath temperature when testing with Benedict's	1 mark
Time allowed before adding maltose solution to maltase solution	1 mark
	Total: 2 marks

The table below shows the results of the students investigation.

Temperature (°C)	Time taken for colour change (min)
10	No colour change
20	20
30	10
40	2
50	10
60	20
70	No colour change

- e) What conclusion could the student make about the effect of increasing temperature on maltase activity between 20 °C and 60 °C?

Increasing the temperature increases the rate of enzyme activity until after 40°C	1 mark
After 40°C the rate of enzyme activity decreases as temperature increases.	
	Total: 1 mark

- f) Explain why there was no colour change when the temperature of the mixture was 10 °C.

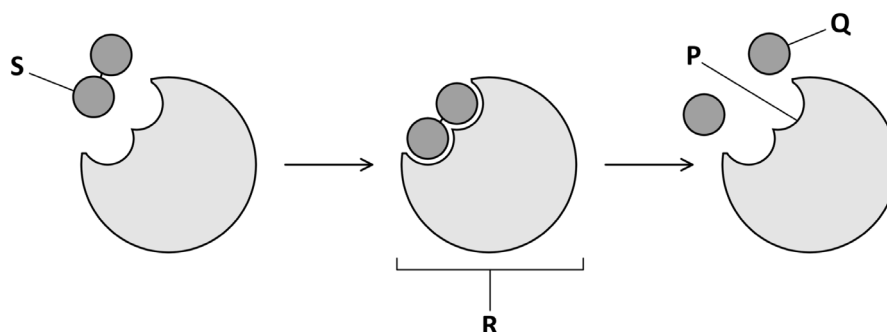
The particles did not have enough kinetic energy	1 mark
Therefore the rate of reaction was too low.	1 mark
	Total: 2 marks

- g) Explain why there was no colour change when the temperature of the mixture was 70 °C.

The enzymes active site has been denatured. This means the active site has changed shape.	1 mark
The substrates cannot bind to the active site therefore no products are formed.	1 mark
Accept no enzyme substrate complexes are formed.	
	Total: 2 marks

(Total for Question 4 is 13 marks)

5. The figure below shows the different stages of the action of an enzyme.



- a) Identify structures S, P, Q and R in the figure above.

S = substrate	1 mark
P = active site	1 mark
Q = product	1 mark
R = enzyme substrate complex.	1 mark
	Total: 4 marks

- b) State the **three** conditions that will cause an enzyme to be denatured.

Low pH	1 mark
High pH	1 mark
High temperature	1 mark
	Total: 3 marks

- c) Lipase is an enzyme involved in digestion. Explain **how** lipase breaks down lipids during digestion.

Lipase separates each lipid molecule into	
Three fatty acids	1 mark
And one glycerol molecule.	1 mark
	Total: 3 marks

(Total for Question 5 is 10 marks)

6. The digestive system has a number of different enzymes.

The table below shows some of the different enzymes of the digestive system. As well as their substrates and their products. Complete the table below.

Food sample	Enzyme	Products
Carbohydrate	Amylase	Maltose
Protein	Protease/ pepsin/ trypsin	Amino acids
Lipid	Lipase	3 fatty acids 1 glycerol

1 mark for each correct box.	
	Total: 5 marks

(Total for Question 6 is 5 marks)

7. The figure below shows the rate of reaction for the enzyme lipase at different temperatures.

Explain why the rate of reaction is different at points P, Q, R and S.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Provides a basic description of the graph. Attempts to explain the difference in rate, but the explanations may be limited or inaccurate. May only focus on one or two points.
Level 2	3 - 4	Provides a reasonable explanation for at least three of the four points (P, Q, R, and S). Mentions some of the key concepts, but the explanation may lack detail or clarity in some areas. May not fully explain the link between temperature and enzyme structure.
Level 3	5 - 6	Provides a detailed and coherent explanation for all four points (P, Q, R, and S). Accurately explains the effect of temperature on enzyme activity, including the concepts of increasing kinetic energy, optimal temperature, and denaturation. Clearly links the different temperatures to the changes in enzyme structure and function.

Indicative Content:	
Point P: - Lower temperature. - Increasing the temperature increases kinetic energy of enzyme and substrate molecules. - More frequent collisions between enzyme and substrate. - More enzyme-substrate complexes formed. - Increased rate of reaction.	

Point Q: • Optimum temperature. • Enzyme working at its maximum rate. • Most enzyme-substrate complexes are being formed in a given time. Point R: • Temperature is becoming too high. • Enzyme starts to denature. • Active site changes shape. • Substrate fits less well/cannot fit into active site. • Rate of reaction decreases. Point S: • High temperature. • Enzyme is denatured. • Active site is significantly changed. • Substrate cannot bind to active site. • Little or no enzyme-substrate complexes formed. • Rate of reaction is very low/zero. Reference to Graph: • Reference to specific temperatures, e.g., at 30 degrees, the rate of reaction is approximately 10. • Comparison of relative rate of reaction at the different points.	
	Total: 6 marks

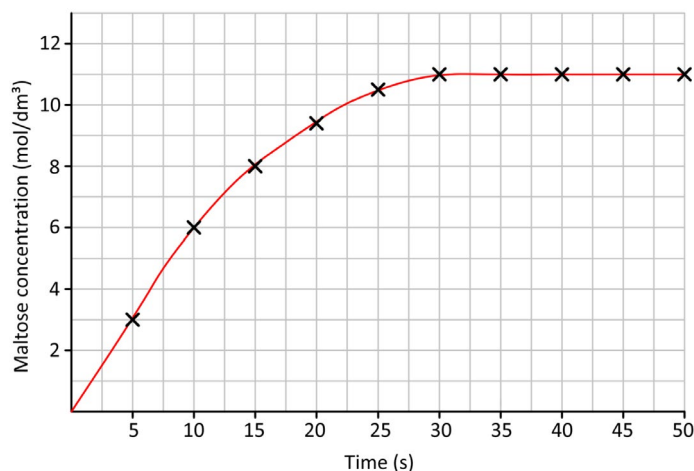
(Total for Question 7 is 6 marks)

8. A student conducted an experiment to investigate the rate of reaction of a carbohydrase enzyme.

a) What enzyme did the student use in their investigation?

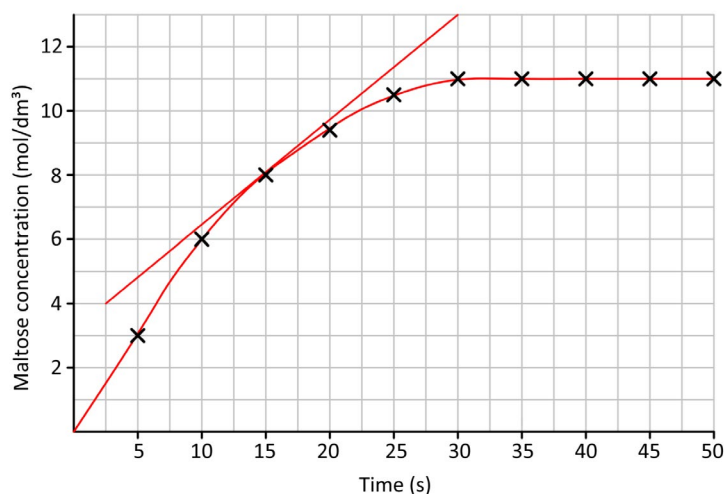
<u>Amylase.</u> Do not accept carbohydrase.	1 mark
	Total: 1 mark

b) Plot the students results on the graph.



Points plotted correctly.	1 mark
Smooth curve of best fit drawn.	1 mark
	Total: 2 marks

c) Use the completed graph to determine the rate of the reaction at 15 seconds.



Use of a tangent to determine rate.	1 mark
Rate of reaction = change in y ÷ change in x	
Rate of reaction = $(13 - 4) \div (30 - 1)$	
Rate of reaction = $9 \div 29 = 0.31 \text{ mol/dm}^3/\text{s}$	1 mark
	Total: 2 marks

d) In terms of substrate molecules, explain why the graph plateaus.

The reaction is complete.	1 mark
The substrate molecules have been converted to products.	1 mark
There are no more substrate molecules present.	1 mark
	Total: 3 marks

(Total for Question 8 is 8 marks)