OCR A-LEVEL BIOLOGY A · H420

BIOLOGY



EXAM QUESTION PACK

2.1.4 ENZYMES

SCORE	PERCENTAGE
/149	%

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Answer **all** the questions.

1. Which inorganic ion can act as a cofactor for amylase?

A OH^-

B PO_4^{3-}

C Cl^-

D HCO_3^-

Your answer ☐

[1]

2. Fig. 2.1 shows the shapes of an enzyme molecule, its substrate and the molecules of three substances, **P, Q** and **R**.
Each substance could bind either to the enzyme or to the substrate to cause an effect.

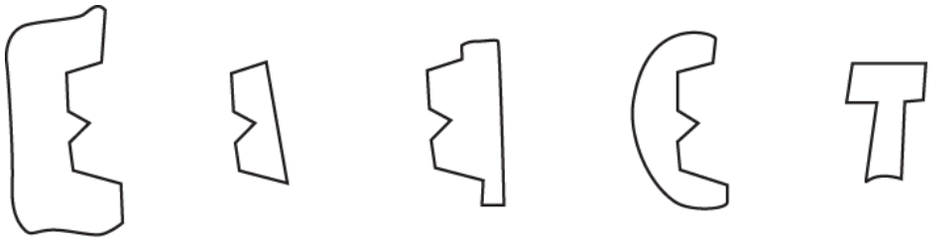


Fig. 2.1

Four tubes were set up:

- The control contained enzyme and substrate only
- **Tube P** contained enzyme, substrate and substance **P**
- **Tube Q** contained enzyme, substrate and substance **Q**
- **Tube R** contained enzyme, substrate and substance **R**.

Which option describes the most likely effect on the rate of reaction in each tube **compared** with the control?

	Tube P	**Tube Q**	**Tube R**
A	increased	no effect	no effect
B	decreased	no effect	decreased
C	decreased	no effect	no effect
D	decreased	decreased	no effect

Your answer ☐

[1]

3. Which of the following factors does **not** affect the shape of the active site of an enzyme?

A a drop in temperature
B non-competitive inhibitor
C a change in pH
D binding of substrate

Your answer ☐

[1]

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4. Enzymes are capable of affecting the metabolism and structure of whole organisms. Which of the following enzymes will have the greatest effect on the **development** of an organism as a whole?

A Methyltransferase: adds methyl groups to DNA allowing genes to be switched on or off.
B Reverse transcriptase: generates complementary DNA from an RNA template.
C Deoxyribonuclease: digests free DNA molecules outside of the nucleus.
D Telomerase: lengthens ends of chromosomes by adding DNA sequences, preventing them from being degraded.

Your answer ☐

[1]

5. Zinc ions are necessary for the enzyme carbonic anhydrase to work.

Which statement correctly describes the nature and function of zinc ions in their interaction with carbonic anhydrase?

A inorganic ions and coenzymes
B vitamins and prosthetic groups
C inorganic ions and prosthetic groups
D vitamins and coenzymes

Your answer ☐

[1]

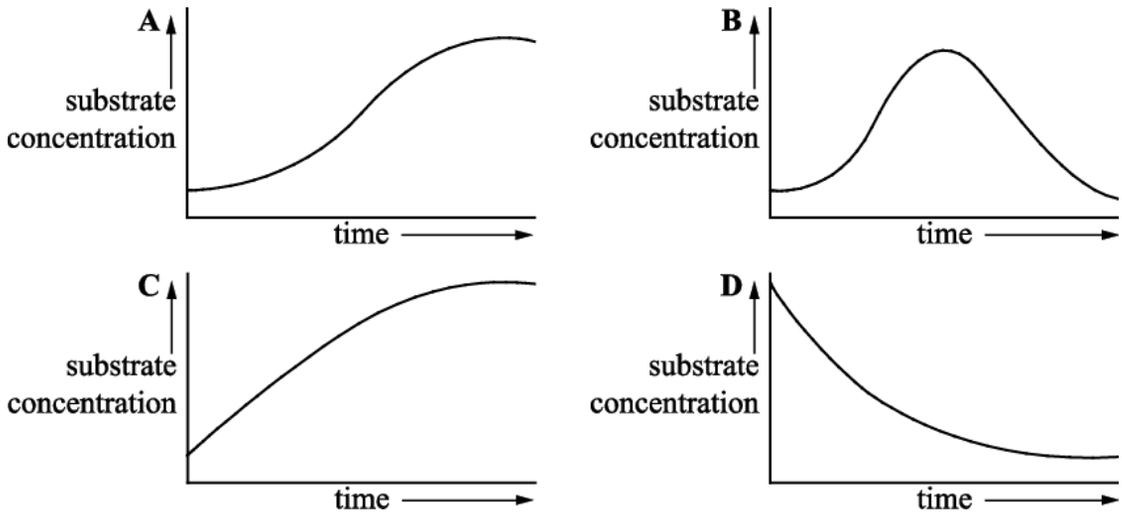
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6. A group of students monitored the **substrate** concentration during an enzyme-controlled reaction.

Select the graph that correctly shows how the substrate concentration changes during the course of the reaction.



Your answer

[1]

7. A chemical produced by a metabolic pathway binds to the initial enzyme in the pathway. The chemical binds to the enzyme at a site away from the active site and inhibits the enzyme action.

Which of the following statements about the mode of action of the chemical is / are correct?

Statement 1: It is an end product inhibitor.
Statement 2: It is a competitive inhibitor.
Statement 3: It binds to the allosteric site of the enzyme.

A 1, 2 and 3
B Only 1 and 2
C Only 1 and 3
D Only 1

Your answer ☐

[1]

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8. The concept of molecules with complementary shapes can be used to explain many processes in living things.

Complete the following passage about the mechanism of enzyme action.

Enzymes are proteins which speed up the rate of biological reactions. They form an

_____ by binding to their substrate at a site known as the

_____ . This site has a specific shape created by the

_____ structure of the protein molecule. This means that each enzyme can bind to only one type of substrate molecule.

This is explained by the lock and key hypothesis. In an alternative hypothesis, the binding site changes shape to fit more closely around the substrate molecule. This is called the

_____ hypothesis. This hypothesis can help to explain how enzymes enable reactions to occur at lower temperatures by reducing the

_____ required for the reaction to occur.

[5]

9. Citrate synthase catalyses the conversion of oxaloacetate into citric acid in the Krebs cycle. It exhibits product inhibition.

Which of the following is the correct description of citrate synthase?

	Type of respiration involved in	Location of enzyme	Inhibitor
A	anaerobic	cytoplasm	citric acid
B	aerobic	mitochondria	citric acid
C	aerobic	mitochondria	oxaloacetate
D	anaerobic	cytoplasm	oxaloacetate

Your answer ☐

[1]

10. Liver cells have a high metabolic rate. Hydrogen peroxide is a metabolic product produced in significant quantities in liver cells. It needs to be removed in order to prevent serious damage to the liver cells.

Hydrogen peroxide is detoxified by the enzyme catalase:

$$2H_2O_2 \square\ 2H_2O + O_2$$

Catalase has a very high turnover number. A single catalase molecule can catalyse the breakdown of approximately 6 million hydrogen peroxide molecules every minute. Catalase is found in peroxisomes inside the liver cells. Peroxisomes are organelles surrounded by a single membrane.

The activity of catalase was investigated in a laboratory, using chopped liver tissue and dilute hydrogen peroxide. When the chopped liver was added to the hydrogen peroxide large quantities of froth as bubbles of oxygen were produced in the liquid.

Fig. 17.3 shows the effect of increasing enzyme concentration on the rate of the reaction.

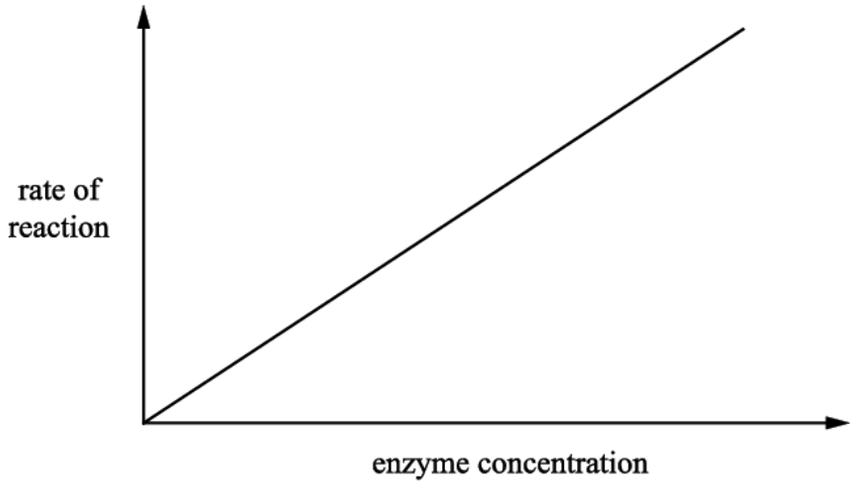


Fig. 17.3

(i) Identify **two** variables that would need to be controlled in this laboratory investigation.

1 ----------

2 ----------

[1]

(ii) How could you control **one** of the variables that you identified in **(i)** in the laboratory investigation?

----

[1]

(iii) * Using the information, deduce why and how catalase activity is regulated inside the liver cells.

[6]

11. Temperature is very important in determining a plant's ability to photosynthesise effectively.
Temperature stress is becoming of great concern to plant physiologists because of climate change.

- High temperature (HT) stress is defined as the rise in temperature that is sufficient to cause irreversible damage to plant growth and development.

Some of the stress effects of temperature have been recorded in various plants and are outlined in **Table 18.1**.

Temperature	Effect
Moderate HT stress	Heat-induced deactivation of RuBisCO No change in chlorophyll fluorescence in PSII Reduction in stomatal aperture
Severe HT stress	Decrease in chlorophyll content as a result of photodeterioration Changes in the ultrastructure of the chloroplast

Table 18.1

(i) Assess the impact of moderate HT stress on the process of photosynthesis.

---**[3]**

(ii) Suggest **two** ways in which the ultrastructure of the chloroplast can be altered by high temperatures.

For each suggestion, explain the effect that it will have on photosynthesis.

Suggestion ---

Explanation ---

Suggestion ---

Explanation ---

---

[4]

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12. *Heliamphora*, shown in Fig. 18.1, is a genus of carnivorous plant. Its leaves are adapted to form water-filled traps for insects. The insects are attracted by nectar, then fall into the traps and drown. The plants digest the insects and absorb the mineral ions produced. This allows *Heliamphora* to survive in soils with low mineral content.



Fig. 18.1

Enzymes digest insects that fall into *Heliamphora* traps.

Is the mode of action of these enzymes extracellular or intracellular? Explain your answer.

---

[3]

13. Respiration is an important metabolic process that takes place in all living cells.

The black widow spider, *Latrodectus hesperus*, paralyses and kills its prey with venom.
The venom contains a toxin known as latrotoxin. If a human is bitten, this toxin can cause serious harm by damaging heart tissue. Latrotoxin causes influx of Ca^{2+} ions, which disrupts normal cell function, including respiration.

An investigation was carried out into the effect of latrotoxin on aerobic respiration in humans.

The rate of activity of malate dehydrogenase, a mitochondrial enzyme involved in aerobic respiration, was analysed at different substrate concentrations. The substrate concentrations used were within the normal range for a living cell.

The data is shown in Table 19.1.

Concentration of malate (mmol dm^{-3})	Rate of reaction of malate dehydrogenase (mmol dm^{-3} s^{-1})
0.0	0.0
1.0	37.7
2.0	55.2
3.0	66.0
4.0	74.8
6.0	83.1
8.0	88.9
10.0	92.3
14.0	96.9
18.0	99.0

(i) Use the space provided to plot a suitable graph of these data.

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[4]

(ii) Calculate the mean increase in malate dehydrogenase activity for every 1 mmol dm^{-3} increase in malate concentration between 1.0 and 10.0 mmol dm^{-3}.

Give your answer to **two significant figures**.

Show your working.

Answer = _____ **[3]**

(iii) The normal maximum rate of malate dehydrogenase activity is 100 mmol dm^{-3} s^{-1}.

The data in Table 19.1, **on the Insert**, were obtained in the presence of latrotoxin.

What can be deduced from these results about latrotoxin's mode of action as a poison? Justify your answer.

_____

_____

_____

_____

_____

_____

_____ **[3]**

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14. Sodium ions and glucose are both reabsorbed into the blood from proximal convoluted tubules (PCTs) in the kidney.

(i) A student designed an experiment to investigate the effect of temperature on the rate of glucose diffusion through dialysis tubing.

State **two** factors that would need to be controlled in this experiment.

1

2

---

[2]

(ii) Describe the structural difference between alpha and beta glucose molecules.

---

[1]

(iii) Sulthiame is a drug that inhibits the enzyme carbonic anhydrase.

Fig. 2.2 shows the role of carbonic anhydrase in the PCT of the kidney.

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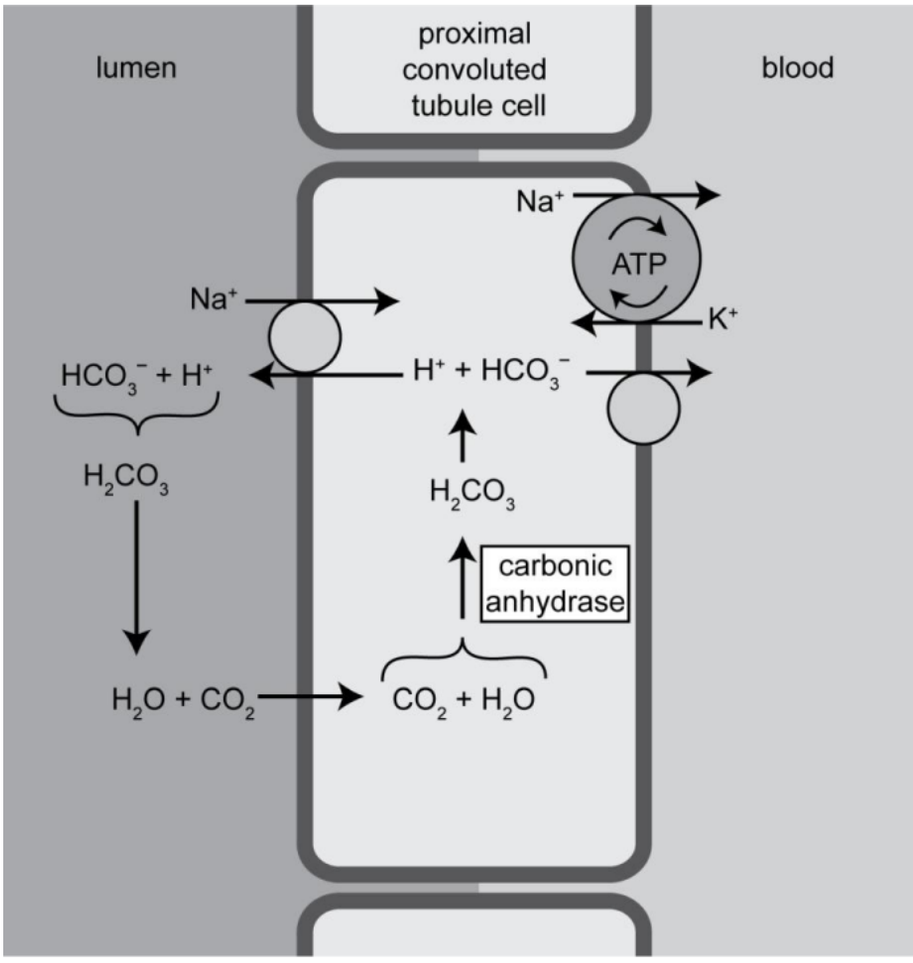


Fig. 2.2

Using the information in Fig. 2.2, what can you conclude about the likely effect of sulthiame on the reabsorption of sodium ions in the PCT?

---

[3]

15. Tissue traces from a crime scene often need to be identified. DNA from the tissue is 'amplified' by the polymerase chain reaction (PCR) to get samples large enough for further analysis.

Modern PCR technique uses DNA polymerase from the bacterium *Thermus aquaticus.* Why is this enzyme chosen?

---

[2]

16(a). The student conducted a further investigation using the same enzyme and substrate.

- A range of substrate concentrations was used.
- The investigation was repeated in the presence of an inhibitor of amylase activity extracted from kidney beans.

Fig. 2.2 shows a sketch of the student's results.

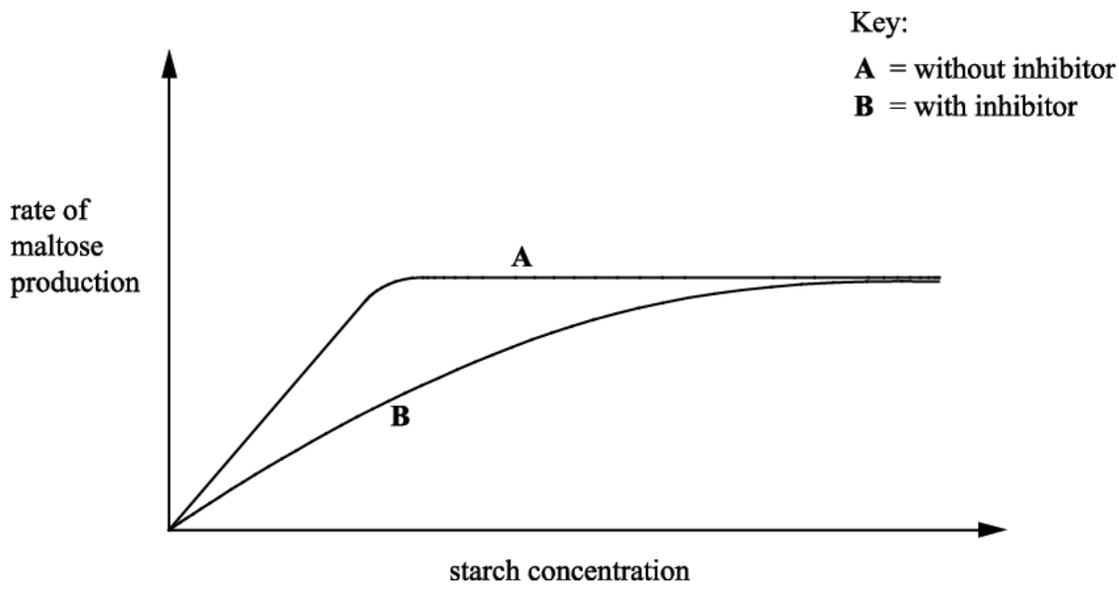


Fig. 2.2

(i) Explain the mechanism by which the extract from the kidney bean inhibited the amylase.

---**[3]**

(ii) What evidence from the graph supports your answer to part **(i)**?

---**[1]**

(b). Amylase is an enzyme that breaks down starch into maltose.

A student investigated the breakdown of starch into maltose. The results are shown in **Fig. 2.1**.

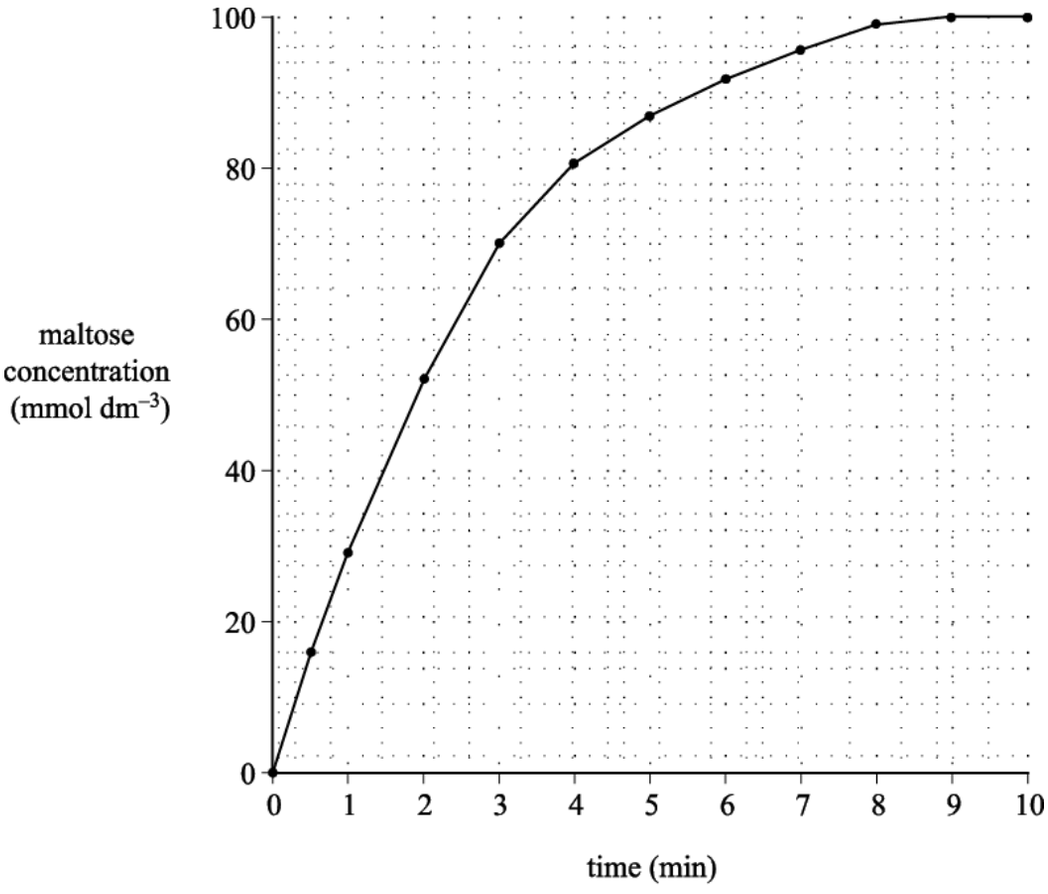


Fig. 2.1

(i) Calculate the rate of maltose production over the first 30 s.

Show your working and use appropriate units.

Answer_____ **[2]**

(ii) How would this calculated rate differ from the 'true' initial rate of reaction?
Explain your answer.

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---**[3]**

(c). The student then investigated the effect of pH on the activity of the amylase.

This was the method used,

- Tubes containing starch and amylase were set up in a range of pH buffer solutions.
- The same concentration of starch and amylase were used each time.
- A small sample of the solution was removed and tested for the presence of starch at 20 s intervals.
- The procedure was repeated three times and a mean was calculated for each pH.

The student presented the results in **Table 2.1**.

pH	4	5	6	7	8	9
Mean amylase activity (% of maximum)	27	68	96	100	50	29

Table 2.1

(i) Another student wanted to replicate the investigation.

Refine the method, by giving additional information, so that reproducible results would be obtained.

---**[3]**

(ii) Explain, with reference to bonding, why amylase activity is low at pH 4.

---

[4]

(iii) The student concluded that the optimum pH for amylase was pH 7.

A teacher made the following statement:

'*The results in **Table 2.1** provide only weak support for the conclusion that the optimum pH for amylase is pH 7.0*'

Evaluate the statement **and** suggest an improvement to the student's procedure that would support the conclusion more strongly.

Evaluation

Improvement

---

[3]

(d). Amylase activity is increased in the presence of chloride ions.

State the name given to any inorganic ion that increases the activity of an enzyme.

---

[1]

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17. A student investigated the effect of pH on the rate at which an enzyme breaks down a substrate.

What would be a suitable control for this investigation?

An identical tube set up with:

A no buffer
B no buffer and no enzyme
C no enzyme
D no substrate

Your answer ☐

[1]

18. Which of the following, **A** to **D,** is an **incorrect** statement about enzymes?

A amylase and trypsin catalyse extracellular reactions
B catalase catalyses intracellular reactions
C extracellular enzymes are produced outside the cell
D intracellular enzymes work inside the cell

Your answer ☐

[1]

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19(a). Catalase is an intracellular enzyme with an iron-containing haem group.

(i) State the term used to describe an ion that is essential for the enzyme to function.

---

[1]

(ii) Name another conjugated protein that contains a haem group.

---

[1]

(b). Fig. 20.2 shows the effect of copper ions on the activity of catalase.

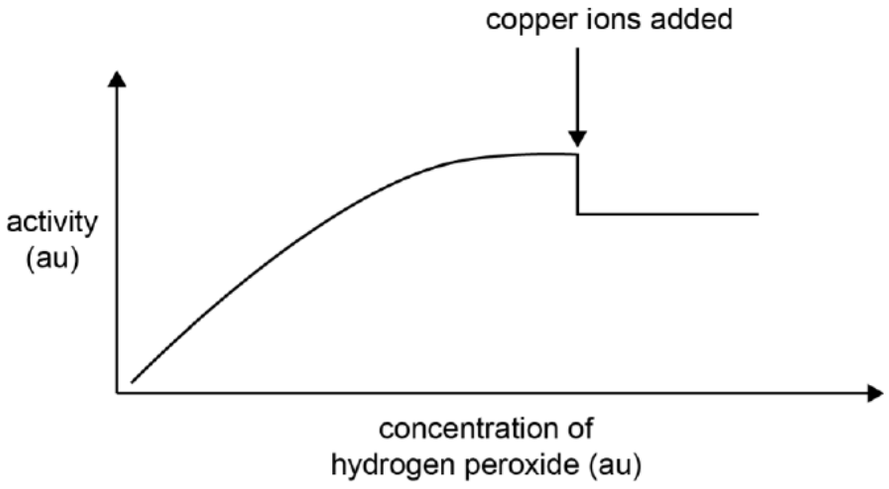


Fig. 20.2

What can you conclude from Fig. 20.2 about the type of inhibition shown? Explain your answer.

---

[2]

20. Some inorganic ions have roles in enzyme-controlled reactions.

Which of the rows, **A** to **D**, in the table below is correct?

	Role of ion	
	Cofactor for amylase	**Prosthetic group for carbonic anhydrase**
A	Zn^{2+}	Cl^-
B	Zn^+	Cl^-
C	Cl^{2-}	Zn^+
D	Cl^-	Zn^{2+}

Your answer

[1]

21(a). Fungi produce enzymes to digest complex food substances. Amylase is an enzyme that catalyses the conversion of starch to maltose.

- A sample of the fungus *Amanita citrina* was placed on agar in a petri dish.
- The agar contained starch.
- The dish was incubated until the thread-like hyphae had grown a few centimetres.
- Iodine solution was then poured onto the surface of the agar.

A diagram representing the results is shown in Fig. 4.

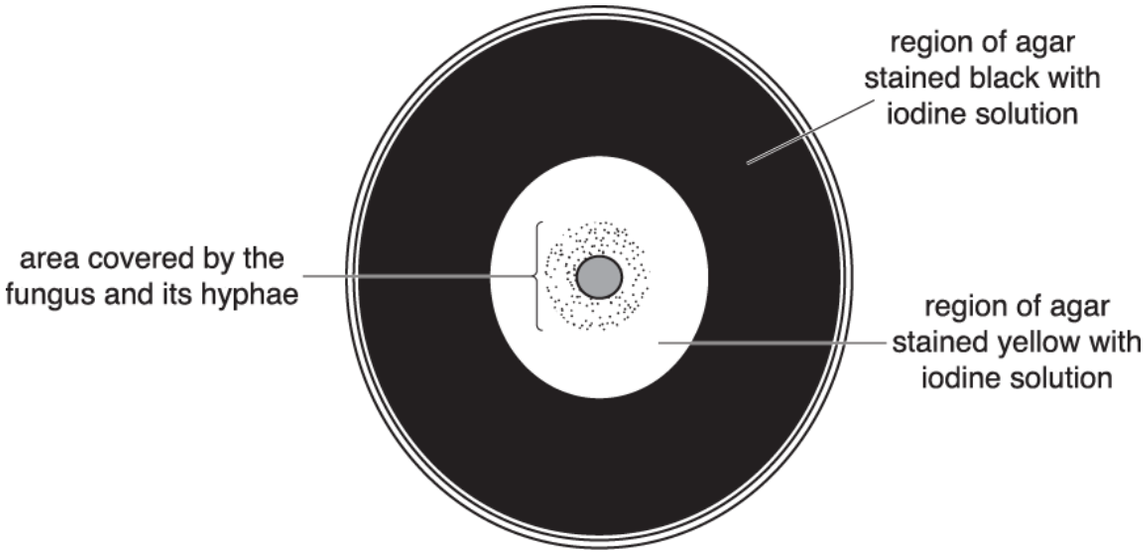


Fig. 4

(i) To which genus does this fungus belong?

---

[1]

(ii) The region of yellow staining shown in Fig. 4 includes part of the agar where the fungus had not yet grown.

What does this pattern indicate about the action of the fungal enzymes?

---

[1]

(b). Lipase is an enzyme that catalyses the breakdown of lipids.

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An investigation was carried out to see the effect of temperature on the activity of a lipase.

- 5 cm^3 of an alkaline solution of lipid was poured into a test tube.
- The test tube was placed into a water bath maintained at 20 °C and left to equilibrate.
- A few drops of an indicator were added to the wells of a white spotting tile. The indicator is pink above pH values of 8.3 and turns colourless at pH values below 8.3.
- Once the lipid solution had equilibrated, 1 cm^3 of 0.5% lipase solution at the same temperature was then added to the test tube.
- For five minutes, at 30 second intervals, the solution was stirred and a few drops were removed from the test tube and placed in a well on the white spotting tile.
- The time was recorded when the solution and indicator did not remain pink.
- The procedure was repeated four more times at 20 °C and then again at a further six temperatures.

The results are shown in Table 4.1 below.

Temperature (°C)	**Time when solution did not remain pink**				
	Replicate 1	**Replicate 2**	**Replicate 3**	**Replicate 4**	**Replicate 5**
20	210	270	240	300	270
25	90	120	210	180	120
30	60	60	90	90	60
35	60	60	60	90	60
40	210	120	210	180	210
45	240	300	300	–	270
50	–	–	–	–	–

Table 4.1

(i) Why is pH **not** a controlled variable in this investigation?

---**[1]**

(ii) Identify **one** variable that has been controlled in this procedure.

---**[1]**

(iii) Identify **one** variable, other than pH, that has **not** been controlled in this procedure.

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[1]

(iv) The procedure required the solution to be stirred and then drops of solution to be placed on a white spotting tile.

Suggest why this procedure was followed rather than simply adding indicator to the test tube, stirring the solution and looking for the colour change in the test tube.

---

[1]

(v) What can be concluded from the results in Table 4.1 about the optimum temperature for lipase activity?

---

[1]

(vi) Describe **two different** ways in which the procedure could be modified to obtain a more accurate value for the optimum temperature for lipase activity.

1

2

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[4]

(c). There are two models for the mechanism of enzyme action. Outline how changes in temperature can affect these mechanisms of lipase action.

[6]

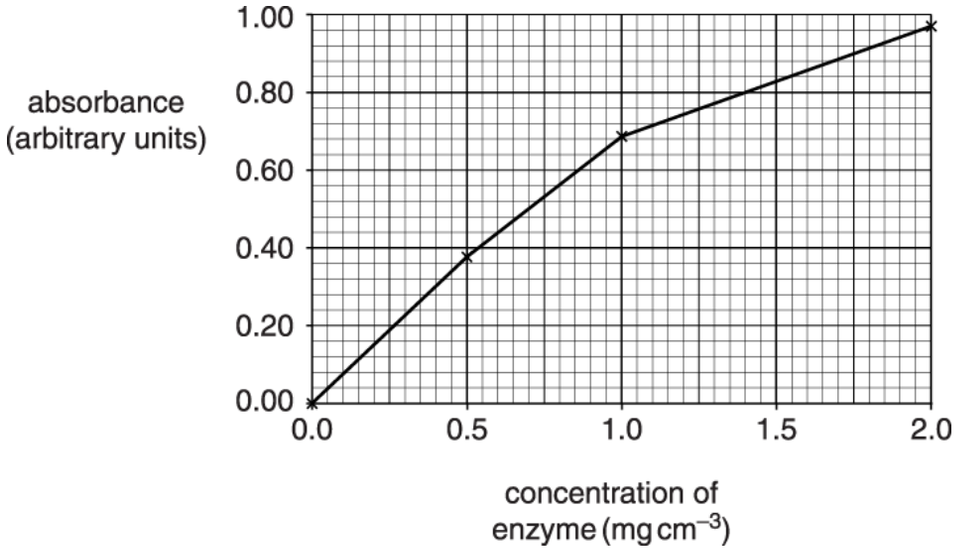
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22(a). A student wished to determine the mass of enzyme in 250 cm^3 of an enzyme solution of unknown concentration.

To determine the concentration of this enzyme solution, the student first carried out the biuret test on three enzyme solutions of known concentration:

- solution **1** — 0.5 mg cm^{-3} of enzyme
- solution **2** — 1.0 mg cm^{-3} of enzyme
- solution **3** — 2.0 mg cm^{-3} of enzyme

After completing the biuret tests, the absorbance of light by each solution was measured using a colorimeter. The student plotted a graph of the results. The graph is shown in the figure.



(i) The student then carried out the same procedure on the enzyme solution of unknown concentration.

The absorbance reading on the colorimeter was 0.8 arbitrary units.

Using the line drawn by the student in the figure, determine the concentration of the enzyme solution.

Concentration = _____ mg cm^{-3}

Calculate the **mass** of enzyme, **in grams**, in 250 cm^3 of the enzyme solution.
Show your working. Give your answer to **two** decimal places.

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Answer = _____ g **[2]**

(ii) The student performed the calculation correctly. However, the teacher said that the value for the mass of enzyme given by the student was inaccurate.

Explain how the student's **method** could be improved to increase the accuracy of this value.

_____

_____

_____

_____

_____ **[2]**

(iii) Outline the practical procedures the student would have taken to generate the point on the graph at the origin (0.0, 0.00).

_____

_____

_____

_____

_____ **[2]**

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(b). Some enzymes work better in the presence of other molecules or ions.

Explain how these molecules or ions increase the activity of enzymes.

---

[5]

23. Large amounts of fat in the diet can lead to obesity.

Orlistat is a drug that directly reduces the breakdown of fat in the small intestine. This reduction in breakdown leads to less fat being absorbed into the body.

Suggest the mechanism by which orlistat reduces the breakdown of fat.

---

[1]

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24(a). A teacher was reviewing some common mistakes in a variety of students' answers to biological questions.

Some of the answers given by the students are written below.

"When investigating the effect of temperature on enzyme activity it is important to keep the amount of substrate the same."

Suggest a more suitable word than 'amount'.

[1]

(b). In response to the question "Explain why some types of food are stored in a freezer", a student wrote:

"Food does not decay when frozen because the very low temperature denatures the bacterial enzymes so the enzymes cannot bind to the substrate molecules in the food."

Suggest a better answer to the question.

[3]

25(a). Describe how an enzyme, such as pepsin, breaks down a substrate.

---

[5]

(b). A student investigated how changing the pH affected the activity of pepsin.

- He used a blender to make a suspension of egg white (protein) in water.
- At the start of the investigation the suspension was cloudy.
- He prepared fixed concentrations of egg white suspension, acid and pepsin to add to each of six test-tubes.
- He removed 0.1 cm^3 of the mixture from each test-tube and used universal indicator to measure the pH of each mixture.
- He incubated each test-tube in a water bath at 35 °C and timed how long it took for the egg white suspension in each tube to clear.
- He prepared a table in which he recorded his results (Table 1.1).

Tube	Volume of egg white suspension	Volume of acid added (cm^3)	Amount of pepsin added (cm^3)	Measured pH	Time for suspension to clear (m)
1	5	2.0	3.0	1	
2	5	1.5	3.0	2	
3	5	1.0	3.0	3	
4	5	0.5	3.0	4	
5	5	0.0	3.0	5	
6	5	2.0	0.0	1	

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Table 1.1

(i) Identify **three** errors the student made in the preparation of his **table** before he recorded his results.

1

2

3

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[3]

(ii) Identify a change the student could make to his procedure that would increase the **validity** of the investigation.

---

[1]

(iii) State the term that best describes the purpose of **tube 6**.

---

[1]

(iv) Another student suggested that he should repeat the investigation at least twice.

How would this have improved the investigation?

---

[2]

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(c). Fig. 1.1 shows the effect of increasing the substrate concentration on the rate of activity of pepsin.

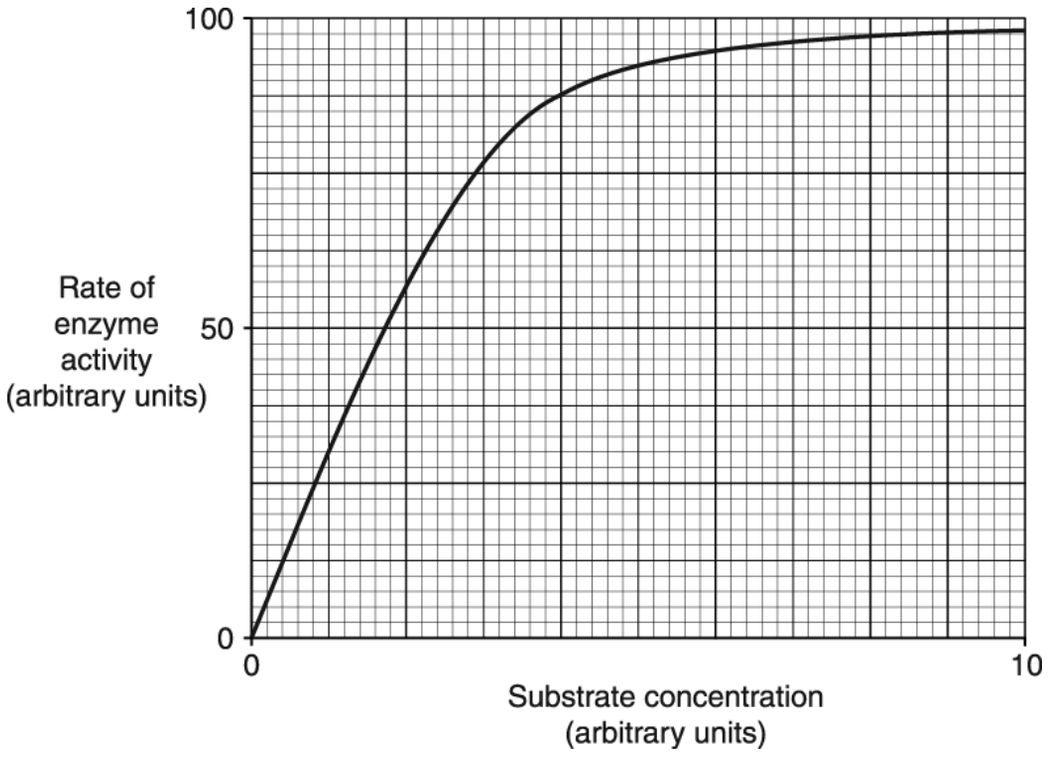


Fig. 1.1

(i) Pepstatin is a competitive inhibitor of pepsin.

On Fig. 1.1, draw a line to represent the effect of adding a fixed concentration of pepstatin on the rate of pepsin activity over the whole range of substrate concentrations.

This should be answered on Fig. 1.1

[2]

(ii) Pepstatin acts as a competitive inhibitor of pepsin.

What can you conclude about the structure of pepstatin?

---

[2]

26(a). Many reactions in living organisms are catalysed by enzymes.

Amylase is an extracellular enzyme that catalyses the breakdown of the polysaccharide starch (amylose) in the digestive system of many animals.

Why is the enzyme amylase described as being extracellular?

---

[1]

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(b). A student investigated the effect of changing the concentration of starch on the rate of starch breakdown by amylase.

The results of the investigation are shown in Fig. 2.1.

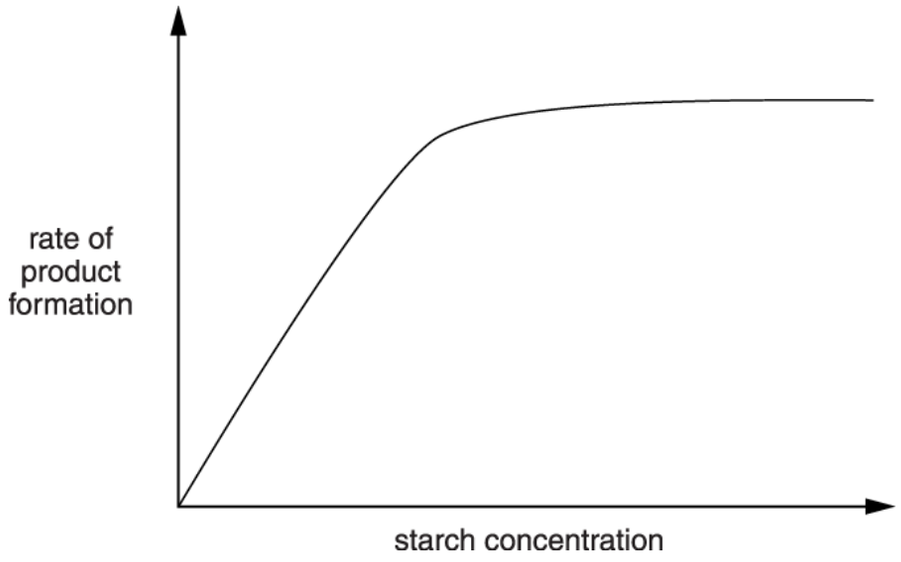


Fig.2.1

(i) To calculate the rate of starch breakdown, the student measured the concentration of the breakdown **product**.

State the other variable the student needed to know in order to calculate the **rate** of this reaction.

---

[1]

(ii) **Explain** the shape of the graph shown in Fig. 2.1.

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[5]

(iii) The student kept the pH of the solution constant during the experiment.

Explain why it is important that the pH was kept constant.

---

[3]

(iv) Suggest **two** other variables the student should have kept constant during the experiment.

1

2

---

[2]

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27. Nicotine molecules have a shape that is complementary to acetylcholine receptors. As a result, nicotine interferes with the nervous systems of insects and mammals by binding with these receptors.

(i) Where, precisely, are acetylcholine receptors found?

---

[1]

(ii) The way that nicotine is thought to work is outlined in Fig. 7.1.

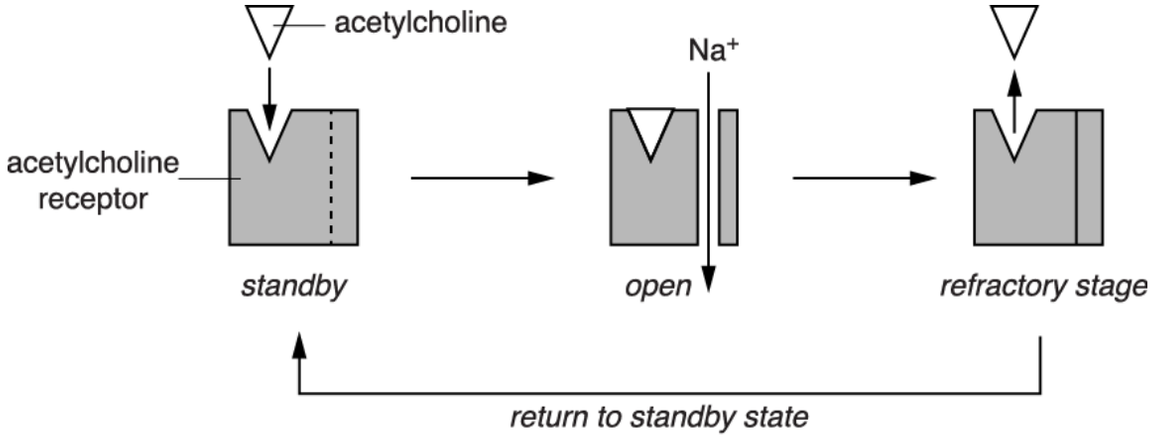


Fig. 7.1(a) When nicotine absent

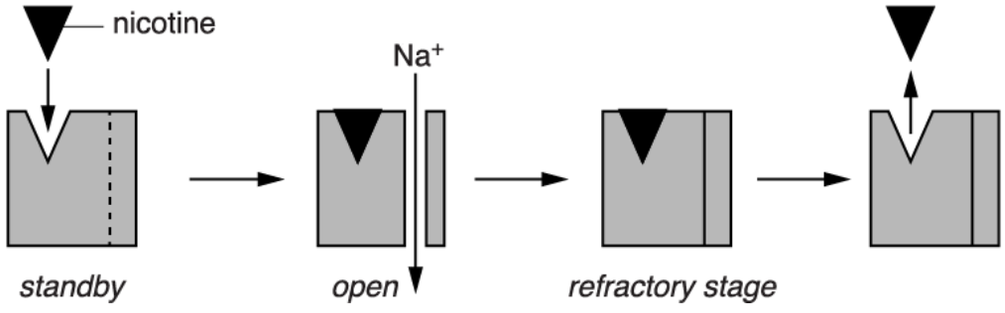


Fig. 7.1(b) When nicotine present

Using the information in Fig. 7.1(a) and Fig. 7.1(b), suggest and explain the effect that nicotine has on the nervous system.

---[3]

28. Many enzymes require cofactors, prosthetic groups and coenzymes to function.

Which of the statements, **A** to **D**, is correct?

A $C\Gamma$ acts as a coenzyme for amylase

B $C\Gamma$ acts as a cofactor for carbonic anhydrase

C Zn^{2+} acts as a prosthetic group for amylase

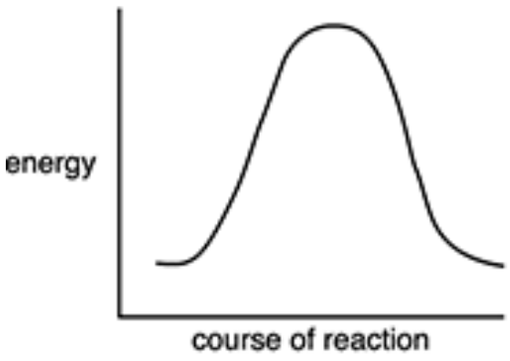
D Zn^{2+} acts as a prosthetic group for carbonic anhydrase

Your answer

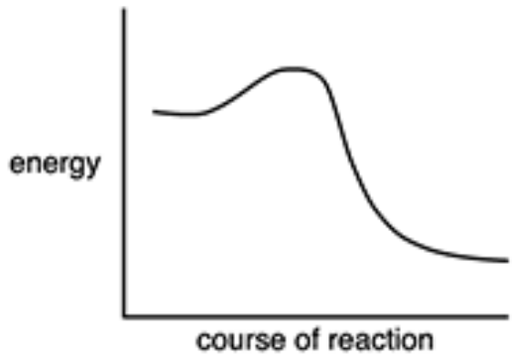
[1]

29. Which of the graphs, **A** to **D**, represents the energy changes involved during an enzyme-controlled anabolic reaction?

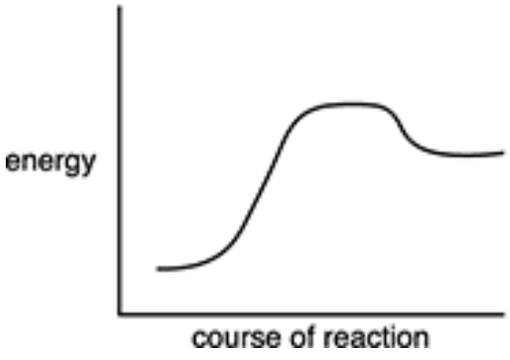
A



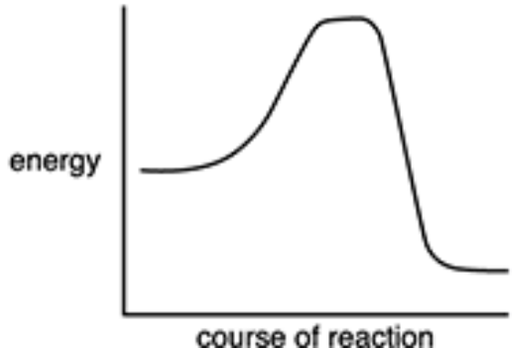
B



C



D



Your answer

[1]

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30. The following statements are about enzyme action.

1 Enzymes can affect the function of organelles.
2 Enzymes can affect the structure of an organism.
3 Enzymes only work inside cells.

Which of the statement(s) is/are correct?

A 1, 2 and 3
B only 1 and 2
C only 2 and 3
D only 1

Your answer

[1]

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31. Red blood cells contain high concentrations of the enzyme carbonic anhydrase.

(i) A scientist planned to investigate the effect of pH on the activity of carbonic anhydrase.

State **two** factors that the scientist would need to control during this investigation.

1

2

---

[2]

(ii) Human blood is maintained at a pH of 7.4 by reactions that occur in red blood cells.

Use your knowledge of these reactions to explain how a pH of 7.4 is maintained.

---

[3]

END OF QUESTION PAPER

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Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2			D	1	
			Total	**1**	
3			A	1	
			Total	**1**	
4			A	1	
			Total	**1**	
5			C	1	
			Total	**1**	
6			D	1	
			Total	**1**	
7			C	1	
			Total	**1**	
8			enzyme–substrate complex (1) active site (1) tertiary (1) induced fit (1) activation energy (1)	5	
			Total	**5**	
9			B	1	
			Total	**1**	
10		i	*two from* pH temperature substrate / hydrogen peroxide concentration (1)	1	Two answers required for 1 mark. **DO NOT ALLOW** an answer that includes mass of liver / enzyme concentration.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*pH* take pH reading / ensure hydrogen peroxide is same pH for all enzymes concentrations tested (1) *temperature* use liver tissue and hydrogen peroxide at room temperature / same temperature for all enzyme concentrations tested (1) *substrate concentration* use same concentration and volume of hydrogen peroxide for all enzyme concentrations tested (1)	1	
		iii	* **Level 3 (5–6 marks)** Deduction includes coherent interpretation of the evidence, clearly linking all ideas to explain why and how activity is regulated. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Deduction includes clear use of some evidence to support conclusion but ideas may not be clearly linked for both how and why. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A simple deduction about how or why based on a limited interpretation of the evidence. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	**Relevant points include:** *Why* • large quantities of hydrogen peroxide and high turnover number of catalase would mean vigorous reaction and lots of oxygen produced very quickly. *How* • isolation of catalase in peroxisomes • released in small quantities • cells can limit expression of catalase • this effectively limits enzyme concentration and therefore reduces reaction rate • cells have no control over temperature or substrate concentration so enzyme concentration is the only method of control.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
11		i	deactivation of RuBisCO will reduce, carbon dioxide fixation / light independent reaction (1) the light dependent reaction will reduce when the supply of NADP is reduced (1) reduction in stomatal aperture will reduce carbon dioxide available for fixation (1)	3	
		ii	*four from* damage to chlorophyll / reduction in pigment (1) which will reduce the light dependent stage (1) damage to membranes in chloroplast / reduction in sites for light capture (1) which will reduce the light dependent stage (1) damage to membranes in chloroplast / reduction in reaction sites for electron transfer (1) which will reduce, photophosphorylation / ATP production in the light dependent stage (1) damage to membrane around chloroplast / release of enzymes (1) which will reduce, light independent stage / Calvin cycle (1)	4	**Award 1 mark for the alteration of the ultrastructure (max 2) and 1 further mark for details of its effect on photosynthesis (max 2).**
			Total	**7**	
12			*extracellular because:* digestion is occurring in (liquid in) trap / leaf (1) not inside cells (1) (enzymes are) released by plant cells, into (liquid in) trap (1) (enzymes may also come from) bacteria (in trap) (1)	3	
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
13		i	axis labelled 'concentration of malate (mmol dm^{-3})' **AND** *y* axis labelled 'rate of reaction of malate dehydrogenase (mmol dm^{-3} s^{-1})' (1) plotted points use ≥50% of area provided **AND** equidistant scales on *x* and *y* axes (1) points plotted correctly ± 1 mm (1) **smooth** line of best fit (1)	4	**ALLOW** landscape **OR** portrait graph **DO NOT ALLOW** any other units, e.g. mM dm^{-3} / mM/dm^3 / mmol/dm^3 (since units are provided on table) **ALLOW** 'conc.' **DO NOT ALLOW** inversion of axes **ALLOW** solidus instead of brackets **NOTE** *x* axis data are non-linear **DO NOT ALLOW** points joined by straight lines (since candidates should recognise shape of curve)
		ii	6.1 (1)(1) mmol dm^{-3} s^{-1} (1)	3	1 mark for evidence of: (92.3 – 37.7) ÷ 9 2 max if answer is not to 2 SF **ALLOW** mmol dm^{-3}/s
		iii	not an enzyme inhibitor / does not inhibit malate dehydrogenase (1) *idea that* similar curve would be expected in absence of inhibitor / in normal conditions (1) allows enzyme / malate dehydrogenase to work at optimal rate / V_{max} (1) *idea that* may inhibit a different enzyme (1)	3	
			Total	**10**	
14		i	initial / AW, glucose concentration (on both sides on the membrane) (1) volume of solution (1) length / diameter, of dialysis tubing (1) type / brand, of dialysis tubing (1)	2	
		ii	*alpha glucose* H above ring / OH below ring, on, carbon 1 / C1 **ORA** (1)	1	**ALLOW** a suitable annotated diagram
		iii	*(less reabsorption because)* *idea of* fewer H^+ ions in PCT cells (1) less / no, co-transport / facilitated diffusion, of Na^+ ions, into cells / from lumen (1) less / no, active transport of Na^+ ions into, blood (1)	3	
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
15			thermostable **OR** does not, denature / AW, at 95 °C (during DNA strand separation) (1) so PCR can be cycled repeatedly without stopping (to reload with enzyme) (1)	2	**ALLOW** temperature values 93 – 97 °C in correct context. **DO NOT ALLOW** "killed“ for denatured. **IGNORE** refs to optimum working temperature, which would apply equally to less thermostable polymerases.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
16	a	i	*three from* competes (with substrate) / competitive (1) enters / fits in / binds to / blocks, active site (1) prevents substrate from entering active site (1) (binds to active site) temporarily (1)	3	
		ii	(at high substrate concentration) rate approaches rate in absence of inhibitor (1)	1	**IGNORE** idea that increased substrate concentration overcomes the inhibition as answer must refer to evidence from the graph.
	b	i	32 (1) mmol dm^{-3} min^{-1} (1)	2	**ALLOW** mmol dm^{-3} / min' or 'mmol dm^{-3} per, min / minute **ALLOW** 0.53 mmol dm^{-3} / s
		ii	(initial rate likely to be) greater (1) *because…* higher concentration of, substrate / amylose, molecules (at start) (1) more chance of, substrate / AW, entering active site (1)	3	**ALLOW** 'starch'
	c	i	*three from* specify volume of starch and amylase to be added to the tubes (1) specify volume (in ml) of the solution that should be removed for testing (1) stir before taking the sample (1) test with iodine (1) all carried out at same temperature (1)	3	
		ii	*four from* ionic / hydrogen, bonds, disrupted / broken (1) (by) high concentration of, hydrogen ions / H^+ (1) tertiary structure / shape of active site, changed (1) substrate no longer fits into active site (1) (enzyme) denatured (1)	4	**IGNORE** active site denatured.

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Question			Answer/Indicative content	Marks	Guidance
		iii	*Evaluation, two from* idea that optimum could be anywhere between pH 6 and pH 8 (1) only one value between pH 6 and pH 8 tested (1) idea that shape of data implies optimum less than pH 7 (1) *Improvement* repeat at more pH values between 6 and 8 (1)	3	
	d		cofactor	1	**IGNORE** coenzyme.
			Total	**20**	
17			C	1	
			Total	**1**	
18			C	1	
			Total	**1**	
19	a	i	cofactor / prosthetic group (1)	1	
		ii	haemoglobin / myoglobin / cytochrome (1)	1	**ACCEPT** other correct named protein
	b		non-competitive (inhibition) (1) the rate of reaction does not continue to rise as substrate concentration rises / in competitive inhibition the rate of reaction would continue to rise as substrate concentration rises (1)	2	
			Total	**4**	
20			D	1	**Examiner's Comments** This question was also straightforward as the material is a clear learning outcome. While many had the ions the wrong way round, the correct choice for the charge of the ions defeated a significant number of candidates.
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
21	a	i	*Amanita* □	1	First letter must be a capital, the rest must be lower case. **Examiner's Comments** Most candidates selected the correct name and wrote it with a capital letter.
		ii	*one from* 1 (starch) digestion in the regions where the, fungus / hyphae, not present □ 2 *enzymes / they, are* released / diffuse away, from the fungus **or** extracellular / secreted □	1	1 **ACCEPT** breaks down (starch) in the, region / area / agar, around the fungus **Examiner's Comments** It was surprisingly rare for candidates to apply their knowledge of kingdom Fungi to realise that digestion here is extracellular, involving enzymes being secreted by the hyphae and acting outside of them. Some referred to 'it' and their subsequent answer did not make it clear whether the answer referred to the enzymes or the fungus.
	b	i	*one from* pH / it, is, the dependent variable / being measured □ (pH changes as) fatty acids are produced □	1	**ACCEPT** pH (change) indicates the rate of the reaction if pH were controlled there would be no, colour change / end point indicated because the pH (change) shows that the, reaction is happening / lipid is being broken down **IGNORE** we are investigating pH / pH is being investigated **Examiner's Comments** A significant proportion of candidates gave 'stock' answers and did not interpret the information given to realise that pH change is a component of the dependent variable due to the production of fatty acids when lipase digests lipid and therefore indicates when the reaction has taken place.

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Question			Answer/Indicative content	Marks	Guidance
		ii	volume of, alkaline / (alkaline) lipid / substrate, solution **or** concentration of, lipase / enzyme, solution **or** volume of, lipase / enzyme, solution **or** temperature **or** time / intervals, between testing of samples □	1	**Mark 1st answer** **IGNORE** amount **IGNORE** 5 cm^3 - this is how the variable was controlled 'volume of 5 cm^3 of alkaline solution' = 1 mark '5 cm^3 of alkaline solution' = 0 marks **IGNORE** 0.5 % - this is how the variable was controlled 'concentration of 0.5% enzyme solution' = 1 mark '0.5% enzyme solution' = 0 marks **IGNORE** 1 cm^3 - this is how the variable was controlled 'volume of 1 cm^3 of lipase solution' = 1 mark '1 cm^3 of lipase solution' = 0 marks **IGNORE** 20°C - this is how the variable was controlled 'a temperature of 20°C' = 1 mark 'keep it at 20°C' = 0 marks **IGNORE** 30 seconds - this is how the variable was controlled 'the times the samples were taken were at intervals of 30 seconds' = 1 mark 'samples taken every 30 seconds' = 0 marks **Examiner's Comments** There were five controlled variables for candidates to select from,but answers commonly lacked an important detail, such as the word 'solution' or a clear description of how the variable was quantified such as volume. Students should be encouraged to replace the imprecise term 'amount' with a more precise descriptor of measurement when talking or writing about experimental variables.

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Question			Answer/Indicative content	Marks	Guidance
		iii	concentration of, alkaline / (alkaline) lipid / substrate, solution **or** volume of indicator (added) **or** number of drops of indicator (added) **or** volume of, sample / mixture / solution (removed) **or** number of drops of, sample / mixture / solution (removed) ☐	1	**Mark 1st answer** **IGNORE** amount **IGNORE** size / volume, of drops **Examiner's Comments** A surprisingly large number of answers stated that temperature was uncontrolled, although the question states that the first run of repeats occurred at 20°C and subsequently at six other temperatures (all of which are listed in the independent variable column in Table 4.1). Correct answers focused on the volume or number of drops of indicator added or sample of reaction mixture solution removed.
		iv	*one from* (looking at, a small volume / against a white background) makes it easier to see the colour change ☐ the indicator (if added to test tube) might affect the progress of the enzyme reaction ☐ better temperature control as test tube not taken in and out of water bath ☐ AVP ☐	1	**ACCEPT** provides a contrasting background to see the colour **ACCEPT ora** e.g. harder to see colour change in the test tube **Examiner's Comments** Many candidates realised the value of a white tile in perceiving a colour change more easily as it provided a contrast.
		v	(the optimum temperature) is between 30°C and 35°C ☐	1	**Must give a range** °C must be stated once **IGNORE** 35°C alone / 'around 35°C' **Examiner's Comments** Most candidates picked a single temperature (35°C) and did not realise that with intervals of 5°C between tests there is a possibility that the true optimum lies to one side of this figure. The correct range was 30°C-35°C based on comparing the data for 30°C and 40°C. Marks were not given on this and the next question if units were omitted.

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Question			Answer/Indicative content	Marks	Guidance
		vi	1A use more intermediate temperature values ☐ 1B in the 30°C - 35°C range ☐ – 2A take samples at more frequent intervals (than 30 seconds) ☐ 2B e.g. every 15 seconds ☐ – 3A use of colorimeter ☐ 3B colour change would be less, subjective / biased ☐ – 4A use of pH, meter / probe / sensor ☐ 4B obtain a numerical value ☐	4	**Mark the first 2 suggestions seen.** **B mark must relate to the appropriate A mark point** 1A e.g. test, every 2°C / at 1°C intervals use temperatures less than 5°C apart 1B **CREDIT** a range of 25°C - 40°C Units must be given once **Note:** 'test a range of temperatures between 30°C and 35°C' 'carry out more experiments between 30°C and 35°C' = 2 marks (mps 1 & 2) 2A **ACCEPT** sample more regularly 2B time interval must be experimentally workable, so should be from 10 and less than 30 seconds. **Note:** 'take samples every 15 seconds' = 2 marks (mps 3&4) 'take samples every 5 seconds' = 1 mark (mp 3 only) 3B obtain a numerical value **Examiner's Comments** Very few candidates scored full or many marks on this task. Candidates needed to focus on the word 'accurate' and consider ways of measurement that would allow the true optimum temperature to be pin-pointed more truly. Refining the temperature range to include smaller temperature intervals in the suspected optimum range, or sampling more often to identify the end point time more closely were the most frequent good suggestions. A few candidates mentioned the use of

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Question			Answer/Indicative content	Marks	Guidance
					more sophisticated equipment such as a colorimeter to detect the end point time, or a pH probe to measure the dependent variable without the need for a subjective colour judgement.
	c		**Level 3 (5–6 marks)** • Provides a description of the 2 mechanisms of enzyme action • Provides a description of the ways in which high and low temperature affects the reactants and active site. *There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.* Awarding at this Level = L3 & 5 ticks □ □ □ □ □ Communication = □ or □ **Level 2 (3–4 marks)** • Describes 1 or both of the mechanisms of enzyme action • Describes some ways in which temperature affects the reactants and / or active site. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* Awarding at this Level = L2 & 3 ticks □ □ □ Communication = □ or □ – **Level 1 (1–2 marks)**	6	***In summary:*** *Read through the whole answer. (**Be prepared to recognise and credit unexpected approaches where they show relevance.**) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, **Level 1**, **Level 2** or **Level 3**, **best describes the overall quality of the answer**.* *Then, award the higher or lower mark within the level, according to the **Communication Statement** (shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Use the green dot in the margin to indicate places where good scientific points are made about the 2 models of enzyme action.** **Use a highlight square in the margin to indicate places where good scientific points are made about the effect of temperature.** **Indicative scientific points may include but are not limited to:** *enzyme action* **1** enzyme-substrate complex formed **2** enzyme-product complex formed

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Question	Answer/Indicative content	Marks	Guidance
	• **either** Describes some aspects of the mechanism of enzyme action **or** Describes an effect of temperature *The information is communicated with some structure but may include a small amount of irrelevant material and some inappropriate use of scientific language.* Awarding at this Level = L1 & 1 tick □ Communication = □ or □ – **0 marks** No response or no response worthy of credit.		**3** product(s) leave the active site **4** lock and key = shape of substrate and enzyme's active site are complementary and so enzyme is specific **5** induced fit = enzyme active site changes shape to accommodate substrate once substrate binds *effect of temperature* *reactants* **6** increase in temperature increases kinetic energy of molecules **7** results in more successful collisions **8** more enzyme-substrate complexes form **9** decrease in temperature reduces kinetic energy of molecules **10** results in fewer successful collisions **11** fewer enzyme-substrate complexes form *active site* **12** enzymes have an optimum temperature **13** (small) increase in temperature affects the bonds involved in tertiary structure **14** change in shape of active site **15** prevents substrate binding to active site **16** high temperature results in denaturing **17** effects of high temperature are irreversible **18** effects of low temperature are reversible **Examiner's Comments** Most candidates achieved a level two response. Descriptions of what is meant by the lock and key model and the induced fit model were mostly good, as was description of the events that lead to denaturing of enzyme structure at high temperatures. Level three responses also described reaction kinetics at low temperatures. Errors included the belief that enzymes denature at low temperatures. The question referred to temperature change and this was frequently repeated in the answer without stating whether the information was linked

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Question			Answer/Indicative content	Marks	Guidance
					to a raising or lowering of temperature. Given the difference in the effect of low and high temperatures on enzyme structure and action, this needed to be clear.
			Total	**17**	

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Question			Answer/Indicative content	Marks	Guidance
22	a	i	concentration 1.4 ± 0.025; 0. 35;	2	**ALLOW ECF** if stated concentration is not 1.4 (i.e. concentration x 250/1000) **Examiner's Comments** This question blended familiar recall, that suited candidates who had spent time learning the specification, with some AO3 questions that many candidates found challenging. The majority of candidates could read off the graph but only half could convert 'mg cm^{-3}' to 'g in 250 cm^3'. There is a higher proportion of mathematical skills in the new specifications which candidates will need to master. Most answers were given to the correct number of decimal places.
		ii	test more (known), concentrations / solutions; between 1.0 and 2.0 / near 1.4;	2	**IGNORE** repeat **IGNORE** bigger range of concentrations **Examiner's Comments** This question blended familiar recall, that suited candidates who had spent time learning the specification, with some AO3 questions that many candidates found challenging. The most common answers described testing more concentrations. Again, with an eye to the new specifications, it was worrying that very few candidates suggested that the key concentrations to test would be those near the original value of 1.4 mg cm^{-3}. Many candidates just suggested the usual 'more repeats', 'calculate a mean', 'identify anomalies' answer, which meant they had not read or did not understand the question.

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Question			Answer/Indicative content	Marks	Guidance
		iii	carry out Biuret test / test again; (using) no enzyme / no protein **/** (distilled) water; set colorimeter to zero;	2 max	**DO NOT CREDIT** 'boiled enzyme' Measure absorbance of biuret solution alone = 2 marks **Examiner's Comments** This question blended familiar recall, that suited candidates who had spent time learning the specification, with some AO3 questions that many candidates found challenging. Most candidates gained some credit, usually for doing something without any enzyme present. Many did gain both marks for, additionally, carrying out the Biuret's test or zeroing the colorimeter.

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Question			Answer/Indicative content	Marks	Guidance
	b		**1** cofactors / coenzymes / prosthetic groups; **2** bind to, enzyme / active site / allosteric site; **3** (cofactors / coenzymes, bind to enzyme) temporarily; **4** change, shape / tertiary structure, of active site; **5** affect charges on active site; **6** bind to / interact with, substrate; **7** increase (likelihood of), substrate binding to active site / ESC formation; **8** carry (named) chemical, between / to, (named) enzymes;	5 max	**2 ACCEPT** prosthetic groups form part of the enzyme **5 ACCEPT** affects, ionic / hydrogen, bonds in active site **6 IGNORE** in context of prosthetic group **7 ACCEPT** help the substrate bind to the active site **7 ACCEPT** make ESC formation easier **8 ACCEPT** substrate as chemical **8 IGNORE** substance **Examiner's Comments** This question blended familiar recall, that suited candidates who had spent time learning the specification, with some AO3 questions that many candidates found challenging. This question differentiated well between candidates of differing abilities. Most candidates understood that cofactors etc. were to be discussed and gained between 2 and 5 marks depending on ability. Only a few missed the point, usually discussing pH or kinetic energy, and failed to score or picked up only a single mark for discussing enzyme substrate complexes. More candidates than usual discussed the role of specific coenzymes, presumably reflecting a large proportion of year 13 candidates re-sitting the paper.
			Total	**11**	

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Question			Answer/Indicative content	Marks	Guidance
23			enzyme / lipase, inhibitor;	1	**ACCEPT** any description of competitive or non- competitive inhibition of enzyme **Examiner's Comments** A small majority of candidates achieved the mark. Some just wrote 'inhibitor' without saying it was the enzyme that was being inhibited. Many of the incorrect answers discussed absorption or indirect effects on breakdown. Something that careful reading of the question might have prevented.
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
24	a		concentration;	1	**IGNORE** volume / mass **Examiner's Comments** A small majority of candidates achieved the mark but almost as many wrote 'volume'.
	b		**1** enzymes not denatured; *Any **two** from* **2** decay / food spoilage, is slow(er); **3** molecules / enzymes / substrates, have little / AW, kinetic energy / KE / E_k; **4** fewer collisions, between substrate and active site/ forming ESC; **5** (liquid) water availability reduced / AW;	3 max	**DO NOT CREDIT** if the answer states that the bacterium has been denatured **3 DO NOT CREDIT** no kinetic energy **4 DO NOT CREDIT** no collisions **Examiner's Comments** Although the mark scheme was rigorous, it was nevertheless surprising to see few candidates achieve more than 1 mark on this question. A significant minority of students believed that enzymes are indeed denatured by low temperatures. Of those who understood the correct science, few wrote answers that were detailed or precise enough to gain all 3 marks. Many answers failed to gain credit because they stated that food will *not* decay because there will be no kinetic energy and *no* collisions.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
25	a		1 substrate / protein, <u>shape</u> is (nearly) <u>complementary</u> to <u>active site</u>; **ora** 2 substrate / protein, enters / fits into, active site (on enzyme); 3 induced fit / description of induced fit; 4 (forms) enzyme-substrate complex / ESC; 5 destabilising / straining / AW, <u>of bonds</u> (in substrate); then (forms) enzyme-product complex; 6 product(s) / amino acids, leave (active site);	5 max	**1 ACCEPT** complimentary **1** "substrate binds to the active site which is complementary to the substrate shape" = 2 marks, mp1 and mp2 **2 ACCEPT** binds to / holds / bonds to **2 IGNORE** collides **5 IGNORE** breaks **6 IGNORE** EPC **Examiner's Comments** Candidates generally showed a good understanding of enzyme action with students frequently using correct terminology; for example, most students appreciated the need to use the term 'active site' rather than 'enzyme'. The question discriminated well and the full range of marks was seen. A few candidates were confused about the position of the active site and those that thought it was on the substrate were not able to access the first two marking points. A number of candidates were not awarded the final marking point because they stated that the 'substrate' left the active site, showing a lack of understanding of the meaning of the term 'substrate'.

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Question			Answer/Indicative content	Marks	Guidance
	b	i		3	**IGNORE** prompt, and mark the first three answers. **IGNORE** subsequent answers. **CREDIT** marks clearly annotated on table
			no units for, 2nd column / egg white;		**ACCEPT** volume of egg white needs cm^3
			amount (rather than volume / in 4th column);		**ACCEPT** 'they should have written volume'
			incorrect unit / m, in final I time, column;		**ACCEPT** should have been s **IGNORE** should have been, sec / sees / seconds **Examiner's Comments** Most got 2 or 3 marks, appreciating the need to not use the word 'amount' and the lack of units for the egg white although a number of students used the word 'measurements' in place of 'units', which A-level students should not be doing. Many candidates correctly identified 'm' as the wrong unit for time – 'm' means 'metres'. However, a large number of these candidates thought 'm' stood for minutes and, where their answers implied that 'm' was the correct unit for minutes, their response was not credited. Candidates should be aware of the correct abbreviations for common units. Some answers referred to problems with the method or the way in which numbers had been entered into the table, misunderstanding the reference to 'preparation of the table' in the question.

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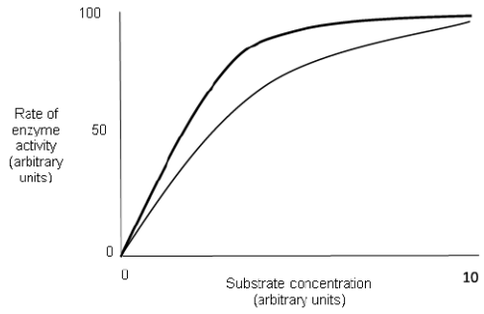
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Question			Answer/Indicative content	Marks	Guidance
		ii	equal <u>volume</u> in each tube; add buffer / control pH;	1	**ACCEPT** "make sure the tubes have the same cm^3" **Examiner's Comments** Less than 5% of candidates were awarded this mark. Common responses were 'increase the range of pH' or 'do repeats'. It was evident that understanding of the term 'validity' was poor. Disappointingly, some candidates cited unequal volumes as a problem in part (i) and then failed to mention it in part (ii).
		iii	<u>control</u>;	1	**DO NOT CREDIT** control variable **Examiner's Comments** The vast majority of candidates got this mark. Although understanding of the term was not always clear, as evidenced by the small number of candidates who answered 'control variable'.
		iv	improve reliability; assess, variability / spread of results; allows calculation of mean;	2	**IGNORE** accurate **ACCEPT** identify, anomalous results / outliers **IGNORE** eliminate anomalous results **ACCEPT** reference to statistical test **ACCEPT** standard deviation / t-test / Mann-Whitney **CREDIT** improves accuracy of mean **Examiner's Comments** Most candidates put both 'reliable' and 'identify anomalies' and most correctly used the word reliable and, in contrast to part (ii), did not confuse it with 'accurate' or 'valid'. Many candidates are uncertain about mean or average and so put both down. The second marking point was rarely seen. Some candidates thought it was reasonable simply to disregard anomalies, a statement for which they received no credit.

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Question			Answer/Indicative content	Marks	Guidance
	c	i	line drawn below line on graph; line from origin that does not peak or plateau;	2	If the line goes above the original line at any point = 0 marks **ALLOW** lines touching at right hand end **DO NOT CREDIT** line with increasing gradient **ALLOW** plateau if it joins the original line **ALLOW** plateau below original line if it starts 4 small squares (or fewer) from the end  = 2 marks **Examiner's Comments** Most candidates knew that an inhibitor would produce a line below that drawn on the graph but a disappointing number were confused about competitive and non-competitive inhibitors and showed the line levelling off well below the original.
		ii	similar <u>shape</u> to, substrate / (part of) albumin / protein; <u>complementary</u> (shape) to (part of) <u>active site</u>;	2	**IGNORE** same **ACCEPT** same shape as part of substrate **IGNORE** structure **ACCEPT** tertiary structure **Examiner's Comments** This question discriminated well and showed a range of understanding of inhibition. The most common incorrect response, seen in a lot of scripts, was 'similar shape to pepsin' – perhaps not understanding that pepsin was the enzyme.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**16**	

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Question			Answer/Indicative content	Marks	Guidance
26	a		(works) outside cells;	1	**ACCEPT** secreted / AW, from cells **ACCEPT** works in named extracellular environment e.g. digestive tract **IGNORE** doesn't work in cells **Examiner's Comments** Most candidates obtained the mark. Those that did not tended to be very uncertain of the nature of an enzyme, or starch, or used the term 'excreted'. A number of candidates wrote that is worked outside the body and were not awarded the mark.
	b	i	time / time taken;	1	**Mark the first answer**. If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks** **ACCEPT** 'how long it took … ' **Examiner's Comments** The majority correctly stated 'time'. Some candidates qualified this further, which was ignored unless it became contradictory, which it did on occasion. For example, 'time to break down the product' received no marks. A minority of candidates did not address the concept of rate and wrote 'substrate concentration' or 'enzyme concentration' for no credit.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*linear part of the graph means …*	5 max	**ACCEPT** glucose / maltose for product throughout **ACCEPT** substrate for starch throughout
			1 more (successful) collisions with (amylase) active site (at increasing starch concentration); **ora**		**1 ACCEPT** few(er) active sites occupied at low starch concentrations
			2 more ESC (at increasing starch concentration); **ora**		**2 ACCEPT** ESC formed more easily
			3 so more product formation in a given time (at increasing starch concentration); **ora**		**3 AWARD** only if linked to the context of marking points **1 or 2** e.g. 'more product formation in a given time because of more collisions with the enzyme' gets mp3 but not mp1 because active site not mentioned **3 IGNORE *rate*** as this is a description of graph
			curve / plateau, means … 4 all / most, active sites (of amylase) are occupied;		**4 ACCEPT** all active sites are full of substrate
			5 enzyme / amylase, working, at / near, maximum rate / V_{max};		**5 ACCEPT** enzyme at full capacity
			6 (so) further increase in starch concentration has no effect (on rate);		**6** Must link to **4** or **5** **6 AWARD** only if mp 4 or 5 given **6 DO NOT CREDIT** rate decreases
			7 enzyme concentration, is / becomes, limiting factor;		**7 ACCEPT** the increasing part of the graph is because starch concentration is the limiting factor **Examiner's Comments** This question was poorly done with most candidates getting only 2 or 3 marks. Responses that explained the reasons why an increasing substrate concentration caused an increased rate of reaction, and then explained why that rate of reaction did not increase further after substrate

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Question			Answer/Indicative content	Marks	Guidance
					concentration had reached a certain level, obtained high marks. Many candidates wrote detailed descriptions of the shape of the curve for no credit. A large number of candidates understood that the question was asking them to use scientific knowledge to explain and clearly understood the science, but failed to use the key term ‘active site’ at all, or to distinguish between enzyme and enzyme concentration when necessary, and so failed to gain full marks. Candidates who used the word ‘optimum’ as a synonym for ‘maximum rate’ were not awarded one of the potential marks. Some candidates discussed the reaction slowing down, clearly misinterpreting the nature of the graph and this made it difficult for them to access many of the marks at all.

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Question			Answer/Indicative content	Marks	Guidance
		iii		3 max	The mark points refer to a constant pH preventing damage to the enzyme. **CREDIT** throughout the appropriate marking point for an answer that describes what would happen if the pH changed.
			1 (so) charges in active site do not change; **ora**		
			2 (so) hydrogen / ionic, bonds unaffected; **ora**		**2 DO NOT CREDIT** peptide / disulphide, bonds break **2 DO NOT CREDIT** in context of heat / vibration **2 IGNORE** hydrophobic / hydrophilic
			3 (so) tertiary structure / 3D shape / active site, unaltered; **ora**		**3 IGNORE** ref to denaturing active site **3 IGNORE** tertiary structure breaks **3 ACCEPT** tertiary structure affected **3** Cannot be inferred from mp5 – must be stated
			4 (so) enzyme / tertiary structure, does not <u>denature</u>; **ora**		**4 IGNORE** ref to denaturing active site **4 DO NOT CREDIT** kill / die
			5 (so) substrate, fits / is complementary shape to, <u>active</u> <u>site</u>; **ora**		**5 IGNORE** enters / binds with
			6 so the results are <u>valid</u> / as the <u>rate</u> (of reaction) will vary if pH varies / so that only one (independent) variable is changed;		**6 IGNORE** fair test / reliable / accurate **Examiner's Comments** In contrast to part (ii), this question was done well, with most candidates gaining at least 2 marks. There was some good use of scientific terminology such as 'active site' that was not evident in part (ii). Most approached answers from the point of view of pH changing and the effects this caused. All marking points were awarded regularly, even those associated with the more detailed biochemistry. Most candidates appreciated the concept of validity but some did not express it with sufficient clarity or use of appropriate terms.

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Question			Answer/Indicative content	Marks	Guidance
		iv	temperature (of the reaction mixture); enzyme / amylase, concentration; (total) volume of (reaction) solution; concentration of, cofactors / chloride ions / Cl^-;	2 max	**Mark the first answer on each prompt line**. If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks** **DO NOT CREDIT** substrate / starch, concentration (as this is the independent variable) **DO NOT CREDIT** amount **ACCEPT** volume of enzyme solution **DO NOT CREDIT** amount **ACCEPT** concentration of coenzymes **IGNORE** time / agitation / inhibitors **Examiner's Comments** Most candidates correctly identified 'temperature' and very many, 'enzyme concentration'. Fewer candidates used the imprecise term 'amount' than was evident in previous sessions. A number of candidates wrote 'volume of enzyme' which was not given a mark unless they mentioned 'solution'.
			Total	**12**	

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Question			Answer/Indicative content	Marks	Guidance
27		i	postsynaptic membrane(s) (in, neurone / neuromuscular junction);	1	**ACCEPT** sarcolemma **DO NOT CREDIT** postsynaptic knob **Examiner's Comments** The majority of candidates gave the precise location of the receptors as being the postsynaptic membrane. A small number realised that this would be the sarcolemmma in this particular case. Both responses gained the mark.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*Effect* Nicotine slows down rate of / stops, transmission of, action potentials / nervous impulses; **Plus any 2 of the following:** *Explain* binds to <u>receptor</u>; (nicotine) has the same response / opens Na^+ channels / causes depolarisation; nicotine remains in receptor for longer; *idea that* <u>receptor</u>, remains in refractory stage for longer / unable to return to standby condition cannot be reactivated;	3 max	**IGNORE** 'nervous system slows down' / 'acts as a depressant' **ACCEPT** competes with acetylcholine for the <u>receptor</u> **DO NOT CREDIT** active site **DO NOT CREDIT** 'acts as competitive inhibitor' **DO NOT CREDIT** binds to receptor permanently **ACCEPT** causes action potential in next neurone / mimics, action / effects, of acetylcholine **IGNORE** 'mimics acetyl choline' alone **IGNORE** delays refractory stage **ACCEPT** permanently in refractory stage **Examiner's Comments** Describing how nicotine is thought to work proved difficult for many. This was usually a result of confusion between this receptor scenario and the action of enzymes, as many references to active sites and nicotine acting as a competitive inhibitor were seen. Correct references to it binding to the receptor causing depolarisation or an action potential gained credit, along with the idea that the receptor was unable to return to the standby state. Other valid ideas included the stopping of action potential transmission altogether or a reduction in the rate of transmission.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
28			D ☐	1	
			Total	**1**	
29			C ☐	1	
			Total	**1**	
30			B ☐	1	
			Total	**1**	
31		i	temperature ☐ enzyme concentration ☐ substrate / carbon dioxide, concentration ☐	2 max	
		ii	idea of H^+ reacts with haemoglobin to form haemoglobinic acid, which lowers pH (back to 7.4)☐ idea of H^+ reacts with HCO_3^- to form H_2CO_3, which lowers pH (back to 7.4)☐ *idea of* H_2CO_3 dissociates to form H^+ and HCO_3^-, which raises pH (back to 7.4)☐	3	
			Total	**5**	

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