A-Level Biology

Proteins and Enzymes

Question Paper

Time available: 78 minutes
Marks available: 60 marks

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1. (a) Describe the induced-fit model of enzyme action **and** how an enzyme acts as a catalyst.

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(3)

(b) Scientists investigated the action of the enzyme ATP synthase. They made reaction mixtures each containing:

- ATP synthase
- buffer (to control pH)
- substrates.

One of the substrates required in these reaction mixtures is inorganic phosphate (Pi).

Tick (✓) **one** box to show which other substrate the scientists must add to the reaction mixtures to produce ATP.

Adenine ☐

Adenosine diphosphate ☐

Glucose ☐

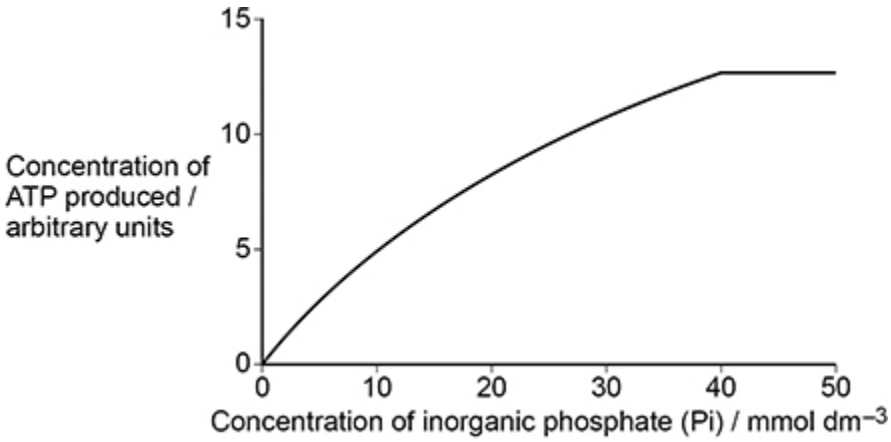
Ribose ☐

(1)

(c) The scientists investigated the effect of concentration of inorganic phosphate (Pi) on ATP synthase activity.

After 2 minutes, they stopped each reaction and then measured the concentration of ATP.

The figure below shows the scientists' results.



Suggest and explain a procedure the scientists could have used to stop each reaction.

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(2)

(d) Explain the change in ATP concentration with increasing inorganic phosphate concentration.

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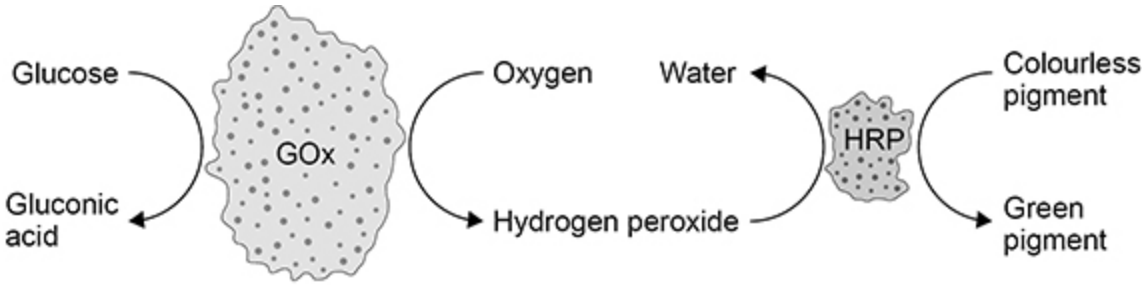
(2)

(Total 8 marks)

2. A scientist investigated a sequence of reactions catalysed by **two** enzymes, GOx and HRP. **Figure 1** shows this sequence of reactions.

Figure 1



(a) Use **Figure 1** to identify all of the products formed when this sequence of reactions is completed.

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_____

(1)

(b) The scientist joined DNA molecules together to make tiny cages. The cages are exactly 20 nm long, 20 nm wide and 17 nm deep.

He trapped **one** GOx molecule and **one** HRP molecule together in each cage. The GOx molecule and HRP molecule fill 9% of the cage volume.

The volume of a GOx molecule is eight times larger than an HRP molecule.

Use this information to calculate the volume of a GOx molecule. Give the appropriate unit with your answer.

Show your working.

Answer _____

(3)

The scientist investigated the activity of GOx and HRP enzymes when they are:

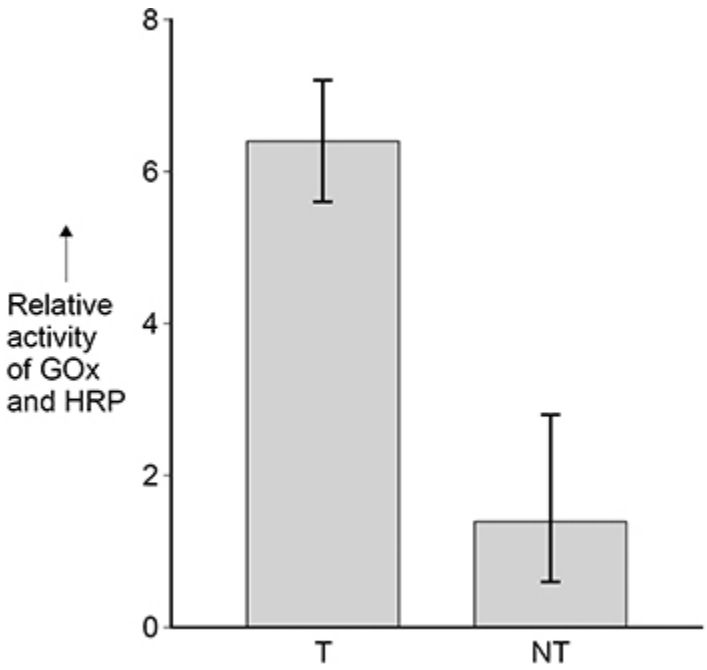
- trapped inside cages (**T**) and
- not trapped (**NT**), but free in solution with **no** cages.

Figure 2 shows his results.

The error bars show ± 2 standard deviations.

± 2 standard deviations include 95% of the data.

Figure 2



(c) What can you conclude from **Figure 2** about the effect of trapping GOx and HRP inside cages?

(3)

(d) The design of the scientist's investigation did **not** include a suitable control.

Suggest a suitable control.

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(1)

(Total 8 marks)

3. (a) A student investigated starch hydrolysis using the enzyme amylase.

During the procedure, the student:

- treated the starch to make it soluble
- prepared 10 cm^3 of different concentrations (mg dm^{-3}) of starch solution
- added an identical concentration of amylase to each starch solution
- measured the time in minutes to completely hydrolyse starch.

He repeated the procedure and calculated the mean time to completely hydrolyse starch in each concentration of starch solution.

Draw a table the student could use to record all of his results.

You only need to show completed column headings.

(2)

(b) Describe the results you would expect the student to obtain.

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_____

_____

(1)

(c) A competitive inhibitor decreases the rate of an enzyme-controlled reaction.
Explain how.

(3)

(d) When bread becomes stale, the structure of some of the starch is changed. This changed starch is called retrograded starch.

Scientists have suggested retrograded starch is a competitive inhibitor of amylase in the small intestine.

Assuming the scientists are correct, suggest how eating stale bread could help to reduce weight gain.

(3)

(Total 9 marks)

4. (a) Explain how the active site of an enzyme causes a high rate of reaction.

(3)

The action of the enzyme catalase is shown below.

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water} + \text{oxygen}$$

A student investigated the effect of hydrogen peroxide concentration on the rate of this reaction. He used catalase from potato tissue.

The student:

- put five potato chips in a flask
- added 20 cm^3 of 0.5 mol dm^{-3} hydrogen peroxide solution to the flask
- measured the time in seconds for production of 10 cm^3 of oxygen gas
- repeated this procedure with four different concentrations of hydrogen peroxide solution.

His results are shown in the table.

Hydrogen peroxide concentration / mol dm^{-3}	Time for production of 10 cm^3 of oxygen gas / seconds	Rate of reaction / arbitrary units
0.5	18	
1.0	10	
1.5	7	
2.0	6	
2.5	6	

(b) Other than those stated, give **one** factor the student would have controlled in his investigation.

_____

_____

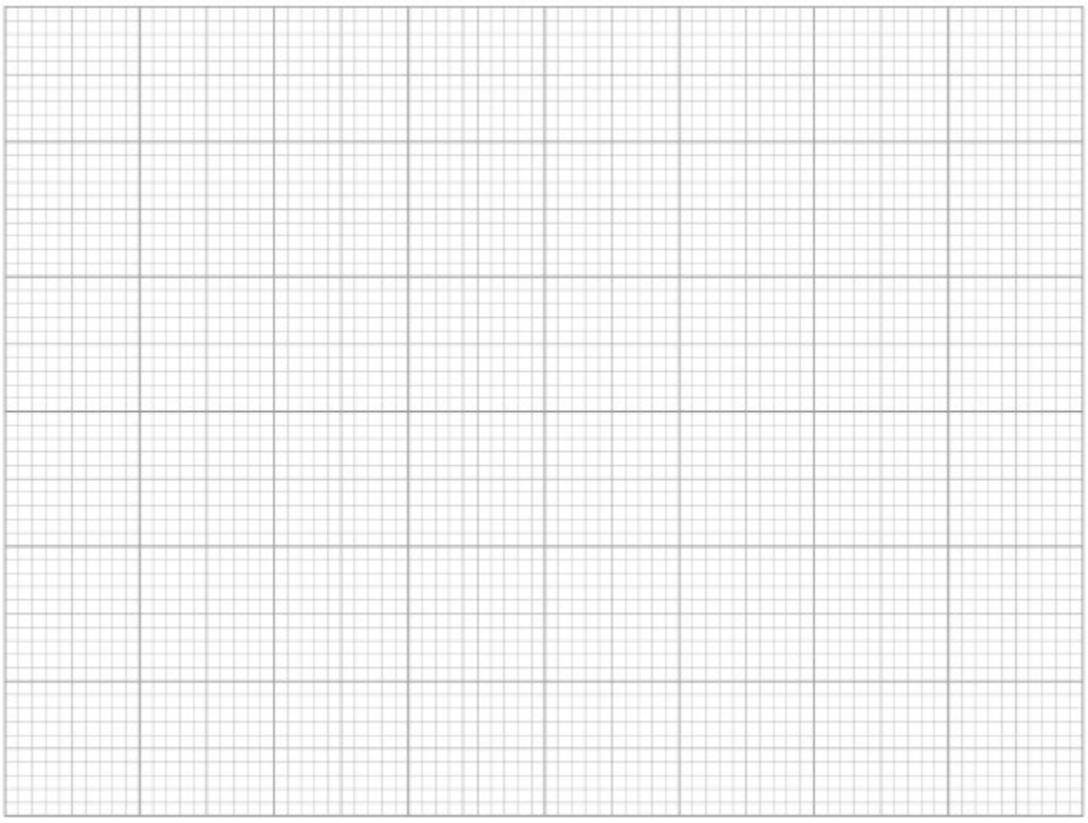
(1)

(c) The student gave the maximum rate of reaction a value of 1.0 arbitrary units.

Complete the table above by calculating the rate of reaction in arbitrary units at each hydrogen peroxide concentration. Record the rates using an appropriate number of significant figures.

(2)

(d) Plot a suitable graph of your processed data shown in the table.



(3)

(e) Suggest a change the student could make to his procedure so that 10 cm^3 of oxygen would be produced in less than 6 seconds.

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(1)

(Total 10 marks)

5. (a) Formation of an enzyme-substrate complex increases the rate of reaction.

Explain how.

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(2)

(b) A scientist measured the rate of removal of amino acids from a polypeptide with and without an enzyme present. With the enzyme present, 578 amino acids were released per second. Without the enzyme, 3.0×10^{-9} amino acids were released per second.

Calculate by how many times the rate of reaction is greater with the enzyme present. Give your answer in standard form.

Answer = _____ times faster

(2)

Another scientist investigated an enzyme that catalyses the following reaction.

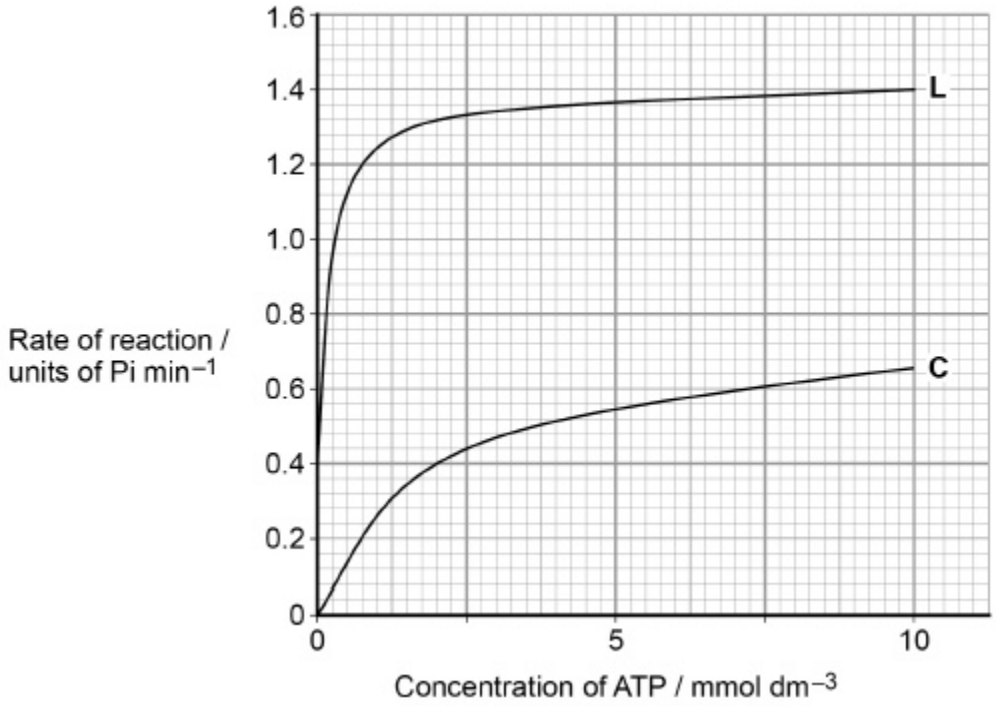
$$ATP \longrightarrow ADP + Pi$$

The scientists set up two experiments, **C** and **L**.

Experiment **C** used
- the enzyme
- different concentrations of ATP.

Experiment **L** used
- the enzyme
- different concentrations of ATP
- a sugar called lyxose.

The scientists measured the rate of reaction in each experiment. Their results are shown in the graph.



(c) Calculate the rate of reaction of the enzyme activity with no lyxose at 2.5 mmol dm^{-3} of ATP as a percentage of the maximum rate shown with lyxose.

Answer = _____ %

(2)

(d) Lyxose binds to the enzyme.

Suggest a reason for the difference in the results shown in the graph with and without lyxose.

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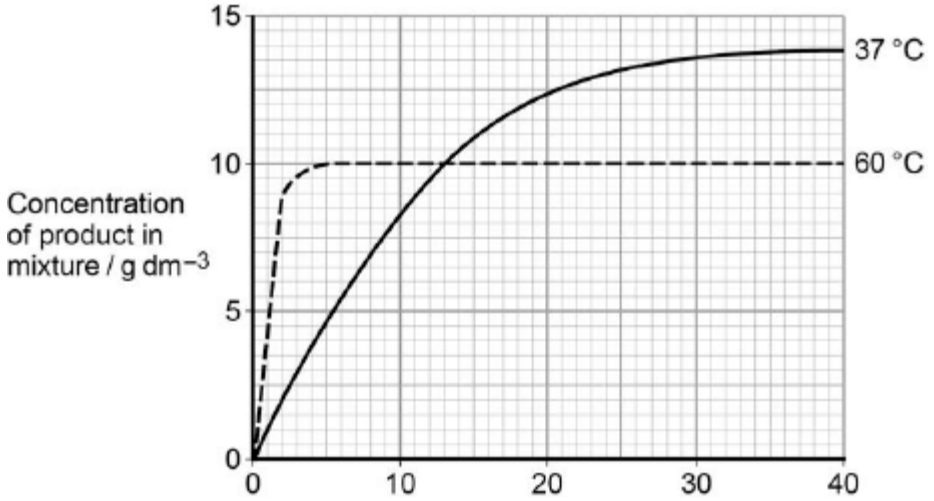
(3)

(Total 9 marks)

6. A technician investigated the effect of temperature on the rate of an enzyme-controlled reaction. At each temperature, he started the reaction using the same concentration of substrate.

The following graph shows his results.



(a) Give **two** other factors the technician would have controlled.

1. _____

2. _____

(1)

(b) Draw a tangent on each curve to find the initial rates of reaction.
Use these values to calculate the ratio of the initial rates of reaction at 60 °C : 37 °C.
Show your working.

Ratio = _____ :1

(2)

(c) Explain the difference in the initial rate of reaction at 60 °C and 37 °C.

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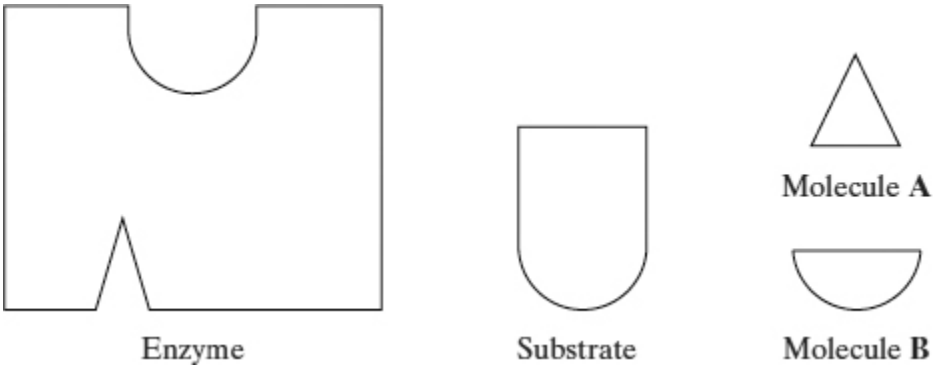
(2)

(d) Explain the difference in the rates of reaction at 60 °C and 37 °C between 20 and 40 minutes.

(4)

(Total 9 marks)

7. (a) The diagrams represent an enzyme, its substrate and two other molecules, **A** and **B**.



The addition of a non-competitive inhibitor will prevent the formation of an enzyme-substrate complex. Draw a labelled diagram based on relevant molecules selected from the diagram above to explain how this occurs.

(2)

(b) A decrease in temperature decreases the kinetic energy of molecules in a solution. Explain how a decrease in temperature decreases the rate of an enzyme-controlled reaction.

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(2)

(c) Urea breaks hydrogen bonds. Explain how the addition of urea would affect the rate of an enzyme-controlled reaction.

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(3)

(Total 7 marks)