IB · SL · Biology

2 hours 20 questions

Structured Questions

Enzymes & Metabolism

Metabolism: Enzymes & Reactions / Enzyme Action / Enzyme Activity: Skills / Enzyme Reaction Rates: Skills / Activation Energy: Skills

Easy (7 questions)	/45
Medium (8 questions)	/51
Hard (5 questions)	/31
Total Marks	**/127**

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Easy Questions

1 (a) Distinguish between anabolic and catabolic reactions.

Include **one** example of each reaction.

(5 marks)

(b) State the main mode of action of enzymes.

(2 marks)

2 (a) The protein Rubisco is an enzyme.

What is the function of the enzyme Rubisco in living organisms?

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(2 marks)

(b) Enzymes have a specific three-dimensional conformation that enables them to carry out their roles in living organisms.

Which part of the amino acid determines the conformation of the protein?

.....

(1 mark)

(c) In certain conditions, such as high temperatures, the 3D conformation of proteins can be lost.

(i) What is the scientific name given to when a protein loses its 3D conformation?

[1]

(ii) State one condition, other than temperature, that can cause the 3D conformation of a protein to be lost.

[1]

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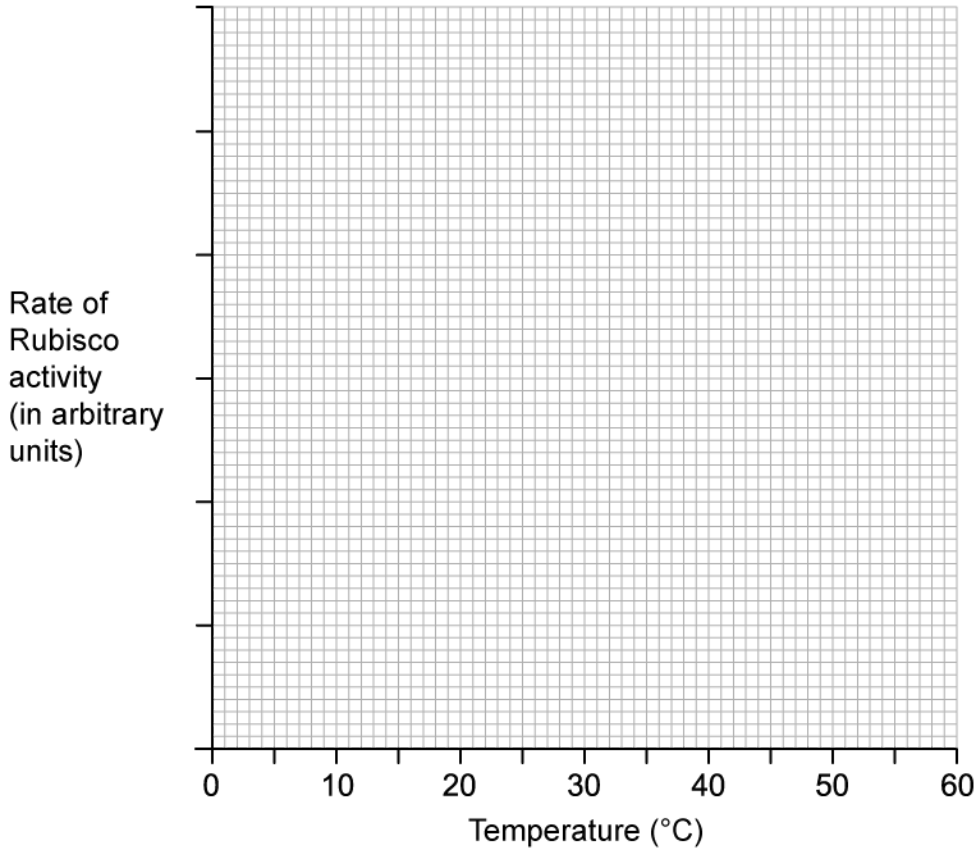
(2 marks)

(d) Sketch a graph to show how the rate of reaction of Rubisco changes over a range of temperatures.

Use the axes provided below.



[2]

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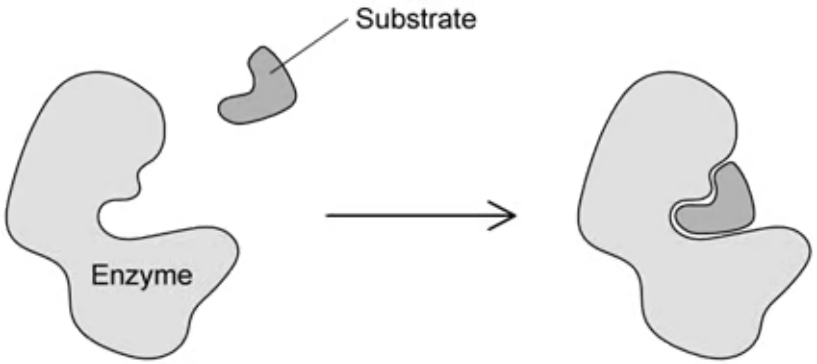
(2 marks)

3 (a) State the reason why enzymes are referred to as biological catalysts.

.....

(1 mark)

(b) The image below shows a representation of an enzyme-controlled reaction.



Describe the events taking place in the image.

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(3 marks)

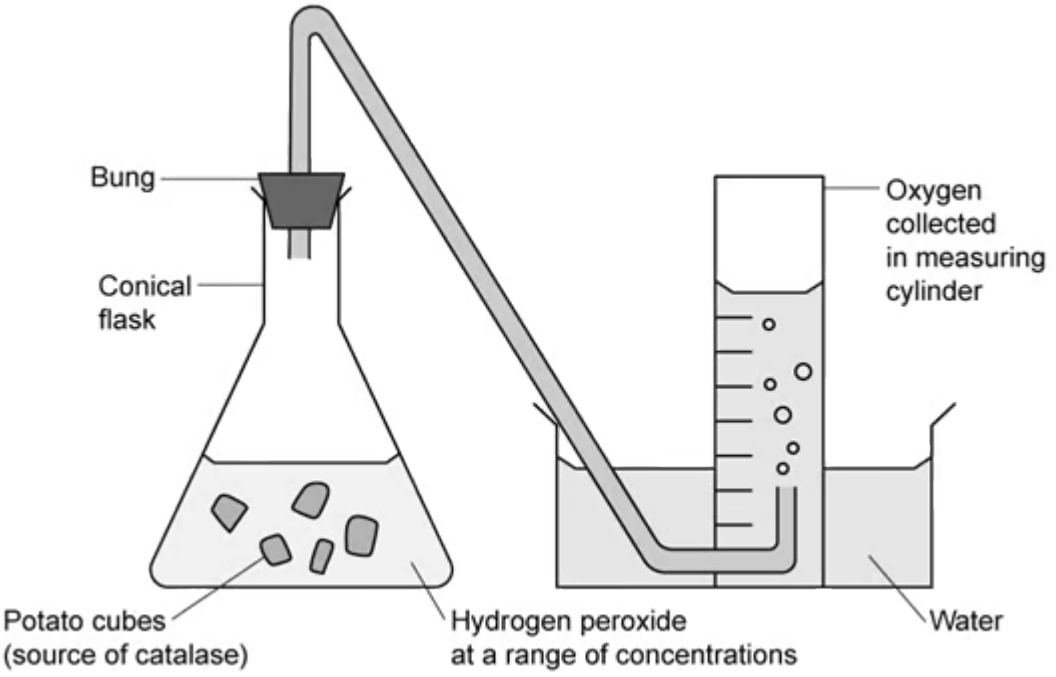
(c) State what is meant by the term 'enzyme specificity'?

.....

.....

(2 marks)

4 (a) A student wanted to investigate the effect of substrate concentration on the activity of an enzyme called catalase. Catalase is an enzyme that commonly occurs inside living cells where it breaks down toxic hydrogen peroxide into oxygen and water. The image below shows the experimental set up done by the student.



List **two** control variables that the student would need to be aware of in the experiment shown in the image.

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(2 marks)

(b) The student decided to make up solutions at five different hydrogen peroxide concentrations. Their measurements for these solutions are shown in the table below.

Concentration of hydrogen peroxide solution (%)	Volume of hydrogen peroxide required (cm^3)	Volume of distilled water required (cm^3)
10	10	90
8	**B**	**C**
6	6	94
A	4	96
2	2	98

Give the measurements needed to fill in gaps **A-C** in the table.

.....

(1 mark)

(c) After measuring out the range of hydrogen peroxide concentrations shown in part (b), the student carried out the experiment using the equipment set up in part (a). They recorded the volume of oxygen (the product) produced after one minute, and repeated this measurement three times at each concentration. Their results are shown in the table below.

Hydrogen peroxide concentration / %	Volume of oxygen produced after 1 minute / cm^3			Mean volume of oxygen / cm^3
	Repeat 1	Repeat 2	Repeat 3	
10	18	20	21	19.7
8	17	18	18	17.7
6	13	11	13	**X**
4	9	9	10	9.3
2	5	6	6	5.7

Use the data in the table to calculate the value missing from the square marked **X**.

.....

(1 mark)

(d) State the purpose of repeating the experiment three times at each concentration of hydrogen peroxide.

.....

.....

(2 marks)

(e) Using the data in part (c), draw a graph of hydrogen peroxide concentration against the mean volume of oxygen.

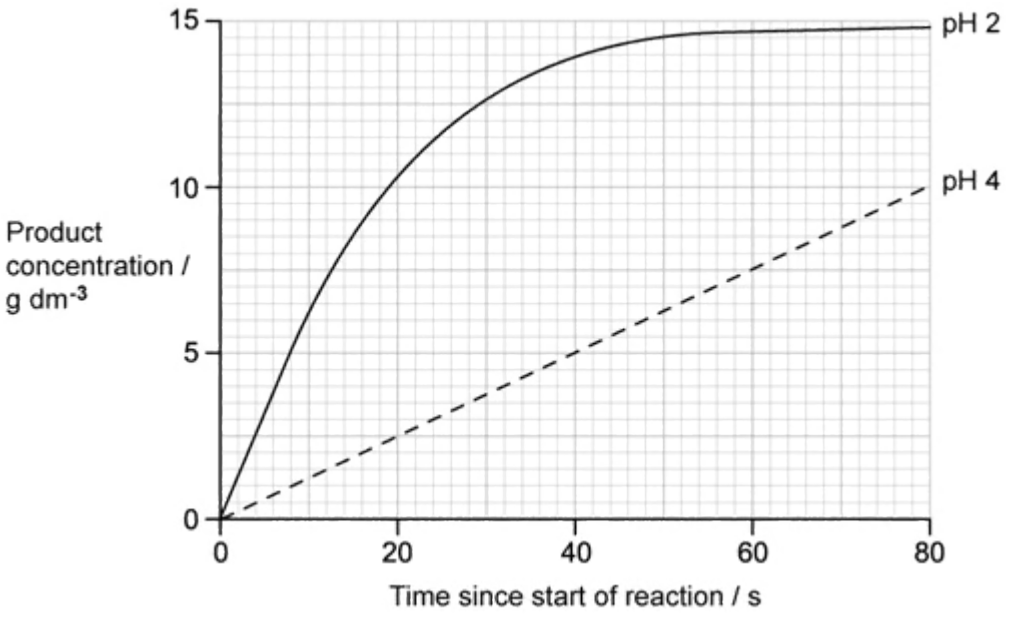
(4 marks)

(f) Deduce the conclusions that can be drawn from your graph from part (e).

(2 marks)

5 (a) A researcher investigated the effect of pH on the activity of stomach enzyme pepsin.

Their results are shown in the image below.



The rate of reaction can be calculated by using the following formula:

$$\text{reaction rate} = \frac{\text{Amount of product produced (g dm}^{-3}\text{)}}{\text{Time (s)}}$$

Calculate the rate of reaction at pH 4. Give your answer with the correct units.

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(2 marks)

(b) Describe the differences between the curves at pH 2 and pH 4.

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.....

(2 marks)

(c) State why product production at pH 2 does not continue indefinitely but reaches a plateau at around 14.75 g.

(1 mark)

(d) (i) Predict the outcome if the pH were increased to pH 10.

[1]

(ii) Explain your answer at part i).

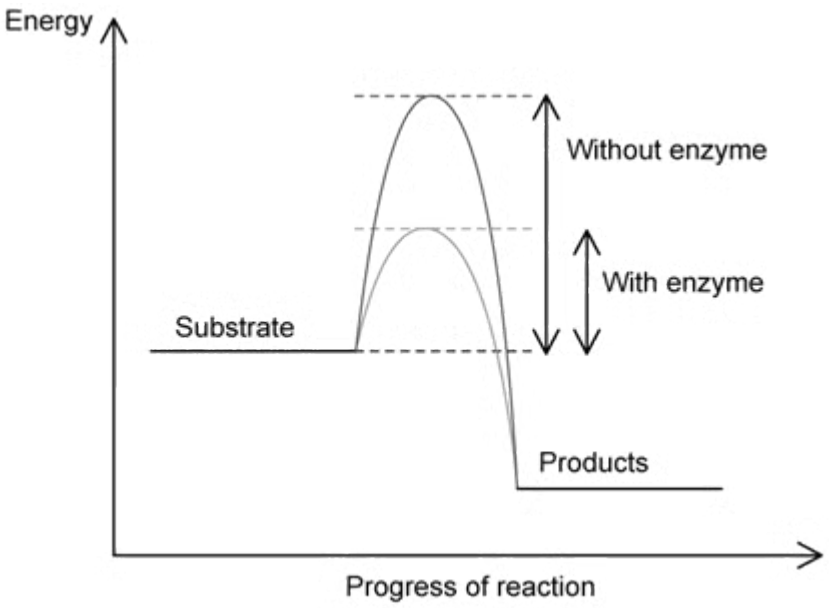
[2]

(3 marks)

6 Outline the events that occur when enzymes are exposed to high temperatures.

(4 marks)

7 The graph below shows how enzymes affect biological reactions.



Use the graph and your own knowledge of enzyme function to explain how enzymes function as biological catalysts.

(1 mark)

Medium Questions

1 (a) Distinguish between anabolic reactions and catabolic reactions.

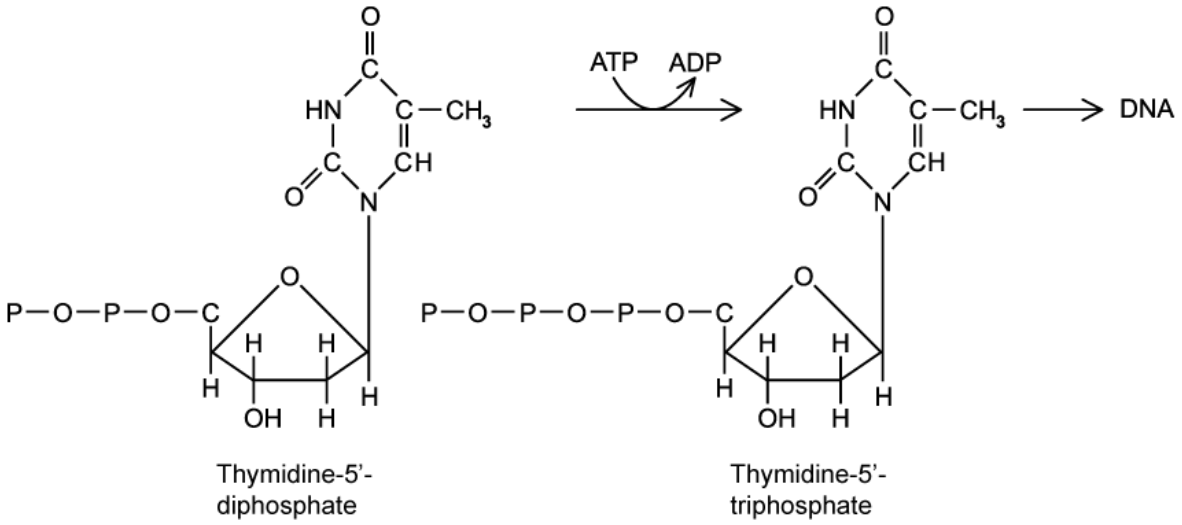
(3 marks)

(b) Complete the table with tick marks (✓) in the appropriate boxes.

Cellular reaction	Anabolic	Catabolic
Fats → fatty acids and glycerol		
Accumulation of starch from sugars in plants		
Anaerobic respiration in yeast cells		
Hydrolysis of polypeptides into amino acids		

(2 marks)

(c) The diagram below shows part of a biochemical pathway that takes place commonly in cells.



Deduce whether the pathway is anabolic or catabolic and give evidence from the diagram for your answer.

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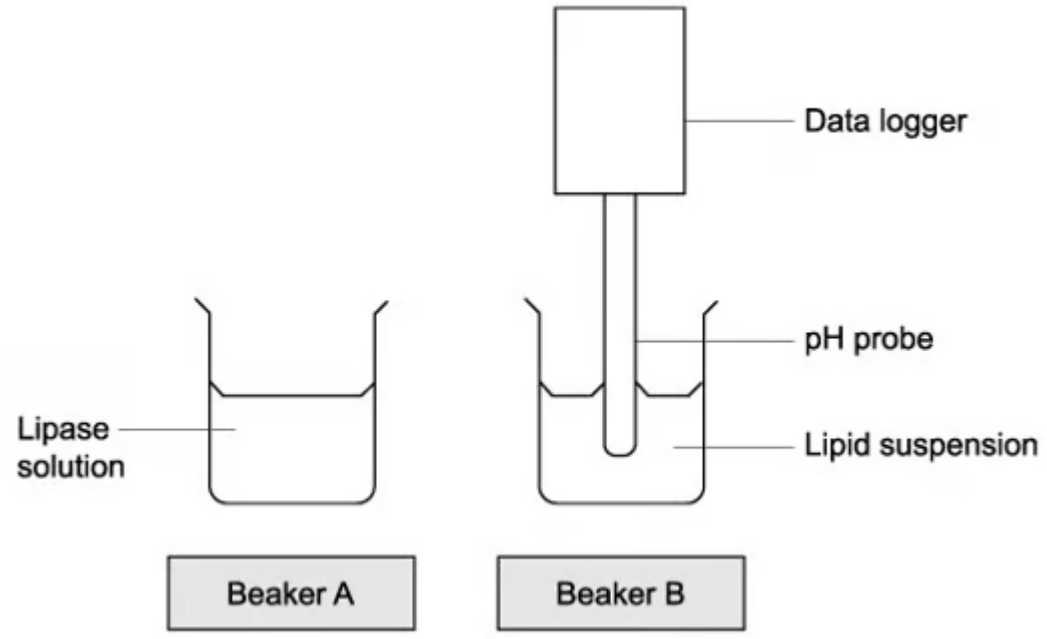
(2 marks)

2 (a) Lipase is an enzyme that breaks down lipids. The diagram below shows an experiment set up by a teacher to investigate the effect of lipase concentration on the hydrolysis of lipids.

The pH of beaker B is measured for 3 minutes at the start of the experiment. Beaker A containing lipase solution is added to beaker B. The data logger recorded the change in pH over the next 5 minutes.



State, with a reason, the predicted change in pH after the lipase has been added.

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(3 marks)

(b) State **two** variables that must be controlled to carry out the experiment in part (a) accurately and reliably.

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.....

(2 marks)

(c) For the experiment in part (a), draw a results table that could be used to record the results of the investigation. Your table should include suggested enzyme concentrations, and units should be stated.

(3 marks)

3 (a) A protease is an enzyme that digests protein. A research scientist isolated protease **C** from a particular species of bacteria. The researcher investigated the effect of temperature on the rate of hydrolysis of a protein by protease **C**. The unprocessed results can be seen in the table below.

Temperature / °C	Mass of protein hydrolysed after 4 minutes / mg	Rate of hydrolysis /
10	470	
15	990	
20	1180	
25	1310	
30	1030	
35	420	
40	110	

Calculate (with appropriate units) the missing details in the table above.

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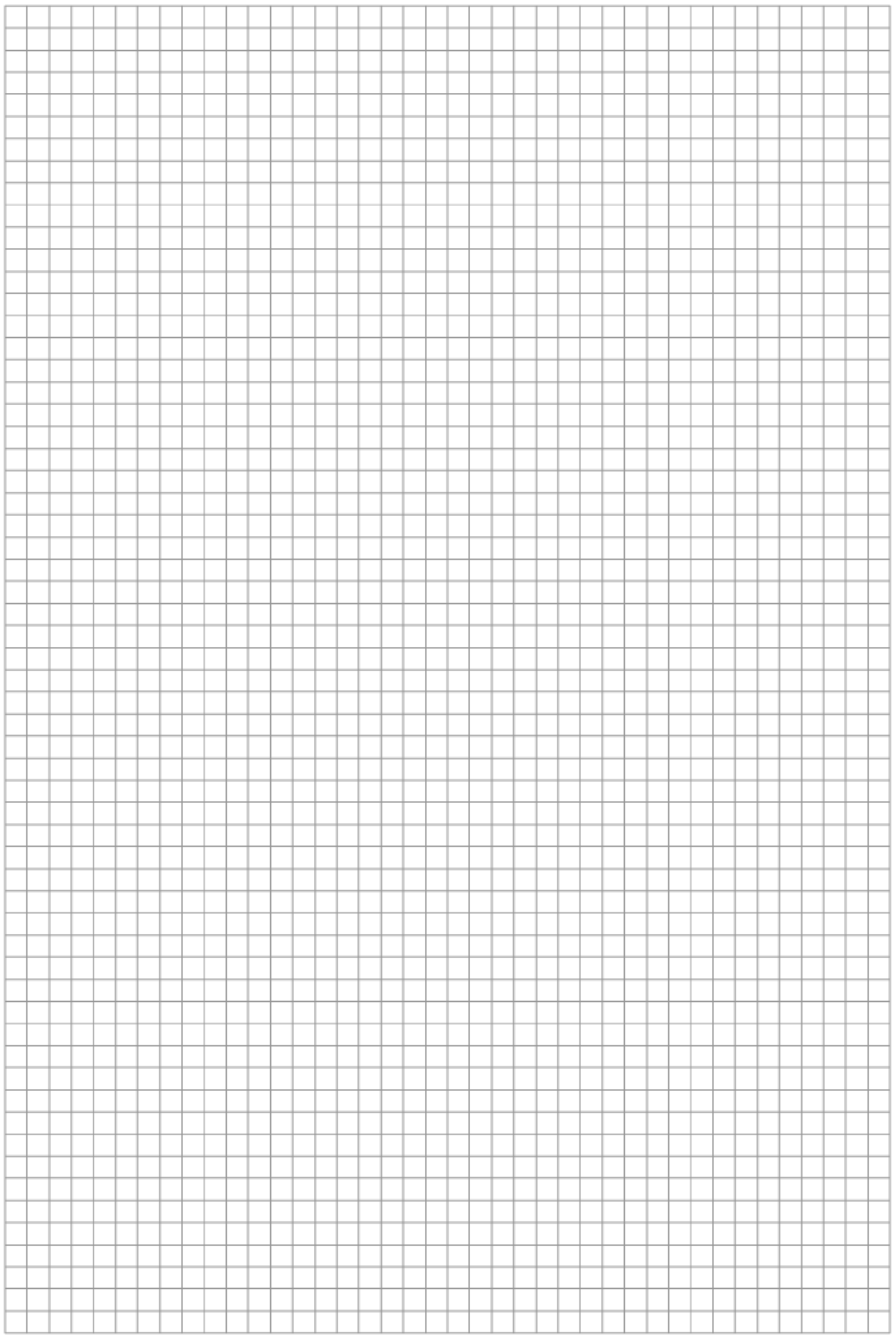
(2 marks)

(b) Draw a graph of the results seen in part (a). Your graph should include an accurate scale and correct axis labels.



(4 marks)

(c) Suggest how the research scientist controlled the pH throughout the experiment.

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(1 mark)

4 (a) Explain the aspect of enzyme and substrate structure that enables successful catalysis of a biochemical reaction.

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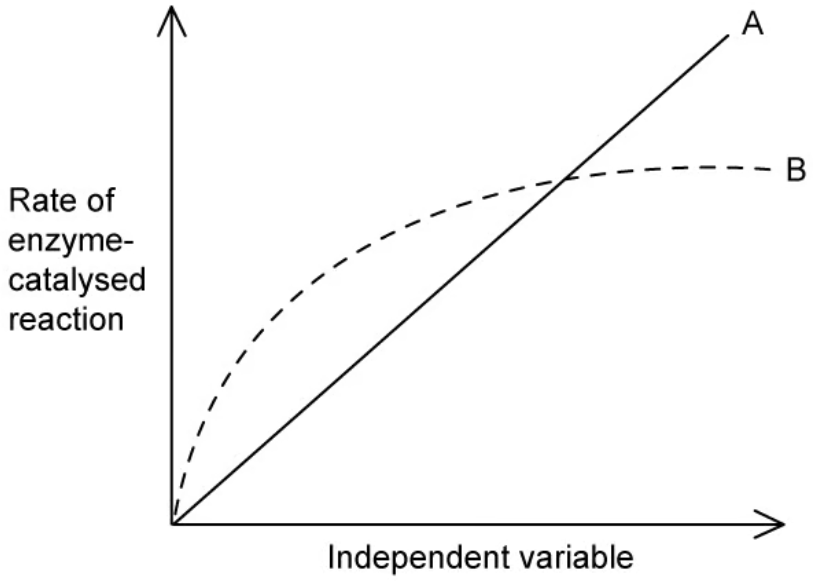
(2 marks)

(b) The sketch graph below shows how the rate of an enzyme-catalysed reaction varies for two separate independent variables. For curve **A** the independent variable is the concentration of enzyme.



Identify the independent variable for Curve **B**.

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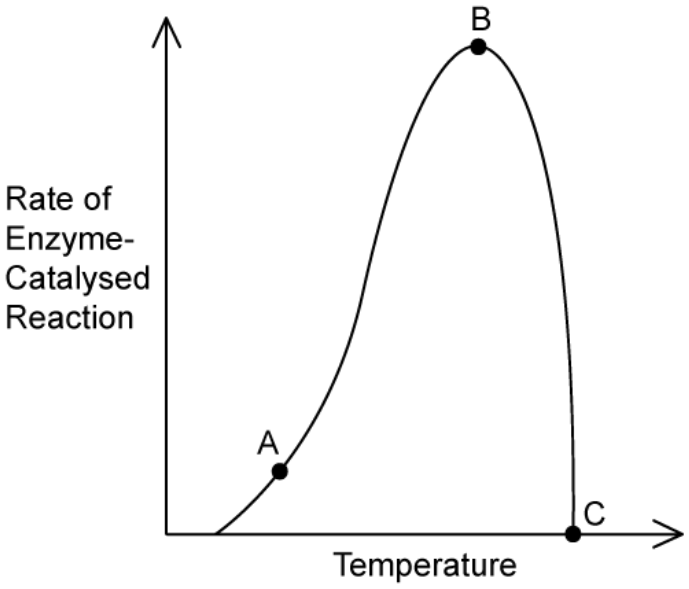
(1 mark)

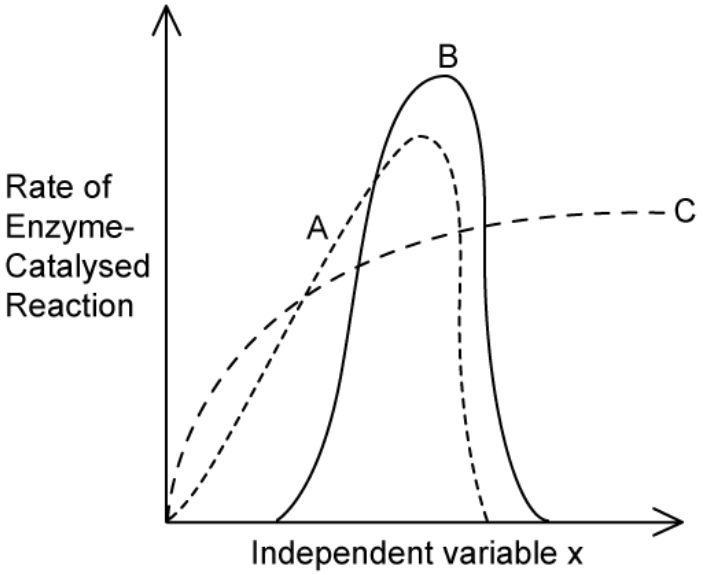
(c) The sketch graph below shows how the rate of an enzyme-catalysed reaction varies as temperature changes.



Explain the rates of reaction at positions **A**, **B**, and **C** on the curve.

(3 marks)

5 (a) The sketch graph below shows the effects of varying the level of the independent variable, X, on the rate of an enzyme-controlled reaction. Lines **A**, **B**, and **C** represent three different independent variables which could be X.



(i) Identify the independent variables that would cause lines **A**, **B**, and **C**.

(ii) Use your knowledge of enzyme activity to explain the changes in reaction rate shown by lines **A**, **B** and **C**.

(7 marks)

(b) An experiment was set up to investigate the effect of temperature on an enzyme-catalysed reaction in which the reaction mixture changes from clear-colourless to clear-dark blue as the reaction progresses.

Describe:

(i) How the independent variable in the experiment could be controlled.

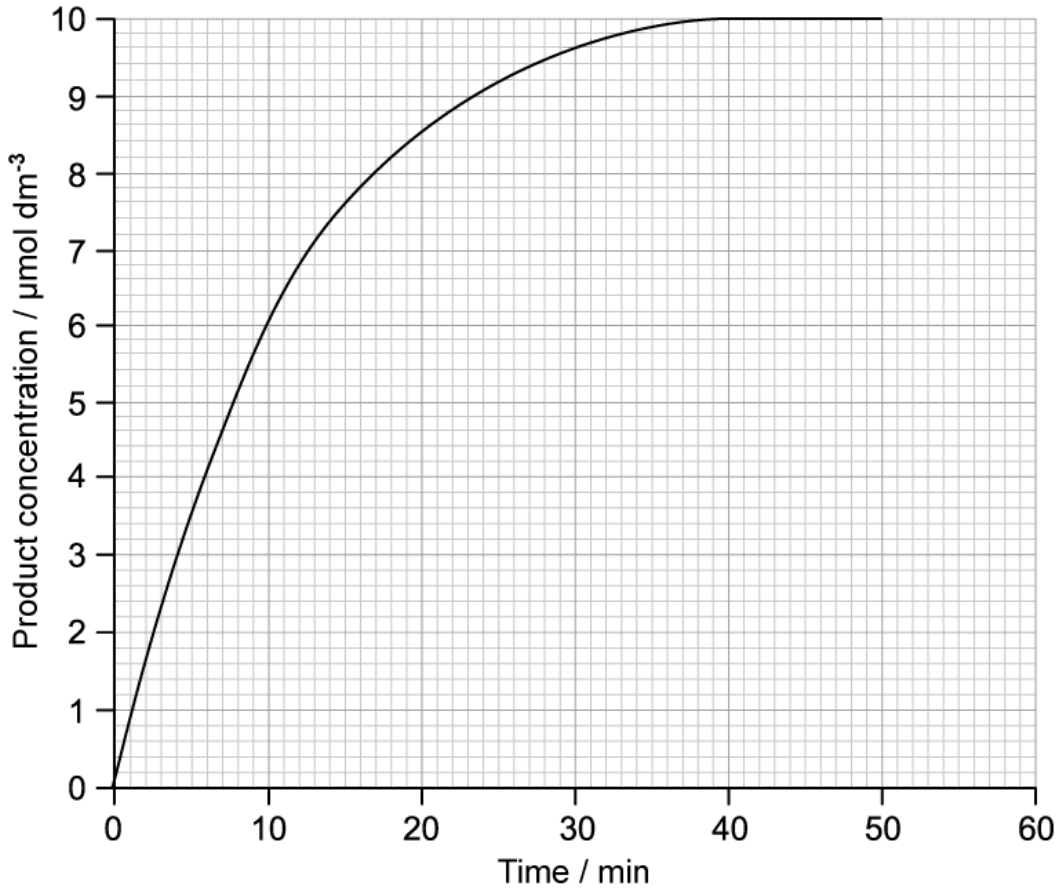
(ii) How a colorimeter could be used to measure colour change.

(4 marks)

6 (a) Trypsin is an enzyme produced by the pancreas that hydrolyses proteins in the small intestine.

The activity of trypsin was investigated by placing a small amount of the enzyme with a known concentration of protein.

The graph below shows the progress of this reaction when it is carried out at 25 °C.



Calculate the initial rate of the reaction in the graph. Show your working.

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(2 marks)

(b) The investigation was extended to compare the initial reaction rates of trypsin obtained from different species of animal.

Suggest **two** advantages of calculating the **initial** reaction rates of enzyme catalysed reactions here rather than the reaction rates at another point during the experiment.

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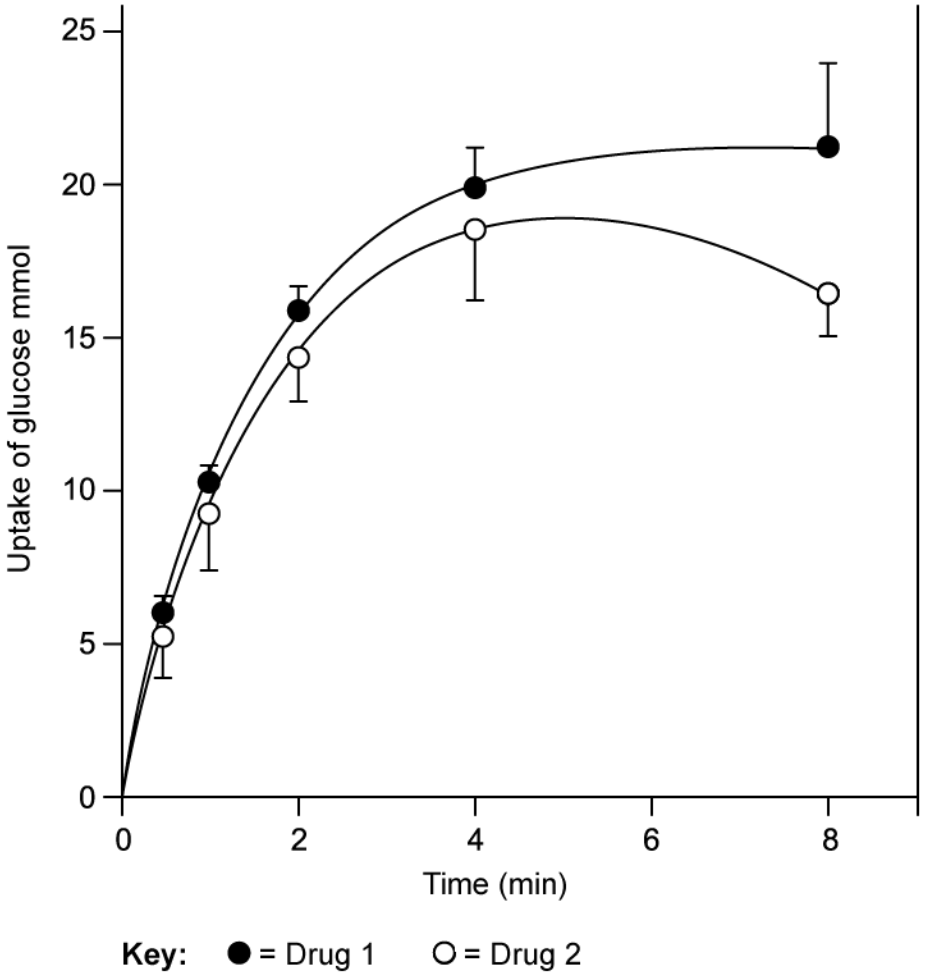
(2 marks)

7 (a) The *Plasmodium falciparum* parasite depends on glycolysis for its survival, particularly the uptake of glucose from its host cells which is mediated by hexokinase.

The scientists investigated the action of hexokinase within *Plasmodium falciparum*. They tagged hexokinase with two different potential drugs that inhibit its action. Their results are shown in the graph below.



Describe how to calculate the rate of reaction from the graph.

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(2 marks)

(b) The scientists concluded that drug 1 was less effective than drug 2.

Evaluate this conclusion.

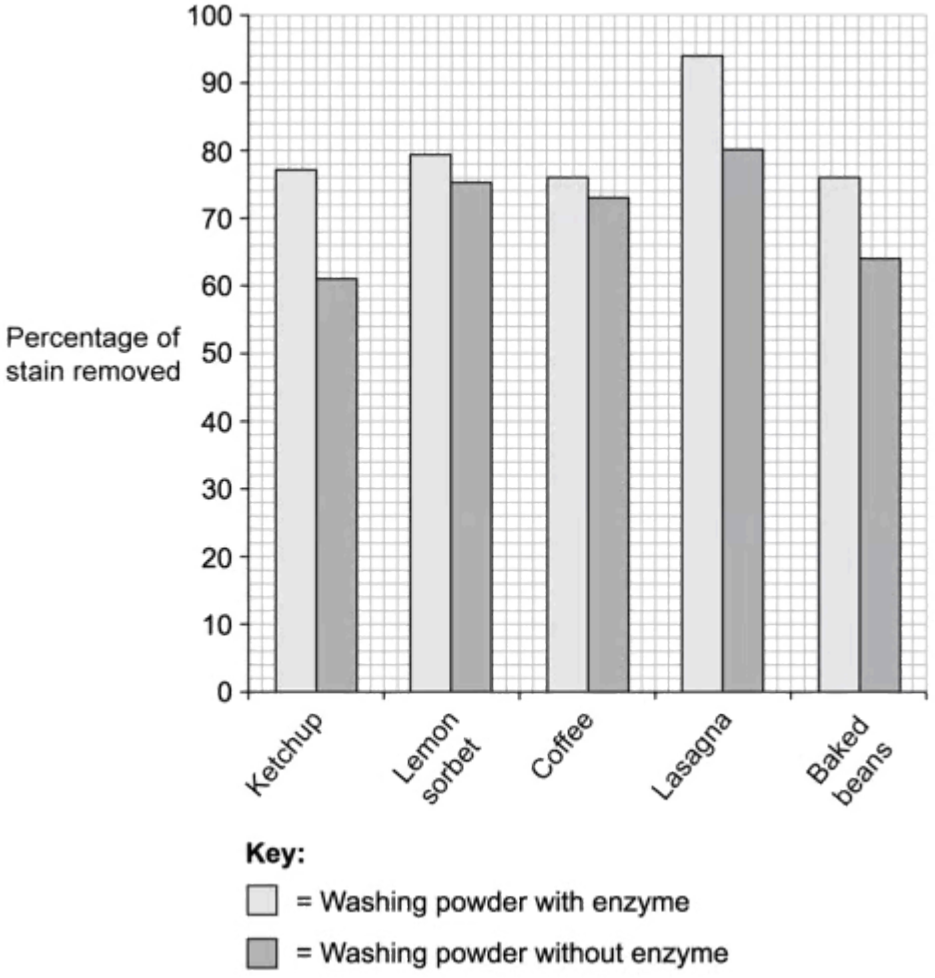
(3 marks)

8 Distinguish between an enzyme catalysed reaction and a non enzymatic reaction.

(3 marks)

Hard Questions

1 (a) Washing powders often contain different types of enzymes that break down substances in stains. An investigation was carried out into washing powder that contained enzymes and washing powder that did not contain enzymes. The graph below shows the results of this investigation.



Some of the substances that cause food stains are large insoluble proteins.

Explain how washing powder containing enzymes would be able to remove these stains.

.....

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(2 marks)

(b) The manufacturers of the washing powder containing enzymes claimed that their washing powder was more effective at removing tough stains compared to the washing powder without enzymes.

Based on the results of the investigation in part a), evaluate the claim of the manufacturers.

(3 marks)

(c) The investigation at part a) was carried out at 40 °C.

Suggest a reason for this.

(1 mark)

(d) The investigation was repeated at a temperature of 85 °C.

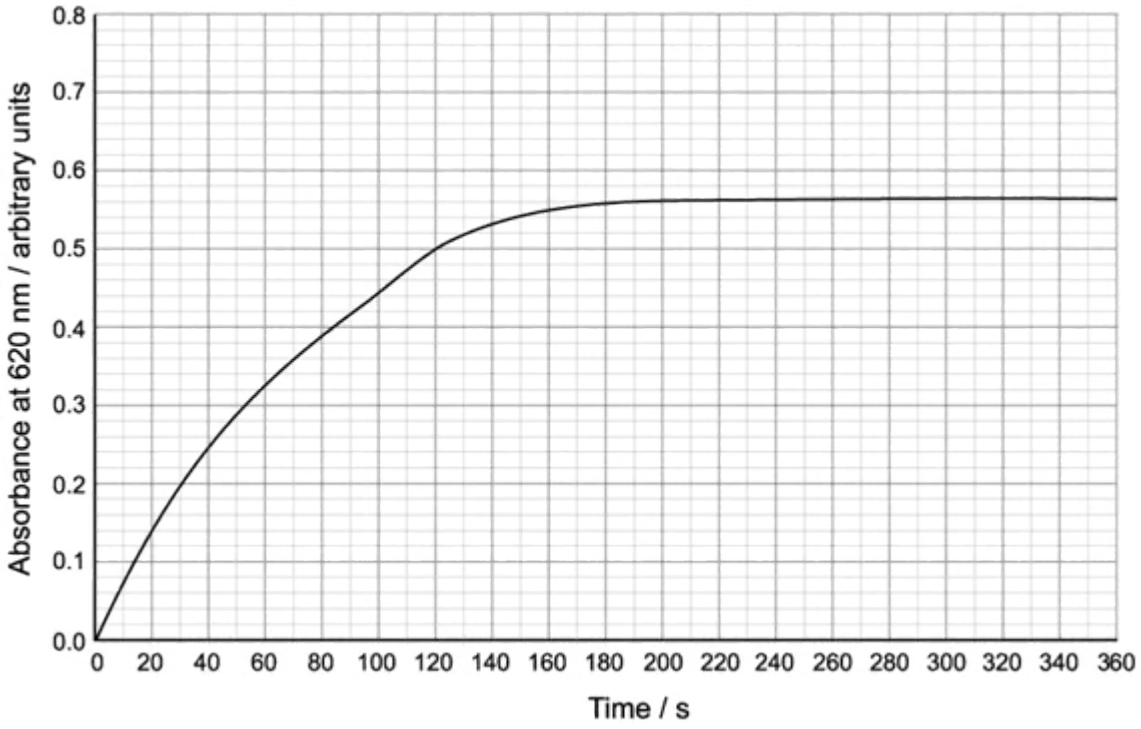
Predict, with a reason, the expected results from this investigation.

(3 marks)

2 (a) Certain plants that reproduce sexually contain an enzyme called pyrophosphatase. This enzyme plays a role in ensuring self-incompatibility, which is a mechanism that prevents a plant from fertilising itself. The selective advantage of self-incompatibility is that more cross-breeding can occur within a species, which has long term benefits for evolution and for maintaining a large pool of alleles.

Known volumes of pyrophosphatase and substrate can be mixed in a cuvette with a dye that starts as colourless and develops into a blue colour over time. The rate of colour development can be measured in a colorimeter by measuring the absorbance of light at a wavelength of 620 nm (red light).

The graph shows the mean rate of reaction of pyrophosphatase measured over five repeats at 20°C.



State why the wavelength of 620 nm was selected for this experimental measurement.

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(1 mark)

(b) Use the graph from part (a) to calculate the rate of the reaction at 100 seconds. Give your answer in suitable units.

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(3 marks)

(c) (i) Predict the effect that a higher enzyme concentration at the start of the experiment would have on the results calculated in part (b).

[1]

(ii) Explain your answer in part (i).

[1]

(2 marks)

3 (a) Outline how changes in substrate concentration affects the rate of enzyme action.

(3 marks)

(b) Plan an investigation to determine how changing the temperature of amylase affects the rate of reaction of the digestion of starch to maltose.

(7 marks)

4 Three rivers in the Scottish Highlands were polluted with copper, which affected the aquatic wildlife. Scientists were provided with one dead brown trout, *Salmo trutta*, from each of the rivers.

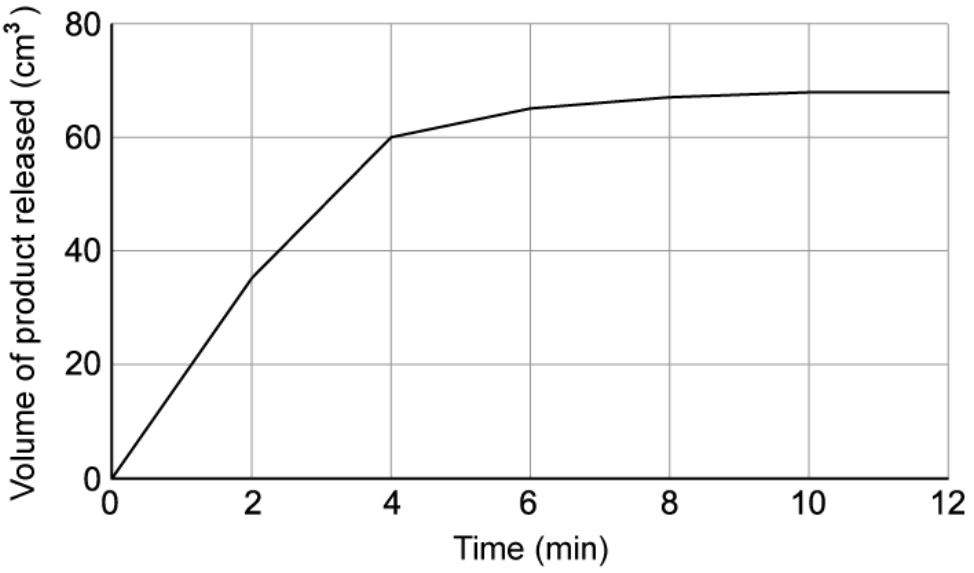
Scientists were unable to take a direct measurement of the copper ion concentration in the river.

Using the information provided in part **(b)**, suggest the dependent, independent and control variables of an experiment using the fish tissue to compare the copper ion pollution in the three rivers.

(3 marks)

5 Scientists were trying to investigate the rate of reaction of alcohol dehydrogenase by measuring the quantity of product, methanoic acid, produced over time, with a fixed quantity of methanol added at the start.

The graph below shows their results.



Use the graph below to calculate the rate of reaction of alcohol dehydrogenase after 3 minutes.

(3 marks)