

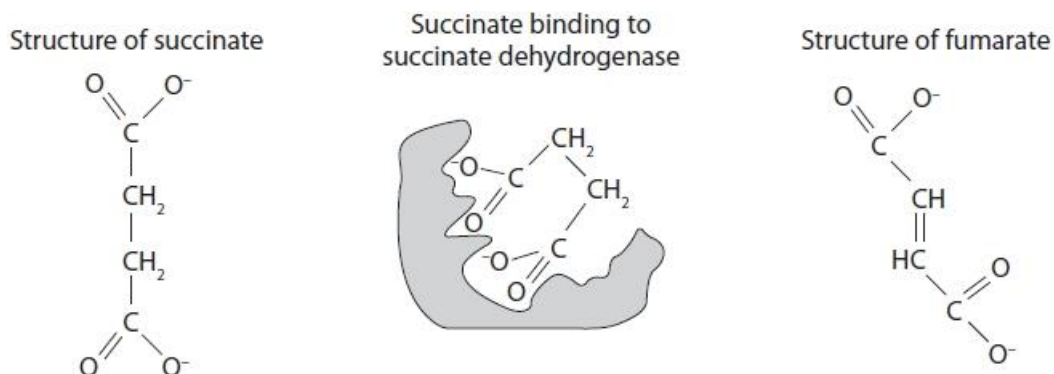
Questions

Q1.

Succinate dehydrogenase is an enzyme found in mitochondria.

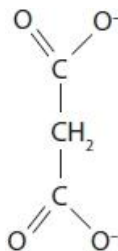
Succinate dehydrogenase converts succinate to fumarate.

The diagrams show the structure of succinate, succinate binding to the active site of succinate dehydrogenase and the structure of fumarate.



(a) The activity of succinate dehydrogenase is inhibited by malonate.

The diagram shows the structure of malonate.



(i) Explain why malonate inhibits the activity of succinate dehydrogenase.

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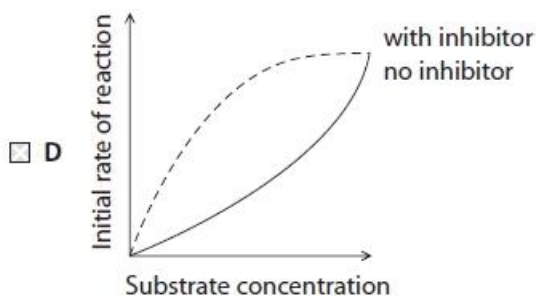
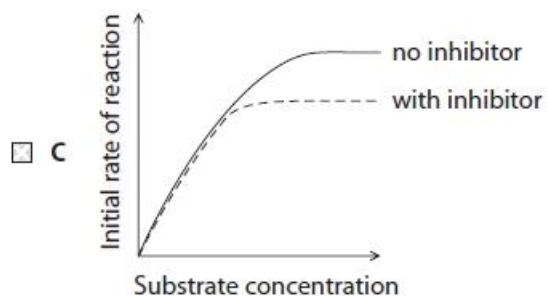
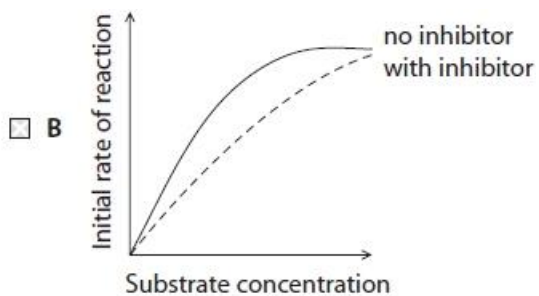
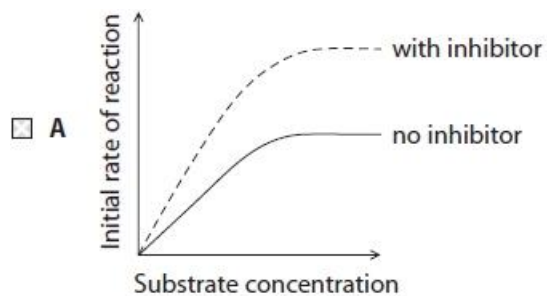
(ii) On the diagram, draw malonate binding to succinate dehydrogenase.

(1)



(iii) Which of the following graphs represents the effect of this type of inhibitor?

(1)



(Total for question = 4 marks)

Q2.

The activity of enzymes is affected by a number of factors.

Explain why increasing the temperature of an enzyme-controlled reaction changes the rate of reaction.

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(Total for question = 3 marks)

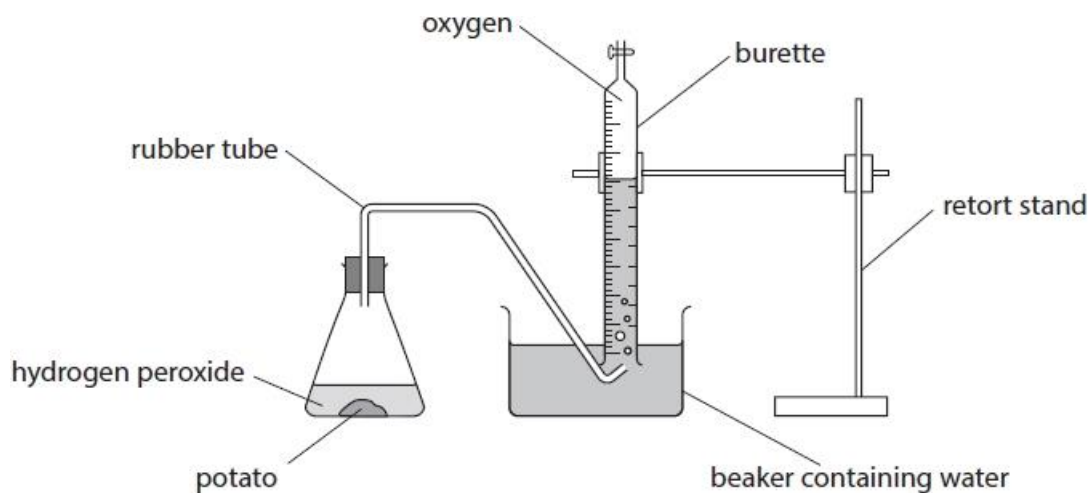
Q3.

The activity of enzymes is affected by a number of factors.

A student investigated the activity of the enzyme catalase in potato.

This enzyme is found in potato cells. It catalyses the conversion of hydrogen peroxide to oxygen and water.

The diagram shows the apparatus used to collect the data.



(i) Describe how two named variables, other than the potato, can be controlled in order to obtain valid results.

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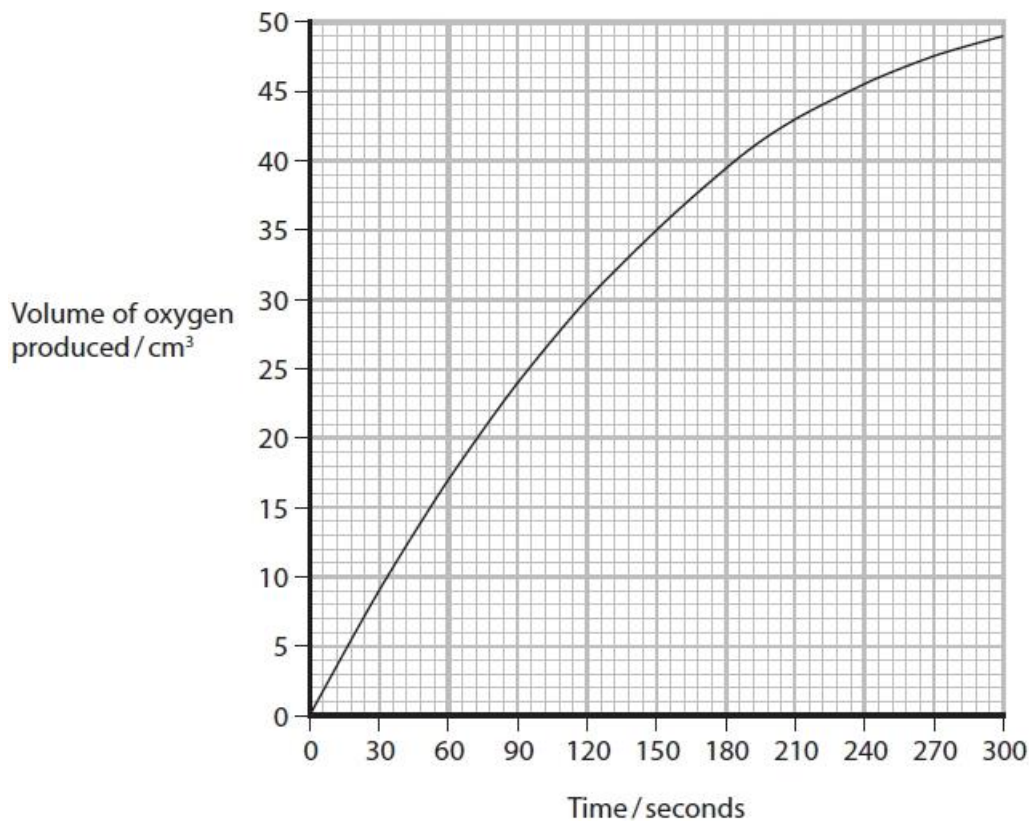
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(ii) The graph shows the results of the investigation.



Determine the initial rate of reaction from this graph.

(1)

Answer

(iii) Explain why the rate of reaction decreases over time.

(2)

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(Total for question = 7 marks)

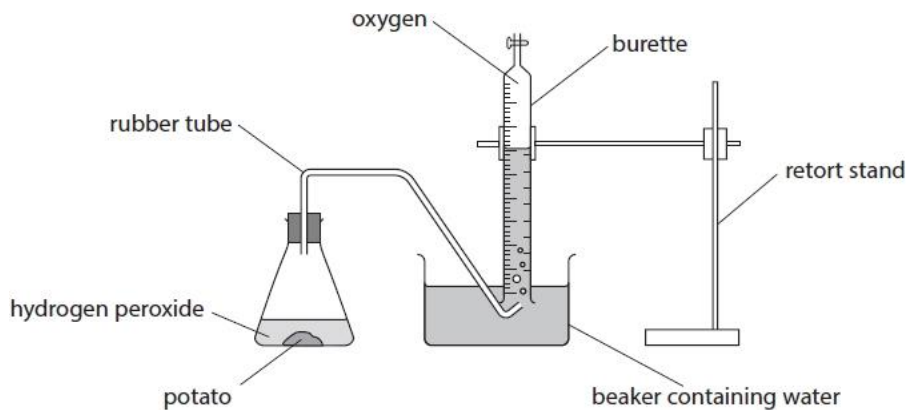
Q4.

The activity of enzymes is affected by a number of factors.

A student investigated the activity of the enzyme catalase in potato.

This enzyme is found in potato cells. It catalyses the conversion of hydrogen peroxide to oxygen and water.

The diagram shows the apparatus used to collect the data.



The student used this apparatus to investigate the effect of using increasing numbers of potato cubes on the rate of reaction.

The potato was cut into 1 cm³ cubes to be used in five trials.

In the first trial, one cube was added to the flask and the volume of oxygen produced in 30 seconds was measured.

The hydrogen peroxide was then replaced.

This was repeated in the other four trials using 2, 3, 4 and 5 cubes of potato.

Explain the results you would expect from this investigation.

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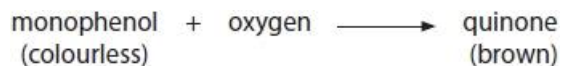
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(Total for question = 3 marks)

Q5.

Polyphenol oxidase is an enzyme found in many plant cells.

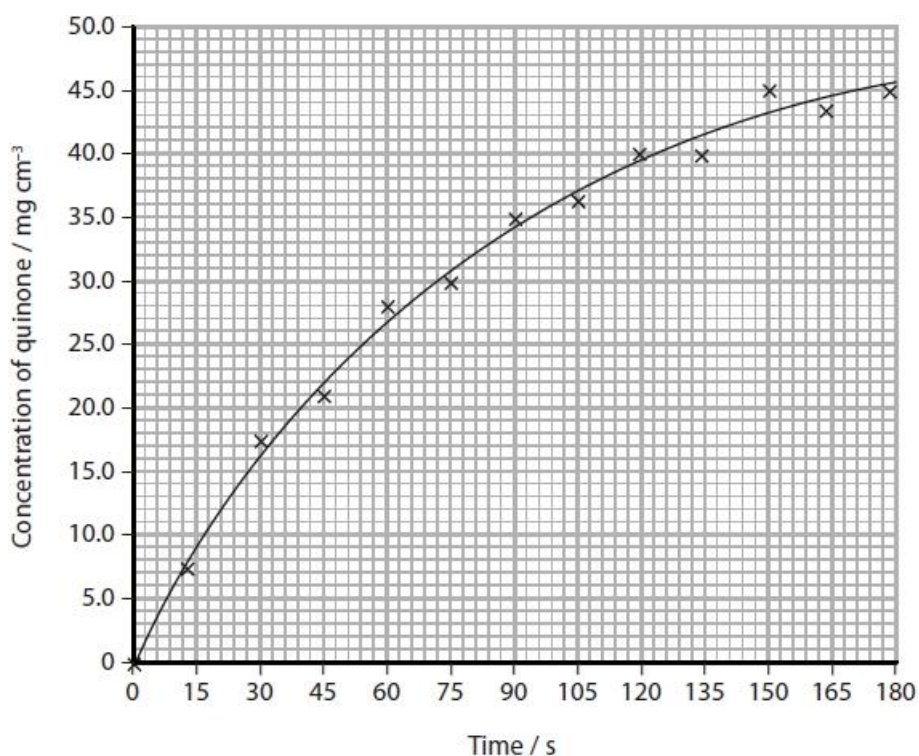
This enzyme catalyses the following reaction



This reaction causes cut fruit to turn brown when exposed to air.

A student carried out an investigation into the rate at which grape juice produced quinone.

The graph shows the results of this investigation.



(i) Calculate the initial rate of this reaction.

(3)

Answer

(ii) Explain why adding citric acid to cut fruit reduces the rate at which the fruit turns brown.

(2)

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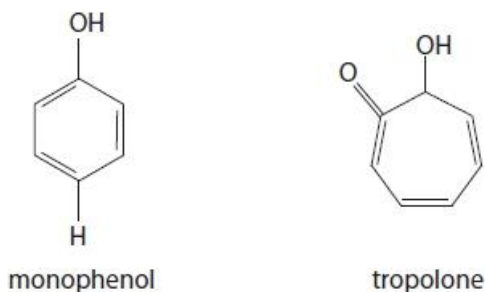
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(iii) The diagram shows the structures of monophenol and a molecule called tropolone.

Tropolone can be added to grape juice to slow the rate at which the juice turns brown.



Explain how tropolone affects the rate at which the grape juice turns brown.

(2)

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(Total for question = 7 marks)

Q6.

Glucose and fructose are monosaccharides.

The makers of sweet tasting drinks use the enzyme glucose isomerase to convert glucose into fructose.

Fructose is a monosaccharide that tastes much sweeter than glucose.

(i) Explain a possible health benefit of converting glucose into fructose for use in sweet tasting drinks.

(2)

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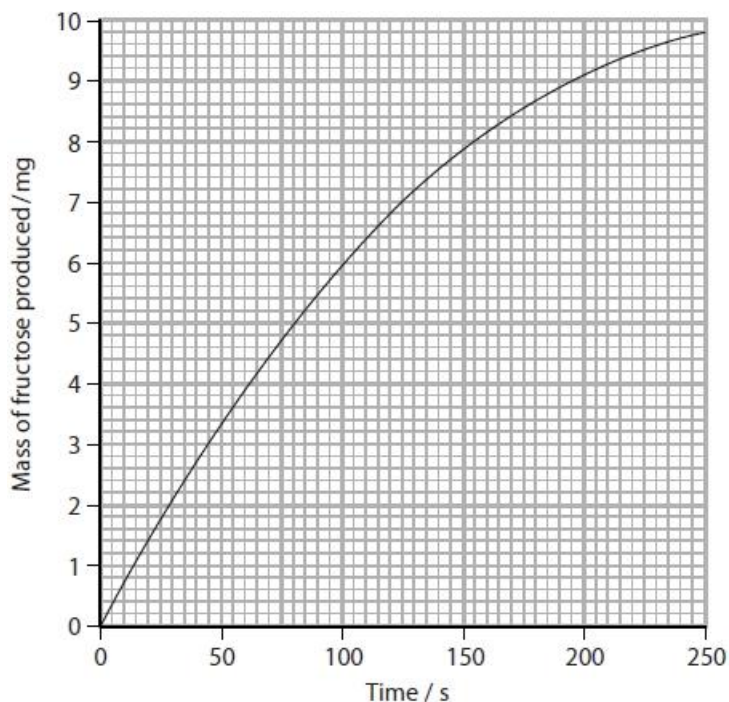
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(ii) A student investigated the activity of glucose isomerase.

The graph shows the results of this investigation.



Determine the initial rate of the reaction.

(1)

Answer

(iii) Cofactors are non-protein molecules that help enzymes to function.

Magnesium ions act as cofactors for some enzymes.

Devise an experiment to investigate the effect of magnesium ions on the initial rate of this reaction.

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(Total for question = 8 marks)

Q7.

Chymosin is an enzyme used to clot milk for the production of cheese.

A farmer investigated the effect of chymosin concentration on the rate of milk clotting.

1 cm³ of a 0.2% chymosin solution was added to 9 cm³ milk and the time taken for the milk to clot was recorded. This was repeated using five other concentrations of chymosin.

The results are shown in the table.

Chymosin concentration (%)	Time for milk to clot / min		Mean rate of milk clotting / min ⁻¹
	Trial 1	Trial 2	
0.2	7.0	7.5	0.14
0.5	3.5	3.0	
1.0	1.5	1.5	0.67
1.5	1.0	1.5	0.80
2.0	0.8	0.7	1.33
3.0	0.5	0.3	2.50

The chymosin used for the investigation costs 3.6p to treat 100 cm³ of milk.

Calculate how much it would cost to treat 200 dm³ milk.

(2)

Answer £

(Total for question = 2 marks)

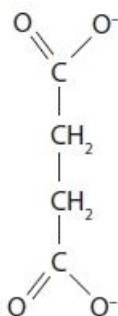
Q8.

Succinate dehydrogenase is an enzyme found in mitochondria.

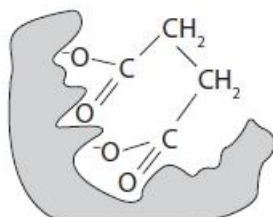
Succinate dehydrogenase converts succinate to fumarate.

The diagrams show the structure of succinate, succinate binding to the active site of succinate dehydrogenase and the structure of fumarate.

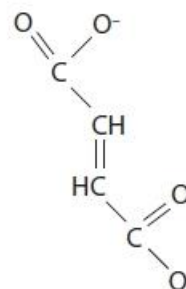
Structure of succinate



Succinate binding to succinate dehydrogenase



Structure of fumarate



* The rate of reaction of succinate dehydrogenase can be measured using a methylene blue solution.

Methylene blue starts off blue but changes to colourless as succinate is converted to fumarate.

A student investigated the effect of malonate on the rate of reaction of succinate dehydrogenase.

The student used the following steps.

Step 1. Succinate solution was poured into a beaker up to the 25 cm³ mark.

Step 2. Ten drops of succinate dehydrogenase solution and three drops of methylene blue solution were added.

Step 3. The beaker was left on the bench until the methylene blue became colourless and the time for this change was recorded.

Step 4. Steps 1 to 3 were repeated using two different concentrations of succinate solution.

The whole procedure was repeated with the addition of 15 cm³ of malonate solution with the succinate solution in **Step 1**.

Criticise the method used in this investigation.

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(Total for question = 6 marks)

Q9.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

The photographs show a black cat and a Siamese cat.



© Tim Macpherson, Cultura/Science photo library



© BSIP Laurent/Gluck/Science photo library

The pigment melanin causes the fur to turn black.
This pigment is produced by tyrosinase, an enzyme coded by the TYR gene.



Siamese cats have a mutation in their TYR gene.
This changes the secondary and tertiary structures of tyrosinase.

(i) Which of the following shows the type of bonding involved in both the secondary and tertiary structures of a protein?

(1)

- A hydrogen only
- B hydrogen and ionic
- C ionic and disulfide
- D ionic only

(ii) Explain why the cooler regions of a Siamese cat have dark coloured fur and the warmer regions have lighter coloured fur.

(3)

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(Total for question = 4 marks)

Q10.

Chymosin is an enzyme used to clot milk for the production of cheese.

A farmer investigated the effect of chymosin concentration on the rate of milk clotting.

1 cm³ of a 0.2% chymosin solution was added to 9 cm³ milk and the time taken for the milk to clot was recorded. This was repeated using five other concentrations of chymosin.

The results are shown in the table.

Chymosin concentration (%)	Time for milk to clot / min		Mean rate of milk clotting / min ⁻¹
	Trial 1	Trial 2	
0.2	7.0	7.5	0.14
0.5	3.5	3.0	
1.0	1.5	1.5	0.67
1.5	1.0	1.5	0.80
2.0	0.8	0.7	1.33
3.0	0.5	0.3	2.50

(i) Calculate the mean rate of milk clotting at a chymosin concentration of 0.5%.

(3)

Answer min⁻¹

(ii) Give one reason why the information in the table is insufficient to conclude which concentration of chymosin would be best for cheese production.

(1)

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(Total for question = 4 marks)

Q11.

Enzymes are catalysts that are sensitive to changes in temperature.

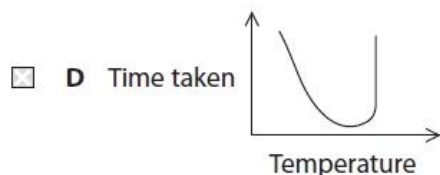
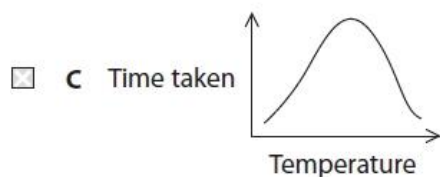
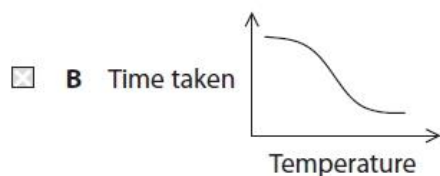
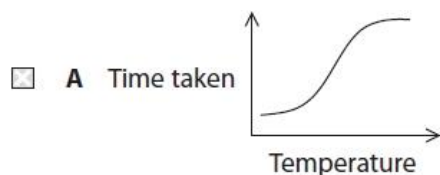
The effect of temperature on the activity of a mammalian enzyme was investigated.

The enzyme was added to a known concentration of the substrate.

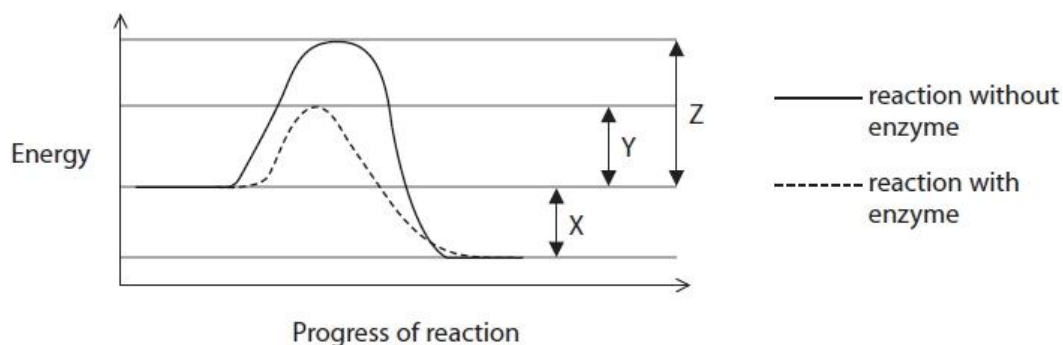
The time taken for all of the substrate to be used up was recorded at several temperatures.

(i) Which graph shows the results of this investigation?

(1)



(ii) The graph shows the energy changes during a reaction with and without an enzyme.



Which of the following represents the decrease in the activation energy of this reaction?

(1)

- A** X
 B X + Y
 C Z
 D Z - Y

(Total for question = 2 marks)

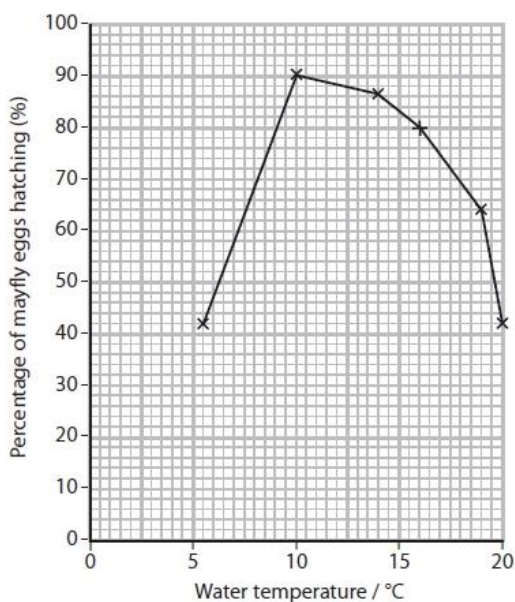
Q12.

The photograph shows an adult mayfly.



Mayflies lay their eggs in water.

The graph shows the effect of water temperature on the percentage of mayfly eggs that hatch.



Explain the effect of temperature on the percentage of mayfly eggs that hatch.

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(Total for question = 4 marks)

Q13.

Enzymes are involved in the breakdown of carbohydrates.

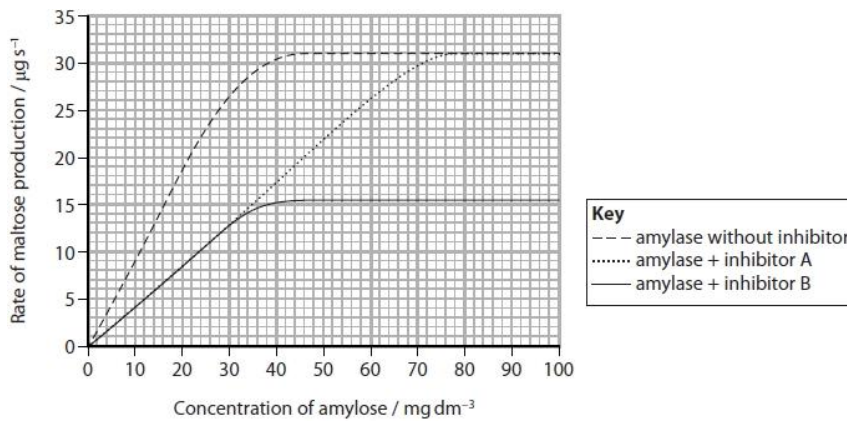
Some plants produce amylase inhibitors.

A student investigated the effects of two inhibitors, A and B, on the activity of amylase.

The same concentration of amylase and the same concentrations of the inhibitors A and B were used.

The rate of maltose production was measured at different concentrations of amylose with each inhibitor and without an inhibitor.

The results are shown in the graph.



(i) Compare and contrast the effects of these two inhibitors on amylase activity.

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(ii) Explain which of the two inhibitors is non-competitive.

(3)

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(Total for question = 5 marks)

Q14.

Catalase is an enzyme found in potato cells.

It catalyses the breakdown of hydrogen peroxide.

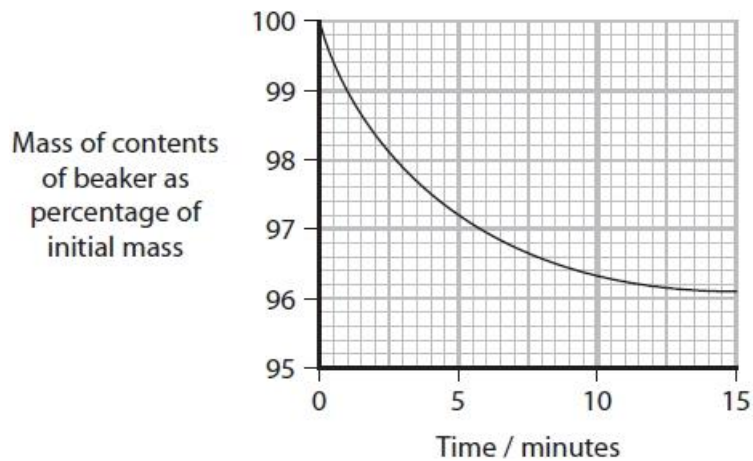


In an investigation, cylinders of potato were cut with a cork borer.

The cylinders were then sliced into discs with the same thickness and put into a small beaker containing 50 cm³ of hydrogen peroxide.

The mass of the beaker and its contents was recorded over a period of 15 minutes.

The graph shows the results of the experiment.



Explain the relationship shown in the graph.

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(Total for question = 4 marks)

Q15.

The photograph shows sweet red peppers growing on a plant.



© Janet Horton / Alamy Stock Photo

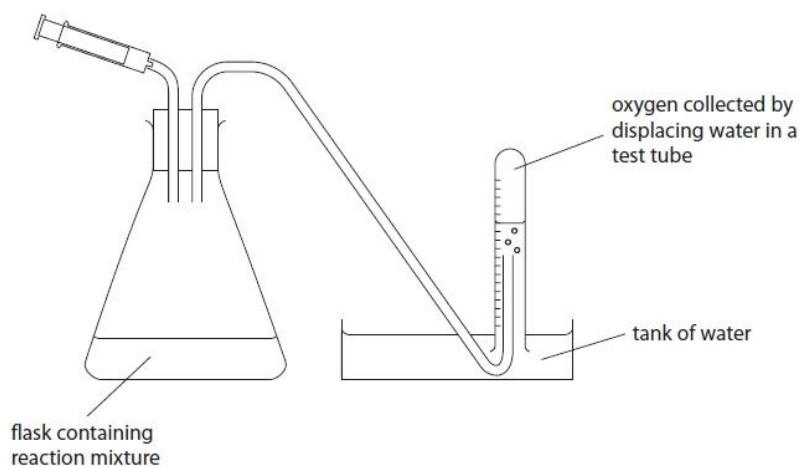
Unripe sweet red peppers contain the enzyme catalase. As these peppers ripen, the activity of catalase decreases.

The equation summarises the reaction catalysed by catalase.



The activity of catalase can be measured by collecting the oxygen produced during the reaction.

The diagram shows apparatus that can be used to collect the oxygen produced.



- (i) When measuring the activity of enzymes, the initial rate of reaction should be measured. Explain why the initial rate of reaction should be measured.

(2)

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*(ii) Devise an investigation, using this apparatus, to show that as sweet red peppers ripen the activity of catalase decreases.

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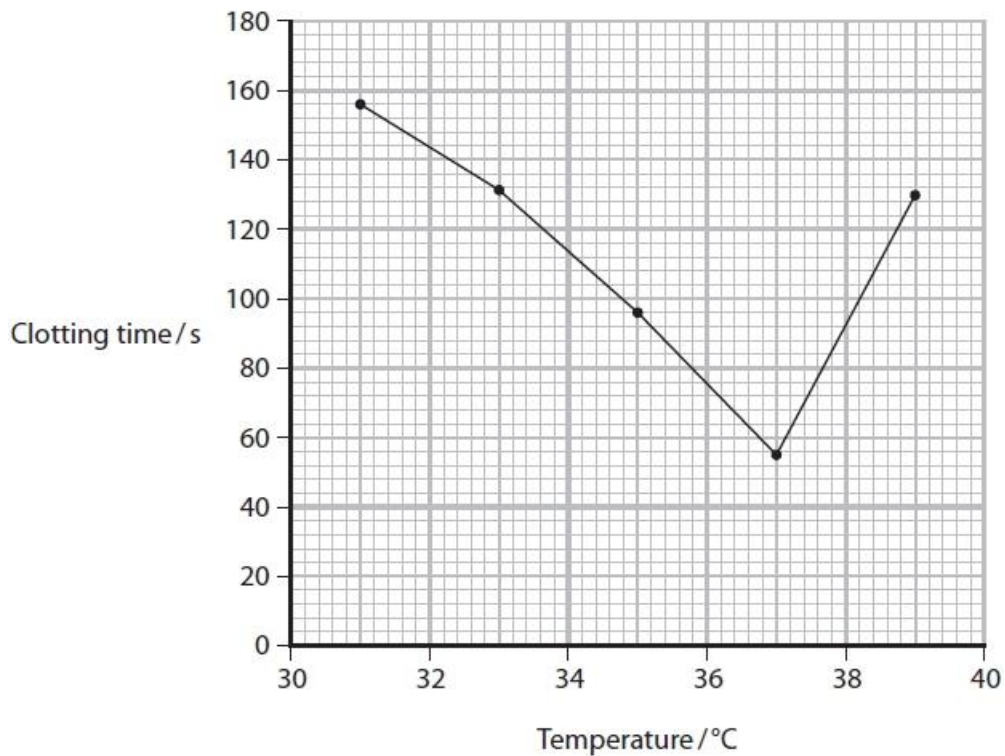
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(Total for question = 8 marks)

Q16.

A scientist investigated the effect of temperature on the time it takes for blood to clot.

The graph shows the results of this investigation.



Explain how these results show that enzymes are involved in blood clotting.

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(Total for question = 3 marks)

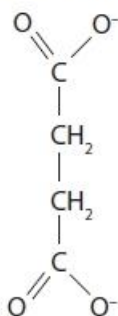
Q17.

Succinate dehydrogenase is an enzyme found in mitochondria.

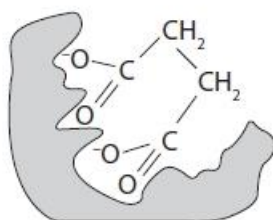
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The diagrams show the structure of succinate, succinate binding to the active site of succinate dehydrogenase and the structure of fumarate.

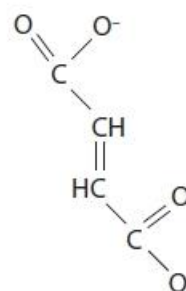
Structure of succinate



Succinate binding to succinate dehydrogenase



Structure of fumarate



Explain the role of the active site in the conversion of succinate to fumarate.

(3)

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(Total for question = 3 marks)

Q18.

When apples are cut, the enzyme polyphenol oxidase is released from the cells.

This enzyme converts colourless phenols into a brown pigment called melanin.

Citric acid or a protease enzyme can be added to apple slices to prevent this browning.

(i) Explain why the addition of citric acid prevents the browning of apple slices.

(2)

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(ii) Explain why the addition of a protease enzyme prevents the browning of apple slices.

(2)

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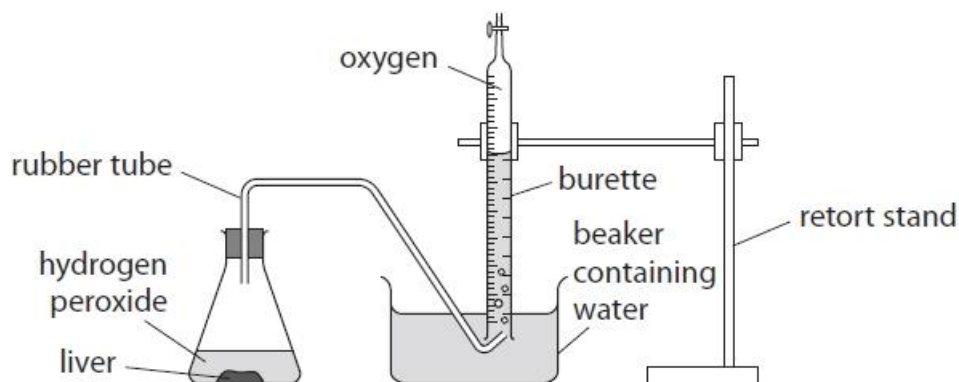
(Total for question = 4 marks)

Q19.

Liver cells contain an enzyme called catalase.

This enzyme changes hydrogen peroxide in the liver cells into water and oxygen.

A group of students used the apparatus shown to compare the activity of catalase in raw liver tissue and in boiled liver tissue.



The students used the following method.

- a burette filled with water is placed in a beaker containing water
- add hydrogen peroxide to the conical flask
- open the conical flask and drop 0.1g of raw liver into the hydrogen peroxide
- replace the bung on the conical flask
- after 10 seconds pinch the rubber tube to stop any more oxygen entering the burette
- measure the volume of oxygen collected in the burette
- repeat this method for boiled liver

The table shows the results obtained by each student.

Student	Volume of oxygen collected in 10 seconds / cm ³	
	Raw liver	Boiled liver
1	19	0
2	40	0
3	28	0
4	38	0
5	42	0
6	29	0
7	34	0
8	46	0
9	38	0

Explain why it was important to measure the volume of oxygen in the first 10 seconds.

(2)

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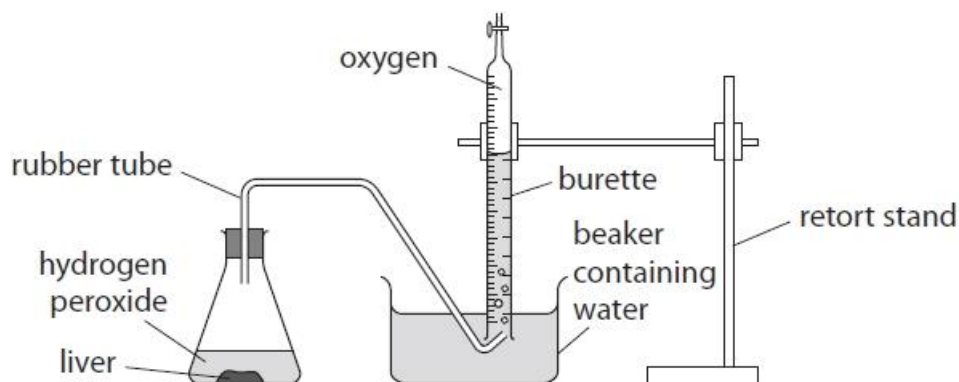
(Total for question = 2 marks)

Q20.

Liver cells contain an enzyme called catalase.

This enzyme changes hydrogen peroxide in the liver cells into water and oxygen.

A group of students used the apparatus shown to compare the activity of catalase in raw liver tissue and in boiled liver tissue.



The students used the following method.

- a burette filled with water is placed in a beaker containing water
- add hydrogen peroxide to the conical flask
- open the conical flask and drop 0.1g of raw liver into the hydrogen peroxide
- replace the bung on the conical flask
- after 10 seconds pinch the rubber tube to stop any more oxygen entering the burette
- measure the volume of oxygen collected in the burette
- repeat this method for boiled liver

The table shows the results obtained by each student.

Student	Volume of oxygen collected in 10 seconds / cm ³	
	Raw liver	Boiled liver
1	19	0
2	40	0
3	28	0
4	38	0
5	42	0
6	29	0
7	34	0
8	46	0
9	38	0

Explain why no oxygen was produced when boiled liver was added to the hydrogen peroxide.

(3)

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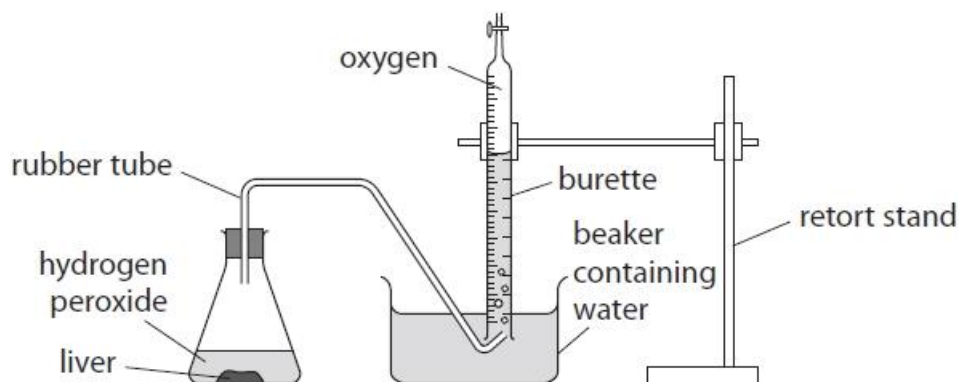
(Total for question = 3 marks)

Q21.

Liver cells contain an enzyme called catalase.

This enzyme changes hydrogen peroxide in the liver cells into water and oxygen.

A group of students used the apparatus shown to compare the activity of catalase in raw liver tissue and in boiled liver tissue.



The students used the following method.

- a burette filled with water is placed in a beaker containing water
- add hydrogen peroxide to the conical flask
- open the conical flask and drop 0.1g of raw liver into the hydrogen peroxide
- replace the bung on the conical flask
- after 10 seconds pinch the rubber tube to stop any more oxygen entering the burette
- measure the volume of oxygen collected in the burette
- repeat this method for boiled liver

The table shows the results obtained by each student.

Student	Volume of oxygen collected in 10 seconds / cm ³	
	Raw liver	Boiled liver
1	19	0
2	40	0
3	28	0
4	38	0
5	42	0
6	29	0
7	34	0
8	46	0
9	38	0

The results for the volume of oxygen collected by each student using raw liver were different.

Give **four** possible improvements to the method used by these students that would reduce the variability of the results.

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(Total for question = 4 marks)

Q22.

Leeches are parasites that feed by sucking blood. When they bite, they secrete saliva into the wound. The saliva contains a globular protein called hirudin.

Hirudin is an inhibitor that forms hydrogen bonds with an enzyme.

Explain how hirudin would inhibit the activity of the enzyme.

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(Total for question = 3 marks)

Q23.

Some chemical pesticides, such as diisopropyl fluorophosphate (DFP), affect the activity of synapses.

This pesticide acts by binding irreversibly to the R group of an amino acid in the active site of acetylcholinesterase.

(i) Explain why DFP inhibits the activity of acetylcholinesterase.

(2)

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(ii) Explain why a person poisoned with DFP has a slower heart rate.

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(Total for question = 5 marks)

Q26.

Cattle with bovine spongiform encephalopathy (BSE) have microscopic holes in their brain tissue.

This disease involves the misfolding of proteins which then form clumps.

Clumps of misfolded proteins can be seen with an electron microscope.

The misfolded proteins have a changed secondary structure. Therefore they cannot be digested by some protease enzymes.

(i) Describe what is meant by the secondary structure of a protein.

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(ii) Explain why the misfolded protein cannot be digested by some protease enzymes.

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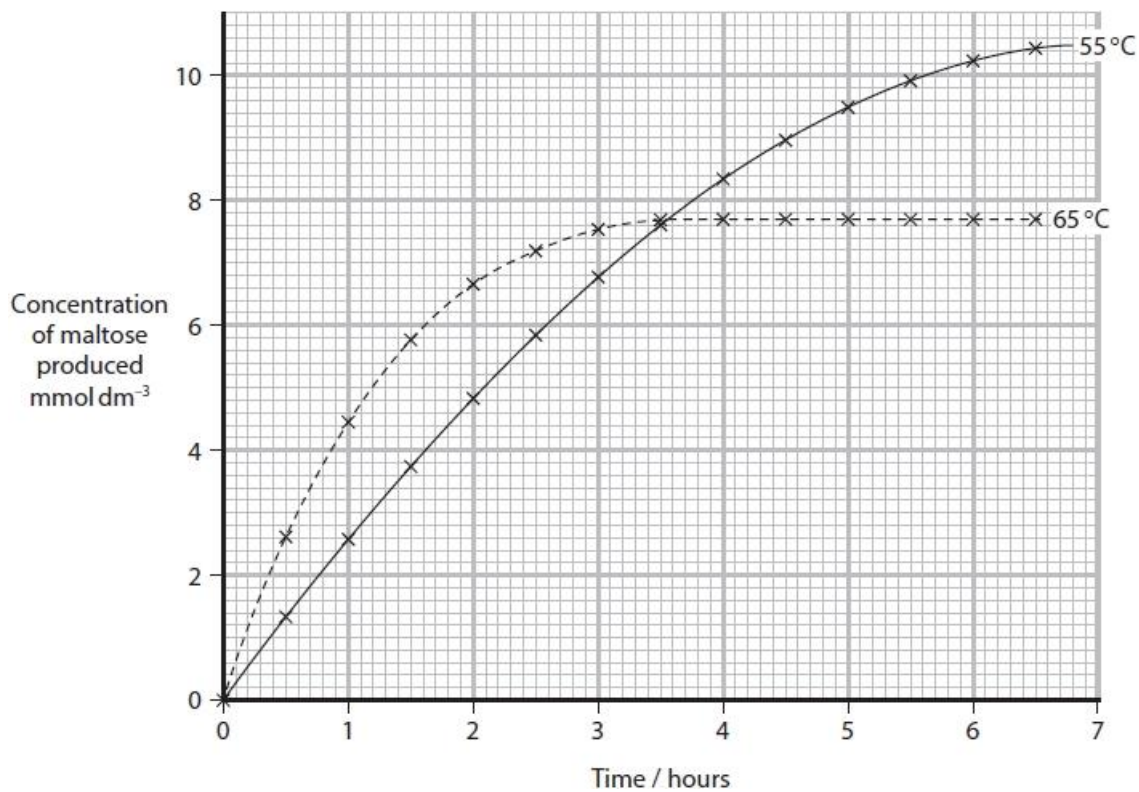
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(Total for question = 5 marks)

Q27.

The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



Calculate the initial rate of reaction at 55 °C in $\text{mmol dm}^{-3} \text{ min}^{-1}$.

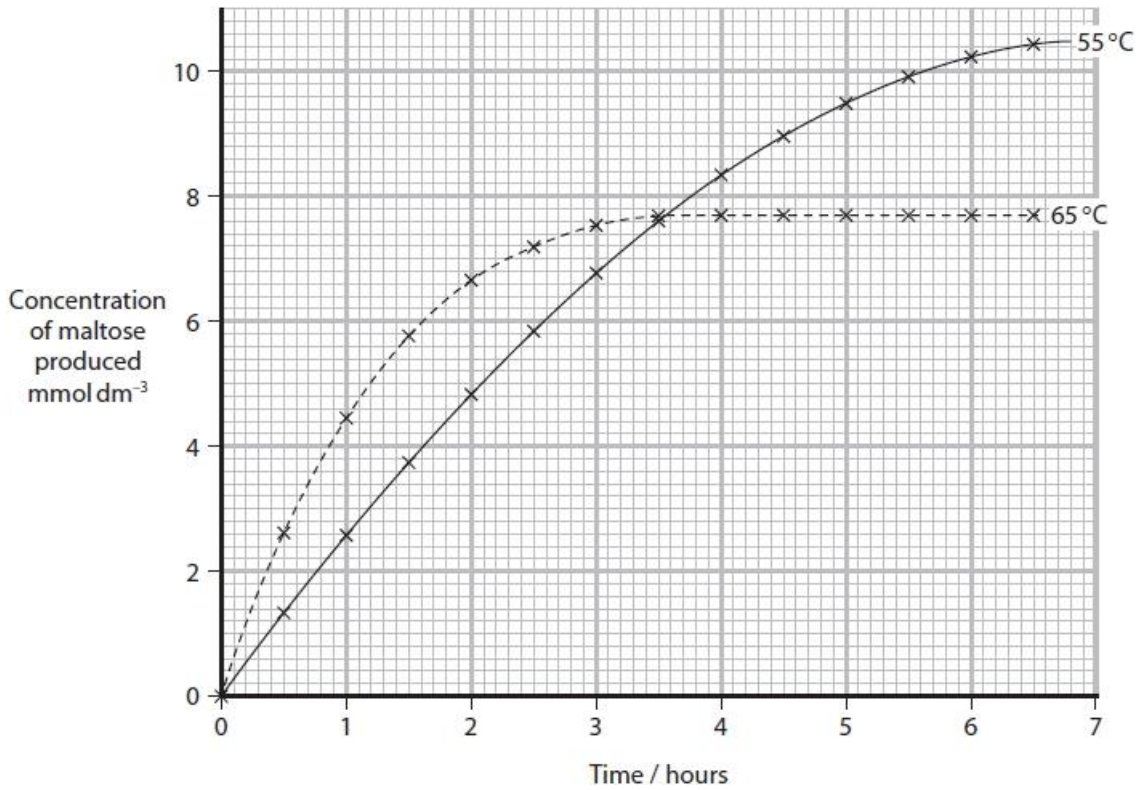
(2)

Answer

(Total for question = 2 marks)

Q28.

The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



Explain the difference between the two curves from 4 and 6 hours.

(2)

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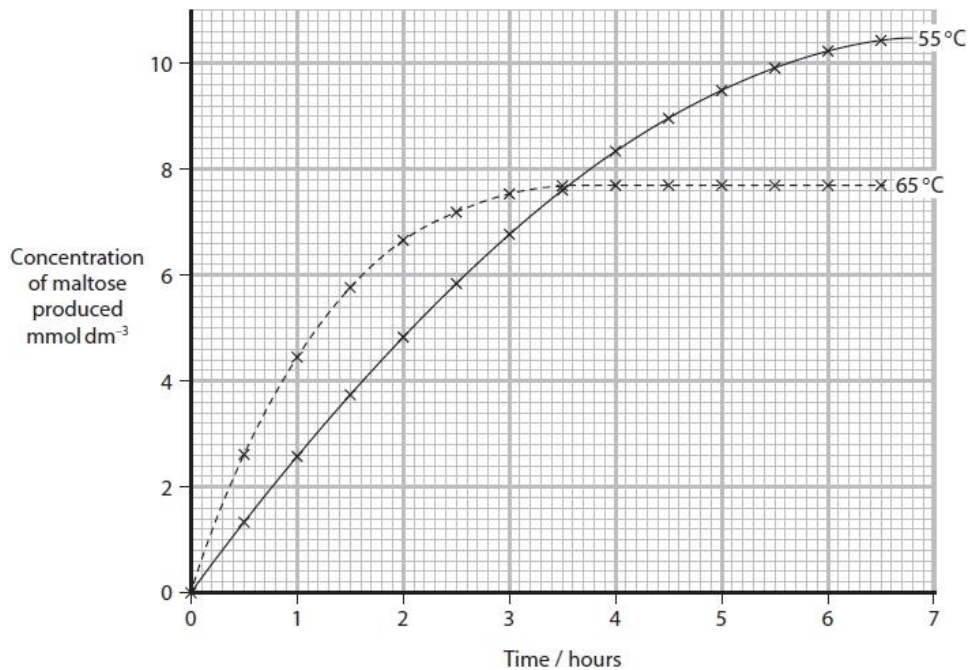
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(Total for question = 2 marks)

Q29.

The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



In this experiment:

- two beakers were prepared containing 1cm³ of amylase and 100 cm³ of starch solution at room temperature
- these beakers were then placed in the water baths at two different temperatures, 55 °C and 65 °C
- every 30 minutes a sample of the mixture was extracted and the concentration of maltose was measured.

(i) Analyse the information to explain why the initial rate of this reaction was faster at 65 °C than it was at 55 °C.

(3)

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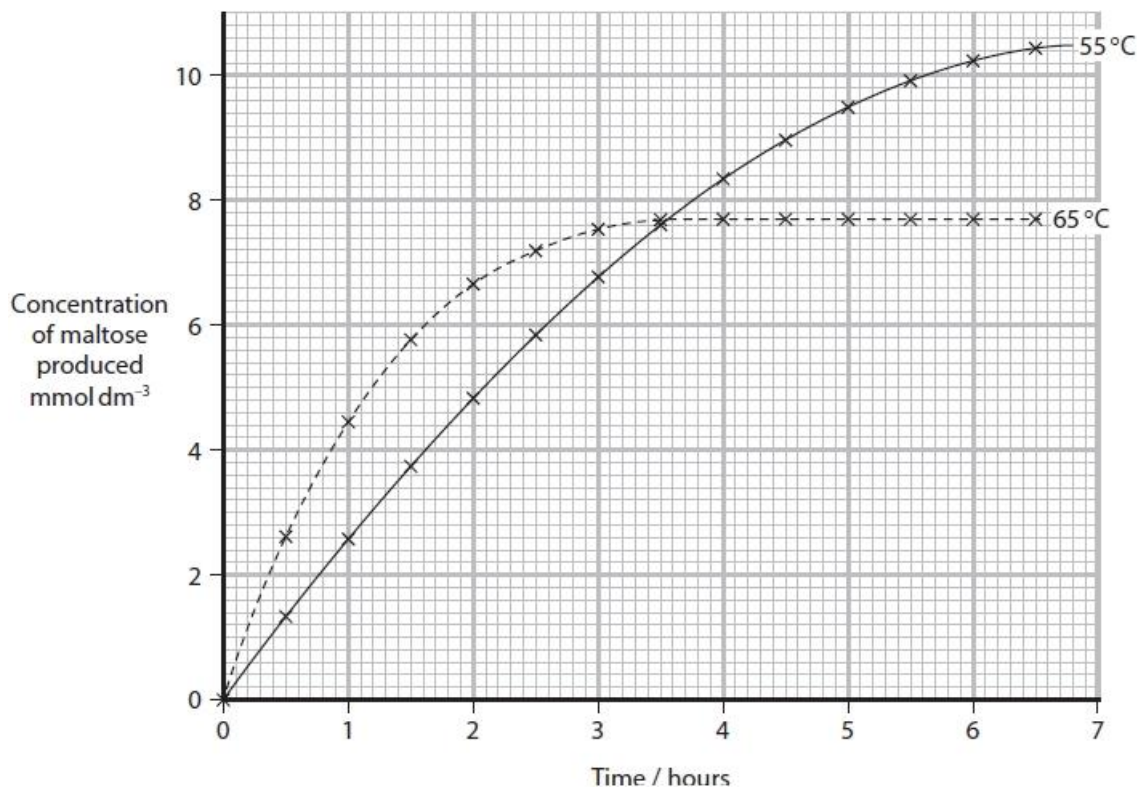
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(Total for question = 3 marks)

Q30.

The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



In this experiment:

- two beakers were prepared containing 1 cm³ of amylase and 100 cm³ of starch solution at room temperature
- these beakers were then placed in the water baths at two different temperatures, 55 °C and 65 °C
- every 30 minutes a sample of the mixture was extracted, and the concentration of maltose was measured.

*Evaluate the method used in this investigation and suggest improvements.

(Total for question = 6 marks)

Q31.

The venom from some species of snake contains enzymes that affect the blood clotting process.

(i) Which is a correct statement about enzymes?

(1)

- A** enzymes decrease the activation energy of metabolic reactions and decrease reaction time
- B** enzymes decrease the activation energy of metabolic reactions and increase reaction time
- C** enzymes increase the activation energy of metabolic reactions and decrease reaction time
- D** enzymes increase the activation energy of metabolic reactions and increase reaction time

(ii) Which components of the blood clotting process are active enzymes?

(1)

- A** fibrin and thrombin
- B** fibrinogen and thrombin
- C** fibrinogen and thromboplastin
- D** thrombin and thromboplastin

(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> because it has a similar {structure / shape} / both ends of the molecule have a COO⁻ group (1) therefore it can {fit / bind} into the active site / act as a competitive inhibitor (1) 		(2)
Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	<p>A drawing that shows the following:</p> <ul style="list-style-type: none"> the four oxygens drawn in the active site in the correct position (1) 	Two must be =O and two must be -O ⁻ in the same position as the succinate binding i.e. -O ⁻ then =O then -O ⁻ then =O all joined by CH ₂ (see original diagram on page 28)	(1)
Question Number	Answer	Additional Guidance	Mark
(iii)	B		(1)

Q2.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that contains three of the following:</p> <ul style="list-style-type: none"> • higher kinetic energy so more enzyme-substrate complexes formed (1) • at very high temperatures the rate decreases due to denaturation (1) • because of bond changes in the enzyme altering the active site (1) • so substrate no longer fits active site (and rate of product formation decreases) 	<p>Accept higher kinetic energy increases rate of collisions (between enzyme and substrate)</p> <p>Accept at temperatures above the optimum the rate decreases due to denaturation</p> <p>Accept changes to tertiary structure change the shape of the active site Accept bonds break in the enzyme altering the active site Do not accept peptide bonds</p> <p>Accept substrate longer complementary to active site</p>	<p>Exp (3)</p>

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer including two of the following variables with suitable methods of control:</p> <ul style="list-style-type: none"> • appropriate named variable (1) • description of how the variable is controlled (1) • appropriate named second variable (1) • description of how second variable is controlled (1) 	<p>eg</p> <ul style="list-style-type: none"> • volume of hydrogen peroxide / accept stated volume - measuring cylinder / syringe / pipette (to measure same volume) • concentration of hydrogen peroxide / accept stated concentration - dilute / make up solution to same % concentration / use of stock solution • temperature / accept stated temp - flask in thermostatically controlled waterbath / accept descriptions • pH / accept stated pH - buffer in flask 	Exp (4)

Question Number	Answer	Additional Guidance	Mark
(ii)	Initial rate of reaction calculated (1)	<p>Answer uses seconds $0.33 \text{ cm}^3 \text{ s}^{-1}$</p> <p>Accept: values in range: $0.28 \text{ to } 0.35 \text{ cm}^3 \text{ s}^{-1}$</p> <p>Accept: cm^3/s : cm^3 per second</p> <p>Answer uses minutes $19.8 \text{ cm}^3 \text{ min}^{-1}$</p> <p>Accept: values in range $16.8 \text{ to } 21.0 \text{ cm}^3 \text{ min}^{-1}$</p> <p>Accept: cm^3/min : cm^3 per min</p>	Grad (1)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation including the following</p> <ul style="list-style-type: none"> {hydrogen peroxide / substrate} is {converted to products / used up} (1) so less substrate to collide with the enzyme (1) 	<p>Accept {hydrogen peroxide / substrate} becomes a limiting factor Accept concentration of {hydrogen peroxide / substrate} decreases</p> <p>Accept less substrate so fewer enzyme-substrate complexes form</p>	Exp (2)

Q4.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation including three of the following</p> <ul style="list-style-type: none"> As more potato is added more oxygen is produced because more enzyme is present (1) increase in volume of oxygen expected as surface area increases (1) {volume of oxygen produced / graph / rate of reaction} may level off as substrate {is not in excess / is used up} (1) 	<p>Accept rate of reaction would increase because there is more enzyme available</p> <p>Accept increased rate of reaction expected as surface area increases</p> <p>Accept at a higher number of cubes, concentration of hydrogen peroxide may be a limiting factor</p>	Exp (3)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A calculation that makes reference to the following:</p> <ul style="list-style-type: none"> • correct tangent to the curve (1) • correct measurement of the y axis and x axis distances (1) • correct calculation of gradient (1) 	<p>Accept a straight line that must through or between 19.0 mg cm^{-3} or 24.0 mg cm^{-3} at 30 s.</p> <p>TE for mark points 2 and 3 from wrong tangent</p> <p>TE for mark point 3 for correct gradient calculation with no tangent ($y \div x$)</p> <p><u>Example of calculation:</u></p> <p>$21.0 / 30 = 0.70 \text{ mg cm}^{-3} \text{ s}^{-1}$</p> <p>(accept range of between $0.63 \text{ mg cm}^{-3} \text{ s}^{-1}$ to $0.80 \text{ mg cm}^{-3} \text{ s}^{-1}$)</p> <p>Correct answer with no working gains full marks</p>	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • active site (of enzyme) {shape / structure} changes (1) • because {H^+ ions / acid} {affects ionic bonds / affects hydrogen bonds} (of enzyme) (1) • so {substrate/ monophenol} no longer fits / binds (1) 	<p>Accept {shape / structure} of monophenol changes so it no longer fits active site</p> <p>Accept because H^+ ions / bind to monophenol</p> <p>Accept E/S complexes do not form</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to two the following:</p> <ul style="list-style-type: none"> tropolone is similar in {shape / structure} to monophenol (1) tropolone acts as a competitive inhibitor / binds in the active site (1) so it prevents {binding of monophenol / enzyme substrate complexes forming} decreasing the {rate of reaction / production of quinone / enzyme activity}(1) 		(2)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> less needed for same sweet effect (1) therefore less {energy / calorie} intake (1) therefore less risk of appropriate named health benefit (1) 	<p>e.g. reduced obesity / (type 2) diabetes / tooth decay / heart disease / atherosclerosis / high blood pressure / CVD / CHD</p>	(2)

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> 0.066 to 0.074 	DO NOT ACCEPT 0.06°	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> with and without magnesium ions (1) use same {volume / stated cm^3 / concentration} of isomerase enzyme (1) use excess {glucose / substrate} (1) control {temperature / pH} (1) repeat to {calculate mean / calculate average / standard deviation / standard error / recognise anomalies} (1) 	<p>ACCEPT same mass</p> <p>DO NOT ACCEPT if in list</p>	(5)

Q7.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> interconvert dm^3 and cm^3 (1) cost calculated (1) 	<p>$200 \text{ dm}^3 = 200000 \text{ cm}^3$ or $100 \text{ cm}^3 = 0.1 \text{ dm}^3$ $3.6 \times 2000 = \text{£}72$</p>	(2)

Q8.

Question Number	Indicative content
	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none"> • concentrations of solutions not controlled / volume not controlled eg beaker • measuring cylinders used to measure volumes of succinate / 15 cm³ of water should have been added to the beaker in the experiment without inhibitor • concentration will affect rate of reaction because of collisions between substrate and enzyme active site • temperature not controlled • use a water bath to keep the temperature constant • enzyme could be denatured or rate of reaction changes with kinetic energy • pH not controlled • use a buffer • pH affects shape of active site and therefore rate of reaction • initial rate of reaction should have been measured • add methylene blue before adding the dehydrogenase / use colorimeter • substrate concentration will fall with time therefore rate will be lower • measuring end point is subjective • use a colorimeter • improve the accuracy of the quantitative data • only one concentration of malonate was used • at least four concentrations of malonate should have been used • so that the type of inhibition can be identified • only three concentrations of succinate used • at least five concentrations of succinate should have been used • so that an accurate line could be drawn onto the graph • separate experiments not repeated • repetition of each experiment • so you can {calculate a mean average / deal with anomalies / statistical analysis}

Level	Marks	
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.
Additional Guidance		

Level 1 response = two issues that could affect validity identified OR two suggestions made on how to improve the validity which are not related to any issues identified [e.g. two random points from indicative contents met]
 Level 2 response = at least three suggestions made on how to improve the validity related to specific issues identified
 [e.g. at least three pairs from the indicative content]
 Level 3 response = a range of suggestions made on how to improve the validity related to specific issues identified with some appreciation on the impact of the {issue / improvement} on the data obtained [e.g. at least two triplets with some additional indicative content]

Q9.

Question Number	Answer	Mark
(i)	The only correct answer is A hydrogen only B is incorrect because ionic bonds are not involved in the secondary structure C is incorrect because disulfide bonds are not involved in the secondary structure D is incorrect because ionic bonds are not involved in the secondary structure	1

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> {tyrosinase active / melanin made} in cooler regions (1) tyrosinase denatures / {hydrogen / ionic} bonds break (in warm / light regions) (1) active site changes shape / tertiary structure changes (1) no enzyme substrate complexes form / tyrosine does not bind (to tyrosinase / enzyme) (1) 	<p>ACCEPT converse throughout</p> <p>ACCEPT enzyme for tyrosinase for all mark points</p> <p>ACCEPT optimum temperature is cool / low</p>	3

Q10.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> mean calculated (1) mean rate calculated (1) expressed as appropriate significant figures 	<p>3.25 min</p> <p>0.3077 min⁻¹</p> <p>0.31 min⁻¹</p> <p>accept ECF</p>	(3)

Question Number	Answer	Additional Guidance	Mark
ii	<p>An answer that includes one of the following reasons</p> <ul style="list-style-type: none"> there is no information about the effect of other variables e.g. temperature, type of milk used (1) there is no consideration about the time needed for a useful yield of cheese (1) 		(1)

Q11.

Question Number	Answer	Additional Guidance	Mark
i	D		(1)

Question Number	Answer	Additional Guidance	Mark
ii	D Z-Y		(1)

Q12.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> • as temperature increases up to 10°C hatching increases and then decreases (1) • enzyme activity affects {hatching / development / growth} (1) • (below 10°C) increase in temperature increases {kinetic energy / enzyme-substrate complexes / successful collisions between enzyme} (1) • (above 10°C) temperature too high denatures enzymes (1) • higher temperature results in less dissolved oxygen available (1) 	<p>Piece together</p> <p>ACCEPT converse</p> <p>DO NOT ACCEPT starts to denature ACCEPT shape of active site changed</p>	(4)

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following:</p> <p>One from:</p> <ul style="list-style-type: none"> • (increase in) rates are same up to 30 to 32 (mg dm^{-3}) / at 13 ($\mu\text{g s}^{-1}$) (1) • both reduce rate up to 30 to 32 (mg dm^{-3}) / at 13 ($\mu\text{g s}^{-1}$) (1) <p>Then:</p> <ul style="list-style-type: none"> • B stops increasing but A continues to increase (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following</p> <ul style="list-style-type: none"> • inhibitor B because reaction does not reach rate without inhibitor (1) • because it binds to {enzyme / allosteric site} (1) • changes {active site} (1) 	<p>ACCEPT levels off / plateaus / stays the same / does not maximum rate</p> <p>DO NOT ACCEPT binds to active site</p>	(3)

Q14.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that includes four of the following:</p> <ul style="list-style-type: none"> • mass of contents of the beaker reduce over time (1) • because oxygen is released (1) • the rate of decrease in mass is non-linear / loss of mass reduces over time (1) • because the substrate is used up / lower substrate concentration (1) • resulting in fewer collisions between the active site and the substrate (1) 	<p>Allow oxygen is a gas (NOT gas has no mass)</p> <p>Allow Rate of reaction decreases</p> <p>Allow fewer enzyme substrate complexes</p>	(4)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • because as soon as the reaction starts the substrate is {broken down / decreasing} (1) • so the substrate concentration is no longer controlled (1) • substrate concentration should not limit the rate of reaction(1) 		(2) EXP

Question Number	Indicative content
* (ii)	<p>Indicative content:</p> <ul style="list-style-type: none"> • {pieces / extract} of red peppers used • peppers at various stages of ripeness tested • red pepper added to flask containing hydrogen peroxide • volume of oxygen collected recorded at regular (short) time intervals <ul style="list-style-type: none"> • temperature controlled using water bath • pH controlled using a buffer • same {volume / concentration} of hydrogen peroxide • same {type / size} of red pepper used • investigation repeated with different red peppers at each stage of ripeness <ul style="list-style-type: none"> • graph plotted of volume of oxygen collected against time (for each pepper) • tangent drawn to work out initial rate of reaction • cm³ per minute • graph plotted of initial rate against ripeness of red pepper <p>Level 1 : method described to measure activity of catalase in red peppers</p> <p>Level 2 : method includes using red peppers at varying degrees of ripeness with a consideration of controlling other variables for valid data</p> <p>Level 3 : method includes a description of how to measure initial rate of reaction</p>

Q16.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • clotting takes longer at low temperature due to {low kinetic energy / fewer enzyme-substrate collisions} (1) • clotting time is least at {body/optimum} temperature (1) • (clotting takes longer) at {temperatures above 37°C / high temperatures} (because) enzymes are denatured (1) 	<p>Accept clotting takes less time as temperature increases because {kinetic energy increases / more enzyme-substrate collisions}</p>	(3)

Q17.

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> specific shape to fit the {substrate / succinate} (1) lowers the activation energy (1) so two hydrogens can be removed / a double bond formed between the carbons (1) 	<p>Allow complementary in shape / interaction of R groups and substrate / conformational change / induced fit</p> <p>Allow forms an {enzyme substrate complex / stable intermediate compound}</p>	(3)

Q18.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> lowers the pH which denatures the {polyphenol oxidase / enzyme} (1) so that the phenols no longer fit the active site (1) 	<p>ACCEPT lower pH changes {structure/shape} of the {enzyme / active site}</p> <p>ACCEPT can't form enzyme-substrate complex / prevents binding of the substrate to the enzyme</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> digests the {polyphenol oxidase / enzyme} (1) because this is a protein (1) 	<p>ACCEPT effects on substrate or product</p> <p>ACCEPT {breaks down / hydrolyses} the enzyme</p> <p>ACCEPT the enzyme digests protein</p>	(2)

Q19.

Question Number	Answer	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none">• it is the initial rate of reaction (1)• substrate / hydrogen peroxide is in excess / not limiting / substrate / hydrogen peroxide decreases / becomes limiting (1)	(2)

Q20.

Question Number	Answer	Mark
	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none">• catalase / enzyme {denatured / change to tertiary structure} (1)• because {hydrogen / ionic / disulfide} bonds are broken (1)• {shape} of active site changed (1)• therefore no longer {binds / fits / attaches} to {substrate / hydrogen peroxide} / no enzyme substrate complexes (1)	(3)

Q21.

Question Number	Answer	Mark
	<p>An answer that makes reference to four of the following:</p> <ul style="list-style-type: none"> • use liver with same surface area to volume ratio (1) • control temperature (1) • control {volume / concentration} of hydrogen peroxide (1) • replace bung quickly (1) • use gas syringe to collect oxygen (1) 	(4)

Q22.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • hirudin changes the structure of the enzyme (1) • this results in a change in the active site of the enzyme (1) • which prevents the substrate from binding (1) 	<p>accept binds to the active site</p> <p>accept prevents enzyme substrate forming</p>	(3)

Q23.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • {charge / shape} of active site changes (1) • so acetylcholine will not bind / can no longer form E/S complex (1) 		2

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> acetylcholine (from parasympathetic neurone) is not broken down / builds up in synaptic cleft (1) so continues to bind to (acetylcholine) <u>receptors</u> (in SA node) (1) so fewer impulses from SA node (1) and noradrenaline has no / less effect (1) 	<p>Accept fewer depolarisations from SA node</p>	3

Q24.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> (the nitrogen can be incorporated into) protein (1) 	<p>Allow {DNA / RNA / organic base / amino acid / named protein / ATP /chlorophyll}</p>	(1)
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> enzyme lowers the activation energy (for the reaction) (1) a large number of ATP molecules is used (1) because the reaction needs a lot of energy (1) to compensate for nitrogen being unreactive (1) 		(4)

Q25.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to six of the following:</p> <ul style="list-style-type: none"> • make extract of pineapple juice (1) • same {volume of skimmed milk / volume of pineapple juice extract} (1) • {use colorimeter to measure changes in absorbance with time / beaker over a black cross and time to disappear} (1) • calculation of initial rate (1) • at a range of temperatures using a water bath (1) • pH controlled using buffer (1) • plot graph of initial rate against temperature (1) 	<p>Allow other appropriate methods</p> <p>Allow use colorimeter to measure transmission</p> <p>Allow measure absorbance every 30s</p> <p>Allow 10 – 80°C (must be at least 5 temps)</p>	(6)

Q26.

Question Number	Answer	Additional Guidance	Mark
i	<p>A description that makes reference to two of the following:</p> <ul style="list-style-type: none"> • folding of the {primary structure / polypeptide chain} (1) • into α-helix or β pleated sheet (1) • due to formation of hydrogen bonds (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
ii	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> protease enzymes have an active site specific to certain amino acid sequences (1) so the misfolded protein will not fit in the active site (of the protease enzyme) (1) therefore enzyme is unable to hydrolyse peptide bond (1) 		(3)

Q27.

Question Number	Answer	Additional Guidance	Mark
	<p>A calculation that shows:</p> <ul style="list-style-type: none"> An initial gradient line drawn / a relevant early value read off graph (1) Gradient measured / divide amount of product produced by time taken (1) 	<p><u>Example of calculation</u></p> <ul style="list-style-type: none"> (2.5 - 2.6) after 1 hour / (1.3-1.4) after 30min $2.6 \div 60 = 0.043 \text{ (mmol dm}^{-3} \text{ min}^{-1}\text{)}$ <p>Allow answers between 0.041-0.047</p> <p>correct answer gets both marks</p>	(2)

Q28.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> the enzyme may have denatured at 65 °C / the enzyme's active site may have changed shape at 65 °C (1) because {hydrogen bonds / bonding} has been disrupted (1) 	Allow converse	(2)

Q29.

Question Number	Answer	Additional Guidance	Mark
	<p>An analysis that makes reference to three of the following:</p> <ul style="list-style-type: none"> higher temperatures mean molecules have more kinetic energy (1) therefore there is a greater chance of a collision between the enzyme and substrate (1) therefore more chance of an enzyme-substrate complex being formed (1) reaction mixture {is warming up / has not reached equilibration / not hot enough to denature enzyme yet } (1) 		(3)

Q30.

Question Number	Indicative content
	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none"> • temperature not controlled at the start • allow time for equilibration in the water bath before mixing and starting the reaction • rate of reaction changes while the mixture warms up • Only two temperatures tested • Use a wider range of temperatures • It would help identify the temperature at which the enzyme is denatured • pH not controlled • use a buffer • pH affects shape of active site and therefore rate of reaction • separate experiments not repeated • repetition of each experiment • so you can {calculate a mean average / deal with anomalies / statistical analysis} • values and reactants, products not specified • specific e.g. how product measured etc • Volume of mixture removed not mentioned • Removal of mixture may alter concentrations in reaction mixture • Enzyme may continue to hydrolyse starch while measuring maltose concentration • Same volume of amylase and starch used

		<ul style="list-style-type: none"> Initial concentrations the same Comment on timings e.g. the same sampling used for both / more frequent sampling could take place The same sampling time will mean there will be the same reduction of volume in each mixture
Level	Marks	
0	0	No awardable content
1	1-2	<p>An explanation of how the investigation should be carried out may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>
2	3-4	<p>An explanation of how the investigation should be carried out will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information, including some consideration of the limitations of the data obtained</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p>
3	5-6	<p>An explanation of how the investigation should be carried out is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information, including consideration of the value of the results and additional data that may be required.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.</p>

Additional Guidance

Level 1 response = two issues that could {reduce / help} validity identified OR two suggestions made on how to improve the validity which are not related to any issues identified [e.g. two random points from indicative contents met]

Level 2 response = at least two suggestions made on how to improve the validity related to specific issues identified [e.g. at least two pairs from the indicative content]

Level 3 response = a range of suggestions made on how to improve the validity related to specific issues identified with some appreciation on the impact of the {issue / improvement} on the data obtained [e.g. at least two triplets with some additional indicative content]

Q31.

Question Number	Answer	Mark
(i)	<p>The only correct answer is A</p> <p><i>B is not correct because enzymes decrease reaction time</i></p> <p><i>C is not correct because enzymes decrease activation energy</i></p> <p><i>D is not correct because enzymes decrease activation energy and decrease reaction time</i></p>	(1)

Question Number	Answer	Mark
(ii)	<p>The only correct answer is D</p> <p><i>A is not correct because fibrin is not an enzyme</i></p> <p><i>B is not correct because fibrinogen is not an enzyme</i></p> <p><i>C is not correct because fibrinogen is not an enzyme</i></p>	(1)