Enzymes

(Past Year Topical Questions 2010-2015)

May/June 2010 (21)/Q1

(c) The reaction shown in Fig. 1.1 is catalysed by the enzyme sucrase. Fig. 1.2 shows an enzyme-catalysed reaction.

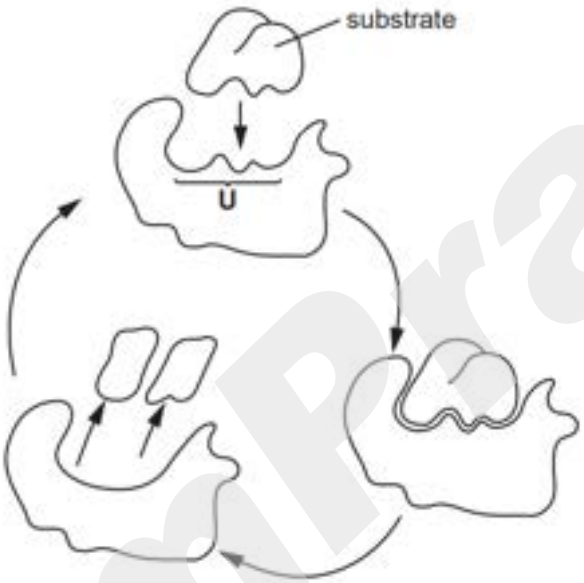

Fig. 1.2

(i) Name the part of the enzyme labelled **U**.

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(ii) With reference to Fig. 1.2, explain the mode of action of enzymes.

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May/June 2010 (23)/Q5

(c) The enzyme urease is known to be affected by competitive inhibitors. A student carried out an investigation to determine the percentage of urea hydrolysed by urease at various time intervals

- without any inhibitor
- with a competitive inhibitor.

The experiment was carried out in test tubes set up as follows:

Tube **A** – 1 cm^3 of urease solution, 10 cm^3 pH 7.5 buffer solution, 1 cm^3 urea solution.
Tube **B** – 1 cm^3 urease solution, 9 cm^3 pH 7.5 buffer solution, 1 cm^3 inhibitor, 1 cm^3 urea solution.
Tube **C** – 1 cm^3 water, 10 cm^3 pH 7.5 buffer solution, 1 cm^3 urea solution.

The results are shown in the table below.

time / min	percentage of urea remaining		
	Tube **A**	Tube B	Tube **C**
0	100	100	100
5	55	99	100
10	29	98	100
15	14	96	100
20	8	95	100
25	5	92	100
30	3	90	100

(i) State how Tube **C** acts as a control for this investigation.

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(ii) Explain the difference in results between Tube **A** and Tube **B**.

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Oct/Nov 2010 (22)/Q3

(b) Enzymes can be used to remove cell walls from plant and fungal cells. The cells are incubated in a solution that contains a mixture of enzymes.

(i) Suggest an explanation for the fact that a different mixture of enzymes is required to remove the walls of plant cells compared to the walls of fungal cells.

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(ii) Explain why, when plant cells are incubated with enzymes to remove their cell walls, it is important to maintain an optimum pH.

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Oct/Nov 2010 (23)

3 The enzyme sucrase is used by many organisms for the hydrolysis of sucrose. Fig. 3.1 shows a diagram of the enzyme and its substrate.

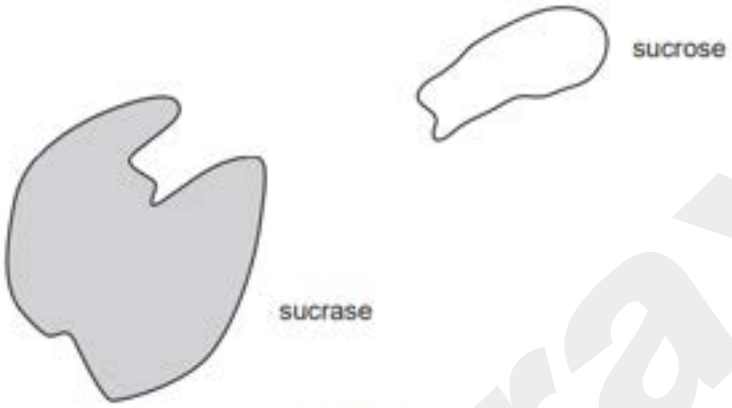

Fig. 3.1

(ii) With reference to Fig. 3.1, describe the mechanism of action of the enzyme in converting the substrate to products.

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(iii) Copper ions (Cu^{2+}) will inhibit the enzyme sucrase.
Suggest which type of inhibition occurs.

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May/June 2011 (21)

4 The enzyme sucrase catalyses the breakdown of the glycosidic bond in sucrose.

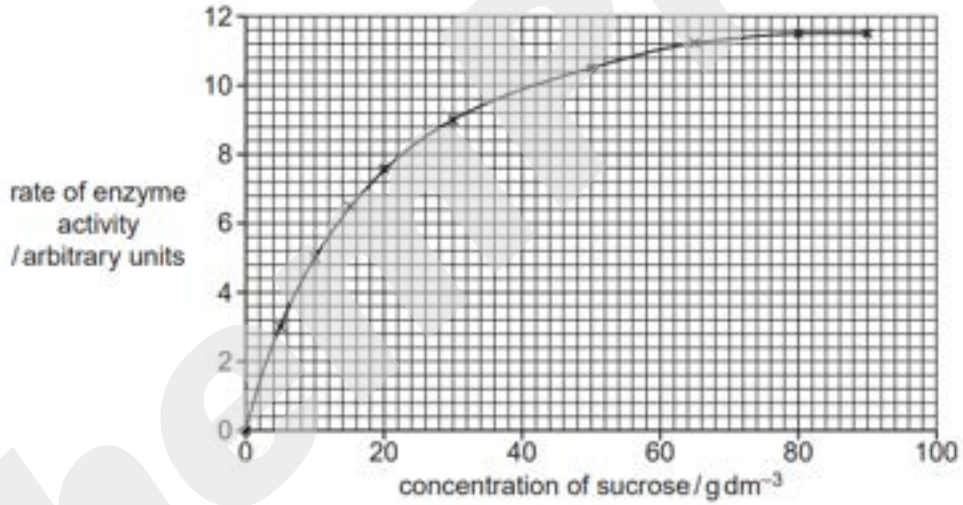
A student investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase.

Ten test-tubes were set up with each containing $5\,cm^3$ of different concentrations of a sucrose solution. The test-tubes were placed in a water bath at 40 °C for ten minutes. A flask containing a sucrase solution was also put into the water bath.

After ten minutes, $1\,cm^3$ of the sucrase solution was added to each test-tube. The reaction mixtures were kept at 40 °C for a further ten minutes.

After ten minutes, the temperature of the water bath was raised to boiling point. Benedict's solution was added to each test-tube. The time taken for a colour change was recorded and used to calculate rates of enzyme activity.

The results are shown in Fig. 4.1.



(a) (i) Name the type of reaction catalysed by sucrase.

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(ii) Explain why the temperature of the water was raised to boiling point.

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(b) Describe **and** explain the results shown in Fig. 4.1.

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May/June 2011 (22)

A student carried out an investigation into the digestion of triglycerides using lipase.

Ten cm^3 of olive oil, adjusted to pH 8.0, was added to a test-tube, which was then put in a water bath at 37 °C for ten minutes.

One cm^3 of lipase solution was incubated at the same temperature in a separate test-tube before being added to the olive oil.

The initial pH of the reaction mixture was measured using a pH meter. The pH was recorded at five minute intervals for 60 minutes.

(c) Suggest why the olive oil was adjusted to pH 8.0 before the lipase was added.

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(d) Fig. 5.2 shows the results of the investigation.

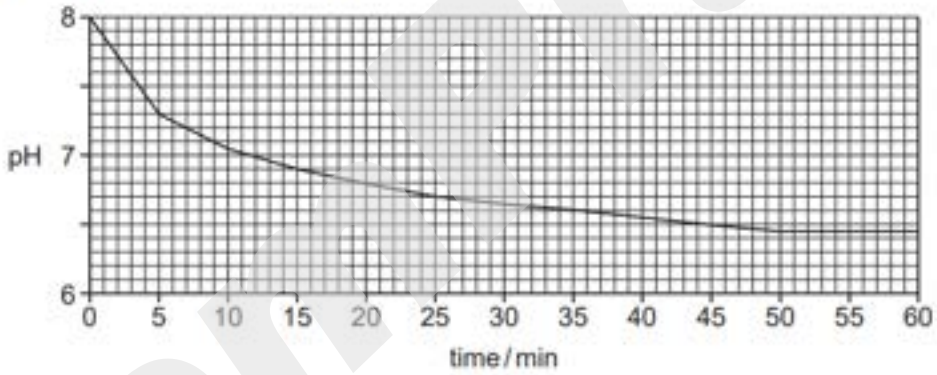

Fig. 5.2

With reference to Fig. 5.2,

(i) describe the results of the investigation

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(ii) explain the results of the investigation.

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Oct/Nov 2011 (21)

2 A student investigated the initial rate of reaction of catalase in breaking down hydrogen peroxide into oxygen and water:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

The volume of oxygen collected was recorded over a period of 140 seconds. The results are shown in Fig. 2.1.

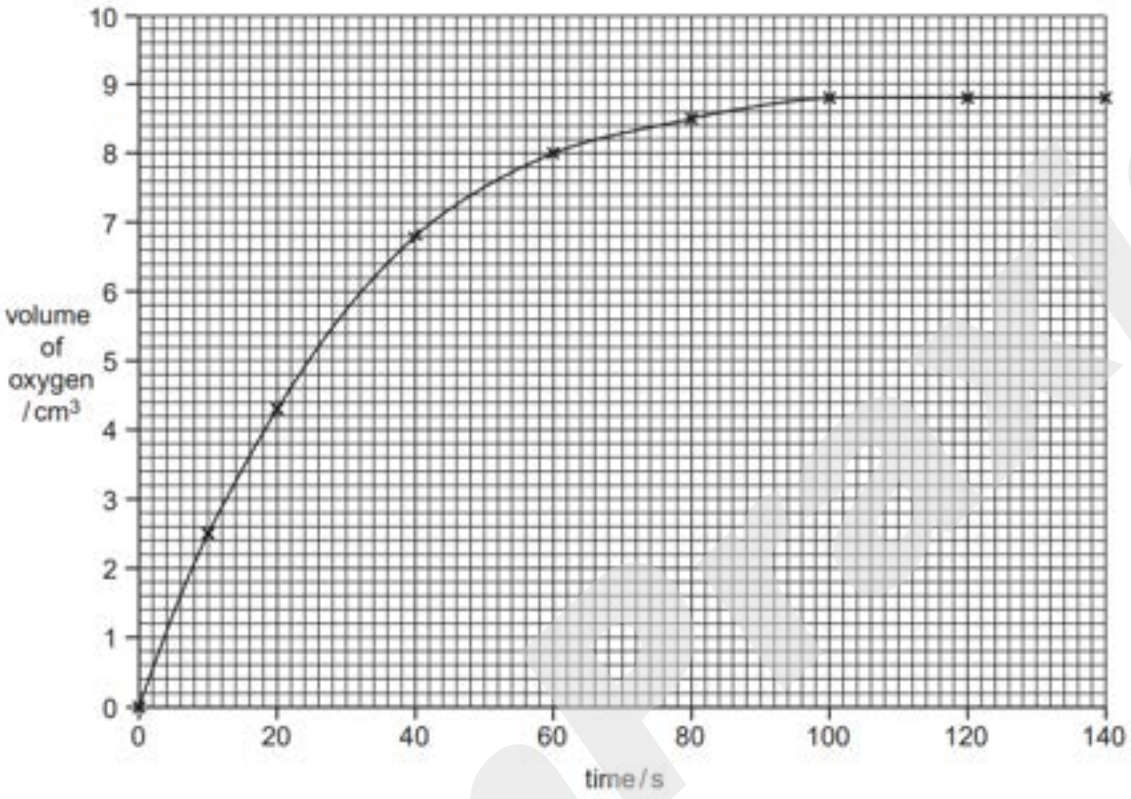

Fig. 2.1

(a) (i) Use the information in Fig. 2.1 to calculate the **initial rate of reaction** in $cm^3\ s^{-1}$.

Show your working.

answer ..... $cm^3\ s^{-1}$ [2]

(ii) Explain the change in volume of oxygen collected as shown in Fig. 2.1.

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The student continued the investigation by determining the initial rates of reaction for five different concentrations of hydrogen peroxide. The line marked **W** in Fig. 2.2 shows the results.

The whole procedure was repeated after adding copper ions to the different concentrations of hydrogen peroxide. The line marked **V** on Fig. 2.2 shows the results.

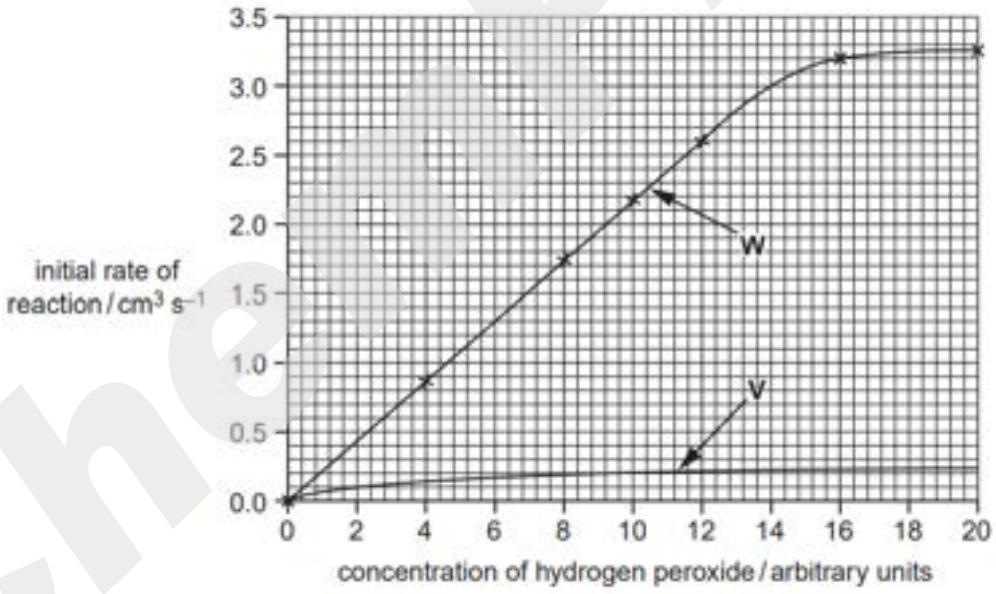

Fig. 2.2

(b) Use the information in Fig. 2.2 to explain the effect of copper ions on the action of an enzyme, such as catalase.

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May/June 2012 (21)

4 Penicillin is an antibiotic that interferes with the synthesis of cell walls in bacteria. Even before penicillin became widely available in the 1940s, the enzyme penicillinase which breaks down penicillin had been isolated. This enzyme is now found in many bacteria and gives them resistance to penicillin.

Fig. 4.1 is a ribbon model of the structure of the enzyme penicillinase. The arrow indicates the active site of the enzyme.

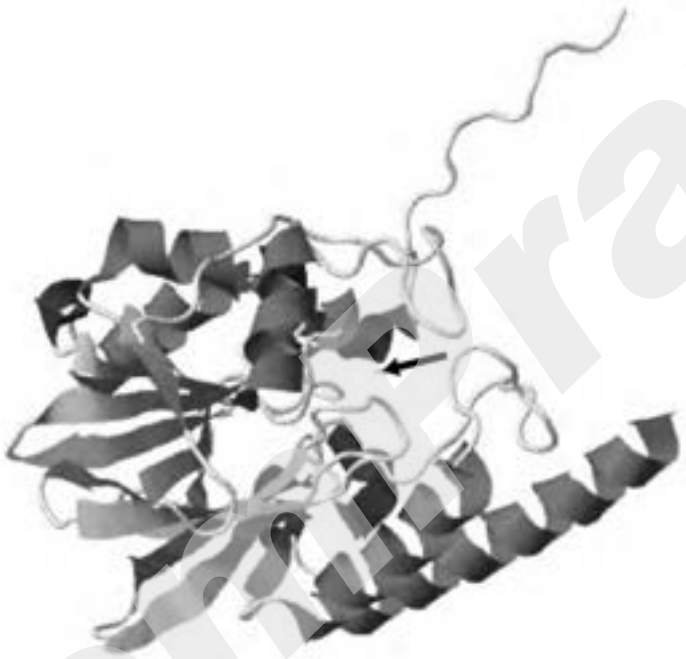

Fig. 4.1

(a) Explain why the shape of the active site of an enzyme, such as penicillinase, is important.

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Fig. 4.2 shows the changes in energy during the progress of an uncatalysed reaction.

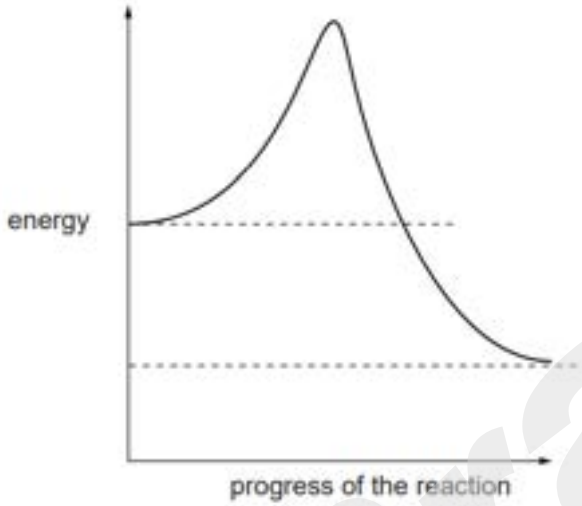

Fig. 4.2

(c) (i) Draw on Fig. 4.2 a curve to show changes in energy during the progress of the same reaction when catalysed by an enzyme. [2]

(ii) State the term given to the energy level that must be overcome before a reaction can progress.

.....[1]

May/June 2012 (22)/Q5

(b) NQR is an important respiratory enzyme located in the cell surface membrane of the bacterium that causes cholera.

A student suggested that an inhibitor of the enzyme NQR could be used as a drug in the prevention and control of cholera.

Suggest and explain how this inhibitor would function.

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Oct/Nov 2012 (22)/Q5

(e) DNA polymerase is an enzyme involved in the replication of DNA.

One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP.

The results of the investigation are shown in Fig. 5.1.

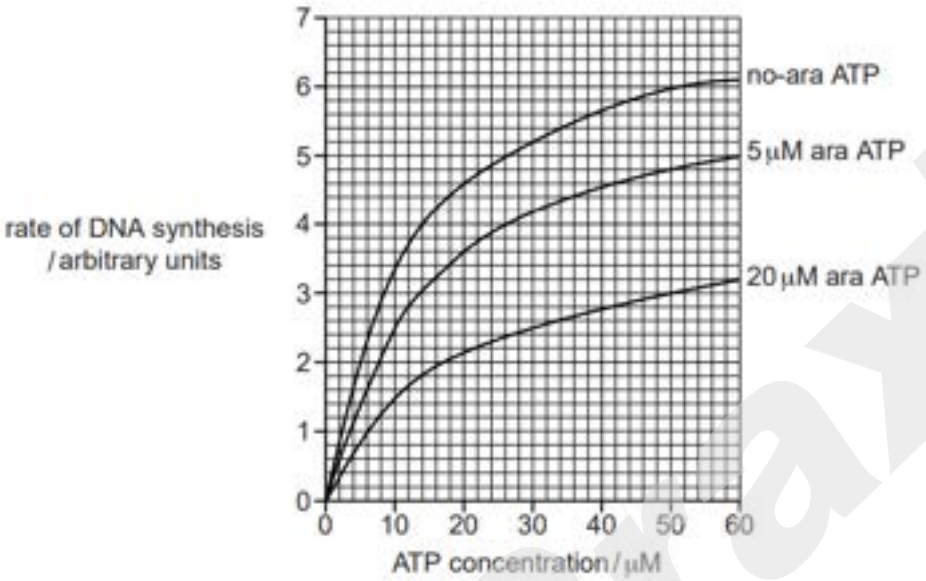

Fig. 5.1

Explain, in terms of the mode of action of enzymes, the results of the investigation shown in Fig. 5.1.

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Oct/Nov 2012 (23)/Q2

(c) Some antibiotics act as competitive inhibitors of enzymes in pathogens.

(i) Describe what is meant by the term competitive inhibitor.

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May/June 2014 (21)/Q4

HIV enters T-lymphocytes by a form of endocytosis. Two of the enzymes in HIV are:

- reverse transcriptase, which uses viral RNA as a template to make DNA to incorporate into the chromosomes of the host's cells
- protease, which is used to break a polypeptide into smaller molecules. These molecules are used to make the protein coat of new viral particles, which will infect other cells.

Various drugs have been developed to treat HIV infections. Table 4.1 gives information about some of these drugs.

Table 4.1

drug	enzyme inhibited	mode of action
zidovudine	reverse transcriptase	occupies active site
tenofovir	reverse transcriptase	occupies active site
efavirenz	reverse transcriptase	occupies sites other than the active site
atazanavir	protease	occupies active site

(b) Explain the difference between the mode of action of zidovudine and efavirenz.

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May/June 2013 (22)/Q4

(d) Freezing temperatures can also completely stop enzyme activity by causing the molecules to undergo 'cold denaturation'. Enzyme activity is not recovered when temperatures are increased to a normal working temperature range.

(i) Explain the mode of action of enzymes.

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(ii) Suggest how the molecular structure of the enzyme changes during 'cold denaturation'.

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(e) Cryoprotectants, such as trehalose, are of particular interest in their application to preserving cells, tissues or organisms for future use.

An investigation was carried out to find the protective effect given by different concentrations of two cryoprotectants, trehalose and glycerol, on a respiratory enzyme.

The enzyme was subjected to a freezing temperature and then returned to its optimum temperature. The activity of the enzyme was measured at its optimum temperature.

Fig. 4.2 is a graph showing the results of the investigation.

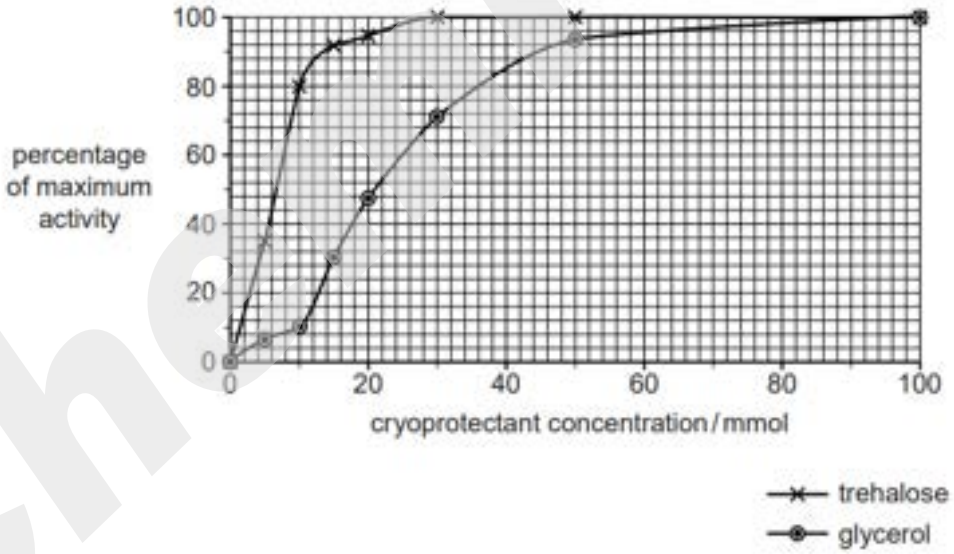

Fig. 4.2

With reference to Fig. 4.2, **describe** the results of the investigation.

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May/June 2013 (23)

4 The enzyme, catechol oxidase, causes a brown colour to develop when slices of many fruits, such as apples, are exposed to air.

The enzyme catalyses the following reaction:

$$\text{catechol} + \text{oxygen} \xrightarrow{\text{catechol oxidase}} \text{quinone} + \text{water}$$

Quinone is then immediately further oxidized in air to a brown-coloured substance. Catechol and quinone are colourless.

A student investigated the rate of this reaction under different conditions.

(a) State how the student could follow the progress of this reaction.

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In the first investigation, the student measured the initial rate of the reaction in varying concentrations of catechol. The results are shown in Fig. 4.1.

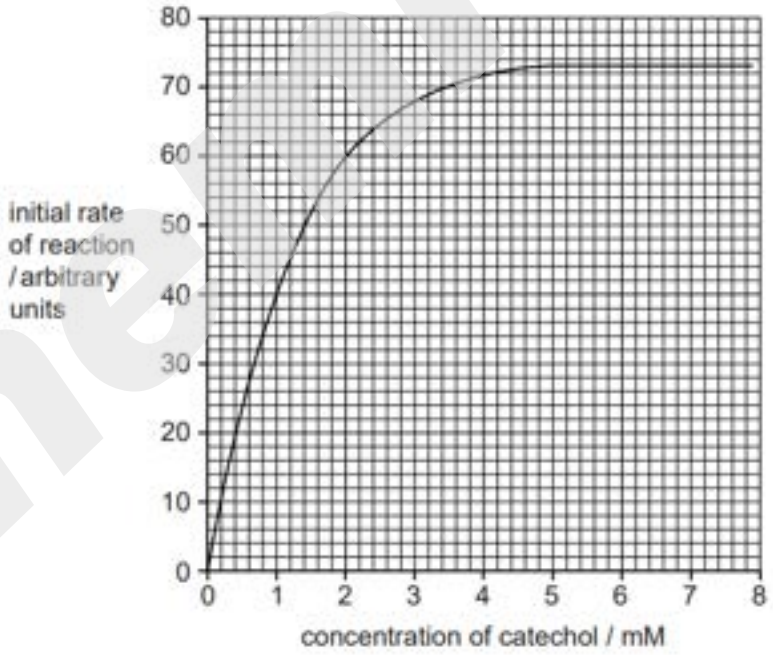

Fig. 4.1

(b) Explain the results shown in Fig. 4.1.

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(c) In a second investigation, the student repeated the experiment, but this time added a competitive inhibitor, para-hydroxybenzoic acid (PHBA), to each reaction mixture.

(i) Sketch **on Fig. 4.1** the results that would be obtained for this second investigation. [2]

(ii) Explain the effect that PHBA will have on the action of phenoloxidase.

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(d) Lemon juice contains citric acid. Adding even a small amount of diluted lemon juice to apple slices slows the appearance of the brown colour.

Suggest an explanation for this observation.

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Oct/Nov 2013 (22)/Q2

(b) Chitin and the products of chitin hydrolysis have many useful medical and environmental applications. Chitinase enzymes can be used commercially to hydrolyse chitin. Enzyme stability and activity are important considerations in technological applications of chitinase.

Fig. 2.2 is a graph showing the effects of temperature on chitinase extracted from a soil bacterium.

The relative activity of the enzyme was measured at different temperatures, with 100% representing maximum enzyme activity.

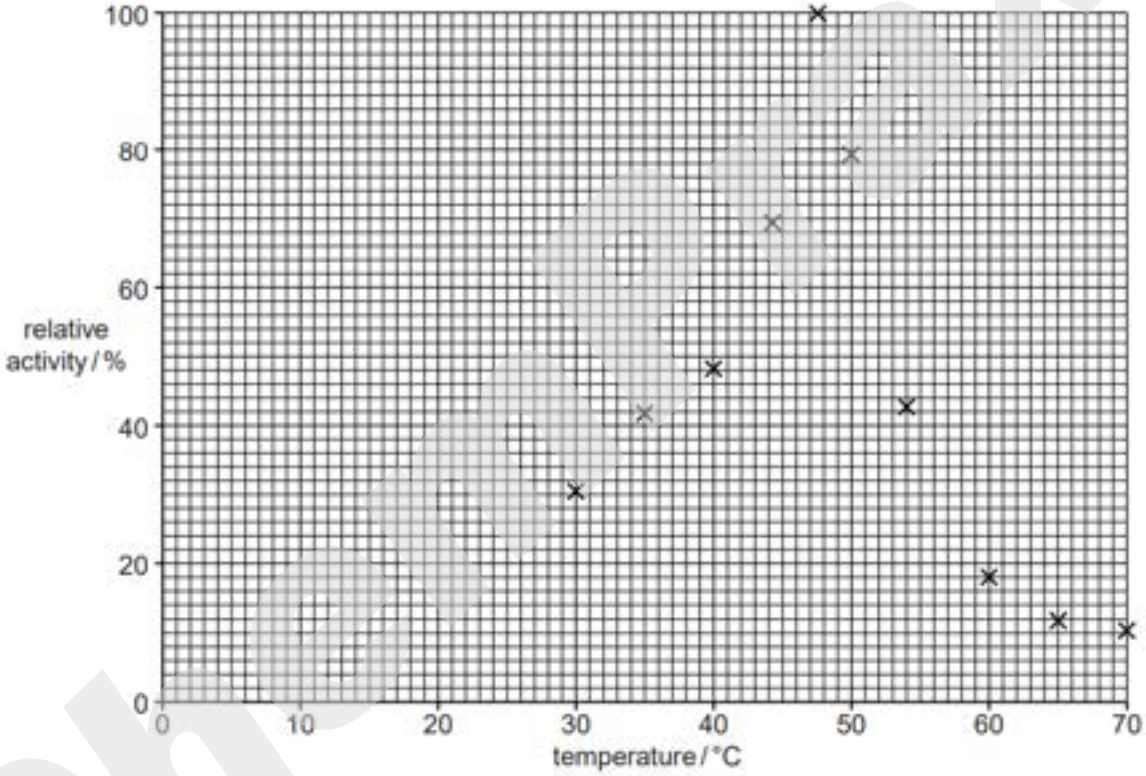

Fig. 2.2

(i) With reference to Fig. 2.2, state the optimum temperature for the chitinase enzyme.

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Fig. 2.3 is a graph showing how temperature affects the stability of chitinase. The activity of the enzyme was measured over a time period of 72 hours at each of five different temperatures.

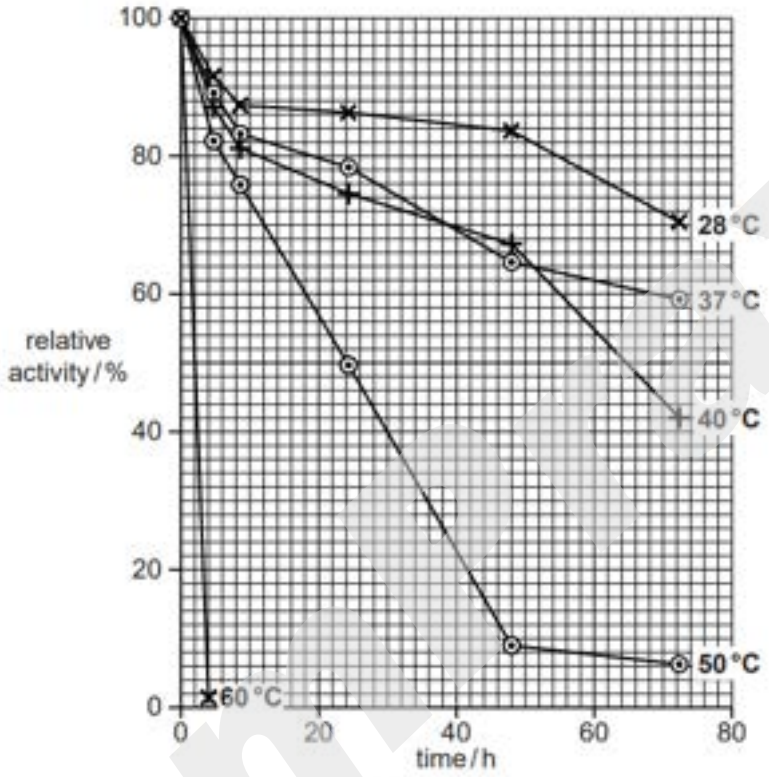

Fig. 2.3

(ii) With reference to Fig. 2.2 and Fig. 2.3, describe **and** discuss the effect of temperature on chitinase activity **and** stability.

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Oct/Nov 2013 (23)/Q6

(c) Some enzymes are found in phloem tissue.
Describe how enzymes catalyse reactions.

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May/June 2014 (21)/Q3

(c) Type 2 diabetes (insulin-independent diabetes) is a non-infectious disease.

If not treated, this disease is characterised by large fluctuations in the concentration of glucose in the blood.

Maltase is an enzyme that completes the digestion of starch in humans. Molecules of maltase are bound to the microvilli of epithelial cells in the small intestine.

Ascorbase is a drug used in the treatment of type 2 diabetes. Molecules of ascorbase have a very similar shape to that of the substrate for maltase.

(i) Explain how ascorbase acts to inhibit these membrane-bound enzymes.

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May/June 2014 (23)

3 The enzyme glutamyl-tRNA reductase (GluTR) is present in many bacteria to make a product which is essential to their survival.

GluTR acts on the substrate glutamyl-tRNA, which is composed of the amino acid glutamic acid attached to a tRNA.

Fig. 3.1 shows the structure of glutamyl-tRNA and another compound called glutamycin.

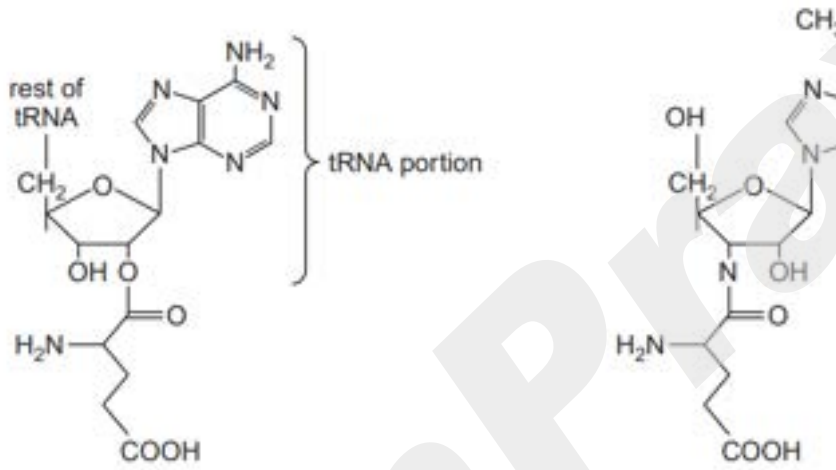

Fig. 3.1

(a) Explain how glutamycin can act as an inhibitor for the enzyme GluTR.

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Oct/Nov 2014 (22)/Q3

(e) Before acclimatisation can occur, some people develop a condition known as acute mountain sickness when they travel to high altitude areas.
Acetazolamide is a non-competitive enzyme inhibitor that is used as a drug to prevent and treat acute mountain sickness.

Explain the effects of a non-competitive inhibitor on the rate of enzyme activity.

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Oct/Nov 2014 (23)

4 Fig. 4.1 is a computer-generated image of the enzyme hexokinase binding with its substrate, glucose. The product of the enzyme-catalysed reaction is glucose-6-phosphate.

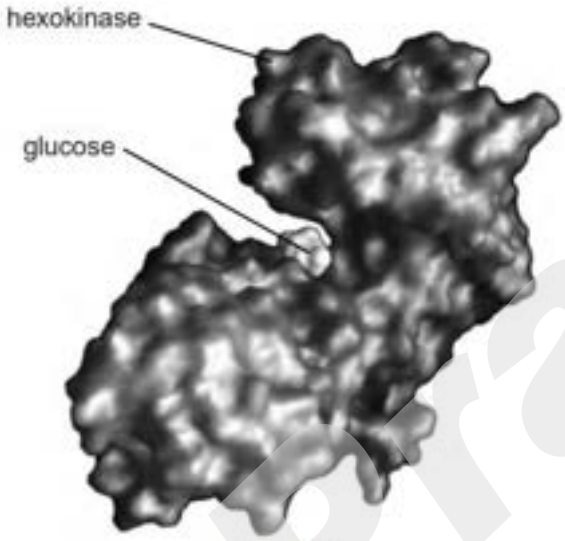

Fig. 4.1

(a) Hexokinase binds with glucose using the induced fit mechanism.
Describe how an enzyme-substrate complex forms by this mechanism.

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(b) Suggest how enzymes which use the induced fit mechanism can be less affected by competitive inhibitors than those which use the lock and key mechanism.

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(c) When a solution of the enzyme hexokinase is heated to 45 °C for 10 minutes, the quantity of product formed decreases by 50% compared to a sample kept between 30 °C and 40 °C.

Explain this result.

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May/June 2015 (21)

4 **(a)** Fig. 4.1 shows two ways in which enzymes interact with their substrates.

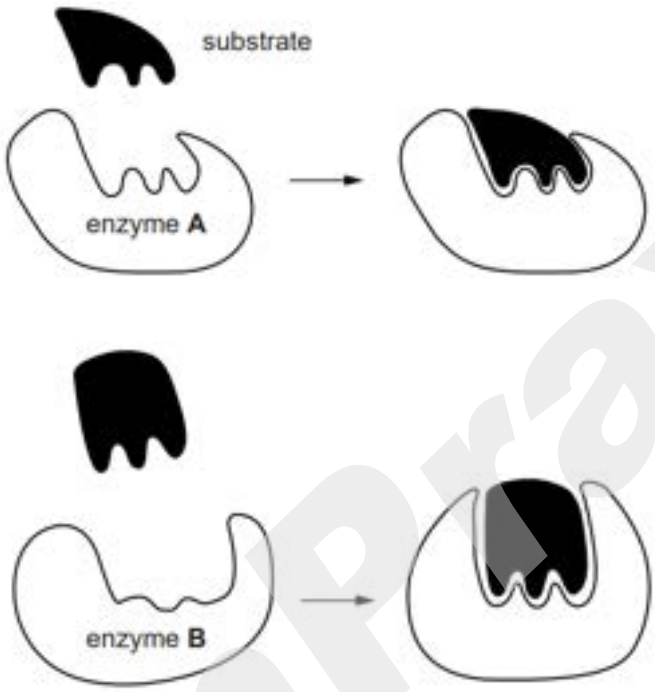

Fig. **4.1**

Explain the difference between the two ways in which enzymes interact with their substrates as shown in Fig. 4.1.

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May/June 2015 (22)/Q4

(b) β-glucosidase was extracted from two different bacteria, *Agrobacterium tumefaciens* and *Thermotoga maritima*.

Fig. 4.1 shows the results of an investigation into the effect of temperature between 0 °C and 100 °C, on the activity of each enzyme.

- **L** represents the lowest temperature at which activity of each enzyme was detected.
- **H** represents the highest temperature at which activity of each enzyme was detected.

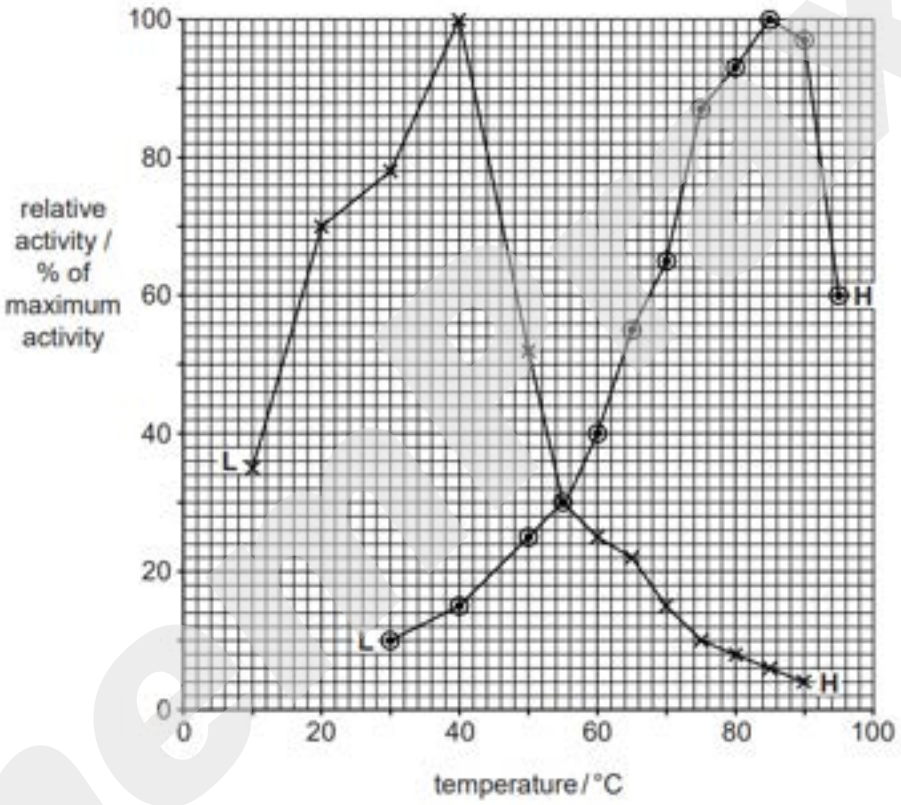

Fig. 4.1

(i) With reference to Fig. 4.1, describe the **differences** in the results for the two enzymes, **A** and **T**.

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.....[4]

(ii) Both enzyme **A** and enzyme **T** act on cellobiose. They have a similar, but not identical, primary structure.

Suggest how similarities **and** differences in the primary structure of the two enzymes could help to explain the results obtained in the investigation.

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May/June 2015 (23)/Q4

(c) People with high blood pressure can be treated with a drug which lowers the concentration of angiotensin in the blood.

This drug is a competitive inhibitor of ACE.

Explain how this drug acts as a competitive inhibitor.

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Oct/Nov 2015 (22)/Q2

(c) The synthesis and release of elastase enzymes by macrophages and neutrophils is an important feature in the development and progression of emphysema. Elastase causes the breakdown of the protein elastin, the main component of elastic fibres.

(i) Explain what is meant by an enzyme.

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..... [2]

(ii) Elastase has an active site with a specific shape. The mode of action of this enzyme supports the lock and key hypothesis.

Explain the mode of action of elastase.

You may use the space below to draw a diagram or diagrams to help your answer.

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(d) There are two inhibitors of elastase that are produced in the body, TIMP-1 and A1AT:

- macrophage elastase is inhibited by TIMP-1
- neutrophil elastase is inhibited by A1AT.

The inhibitors can be inactivated by the elastase enzymes:

- macrophage elastase can inactivate A1AT
- neutrophil elastase can inactivate TIMP-1.

In healthy lungs, the activity of elastase enzymes is regulated. Tobacco smoke can disrupt this regulation.

(i) One effect of tobacco smoke is to cause changes in the structure of A1AT, a competitive inhibitor.

Suggest how structural changes to A1AT will affect its mode of action.

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Oct/Nov 2015 (23)

3 The enzyme catalase is found in many plant and animal tissues.
The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *Anopheles gambiae*, an important vector of malaria. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in Fig. 3.1.

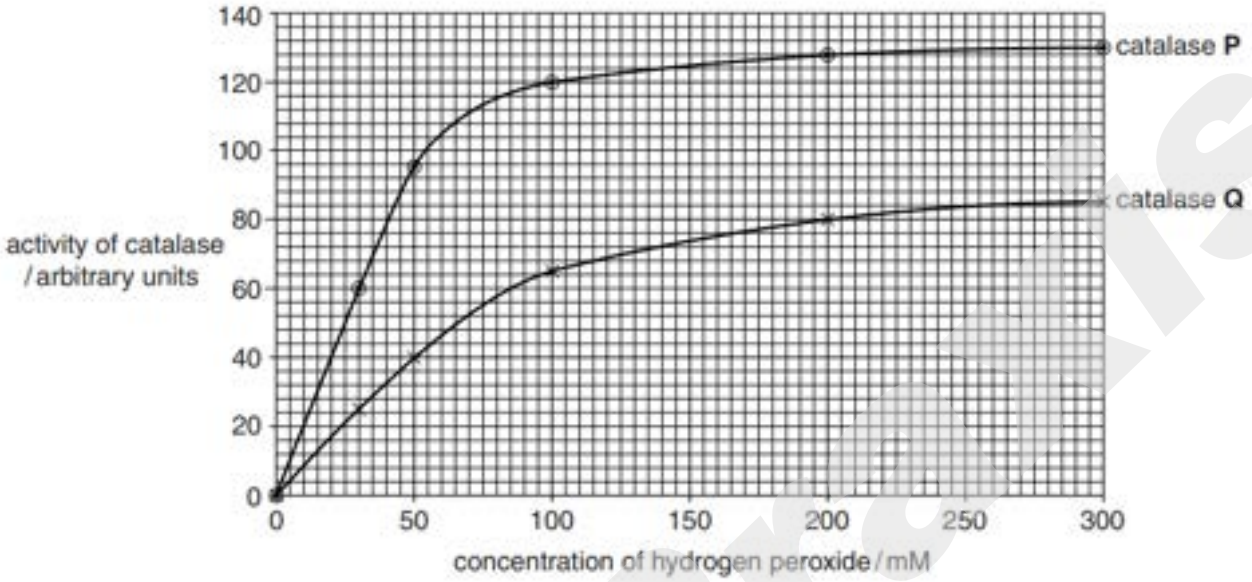

Fig. 3.1

(a) With reference to Fig. 3.1, describe **and** explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

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(d) Metal ions can act as a non-competitive inhibitor of catalase.

Explain how copper ions can act as a non-competitive inhibitor.

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