F212: Nodule 1: Enzymes
June 2009-January 2013
Questions

(a) state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms;
(b) state that enzyme action may be intracellular or extracellular;
(c) describe, with the aid of diagrams, the mechanism of action of enzyme molecules, with reference to specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex and lowering of activation energy;
(d) describe and explain the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity;
(e) describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally;
(f) explain the effects of competitive and noncompetitive inhibitors on the rate of enzyme-controlled reactions, with reference to both reversible and non-reversible inhibitors;
(g) explain the importance of cofactors and coenzymes in enzyme-controlled reactions;
(h) state that metabolic poisons may be enzyme inhibitors, and describe the action of one named poison;
(i) state that some medicinal drugs work by inhibiting the activity of enzymes

3 (a) Complete the passage below using the most appropriate terms.

Enzymes are ..... proteins and are therefore soluble. They alter the rate of metabolic reactions and are described as biological ..... .

Some enzymes, such as those found in cytoplasm, are described as ..... enzymes. Other enzymes, such as those that digest food in the small intestine, are known as ..... enzymes. Some medicinal drugs reduce enzyme activity. These are called enzyme ..... . [5]

(b) Many enzymes are associated with non-protein molecules known as cofactors. Some cofactors are small inorganic ions.

Rennin is an enzyme that is involved in the digestion of milk. It converts soluble caseinogen in milk into insoluble casein. The cofactor Ca^{2+} is associated with this reaction.

A student wished to investigate the effect of Ca^{2+} on the action of rennin.

Describe how the student could carry out this investigation and produce valid results.

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..... [5]

(c) Enzyme cofactors are often derived from vitamins and minerals in the diet.

Proteins are required in large amounts in the diet whereas vitamins and minerals are required only in small amounts.

Suggest why.

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[Total: 11]

Question 4 begins on page 12

Answer **all** the questions.

1 Enzymes are important in a wide range of biological reactions.

(a) Fig. 1.1 represents a mechanism of enzyme action.

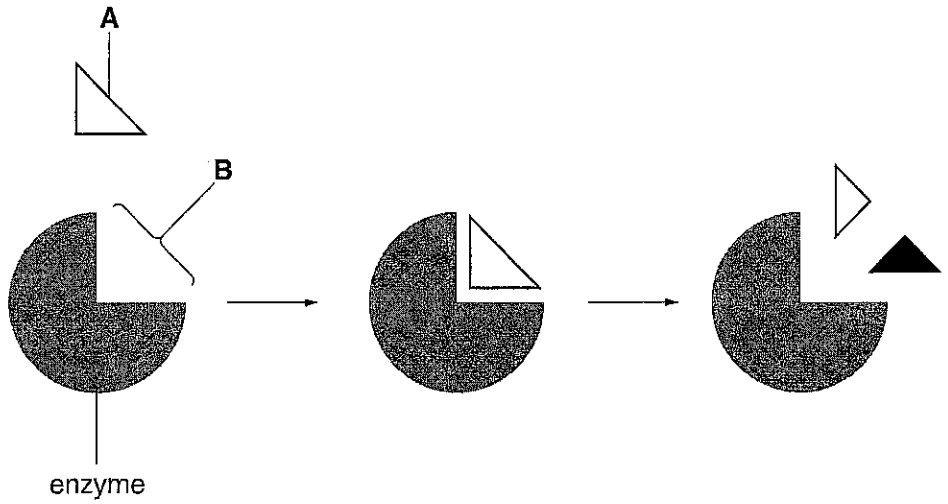

Fig. 1.1

(i) Name the structures represented by the letters **A** and **B**.

A .....

B ..... **[2]**

(ii) The mechanism of enzyme action was originally explained in terms of the 'lock-and-key model'. It is now more often explained in terms of the 'induced-fit' model.

Suggest why the lock-and-key and induced-fit explanations are termed **models**.

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(iii) Suggest why most scientists now accept the induced-fit model rather than the lock-and-key model.

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..... **[1]**

(b) Many fish live in the Antarctic where the water temperature can be close to 0 °C.

- Scientists have studied enzymes from these Antarctic fish and also from non-Antarctic fish that live in water at a temperature of 10 °C.
- One of the enzymes studied has been lactate dehydrogenase (LDH), an important enzyme involved in cell metabolism.
- One way in which LDH works is to catalyse the conversion of lactate to an important compound known as pyruvate.

(i) Scientists investigated the rates of reaction of LDH from Antarctic and non-Antarctic fish at a range of temperatures.

Suggest **three** variables that should be controlled in an investigation of this type.

1 .....

2 .....

3 ..... **[3]**

(ii) Some suggested controls used in this investigation are listed below.

J	water, lactate and heated LDH (non-Antarctic at 10 °C)
K	lactate alone at all temperatures
L	lactate and water at all temperatures
M	boiled LDH (Antarctic and non-Antarctic) at all temperatures
N	pyruvate and water at all temperatures

Select the letter, **J**, **K**, **L**, **M** or **N**, that represents the most appropriate control to be used in this investigation.

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(iii) The rate of conversion of lactate to pyruvate at 1 °C was found to be relatively slow when catalysed with LDH from **non-Antarctic fish**.

Suggest reasons for this result.

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(iv) It was discovered that the rate of conversion of lactate to pyruvate at 1 °C was higher if catalysed with LDH enzyme from Antarctic fish than when catalysed with LDH enzyme from non-Antarctic fish.

Certain parts of the enzyme molecule from the Antarctic fish are more flexible than the equivalent parts of the molecule from the non-Antarctic fish.

Suggest how a more flexible structure might help this enzyme work faster at lower temperatures.

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(c) Enzymes are proteins. The enzymes in Antarctic fish have a different structure from those found in non-Antarctic fish.

(i) Suggest how the structure of the **enzymes** may differ in Antarctic and non-Antarctic fish.

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(ii) Suggest how the **DNA** of the Antarctic and non-Antarctic fish might differ.

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(d) If species of Antarctic fish were to become extinct, their unique enzymes would be lost.

(i) Suggest why the loss of these **enzymes** might be undesirable.

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(ii) Suggest **two** ways in which the population of Antarctic fish could be conserved.

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[Total: 18]

2 **(a)** Enzymes are biological catalysts.

Explain the term *biological catalyst.*

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(b) When the enzyme catalase is added to hydrogen peroxide, the following reaction occurs:

$$\underset{\text{hydrogen peroxide}}{H_2O_{2(l)}} \xrightarrow{\text{catalase}} 2\,H_2O_{(l)} + O_{2(g)}$$

In an investigation into the effect of temperature on the rate of this reaction, a student set up apparatus as shown in Fig. 2.1, using liquidised celery as a source of catalase.

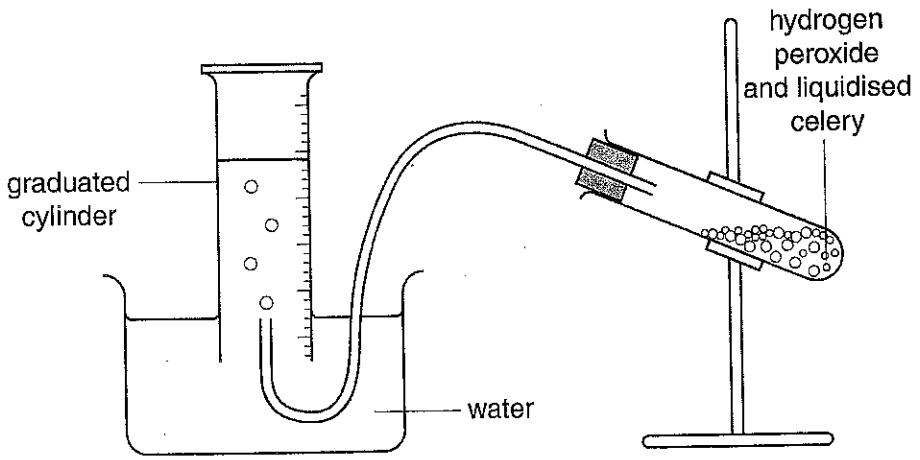

Fig. 2.1

The student measured the volume of oxygen produced at five different temperatures using samples of the liquidised celery.

(i) State the other variable that needs to be measured in order to calculate the **rate** of reaction.

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(ii) Identify **one** potential problem with using samples of liquidised celery as a source of catalase in this investigation **and** suggest a way to minimise this problem.

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(iii) The student collected the data shown in Table 2.1.

Table 2.1

temperature (°C)	volume of oxygen (cm^3)
5	4
10	7
12	10
25	28
28	32

Suggest how the student could check the reliability of the data.

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(c) Another student carried out a similar procedure and presented his results as a graph. The graph that he drew is shown in Fig. 2.2.

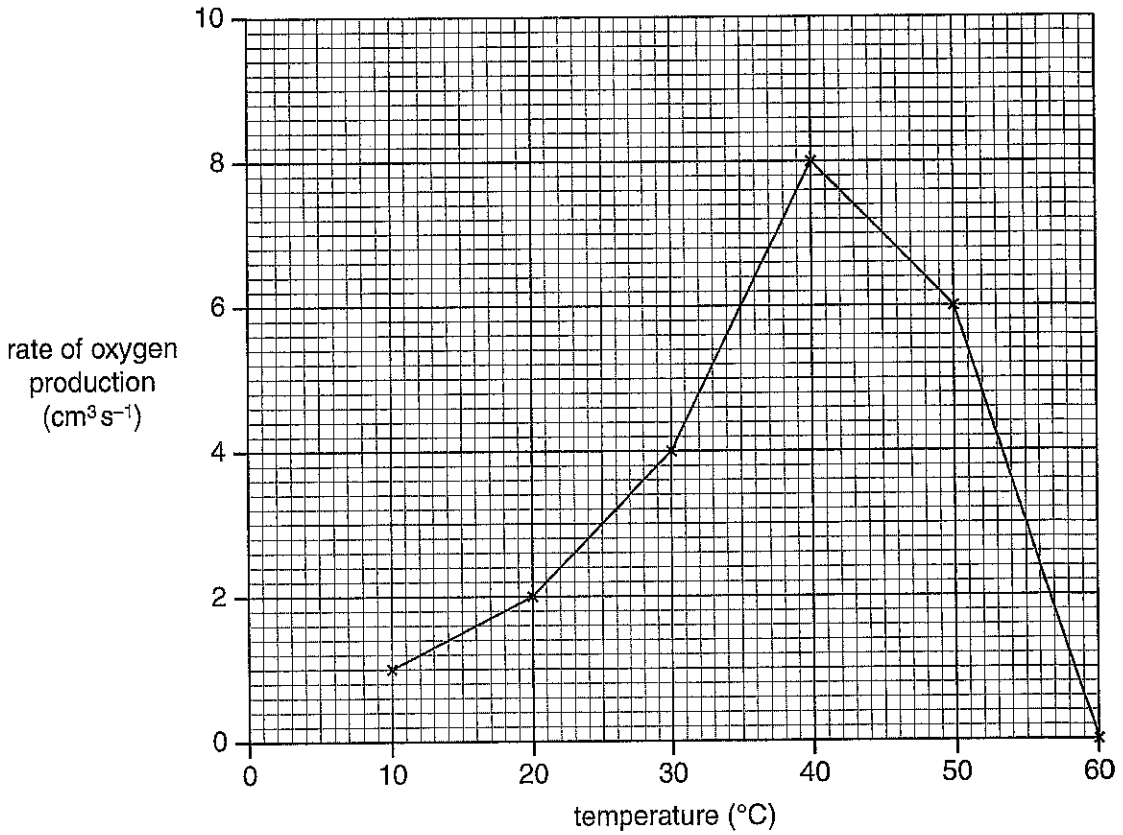

Fig. 2.2

(i) Describe the data shown in Fig. 2.2.

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(ii) Q_{10} is a measure of the increase in the rate of reaction for a 10 °C rise in temperature.

It is calculated using the following formula:

$$Q_{10} = \frac{\text{rate at } (t + 10\,°C)}{\text{rate at } t\,°C}$$

where t + 10 °C = rate at the higher temperature
t = rate at the lower temperature

Using the information in Fig. 2.2, calculate Q_{10} between 15 °C and 25 °C.

Show your working.

Answer = ... **[1]**

(iii) In the conclusion to this experiment, the student wrote the following:

> ***As the heat increased, the reaction went faster until it got to its highest. After this, the rate of reaction fell. This happened because the enzyme was killed and the hydrogen peroxide could not fit into the enzyme's key site.***

Suggest a more appropriate word to replace each of the underlined words.

heat should be replaced with .....

highest should be replaced with .....

killed should be replaced with .....

key should be replaced with ..... **[4]**

[Total: 16]

2 Fig. 2.1 shows part of an **amylose** molecule. This is an unbranched form of starch.

When iodine solution is added to starch, iodine fits into the helix of the amylose molecule, producing a colour change.

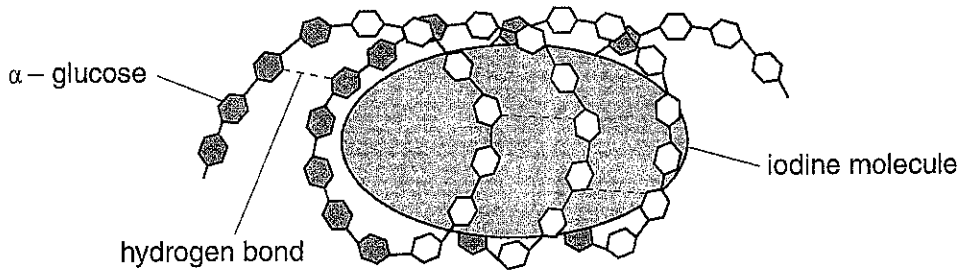

Fig. 2.1

(a) (i) State the colour of iodine solution in the presence of starch.

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(ii) Hydrogen bonds hold the amylose molecule in its helical shape.

Describe how a hydrogen bond is formed.

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(iii) Using the information in Fig. 2.1, suggest what would happen to the iodine-amylose complex if the solution was heated to 60 °C.

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(b) **Amylase** is an enzyme that hydrolyses amylose to maltose. Maltose, like glucose, is a reducing sugar.

A student investigated the action of amylase on amylose. She mixed amylase with amylose and placed the mixture in a water bath.

Describe how she could measure the change in concentration of maltose (reducing sugar) as the reaction proceeds.

In your answer, you should ensure that the steps in the procedure are sequenced correctly.

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(c) Fig. 2.2 shows the results that the student obtained from a practical procedure in which the rate of formation of maltose was measured in the presence and absence of chloride ions.

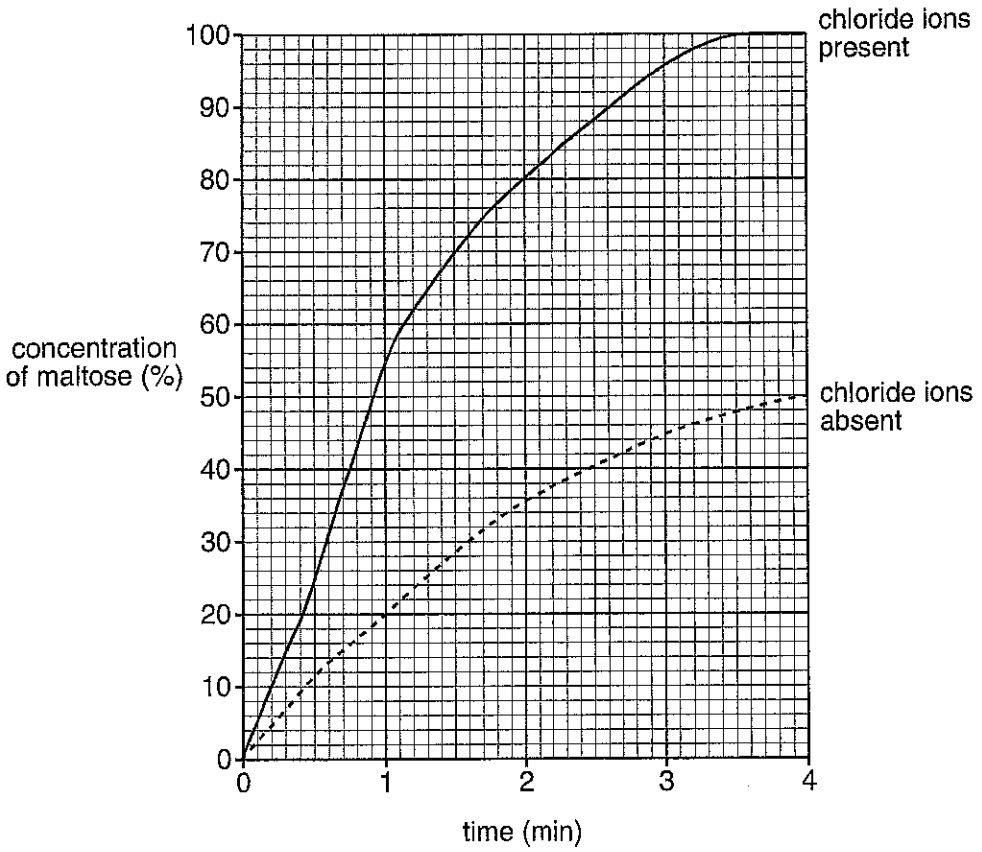

Fig. 2.2

(i) Describe the effect of chloride ions on the rate of reaction.

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(ii) Suggest how chloride ions have this effect on the rate of reaction.

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(iii) State **three** variables that need to be controlled in this practical procedure in order to produce valid results.

1 .....

2 .....

3 ..... **[3]**

[Total: 19]

QUESTION 3 STARTS ON PAGE 8

(b) Enzymes are involved in the production of mRNA in eukaryotic cells. One enzyme is inhibited by the toxin, α-amanitin.

Fig. 4.2 shows the effect when α-amanitin attaches to this enzyme.

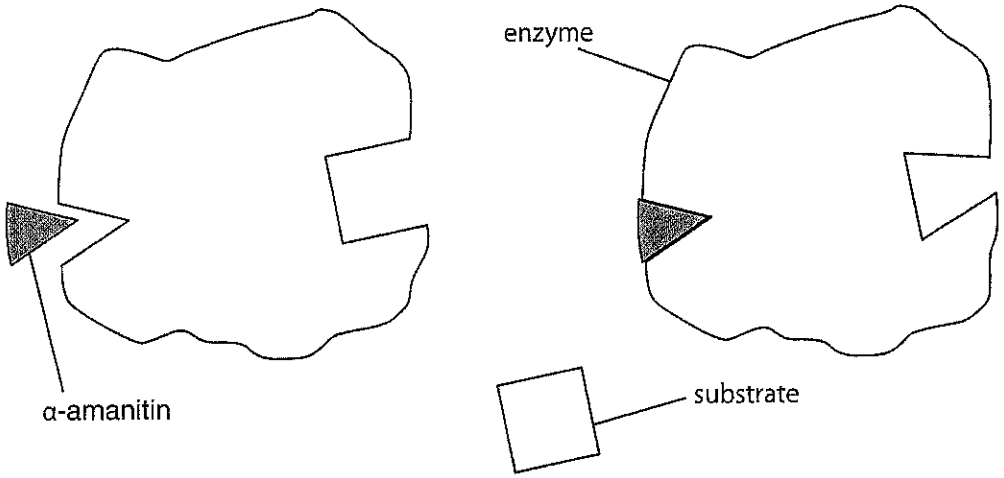

Fig. 4.2

(i) Explain how α-amanitin stops the formation of an enzyme-substrate complex during RNA production.

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(ii) The Roman Emperor Claudius was poisoned by his wife Agrippina when she gave him death cap fungus to eat. The death cap fungus contains α-amanitin.

Suggest how the toxin α-amanitin may lead to the death of an organism.

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(c) (i) Enzymes are globular proteins with a specific three dimensional shape. The shape is determined by the primary structure.

State the meaning of the term *primary structure.*

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Fig. 4.3 shows some of the chemical bonds that hold the **tertiary** structure of a protein together.

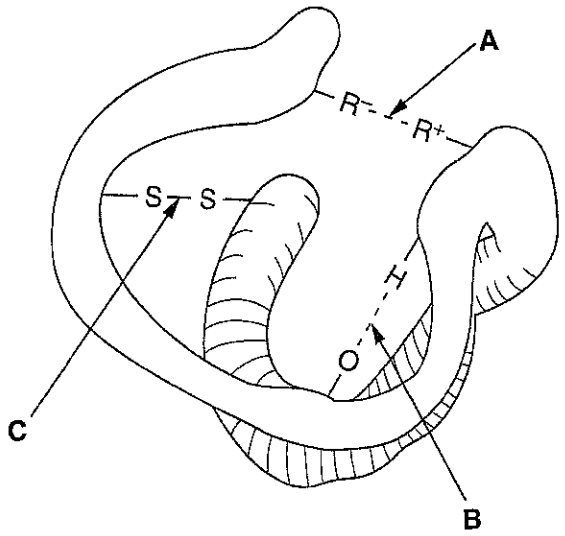

Fig. 4.3

(ii) Name the bonds labelled **A**, **B** and **C**.

A.....

B.....

C ..... **[3]**

(d) When proteins are heated to a high temperature, their tertiary structure is disrupted.

Explain how this occurs.

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[Total: 17]

3 (a) The enzyme DHPS is involved in the production of folic acid in bacteria.

- The substrate for DHPS is a molecule known as PABA.
- The enzyme DHPS is inhibited by the drug sulfonamide.

Fig. 3.1 shows the structure of PABA and that of sulfonamide.

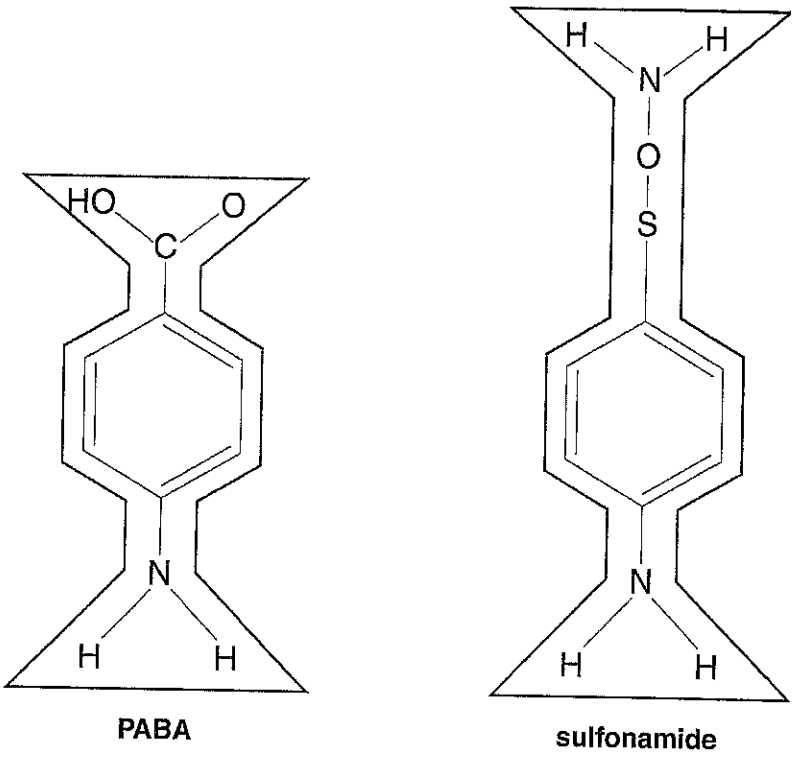
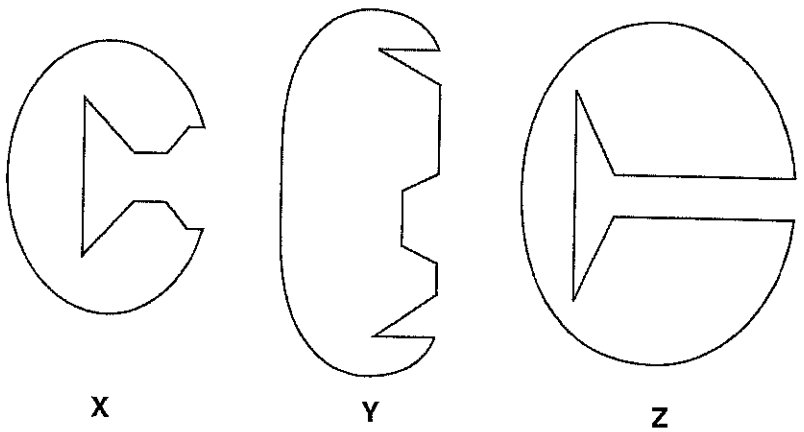


Fig. 3.1

(i) Diagrams **X**, **Y** and **Z** represent these enzyme molecules and their active sites.



State the letter, **X**, **Y** or **Z**, that most accurately represents the enzyme DHPS.

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(ii) Using the information in Fig. 3.1, explain why sulfonamide acts as a competitive inhibitor of DHPS.

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QUESTION 3(b) STARTS ON PAGE 10

(b) Fig. 3.2 shows the effect of increasing the concentration of the substrate (PABA) on the rate of reaction.

- Curve **A** shows the rate of reaction without the presence of the competitive inhibitor sulfonamide.
- Curve **B** shows the rate of reaction in the presence of the competitive inhibitor sulfonamide.

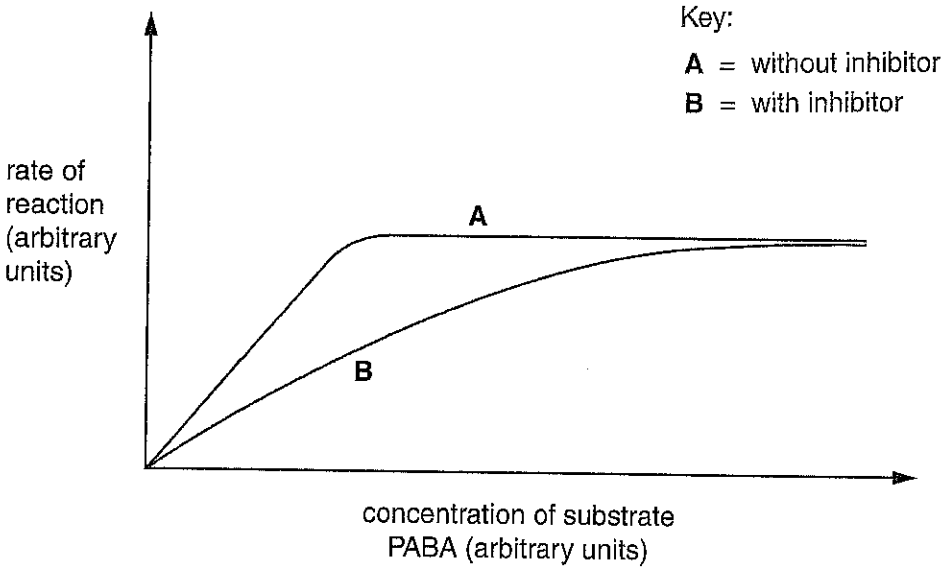

Fig. 3.2

Explain the effect of increasing the concentration of substrate on the rate of reaction;

(i) without inhibitor,

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..... **[3]**

(ii) with inhibitor.

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