Name:_____ Per:_____

AICE Biology Problem Set: Enzymes

Complete all of the following practice problems relating to enzymes and their reactions. You may check your work when you are completely finished. This problem set is worth 20 points and is due the day of your test, Friday, September 22.

1. Which statements about competitive inhibitors of enzyme action are correct?

1 Increasing the concentration of the enzyme's substrate will reduce their effect.

2 They bind to an enzyme at its active site.

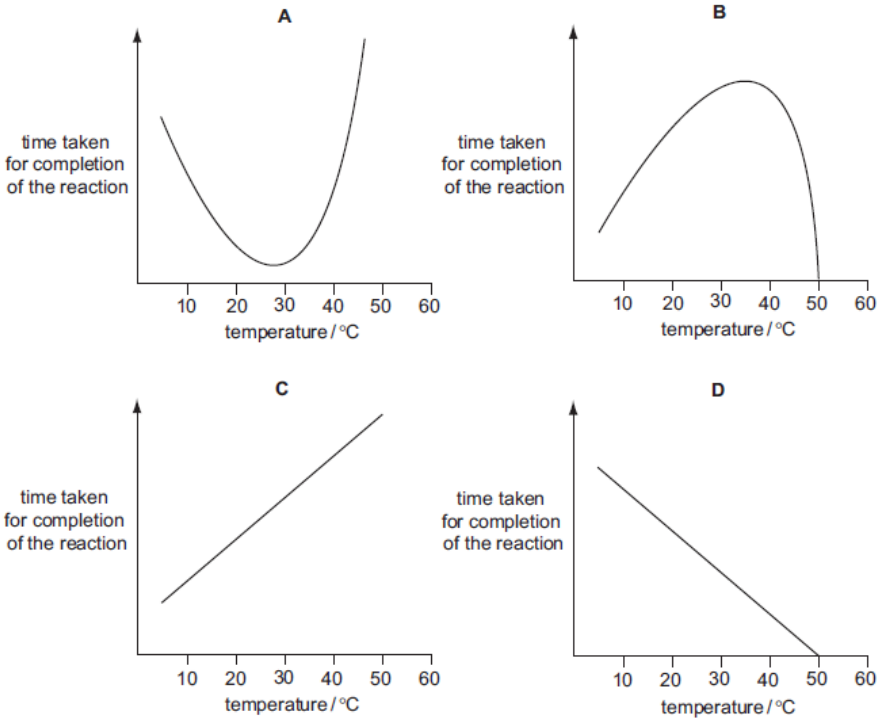
3 They reduce the activation energy required for a reaction to take place.

4 They reduce the maximum rate of reaction.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 2, 3 and 4 only

2. An enzyme is completely denatured at 50 °C. A fixed concentration of this enzyme is added to a fixed concentration of its substrate. The time taken for completion of the reaction is measured at different temperatures.

Which graph shows the results?



3. The enzyme lysozyme secreted from tear glands forms deposits on contact lenses.

Which ingredient would be effective in a contact lens cleaner for removing these deposits?

A ethanol

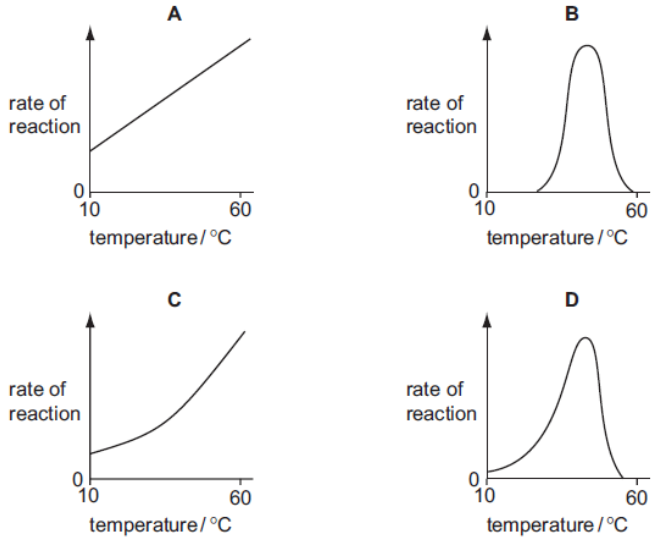
B lysosomes

C pH buffers

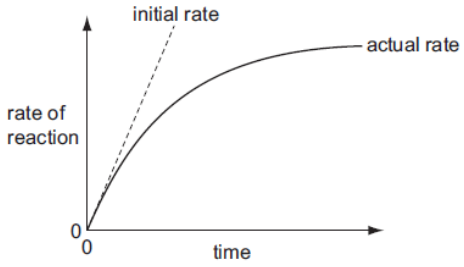
D proteases

4. The rate of an enzyme controlled reaction was measured at temperatures within the range 10 - 60 °C.

Which curve represents the most usual relationship between temperature and enzyme activity?



5. A fixed volume of the enzyme catalase was added to a fixed volume of hydrogen peroxide solution. The diagram shows how the rate of the reaction changed over the course of the reaction.



Why did the actual rate of reaction decrease over time?

A The enzyme active sites become saturated.

B The enzymes were denatured.

C The product inhibited the reaction.

D The substrate molecules were used up.

6. Which levels of protein structure are always involved when competitive and non-competitive inhibitors bind to enzymes?

	competitive	non-competitive
A	primary, secondary and tertiary	secondary
B	quaternary and tertiary	quaternary and tertiary
C	secondary	primary and tertiary
D	tertiary	tertiary

7. HIV-1 protease is an enzyme produced by the HIV virus.

Two identical chains of 99 amino acids form the enzyme. In each chain, amino acids 25, 26 and 27 in the sequence form part of the active site.

Which orders of protein structure control the shape of the active site?

A primary, secondary, tertiary and quaternary

B primary, secondary and tertiary only

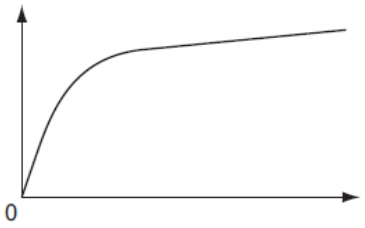
C primary and quaternary only

D quaternary only

8. In an experiment, 5 cm^3 of 1 % salivary amylase are added to 100 cm^3 of different concentrations of starch.

Which graph shows the results of plotting the initial rate of reaction (y-axis) against the concentration of substrate (x-axis)?

A



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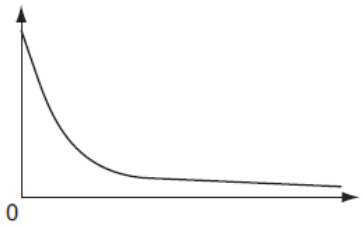

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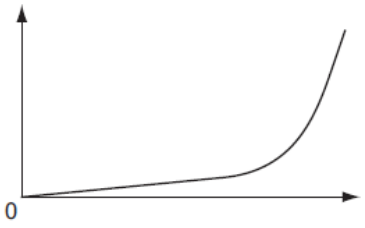

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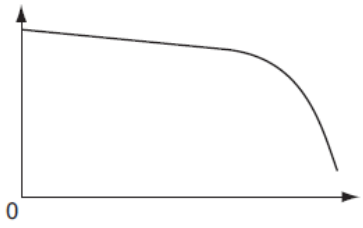


9. Which statements about the effect of **all** enzyme inhibitors are correct?

1 alter the shape of the active site

2 denature the enzyme

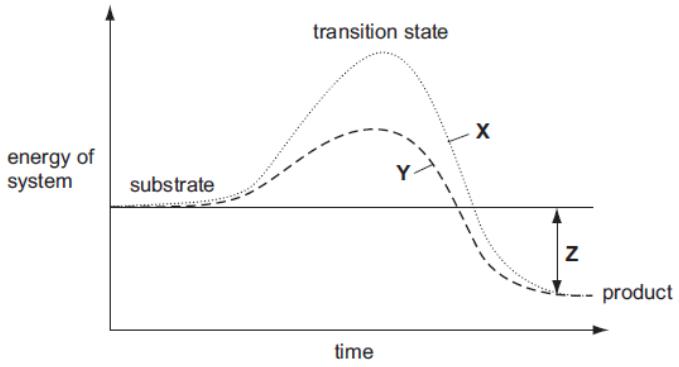
3 reduce the rate of the enzyme catalysed reaction

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 3 only

10. In an enzyme-catalysed reaction, which combination of inhibitor and substrate would result in the highest rate of reaction?

	inhibitor	substrate concentration
A	competitive	high
B	competitive	low
C	non-competitive	high
D	non-competitive	low

11. The graph shows the effect of an enzyme on a reaction.



Which combination identifies **X**, **Y** and **Z**?

	X	Y	Z
A	catalysed reaction	uncatalysed reaction	energy lost by product
B	catalysed reaction	uncatalysed reaction	total energy lost during reaction
C	uncatalysed reaction	catalysed reaction	energy gained by product
D	uncatalysed reaction	catalysed reaction	total energy change during reaction

12. Following a heart attack, the enzyme lactate dehydrogenase leaks into the blood plasma from damaged heart muscle.

Which steps are required to obtain the best estimate of lactate dehydrogenase activity in a sample of blood plasma?

	sterilise blood plasma by heating	incubate with substrate for lactate dehydrogenase	incubate with lactate dehydrogenase inhibitor
A	✓	✓	✓
B	✗	✓	✓
C	✗	✓	✗
D	✗	✗	✓

key
✓ = step required
✗ = step not required

13. Ethylene glycol is a chemical used to prevent water from freezing. If ethylene glycol is swallowed accidentally, it is metabolised by an enzyme found in liver cells to produce a toxic product.

The enzyme normally catalyses the oxidation of ethanol to a harmless product.

People who have swallowed ethylene glycol are treated with large doses of ethanol. This prevents formation of a toxic product and allows the body to excrete the ethylene glycol.

Which statement describes why this treatment works?

A Ethanol binds near the active site on the enzyme, altering its shape.

B Ethanol binds permanently to the active site of the enzyme, blocking it.

C Ethanol changes the tertiary structure of the enzyme, denaturing it.

D Ethanol is more likely to bind to the active site on the enzyme.

14. Why do large increases in the temperature **or** pH alter enzyme activity?

1 They change the three-dimensional shape of the enzyme.

2 They disrupt hydrogen and ionic bonds in the enzyme.

3 They increase hydrophobic interactions in the enzyme.

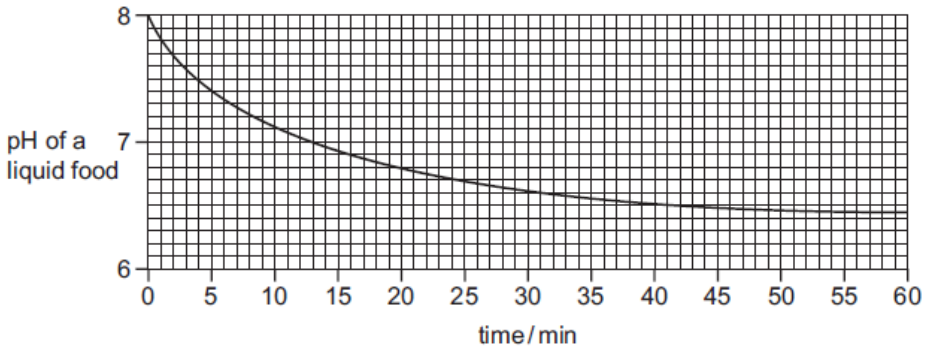
A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1 only

15. Which words from the table correctly complete the paragraph about enzymes?

When the pH of an environment is decreased below an enzyme's optimum pH, ……1…… bonds between adjacent ……2…… groups, holding the ……3…… structure, are disrupted.

	1	2	3
A	hydrogen and ionic	R	tertiary
B	hydrogen	hydroxyl	secondary
C	ionic and peptide	R	primary and tertiary
D	peptide	amine	primary

16. Lipase is a digestive enzyme produced by the pancreas that catalyses the hydrolysis of dietary lipids. The table shows how the pH of a liquid food containing a high proportion of lipids decreases over time.



Which statements are possible explanations of the results of the experiment between 50 and 60 minutes?

1 Enzyme concentration becomes the limiting factor.

2 Substrate concentration becomes the limiting factor.

3 All the enzyme active sites are saturated.

4 Denaturation of the enzyme by the products.

5 Products are acting as competitive inhibitors.

A 1, 2 and 3 **B** 1, 4 and 5 **C** 2, 3 and 4 **D** 2, 4 and 5

17. The AIDS virus produces a long polypeptide that is hydrolysed by a protease enzyme, producing several smaller peptides. This viral protease is the target of anti-AIDS drugs.

Which feature is essential for the success of these drugs?

A a complex structure that inhibits many types of viral enzyme

B a molecule containing a heavy metal atom that is a non-competitive inhibitor of enzymes

C a protein that can act as a competitive inhibitor of protease enzymes

D a specific structure that inhibits only viral protease

18. What is the effect of an enzyme in an enzyme-catalysed reaction?

A decreases both the activation energy and the energy yield

B decreases the activation energy and has no effect on the energy yield

C increases both the activation energy and the energy yield

D increases the energy yield and decreases the activation energy

19. What describes a globular protein that is **not** soluble in water?

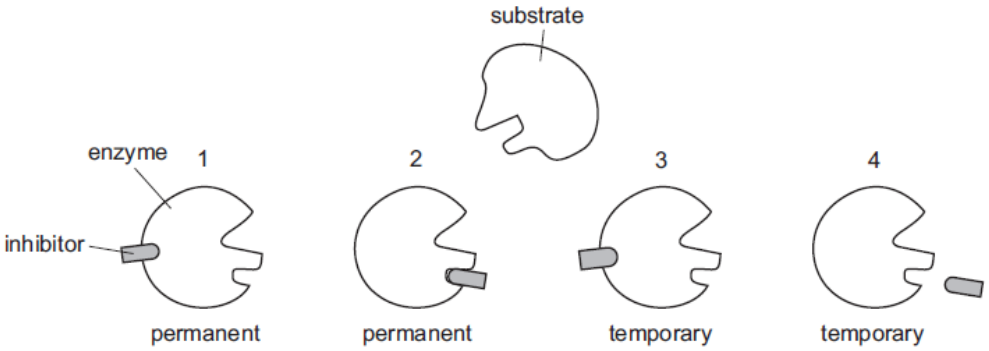
A having amino acids with hydrophilic R groups facing out

B having amino acids with polar R groups facing out

C having a central core of amino acids with hydrophobic R groups

D having amino acids with hydrophobic R groups facing out

20. The diagrams show where an inhibitor becomes attached to an enzyme and whether this is permanent or temporary.



Which diagrams represent a non-competitive inhibitor?

A 1 and 2 only

B 2 and 3 only

C 3 and 4 only

D 1, 2 and 3 only

21. 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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(ii) Suggest why ascorbase can be used to treat people who have type 2 diabetes.

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

For Examiner's Use

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.

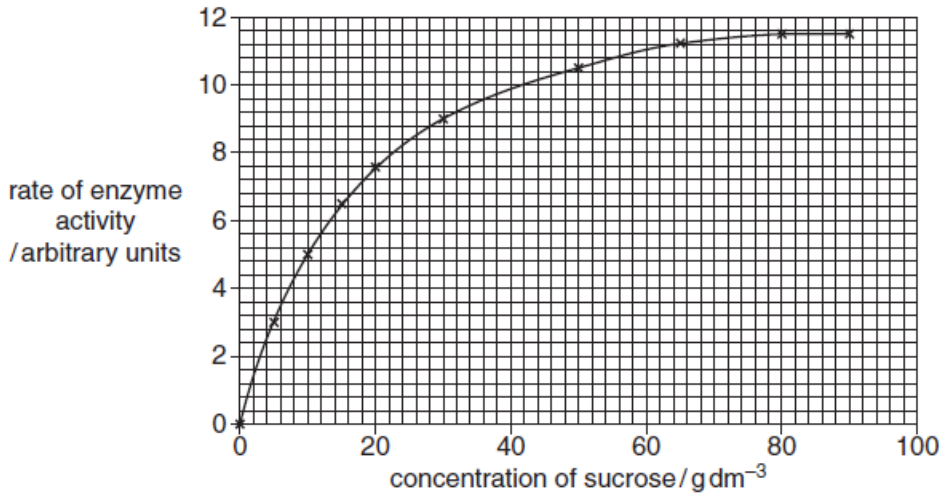

Fig. 4.1

(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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22. continued...

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

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[Total: 8]

23. Fig. 5.1 represents a molecule of a triglyceride.

Name the components **A** and **C** and name the bond **B**.

Write your answers on the dotted lines provided in Fig. 5.1.

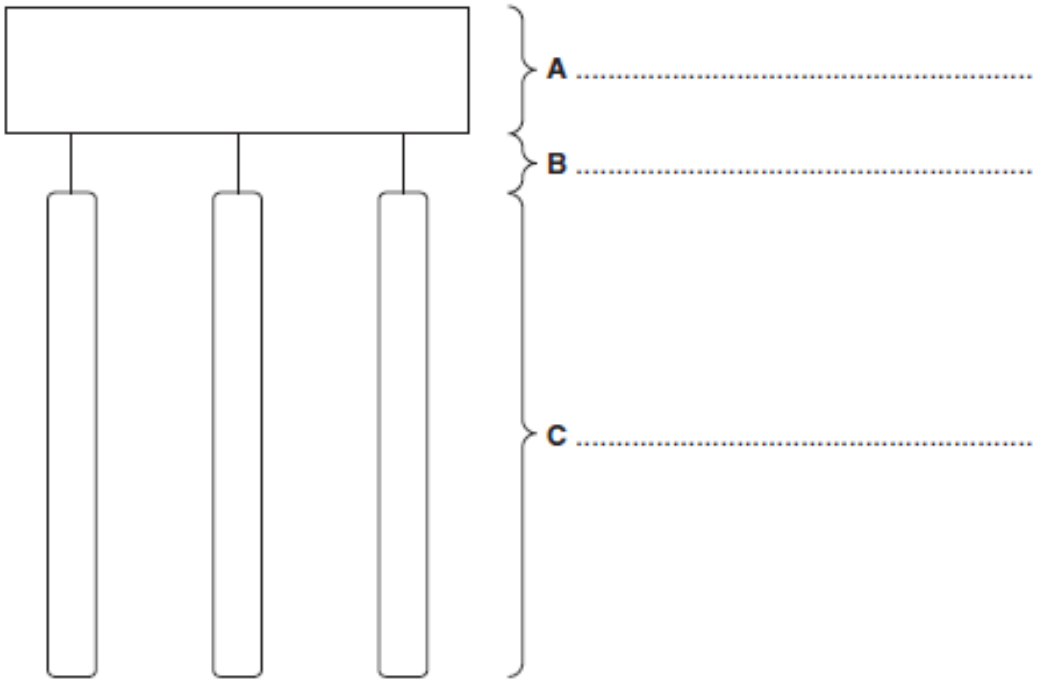

Fig. 5.1 [3]

23. continued…

(b) A phospholipid is sometimes described as a modified triglyceride.

(i) State how the structure of a phospholipid differs from a triglyceride.

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(ii) Explain how a phospholipid is suited to its role in cell membranes.

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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.

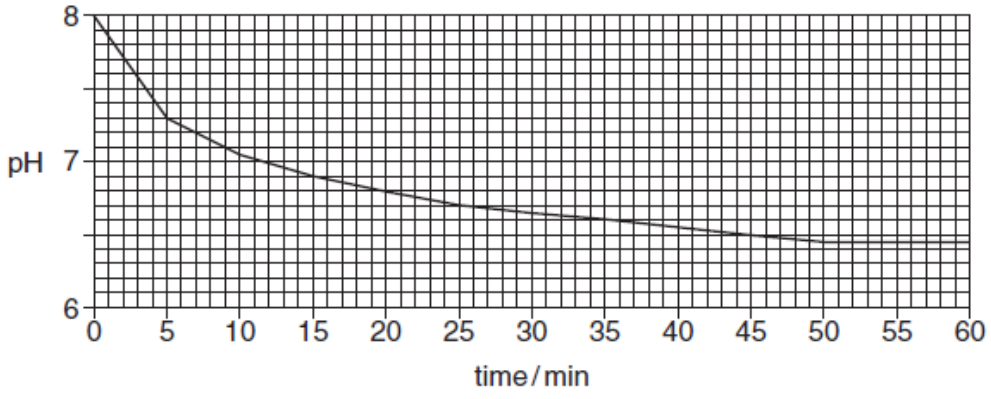

Fig. 5.2

23. continued...

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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24. Phosphatases are enzymes that catalyse the removal of phosphate groups from organic compounds.

Some students investigated the effect of substrate concentration on the rate of the reaction catalysed by an acid phosphatase (enzyme **A**). The results are shown in Fig. 2.1.

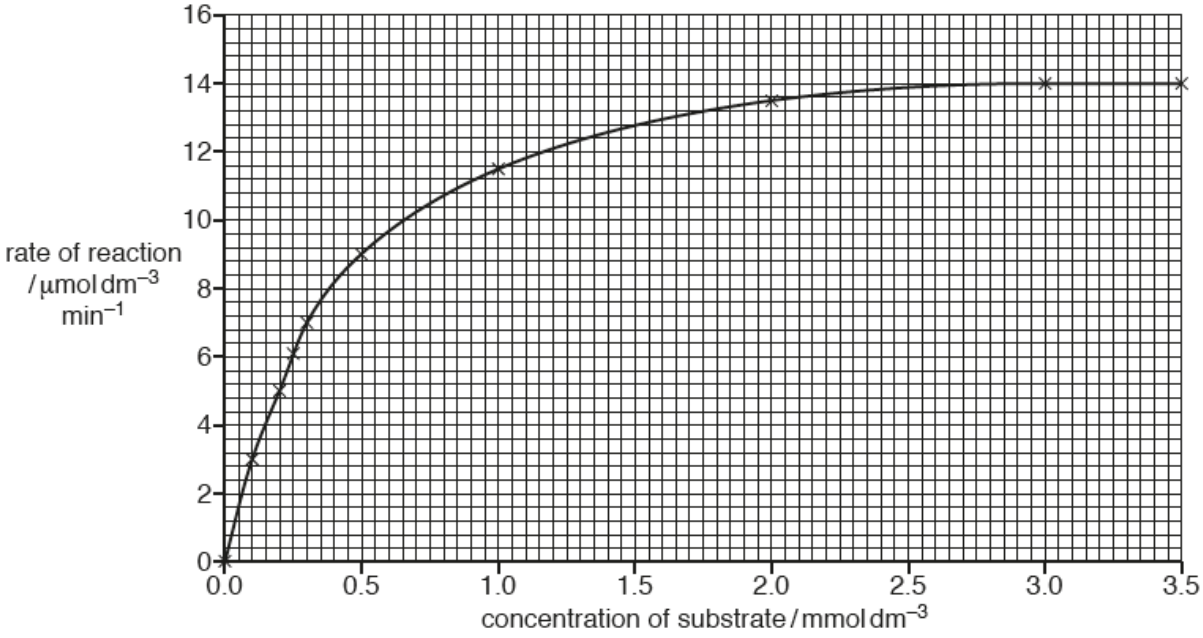

Fig. 2.1

(a) The students used Fig. 2.1 to derive the Michaelis-Menten constant (K_m) for enzyme **A** as 0.3 mmol dm^{-3}.

Explain how they derived K_m.

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(b) The students investigated a different phosphatase enzyme (enzyme **B**) and found the value of K_m to be higher than $0.3\,mmol\,dm^{-3}$.

Explain the difference between the values of K_m for these two phosphatase enzymes.

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(c) The students repeated their investigation on enzyme **A** with a competitive inhibitor.

They used the same concentrations of substrate as before, but added a competitive inhibitor to each reaction mixture.

They used the same concentration of the inhibitor in each reaction mixture.

The students found that V_{max} was the same as before, but K_m was higher than $0.3\,mmol\,dm^{-3}$.

Explain how the addition of the competitive inhibitor results in the same value for V_{max} but a higher value for K_m.

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[Total: 8]

25. **(a)** Explain how enzymes lower the activation energy needed to allow reactions to proceed.

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(b) Folic acid is a molecule used by all cells for growth. Bacteria cannot absorb folic acid from their surroundings. Bacteria use an enzyme to make a molecule called PABA. PABA is used to make folic acid.

An investigation was carried out to determine the effect on the production of PABA when the concentration of an enzyme inhibitor is increased. Four different concentrations (1 µM to 30 µM) of the inhibitor were used, together with a control with no inhibitor.

The concentration of PABA produced in each reaction mixture was determined at 10 minute intervals.

The results are shown in Fig. 2.1.

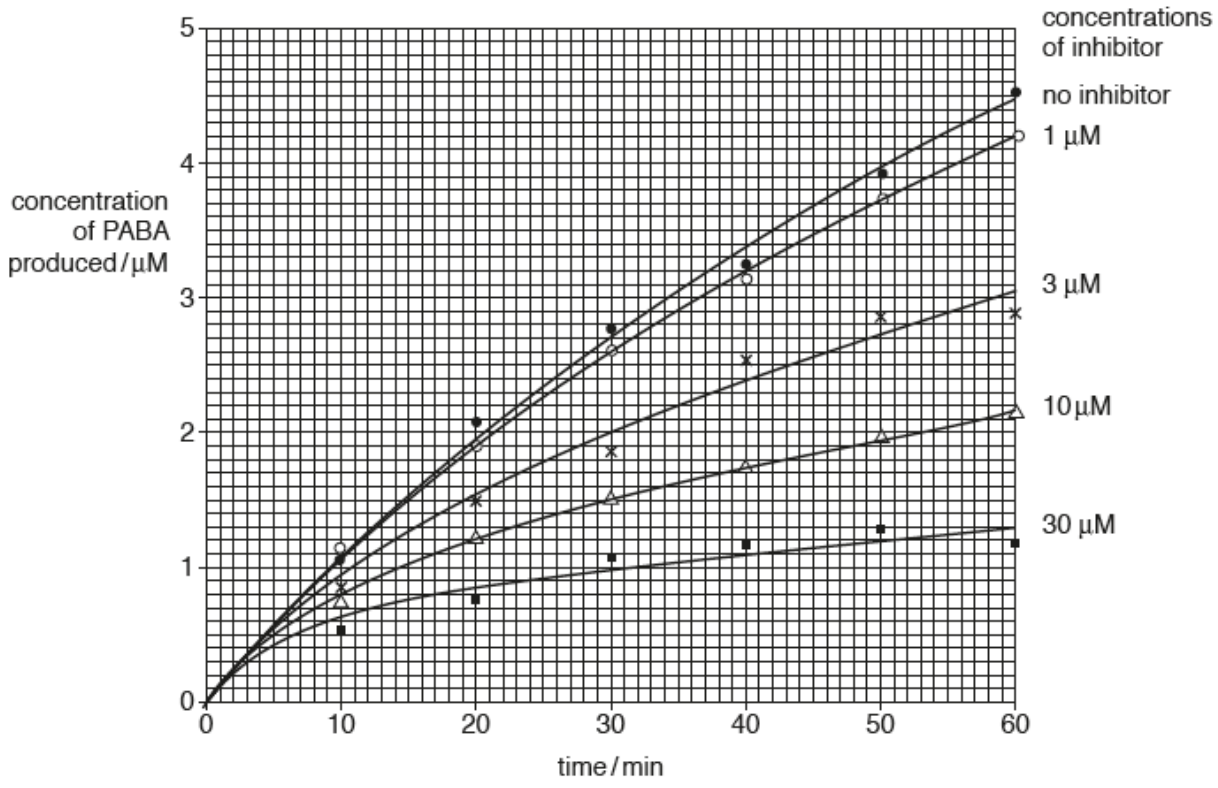

Fig. 2.1

25. continued…

(i) Use Fig. 2.1 to describe the results of the investigation.

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(ii) Outline an experiment that could be carried out to determine whether the inhibitor of the enzyme that catalyses the reaction to produce PABA is competitive or non-competitive.

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(iii) Folic acid from the diet is able to enter human cells, but is **not** able to cross bacterial cell walls. Human cells do **not** have an enzyme to make PABA.

Suggest why the inhibitor of this enzyme could be used as a drug to treat bacterial infections in humans.

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25. continued…

(iv) Suggest why there are few drugs that have any effect on viruses.

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(c) The search for new antibiotics is important because there are many strains of bacteria that are resistant to antibiotics.

Suggest two ways to reduce the spread of antibiotic resistance.

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[Total: 14]

26. In the space below, create a diagram that outlines how enzymes can be immobilized using sodium alginate. Include a pro and con list/chart for this technique.