Enzymes

Question Paper 9

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Enzymes
Sub Topic	Enzymes
Booklet	Theory
Paper Type	Question Paper 9

Time Allowed : **78 minutes**

Score : **/ 65**

Percentage : **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** The first diagnostic test strip using immobilised enzymes was a dip stick to estimate the concentration of glucose in urine.

The dip stick is a thin strip of plastic with a cellulose pad containing two enzymes and a colour reagent (chromogen) at one end. The pad responds with a colour change after being dipped into a sample of urine that contains glucose. The colour can be matched against a graded colour chart to give a 'semi-quantitative' estimate of the concentration of glucose in the sample, as shown in Fig. 2.1. The chart shows the colours of a negative reaction (–) and three increasingly positive reactions (+, ++ and +++).

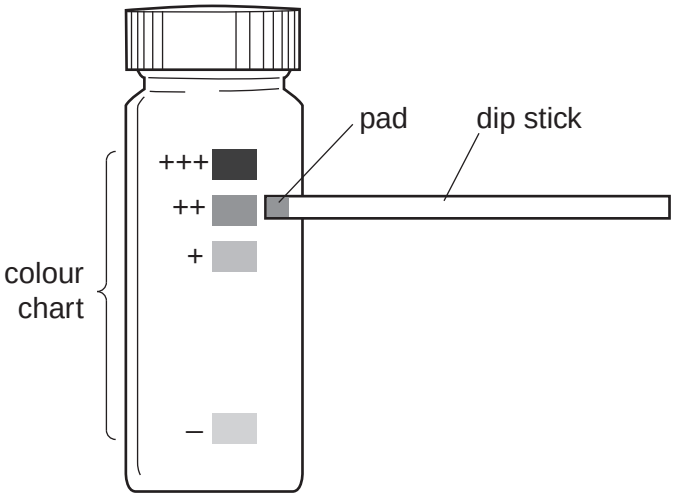

Fig. 2.1

Explain why the estimate of glucose concentration achieved by this method is only 'semi-quantitative'.

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..... [2]

(b) One of the two enzymes immobilised in the cellulose pad on the test strip is glucose oxidase, which catalyses the following reaction:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{glucose oxidase}} \text{gluconic acid} + \text{hydrogen peroxide}$$

This reaction does **not** result in the development of colour by the chromogen. This is achieved by the activity of the second immobilised enzyme in the pad.

(i) Name the second immobilised enzyme in the pad.

.....[1]

(ii) Explain how the reaction catalysed by this enzyme results in the chromogen changing colour.

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.....[2]

(iii) The cellulose pad on the test strip is covered by a layer of cellulose acetate, which is permeable to glucose molecules, but not to larger molecules.

Suggest why the layer of cellulose acetate is present.

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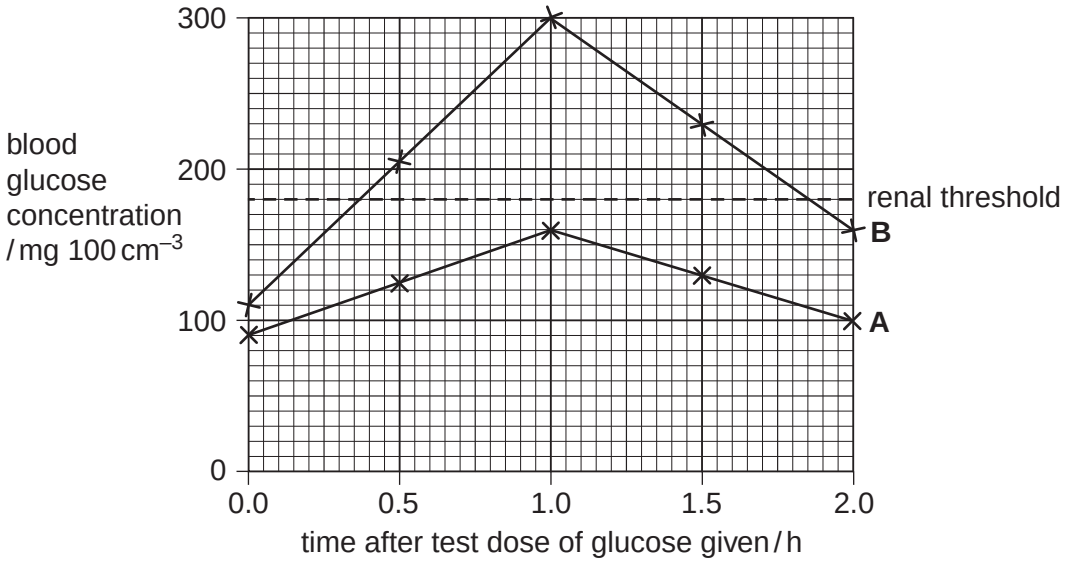
(c) Two young men, subjects **A** and **B**, were each given a standardised test dose of glucose after fasting.

- The blood glucose concentration of each subject was then measured immediately and at 30 minute intervals for two hours.
- Samples of their urine were taken and tested at the same time intervals. The colour change of each test strip was compared with the colour chart and recorded as **–**, **+**, **++** or **+++**.

The results of the investigation are shown in Fig. 2.2.



Results of urine tests:

	time after test dose of glucose given / h				
subject	0.0	0.5	1.0	1.5	2.0
A	**–**	**–**			
B	–	+	++	++	+++

Fig. 2.2

With reference to Fig. 2.2:

(i) explain the differences between the **blood glucose** concentrations of **A** and **B**

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.....[4]

(ii) suggest what is meant by the term 'renal threshold'

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.....[1]

(iii) describe the events in the kidneys, after ultrafiltration, that result in the increasing quantity of glucose in **B**'s urine.

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[Total: 15]

2 **(a)** Cellulose is a polysaccharide.

Fig. 5.1 shows three sub-units from a molecule of cellulose.

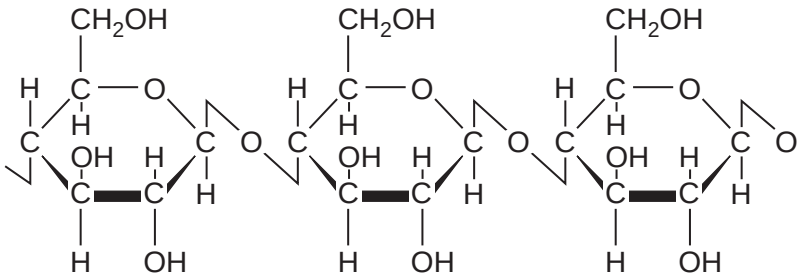

Fig. 5.1

(i) Name the sub-unit molecule of cellulose.

.....[1]

(ii) Name the bonds that attach the sub-unit molecules together within cellulose.

.....[1]

(b) Cellulose has high mechanical strength which makes it suitable for the cell walls of plants.

Explain how cellulose has such a high mechanical strength making it suitable for the cell walls of plants.

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.....[2]

Plant cell walls consist of cellulose that is embedded in a matrix of compounds, such as pectins and proteins.

Cell wall material is synthesised inside the cell and transported to the cell surface membrane as shown in the drawing made from an electron micrograph in Fig. 5.2.

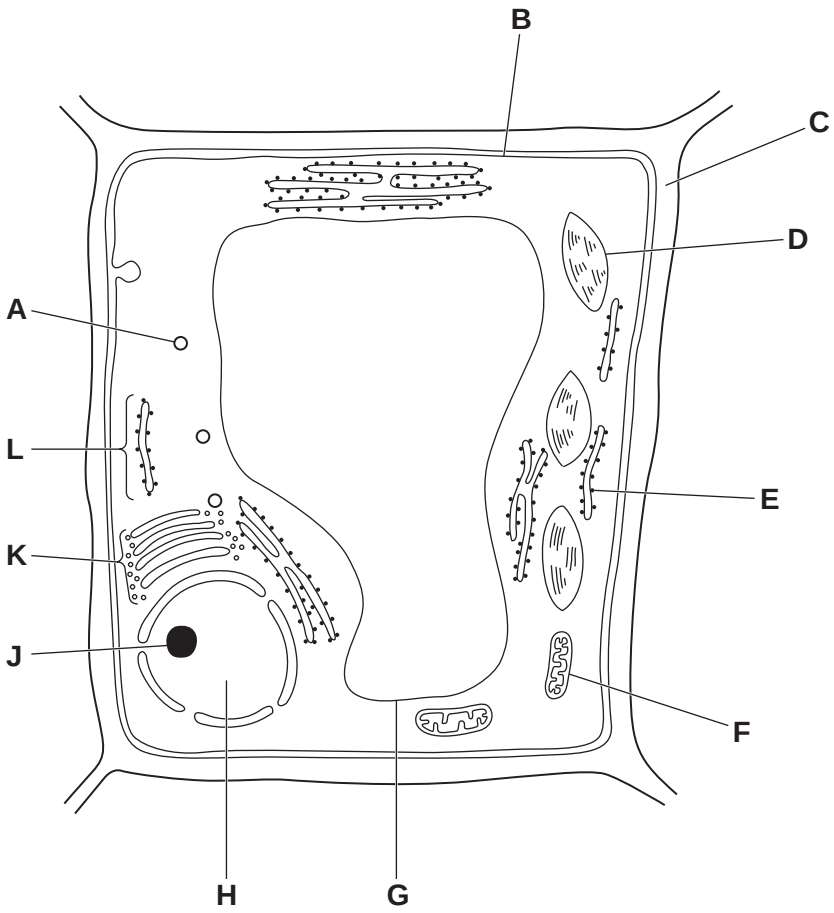

Fig. 5.2

(c) Locate the parts of the cell labelled in Fig. 5.2 which apply to each of the following statements. You must only give one letter in each case. You may use each letter once, more than once or not at all. The first answer has been completed for you.

statement	letter from Fig. 5.2
organelle that contains DNA	**H**
transports cell wall material to the cell surface membrane	
site of transcription	
site of ribosome synthesis	
site of photosynthesis	

[4]

(d) Enzymes known as expansins are found in the matrix of cell walls to help the growth of cells.

Use the information in Fig. 5.2 to describe how proteins made by the ribosomes reach the matrix of the cell wall.

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..... [3]

[Total: 11]

3 Proteases that work in alkaline conditions are made in large quantities for use in the detergent industry. The microorganism that is generally used for this is the bacterium *Bacillus subtilis*.

An investigation was carried out to compare three potential production methods:

- using free cells of *B. subtilis*
- using *B. subtilis* cells immobilised in cubes of agar
- using *B. subtilis* cells immobilised in beads of sodium alginate.

To immobilise the cells in agar, the agar was dissolved and cooled. A suspension of *B. subtilis* was then added. The agar-bacterium mixture was poured into sterile dishes and allowed to solidify. It was then cut into cubes with sides of 2 mm.

(a) (i) Explain why the agar was cooled before the suspension of *B. subtilis* was added.

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..... [1]

(ii) Describe how cells of *B. subtilis* could be immobilised in beads of alginate.

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..... [3]

(b) A liquid medium containing glucose, a nitrogen source and various mineral ions was made up, and 50 cm^3 placed into each of three flasks.

Samples of a culture of free cells of *B. subtilis*, agar cubes containing immobilised *B. subtilis* and alginate beads containing *B. subtilis* were placed in the three flasks. Each flask contained the same number of bacteria. All the flasks were incubated at 37 °C for 48 hours.

Samples of the liquid medium in each flask were taken at six hourly intervals and the concentration of protease measured.

The results are shown in Fig. 3.1.

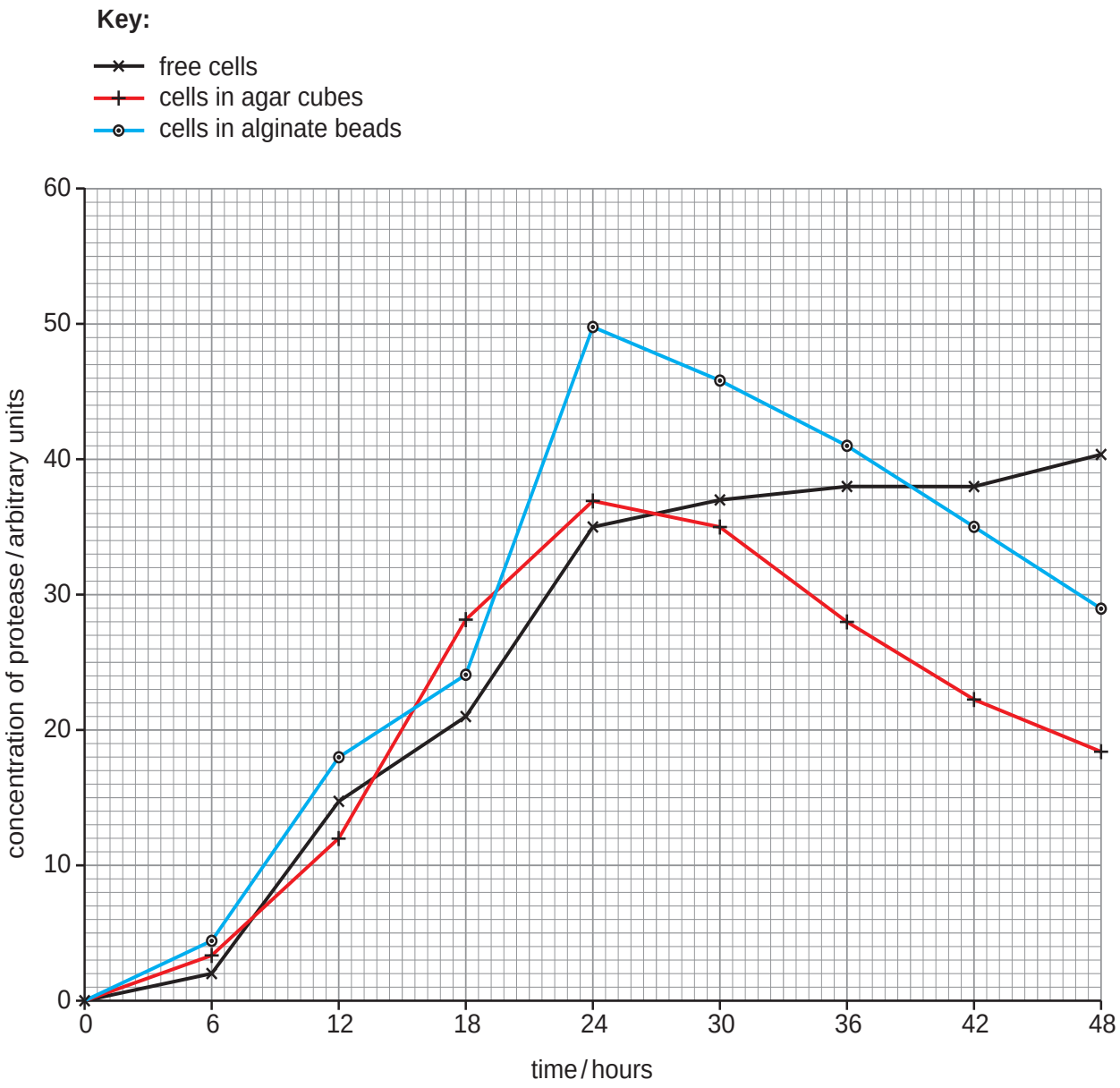

Fig. 3.1

(i) With reference to Fig. 3.1, compare the results for the free cells of *B. subtilis* and cells immobilised in alginate beads.

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..... [4]

(ii) Suggest why lower concentrations of protease were produced by *B. subtilis* immobilised in agar cubes than *B. subtilis* immobilised in alginate beads.

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.....[2]

(c) Two new cultures of immobilised *B. subtilis* were set up as described in **(b)**.
However, this time a repeat batch fermentation method was used, in which the liquid medium was replaced every 24 hours. This was continued until the cubes or beads had begun to disintegrate.

The results are shown in Table 3.1.

Table 3.1

	number of batches before cubes or beads disintegrated	total fermentation time / hours	total protease produced / arbitrary units	mean productivity of protease / arbitrary units per hour
agar cubes	6	144	1792	12.44
alginate beads	9	216	3264	15.11

With reference to Table 3.1

(i) calculate the percentage increase in the total protease produced when the bacteria were immobilised in alginate rather than agar.

Show your working.

.....[2]

(ii) explain why using bacteria immobilised in alginate rather than agar would be a more cost-effective production of protease.

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.....[3]

[Total: 15]

4 Trypsin is a protease enzyme, which hydrolyses protein molecules, such as albumen, to amino acids.

A student investigated the effect of substrate concentration on the activity of trypsin. Six different concentrations of albumen were prepared and trypsin was added to each in turn. The student measured the time for albumen to break down and then calculated the rate of reaction. The investigation was carried out at 35 °C.

The student's results are shown in Fig. 3.1.

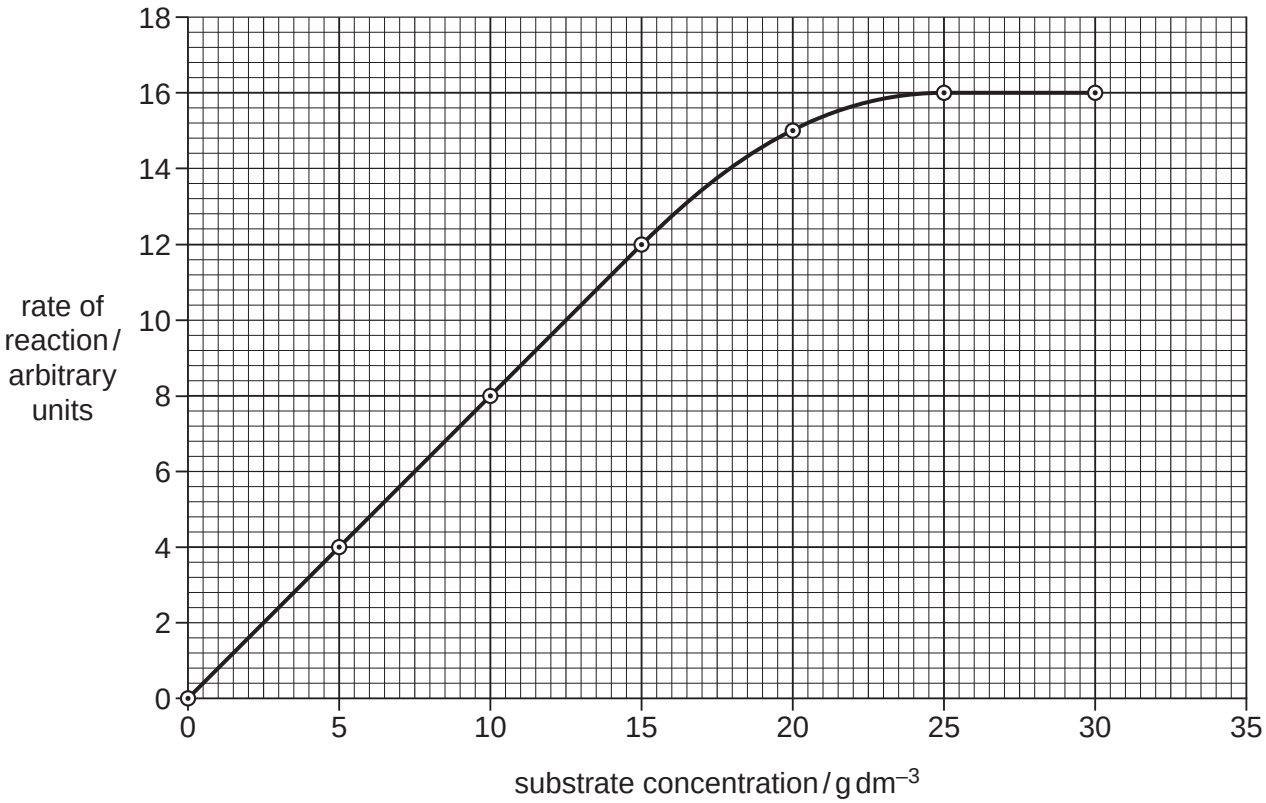

Fig. 3.1

(a) Explain the results shown in Fig. 3.1.

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..... [3]

(b) The student repeated the investigation at 25 °C.

Draw on Fig. 3.1 a curve to show the results that you would expect. [2]

During infections of the lungs, phagocytes move from the blood to the lining of the alveoli.

Phagocytes release the enzyme elastase (a protease) in order to digest a pathway through the alveolar wall. Most people produce a glycoprotein, alpha 1-antitrypsin (AAT), in the lung which inhibits elastase and so prevents widespread breakdown of alveoli. The inhibitory action of AAT was investigated using the enzyme trypsin.

(c) Describe **one** way in which AAT may act to inhibit the enzyme elastase.

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(d) Explain how you would adapt the student's investigation with trypsin to find out how AAT acts as an inhibitor.

You may use the space below to sketch the graph of the results that you might expect.

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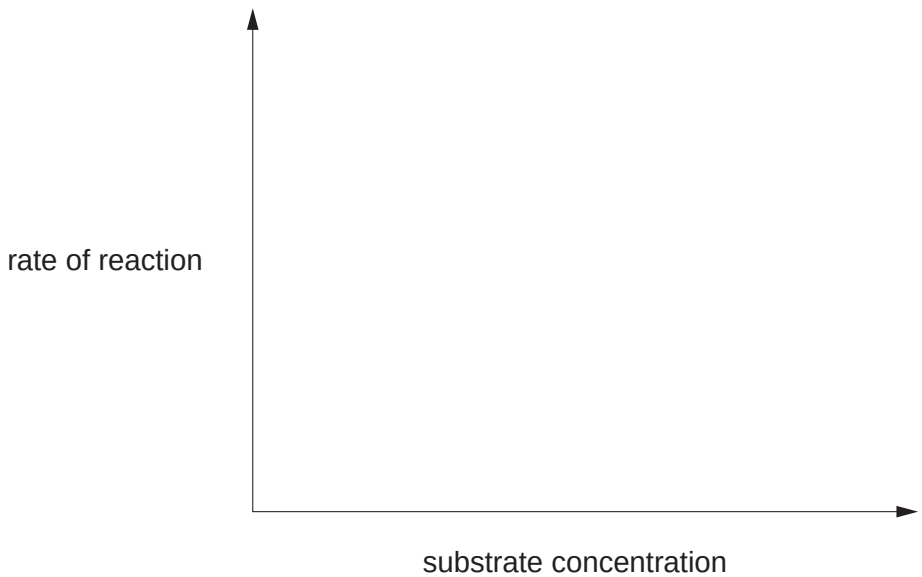

[4]

(e) Elastase breaks down the protein elastin. Describe the function of elastin in the lungs.

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..... [2]

(f) Tobacco smoke inactivates AAT. In long-term smokers this can result in the breakdown of much of the elastin in the lungs.

State the name of the condition that results from breakdown of elastin that occurs in some long-term smokers.

..... [1]

[Total: 15]

5 Starch, glycogen and cellulose are all polysaccharides. They are made from monomers that are joined by covalent bonds.

(a) Complete the table below to show which of the statements apply to each of the polysaccharides.

Fill in each box using a tick (✓) to show that the statement applies and a cross (✗) if it does not.

statement	starch	glycogen	cellulose
glycosidic bonds between monomers			
monomer is β glucose			
stored within chloroplasts			
stored in muscle cells			
exists in two forms – branched and unbranched chains			

[5]

A solution of the enzyme amylase was added to a solution of starch and kept at 25 °C. The starch was broken down by hydrolysis.

(b) Explain how you would determine the rate of hydrolysis.

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.....[4]

[Total: 9]