WJEC EDUQAS AS BIOLOGY · COMPONENT 1

BIOLOGY



EXAM QUESTION PACK

1.4 ENZYMES

SCORE	PERCENTAGE
/91	%

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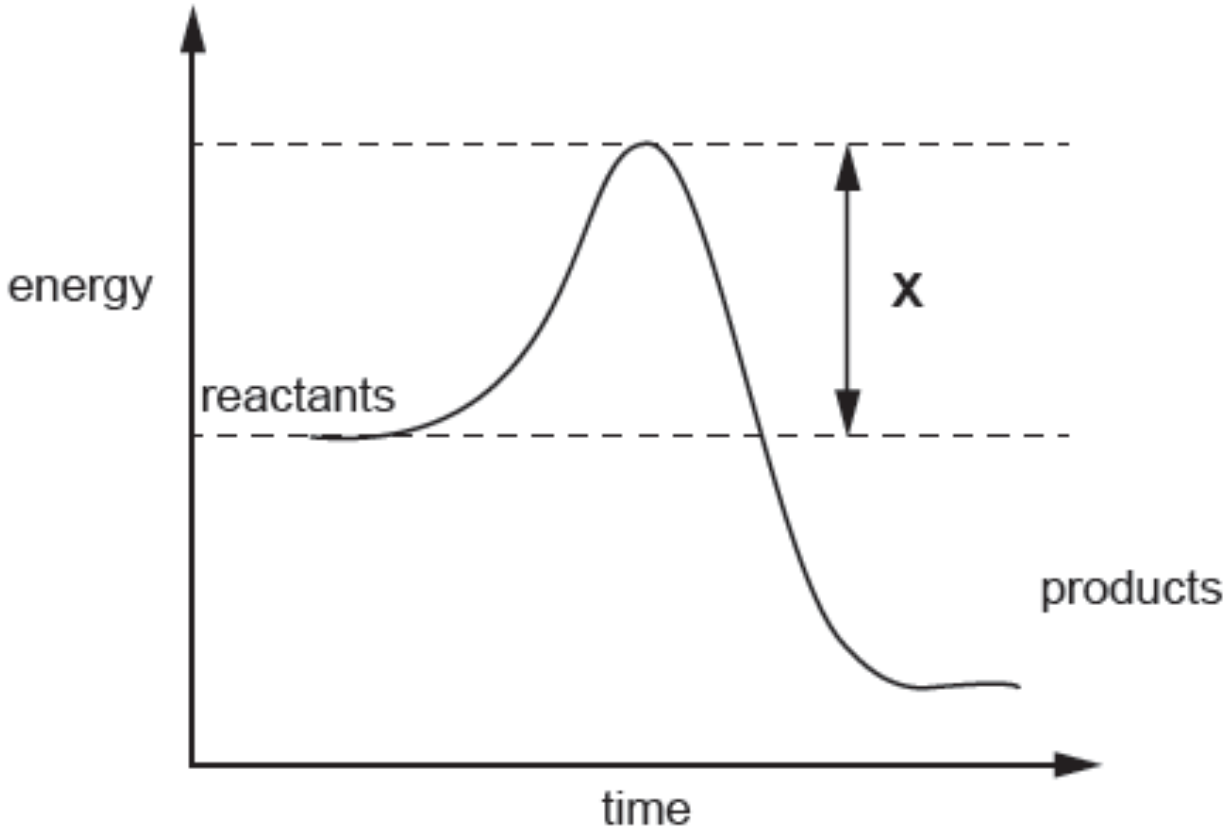
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1. The graph below shows the energy changes that take place during a chemical reaction.



(a) (i) What is represented by **X** on the graph above?

[1]

(ii) Enzymes are biological catalysts.

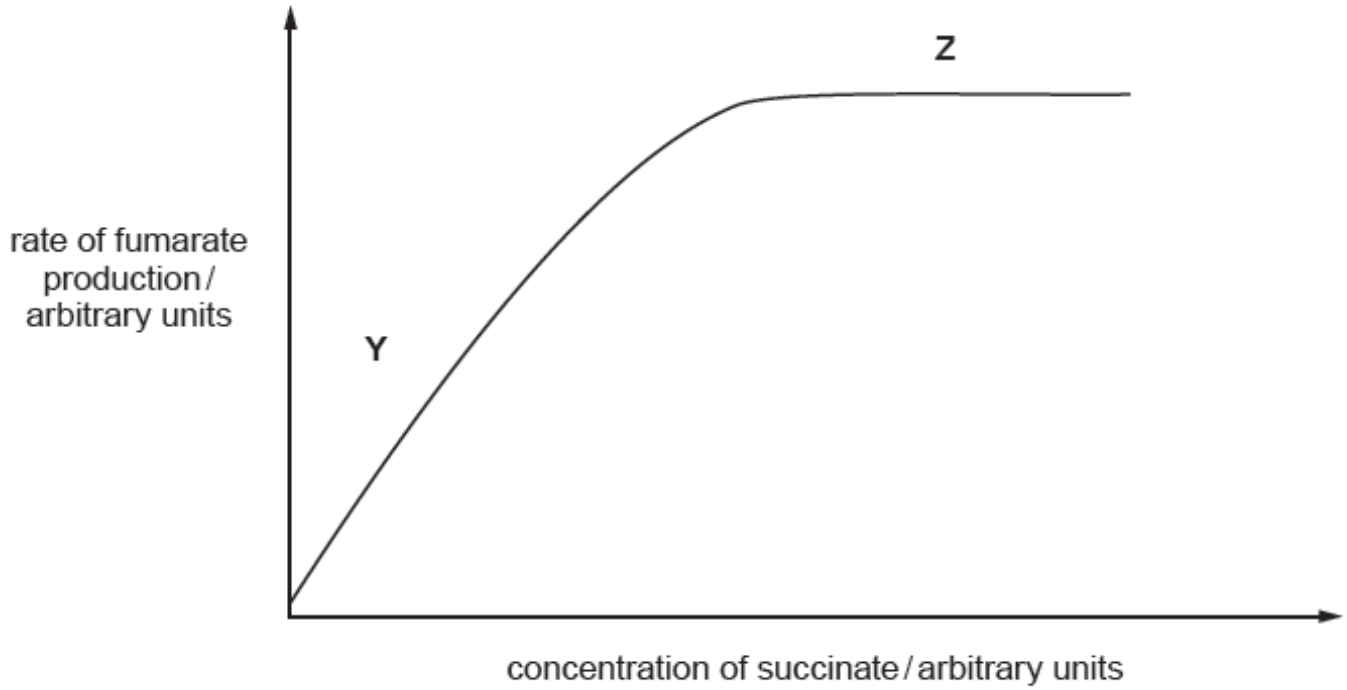
Draw a line on the graph above to show the energy changes that would take place if an enzyme was present during the reaction.

[1]

(b) Succinate dehydrogenase is an enzyme found in mitochondria and is involved in respiration. The enzyme catalyses the conversion of succinate into fumarate. Using your knowledge of enzyme structure, explain why this is the **only** reaction succinate dehydrogenase can catalyse.

[2]

(c) The graph below shows the rate of fumarate production at varying concentrations of succinate, at optimum temperature and pH with no inhibitors present.



(i) I. State what factor is limiting the rate of reaction in the region marked **Y** on the graph.

[1]

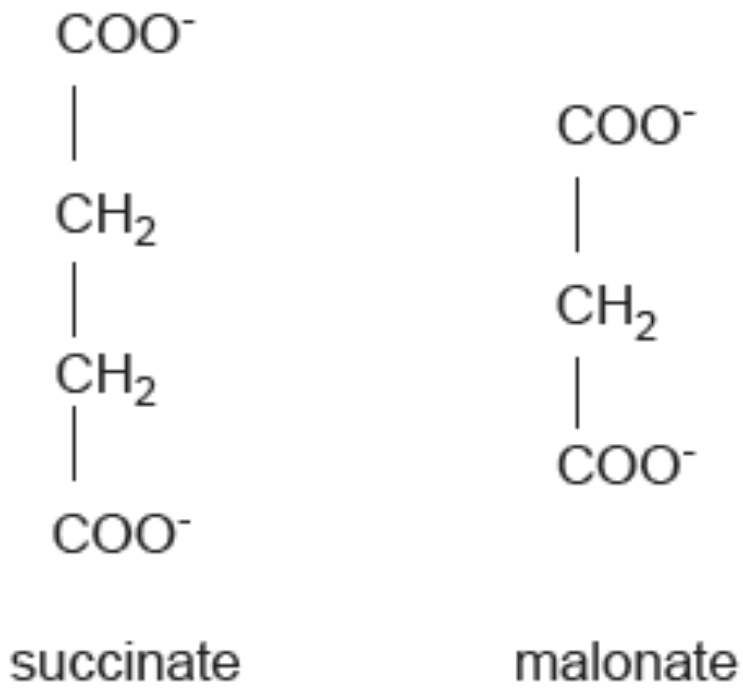
II. Use evidence from the graph to support your answer.

[1]

(ii) Explain what is limiting the rate of reaction in the region marked **Z** on the graph.

[2]

(d) Malonate is a competitive inhibitor of succinate dehydrogenase. The diagrams below show the structural formulae of succinate and malonate.



succinate malonate

(i) Using the information in the diagram above and your own knowledge, explain how malonate inhibits succinate dehydrogenase.

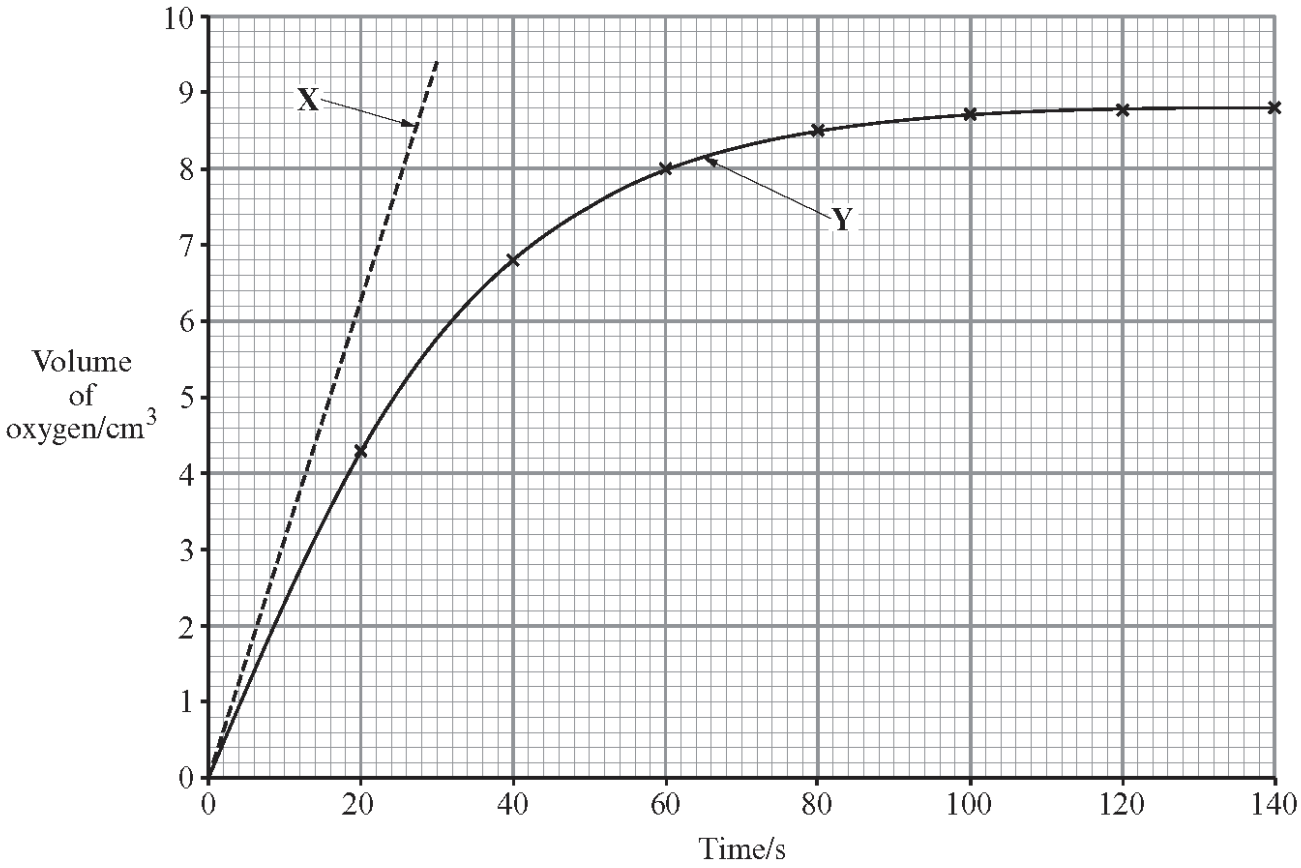
[3]

(ii) On the graph in part (c) opposite draw a curve to show the rate of reaction when malonate is present.

[1]

2.

A student investigated the action of the enzyme catalase. This enzyme catalyses the breakdown of hydrogen peroxide into oxygen and water.
The student collected the oxygen given off in a measuring cylinder. The volume of gas was recorded every 20 seconds as shown on the graph labelled **Y** below.



(a) The rate of reaction can be calculated using the formula:

$$\frac{\text{Volume of oxygen collected}}{\text{Time taken to collect}}$$

Use the formula to calculate the rate in $cm^3 min^{-1}$ for the first 30 seconds. [2]

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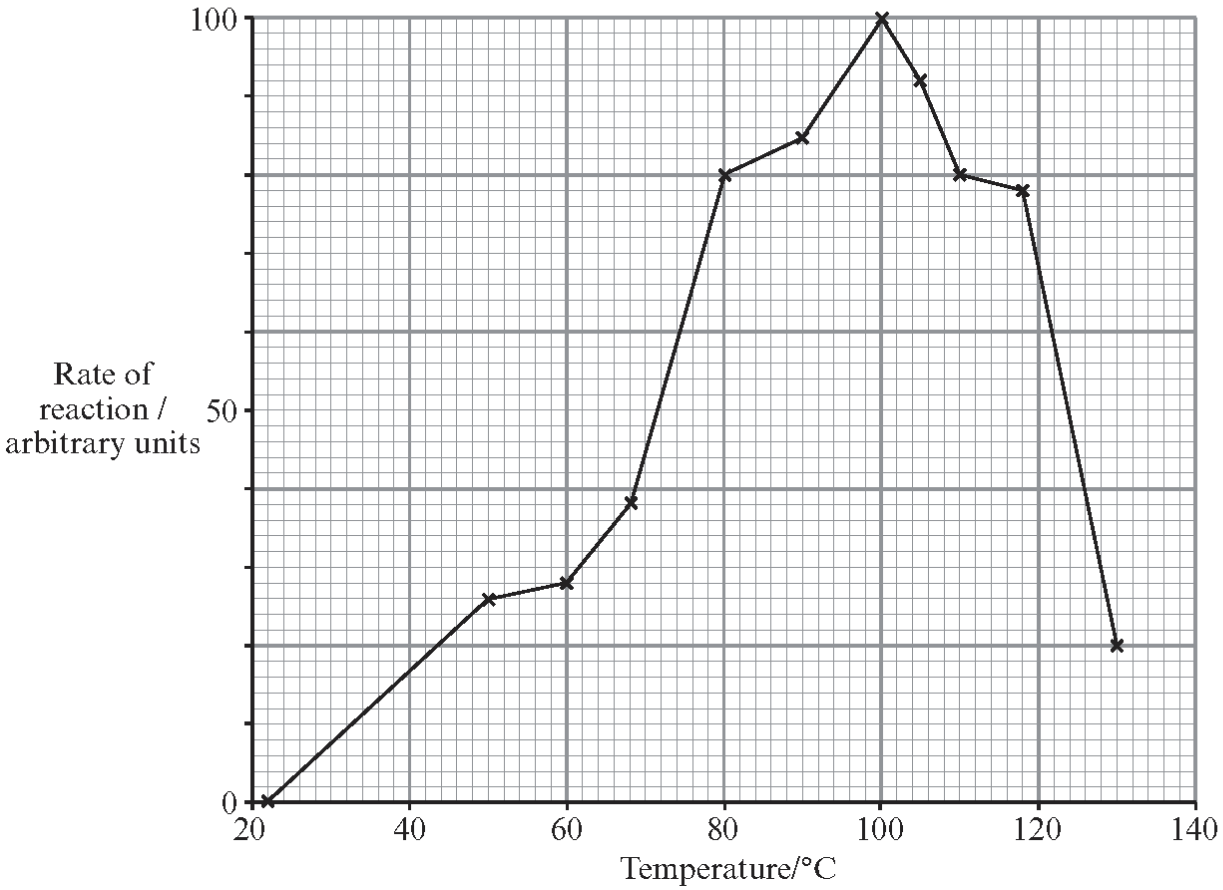
(b) The initial rate is the rate of reaction at the beginning and is the maximum rate. It is shown by line **X**. The initial rate is $19\,cm^3 min^{-1}$.
Explain why the initial rate is greater than the rate calculated in *(a)*. [2]

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(c) The graph below shows the effect of temperature on the activity of an amylase enzyme found in bacteria that live in hot water in volcanic regions.



(i) Using the graph, describe and explain the effect of temperature on the rate of activity of the amylase. [6]

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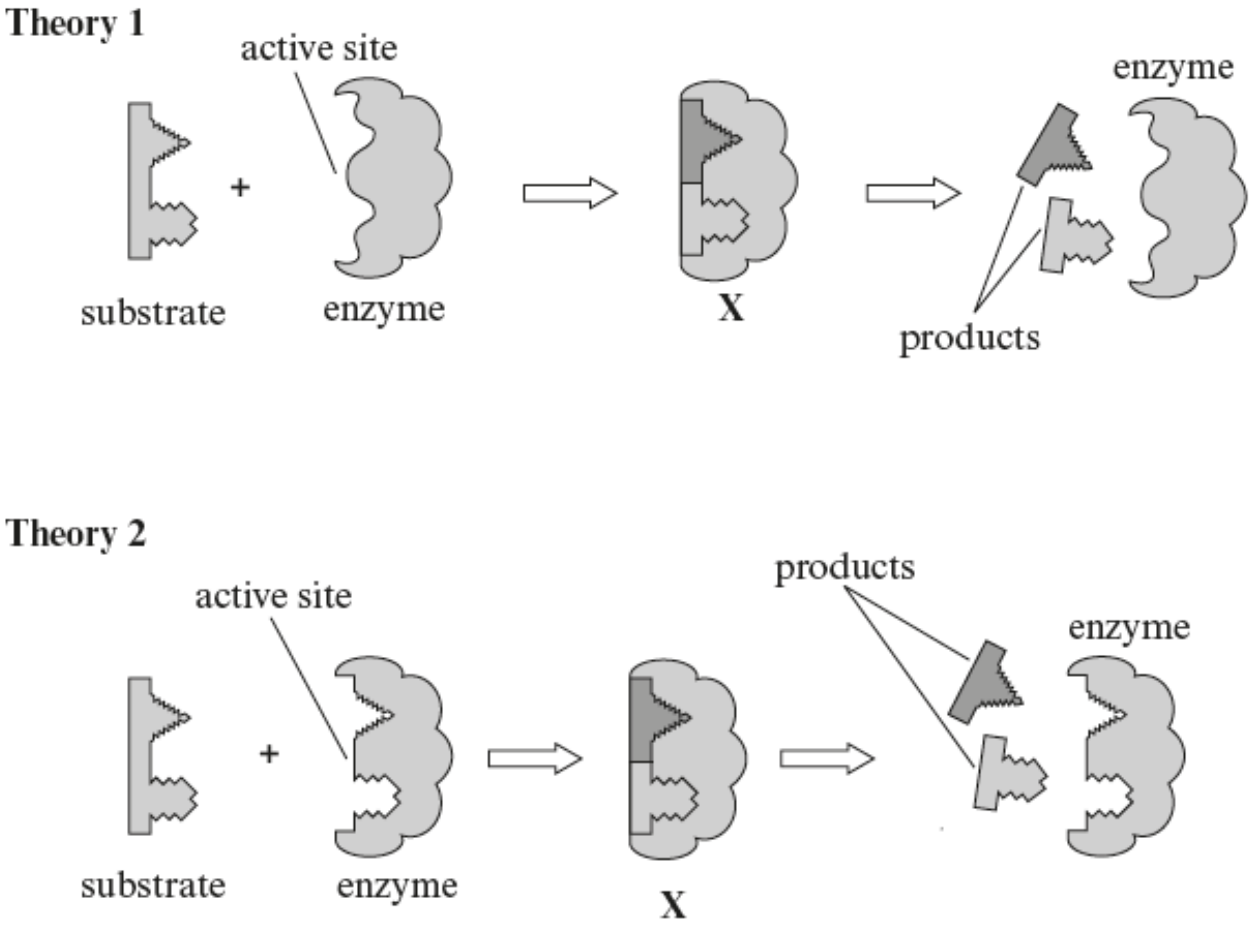
(ii) State the difference between bacterial amylase and an amylase found in humans. [2]

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(Total 12 Marks)

4. The diagram below shows two theories used to explain enzyme activity.



(a) (i) **Theory 1** shows the induced fit hypothesis. What name is given to **Theory 2**? [1]

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(ii) Which theory represents the activity of lysozyme? [1]

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(b) Name **X** as shown in both theories. [1]

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(c) Enzymes are biological catalysts. How do they bring about their effect of speeding up a reaction? [1]

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[1]

(d) What characteristic of an enzyme at the **end of a reaction** is visible in both diagrams?

[1]

(e) State **three** factors which affect enzyme activity, excluding the presence of inhibitors.

[3]

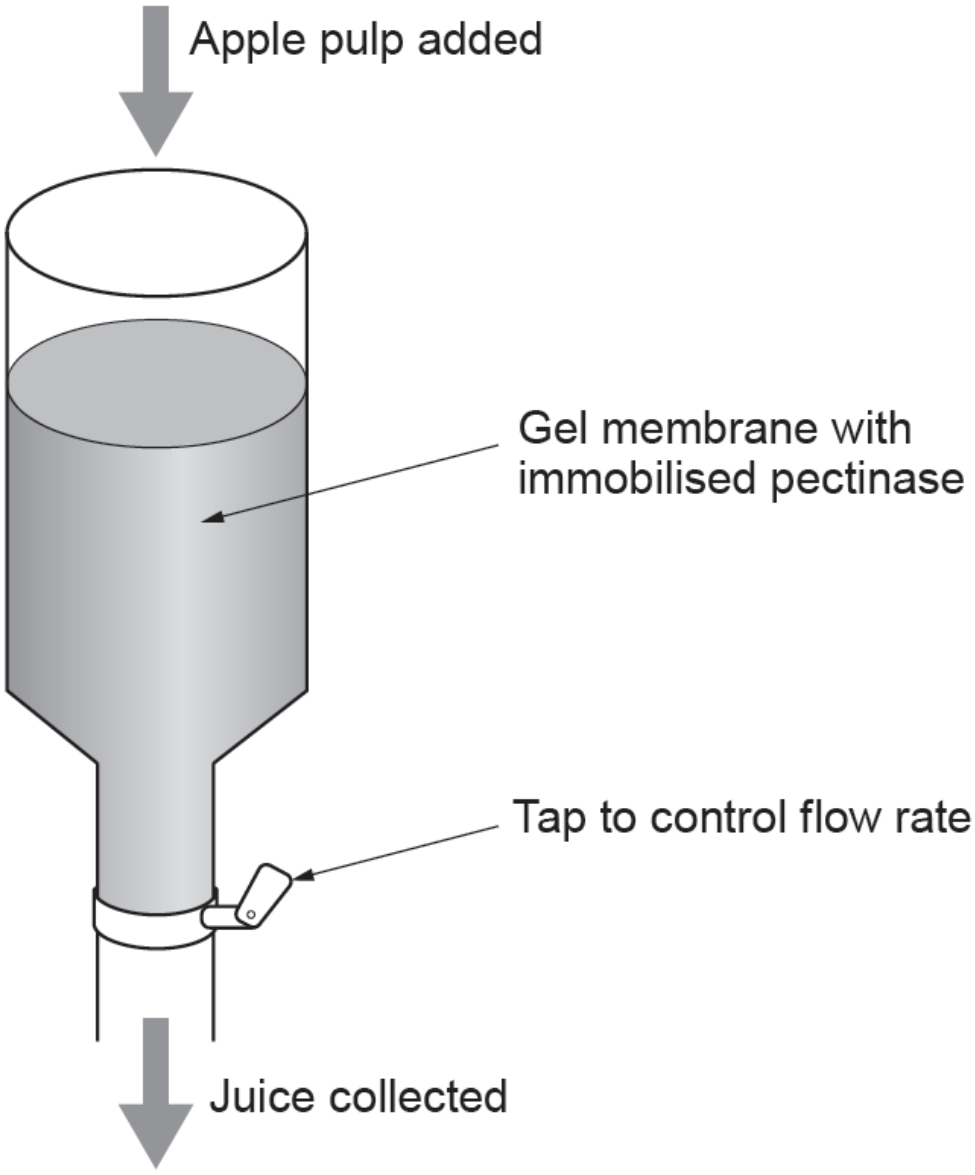
(f) Distinguish between intracellular and extracellular enzymes.

[1]

Total

[9]

4. Pectin is a structural polysaccharide found in the cell walls of plant cells and in the middle lamella between cells, where it helps to bind cells together. Pectinases are enzymes that are routinely used in industry to increase the volume and clarity of fruit juice extracted from apples. The enzyme is immobilised onto the surface of a gel membrane which is then placed inside a column. Apple pulp is added at the top, and juice is collected at the bottom. The process is shown in the diagram below.



(a) Immobilising enzymes can increase the temperature range over which they can be used.

Describe **two** other advantages of immobilising pectinases

[2]

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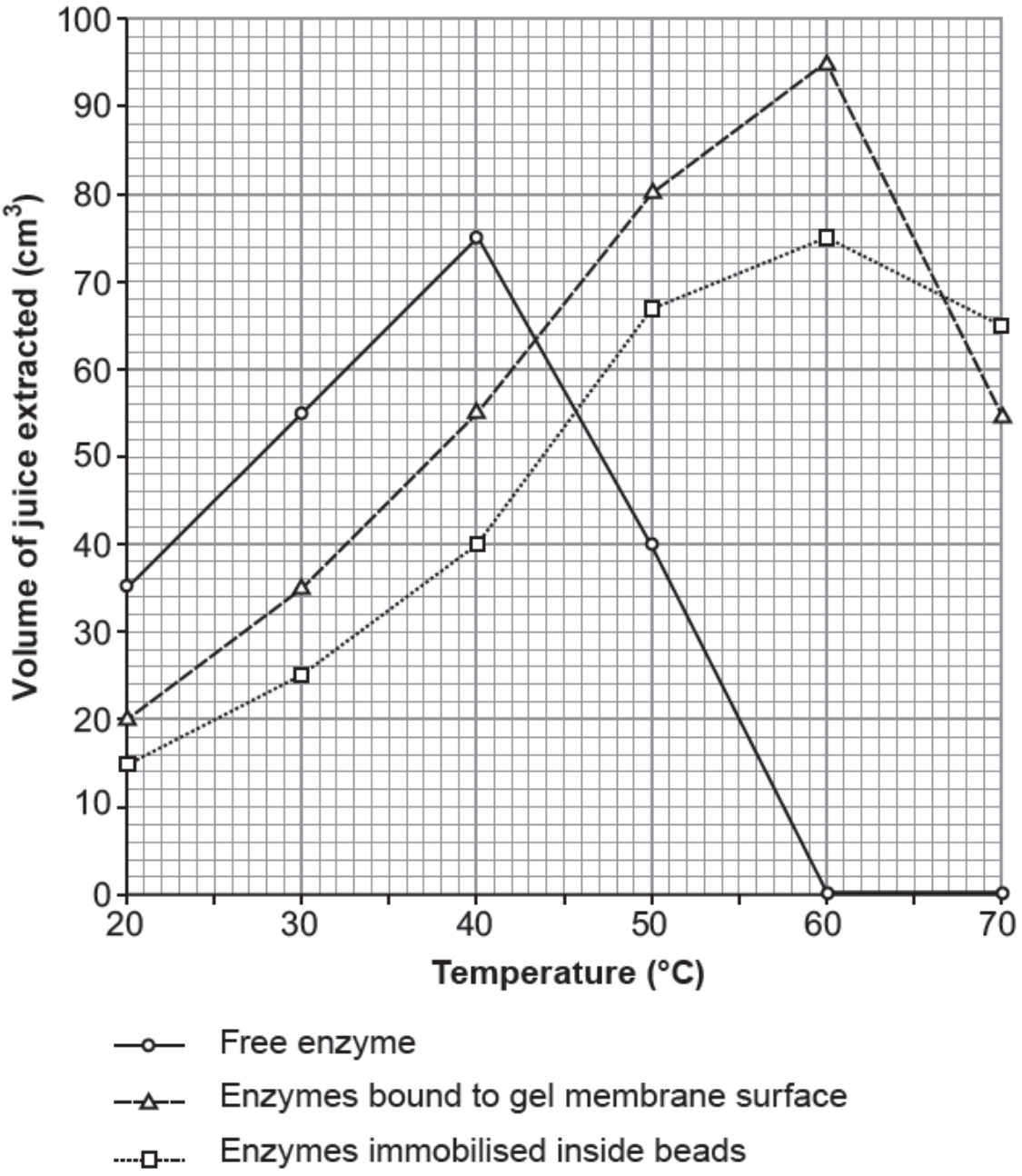
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(b) Suggest why reducing the flow rate of material through the column would result in an increased volume of juice being collected.

[2]

(c) The extraction of juice using pectinase was compared using equal volumes and concentrations of free enzyme, enzymes bound to the surface of a gel membrane and enzymes immobilised inside alginate beads. The results are shown in the graph below.



Using the graph and your own knowledge of enzymes, answer the following questions.

(i) Describe and explain the results for the free enzyme at temperatures above 40°C.

[4]

(ii) Explain why a higher yield of juice was obtained when using free enzyme between temperatures of 20°C and 40°C than when using immobilised enzyme.

[2]

(iii) Suggest a reason for the differences seen in the results for the enzymes bound to the gel membrane surface with those immobilised inside the beads, between temperatures of 20°C and 60°C.

[2]

5. A new biological washing powder has been developed containing three protease enzymes (**A**, **B** and **C**), each removing different protein based stains. The manufacturer claims their revolutionary new washing powder works "best at 35°C, but offers superior removal of tough protein stains at higher temperatures".

(a) Enzymes are biological catalysts. Describe what is meant by the term *biological catalyst.* [2]

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Graph showing protease activity

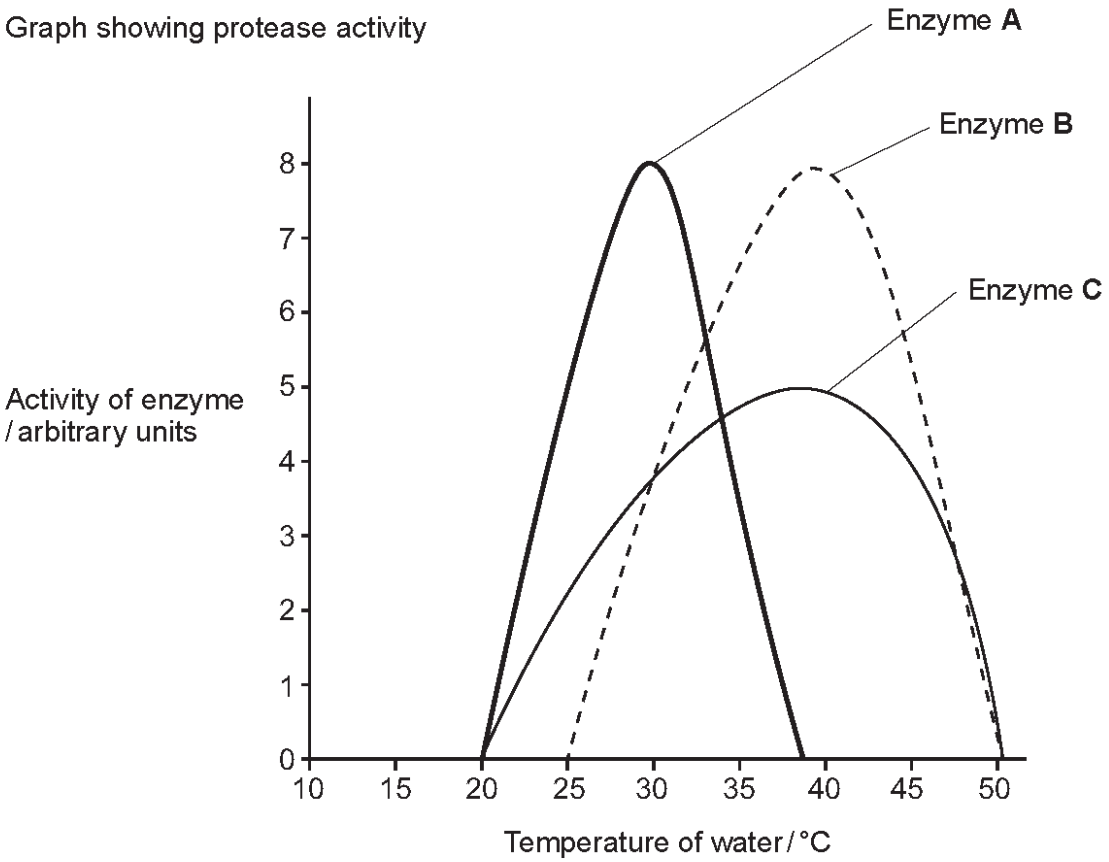


Table showing type of food stain removed

Protease enzyme	Food stain removed		
	Blood	Meat	Egg
A	Yes	No	No
B	No	Yes	No
C	No	No	Yes

(b) Using the graph and table, together with your knowledge of enzymes, answer the following questions.

(i) Explain why the washing powder works best at 35°C. [1]

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(ii) Which stain would not be removed when washing at 40°C? [1]

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(iii) Suggest why three different enzymes are needed to remove blood, meat and egg stains. [2]

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(iv) Explain fully why washing at 60°C would not be recommended for removing protein stains when using this washing powder. [4]

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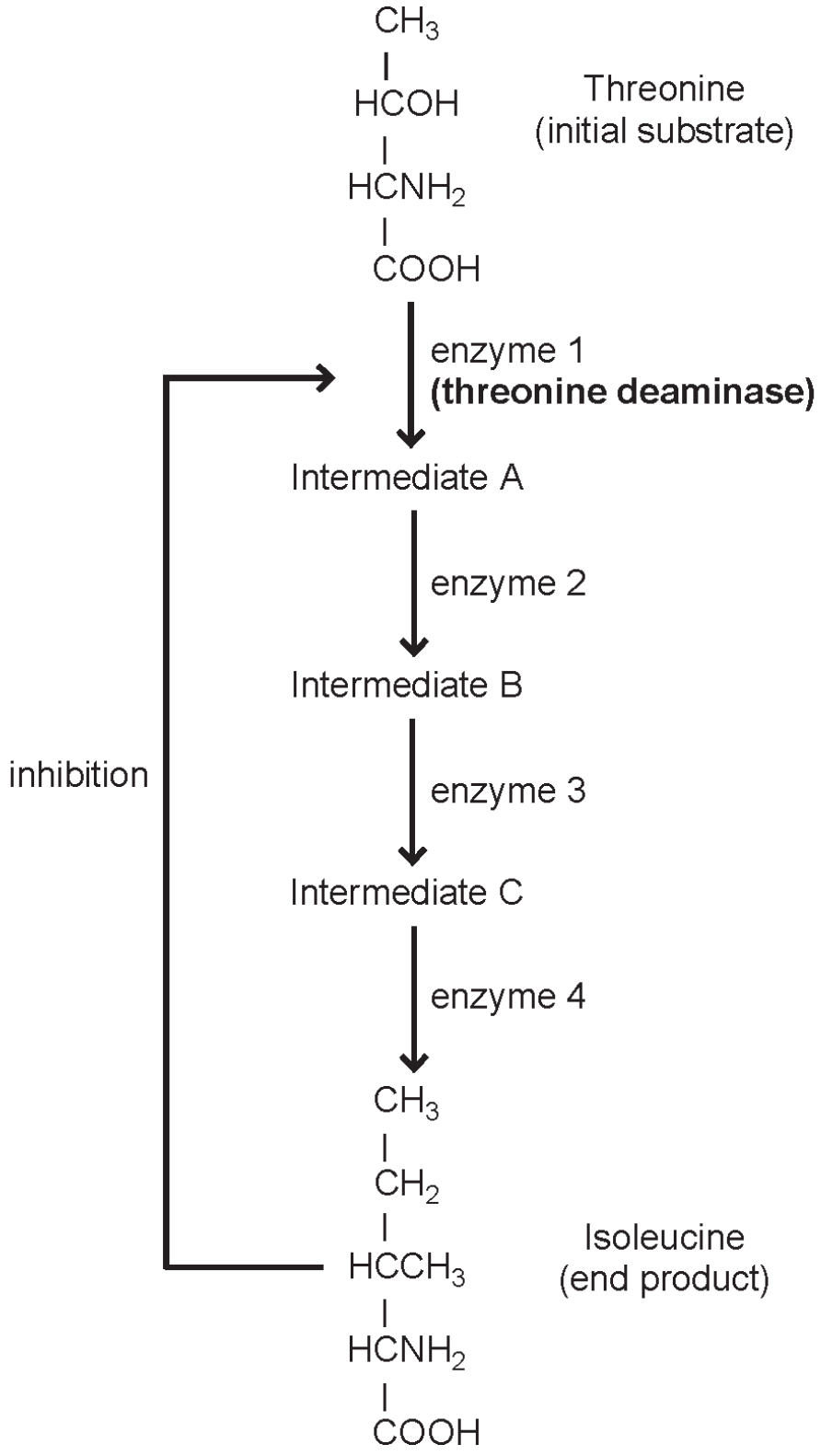
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(c) Many metabolic pathways are switched off by their end products which act as competitive inhibitors of the first enzyme in the pathway. In the example below, the end product isoleucine inhibits threonine deaminase.



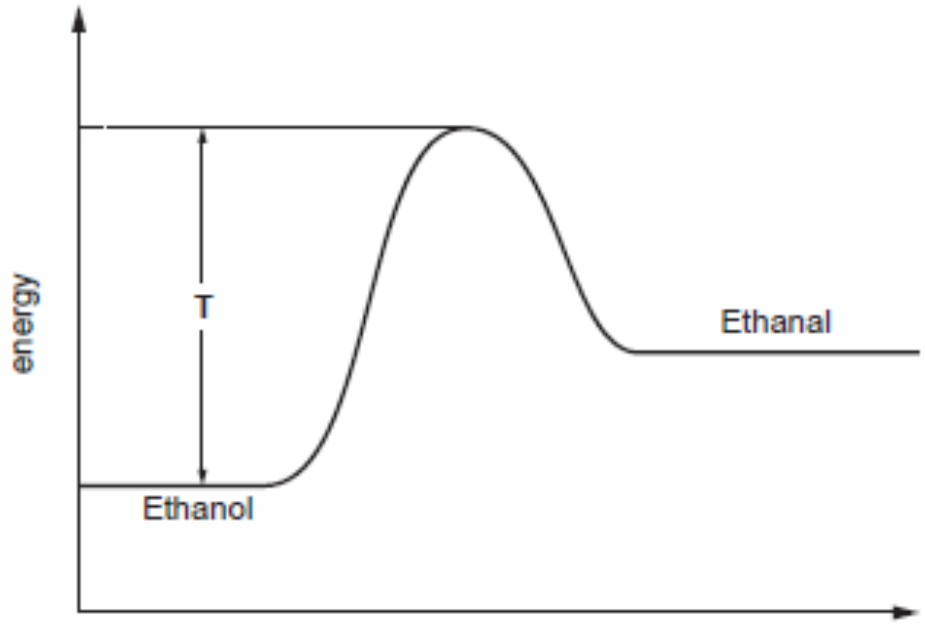
(i) Explain how isoleucine works as a **competitive inhibitor**. [4]

(ii) Suggest a reason why this might be useful to the cell. [1]

15

6. Alcohol dehydrogenase is an enzyme that catalyses the conversion of ethanol into ethanal.

The graph below shows the change in energy state when ethanol is converted to ethanal when no enzyme is present.



(a) (i) State what is represented by the region labelled **T**. [1]

……

(ii) Draw a curve on the diagram to show the change in energy level when alcohol dehydrogenase is present. [1]

(b) Describe how alcohol dehydrogenase can catalyse the conversion of ethanol into ethanal. [3]

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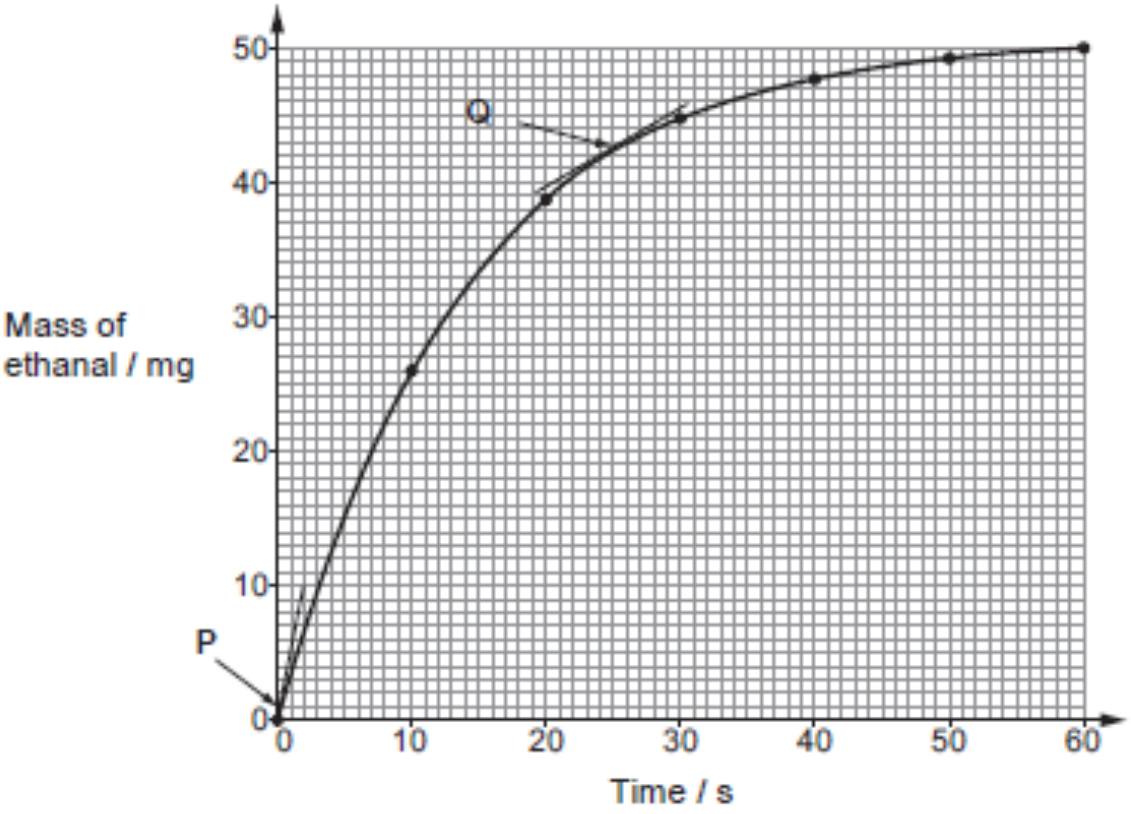
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(c) A fixed mass of ethanol was added to a test tube containing alcohol dehydrogenase and a pH7 buffer solution. The test tube was incubated at 30°C and the mass of ethanal produced over time was recorded. The results are shown below.



(i) The rate of reaction at P was $5\,mg\,s^{-1}$.
Calculate the rate of reaction at Q. [2]

rate = ... mg s^{-1}

(ii) What conclusions can be drawn that would account for the difference in rate at P and at Q? [4]

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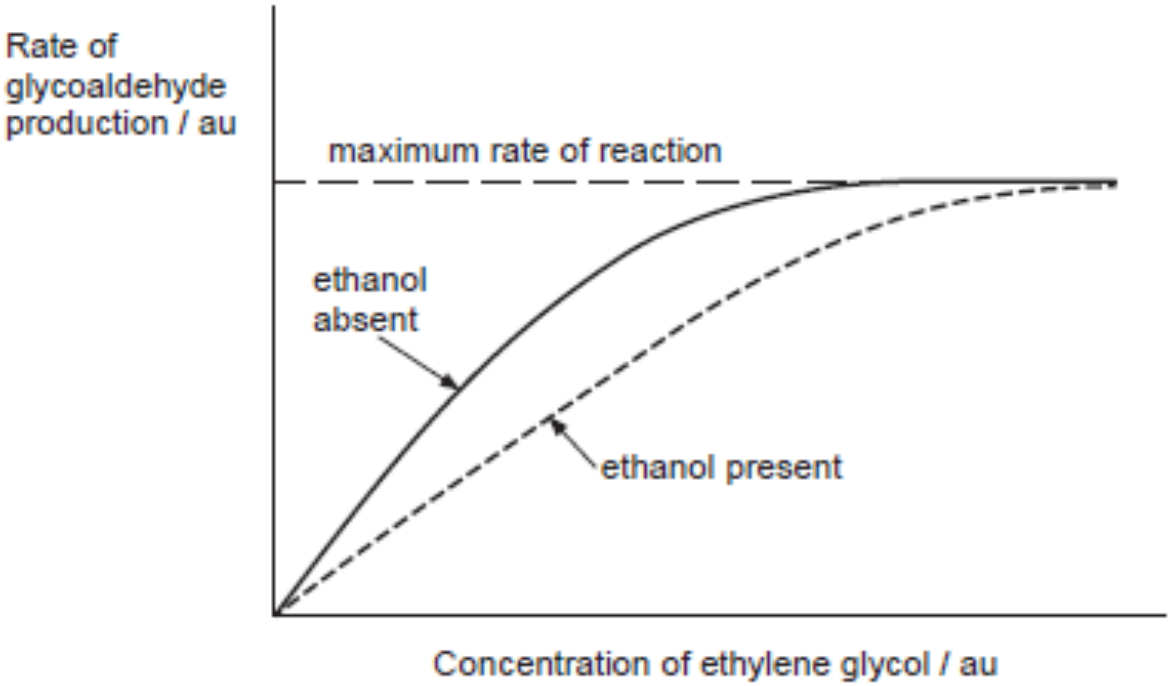
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(d) Ethylene glycol is a colourless, odourless, sweet liquid, commonly found in antifreeze. It is highly toxic if ingested because once inside the body ethylene glycol is converted into glycoaldehyde. This reaction is also catalysed by alcohol dehydrogenase.

Treatment of ethylene glycol poisoning includes giving the patient ethanol, either intravenously or orally.

The graph below shows the rate of glycoaldehyde production in the presence, and absence of ethanol.



Use the information provided to explain why this treatment would reduce the effects of ethylene glycol poisoning. [5]

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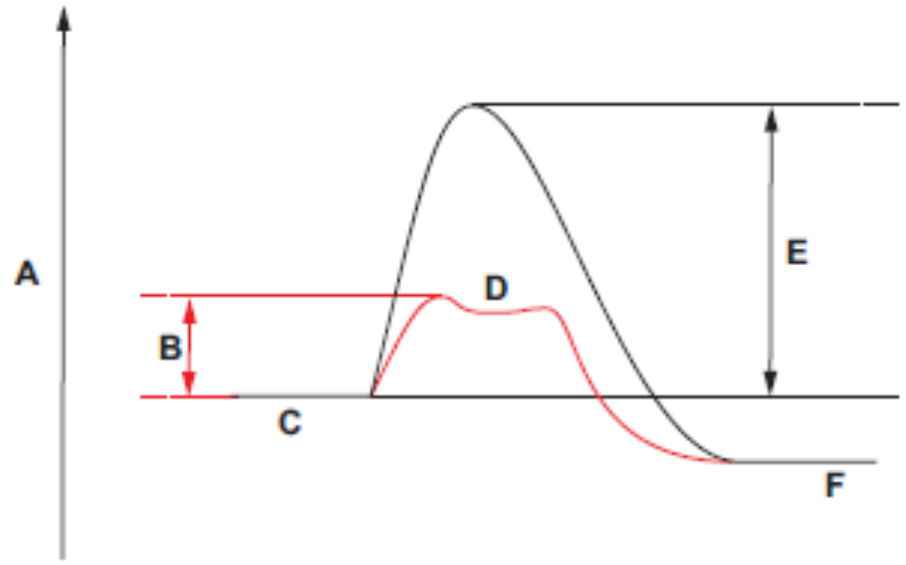
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7. Enzymes catalyse reactions by lowering the activation energy of a reaction. This is shown in the graph below.



(a) Using letters from the graph, identify the following: [2]

- the energy level of the products of an enzyme catalysed reaction .....
- the activation energy of an enzyme catalysed reaction .....
- the energy level of an enzyme-substrate complex .....

(b) Adenylate kinase (ADK) is a globular protein that acts as an enzyme involved in the regeneration of ATP in muscle. There are several types of this enzyme. One form catalyses the following reaction:

$$2ADP \longrightarrow AMP + ATP$$

(AMP = adenosine monophosphate)

(i) Suggest why the activity of ADK would be an advantage to muscle. [1]

.....

.....

(ii) The 'lock and key' model of enzyme action was first proposed in 1894 by Emil Fischer and provides a simple explanation of how enzymes and substrates interact. However, ADK interacts with its substrates by the induced fit mechanism proposed in 1958 by Daniel Koshland.

Explain how the induced fit mechanism differs from the lock and key model. [2]

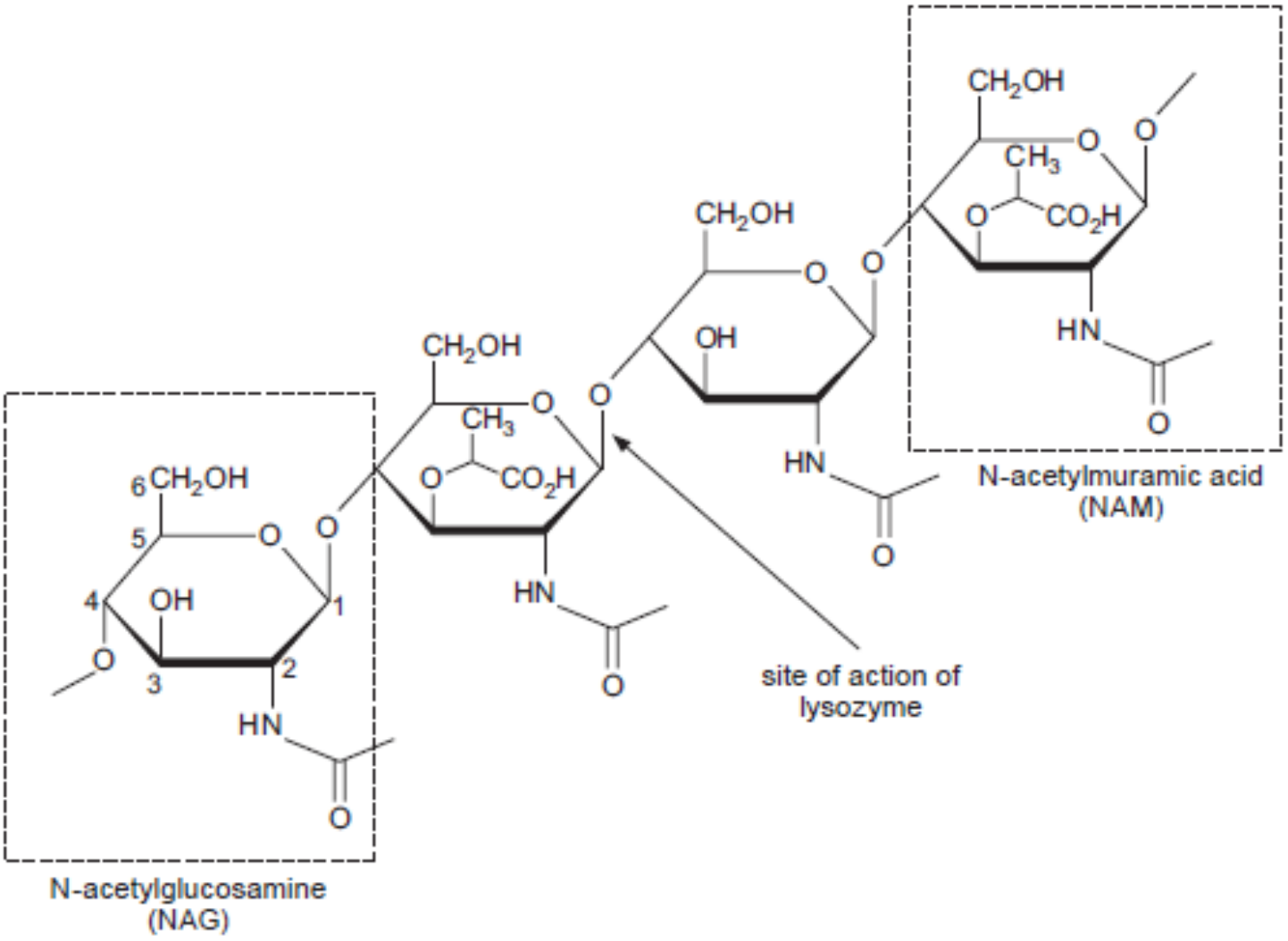
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(c) Lysozyme is an enzyme which also forms enzyme-substrate complexes through the induced fit mechanism and can function both intra- and extra-cellularly. It catalyses the hydrolysis of a bond in the peptidoglycan component of the cell walls of some bacteria. This is shown in the diagram below. The carbon atoms have been numbered on one molecule of NAG (N-acetylglucosamine).



(i) State the difference between an intra- and an extra-cellular enzyme. [1]

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.....

(i

.....

.....

(ii

.....

.....

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1.

Question			Marking details	Marks Available
1	*(a)*	(i)	Activation energy;	1
		(ii)	Line starting and finishing at the same point but with a lower activation energy;	1
	(b)		The <u>active site</u> (of succinate dehydrogenase) has a <u>specific shape</u>; Succinate has a <u>complementary</u> shape; (and therefore) {fits/ binds/ bonds to} into the active site; NOT attaches	Max 2
	(c)	(i)	I The concentration of succinate/ substrate; II As the concentration of the {succinate/substrate} increases {the rate of reaction/production of fumarate increases};	1 1
		(ii)	The concentration of succinate dehydrogenase/ enzyme; all of its active sites are occupied (at any given moment);	2
	(d)	(i)	Malonate has a similar {shape/structure} to {succinate/ substrate} / malonate has a complementary {shape/structure} the active site; NOT same shape Malonate {binds/ competes} to the active site; Prevents succinate binding / fewer enzyme-substrate complexes are formed; (MP3 must be in context of competitive inhibition)	3
		(ii)	Curve rising at a lower rate and plateaus at the max rate at a higher concentration; Accept max rate may not be reached	1
			Question 1 Total	**[12]**

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2.

(a)	$\frac{5.8}{0.5}$; 11.6 cm^3 min^{-1}; (allow: 5.8/30 x 60) correct answer + units =2; correct answer - units =1; incorrect answer, correct working = 1	**2**
(b)	Maximum/higher concentration of substrate;	
	all active sites occupied; (not: ref. unoccupied at start)	**2**
(c) (i)	increase in rate from 20 - 100°C/up to 100°C;	
	fall from 100 - 130°C;	
	increase in kinetic energy;	
	molecules move faster; (not: more)	
	More successful collisions/more enzyme-substrate complexes formed;	
	up to optimum; (not: 100°C unqualified)	
	above optimum increased vibrations;	
	hydrogen bonds break;	
	Loss/change of shape of active site; (not: ref. enzyme)	
	denature;	**6 max**
(ii)	enzymes have different optimum temperatures/	
	human amylase has optimum of 37°C, bacterial 100°C;	**1**
	human amylase denatures at a lower temperature;	**1**
		(Total 12 marks)

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3.

Question			Marking details	Marks Available
3	(a)	(i)	Lock and key;	1
		(ii)	Theory 1/ induced fit;	1
	(b)		Enzyme substrate complex; NOT ESC/ ES complex	1
	(c)		Lower the activation energy/eq;	1
	(d)		Enzyme/ active site is unchanged/can be re-used; NOT active sites are a specific shape unqualified	1
	(e)		Temperature (not heat); pH; NOT acidity Enzyme concentration; Substrate concentration; NOT amount	3
	(f)		Intracellular: inside the cell + Extracellular:outside the cell; NOT inside body	1
			Question 3 total	**[9]**

4.

Question			Marking details	Marks Available
4	(a)		Any **two** from Product not contaminated with enzyme; Enzyme can be re-used/ small quantity of enzyme required; Can {withstand/tolerate} a wider range of pH; Can be used in a continuous process;	Max 2
	(b)		Increases (contact) time between enzymes and substrate/ more time for pectinase to digest {apple pulp/pectin}; More successful collisions/more enzyme substrate complexes formed; NOT ESC	2
	(c)	(i)	40°C to 60°C {decrease in/less} (volume of) juice extracted; NOT less juice extracted above 40 °C Above 60 °C no juice extracted; Between 40 °C and 60 °C enzymes are denaturing/ above 60°C they are denatured; Hydrogen bonds break; {Tertiary structure deformed / active site changes shape} {Substrate can no longer fit/ fewer enzyme substrate complexes formed};	Max 4
		(ii)	(Free enzymes) can move; Increased chance of successful collision / more enzyme substrate complexes formed;	2
		(iii)	(Increased juice extracted with membrane bound enzymes) because membrane bound enzymes are {more accessible/OWTTE} to substrate; (Enzymes immobilised inside bead) substrate has to {diffuse/pass} into bead;	2
			Question 4 Total	**[12]**

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5.

Question			Marking details	Marks Available
5	*(a)*		Produced by cells / is a protein; speed up (the rate of a) reaction (without being used or changed themselves) ; NOT activation energy	2
	(b)	(i)	all (three) enzymes {have high activity / are working well};	1
		(ii)	blood;	1
		(iii)	1. enzymes are specific; 2. each {stain / protein} has a different shape / different shaped substrates; NOT structure alone 3. would not fit one active site / three different active sites are needed;	Max 2
		(iv)	1. (at this temperature) all (three) enzymes {non-functional / denatured / no activity}; 2. due to breaking of hydrogen bonds; Allow H bonds REJECT listing of all bonds 3. active site deforms; 4. {prevents / no} { enzyme-substrate complexes forming / successful collisions}; REJECT: less enzyme-substrate complexes	4

	(c)	(i)	Any **4** from 1. (Isoleucine) has a similar {shape / structure} to threonine / complementary to the active site of {enzyme 1 / threonine deaminase}; NOT same shape 2. Less enzyme substrate complexes formed/ more enzyme inhibitor complexes formed / fewer successful collisions; NOT no enzyme substrate complexes 3. Less threonine is converted / reaction decreases; NOT no threonine (ecf) 4. So (concentration) of {isoleucine/product} decreases / less product; 5. {increasing concentration of threonine / more threonine added} reduces effect of {inhibitor / isoleucine};	Max 4
		(ii)	prevents {build up /overproduction} of {end product / isoleucine / harmful concentrations} / (pathway) stops when {sufficient / enough} product is made / regulating the production of {isoleucine / product} / stops isoleucine reaching toxic levels;	1
			Question 5 total	**[15]**

6.

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)		Activation energy	1			1		
		(ii)		Curve drawn with a lower activation energy under existing curve – energy state at beginning and end must be the same.	1			1		
	(b)			{Alcohol dehydrogenase/ enzyme} has a specific {shaped active site/ tertiary structure/ OWTTE} (1) {Ethanol/ substrate} has a complementary (shape) (1) (The two fit together) to form an enzyme-substrate complex (1)	3			3		
	(c)	(i)		Any answer between 0.57 - 0.63 = 2 marks If incorrect award 1 mark for sight of : attempted calculation of gradient		2		2	2	
		(ii)		1. P: the rate of reaction is higher as the concentration of {ethanol/ substrate} is high (1) 2. The concentration of {alcohol dehydrogenase/ enzyme} is limiting the rate of reaction; (1) 3. Q: the rate of reaction is lower the concentration of {ethanol/ substrate} decreases(1) 4. The concentration of {ethanol/ substrate} becomes the limiting factor. (1)		2	2	4		
6	(d)			1. Ethanol and ethylene glycol must have a similar structure / Ethanol and ethylene glycol must both be complementary to the shape of the active site of {alcohol dehydrogenase/ the enzyme} (1) 2. ethanol acts as a competitive inhibitor (1) 3. When ethanol binds to the active site it prevents ethylene glycol from attaching (1) 4. Fewer enzyme-substrate complexes form (1) 5. Which reduces the rate of production of {glycoaldehyde/ product} (1)		3	2	5		
				Question 6 total	5	7	4	16	2	

7.

Question				Marking details		Marks Available					
					S	AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		F B D All 3 ✓ =2, 2 ✓ = 1;		2			2		
	(b)	(i)		ATP can be regenerated quickly/More ATP for muscle contraction (1) Not: more energy produced			1		1		
		(ii)		lock and key active site shape already 'fixed'/ 'perfectly complementary' (1) (3D) active site changes shape when substrate binds/OWTTE (1)		2			2		
	(c)	(i)		intra act within a cell + extra outside a cell (1)		1			1		
				Question 7 total		**5**	**1**	**0**	**6**	**0**	**0**