CAMBRIDGE INTERNATIONAL AS & A LEVEL BIOLOGY · 9700

BIOLOGY



EXAM QUESTION PACK

3 ENZYMES

SCORE	PERCENTAGE
/	%

STEMUP

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Chapter 3

Enzymes

3.1 Mode of action of enzymes

461. 9700_s20_qp_11 Q: 12

Protease enzymes are found in many locations inside and outside the cells. Four of these locations are listed.

1 lysosomes

2 lumen of the stomach

3 at a telophase spindle

4 mucus in the trachea

Which of these locations are sites of intracellular hydrolysis?

A 1, 2, 3 and 4

B 1, 2 and 4 only

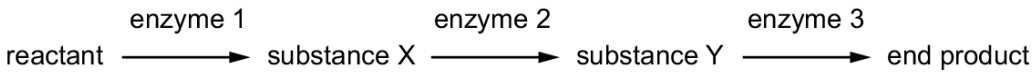
C 1 and 3 only

D 2 and 4 only

---

462. 9700_s20_qp_12 Q: 13

The diagram shows a metabolic pathway.



What would be the effect of adding a small amount of a non-competitive inhibitor of enzyme 2?

A Enzyme 2 would be partially denatured.

B Substance X would increase in concentration.

C Substance Y would no longer be formed.

D The initial reactant would no longer be metabolised.

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463. 9700_s20_qp_12 Q: 14

Two enzymes are added to a solution containing a low concentration of a substrate that they can both use.

Which statement is correct?

A Both enzymes will use equal amounts of the substrate.

B Neither enzyme will be able to use the substrate.

C The enzyme with the lower V_{max} will use less of the substrate than the other enzyme.

D The enzyme with the lower V_{max} will use more of the substrate than the other enzyme.

---

464. 9700_w20_qp_11 Q: 13

Which enzyme is extracellular?

A Amylase in saliva is an enzyme that catalyses the breakdown of starch in the mouth.

B ATP synthetase is an enzyme found in mitochondria that synthesises ATP.

C DNA polymerase is an enzyme that helps build DNA molecules by assembling nucleotides.

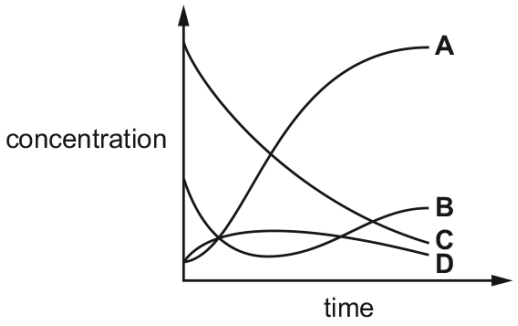
D RNA polymerase is an enzyme involved in the process of gene transcription.

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465. 9700_w20_qp_11 Q: 14

The graph shows how the concentration of components of an enzyme-catalysed reaction changes with time.

Which line represents enzymes with empty active sites?



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466. 9700_w20_qp_12 Q: 12

Which statements describe some enzyme actions?

1 Enzymes hold reacting molecules so that their reactive groups are close together.

2 In an enzyme-catalysed reaction, more molecules have sufficient energy to react than in the absence of the enzyme.

3 Reactions catalysed by enzymes take place at a lower temperature than they would without the enzyme.

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

---

467. 9700_w20_qp_12 Q: 14

The painkiller ibuprofen reduces the activity of an enzyme involved in the production of prostaglandin.

Ibuprofen binds reversibly to the active site of the enzyme.

Which type of enzyme inhibition describes this example and why?

A competitive inhibition because ibuprofen alters the shape of the enzyme

B competitive inhibition because ibuprofen and the substrate cannot bind at the same time

C non-competitive inhibition because ibuprofen blocks the active site

D non-competitive inhibition because ibuprofen has the same shape as the substrate

---

468. 9700_w20_qp_13 Q: 13

Lysozyme occurs in human tears, saliva, milk and mucus.

Lysozyme has a role in the immune system and hydrolyses peptidoglycan.

Which description of lysozyme is correct?

A It is an extracellular antibody.

B It is an intracellular antibody.

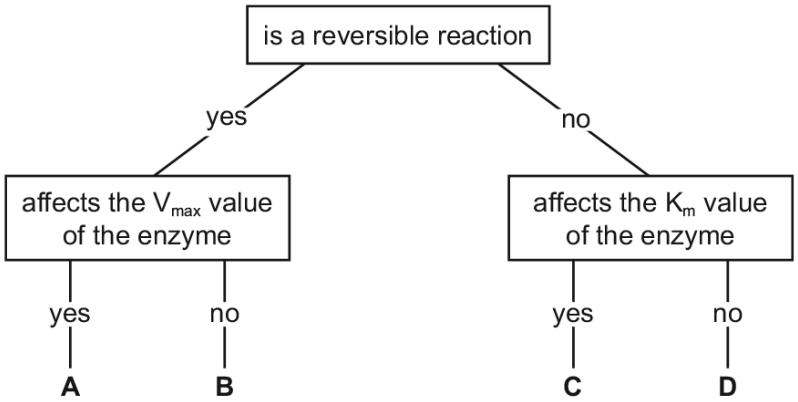
C It is an extracellular antibacterial protein.

D It is an intracellular antibacterial protein.

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469. 9700_w20_qp_13 Q: 14

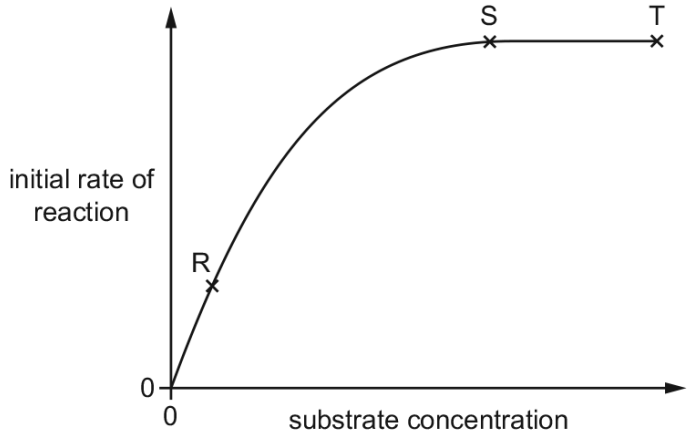
Which letter in the flow diagram shows the effect of adding a competitive inhibitor to an enzyme-catalysed reaction?



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470. 9700_m19_qp_12 Q: 15

The graph shows the effect of substrate concentration on the initial rate of an enzyme-catalysed reaction. The enzyme concentration is constant.



Which statement about the graph is correct?

A Between R and S the number of enzyme molecules is limiting the rate of reaction.

B Between R and S the number of product molecules is limiting the rate of reaction.

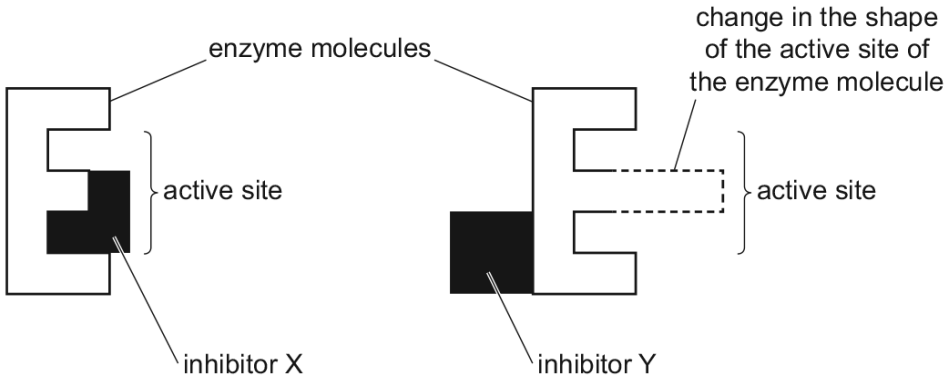
C Between S and T the number of enzyme molecules is limiting the rate of reaction.

D Between S and T the number of substrate molecules is limiting the rate of reaction.

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471. 9700_m19_qp_12 Q: 16

The diagram represents the reversible interaction between the active site of an enzyme and different inhibitors, X and Y.



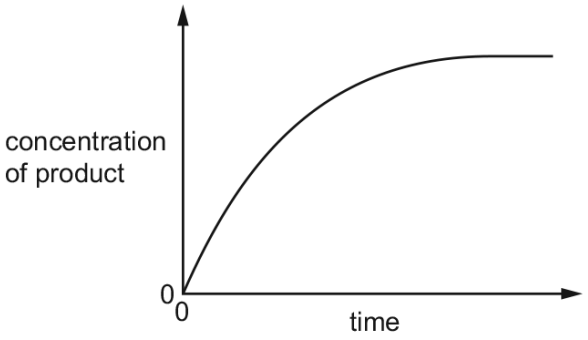
Which row correctly identifies the type of inhibition shown by inhibitor X and inhibitor Y?

	X	Y
A	competitive	competitive
B	competitive	non-competitive
C	non-competitive	competitive
D	non-competitive	non-competitive

---

472. 9700_s19_qp_12 Q: 10

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



What explains the shape of this graph?

A The active sites become saturated.

B The enzyme was denatured.

C The hydrogen peroxide inhibited the reaction.

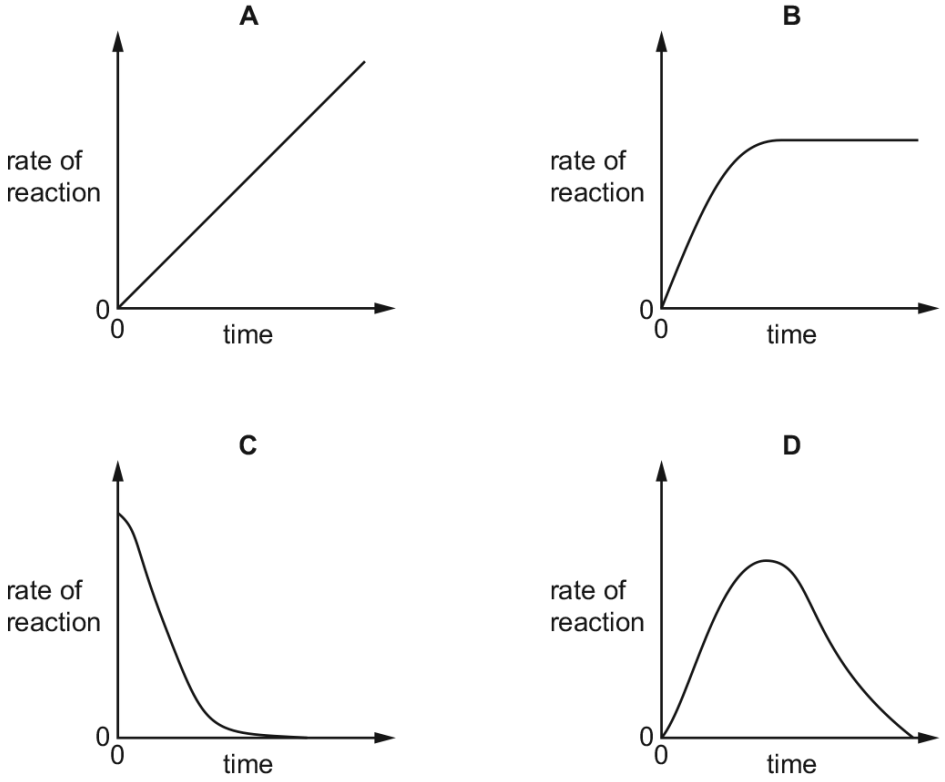
D The substrate molecules were used up.

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473. 9700_s19_qp_12 Q: 11

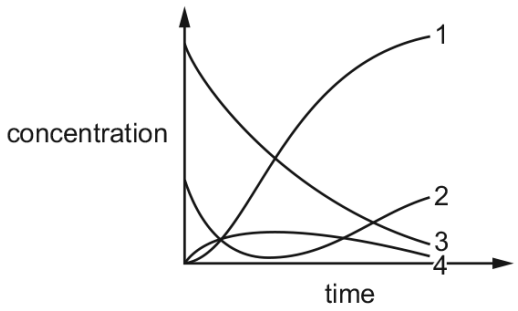
A fixed volume and concentration of substrate and enzyme were mixed. All other variables were kept constant. The enzyme-catalysed reaction was left until it was complete.

Which graph shows how the rate of reaction changes with time?



474. 9700_w19_qp_11 Q: 14

The graph shows how the concentration of components,1, 2, 3 and 4, of an enzyme-catalysed reaction changes with time.



Which row identifies the components of this reaction?

	component 1	component 2	component 3	component 4
A	enzyme–substrate complex	unbound enzyme	product	substrate
B	enzyme–substrate complex	product	substrate	unbound enzyme
C	product	enzyme–substrate complex	unbound enzyme	substrate
D	product	unbound enzyme	substrate	enzyme–substrate complex

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475. 9700_w19_qp_12 Q: 14

Which statement about the active site of an enzyme is correct?

A It always has a specific fixed shape.

B It reduces the total energy of the product.

C It does not form chemical bonds with its substrate.

D It is determined by the primary structure of the enzyme.

---

476. 9700_m18_qp_12 Q: 13

Lysosomes contain many different hydrolytic enzymes that may act within cells (intracellular enzymes) or outside cells (extracellular enzymes).

Which process must occur in order for lysosomal enzymes to act outside the cell?

A active transport

B endocytosis

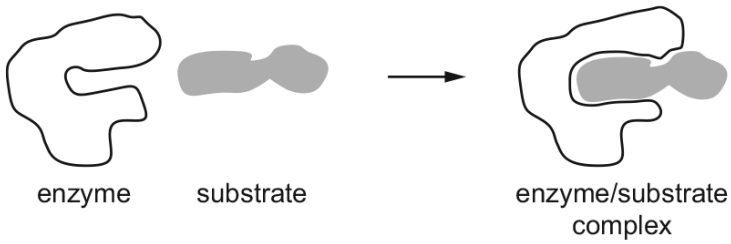
C exocytosis

D phagocytosis

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477. 9700_m18_qp_12 Q: 14

The diagram shows an enzyme, its substrate and an enzyme/substrate complex.



Which statement explains how the substrate is able to enter the active site of the enzyme?

A Contact between the substrate and the enzyme causes a change in the enzyme shape.

B The shape of the active site and the shape of the substrate are complementary.

C The substrate within the active site forms hydrogen bonds with amino acids.

D When the enzyme/substrate complex forms, the tertiary structure of the enzyme changes.

---

478. 9700_m18_qp_12 Q: 15

What could be used to calculate the rate of an enzyme-catalysed reaction?

1 the appearance of product

2 the disappearance of substrate

3 the Michaelis-Menten constant (K_m)

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

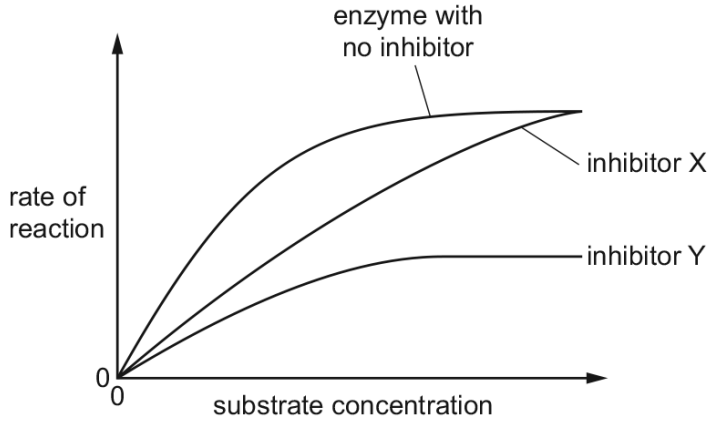
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479. 9700_s18_qp_11 Q: 13

The effect of substrate concentration on an enzyme-catalysed reaction was measured in three different conditions:

- with no inhibitor
- with a competitive inhibitor
- with a non-competitive inhibitor.

The graph shows the results.



Which statement is correct?

A X is a competitive inhibitor which binds to a site other than the active site of the enzyme.

B X is a non-competitive inhibitor which has a similar shape to the active site of the enzyme.

C Y is a competitive inhibitor which has a similar shape to the active site of the enzyme.

D Y is a non-competitive inhibitor which binds to a site other than the active site of the enzyme.

480. 9700_s18_qp_13 Q: 14

Four students investigated the effect of catalase on hydrogen peroxide.

Each student started a digital clock at the beginning of the experiment and stopped the clock after 25 bubbles had been counted.

The time recorded on the digital clock is shown below.

hours	minutes	seconds	hundredths of a second
00	01	33	54

Which of the times recorded by the students is appropriate for this experiment?

A 1.34 minutes

B 1 minute 33.54 seconds

C 94 seconds

D 93.54 seconds

---

481. 9700_s18_qp_13 Q: 15

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

A decreases the activation energy and decreases the energy yield

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

C increases the activation energy and increases the energy yield

D increases the energy yield and decreases the activation energy

---

482. 9700_w18_qp_13 Q: 15

An investigation was carried out on the effect of temperature on an enzyme-catalysed reaction.

The enzyme and its substrate were initially placed into separate test-tubes and raised to the temperature required. They were then mixed and placed into four tubes **A**, **B**, **C** and **D**.

These tubes were incubated for the time and at the temperature stated. The mass of the product formed was then measured.

In which tube was the rate of reaction highest?

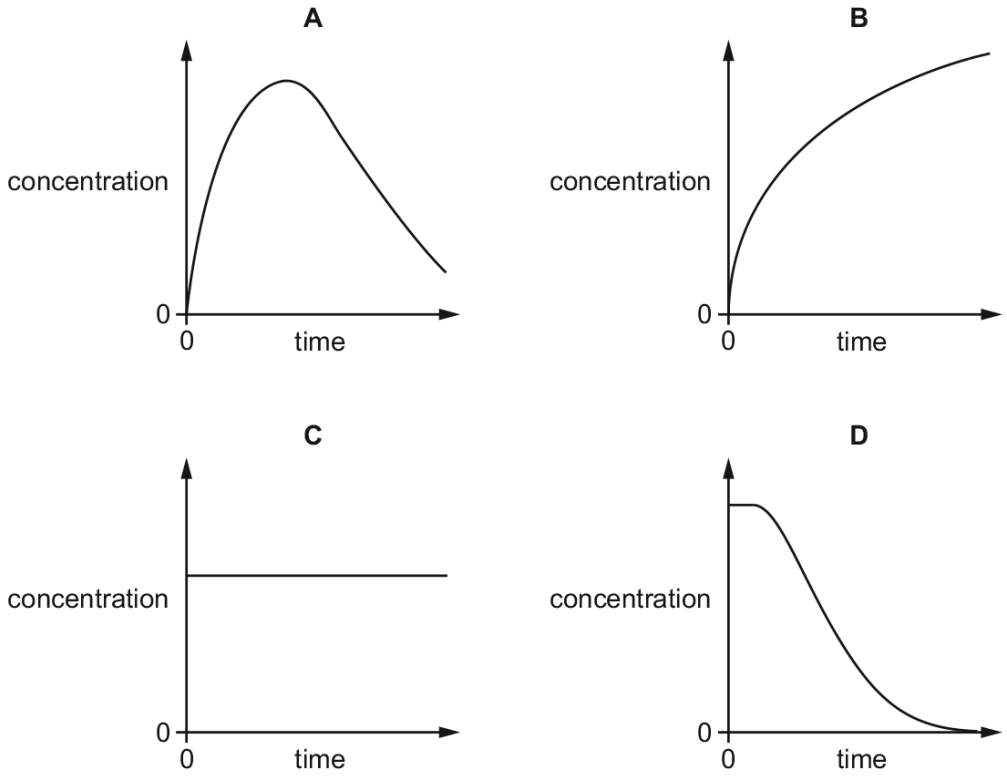
	incubation time / s	incubation temperature / °C	mass of product / μg
A	30	25	2.5
B	30	45	5.0
C	600	25	32.0
D	600	45	10.0

483. 9700_m17_qp_12 Q: 14

An enzyme was added to a small excess of its substrate. All variables were kept constant.

A student was asked to sketch a graph to show how the concentration of the enzyme-substrate complex changes over time.

Which graph shows this correctly?

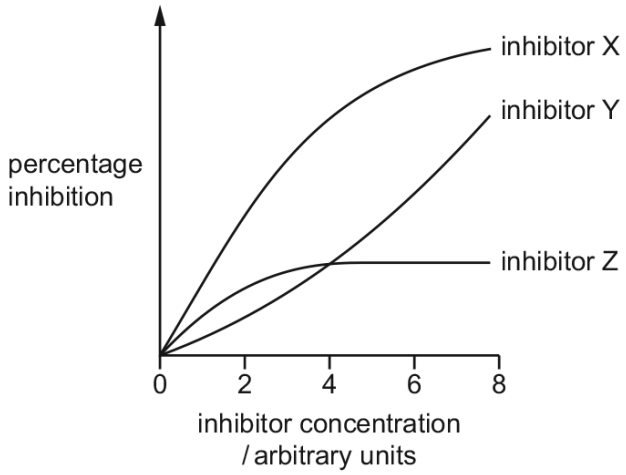


484. 9700_s17_qp_12 Q: 10

The enzyme invertase catalyses the breakdown of sucrose to glucose and fructose.

Three different enzyme inhibitors of invertase X, Y and Z were investigated. The percentage inhibition of invertase was measured at different concentrations of inhibitor.

The graph shows the result of the investigation.



Which are valid conclusions from these results?

1 The higher the concentration of inhibitor X, the less sucrose is broken down.

2 The production of glucose and fructose using inhibitor Y is higher than when inhibitor Z is used.

3 The production of glucose and fructose at an inhibitor concentration of 2 arbitrary units is lower than at an inhibitor concentration of 4 arbitrary units, for all inhibitors.

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

---

485. 9700_s17_qp_12 Q: 11

The following statements are about enzymes.

1 Folding of an enzyme molecule causes the formation of the active site.

2 The shape of the active site changes to enable the substrate to bind.

3 Temporary bonds hold the substrate in the active site.

4 More enzyme-substrate complexes are formed at the optimum temperature.

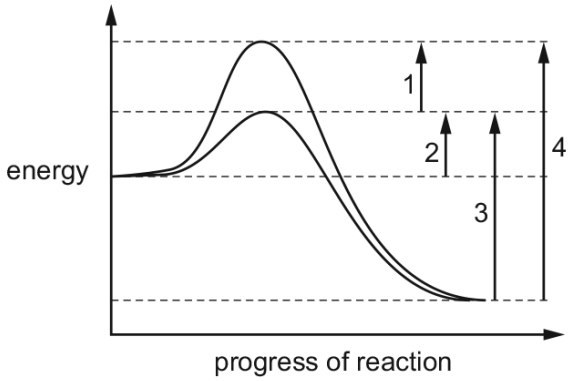
Which statements are correct for the induced fit hypothesis?

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

---

486. 9700_s17_qp_13 Q: 10

The graph shows energy changes in a chemical reaction.



What is the activation energy when an enzyme is added?

A 1 + 2 **B** 2 only **C** 3 – 2 **D** 4

---

487. 9700_w17_qp_11 Q: 11

Some RNA molecules, called ribozymes, can catalyse reactions in a similar way to protein enzymes.

Most of these ribozymes have other RNA molecules as their substrates and catalyse reactions that break specific sugar phosphate bonds in the substrate molecules.

Which statements about these ribozymes are correct?

1 Hydrogen, ionic and disulfide bonds will be involved in the ribozyme structure.

2 The active site of a ribozyme is formed from a specific sequence of nucleotides.

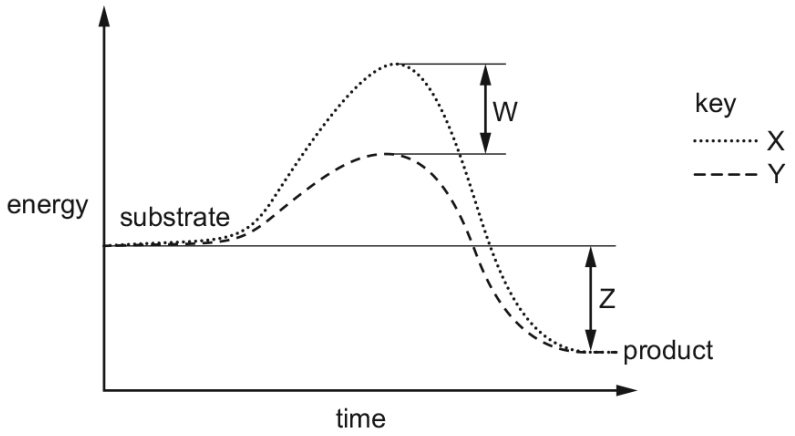
3 Ribozymes can form because RNA can have a specific secondary and tertiary structure.

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

---

488. 9700_w17_qp_11 Q: 12

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



Which labels are correct?

A X is the reaction without the enzyme, W is the activation energy.

B X is the reaction with the enzyme, Z is the overall energy change.

C Y is the reaction with the enzyme, W is the difference in activation energy.

D Z is the energy gained by the product, W is the activation energy with the enzyme.

---

489. 9700_w17_qp_11 Q: 14

The following are all processes that allow movement into cells.

1 phagocytosis

2 active transport

3 facilitated diffusion

Which processes require ATP?

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

---

490. 9700_w17_qp_12 Q: 14

Which of these statements describe the action of an extracellular enzyme?

1 synthesis of a polynucleotide in the nucleus during DNA replication

2 digestion of macromolecules in the lumen of the small intestine

3 synthesis of ATP molecules in the mitochondria

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

---

491. 9700_w17_qp_12 Q: 16

Which statement about the effect of substrate concentration on the activity of an enzyme is correct?

A Above a certain concentration of substrate an enzyme reaches its maximum rate of reaction.

B At high concentration of competitive inhibitor increasing the substrate concentration has no effect.

C At high substrate concentration a non-competitive inhibitor no longer affects the enzyme activity.

D The higher the concentration of substrate the faster an enzyme can catalyse a reaction.

---

492. 9700_w17_qp_13 Q: 14

An investigation was carried out into the effect of an increasing concentration of substrate molecules on the rate of an enzyme-catalysed reaction. All other variables were standardised.

Which statement is correct?

A The rate increases to a maximum and then levels off.

B The rate increases to an optimum and then decreases.

C The value of K_m will increase.

D The V_{max} will never be reached.

---

493. 9700_w17_qp_13 Q: 15

Which features are correct for a competitive inhibitor of an enzyme-catalysed reaction?

	binds to active site	changes shape of enzyme	similar shape to substrate	rate of reaction affected by concentration of inhibitor
A	✓	✗	✓	✓
B	✓	✗	✗	✓
C	✗	✓	✓	✗
D	✗	✓	✗	✗

key
✓ = correct
✗ = incorrect

---

494. 9700_m16_qp_12 Q: 11

The rate of enzyme-catalysed reactions in human cells is regulated.

What may be involved in such regulation?

1 a change in enzyme concentration

2 a change in substrate concentration

3 inhibition by the final product of the reaction

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

---

495. 9700_m16_qp_12 Q: 13

Which statement correctly describes the action of competitive enzyme inhibitors?

A They bind permanently to the active site.

B They change the shape of the active site.

C They limit the formation of enzyme-substrate complexes.

D They lower the activation energy of the reaction.

---

496. 9700_s16_qp_11 Q: 12

Influenza virus has an enzyme called neuraminidase which breaks down glycoproteins in the membrane of the cell that the virus will infect. The glycoprotein binds to the active site of neuraminidase by induced fit.

Which statements about the induced fit hypothesis of enzyme action are correct?

1 The active site must have a complementary shape to the substrate for them to bind together.

2 This enzyme is less likely to be affected by non-competitive inhibitors than an enzyme working by the lock and key mechanism.

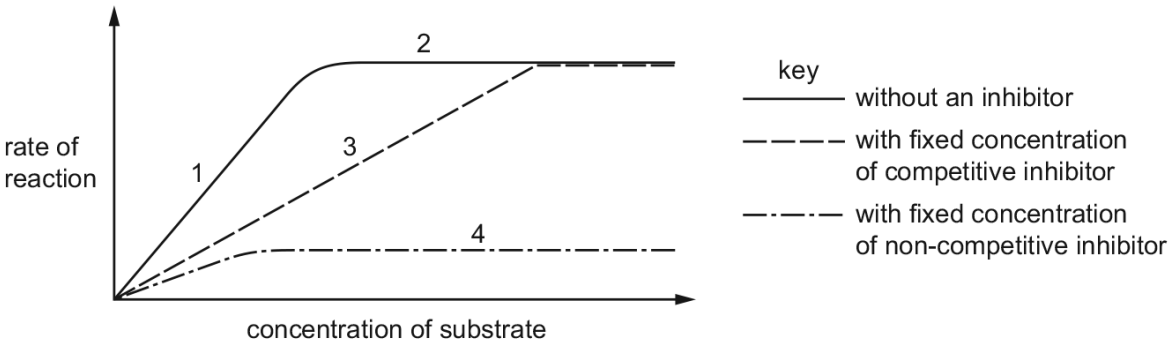
3 The substrate is converted to product by specific R-groups in the active site just like the lock and key mechanism.

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

---

497. 9700_s16_qp_11 Q: 14

The graph shows the effect of increasing the concentration of substrate on the rate of an enzyme-catalysed reaction.



What is limiting the rate of the enzyme-catalysed reaction at 1, 2, 3 and 4 on the graph?

	1	2	3	4
A	enzyme concentration	substrate concentration	competitive inhibitor	non-competitive inhibitor
B	enzyme concentration	substrate concentration	non-competitive inhibitor	competitive inhibitor
C	substrate concentration	enzyme concentration	competitive inhibitor	non-competitive inhibitor
D	substrate concentration	enzyme concentration	non-competitive inhibitor	competitive inhibitor

---

498. 9700_s16_qp_12 Q: 10

In two investigations, the rate of an enzyme-catalysed reaction was measured in the presence of either a competitive inhibitor or a non-competitive inhibitor.

What could be the effect of increasing the substrate concentration on each rate of reaction?

	rate of reaction	
	with competitive inhibitor	with non-competitive inhibitor
A	decreases	no change
B	increases	decreases
C	increases	no change
D	no change	decreases

---

499. 9700_s16_qp_13 Q: 11

Which statement is **only** true for the induced fit theory of enzyme action?

A A few amino acids give the active site a specific shape.

B An enzyme has a substrate with a specific shape.

C The enzyme changes shape in the presence of the substrate.

D The substrate molecules are complementary to the active site.

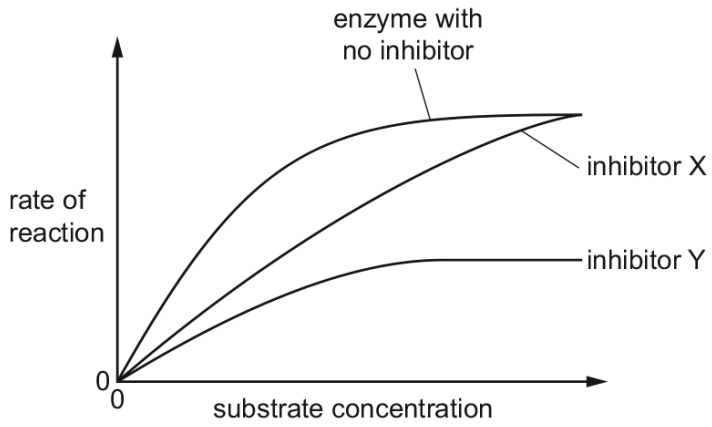
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500. 9700_s16_qp_13 Q: 12

The effect of substrate concentration on an enzyme-catalysed reaction was measured in three different conditions:

- with no inhibitor
- with inhibitor X
- with inhibitor Y.

The graph shows the results.



Which statement is correct?

A X is a competitive inhibitor which binds away from the active site of the enzyme.

B X is a non-competitive inhibitor which has a similar shape to the substrate.

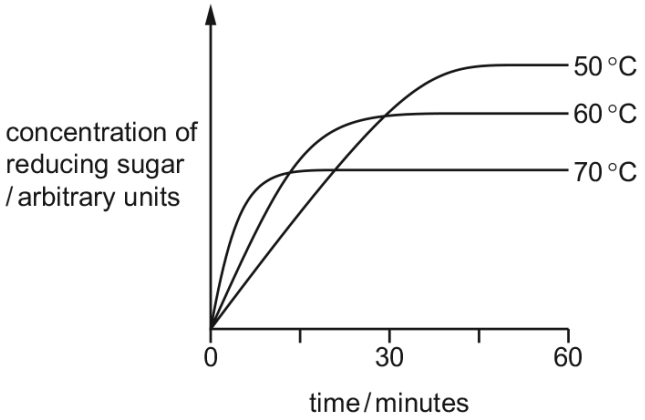
C Y is a competitive inhibitor which has a similar shape to the substrate.

D Y is a non-competitive inhibitor which binds away from the active site of the enzyme.

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501. 9700_w16_qp_12 Q: 14

The graph shows the results of an investigation into the effect of amylase on starch at three different temperatures.



Which statements are correct conclusions using these results?

1 The optimum temperature is 50 °C.

2 The initial rate of reaction is highest at 70 °C.

3 The higher the temperature the more quickly the enzyme denatures.

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

---

502. 9700_w16_qp_13 Q: 11

An investigation into the rate of an enzyme-catalysed reaction was carried out. During the investigation the concentration of the substrate was kept higher than the concentration of the enzyme.

During this investigation, which change in the variables would always lead to an increase in the rate of the reaction?

1 increase in enzyme concentration

2 increase in pH

3 increase in temperature

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

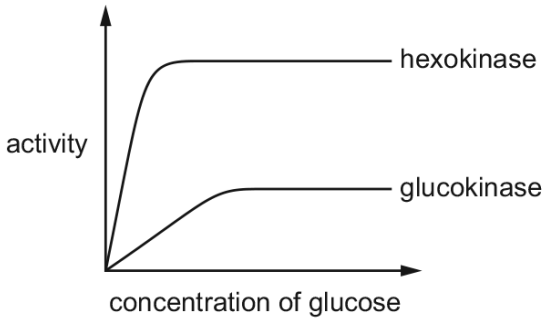
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503. 9700_w16_qp_13 Q: 12

The enzymes glucokinase in the liver and hexokinase in the brain both catalyse the phosphorylation of glucose:

$$\text{glucose} + \text{ATP} \rightarrow \text{glucose phosphate} + \text{ADP}$$

The activity of each enzyme was measured at different concentrations of glucose. The graph shows the results.



What describes the different activities of the two enzymes?

A Both enzymes hold glucose and ATP molecules together at the active site.

B Glucokinase becomes saturated with glucose at a lower concentration of glucose than hexokinase.

C Glucokinase phosphorylates more molecules of glucose per minute.

D The affinity of hexokinase for glucose is greater than that of glucokinase.

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504. 9700_s15_qp_11 Q: 13

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

1 change 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

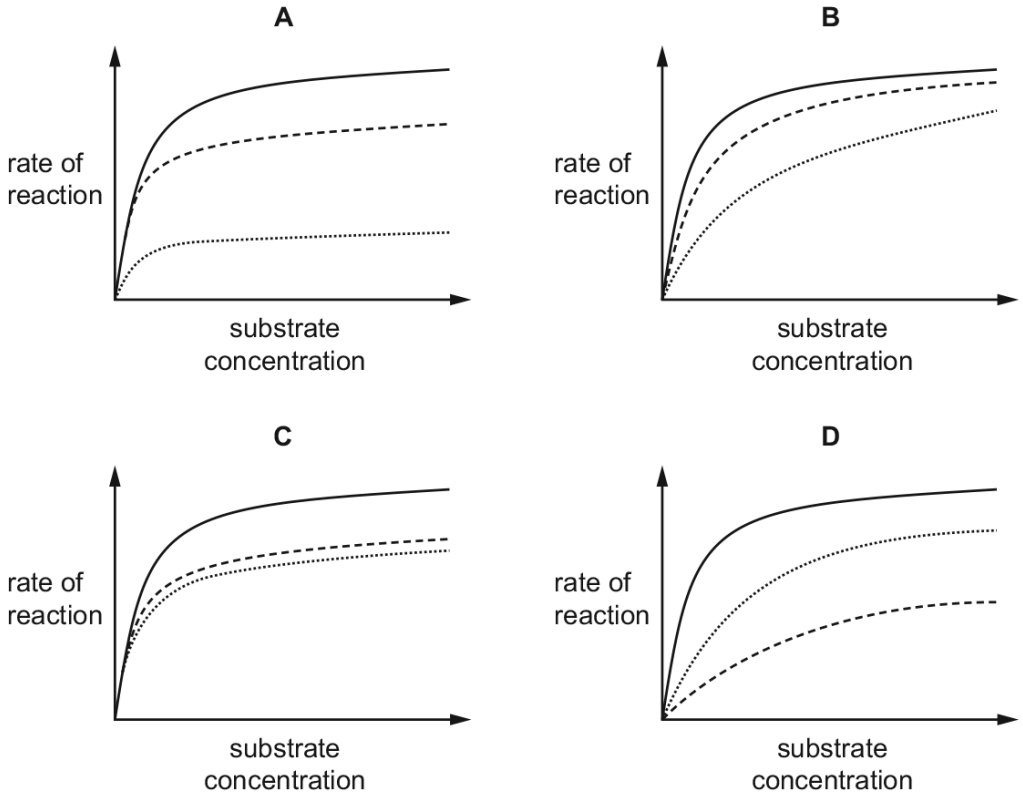
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505. 9700_s15_qp_11 Q: 14

The graphs show the rate of reaction of an enzyme-catalysed reaction.

Which graph shows the effect of increasing the concentration of the substrate at two different concentrations of a competitive inhibitor?

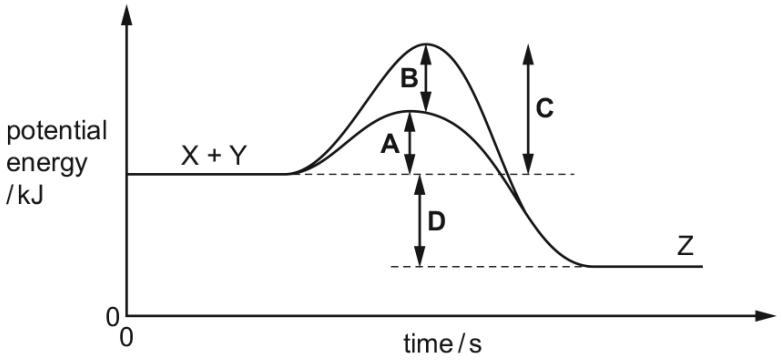
key
——— no inhibitor
- - - - - - low concentration of inhibitor
..... high concentration of inhibitor



506. 9700_w15_qp_11 Q: 12

The graph shows the energy levels involved in an enzyme-catalysed reaction. Substrate molecules X and Y combine to give product Z.

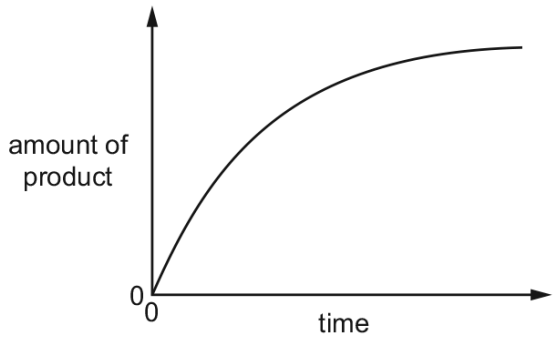
Which arrow shows the reduction in activation energy due to the enzyme?



---

507. 9700_w15_qp_11 Q: 14

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



What explains the shape of this graph?

A The active sites become saturated.

B The enzyme was denatured.

C The hydrogen peroxide inhibited the reaction.

D The substrate molecules were used up.

---

508. 9700_w15_qp_11 Q: 15

Which descriptions are correct about transport across cell surface membranes?

	active processes	passive processes
A	endocytosis and exocytosis	diffusion and osmosis
B	exocytosis and facilitated diffusion	osmosis and endocytosis
C	facilitated diffusion	exocytosis and osmosis
D	facilitated diffusion and exocytosis	endocytosis and diffusion

---

509. 9700_w15_qp_12 Q: 12

Which statements describe some enzyme actions?

1 Enzymes hold reacting molecules in such a way that their reactive groups are brought close together.

2 In an enzyme-catalysed reaction, more molecules have sufficient energy to react than in the absence of the enzyme.

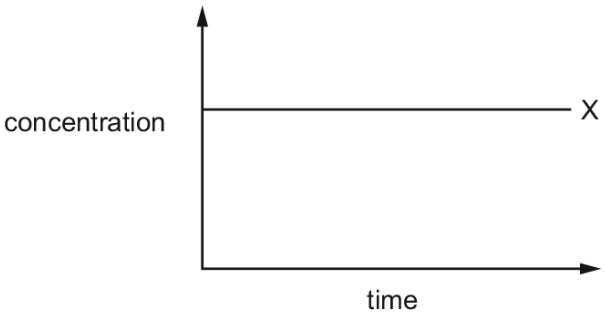
3 Reactions catalysed by enzymes take place at a lower temperature than they would without the enzyme.

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

---

510. 9700_w15_qp_13 Q: 12

The graph shows the concentration of one of the substances which is involved in an enzyme-catalysed reaction.



Which substance is shown by line X?

A enzyme

B enzyme-product complex

C enzyme-substrate complex

D substrate

---

511. 9700_w15_qp_13 Q: 13

What describes the induced fit mode of action of an enzyme?

A The binding of the active site to the substrate causes the enzyme to change shape.

B The substrate and active site have complementary shapes that form temporary bonds.

C The substrate causes a change in enzyme shape so the active site can bind.

D The substrate changes shape so it can bind to the active site.

3.2 Factors that affect enzyme action

512. 9700_m20_qp_12 Q: 13

What is the most appropriate set of controls to use in an investigation into the rate of an enzyme-catalysed reaction over a range of temperatures from 25 °C to 65 °C?

A enzyme and substrate at all temperatures tested

B enzyme and boiled substrate at all temperatures tested

C boiled enzyme only at all temperatures tested

D substrate only at all temperatures tested

---

513. 9700_m20_qp_12 Q: 14

An investigation is carried out with an enzyme at its optimum temperature and pH.

The rate of the enzyme reaction is measured at different substrate concentrations.

The investigation is repeated in the presence of a competitive inhibitor.

How will the results with the competitive inhibitor be different from the original results?

	K_m with competitive inhibitor	V_{max} with competitive inhibitor
A	higher	lower
B	higher	the same
C	the same	lower
D	the same	the same

---

514. 9700_s20_qp_11 Q: 13

An enzyme is modified for industrial use. It has a lower Michaelis-Menten constant (K_m) than the unmodified enzyme.

What is true of the modified enzyme?

A It is more specific.

B It has a higher affinity for its substrate.

C It has a lower maximum rate of reaction (V_{max}).

D It needs more substrate to become saturated.

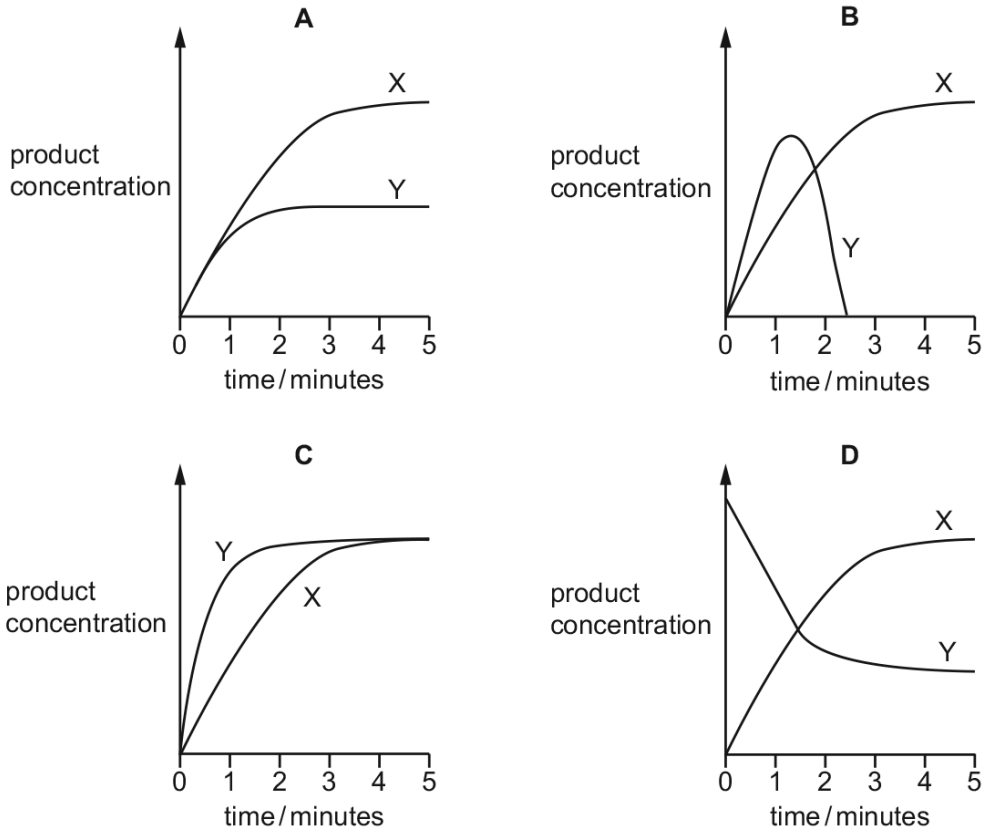
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515. 9700_s20_qp_13 Q: 12

Two experiments, X and Y, were carried out using an enzyme from humans.

Experiment X was carried out at a constant temperature of 37 °C. During experiment Y, the temperature was increased from 37 °C to 80 °C. All other factors were kept the same.

Which graph shows the results?



---

516. 9700_s20_qp_13 Q: 13

What affects the rate of an enzyme-catalysed reaction when in the presence of a non-competitive inhibitor?

1 enzyme concentration

2 inhibitor concentration

3 substrate concentration

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

---

517. 9700_w20_qp_11 Q: 15

Which effects can non-competitive inhibitors have on enzyme-controlled reactions?

1 lower the K_m value

2 reduce the concentration of the product

3 reduce the rate of a metabolic pathway

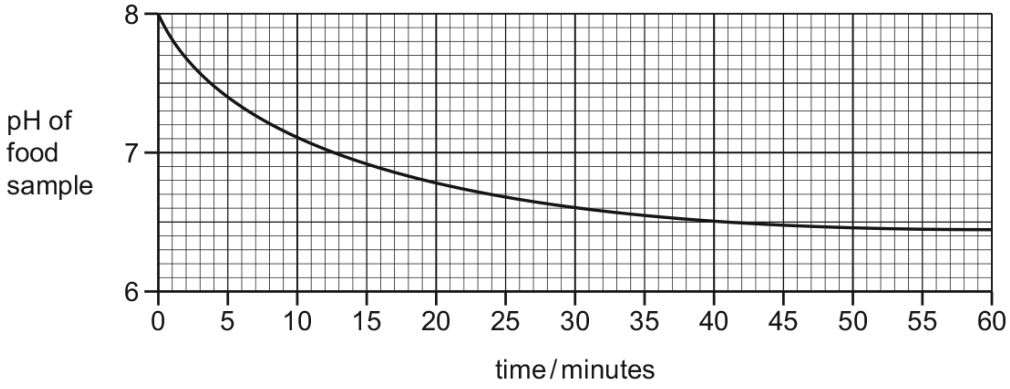
A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

---

518. 9700_w20_qp_12 Q: 13

Lipase is an enzyme that catalyses the hydrolysis of lipids. An experiment was carried out to investigate changes in pH when lipase is added to a food sample containing a high proportion of lipids.

The results are shown in the graph.



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

1 Enzyme concentration becomes the limiting factor.

2 Substrate concentration becomes the limiting factor.

3 All the enzyme active sites are occupied.

4 Denaturation of the enzyme by the products takes place.

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

---

519. 9700_s19_qp_11 Q: 14

What is the definition of the Michaelis-Menten constant, K_m, for an enzyme?

A V_{max}

B half V_{max}

C the substrate concentration that gives V_{max}

D the substrate concentration that gives half V_{max}

---

520. 9700_s19_qp_13 Q: 15

The enzyme β-galactosidase can catalyse the hydrolysis of four substrates, **A**, **B**, **C** and **D**, with similar structures.

Each substrate has a different K_m value.

For which substrate does β-galactosidase have the **lowest** affinity?

A $K_m = 4 \times 10^{-3}\,\text{mol dm}^{-3}$

B $K_m = 1 \times 10^{-3}\,\text{mol dm}^{-3}$

C $K_m = 2 \times 10^{-4}\,\text{mol dm}^{-3}$

D $K_m = 1 \times 10^{-4}\,\text{mol dm}^{-3}$

---

521. 9700_s19_qp_13 Q: 16

Which is correct for competitive inhibitors of enzymes?

1 They occupy the active site of an enzyme.

2 They have exactly the same shape as the substrate.

3 They can be used to control the rate of enzyme activity.

4 They can bind to a site on an enzyme other than the active site.

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

---

522. 9700_w19_qp_11 Q: 13

The V_{max} and K_m are determined for an enzyme-catalysed reaction.

What will be the effects on the V_{max} and K_m in the presence of a competitive inhibitor?

	V_{max}	K_m
A	decreases	increases
B	increases	decreases
C	stays the same	decreases
D	stays the same	increases

---

523. 9700_w19_qp_12 Q: 15

When investigating the rate of reaction of the enzyme lipase on the hydrolysis of triglycerides, the pH must be maintained at an optimum to prevent the lipase denaturing.

What is the reason for this?

A The addition of water molecules produced by hydrolysis increases the pH.

B The products of hydrolysis decrease the pH.

C The products of hydrolysis increase the pH.

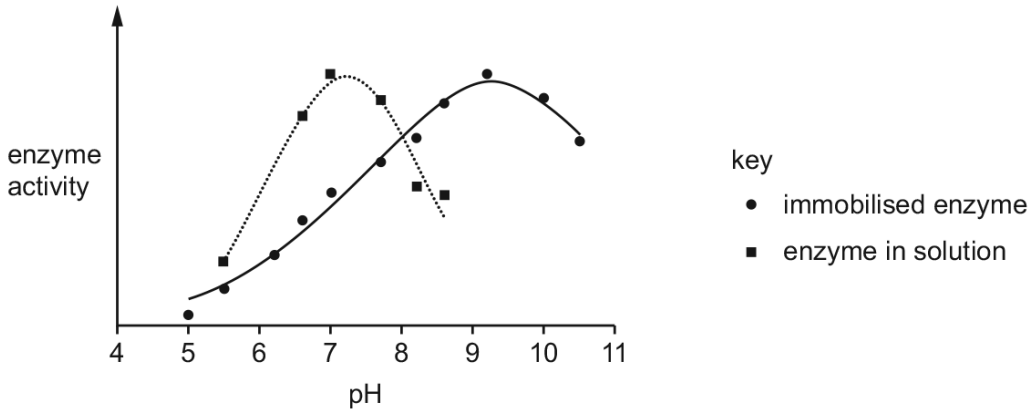
D The removal of water molecules used in hydrolysis decreases the pH.

---

524. 9700_w19_qp_12 Q: 16

An experiment was carried out to compare the effect of pH on the activity of an enzyme that was in solution and the same enzyme that had been immobilised on a gel. All other variables were kept the same.

The results are shown in the graph.



Which statement explains these results when the enzyme is immobilised?

A The primary structure has changed.

B The secondary structure has changed.

C The tertiary structure has changed.

D The quaternary structure has changed.

---

525. 9700_w19_qp_13 Q: 12

The Michaelis-Menten constant for an enzyme-catalysed reaction is referred to as K_m, and the maximum velocity of such a reaction is known as V_{max}.

Which statement about K_m and V_{max} is correct?

A An enzyme with a high value of K_m can reach its V_{max} at a low substrate concentration.

B An enzyme with a high value of K_m has a high affinity to its substrate.

C An enzyme with a low value of K_m can reach its V_{max} at a high substrate concentration.

D An enzyme with a low value of K_m has a high affinity to its substrate.

---

526. 9700_s18_qp_11 Q: 12

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

When the pH of an environment is decreased below the optimum pH of an enzyme, ……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

---

527. 9700_s18_qp_12 Q: 12

A student investigated the hydrolysis of the lipid in high-fat milk, using the enzyme lipase.

- 1 cm^3 of enzyme solution was added to 10 cm^3 of high-fat milk.
- The temperature was kept constant.
- The pH of the reaction mixture was recorded at time 0 minutes and every minute for 20 minutes.

Which statements could be supported by the results of the investigation?

1 Less product is made as time proceeds because the substrate is decreasing.

2 The pH of the reaction mixture changes more rapidly in the first few minutes and then changes less rapidly.

3 The product gradually causes more lipase molecules to denature.

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

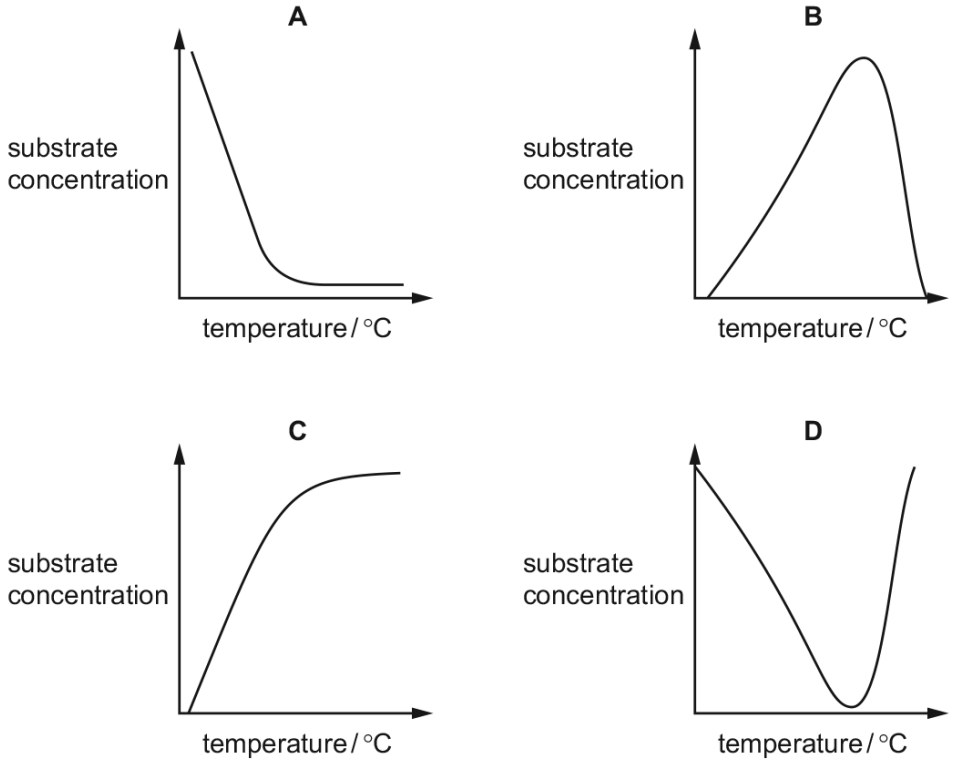
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528. 9700_s18_qp_12 Q: 13

A student carried out an investigation into the effect of temperature on the rate of an enzyme-catalysed reaction.

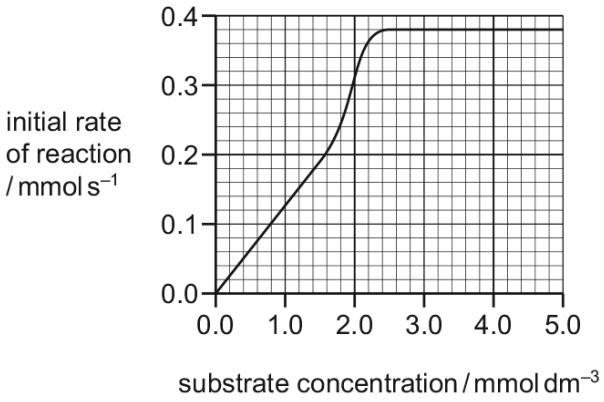
At each temperature, the substrate concentration was measured after 10 minutes. All the other variables were kept constant.

Which graph shows the effect of increasing temperature on the substrate concentration after 10 minutes?



529. 9700_s18_qp_12 Q: 14

The graph shows how the rate of an enzyme-catalysed reaction depends on the concentration of substrate.



What is the Michaelis-Menten constant (K_m) for this enzyme under these conditions?

A 0.19 mmol dm^{-3}

B 0.38 mmol dm^{-3}

C 1.5 mmol dm^{-3}

D 5.0 mmol dm^{-3}

---

530. 9700_s18_qp_13 Q: 13

Catechol is a chemical found in a number of fruits. Catechol can be oxidised to a quinone by the enzyme catechol oxidase.

Catechol oxidase is inhibited by parahyroxybenzoic acid (PHBA) which is structurally similar to catechol.

Catechol oxidase is also inhibited by phenylthiourea (PTU) which binds to a copper atom in the enzyme.

How do both these inhibitors reduce the enzyme activity?

1 altering the specificity of the enzyme

2 competing with substrates for the active site

3 decreasing the V_{max} of the reaction

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

---

531. 9700_w18_qp_11 Q: 14

Which row is correct for an enzyme with a low Michaelis-Menten constant?

	affinity of enzyme for substrate	substrate concentration at maximum reaction rate
A	high	high
B	high	low
C	low	high
D	low	low

---

532. 9700_w18_qp_12 Q: 14

Aspirin inhibits an enzyme by reacting with an amino acid that forms an essential part of the 3D structure of the enzyme. Part of the aspirin molecule binds firmly with the amino acid.

What describes this inhibition?

1 competitive inhibition

2 non-competitive inhibition

3 reversible inhibition

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

---

533. 9700_w18_qp_12 Q: 15

The table shows the Michaelis-Menten constant, K_m, for three enzymes.

enzyme	K_m / mmoldm^{-3}
C	1.5×10^{-2}
P	3.0×10^{-4}
F	5.0×10^{-6}

Which interpretation of the information is correct?

A Enzyme C has a V_{max} which is half that of enzyme P.

B Enzyme C will reach V_{max} in the shortest time interval.

C Enzyme F has the greatest affinity for its substrate.

D Enzyme P has a V_{max} of 6.0×10^{-3} mmoldm^{-3}.

---

534. 9700_w18_qp_13 Q: 13

Which statement about the typical modes of action of a competitive inhibitor and a non-competitive inhibitor is correct?

A Competitive inhibitors can bind to alternative (allosteric) sites of an enzyme, non-competitive inhibitors have an irreversible effect on the enzyme.

B Competitive inhibitors have exactly the same shape as the substrate, non-competitive inhibitors can have any shape.

C Competitive inhibitors may be used to regulate enzyme activity, non-competitive inhibitors have no functions in enzyme regulation.

D Competitive inhibitors will not alter V_{max}, non-competitive inhibitors will reduce V_{max}.

---

535. 9700_m17_qp_12 Q: 15

The table contains results recorded by a student from an investigation into the effect of temperature on an enzyme-catalysed reaction. All other variables were standardised.

temperature / °C	rate of reaction / arbitrary units
10	3
20	7
30	16
40	33
50	32
60	14

What is the correct conclusion?

A 40 °C was the optimum temperature.

B The data for 50 °C was anomalous.

C The optimum temperature was between 30 °C and 50 °C.

D The optimum temperature was between 40 °C and 50 °C.

---

536. 9700_s17_qp_11 Q: 14

A student carried out experiments to investigate the effect of enzyme concentration on the rate of hydrolysis (break down) of protein in milk.

When the enzyme and milk were mixed, the protein was hydrolysed and the mixture changed from cloudy to clear.

The student investigated five different enzyme concentrations and recorded the time taken to reach the end-point for each.

What is an appropriate control for this investigation?

A Carrying out a further experiment where the enzyme solution is replaced with water.

B Carrying out each experiment in a thermostatically regulated water-bath at 35 °C.

C Performing three repeat experiments for each of the five enzyme concentrations.

D Using the same volume of enzyme solution for each of the five experiments.

---

537. 9700_s17_qp_11 Q: 15

What determines the specificity of an enzyme?

1 the bonding between R groups of the polypeptide

2 the optimum pH of the enzyme

3 the peptide bonds between amino acids of the polypeptide

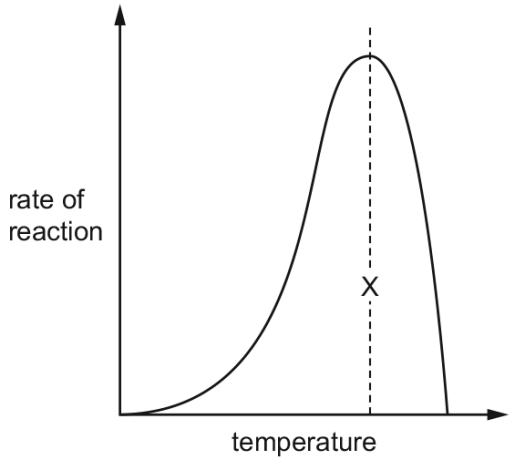
4 the shape of the substrate molecule

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

---

538. 9700_s17_qp_11 Q: 16

The graph shows the effect of temperature on the rate at which the enzyme in a biological washing powder digests and removes fruit juice stains.



Which statements explain the shape of the graph at temperatures higher than X?

1 Bonds are broken between the R groups of the amino acids in the polypeptide chains of the enzyme.

2 There are more collisions between the enzyme and its substrate.

3 The tertiary structure of the enzyme is altered.

4 The shapes of the active site and the substrate are no longer complementary.

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

---

539. 9700_s17_qp_12 Q: 12

How is the Michaelis-Menten constant (K_m) used?

A to assess the efficiency of an enzyme in catalysing a reaction

B to compare the affinity of enzymes for their substrate

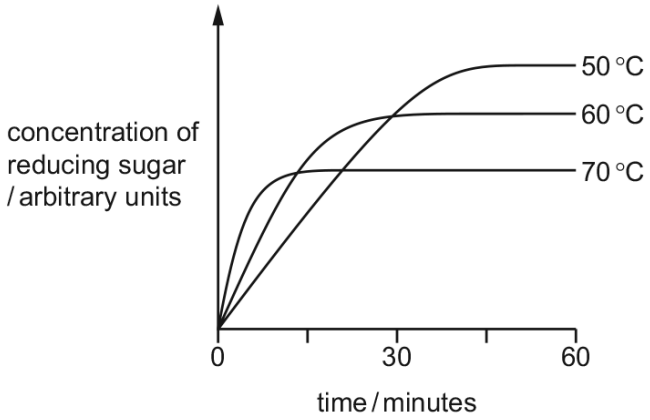
C to find the maximum velocity of an enzyme (V_{max})

D to find the rate at which substrate is loaded by an enzyme

---

540. 9700_s17_qp_13 Q: 11

The graph shows the results of investigations into the effect of amylase on the hydrolysis of starch at three different temperatures.



In each investigation the concentration and volume of the solutions was kept constant.

Which conclusion may be drawn?

A 50 °C is the optimum temperature of amylase.

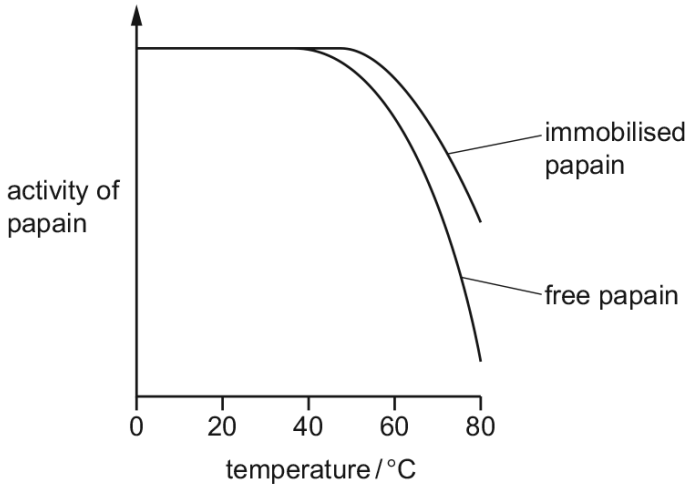
B At 60 °C all the starch is hydrolysed after 30 minutes.

C At 70 °C the amylase is denatured before hydrolysis is complete.

D The rate of hydrolysis of starch is faster at 50 °C than at 70 °C.

541. 9700_s17_qp_13 Q: 12

The graph compares the effect of temperature on the activity of the protease enzyme, papain, when in solution (free) and when immobilised in alginate beads.



Which statement about the effect of immobilisation of papain is correct?

A It alters the shape of papain's active site at higher temperatures.

B It decreases the activity of papain at higher temperatures.

C It increases the stability of papain at higher temperatures.

D It reduces the number of collisions of papain with the substrate.

---

542. 9700_w17_qp_11 Q: 13

Which statements about non-competitive enzyme inhibitors are correct?

1 The inhibitor can bind to the enzyme whether or not the enzyme has its substrate bound in the active site.

2 The inhibitor may bind at an allosteric site.

3 The inhibitor may not prevent substrate binding at the active site, but will prevent product formation.

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

---

543. 9700_w17_qp_12 Q: 15

An experiment was carried out in which the enzyme lipase was used to hydrolyse a triglyceride.

The pH was recorded at regular intervals during the reaction.

The results are shown in the table.

time / minutes	pH
0	7.0
2	6.2
4	5.6
6	5.1
8	4.7
10	4.6
12	4.6
14	4.6

At 14 minutes unreacted triglyceride was still present.

What explains the results after 10 minutes?

A The end-products acted as competitive inhibitors.

B The end-products acted as non-competitive inhibitors.

C The enzyme reaction had reached V_{max}.

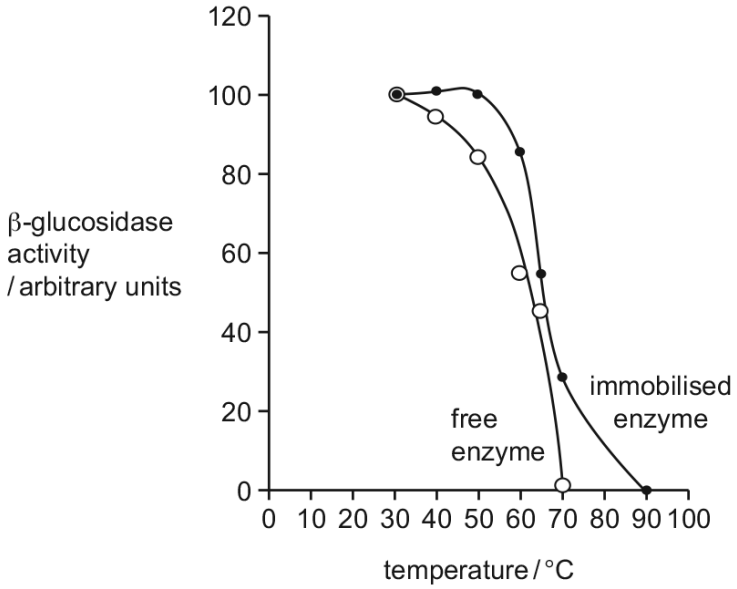
D The tertiary structure of the enzyme had been lost.

---

544. 9700_w17_qp_13 Q: 13

An experiment was conducted to investigate the effect of temperature on the activity of the enzyme β-glucosidase. The enzyme was tested when in solution (free) and when immobilised in alginate beads.

The results are shown in the graph below.



Which statement about the effect of immobilisation of β-glucosidase is correct?

A It increases the kinetic energy of the enzyme.

B It inhibits the activity of the enzyme.

C It reduces the optimum temperature of the enzyme.

D It stabilises the enzyme against denaturation.

545. 9700_w17_qp_13 Q: 16

Liver cells contain membrane-bound organelles called peroxisomes, which contain the enzyme catalase. This enzyme hydrolyses hydrogen peroxide into water and oxygen gas.

A student cut two identical sized pieces of liver and placed one in a refrigerator at 5 °C and the other in a freezer at –18 °C.

After 12 hours both pieces were raised to room temperature and placed in equal volumes of hydrogen peroxide.

The liver that had been at –18°C produced bubbles of oxygen more rapidly than the liver that had been at 5 °C.

Which statement explains why the liver that had been at –18 °C produced bubbles of oxygen more rapidly than the liver that had been at 5 °C?

A At 5 °C the cell surface membrane allowed water to enter cells and dilute the catalase.

B Freezing at –18 °C made the cell walls more permeable to hydrogen peroxide.

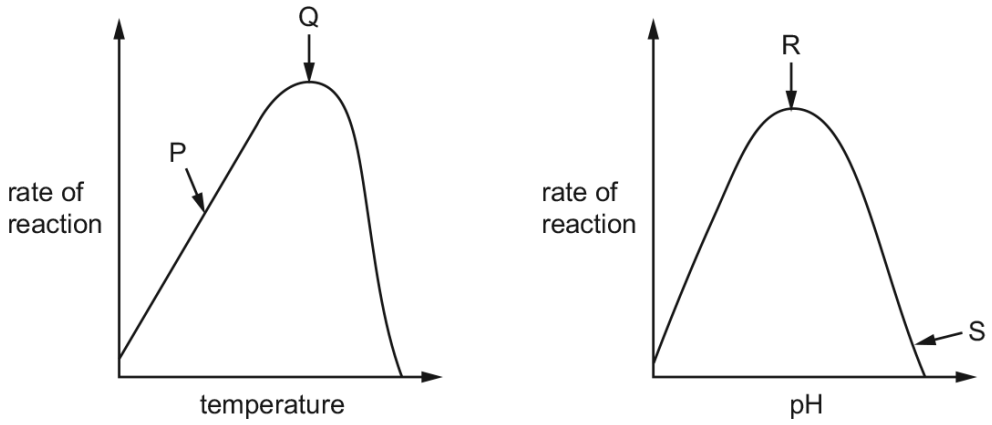
C Ice crystals damaged the cell membranes of the liver cells at –18 °C.

D The higher temperature had denatured some of the catalase.

---

546. 9700_m16_qp_12 Q: 12

The graphs show the effects of temperature and pH on enzyme activity.



Which statement is a correct explanation of the enzyme activity?

A At P, hydrogen bonds are formed between enzyme and substrate.

B At Q, the kinetic energy of enzyme and substrate is highest.

C At R, disulfide bonds in the enzyme begin to break.

D At S, the enzyme is completely denatured.

---

547. 9700_s16_qp_11 Q: 13

Which row about competitive inhibitors of enzymes is correct?

	bind to a site other than the active site	lower the activation energy needed for a reaction to occur
A	✓	✓
B	✓	✗
C	✗	✓
D	✗	✗

key
✓ = true
✗ = false

---

548. 9700_s16_qp_12 Q: 11

Two enzymes, X and Y, were used in an experiment.

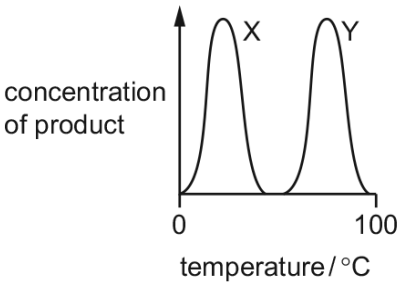
Enzyme X was from bacteria that live in rivers and lakes at temperatures from 5 °C to 20 °C.

Enzyme Y was from bacteria that live in hot water springs at temperatures from 40 °C to 85 °C.

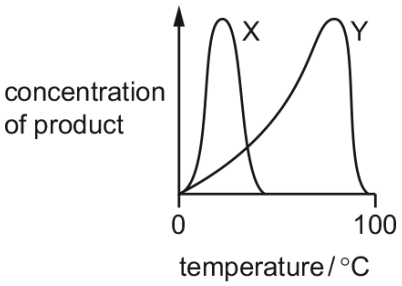
The experiment measured the concentration of product produced by each enzyme at temperatures between 0 °C and 100 °C after 5 minutes.

Which graph shows the results?

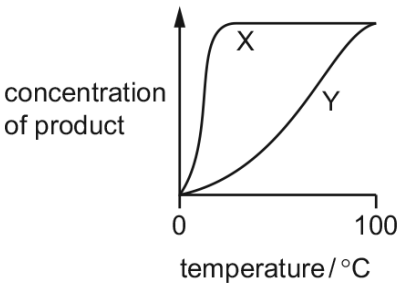
A



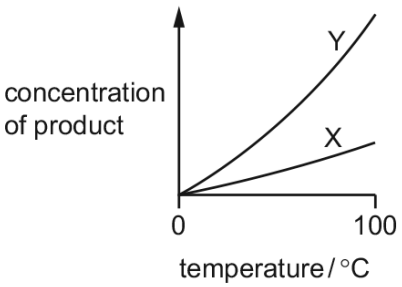
B



C



D



---

549. 9700_s16_qp_13 Q: 10

Which of the bonds will be last to break as the temperature of an enzyme is increased?

A hydrogen

B hydrophobic interactions

C ionic

D peptide

---

550. 9700_w16_qp_11 Q: 12

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

Which steps are required to obtain an 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

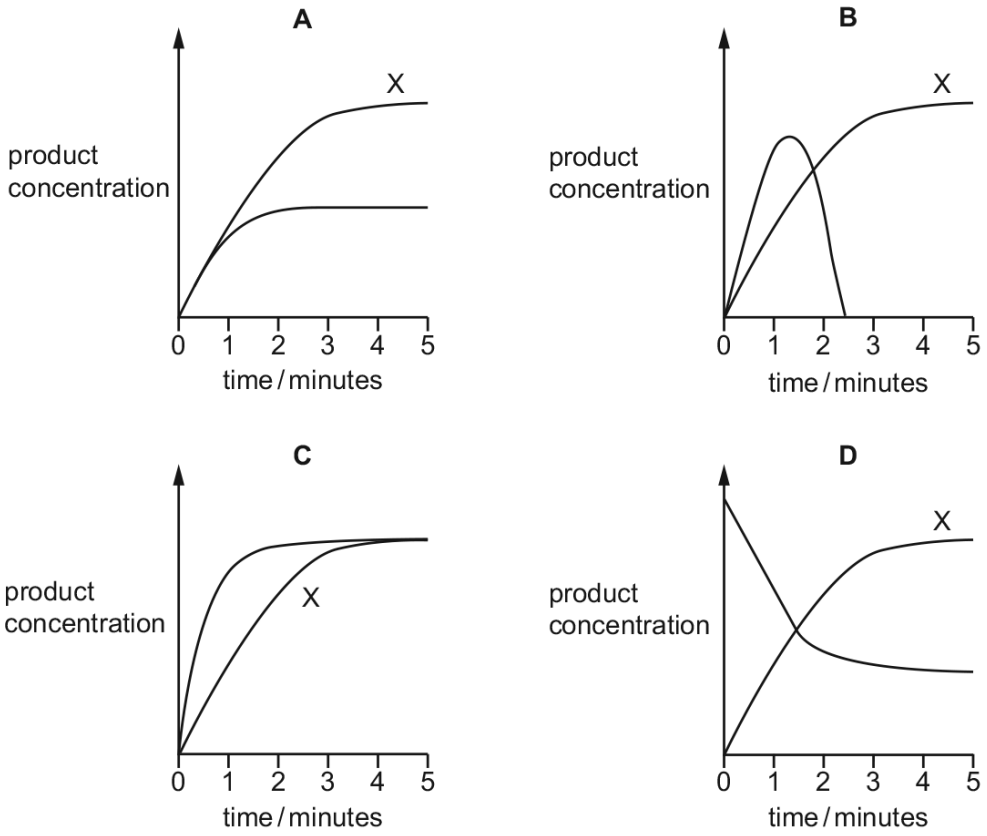
✗ = step not required

---

551. 9700_w16_qp_11 Q: 13

Two experiments were carried out using an enzyme from humans. The first experiment, X, was carried out at a constant temperature of 37 °C. During the second experiment, the temperature was increased from 37 °C to 80 °C. All other factors were kept the same.

Which graph shows the results?



552. 9700_w16_qp_12 Q: 15

Substances called furanocoumarins are found in some fruits, where they act as inhibitors of the enzyme CYP3A4. This enzyme is needed to break down toxins in the human digestive system, so dangerous levels of these toxins may develop if these fruits are eaten.

What does this information suggest about molecules of the enzyme CYP3A4?

A They lower the activation energy of the toxin breakdown process.

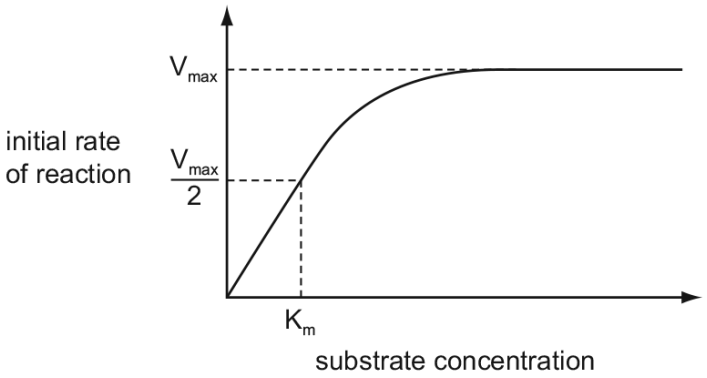
B They show specificity for a particular substrate found in fruits.

C They will change permanently when acted upon by furanocoumarin molecules.

D They will resume normal activity when levels of furanocoumarins decrease.

553. 9700_w16_qp_13 Q: 13

The value K_m is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{V_{max}}{2}$.



The K_m was measured in the presence of a competitive inhibitor and in the presence of a non-competitive inhibitor.

What could be the value of K_m with inhibitor compared to the value of K_m with no inhibitor?

	value of K_m in presence of	
	competitive inhibitor	non-competitive inhibitor
A	less	less
B	less	more
C	more	less
D	the same	more

---

554. 9700_s15_qp_12 Q: 13

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

---

555. 9700_s15_qp_13 Q: 13

Some inhibitors of enzyme reactions bind to the enzyme-substrate complex.

Which statements about this type of inhibition are correct?

1 The active site changes shape.

2 The inhibitor is non-competitive.

3 The initial rate of reaction is reduced.

4 The maximum rate of reaction (V_{max}) stays the same.

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

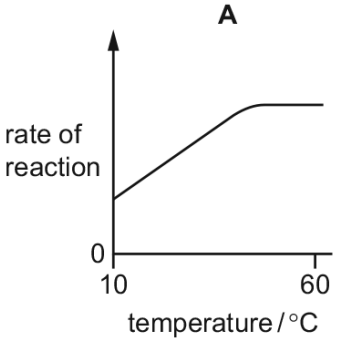
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556. 9700_s15_qp_13 Q: 14

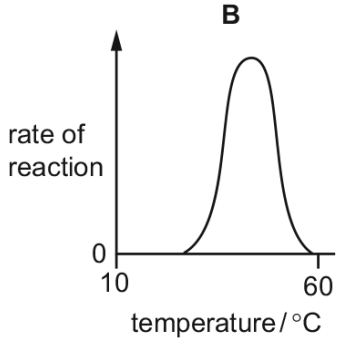
The enzyme DNA polymerase is used in DNA replication. This enzyme was extracted from bacteria living in natural hot water springs where the water temperature is between 85 °C and 95 °C.

Which graph would represent the relationship between temperature and the rate of DNA replication when catalysed by the enzyme from these bacteria?

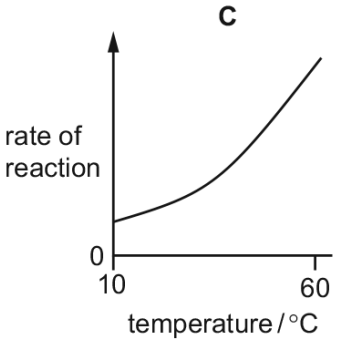
A



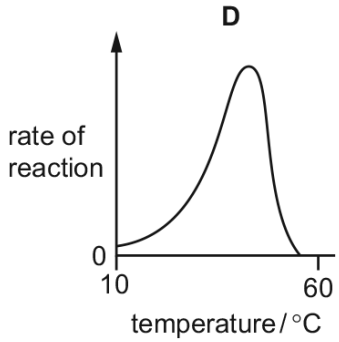
B



C



D



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557. 9700_w15_qp_11 Q: 13

Which statements about enzyme inhibitors are correct?

1 Competitive inhibitors may be similar shapes to the substrate.

2 Competitive inhibitors bind to the active site.

3 Non-competitive inhibitors alter the shape of the enzyme.

4 Non-competitive inhibitors bind to the substrate.

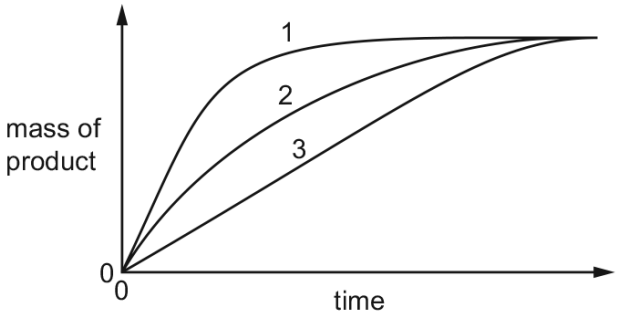
A 1, 2 and 3 **B** 2, 3 and 4 **C** 1 and 2 only **D** 3 and 4 only

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558. 9700_w15_qp_12 Q: 13

The diagram shows the mass of product formed over time in three reactions using the same substrate and enzyme.

The volumes of substrate, enzyme and temperature were kept constant in each reaction.



Which statement explains the difference in these reactions?

A The pH in reactions 2 and 3 has denatured the enzyme.

B There is a non-competitive inhibitor present in reaction 3.

C There is the highest concentration of enzyme in reaction 1.

D There is the highest concentration of substrate in reaction 1.

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559. 9700_w15_qp_12 Q: 14

Tyrosinase is an enzyme that catalyses the conversion of the amino acid tyrosine into the black pigment melanin. It is responsible for the black fur colour of some rabbits.

A group of rabbits kept at 30°C resulted in 90% of the rabbits with light fur colour. A second group of rabbits kept at 10°C resulted in 90% of the rabbits with black fur colour.

Which hypothesis is supported by these results?

A An inhibitor is present in rabbit skin cells that can bind strongly to tyrosinase when the external temperature is 30°C.

B At 10°C external temperature there are fewer tyrosinase-tyrosine complexes formed and less melanin is produced.

C Tyrosinase is an enzyme that is coded for by a gene that is switched off when the external temperature is 10°C.

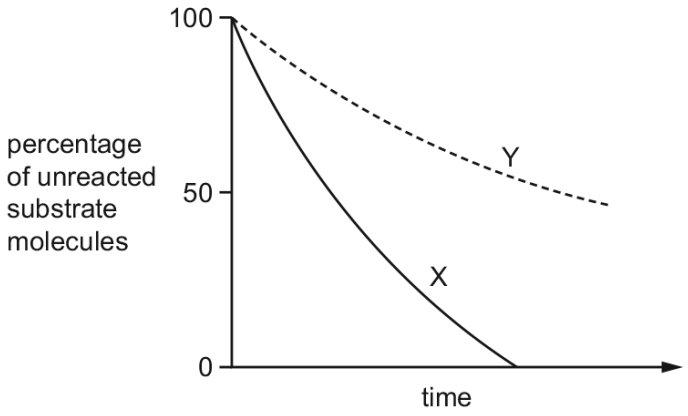
D Tyrosinase is a temperature-sensitive molecule that is only activated when the external temperature is 30°C.

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560. 9700_w15_qp_13 Q: 14

Line X represents the course of an enzyme-catalysed reaction under optimum conditions.

Line Y shows the action of the same enzyme on the same substrate but with one variable changed: substrate concentration or pH or temperature.



Which changes to the variables could give the results shown by line Y?

1 decreased substrate concentration

2 higher pH

3 lower temperature

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

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Chapter 3

Enzymes

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3.1 Mode of action of enzymes

13. 9700_w20_qp_21 Q: 2

(a) Fig. 2.1 shows the molecular structure of a triglyceride molecule.

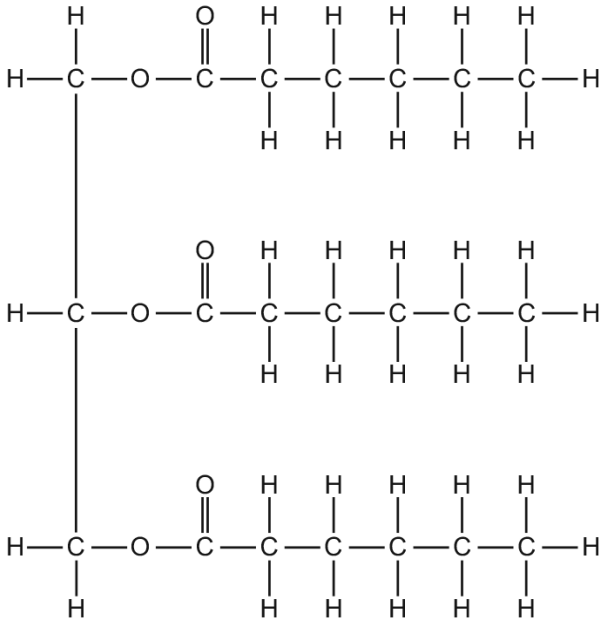


Fig. 2.1

(i) Draw a circle around an ester bond shown in Fig. 2.1. [1]

(ii) Name the type of reaction used to produce a triglyceride from its components.

State the number of water molecules produced during this reaction.

type of reaction .....

number of water molecules produced .....
[2]

(b) Lipases are enzymes that digest triglycerides in the lumen of the human intestine. These enzymes are released by exocytosis from intestinal epithelial cells.

(i) Underline **all** the terms from the list that are used to describe these lipases.

macromolecule **extracellular enzyme** **fibrous protein** **polysaccharide**

[1]

Scientists have found that treating milk with lipase can improve its taste.

The scientists carried out an experiment to determine the effect of lipase activity on the triglycerides found in milk.

- Lipase was immobilised in alginate beads.
- The pH of a known volume of milk was adjusted to pH 8 by adding an alkali.
- The beads were then mixed with this milk in a beaker.
- The pH of the reaction mixture was recorded over a period of 24 hours.

The results are shown in Fig. 2.2.

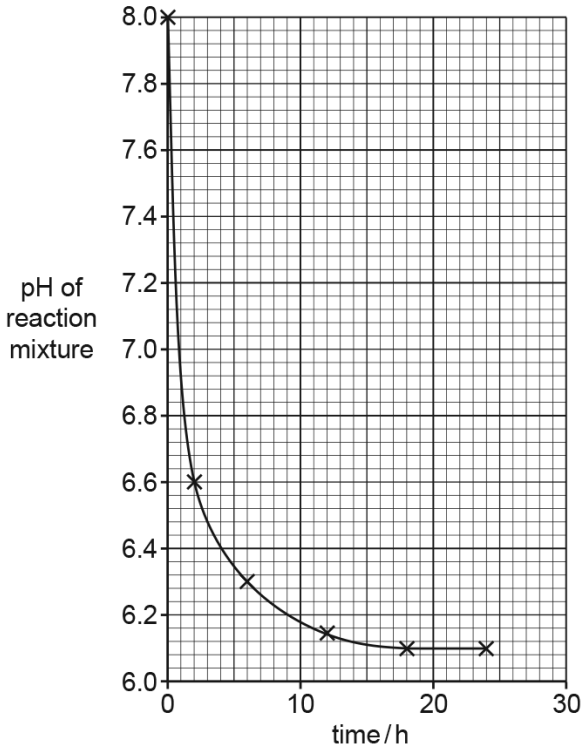


Fig. 2.2

Fig. 2.2 shows that the pH decreases steeply and then, after 18 hours, remains constant.

(ii) Calculate the time taken for the pH to decrease from pH 6.6 to pH 6.3.

time taken = ... h [1]

(iii) Explain the results shown in Fig. 2.2.

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..... [4]

(iv) The scientists repeated the experiment using a higher concentration of lipase. All other variables remained constant.

Predict how an increase in the concentration of the lipase would affect the results of the experiment.

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..... [2]

[Total: 11]

14. 9700_s18_qp_23 Q: 2

Adipose tissue, which is composed of cells known as adipocytes, stores large quantities of triglycerides and functions as an energy storage tissue.

Fig. 2.1 is a photomicrograph of adipose tissue.

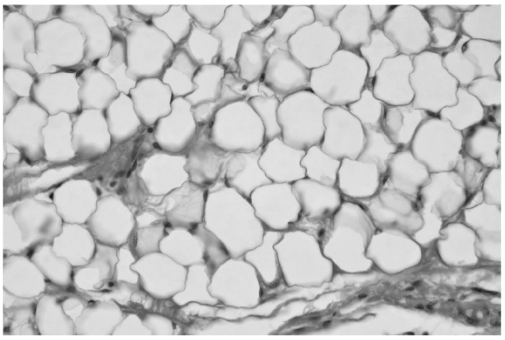


Fig. 2.1

(a) Adipocytes can be very large in size compared to other body cells. This is due to a large lipid droplet within the cell.

The largest adipocyte in Fig. 2.1 has a mean diameter of 35 μm. A person with good eyesight can see cells of 0.05 mm or greater diameter without a magnifying glass or any other optical aid.

State whether the person can see this adipocyte without any optical aid. Show your working to justify your answer.

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.....[1]

(b) Only some of the organelles within the adipocyte can be seen using a high quality light microscope set at the highest magnification.

Organelles such as rough endoplasmic reticulum, smooth endoplasmic reticulum and ribosomes are only visible using an electron microscope.

Explain why these organelles are **not** visible using a light microscope.

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.....[2]

(c) Adipocytes synthesise triglyceride lipase (ATGL), an enzyme that catalyses the formation or breakdown of triglycerides, as shown in Fig. 2.1.

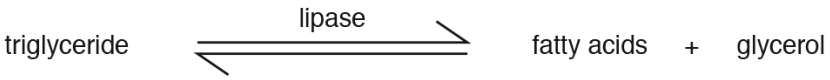


Fig. 2.1

The balance between triglyceride formation and breakdown is controlled by hormones. Fig. 2.2 is a summary of events occurring in an adipocyte when glycogen energy stores have been used up.

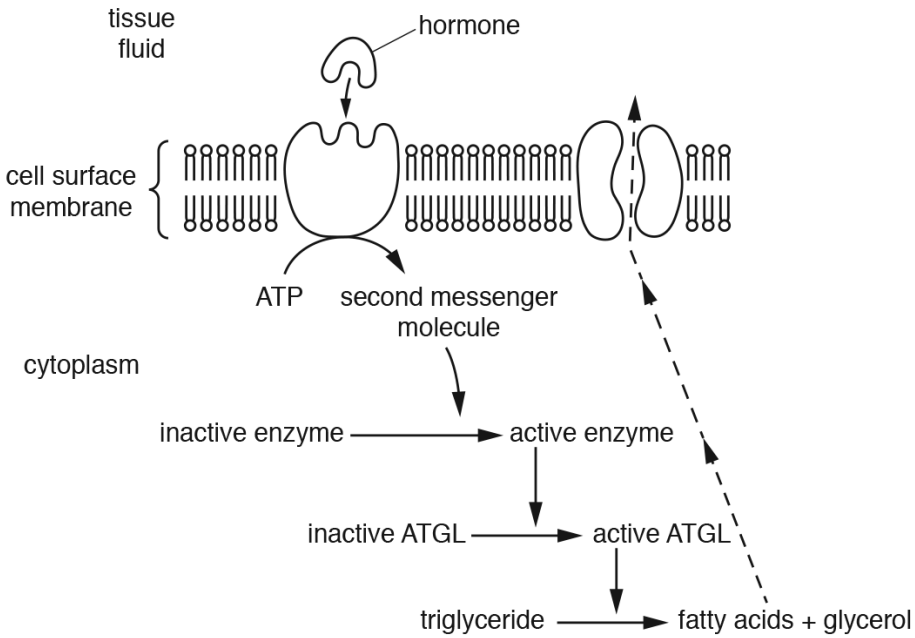


Fig. 2.2

(i) Name the type of bond broken by active ATGL to produce fatty acids and glycerol.

.....[1]

(ii) Name **and** outline the process by which the fatty acids shown in Fig. 2.2 exit the cell.

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.....[3]

(iii) Fig. 2.2 is an example of cell signalling within the body.

With reference to Fig. 2.2, outline the process of cell signalling.

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.....[4]

(d) The fatty acids released from adipocytes are transported in blood plasma and are taken up by cells.

Although most cell types can metabolise fatty acids to synthesise ATP in the presence of oxygen, red blood cells **cannot** do this.

Suggest why red blood cells **cannot** metabolise fatty acids to synthesise ATP.

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.....[1]

[Total: 12]

3.2 Factors that affect enzyme action

15. 9700_m20_qp_22 Q: 2

Phosphatidate phosphatase (PAP) enzymes have an important role in lipid metabolism.

The reaction catalysed by PAP is shown in Fig. 2.1.



Fig. 2.1

Experiments were carried out to investigate the activity of PAP extracted from the cotyledons (seed leaves) of bitter gourd, *Momordica charantia*.

(a) There are two types of PAP enzymes:

- PAP1 enzymes need magnesium ions (Mg^{2+}) in the active site to function
- PAP2 enzymes do not need Mg^{2+}.

The effect of different concentrations of Mg^{2+} on the activity of PAP extracted from *M. charantia* was investigated.

The results are shown in Fig. 2.2.

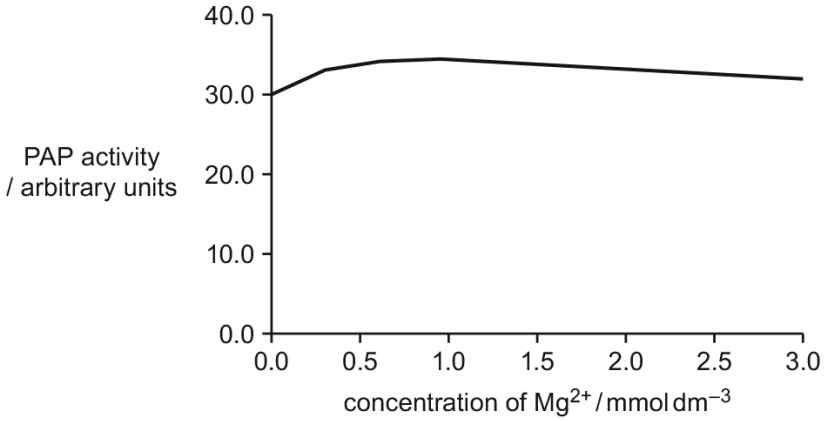


Fig. 2.2

Explain, with reference to Fig. 2.2, whether the PAP extracted from *M. charantia* is a PAP1 enzyme or a PAP2 enzyme.

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..... [2]

(b) Fig. 2.3 shows the effect of increasing phosphatidate concentration on the activity of PAP extracted from *M. charantia*.

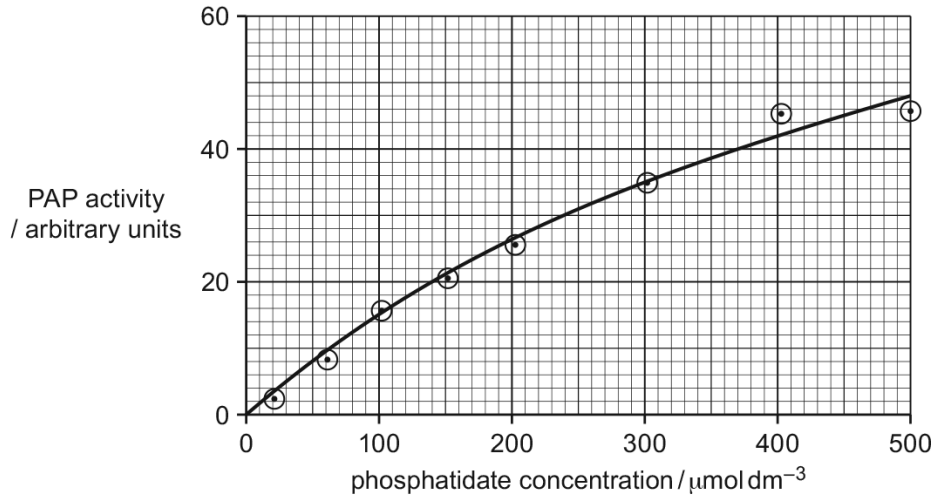


Fig. 2.3

With reference to Fig. 2.3, describe **and** explain the effect of increasing phosphatidate concentration on the activity of PAP.

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..... [4]

(c) The diglycerides formed as a result of the action of PAP can be used to synthesise triglycerides and membrane phospholipids.

(i) Explain how the structure of a triglyceride is suited to its function as an energy storage molecule.

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..... [2]

(ii) Explain why phospholipids are able to form a bilayer in cell membranes.

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..... [2]

[Total: 10]

16. 9700_s20_qp_21 Q: 3

The enzyme glucose 6-phosphate dehydrogenase (G6PD) is composed of two identical polypeptide chains.

(a) Students investigated the activity of two forms of G6PD, **J** and **K**, at different concentrations of substrate. **K** is a form of the enzyme that results from a mutation that changes one amino acid in the polypeptide.

The results are shown in Fig. 3.1.

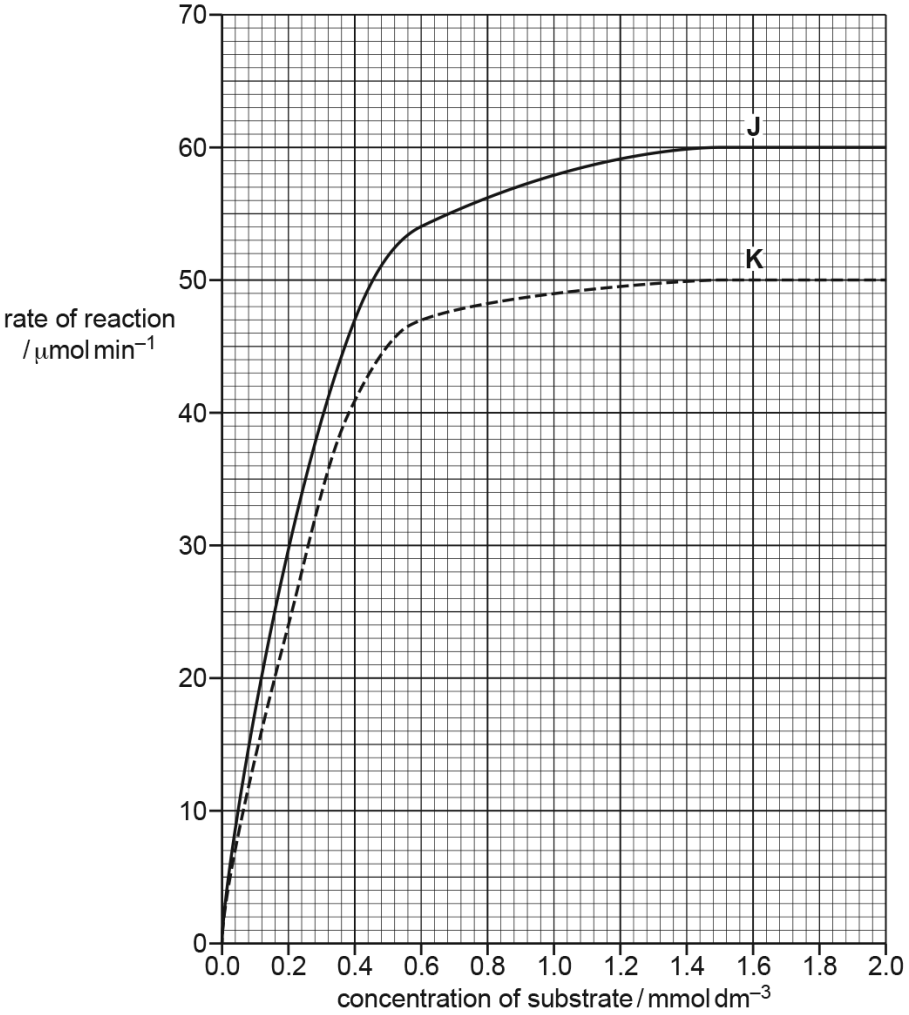


Fig. 3.1

(i) Use Fig. 3.1 to complete Table 3.1 by stating:

- the V_{max} and the K_m for enzymes **J** and **K**
- the units for V_{max} and K_m.

Table 3.1

	V_{max} /	K_m /
J		
K		

[3]

(ii) With reference to Fig. 3.1 and Table 3.1, describe the effect of the mutation on the activity of G6PD **and** suggest an explanation for this effect.

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..... [4]

(b) In certain conditions, G6PD may also exist as four identical polypeptide chains rather than two identical polypeptide chains.

Explain why both of these types of G6PD have all four levels of protein structure.

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..... [2]

[Total: 9]

17. 9700_s20_qp_23 Q: 4

Saccharomyces cerevisiae is a unicellular fungus that is important in the brewing and baking industries.

Fig. 4.1 is a diagram of a transmission electron micrograph of *S. cerevisiae*.

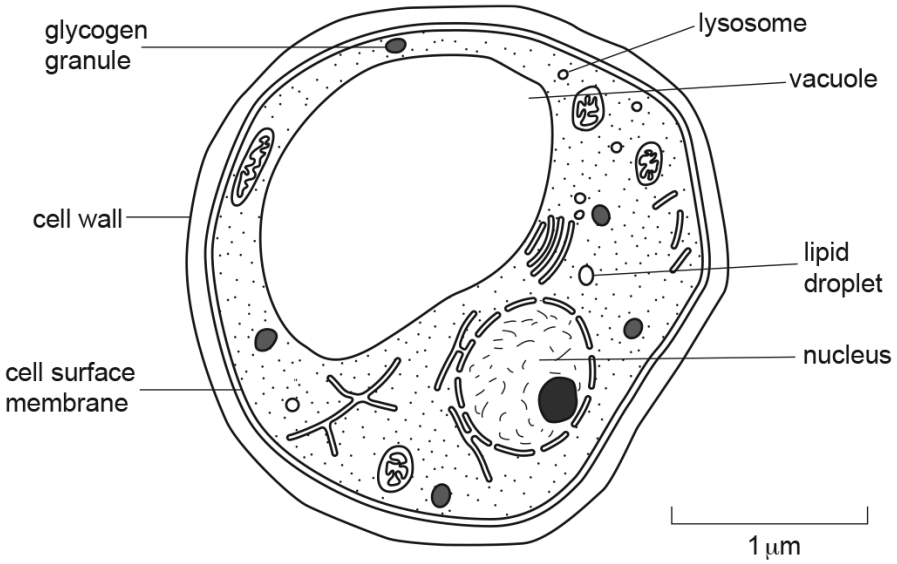


Fig. 4.1

(a) A student was asked to calculate the magnification of the image shown in Fig. 4.1.

The student began by measuring the length of the scale bar in millimetres using a millimetre ruler.

State what the student should do next to obtain the correct answer.

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..... [1]

(b) One function of the lipid droplets shown in Fig. 4.1 is to store triglycerides.

The triglycerides in a lipid droplet are surrounded by a single layer (monolayer) of phospholipids.

Suggest **and** explain why phospholipids, rather than triglycerides, are used for the outer monolayer of the lipid droplet.

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..... [2]

(c) The lysosomes and vacuole of *S. cerevisiae* contain acid hydrolases (hydrolytic enzymes) that function in an acid pH.

Explain why lysosomes need hydrolases to carry out their function.

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..... [1]

(d) A disaccharide, trehalose, is a reserve store of energy for *S. cerevisiae* when glycogen stores decrease. The monomer of glycogen and trehalose is α-glucose.

(i) Complete Fig. 4.2 to show the ring structure of **one** α-glucose molecule.

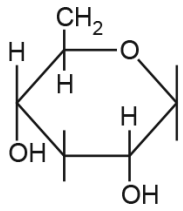


Fig. 4.2

[2]

(ii) A student carried out tests on a solution of trehalose and correctly concluded that trehalose is a **non-reducing** sugar.

Outline the procedure carried out by the student **and** state the results that were obtained.

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..... [3]

(e) The hydrolysis of trehalose is catalysed by two different enzymes produced by *S. cerevisiae*, regulatory trehalase and non-regulatory trehalase.

A study was carried out to compare regulatory trehalase and non-regulatory trehalase extracted from *S. cerevisiae*.

The results of the study showed that:

- regulatory trehalase had a higher K_m value (Michaelis-Menten constant) than non-regulatory trehalase
- the optimum pH of regulatory trehalase was pH 7.0–7.8
- the optimum pH of non-regulatory trehalase was pH 4.5–5.0.

(i) Explain what is meant by a higher K_m value.

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..... [2]

(ii) Regulatory trehalase is found only in the cytosol, the fluid part of the cytoplasm.

Non-regulatory trehalase has been found on the external surface of the cell surface membrane and inside the cell.

State the location inside the cell where non-regulatory trehalase is likely to be found **and** explain the reason for your answer.

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..... [2]

(iii) Explain whether both types of trehalase, regulatory and non-regulatory, can be described as intracellular enzymes.

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..... [1]

(f) *Saccharomyces boulardii* is a strain of *S. cerevisiae*. It has been researched for its possible health benefits for some gut diseases.

Researchers investigating trehalase extracted from *S. boulardii* concluded that only one type of trehalase was present in the extract.

Fig. 4.3 shows the effect of pH on the activity of the trehalase extracted from *S. boulardii*.

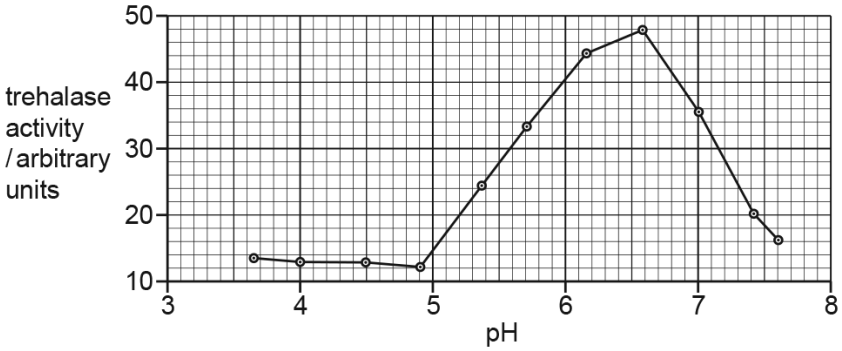


Fig. 4.3

With reference to Fig. 4.3 and to the two different types of trehalase enzyme produced by *S. cerevisiae*, state **and** explain what can be deduced about the type of trehalase present in *S. boulardii*.

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..... [3]

[Total: 17]

18. 9700_w20_qp_22 Q: 5

Sucrose phosphorylase is an enzyme found in some species of bacteria. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

Fig. 5.1 shows the reversible reaction that takes place within the bacterial cell.

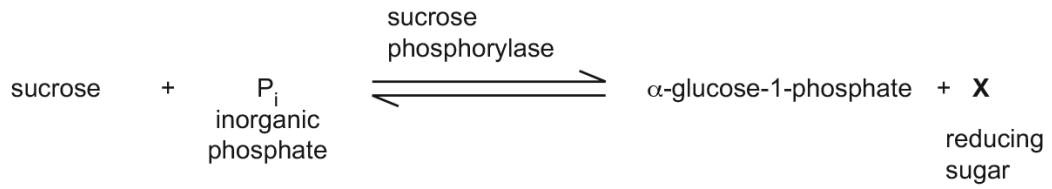


Fig. 5.1

(a) Name reducing sugar **X** in Fig. 5.1.

..... [1]

(b) In the absence of sucrose phosphorylase as a catalyst, the reaction shown in Fig. 5.1 would take too long to occur to allow the bacterial cell to function efficiently.

Explain why the reaction shown in Fig. 5.1 proceeds at a much faster rate in the presence of the enzyme.

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..... [2]

(c) An enzyme that catalyses a reaction of commercial interest needs to be investigated to see if it is suitable for use in industry.
For example:

- immobilised enzymes may be used as they have a longer shelf-life than the enzyme free in solution
- many industrial reactions are carried out at higher temperatures to minimise contamination of products by microorganisms.

Fig. 5.2 shows the results of an investigation to compare the activity of sucrose phosphorylase free in solution (free enzyme) with immobilised sucrose phosphorylase (immobilised enzyme) at different pHs.

Fig. 5.3 shows the activity of the free enzyme and immobilised enzyme at different temperatures.

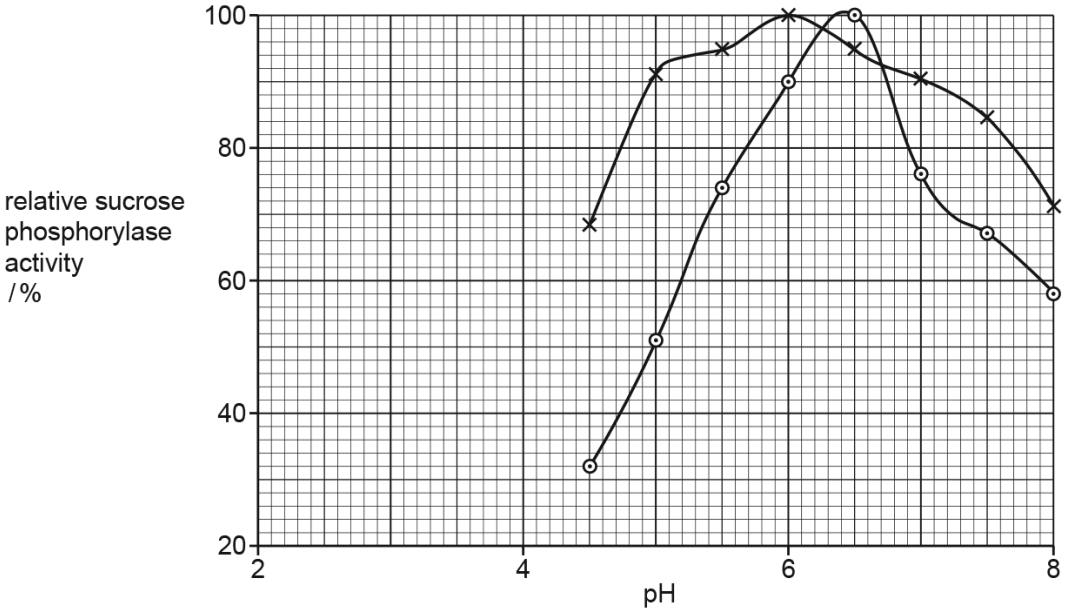
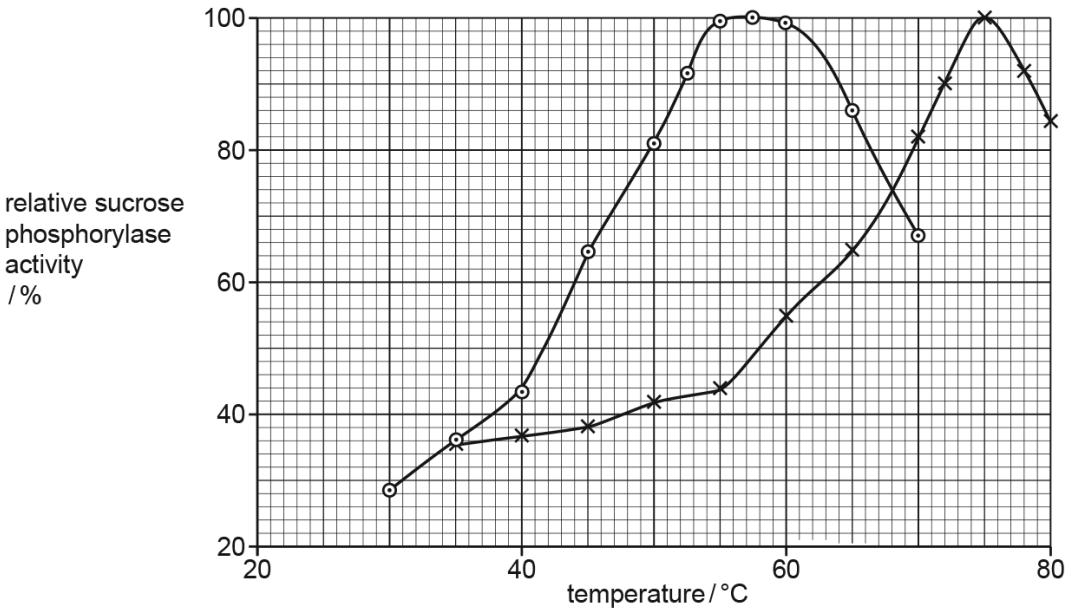


Fig. 5.2



Key

⊙ free enzyme

× immobilised enzyme

Fig. 5.3

With reference to the results shown in Fig. 5.2 and Fig. 5.3, discuss which sucrose phosphorylase enzyme, free or immobilised, is better for use in industrial reactions.

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..... [4]

[Total: 7]

19. 9700_s19_qp_21 Q: 3

Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®.

The student made four reaction mixtures in test-tubes **A** to **D**. Test-tubes **A** to **C** contained equal volumes of protein solution and 0.1 cm^3 of solutions of copper sulfate or potassium sulfate. Test-tube **D** contained the same volume of protein solution and 0.1 cm^3 of water.

0.5 cm^3 of a 1% Neutrase® solution was added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 3.1.

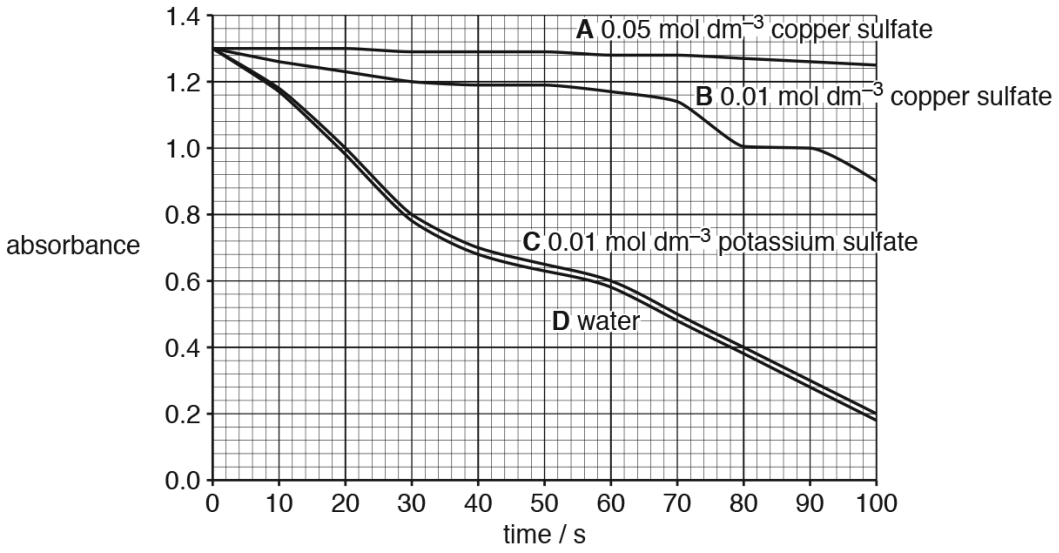


Fig. 3.1

(a) (i) Suggest **and** explain why measuring the absorbance of the reaction mixture over 100 s is a suitable method for determining the activity of Neutrase®.

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..... [2]

(ii) With reference to Fig. 3.1:

- describe the effects of copper sulfate solution and potassium sulfate solution on the activity of Neutrase®
- suggest explanations for the effects that you have described.

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..... [5]

(b) Neutrase® can be immobilised in alginate. Immobilised Neutrase® is used in the food industry to produce foods with high nutritional content.

Explain the advantages of using immobilised enzymes, such as Neutrase®, compared with using the same enzymes free in solution.

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..... [2]

[Total: 9]

20. 9700_s19_qp_22 Q: 6

Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, which is a waste product of cell metabolism.

The reaction catalysed by catalase is shown in Fig. 6.1.

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

Fig. 6.1

(a) A student carried out two experiments to investigate the progress of the reaction shown in Fig. 6.1. Potato tissue was used as the source of the enzyme.

Six pieces of potato were cut, each measuring 20 mm × 10 mm × 10 mm.

In the first experiment, hydrogen peroxide solution was added to three of the pieces of potato tissue and the progress of the reaction was measured.

Fig. 6.2 shows how the first experiment was set up.

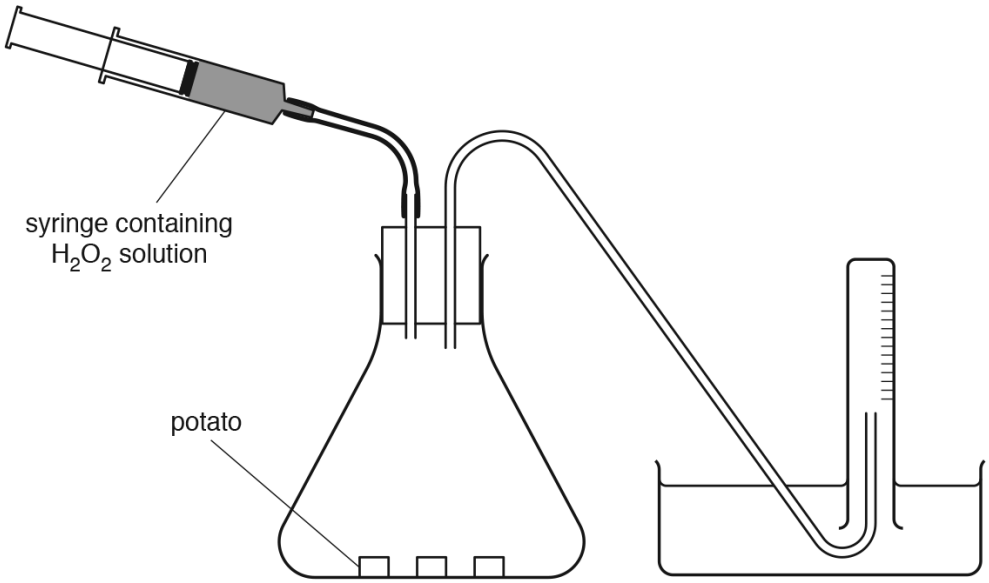


Fig. 6.2

(i) Suggest how the progress of the reaction could be measured.

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..... [2]

(ii) In the second experiment, the student cut each of the three remaining pieces of potato to obtain six pieces, each measuring 10 mm × 10 mm × 10 mm.

Using exactly the same conditions, the student measured the progress of the reaction and obtained different results to the first experiment.

Explain why the results of the second experiment were different from the results of the first experiment.

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..... [2]

(b) The student then investigated the effect of temperature on the activity of catalase.

On Fig. 6.3, sketch a curve to show how temperature affects the activity of an enzyme such as catalase.

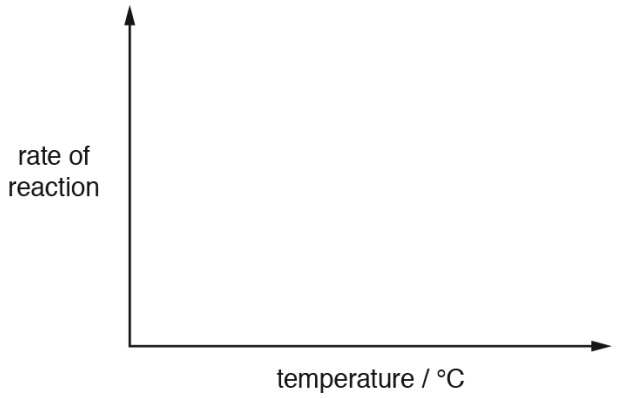


Fig. 6.3

[1]

[Total: 5]

21. 9700_m18_qp_22 Q: 3

The unicellular fungus *Kluyveromyces lactis* is found in dairy products. It is a safe microorganism to culture for the extraction of the enzyme lactase. Lactase catalyses the breakdown of lactose, a sugar found in milk.

The reaction catalysed by lactase is summarised in Fig. 3.1.

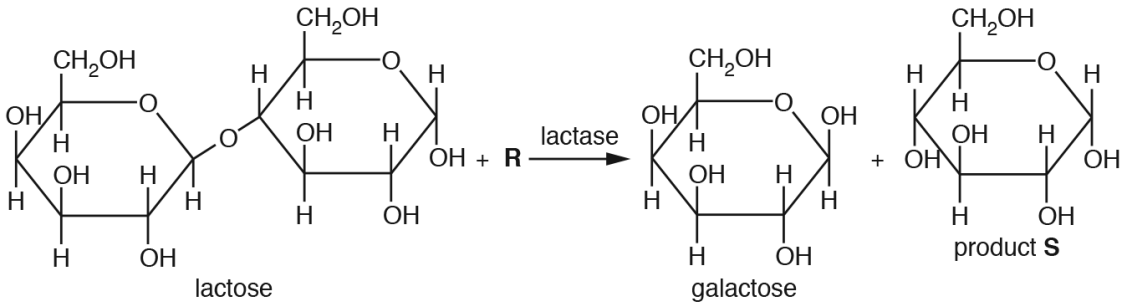


Fig. 3.1

(a) Describe the reaction that is catalysed by lactase. Use Fig. 3.1 to help you.

In your answer, identify **R** and product **S**.

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..... [4]

(b) On a commercial scale, immobilised lactase can be used to produce lactose-free milk.

One of the products of the reaction shown in Fig. 3.1 acts as an inhibitor of lactase. This is an example of product inhibition.

(i) Suggest why product inhibition is useful in *K. lactis* when lactase is acting as an intracellular enzyme, but can be a disadvantage when extracted lactase is used free in solution for the production of lactose-free milk.

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..... [2]

(ii) Suggest how using immobilised lactase in a commercial application helps to reduce the problem of product inhibition.

.....

..... [1]

(iii) The first large-scale production of lactose-free milk with an immobilised enzyme used lactase trapped in cellulose triacetate fibres.

Suggest **one** feature of cellulose triacetate that makes it useful as an immobilising material.

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..... [1]

(c) For a commercial application using an enzyme, the progress of the enzyme-catalysed reaction needs to be studied.

Outline how the progress of an enzyme-catalysed reaction can be investigated experimentally.

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..... [3]

[Total: 11]

22. 9700_s18_qp_21 Q: 3

Researchers isolated a sucrase enzyme from the bacterium *Bacillus subtilis*. They immobilised the enzyme in alginate beads.

The researchers investigated the effects of temperature on the activity of the immobilised sucrase compared with the activity of the same enzyme free in solution.

The results are shown in Fig. 3.1.

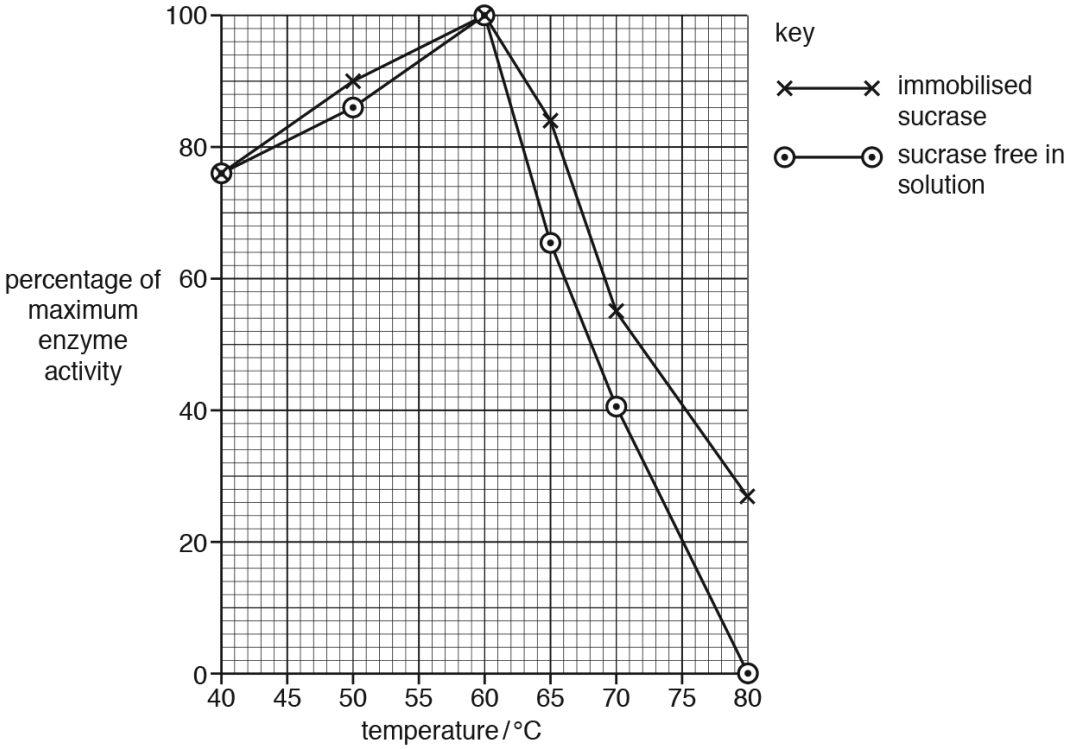


Fig. 3.1

(a) With reference to Fig. 3.1, **compare** the effects of temperature on the activity of immobilised sucrase with the activity of sucrase free in solution.

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.....[4]

The researchers also investigated the effects of pH on the activity of the immobilised sucrase compared with its activity free in solution.

The results are shown in Fig. 3.2.

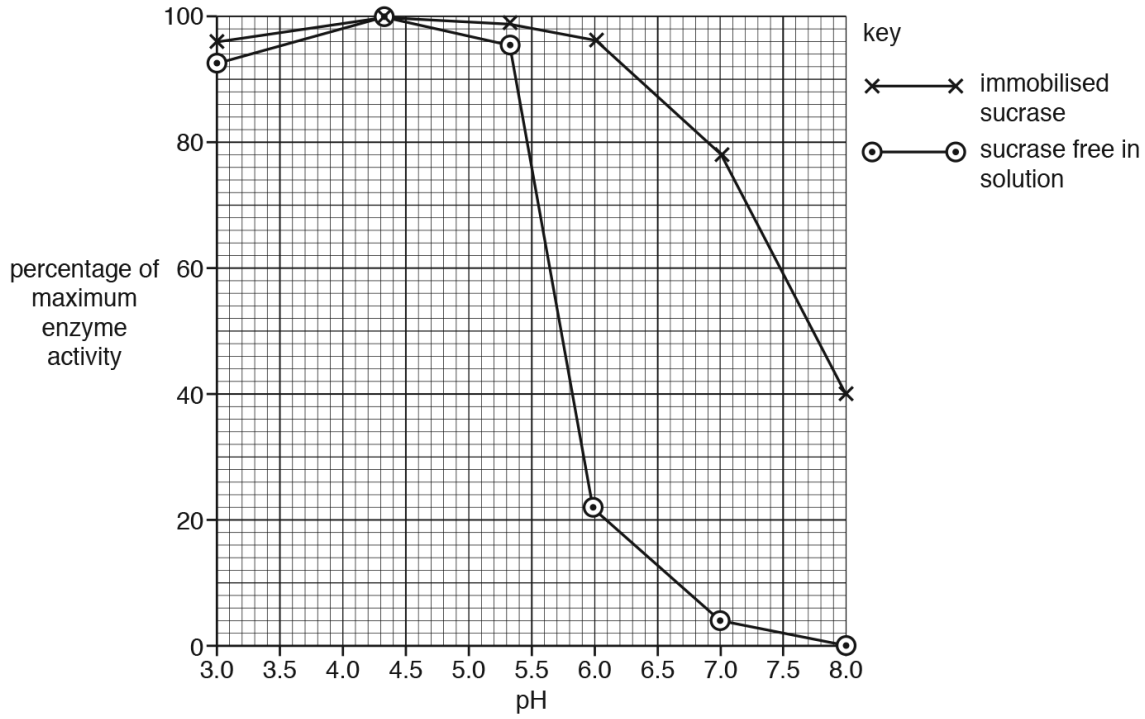


Fig. 3.2

(b) Fig. 3.2 shows that immobilised sucrase remains active over a wider range of pH compared with sucrase free in solution.

Suggest reasons for the higher activity of immobilised sucrase over the range of pH between 5.5 and 8.0.

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.....[2]

(c) State **one** variable that the researchers should keep constant in **both** investigations **and** explain your answer in terms of enzyme action.

variable .....

.....

explanation .....

.....

.....

.....[2]

(d) There are many advantages of using immobilised enzymes in industry.

Suggest **two** advantages of using immobilised enzymes in industry **other than** remaining active over a greater range of pH.

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.....[2]

[Total: 10]

23. 9700_s18_qp_23 Q: 5

The fig tree, *Ficus carica*, and the papaya tree, *Carica papaya*, produce a milky-looking fluid known as latex. The latex is released when plant tissue is wounded and it is thought to act as a defence against attack by herbivorous insects or parasitic worms.

Latex is a complex mixture of substances and the exact composition of the mixture depends on the plant species. A group of enzymes that hydrolyse proteins, known as cysteine proteases, are commonly found in latex.

Ficin, found in *F. carica*, and papain, found in *C. papaya*, are both cysteine protease enzymes. These enzymes have been extracted and purified for use commercially.

(a) An investigation was carried out to compare the effect of temperature on the activity of ficin and papain.

The results are shown in Fig. 5.1.

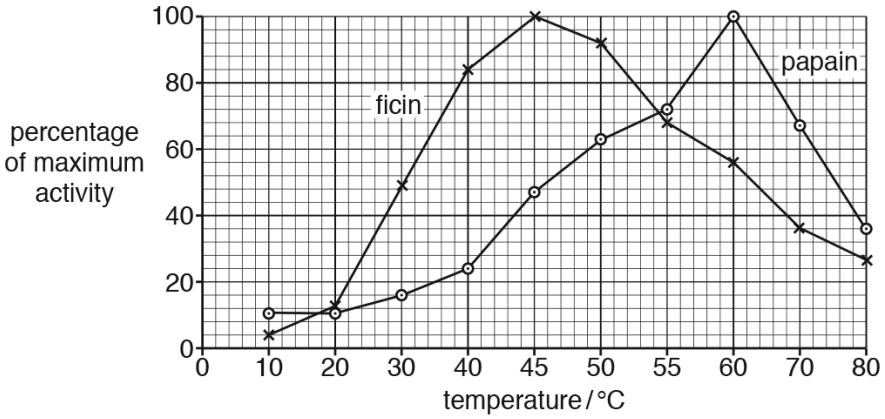


Fig. 5.1

(i) With reference to Fig. 5.1, describe the differences between the activity of papain compared to the activity of ficin between 20 °C and 80 °C.

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.....[3]

(ii) Ficin and papain have been shown to be effective in the digestion of parasitic nematodes (roundworms).

With reference to Fig. 5.1, explain which enzyme you would select to use in an oral medication for the treatment of human intestinal parasitic nematodes.

.....

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.....[1]

(b) One commercial use of the enzyme ficin is the production of Fab fragments (antigen binding regions) of mouse IgG antibodies for use in immunological studies. The process uses immobilised ficin to cleave (cut) the antibodies in the hinge region.

Suggest **one** practical advantage of using immobilised ficin for this process, rather than ficin free in solution.

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.....[1]

(c) *Streptococcus pyogenes* is a bacterium that can cause a range of diseases in humans.

S. pyogenes synthesises streptopain, a cysteine protease that hydrolyses structural proteins in human connective tissue.

(i) Streptopain is secreted to the outside of the cell.

State the term given to an enzyme that is produced by a cell and is then secreted to the outside, where it has its action.

.....[1]

(ii) Suggest **one** example of a structural protein in connective tissue that can be hydrolysed by streptopain.

.....[1]

[Total: 7]

24. 9700_w18_qp_21 Q: 2

Fig. 2.1 shows the disaccharide lactose, which is found in milk.

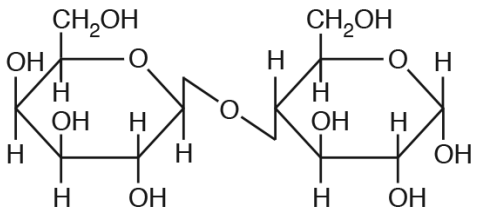


Fig. 2.1

(a) Name the type of bond that joins the two monosaccharides in lactose.

..... [1]

(b) The enzyme lactase catalyses the breakage of the bond between the two monosaccharides in lactose.

(i) Name the type of reaction that breaks this bond.

..... [1]

(ii) Some people do not produce the enzyme lactase, so cannot digest lactose.

The presence of lactose in the lumen of the intestine reduces the volume of water absorbed into the blood, resulting in diarrhoea.

Suggest why the presence of lactose in the intestine reduces the volume of water absorbed.

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..... [2]

(c) Enzymes, such as lactase, are often immobilised for use in the food industry.

A scientist carried out an investigation to determine the effects of temperature on the activity of lactase when it was immobilised and when it was free in solution.

The scientist produced alginate beads containing lactase for use in this investigation. The beads varied in size. The scientist selected small beads for the investigation and put them into a glass column.

(i) Suggest the advantage of using small beads rather than large beads.

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..... [2]

(ii) Fig. 2.2 shows the results of the investigation to determine the effects of temperature on the activity of lactase when it was immobilised, **I**, and when it was free in solution, **F**.

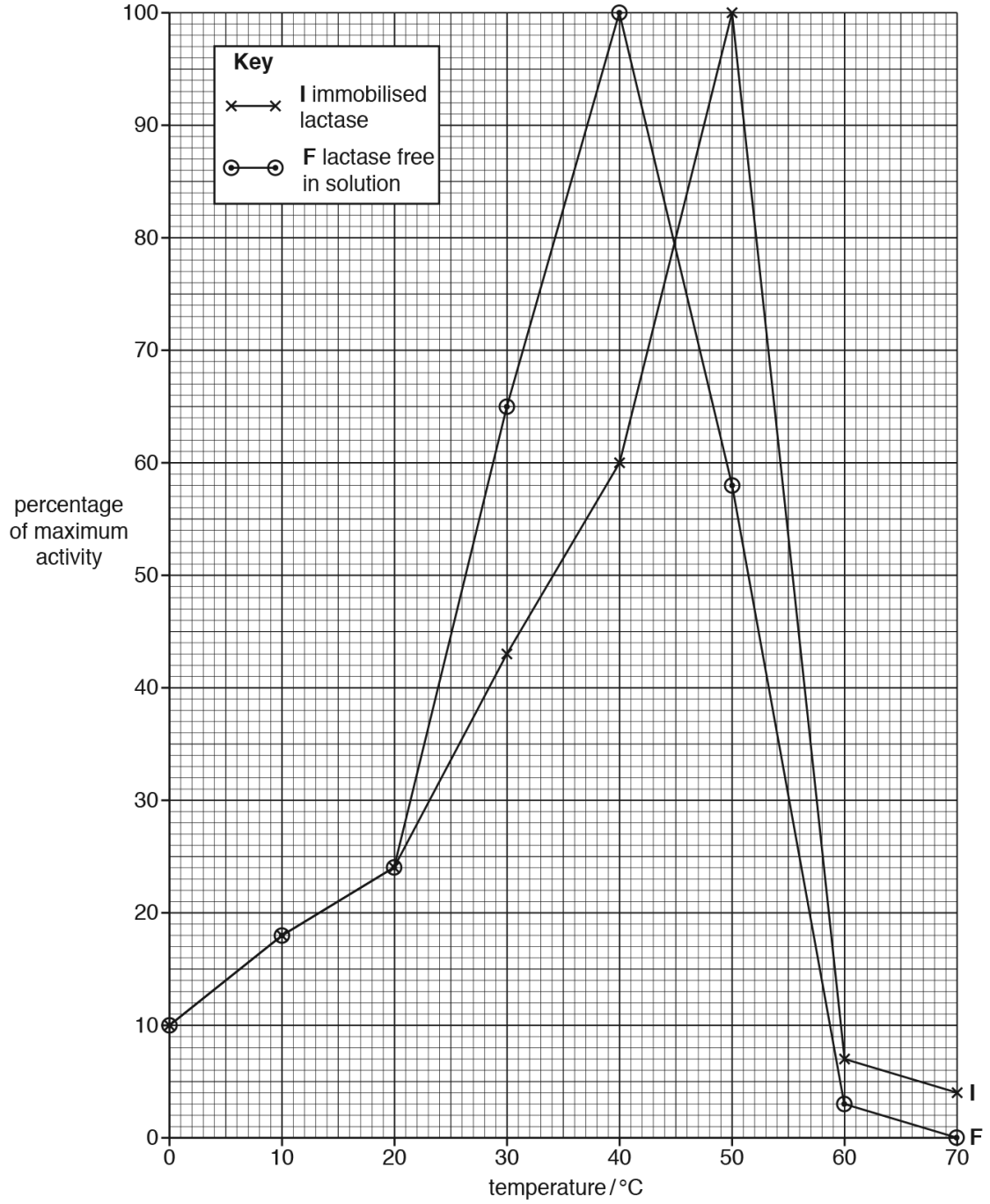


Fig. 2.2

With reference to Fig. 2.2, compare the effect of temperature on the activity of immobilised lactase, **I**, and lactase free in solution, **F**.

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..... [3]

[Total: 9]

25. 9700_s17_qp_21 Q: 2

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.

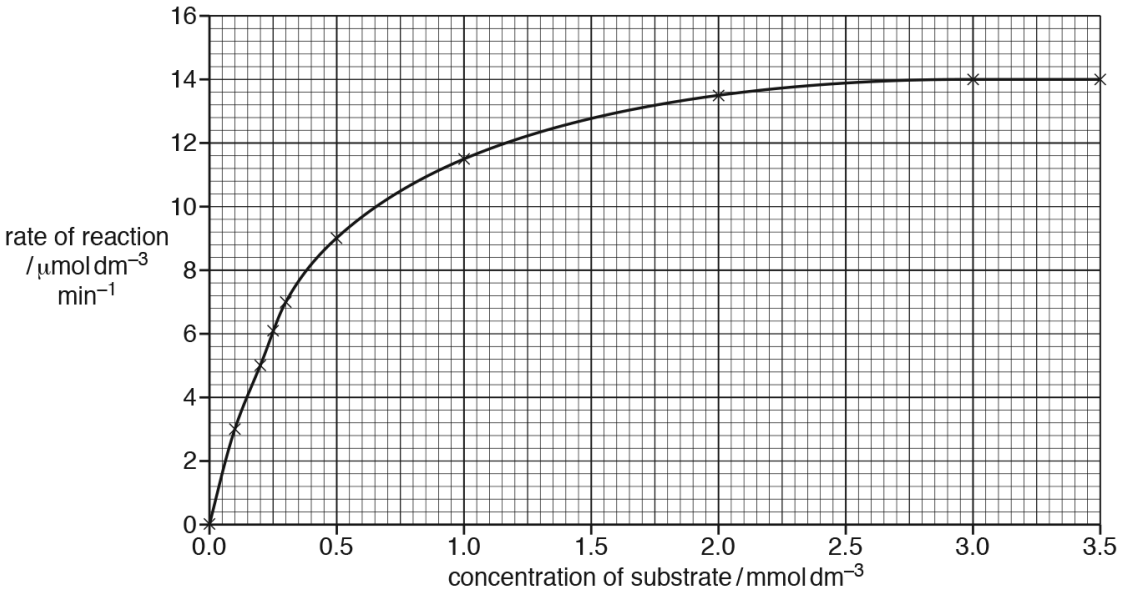


Fig. 2.1

(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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.....[2]

(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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.....[2]

(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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.....[4]

[Total: 8]

26. 9700_s17_qp_22 Q: 2

Lipase is an enzyme with many commercial uses. Some species of bacteria are of great interest as they produce large quantities of lipase.

(a) Complete Fig. 2.1 to show the hydrolysis of triglyceride by lipase.

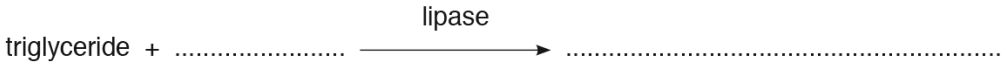


Fig. 2.1

[2]

Researchers carried out investigations into lipase extracted from a bacterium found in hot springs.

(b) To measure the activity of the bacterial lipase during their investigations, the researchers used a method based on the biological test for triglycerides.

Outline a biological test that could be carried out to show the presence of triglyceride in a liquid mixture **and** describe the positive result for this test.

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.....[3]

(c) The researchers investigated the effect of pH values between pH 2.0 and pH 10.5 on the activity of bacterial lipase in hydrolysing triglyceride at a temperature of 37 °C.

The results are shown in Fig. 2.2.

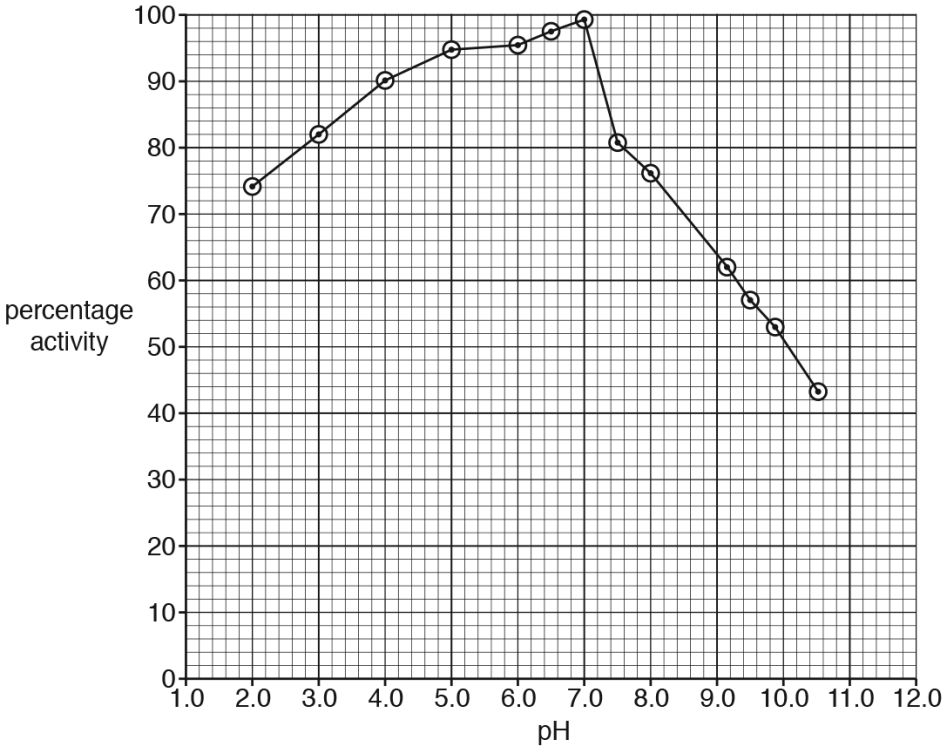


Fig. 2.2

With reference to Fig. 2.2, describe the effect of pH on the activity of bacterial lipase.

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.....[4]

(d) A separate investigation into the effect of pH on the same bacterial lipase compared the enzyme free in solution with the enzyme immobilised by physical attachment to a stable polymer.

At a temperature of 37 °C, the optimum pH of the enzyme free in solution was the same as that shown in Fig. 2.2. The optimum pH of the immobilised enzyme was measured as pH 4.

(i) Suggest **one** reason to explain why the enzyme free in solution has a different optimum pH compared to the immobilised enzyme.

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.....[1]

(ii) Suggest **one** advantage of immobilising the extracted lipase for commercial use.

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.....[1]

[Total: 11]

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27. 9700_s16_qp_22 Q: 1

Statements **A** to **E** are about the structure and functioning of enzymes.

State the correct term to match each of the statements **A** to **E**.

A The energy level, lowered by enzyme action, that needs to be overcome by reactants in order for products to be formed.

.....

B The mechanism of enzyme action that relies on the active site being partially flexible and changing shape in order to bind the substrate.

.....

C The term to describe a protein, such as an enzyme, with a tertiary or quaternary structure that results in an approximately spherical shape.

.....

D The term for enzymes that function outside cells.

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E The concentration of substrate that enables an enzyme to achieve half the maximum rate of reaction.

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[5]

[Total: 5]

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28. 9700_s16_qp_23 Q: 2

Trypsin is a protease enzyme found in the digestive system.

Fig. 2.1 shows how the substrate concentration affects the rate of reaction of trypsin.

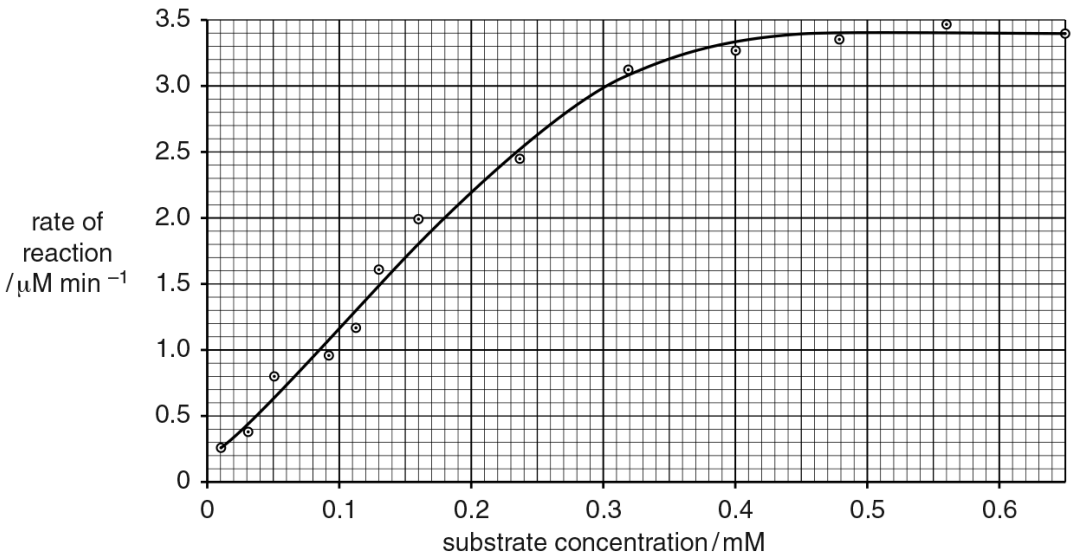


Fig. 2.1

(a) Use Fig. 2.1 to:

(i) determine V_{max} for trypsin

.....[1]

(ii) calculate K_m for trypsin.

Show your working.

.....[2]

(b) Describe **and** explain the shape of the curve in Fig. 2.1.

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.....[4]

(c) Trypsin is composed of one polypeptide chain of 223 amino acids.

The active site of trypsin contains three amino acids which catalyse a hydrolysis reaction. These three amino acids occupy the following positions in the primary structure of trypsin:

- histidine, position 57
- aspartate, position 102
- serine, position 195.

(i) In the functioning enzyme, these three amino acids are close together in the active site.

Explain how the structure of the protein makes this possible.

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.....[3]

(ii) When trypsin acts on a substrate, another substance is required as a reactant.

Name this other substance.

.....[1]

[Total: 11]

29. 9700_w16_qp_21 Q: 3

Fig. 3.1 shows the structure of the enzyme lysozyme.

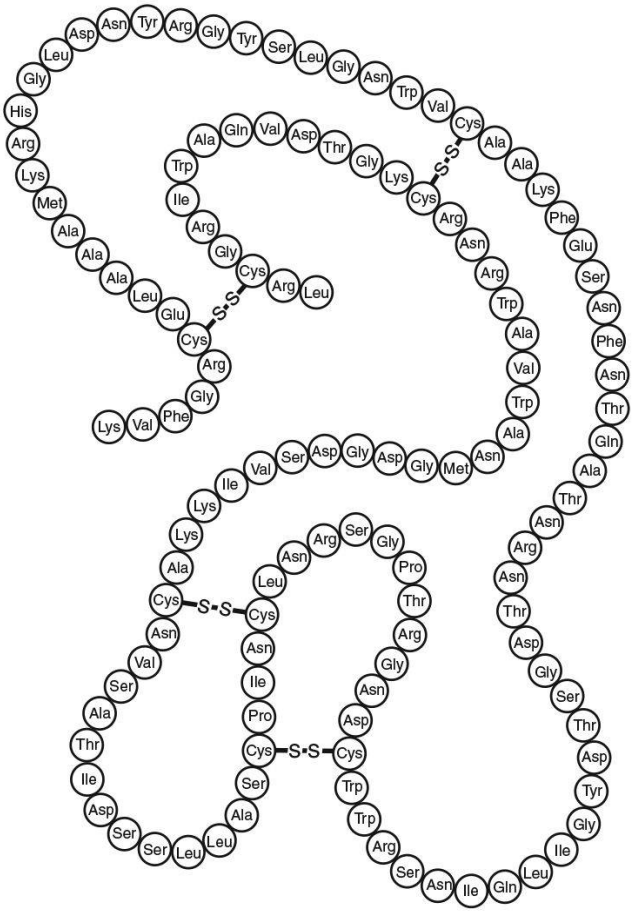


Fig. 3.1

(a) (i) Name the **two** types of covalent bond in the structure in Fig. 3.1.

.....[1]

(ii) The primary structure of lysozyme is shown in Fig. 3.1.

Explain the meaning of the term *primary structure*.

.....

.....

.....[1]

(b) Lysozyme hydrolyses the β-1,4 glycosidic bonds present in compounds found in bacterial cell walls.

(i) State what is meant by the term *hydrolysis*.

.....

.....[1]

(ii) Suggest the type of biological molecule which is the substrate for lysozyme.

.....[1]

(iii) Lysozyme uses the induced fit mechanism.

Explain the mode of action of an enzyme that uses the induced fit mechanism.

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.....[4]

(c) In human tears and saliva, lysozyme acts as an extracellular enzyme.

State what is meant by the term *extracellular*.

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.....[1]

(d) Fig. 3.2 shows the results of an investigation into the effect of substrate concentration on the rate of reaction catalysed by lysozyme.

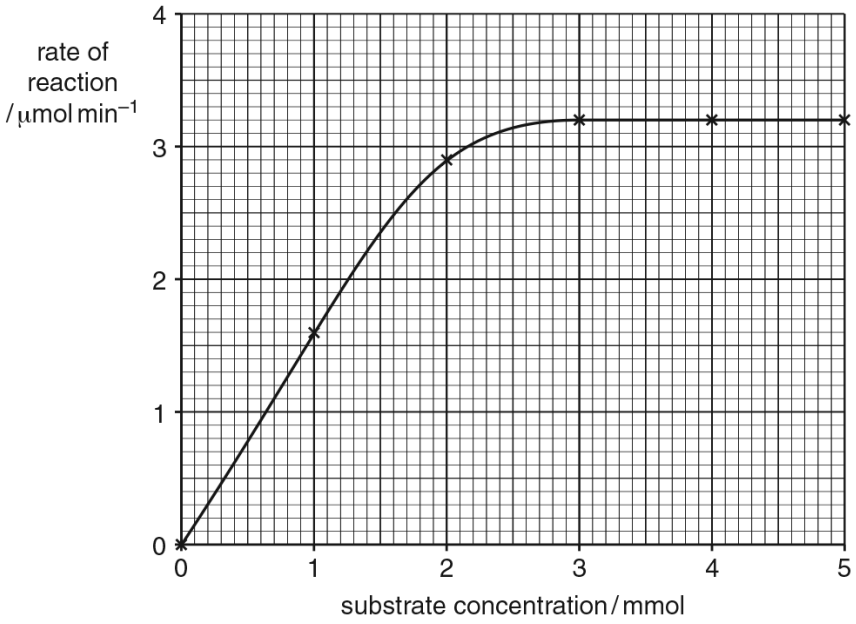


Fig. 3.2

Use Fig. 3.2 to:

(i) state the lowest substrate concentration to give the maximum rate of reaction, V_{max}

.....[1]

(ii) determine the Michaelis-Menten constant, K_m.

K_m = ...[1]

(e) The investigation was repeated in the presence of a competitive inhibitor of lysozyme.

Draw a curve **on Fig. 3.2** to show the expected results. [2]

[Total: 13]

30. 9700_s15_qp_22 Q: 4

Many microorganisms can digest cellulose by using a group of enzymes collectively known as cellulases. Cellobiose is the disaccharide produced during cellulose digestion.

The cellulase known as β-glucosidase completes the digestion of cellulose by hydrolysing the cellobiose molecule to produce two β-glucose molecules.

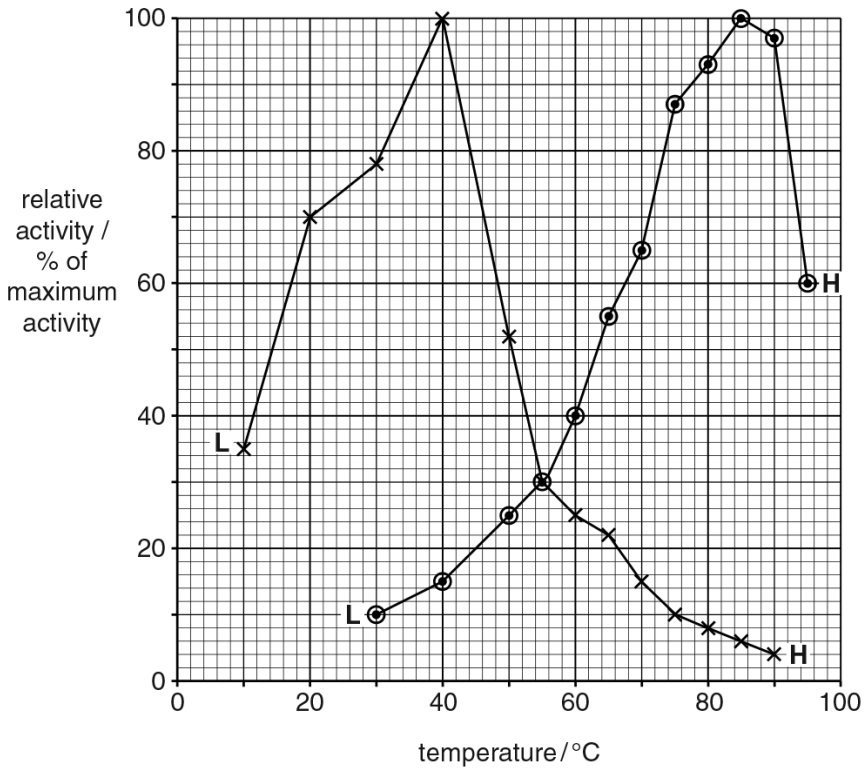
(a) Draw the ring structure of one β-glucose molecule in the space provided.

[2]

(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.



Key

× enzyme **A** (extracted from *A. tumefaciens*)

⊙ enzyme **T** (extracted from *T. maritima*)

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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.....[4]

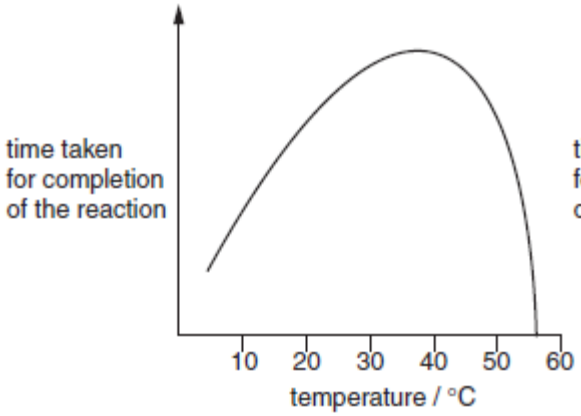
[Total: 10]

1.

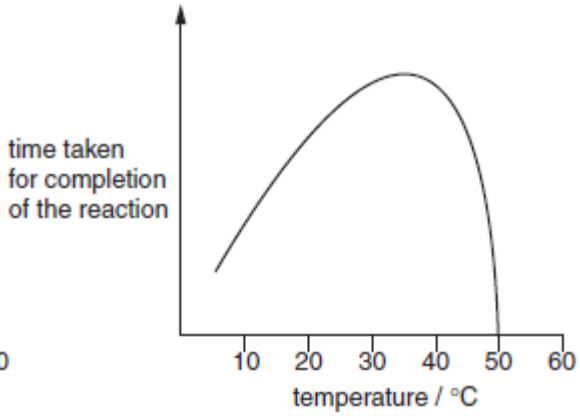
14 An enzyme is completely denatured at 50 °C. A fixed concentration of this enzyme is added to a fixed concentration of its substrate. The time taken for completion of the reaction is measured at different temperatures.

Which graph shows the results?

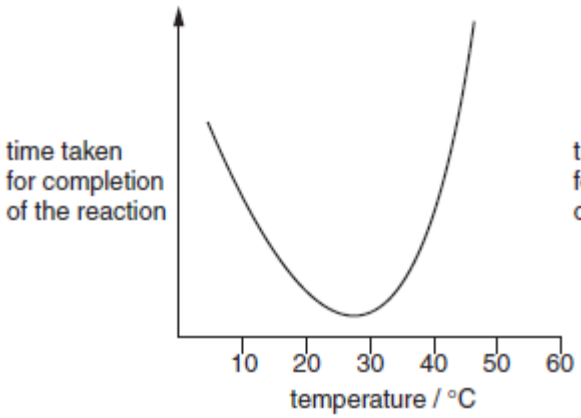
A



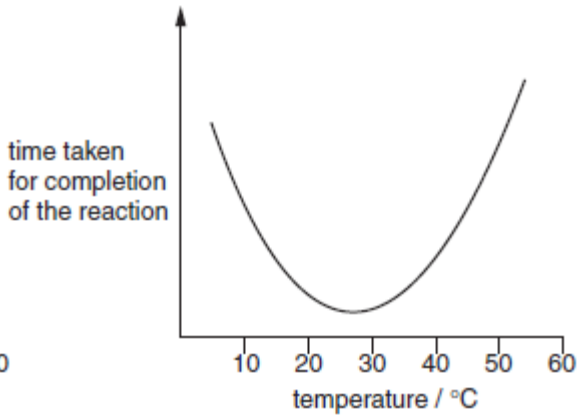
B



C



D



2.

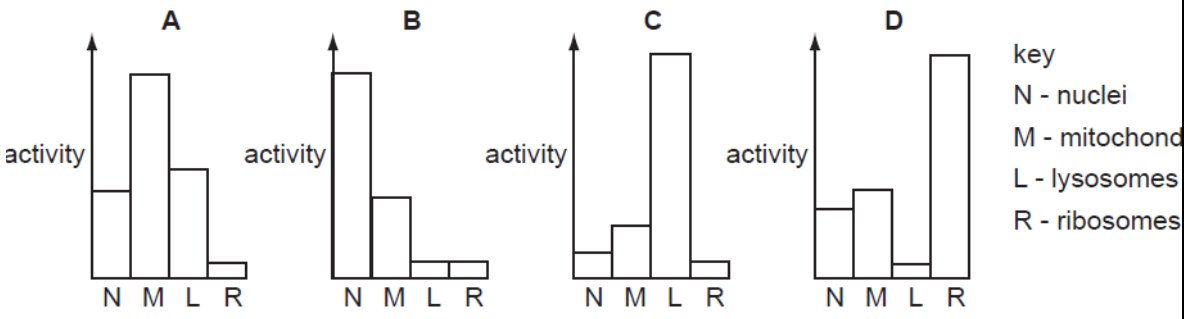
Which properties are characteristic of a non-competitive inhibitor of an enzyme?

	binding	effect of adding more substrate
A	at active site	reduces inhibition
B	at active site	does not reduce inhibition
C	not at active site	reduces inhibition
D	not at active site	does not reduce inhibition

3.

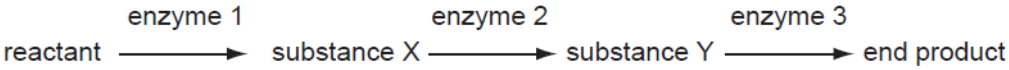
A piece of mammalian tissue was homogenised and subjected to differential centrifugation yield four subcellular fractions. The activity within each fraction, of four different types of enzyr **A**, **B**, **C** and **D**, was investigated.

Which bar chart shows the results of investigating hydrolytic enzyme activity?



4.

A metabolic pathway is



What would be the effect of adding a small amount of a non-competitive inhibitor of enzyme 2?

A Enzyme 2 would be partially denatured.

B Substance X would increase in concentration.

C Substance Y would no longer be formed.

D The initial reactant would no longer be metabolised.

5. The initial rate of a reaction catalysed by an enzyme was measured at various substrate concentrations.

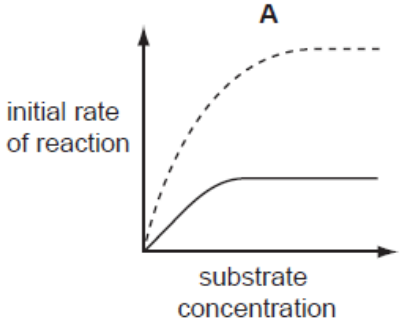
Which graph shows the effect of a low concentration of non-competitive inhibitor on the reaction?

key

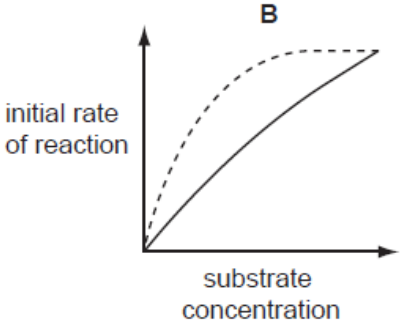
------ uninhibited reaction

——— inhibited reaction

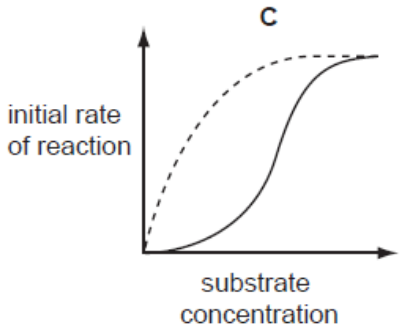
A



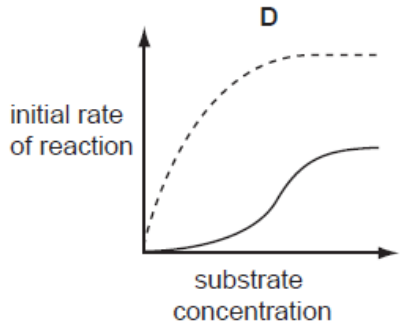
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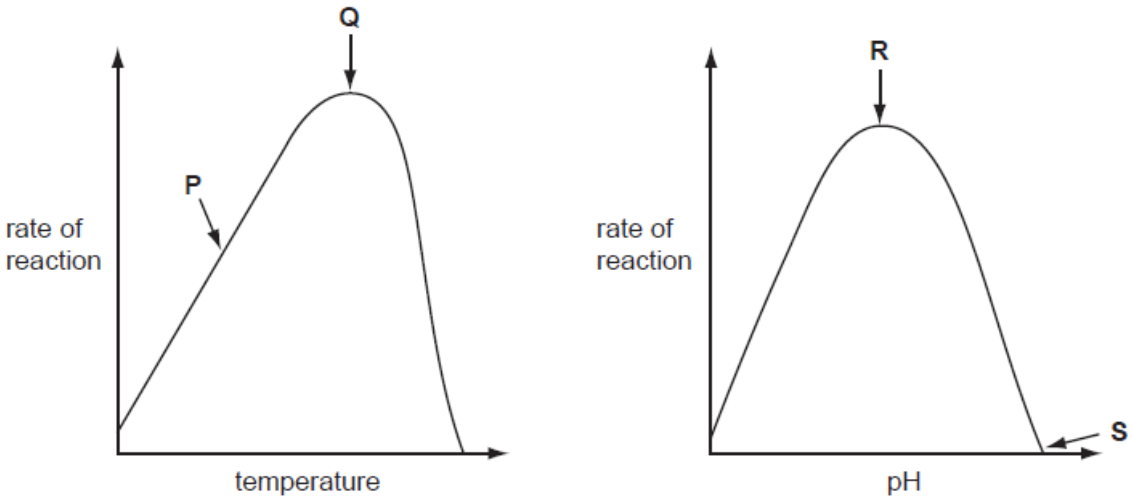
C



D



6. The graphs show the effects of temperature and pH on enzyme activity.



Which statement explains the enzyme activity at the point shown?

A At **P**, hydrogen bonds are formed between enzyme and substrate.

B At **Q**, the kinetic energy of enzyme and substrate is highest.

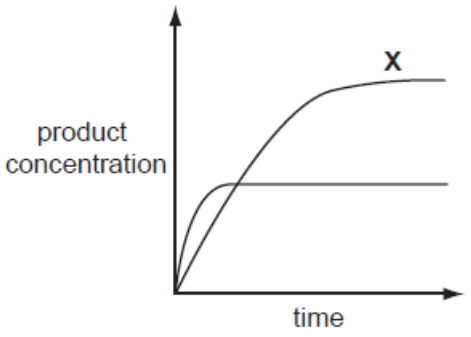
C At **R**, peptide bonds in the enzyme begin to break.

D At **S**, the substrate is completely denatured.

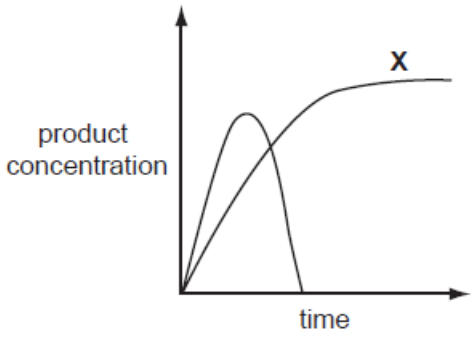
7. Two enzyme experiments were carried out. The first, experiment **X**, was carried out at a constant temperature of 37 °C. During the second experiment the temperature was increased from 37 °C to 80 °C.

Which graph shows the results?

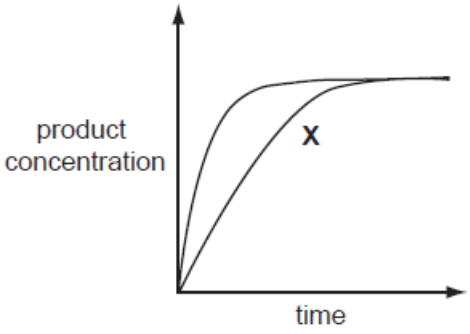
A



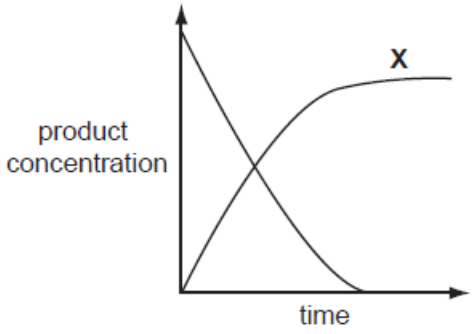
B



C



D



8. Which properties are characteristic of a non-competitive inhibitor of an enzyme?

	binding	effect of adding more substrate
A	at active site	reduces inhibition
B	at active site	does not reduce inhibition
C	not at active site	reduces inhibition
D	not at active site	does not reduce inhibition

9.

The rate of enzyme catalysed reactions in human cells is regulated.

Which of the following may be involved in such regulation?

1 a change in enzyme concentration

2 a change in substrate concentration

3 inhibition by the final product of the reaction

A 1 only

B 3 only

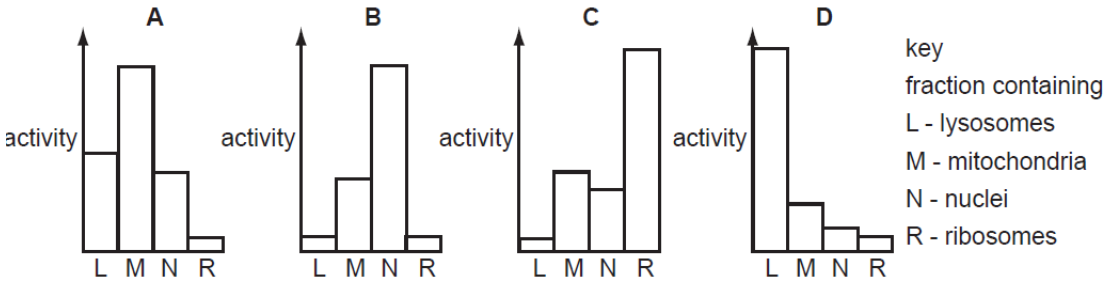
C 1 and 2 only

D 1, 2 and 3

10.

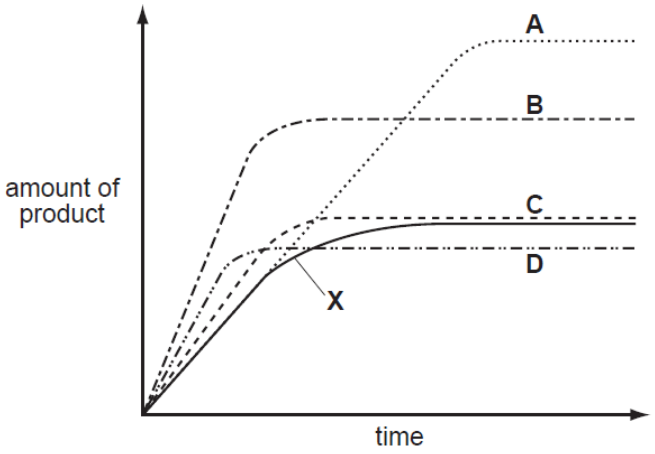
5 A piece of mammalian tissue was homogenised and subjected to differential centrifugation to yield four subcellular fractions. The activity of four different types of enzyme, **A**, **B**, **C** and **D**, was investigated within each fraction.

Which bar chart shows the results of investigating hydrolytic enzyme activity?



11. The curve **X** shows the activity of an enzyme at 20 °C. Curves **A, B, C** and **D** show the effect of different conditions on the activity of the enzyme.

Which curve shows the effect of increasing the temperature by 10 °C and adding extra substrate?



12. When investigating the rate of reaction of the enzyme lipase on the hydrolysis of triglycerides, the pH must be maintained at an optimum to prevent the lipase denaturing.

What is the reason for this?

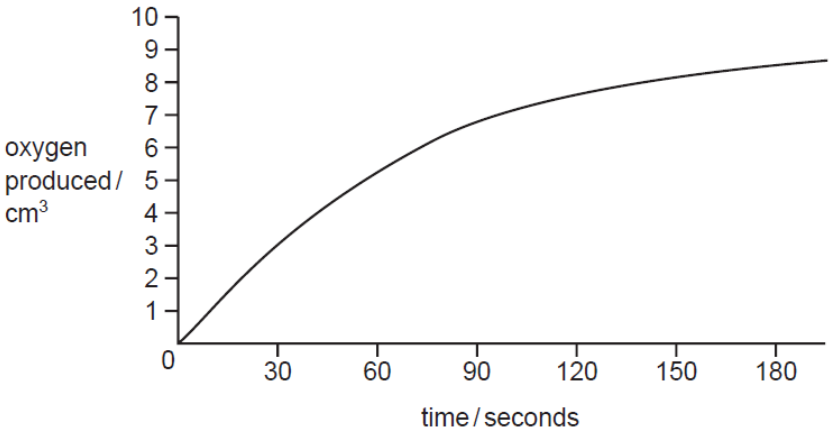
A The addition of water molecules produced by hydrolysis increases pH.

B The products of hydrolysis decrease the pH.

C The products of hydrolysis increase the pH.

D The removal of water molecules used in hydrolysis decreases pH.

13. Catalase was added to hydrogen peroxide solution. The volume of oxygen produced was measured at intervals. The results are shown on the graph.



What was the initial rate of reaction?

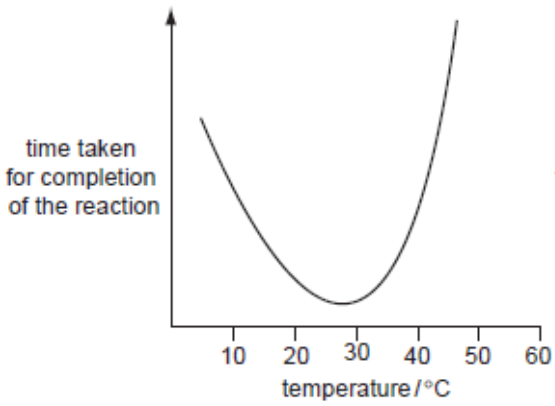
A $0.05\,cm^3\,s^{-1}$ **B** $0.10\,cm^3\,s^{-1}$ **C** $1.00\,cm^3\,s^{-1}$ **D** $10.0\,cm^3\,s^{-1}$

14.

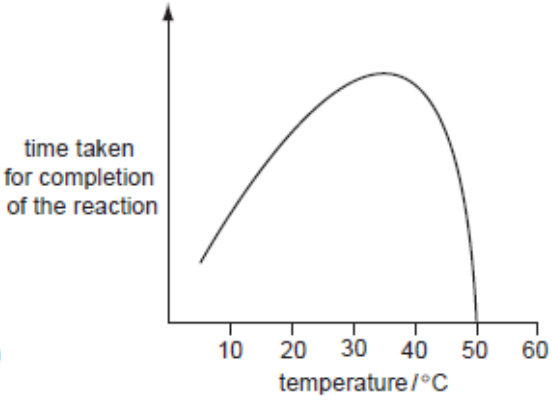
14 An enzyme is completely denatured at 50 °C. A fixed concentration of this enzyme is added to a fixed concentration of its substrate. The time taken for completion of the reaction is measured at different temperatures.

Which graph shows the results?

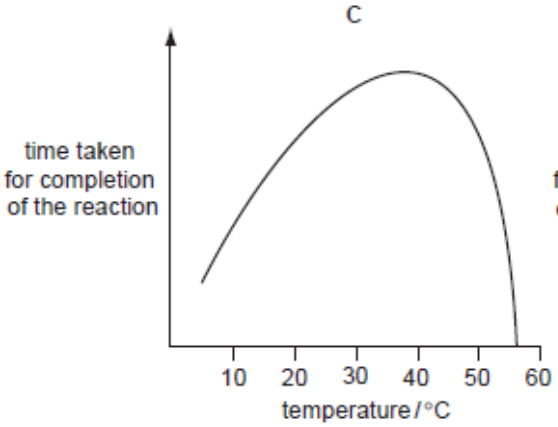
A



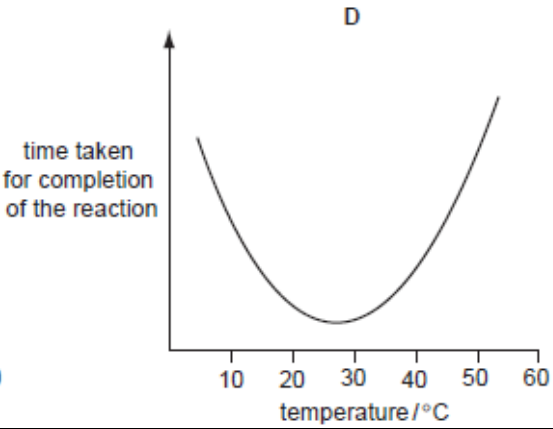
B



C



D



15.

The breakdown of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

In an investigation into the effect of pH on the rate of reaction of catalase, potato cubes were added to hydrogen peroxide.

Which dependent variable should be recorded?

A the change in mass of the potato after a given time

B the pH of the solution at regular time intervals

C the number of potato cubes added at the start

D the volume of oxygen given off at regular time intervals

16. Some inhibitors of enzyme reactions bind to the enzyme/substrate complex.

Which statements about this type of inhibition are correct?

1 The active site changes shape.

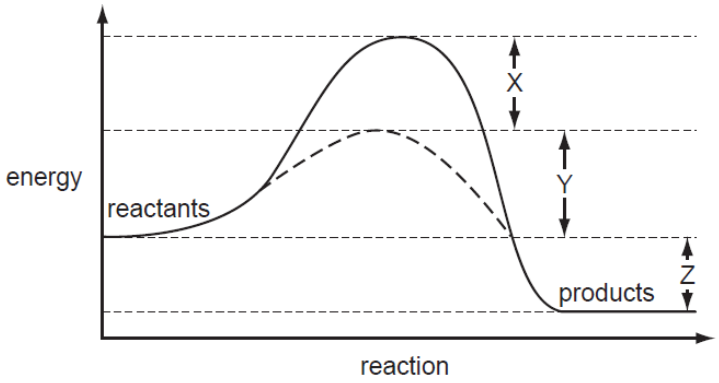
2 The inhibitor is non-competitive.

3 The initial rate of reaction is reduced.

4 The maximum rate of reaction (V_{max}) is increased.

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

17. ! The graph shows the activation energy of an enzyme-catalysed reaction and the same reaction without a catalyst.



Which of the following shows the activation energy of the uncatalysed reaction?

A X + Y – Z **B** X + Z – Y **C** X + Y **D** Y + Z

18. Which of the following statements are true of **all** enzymes?

1 soluble in water

2 catalyse the breakdown of large molecules into smaller molecules

3 only have one active site

4 have a quaternary structure

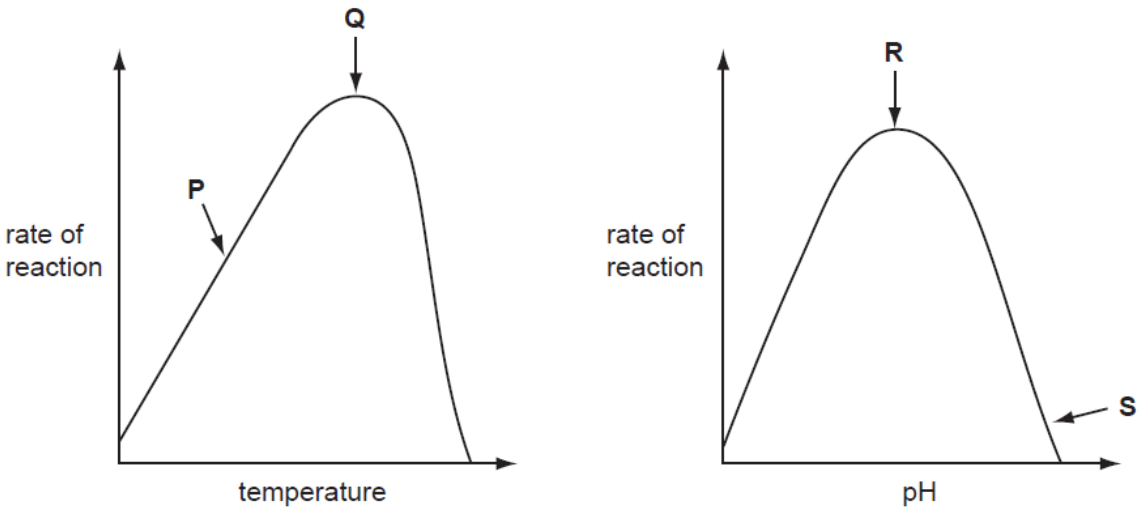
A 1, 2 and 3 only

B 2, 3 and 4 only

C 1 only

D 4 only

19. The graphs show the effects of temperature and pH on enzyme activity.



Which statement explains the enzyme activity at the point shown?

A At **P**, hydrogen bonds are formed between enzyme and substrate.

B At **Q**, the kinetic energy of enzyme and substrate is highest.

C At **R**, peptide bonds in the enzyme begin to break.

D At **S**, the enzyme is completely denatured.

20. Some inhibitors of enzyme reactions bind to the enzyme/substrate complex.

Which statements about this type of inhibition are correct?

1 The active site changes shape.

2 The inhibitor is non-competitive.

3 The initial rate of reaction is reduced.

4 The maximum rate of reaction (V_{max}) is increased.

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

21. The breakdown of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

In an investigation into the effect of pH on the rate of reaction of catalase, potato cubes were added to hydrogen peroxide.

Which dependent variable should be recorded?

A the change in mass of the potato after a given time

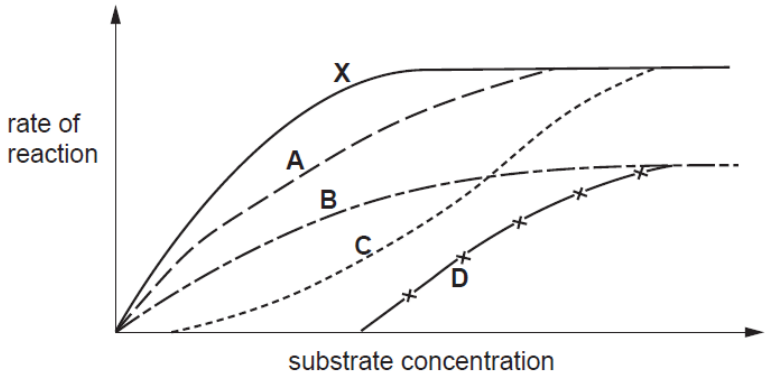
B the pH of the solution at regular time intervals

C the number of potato cubes added at the start

D the volume of oxygen given off at regular time intervals

22. In the graph, **X** represents the relationship between the initial rate of reaction of an enzyme and the concentration of its substrate under optimal conditions and without an inhibitor.

Which curve represents the result when the same experiment is carried out in the presence of a fixed, low concentration of a non-competitive inhibitor?



23. Which bonds hold substrate molecules to the active site of an enzyme?

A disulphide

B glycosidic

C hydrogen

D peptide

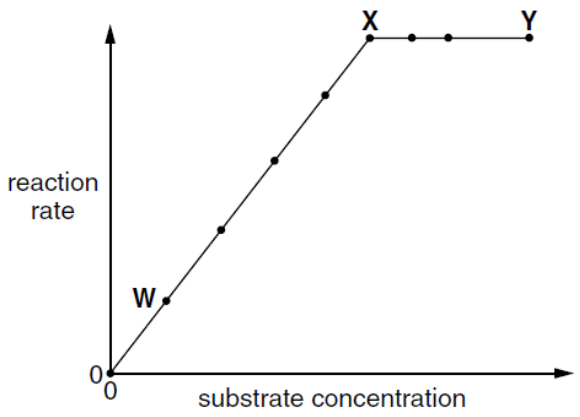
24. The equation shows a reversible reaction.

$$\text{sucrose} + \text{water} \underset{2}{\overset{\text{sucrase}\ 1}{\rightleftharpoons}} \text{glucose} + \text{fructose}$$

In this reaction, on which molecule or molecules do active sites occur and what types of reaction occur at **1** and **2**?

	active site present on	reaction at **1**	reaction at **2**
A	glucose and fructose	condensation	hydrolysis
B	glucose and fructose	hydrolysis	condensation
C	sucrase only	condensation	hydrolysis
D	sucrase only	hydrolysis	condensation

25. The graph shows the effect of substrate concentration on the rate of an enzyme-controlled reaction. The enzyme concentration is constant.



Which statement about the graph is correct?

A Between **W** and **X**, the number of enzyme molecules is limiting.

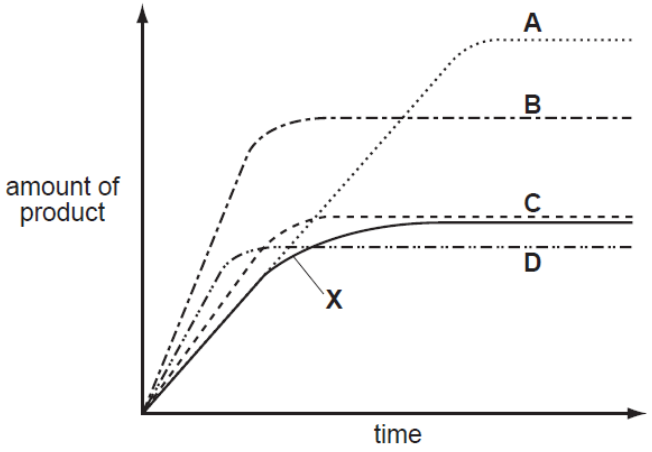
B Between **X** and **Y**, the number of enzyme molecules is limiting.

C Between **X** and **Y**, the number of substrate molecules is limiting.

D Between **X** and **Y**, the product concentration remains the same.

26. The curve **X** shows the activity of an enzyme at 20 °C. Curves **A** to **D** show the effect of different conditions on the activity of the enzyme.

Which curve shows the effect of increasing the temperature by 10 °C and adding extra substrate?



27. What is the effect of increasing substrate concentration on the degree of inhibition of an enzyme-controlled reaction?

	competitive inhibition	non-competitive inhibition
A	decreased	increased
B	decreased	no change
C	increased	decreased
D	no change	increased

28. Which statement is true of all enzymes?

A They are denatured at temperatures above 60 °C.

B They are inactivated at low pH values.

C They catalyse the breakdown of large molecules into smaller ones.

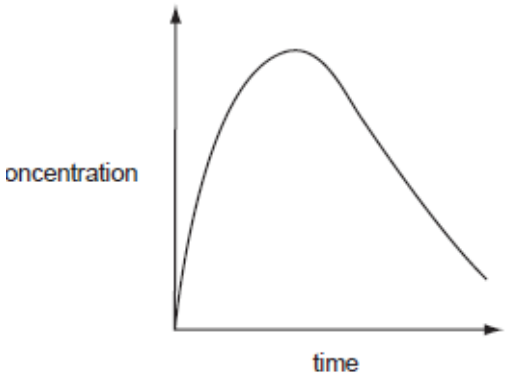
D They reduce the amount of energy required to start a reaction.

29.

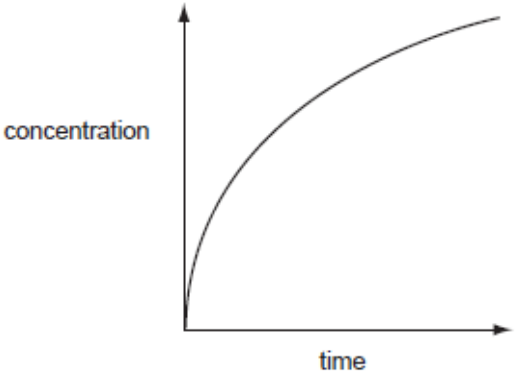
A quantity of an enzyme was added to a quantity of its substrate. The graphs show the changes in concentration of the enzyme, the substrate, the enzyme-substrate complex and the product over time.

Which graph shows the change in the concentration of the enzyme-substrate complex?

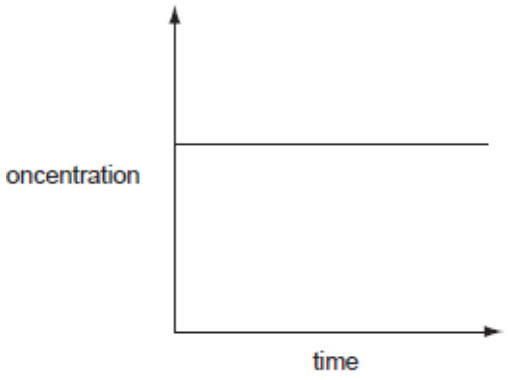
A



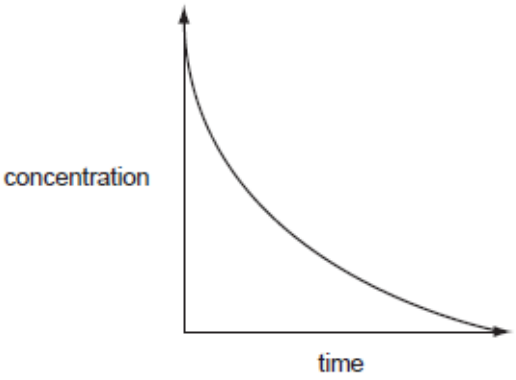
B



C



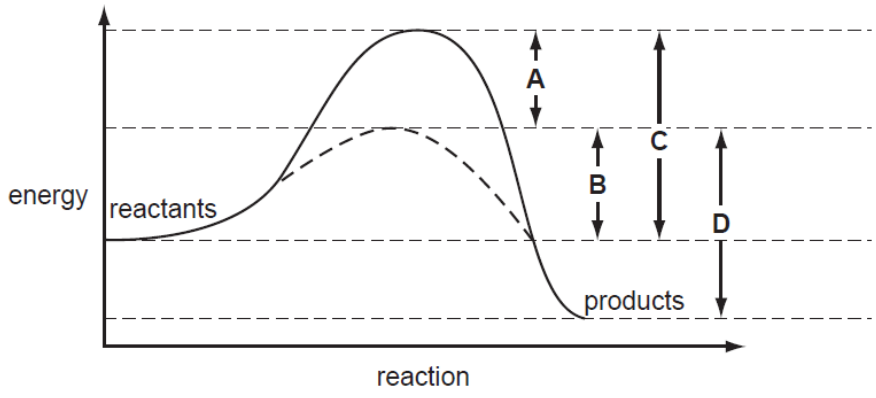
D



30.

The graph shows the activation energy of an enzyme-catalysed reaction and the same reaction without a catalyst.

Which arrow shows the activation energy of the uncatalysed reaction?



31. How does increasing substrate concentration affect the rate of an enzyme-catalysed reaction in the presence of a competitive inhibitor?

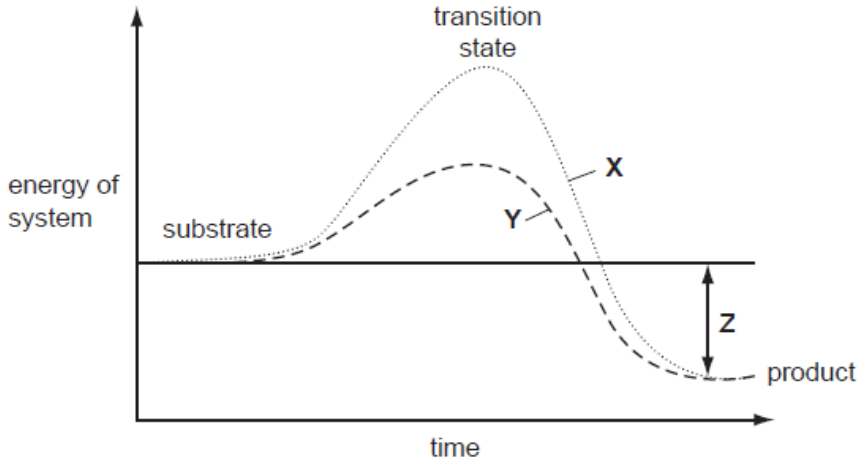
A The rate of the reaction decreases.

B The rate of the reaction decreases initially and then recovers.

C The rate of the reaction increases.

D The rate of the reaction is not affected.

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

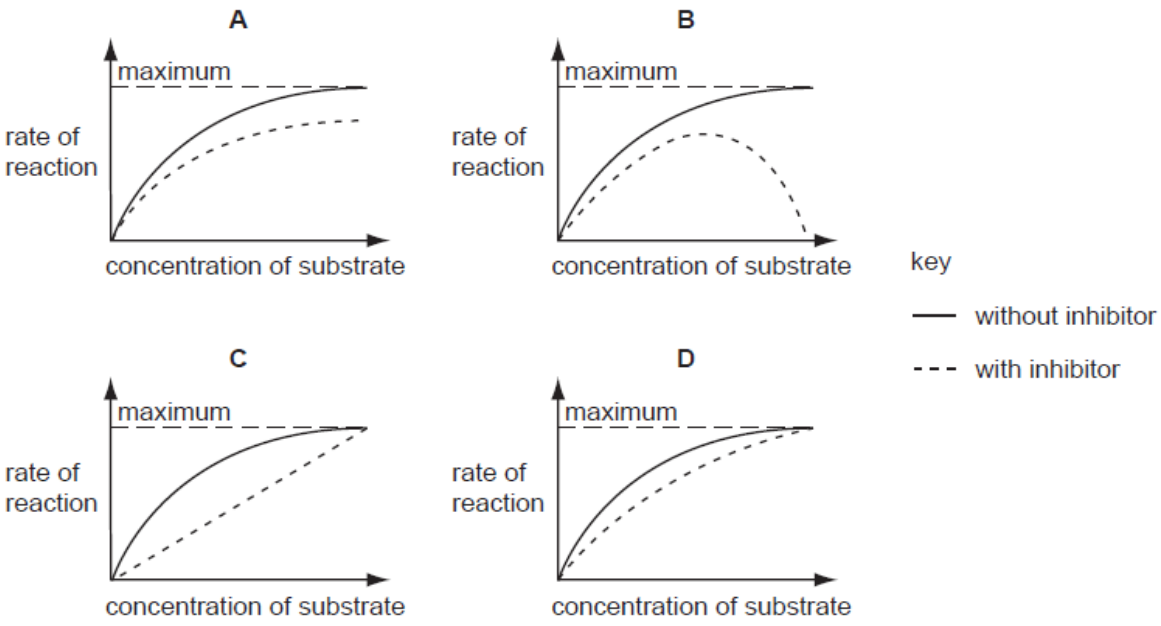


Which combination identifies **X**, **Y** and **Z**?

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

33.

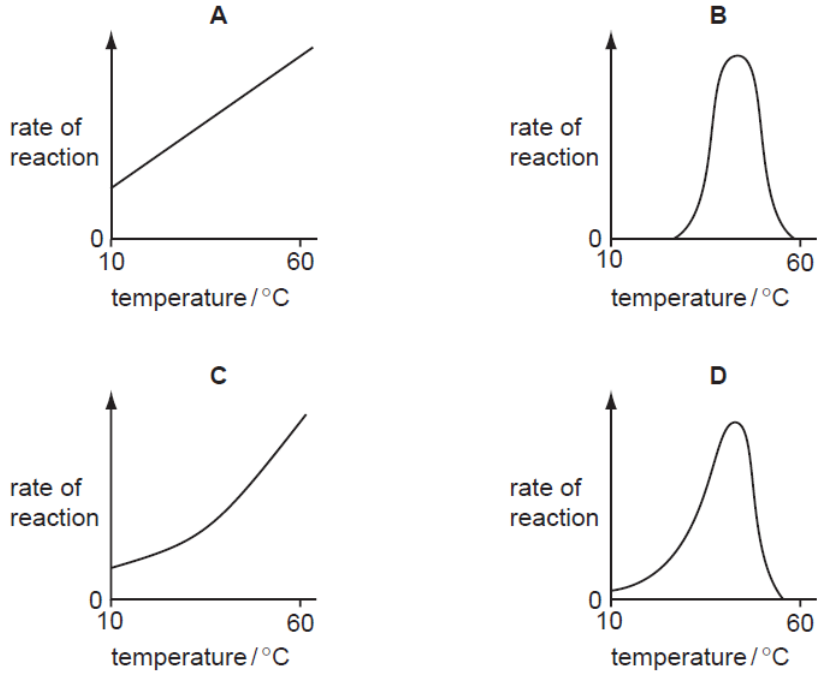
14 Which graph represents the action of a non-competitive inhibitor?



34.

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

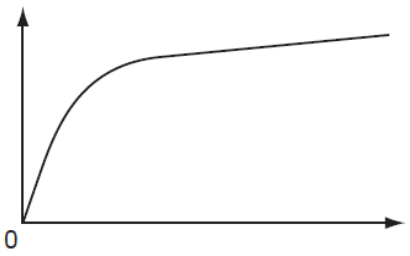
Which curve represents the most usual relationship between temperature and enzyme activity?



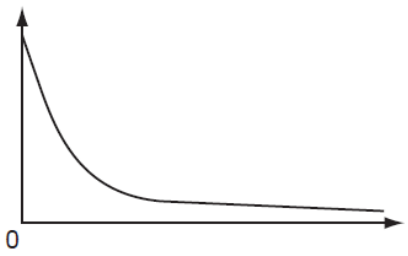
35. In an experiment, 5 cm^3 of 1 % salivary amylase are added to 100 cm^3 of different concentrations of starch.

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

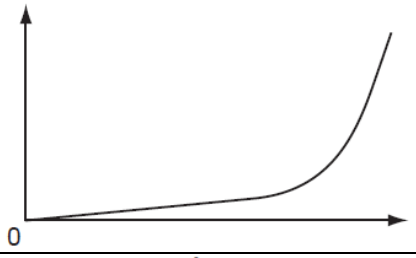
A



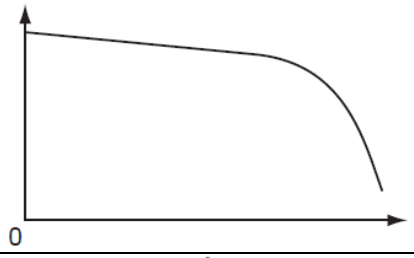
B



C



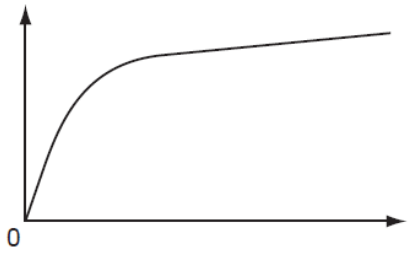
D



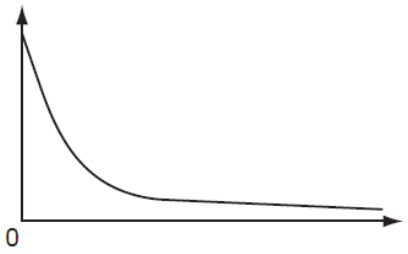
36. In an experiment, 5 cm^3 of 1 % salivary amylase are added to 100 cm^3 of different concentrations of starch.

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

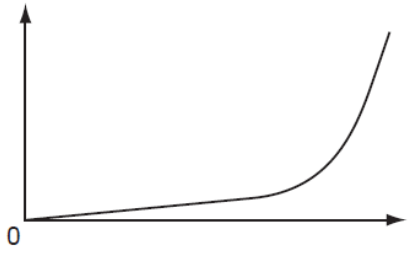
A



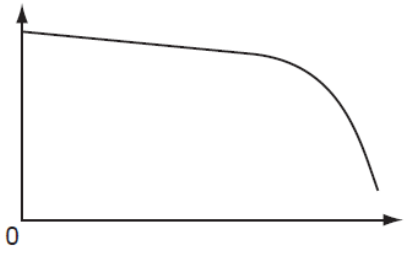
B



C



D



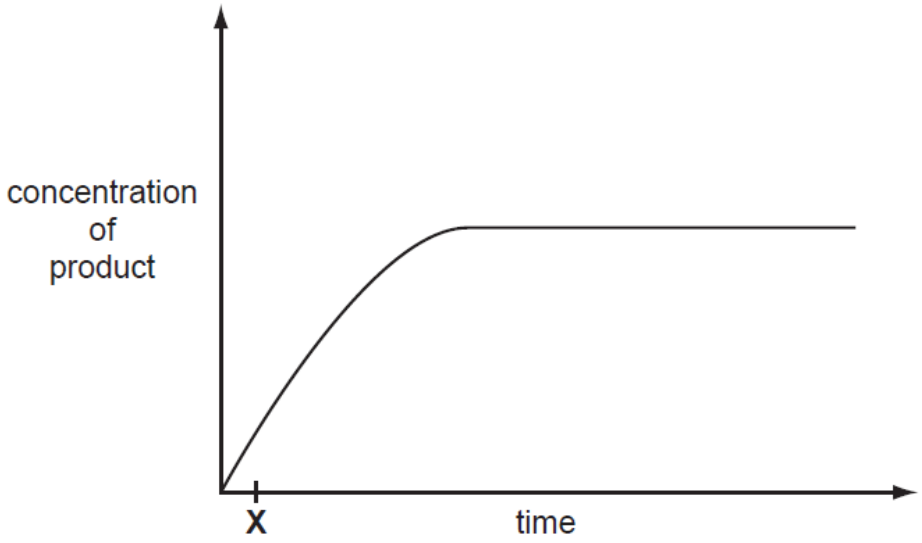
37. The equation shows a reversible reaction.

$$\text{sucrose} + \text{water} \underset{\textbf{2}}{\overset{\text{sucrase}\ \textbf{1}}{\rightleftharpoons}} \text{glucose} + \text{fructose}$$

In this reaction, on which molecule does an active site occur and what types of reaction occur at **1** and **2**?

	active site present on	reaction at **1**	reaction at **2**
A	sucrase	condensation	hydrolysis
B	sucrase	hydrolysis	condensation
C	sucrose	condensation	hydrolysis
D	sucrose	hydrolysis	condensation

38. The graph shows the course of an enzyme-catalysed reaction at 30 °C.



What is true at time **X**?

A Most enzyme molecules will have free active sites.

B The number of available substrate molecules is high.

C The number of enzyme-substrate complexes is low.

D The rate remains the same if more enzyme is added.

39. The rate of enzyme-catalysed reactions in human cells is regulated.

Which may be involved in such regulation?

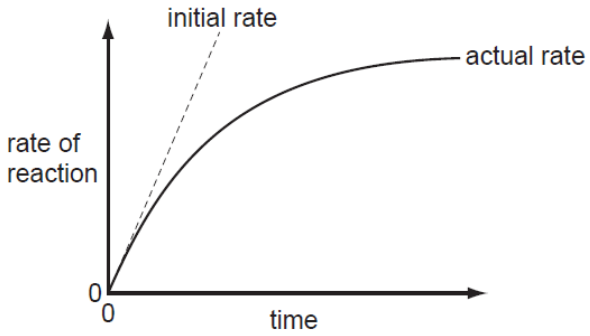
1 a change in enzyme concentration

2 a change in substrate concentration

3 inhibition by the final product of the reaction

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

40. 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.

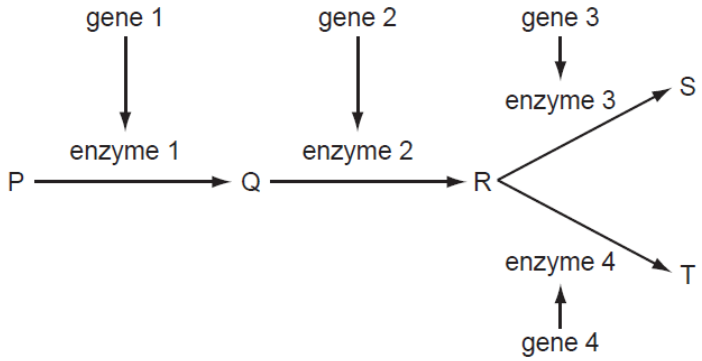
C The product inhibited the reaction.

D The substrate molecules were used up.

41. 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

42. S and T are products of a biochemical pathway. A different enzyme, coded for by different specific genes, catalyses each step in the pathway.



What is the possible outcome to the pathway if a mutation in gene 3 leads to an inactive enzyme?

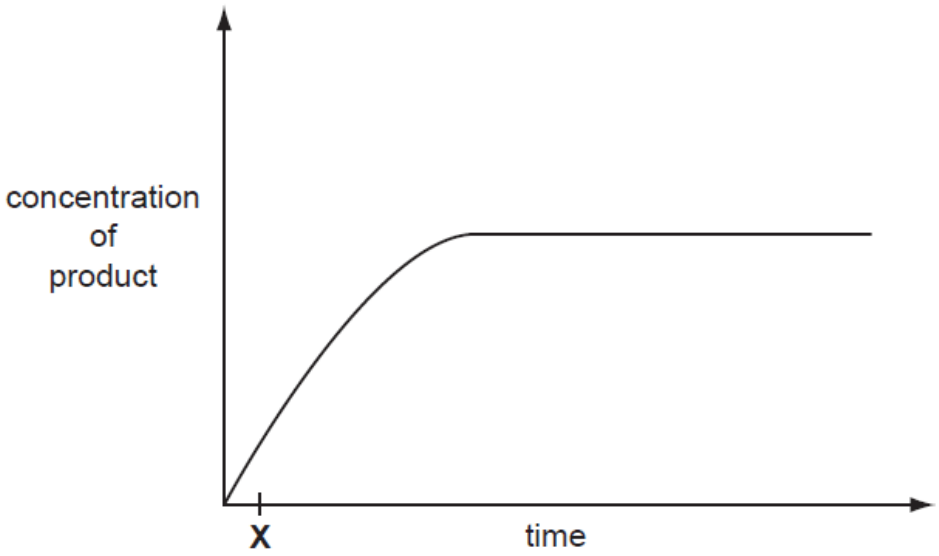
A There is a decrease in the activity of gene 1 and gene 2.

B There is an accumulation of product S.

C There is an increase in the rate of reaction of enzyme 4.

D There is an increase in the production of T.

43. The graph shows the course of an enzyme-catalysed reaction at 30 °C.



What is true at time **X**?

A Most enzyme molecules will have free active sites.

B The number of available substrate molecules is high.

C The number of enzyme-substrate complexes is low.

D The rate remains the same if more enzyme is added.

44. The rate of enzyme-catalysed reactions in human cells is regulated.

Which may be involved in such regulation?

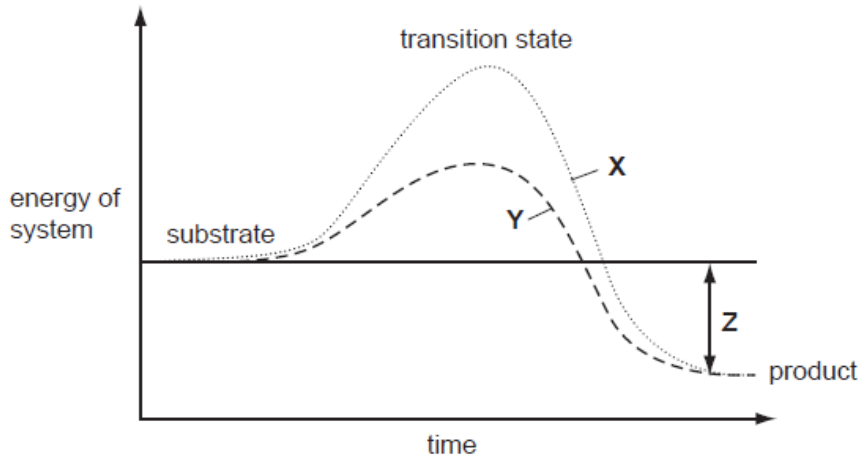
1 a change in enzyme concentration

2 a change in substrate concentration

3 inhibition by the final product of the reaction

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

45. 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

46. 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

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

1 alter the shape of the active site

2 denature the enzyme

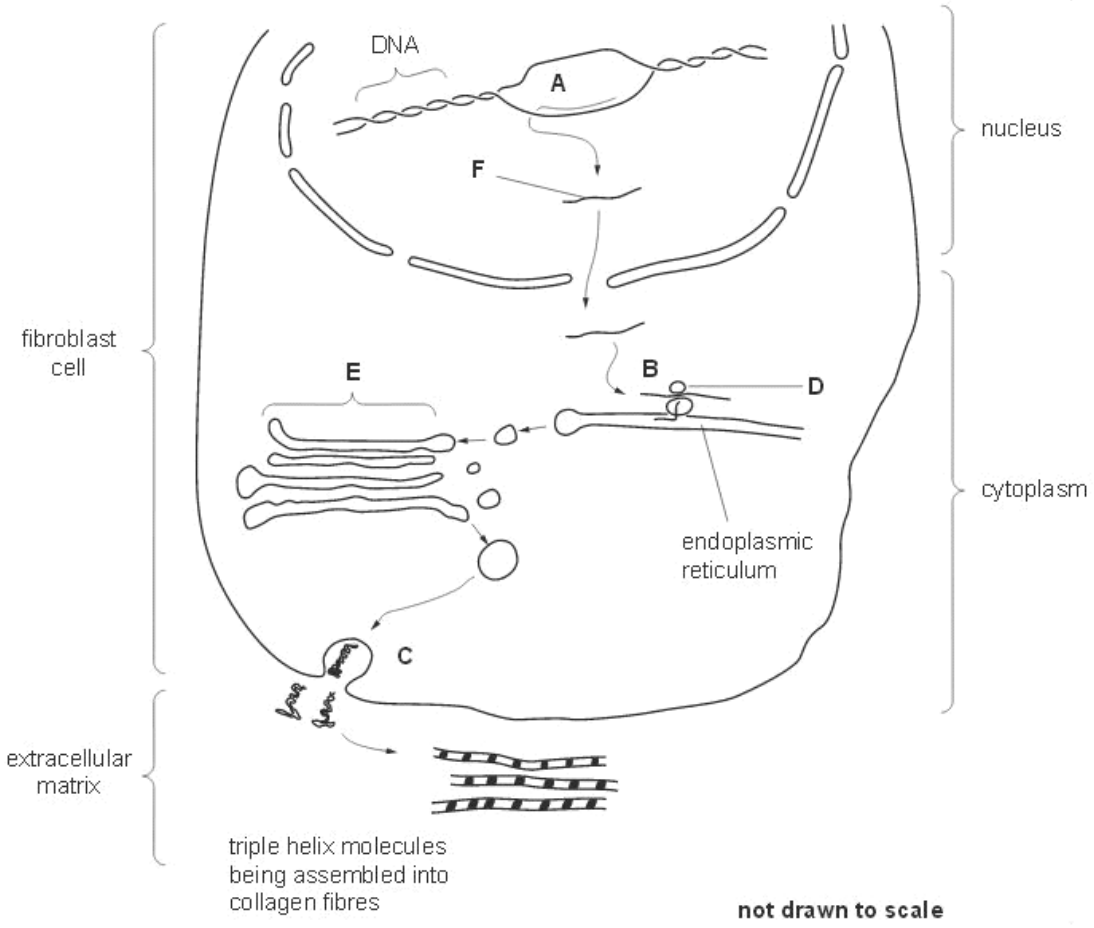
3 reduce the rate of the enzyme catalysed reaction

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

Q1.

4 Collagen is found in the extracellular matrix of muscles, tendons, ligaments and bones. Fibroblast cells in these tissues make collagen by synthesising polypeptides that form molecules with a triple helix shape. These are secreted from fibroblasts into the extracellular matrix where enzymes assemble them into collagen fibres.

Fig. 4.1 is a diagram summarising these events.



(a) (i) Name the processes occurring at **A**, **B** and **C**.

A .....

B .....

C ..... [3]

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(ii) Name structures **D** and **E**.

D .....

E ..... [2]

(iii) Name molecule **F**.

F ..... [1]

Collagen is continuously broken down in the extracellular matrix by the enzyme collagenase, which catalyses the hydrolysis of the peptide bond between the amino acids glycine and isoleucine.

(b) Suggest how collagenase is only able to act on the peptide bond between glycine and isoleucine and not on peptide bonds between any other amino acids.

.....

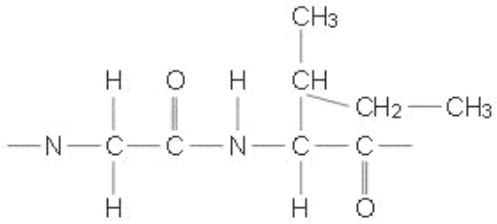
.....

.....

..... [2]

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(c) Draw a diagram below to show how the peptide bond between glycine and isoleucine is broken by hydrolysis including the product or products.



[3]

[Total: 11]

Q2.

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The activity of urease can be measured by following the increase in pH as ammonia is produced in the reaction. A student was provided with urease extracted from bacteria and solutions of urea and two chemical inhibitors, thiourea and lead nitrate. The student prepared six reaction mixtures (**1** to **6**) as shown in Table 5.1 in order to investigate the effect of the two chemical inhibitors on the activity of urease.

Table 5.1

reaction mixture	urea	water	thiourea	lead nitrate	urease	boiled urease
1	✔	✔	✘	✘	✔	✘
2	✔	✘	✔	✘	✔	✘
3	✔	✘	✘	✔	✔	✘
4	✔	✔	✘	✘	✘	✘
5	✘	✔	✔	✘	✔	✘
6	✔	✔	✘	✘	✘	✔

Key ✔ = present in reaction mixture ✘ = absent from reaction mixture

The student recorded an increase in pH in reaction mixtures **1** and **2**. The reaction was faster in **1** than in **2**. The pH in the other reaction mixtures did not change.

(b) The student made some conclusions about the results from the test-tubes. Match the statements to the reaction mixtures, **1** to **6**. You may use the numbers once, more than once or not at all.

(i) 'No reaction took place because urease was denatured.' [1]

(ii) 'There was no reaction because there was no substrate for urease.' [1]

(iii) 'The reaction did not occur because there was an inhibitor present.' [1]

Thiourea has a molecular structure that is very similar to that of urea. The student designed an experiment to find out whether thiourea is a competitive inhibitor. The student set up several reaction mixtures like **1** using increasing concentrations of urea. The student determined the initial rate of the reaction for urease at each concentration of urea. The results are shown in Fig. 5.1.

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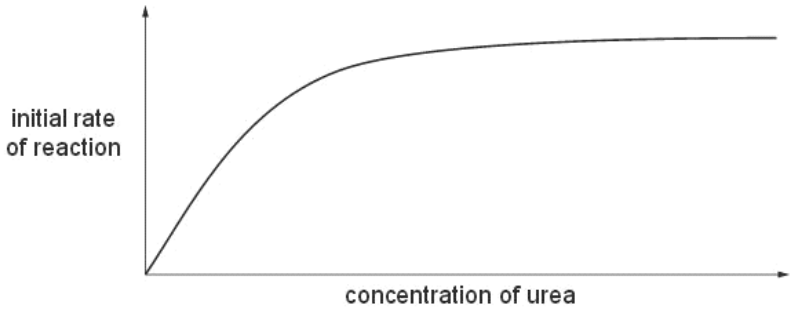


Fig. 5.1

The student then repeated the experiment using the same concentrations of urea. However, the student added the same volume and concentration of a thiourea solution to each test-tube in place of the water.

(c) Sketch a curve on Fig. 5.1 to show the results that the student would expect if thiourea acts as a competitive inhibitor of urease. [2]

(d) Explain why it is important to determine the **initial** rate of reaction when investigating the effect of a competitive inhibitor on an enzyme.

.....

.....

.....

.....[2]

[Total: 10]

Q3.

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2 **(a)** Describe how enzymes take part in chemical reactions.

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.....[4]

Starch phosphorylase is an enzyme found in plant cells. In potato tuber cells, the enzyme takes part in the breakdown of starch when the tuber begins to grow.

$$\text{starch} + \text{phosphate ions} \xrightarrow{\text{starch phosphorylase}} \text{glucose 1-phosphate}$$

A student investigated the effect of pH on this reaction using two buffer solutions.

The student prepared four test-tubes, **A** to **D**, as shown in Table 2.1 and described below.

The student made an extract of potato tissue that contained the enzyme. Some of this extract was boiled.

A solution of potassium dihydrogen phosphate was added to some tubes as a source of phosphate ions.

The test-tubes were left for ten minutes in a water bath at 30 °C and then samples were tested with iodine solution.

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Table 2.1

test-tube	contents					results with iodine solution after ten minutes
	volume of starch solution / cm^3	volume of glucose 1-phosphate solution / cm^3	volume of potassium dihydrogen phosphate solution / cm^3	pH of buffer solution	enzyme extract	
A	2		0.5	6.5	unboiled	negative
B	2		0.5	2.0	unboiled	positive
C	2		0.5	6.5	boiled	positive
D		2		6.5	boiled	negative

(b) (i) State what the student would conclude from a positive result with iodine solution.

.....[1]

(ii) Explain why the student boiled some of the extract in this investigation.

.....

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.....[2]

(c) Explain the results shown in Table 2.1.

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.....[4]

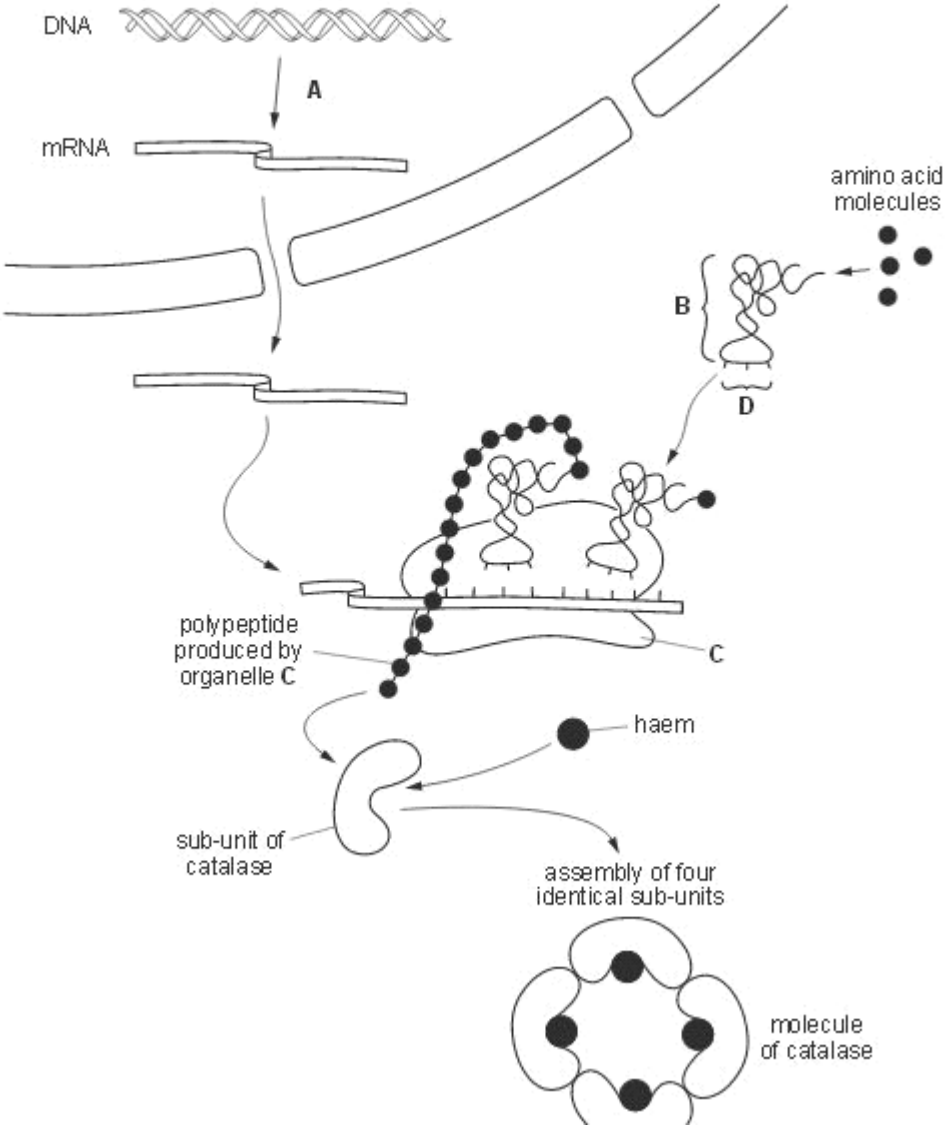
[Total: 11]

Q4.

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4 Catalase is an enzyme with a molecular structure composed of four identical sub-units.

Fig. 4.1 is a diagram that shows how catalase is produced in cells.



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(a) With reference to Fig. 4.1,

For Examiner Use

(i) name

process **A** .....

molecule **B** .....

structure **C** .....

sequence of bases **D** .....[4]

(ii) state two ways in which the structure of catalase is similar to the structure of haemoglobin and one way in which it differs

structural similarities

1. .....

2. .....[2]

structural difference

.....[1]

(iii) State why it is possible for a catalase molecule to bind to four substrate molecules at the same time.

.....[1]

(b) The enzyme amylase catalyses the following reaction:

starch + water ⟶ maltose

The progress of this reaction may be followed by measuring either the starch concentration or the maltose concentration at intervals of time.

State which chemicals you would use to detect the disappearance of the substrate and the appearance of the product, in order to follow the progress of the reaction.

disappearance of substrate .....

.....

appearance of product .....

.....[2]

[Total: 10]

Q5.

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

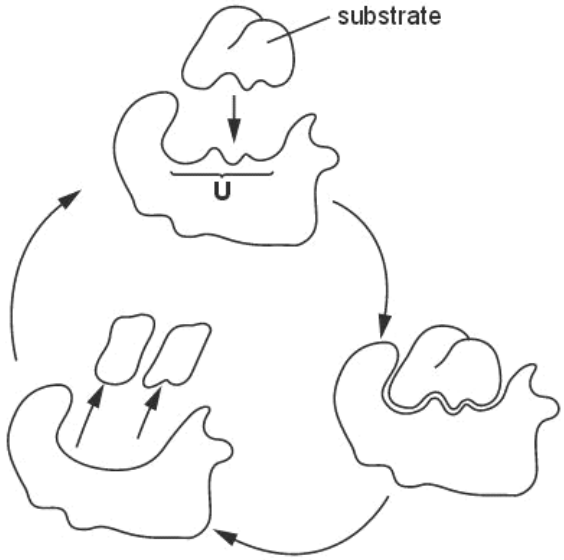


Fig. 1.2

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

.....[1]

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

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.....[4]

Q6.

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(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.

.....

.....[1]

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

.....

.....

.....

.....

.....

.....

.....[4]

Q7.

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.

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The results are shown in Fig. 4.1.

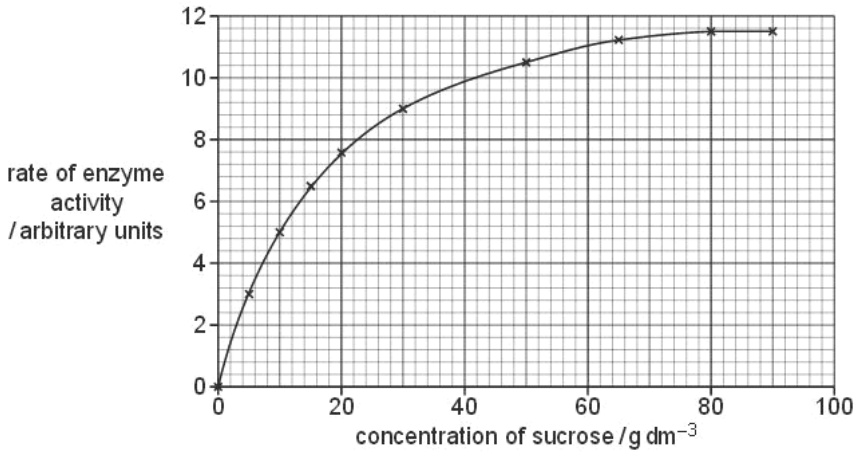


Fig. 4.1

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

.....[1]

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

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.....[2]

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

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.....[5]

[Total: 8]

Q8.

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.

.....[1]

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

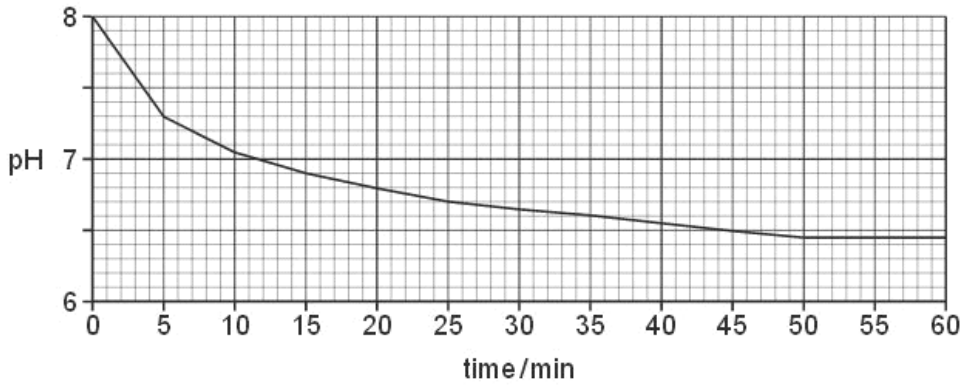


Fig. 5.2

With reference to Fig. 5.2,

(i) describe the results of the investigation

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.....

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.....[2]

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(ii) explain the results of the investigation.

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.....[4]

Q9.

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.

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Fig. 4.1

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

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.....

.....[3]

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(b) With reference to Fig. 4.1, identify the aspects of protein structure that are shown and those that are **not** shown.

aspects of protein structure shown

.....

.....

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.....

aspects of protein structure not shown

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.....[3]

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

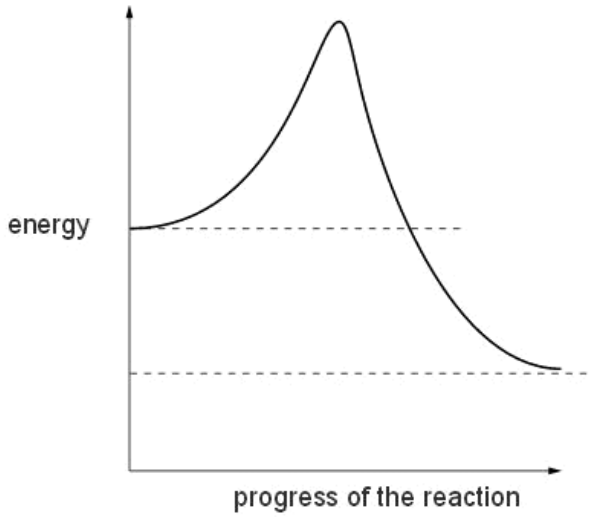


Fig. 4.2

(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]

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

.....[1]

(d) Antibiotic resistance is a serious worldwide problem.

Suggest how antibiotics can be used effectively to avoid the development of widespread resistance in bacteria.

.....

.....

.....

.....[2]

[Total: 11]

Q10.

(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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.....

.....

..... [3]

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

.....

.....

.....

..... [2]

(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.

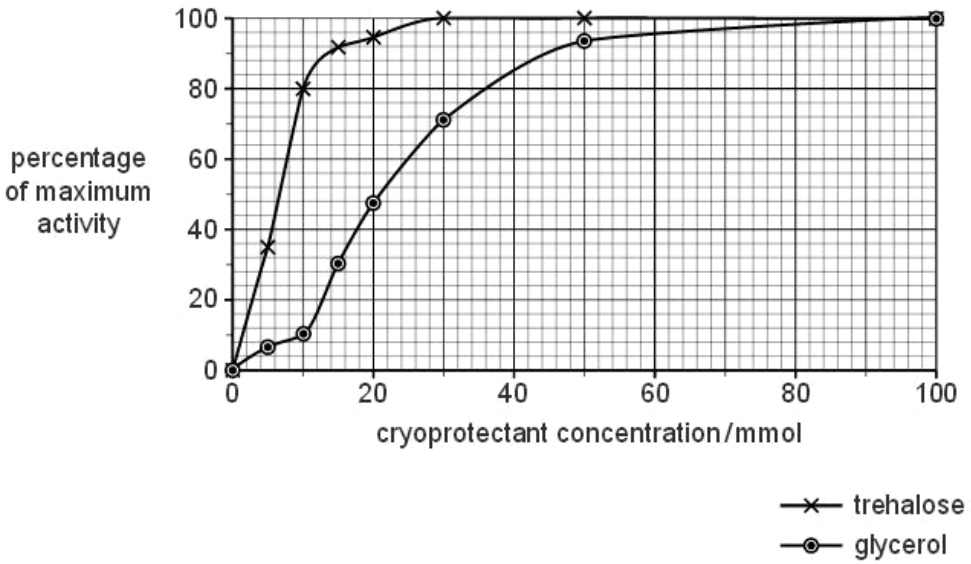


Fig. 4.2

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

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..... [4]

Q11.

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.

.....

..... [1]

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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.

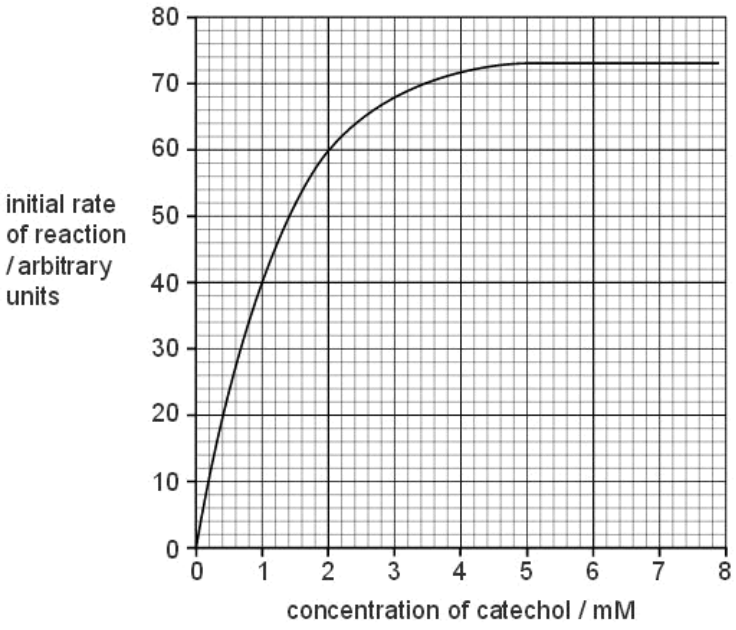


Fig. 4.1

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

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.....

..... [5]

(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.

.....

.....

.....

..... [2]

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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.

.....

.....

.....

..... [2]

[Total: 12]

Q12.

4 Enzymes are globular proteins that catalyse specific reactions.

(a) Explain how enzymes catalyse specific reactions.

.....

.....

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.....

.....

.....[3]

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(b) Restriction enzymes cut DNA into fragments. They cut at specific sites determined by the sequence of bases. Fig. 4.1 shows the base sequences cut by three restriction enzymes and a section of DNA cut by one of these enzymes.

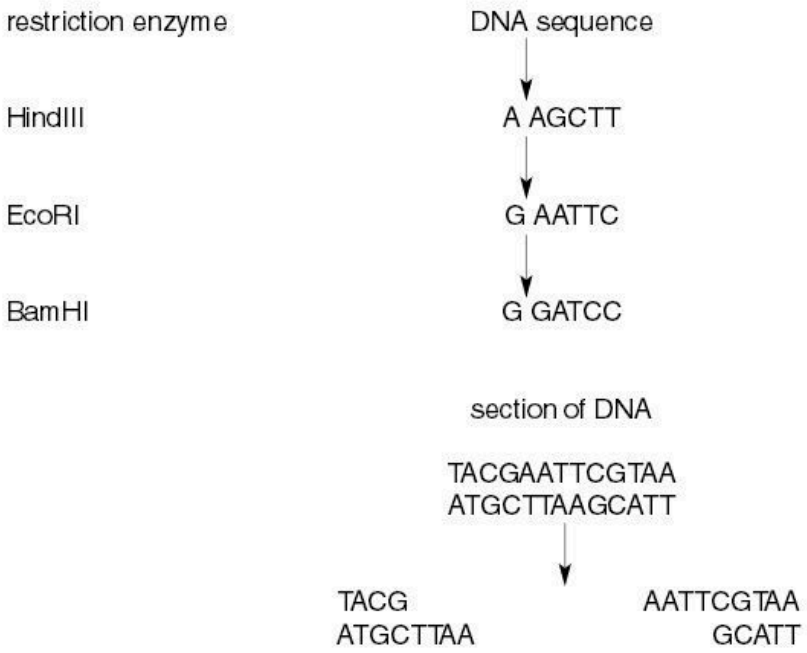


Fig. 4.1

(i) Identify the restriction enzyme that has cut the section of DNA shown in Fig. 4.1.

.....[1]

(ii) State the name given to the unpaired base sequences that remain after DNA has been cut by the three restriction enzymes shown in Fig. 4.1.

.....[1]

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(c) Human genes may be cloned by inserting lengths of DNA into bacteria. This may be carried out by inserting the DNA into a plasmid.

Explain how lengths of DNA, cut by restriction enzymes, are inserted into plasmids.

.....

.....

.....

.....

.....

.....[3]

[Total : 8]

Q13.

5 Enzymes catalyse reactions in which substrate molecules are converted to products.

(a) There are two main approaches to investigation of the activity of an enzyme. State the two ways in which the activity of an enzyme can be found.

1 .....

.....

2 .....

.....[2]

Phosphatase enzymes remove phosphate groups from a wide range of organic compounds that contain phosphate. This makes available a supply of phosphate ions within cells. The reaction catalysed by phosphatase enzymes is as follows:

$$XPO_4 \xrightarrow{\text{phosphatase enzyme}} X + PO_4^{3-}$$

X = an organic compound

The activity of phosphatase was measured at different values of pH by using nine different buffer solutions. The temperature was kept constant at 30 °C. The results are shown in Fig. 5.1.

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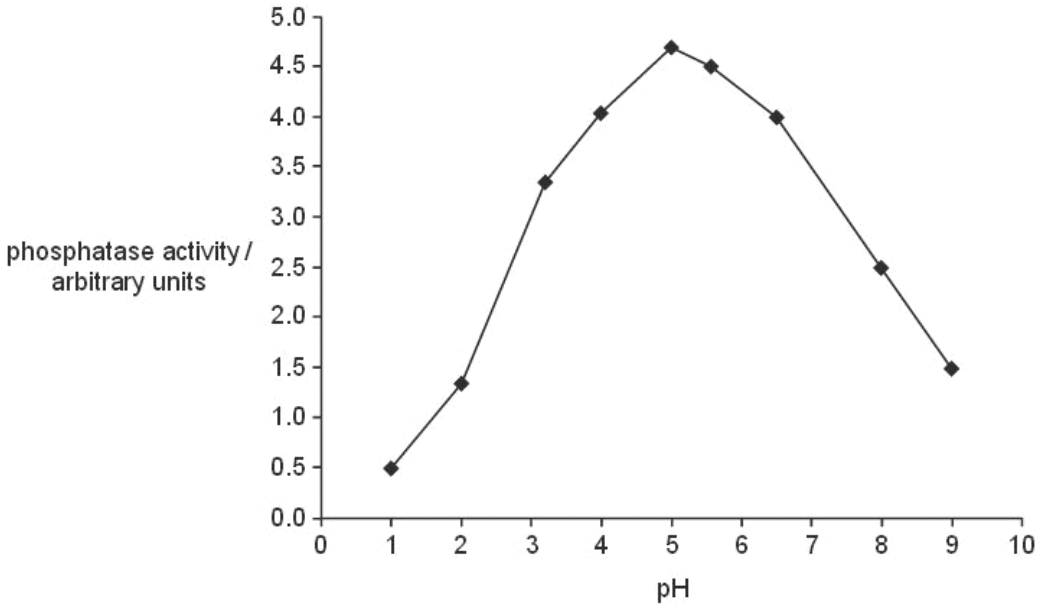


Fig. 5.1

(b) Using the data in Fig. 5.1, describe the effect of pH on the activity of phosphatase.

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.....[3]

(c) Explain why the activity of phosphatase is very low at pH 1.

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.....

.....[4]

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(d) Draw a curve on Fig. 5.1 to show the results you would expect if the experiment was repeated in exactly the same way but at a temperature of 20 °C. [2]

(e) Explain how competitive inhibitors affect the activity of enzymes, such as phosphatase.

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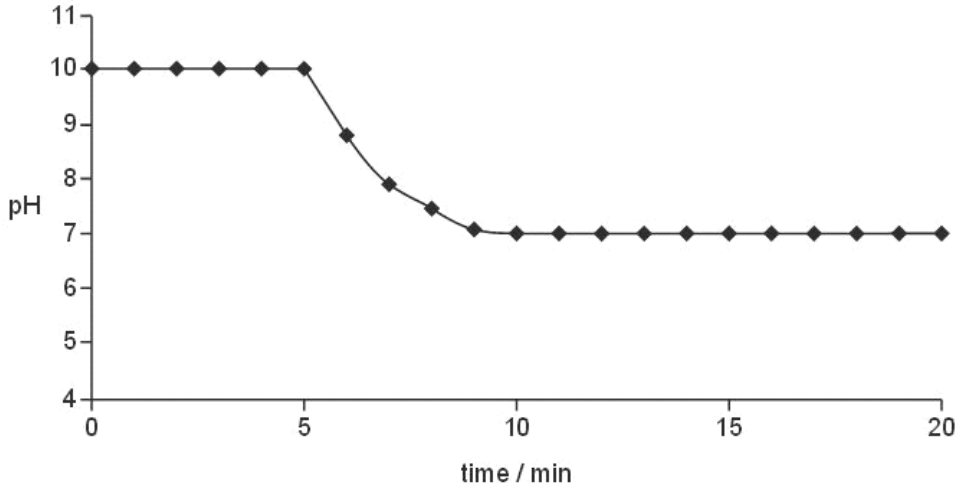
.....[3]

[Total : 14]

Q14.

The enzyme lipase catalyses the hydrolysis of ester bonds in triglycerides. As the reaction proceeds there is a decrease in pH. The progress of the reaction may be followed by using a pH meter.

A solution containing tristearin was placed in a water bath at 25 °C. When the solution had reached this temperature, lipase was added and the mixture stirred. The pH of the reaction mixture was recorded every minute for 20 minutes. The results are shown in Fig. 2.2.



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(d) Using the data in Fig. 2.2, state the time when

(i) lipase was added;

.....[1]

(ii) the reaction ended.

.....[1]

(e) Explain why the pH decreases during this reaction.

.....

.....[1]

(f) A similar solution was placed in a water bath at 35 °C and left for the same length of time to reach this temperature. Lipase was added as before.

Sketch on Fig. 2.2 the results that you would expect. [2]

Q15.

3 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.

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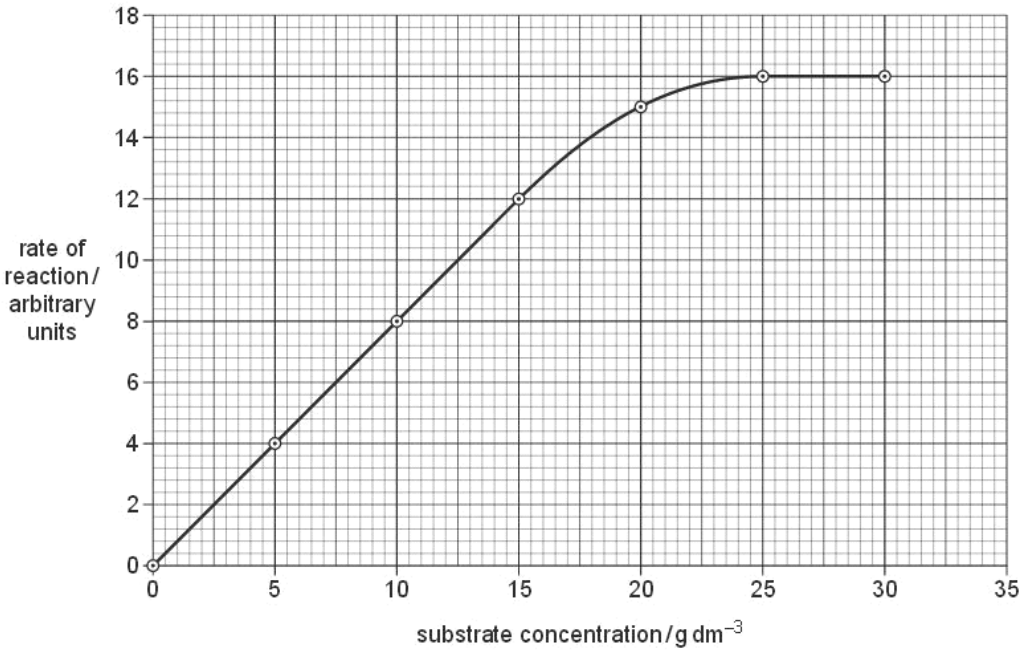


Fig. 3.1

(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]

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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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.....

.....

..... [3]

(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.

.....

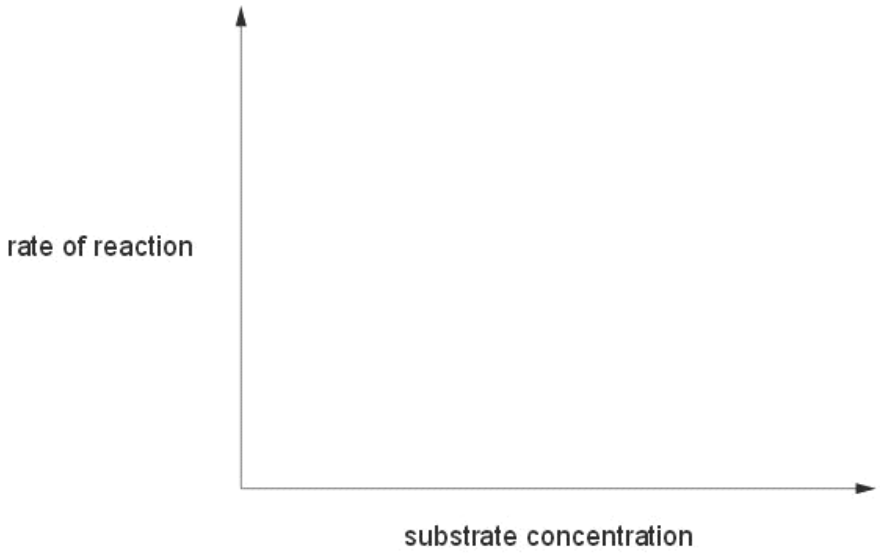
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(e) Elastase breaks down the protein elastin. Describe the function of elastin in the lungs.

.....

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.....

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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]

Q16.

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3 Lysozyme is an enzyme found in many places within the human body. It consists of a single polypeptide folded into a complex shape.

Fig. 3.1 shows a ribbon model of lysozyme.



Fig. 3.1

(a) With reference to Fig. 3.1, state the name given to the level of organisation shown,

(i) by the whole polypeptide

..... [1]

(ii) at region X.

..... [1]

(b) Name the part of the enzyme where the reaction occurs.

..... [1]

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(d) In an investigation of the effects of lysozyme, researchers isolated the enzyme from mice to find how effective the enzyme was at destroying bacteria. Lysozyme catalyses the hydrolysis of glycosidic bonds in certain polysaccharides found in the cell walls of some bacteria.

Ex

Four different concentrations of lysozyme were made. Two pathogenic bacteria, *Escherichia coli* and *Staphylococcus aureus*, were incubated in each concentration for three hours at 37 °C. At the end of the incubation, the researchers determined the number of bacteria still alive and expressed their results as percentages of the number of bacteria present at the start of the incubation.

The results are shown in Fig. 3.3.

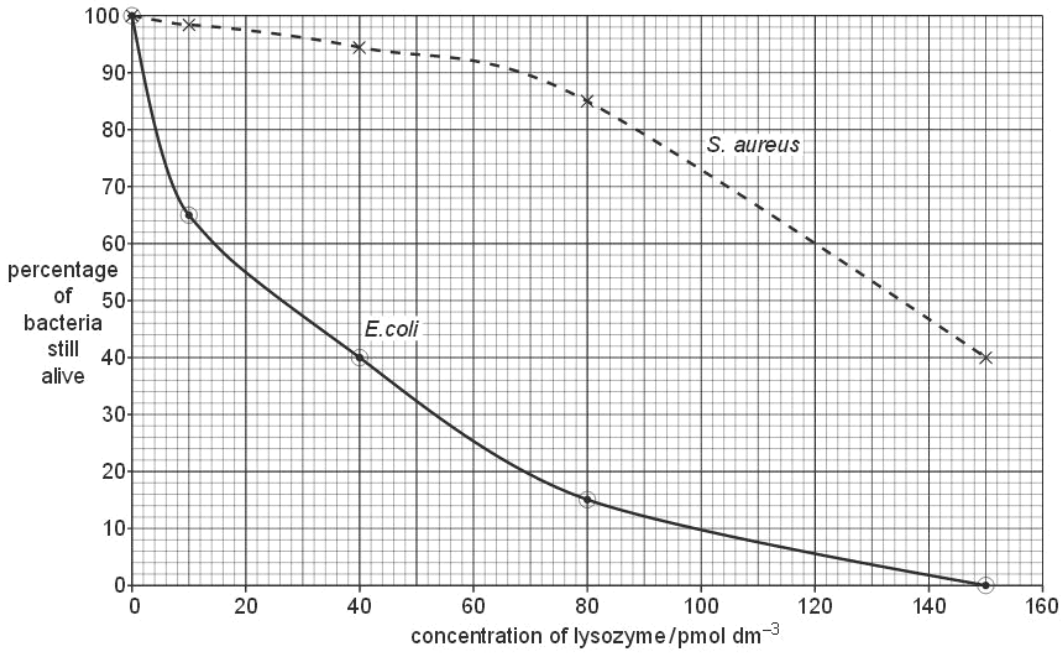


Fig. 3.3

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(i) Using the information in Fig. 3.3, describe the effect of the different concentrations of lysozyme on *E. coli* and *S. aureus*.

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..... [4]

(ii) Suggest a possible explanation for the different effects of lysozyme on *E. coli* and *S. aureus*.

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..... [2]

Q17.

2 Amylase is an enzyme that catalyses the hydrolysis of starch. A student investigated the effect of pH on the activity of the enzyme.

Eight test-tubes were set up each containing 5 cm^3 of the same concentration of amylase solution but in buffer solutions of different pH values. The test-tubes were left in a water-bath at 30 °C for 10 minutes.

After 10 minutes, 5 cm^3 of a starch suspension at 30 °C was added to each test-tube. Immediately, the student took a sample from each test-tube and tested the reaction mixture for the presence of starch. Samples were then taken every minute for 10 minutes and tested in the same way.

The student's results are shown in Table 2.1.

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Table 2.1

pH	time / min										
	0	1	2	3	4	5	6	7	8	9	10
2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
4.0	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
5.0	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗
6.0	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
7.0	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗
8.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
9.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

key
✓ = starch present
✗ = starch absent

(a) Describe how the student would test for the presence of starch.

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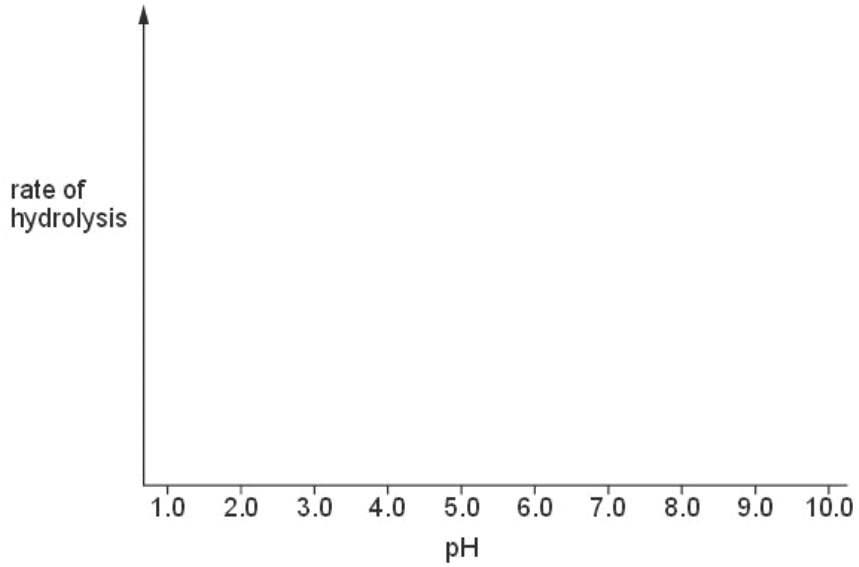
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.....[2]

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(b) Use the axes below to sketch a graph to show the effect of pH on the **rate of hydrolysis** of starch by amylase.



[2]

(c) With reference to the student's results, describe **and** explain the effect of pH on the rate of hydrolysis of starch by amylase.

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.....[5]

[Total: 9]

Q18.

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2 Sucrase is the enzyme that catalyses the hydrolysis of sucrose. A student investigated the effect of substrate concentration on the activity of this enzyme.

Six test-tubes were set up each containing $10\,cm^3$ of different concentrations of sucrose solutions. The test-tubes were left in a water bath at 30 °C for ten minutes.

After ten minutes, $5\,cm^3$ of a sucrase solution at 30 °C was added to each test-tube and the reaction mixtures were stirred.

After a further five minutes, the temperature of the water-bath was raised to above 85 °C and the same volume of Benedict's solution added to each test-tube in turn. The student recorded the time when a green colour first became visible in each test-tube.

The concentrations used and the student's results are shown in Table 2.1.

Table 2.1

concentration of sucrose / g dm^{-3}	time taken for green colour to appear / s
5	278
10	145
15	95
20	75
50	47
100	45

(a) Explain why the temperature of the water-bath was raised to above 85 °C.

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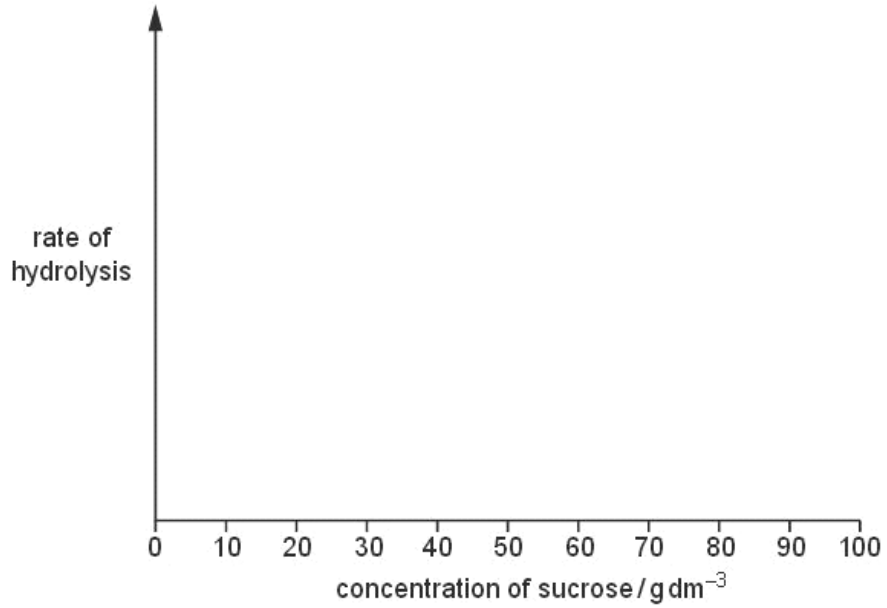
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.....[2]

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(b) Use the axes below to sketch a graph to show the effect of substrate concentration on the **rate of hydrolysis** of sucrose by sucrase.



[2]

(c) With reference to the student's results, describe **and** explain the effect of increasing substrate concentration on the rate of hydrolysis of sucrose by sucrase.

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.....[5]

[Total: 9]

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Q19.

3 **(a)** Enzymes are globular proteins that catalyse metabolic reactions.

Describe the features of globular proteins.

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..... [3]

(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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..... [2]

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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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..... [3]

Q20.

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.

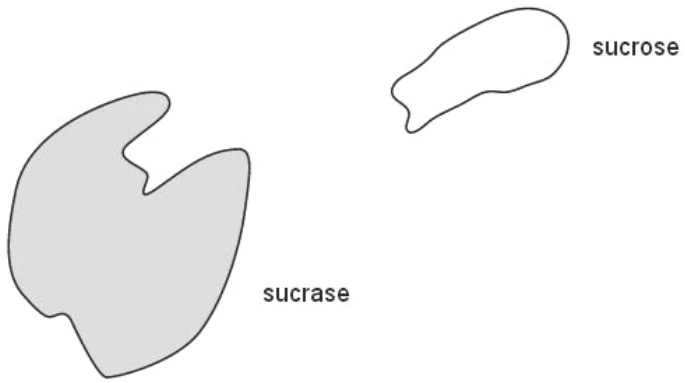


Fig. 3.1

(a) (i) State the names of the products of the hydrolysis of sucrose.

.....[1]

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(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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.....[4]

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

.....[1]

(b) Sucrose is one of the assimilates transported in the phloem sieve tubes of plants from source to sink. Sucrase is found in sinks.

(i) Suggest the role played by sucrase in the process of unloading of sucrose at sinks.

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.....[2]

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(ii) Plant sink organs convert excess products of sucrose hydrolysis to storage molecules, such as starch.

Explain why these products of hydrolysis themselves cannot be stored in plant tissue.

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.....[3]

[Total: 11]

Q21.

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.

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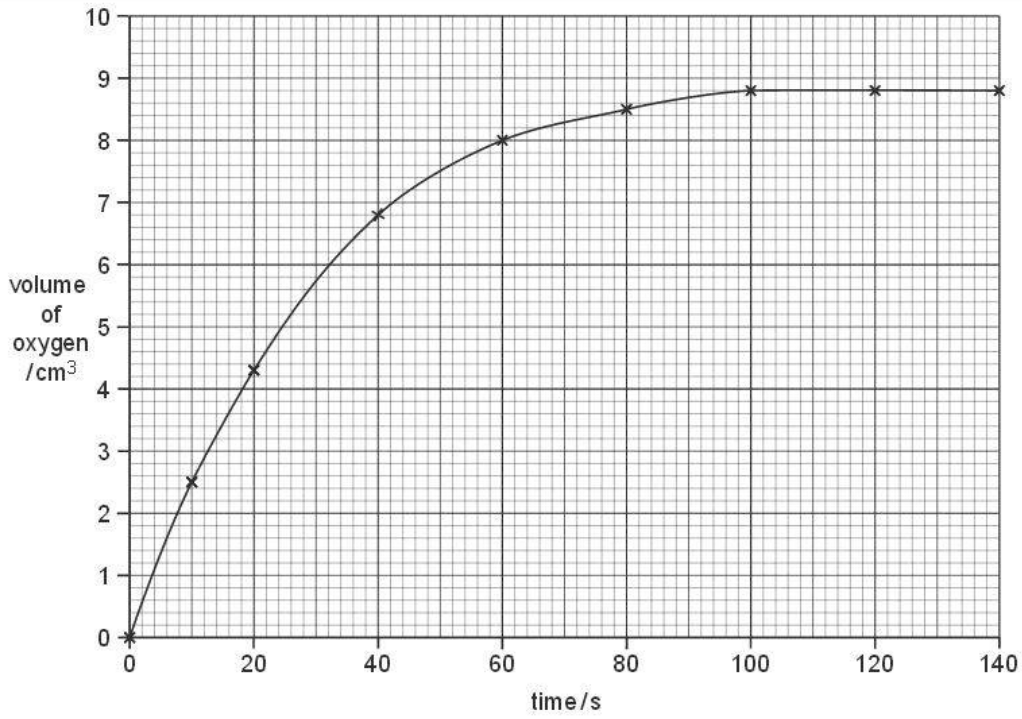


Fig. 2.1

(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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.....[3]

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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.

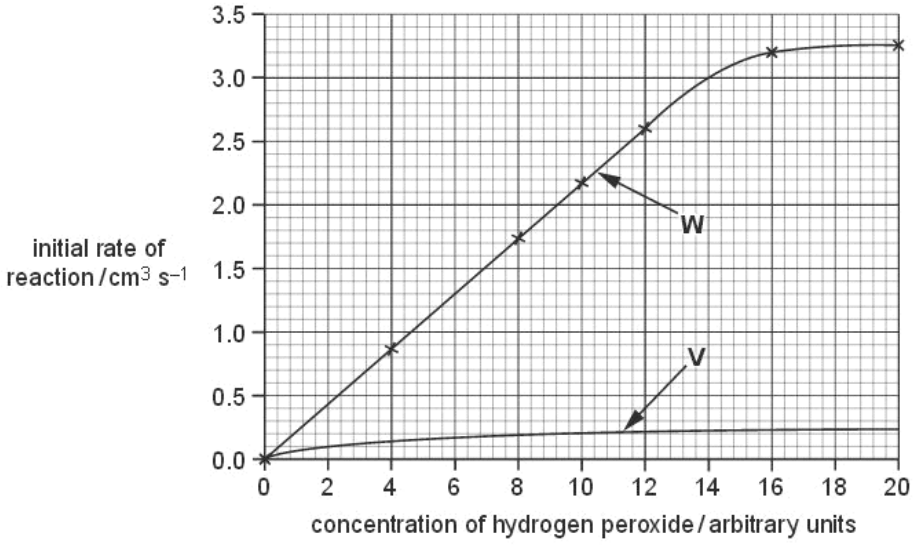


Fig. 2.2

(b) Use the information in Fig. 2.2 to explain the effect of copper ions on the action of an enzyme, such as catalase. [4]

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.....[4]

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(c) Enzyme molecules in cells eventually stop working and are broken down.

Outline how cells replace the enzymes that are broken down.

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.....[3]

[Total: 12]

Q22.

(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.

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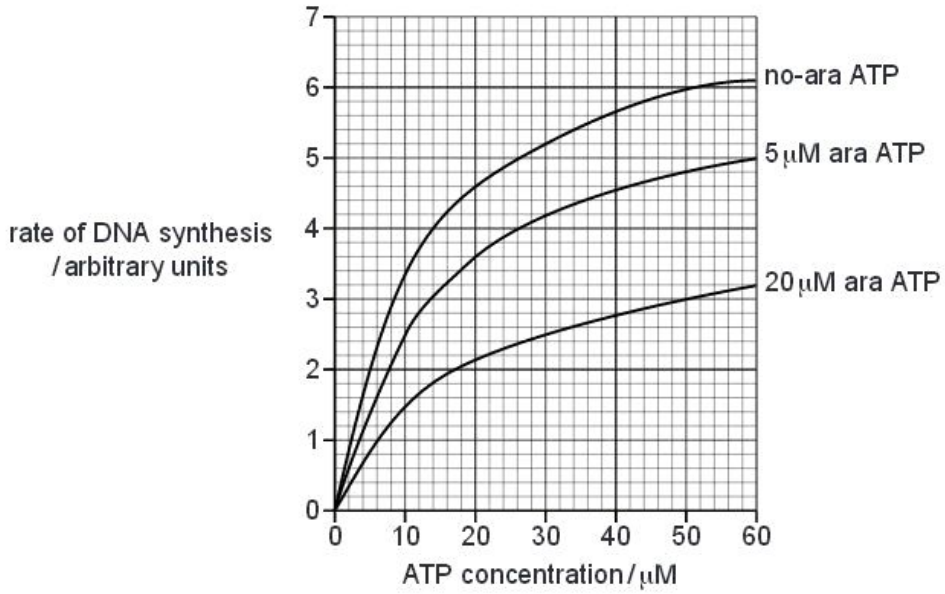


Fig. 5.1

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

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..... [3]

Q23.

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(b) The enzyme nitrogenase is found in free-living and symbiotic nitrogen-fixing bacteria. Nitrogenase catalyses the reaction:

$$N_{2\,(g)} + 6\,e^- + 8H^+_{(aq)} \rightarrow 2NH_4{}^+_{(aq)}$$

Some nitrogenase enzymes have vanadium ions in their active sites; others have molybdenum ions.

Explain how the enzyme nitrogenase functions in the fixation of nitrogen.

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.....[4]

Q24.

(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.

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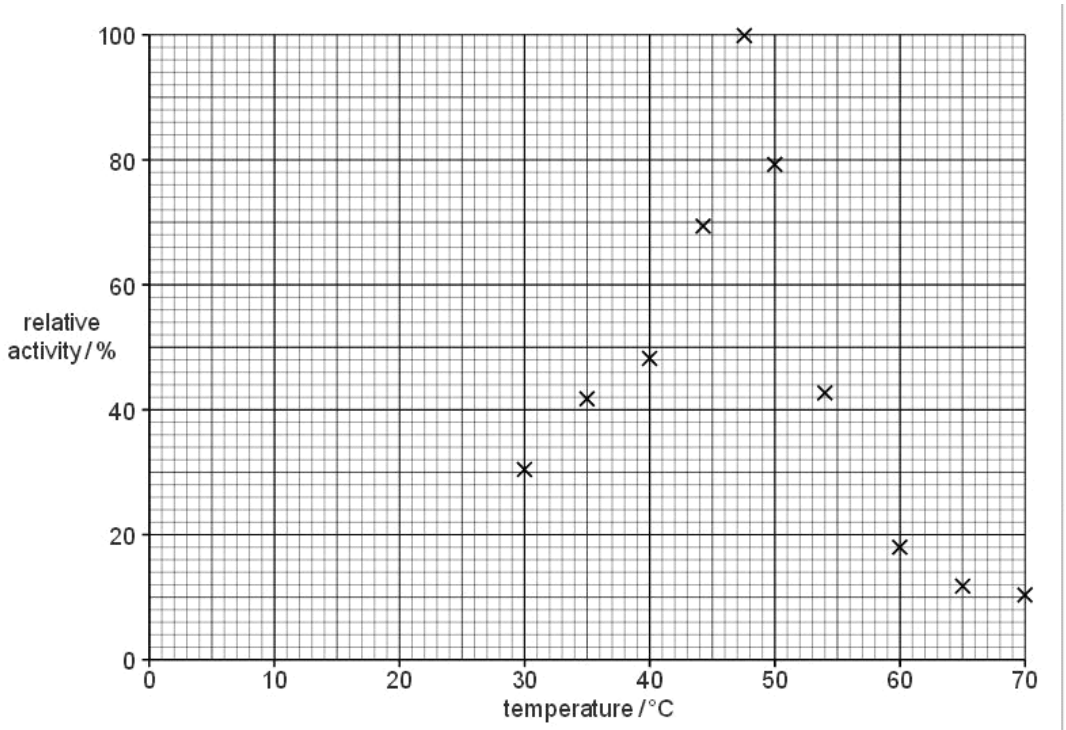


Fig. 2.2

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

.....[1]

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.

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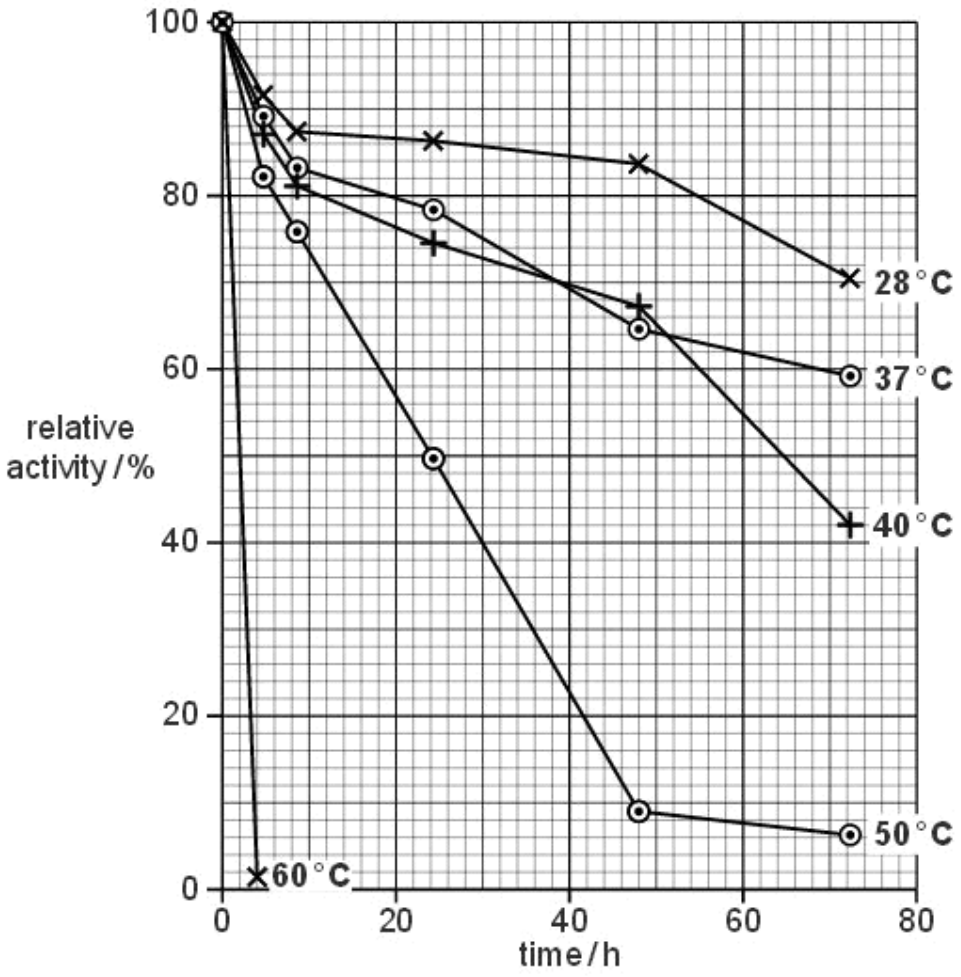


Fig. 2.3

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(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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.....[5]

Q25.

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

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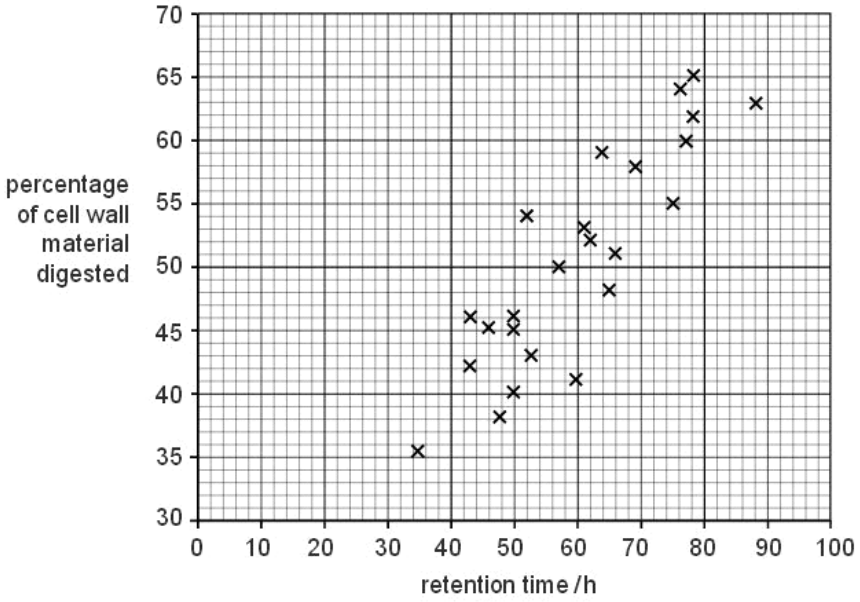
..... [3]

Q26.

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Animals do not have the ability to produce enzymes to digest cellulose. Most herbivores have bacteria in their digestive systems that can digest cellulose.

Fig. 5.1 shows the results of a study on 24 different herbivores. The percentage of cell wall material that was digested by each animal was determined. The time taken for the plant material to pass through the digestive system, the retention time, was also recorded.



(b) (i) With reference to Fig. 5.1, describe the results of this study.

For Examiner Use

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

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Enzymes – AS 9700 Biology June 2022

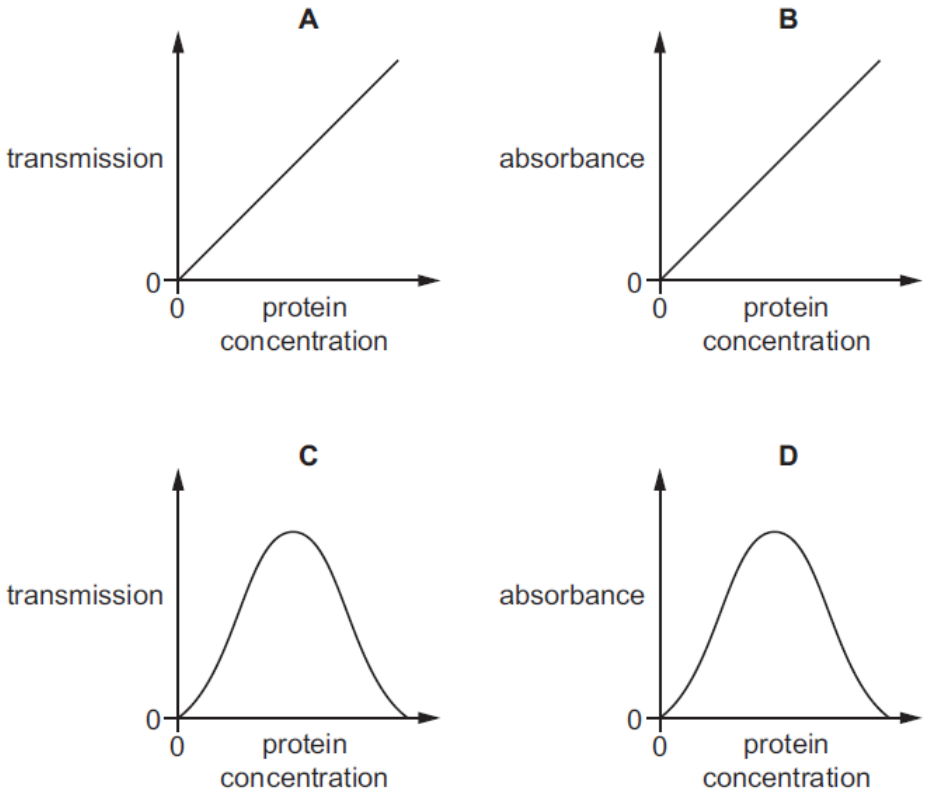
1. June/2022/Paper_11/No.12

A student used colorimetry to monitor the hydrolysis of a protein by a protease enzyme.

The student used biuret solution to determine the concentration of protein in the hydrolysis reaction.

The student produced a calibration curve using known concentrations of protein.

Which diagram shows the calibration curve?



2. June/2022/Paper_11/No.13

A student completed an experiment to measure how increasing concentrations of substrate affects the rate of an enzyme-controlled reaction.

The student then repeated the experiment after adding a fixed quantity of a reversible competitive inhibitor.

Which row describes the effect of a reversible competitive inhibitor on enzyme activity?

	attachment of inhibitor at active site	effect of increasing substrate concentration on rate of enzyme-controlled reaction
A	no	little effect on the rate
B	yes	rate increases
C	no	rate increases
D	yes	little effect on the rate

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3. June/2022/Paper_11/No.20

Telomerase is an enzyme that adds nucleotides to telomeres.

Which statement about telomerase is correct?

A A high concentration of telomerase in a cell damages genes during DNA replication.

B A high concentration of telomerase in cancerous cells limits the rate of tumour growth.

C The low concentration of telomerase in stem cells means that these cells can divide an unlimited number of times.

D The low concentration of telomerase in body cells means that these cells can divide a limited number of times.

4. June/2022/Paper_12/No.11

Typical enzymes are large globular proteins with a specific tertiary shape.

Which molecular interactions are directly involved in maintaining the tertiary shape?

1 hydrogen bonding

2 disulfide bridges

3 hydrophobic interactions

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

5. June/2022/Paper_12/No.12

Which statement about the Michaelis–Menten constant (K_m) is correct for an enzyme with a low affinity for its substrate?

A It has a high K_m and reaches V_{max} at a high substrate concentration.

B It has a high K_m and reaches V_{max} at a low substrate concentration.

C It has a low K_m and reaches V_{max} at a high substrate concentration.

D It has a low K_m and reaches V_{max} at a low substrate concentration.

6. June/2022/Paper_12/No.13

Long chain, saturated fatty acids change from solid to liquid at higher temperatures compared with short chain, unsaturated fatty acids.

Which fatty acids would be more likely to form triglycerides in mammals that live in cold climates?

A long chain saturated

B long chain unsaturated

C short chain saturated

D short chain unsaturated

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7. June/2022/Paper_13/No.13

What is a feature of competitive enzyme inhibition?

A The inhibitor binds permanently to the active site.

B Inhibition can be reversed by increasing the concentration of the substrate.

C The inhibitor molecule changes the secondary structure of the enzyme.

D The substrate and the inhibitor are the same shape.

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8. June/2022/Paper_22/No.4

The enzyme carbonic anhydrase has been found in a wide range of organisms and acts as a catalyst in many tissues.

Studies have shown that there are differences in the protein structure of the enzyme and differences in the number and organisation of introns and exons of the gene coding for the enzyme.

All carbonic anhydrase enzymes catalyse the same reversible reaction, shown in Fig. 4.1.

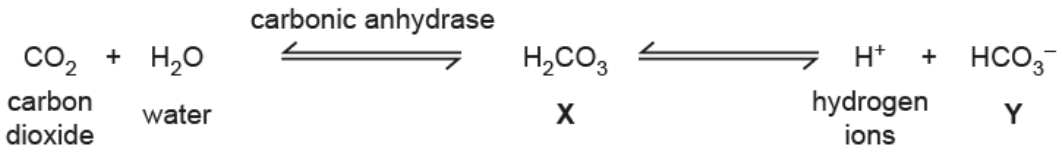


Fig. 4.1

(a) With reference to Fig. 4.1, name **X** and **Y**.

X .....

Y .....

[2]

(b) Carbonic anhydrase enzymes can have different primary structures.

Suggest how all carbonic anhydrase enzymes can catalyse the same reaction, even though they have different primary structures.

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.....

..... [1]

(c) Genes coding for proteins in eukaryotes consist of introns and exons.

Outline the similarities and differences between the introns and the exons of genes coding for proteins such as carbonic anhydrase.

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..... [3]

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All mammals have the same type of carbonic anhydrase, known as α-carbonic anhydrase. Many different forms, or isoforms, of α-carbonic anhydrase have been identified in mammals.

There are 15 isoforms of α-carbonic anhydrase (CA) in humans. Cells of different tissues have one or more isoforms. Within cells the isoforms may be in different locations.

(d) Red blood cells contain two isoforms, CA1 and CA2.

Suggest the location of CA1 and CA2 in red blood cells **and** give a reason for your answer.

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..... [2]

(e) Isoform CA6 forms part of human breast milk. Mammary gland cells package CA6 in Golgi vesicles for release from the cells.

Name the transport mechanism associated with CA6 secretion.

..... [1]

(f) Human CA isoforms in some epithelial cells in the eye have a role in the formation of the clear fluid of the eye known as aqueous humour. Overactivity of the enzyme may lead to a harmful increase of pressure within the eye and cause a condition known as glaucoma.

Acetazolamide is a therapeutic drug that can be used in the treatment of glaucoma. It acts as a reversible non-competitive inhibitor.

Describe the mechanism of action of acetazolamide as a reversible non-competitive inhibitor of carbonic anhydrase.

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..... [3]

[Total: 12]

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9. June/2022/Paper_22/No.5

Arachidonic acid is a fatty acid that is a common component of phospholipids.

Phospholipids can be used as a source of arachidonic acid when it is metabolised within cells in an enzyme-catalysed pathway known as the cyclooxygenase (COX) pathway.

The final products of the COX pathway can be different in different cell types, causing a range of responses. In some cells, the products are involved in the inflammatory response, which is a response by the body to infection. In other cells, cell division is stimulated.

Fig. 5.1 shows the **first reaction** in the COX pathway. This reaction is catalysed by an enzyme known as COX-2.

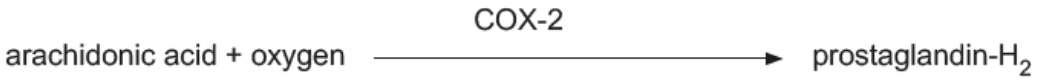


Fig. 5.1

(a) The enzymes involved in the COX pathway are located in the membrane of rough endoplasmic reticulum.

Suggest the advantages to the cell of enzyme pathways being located in cell membranes, rather than in the cytosol of the cell (fluid portion of cytoplasm).

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..... [2]

(b) During an inflammatory response, compounds produced by the COX pathway cause an increased sensitivity to pain.

Some anti-inflammatory drugs are reversible competitive inhibitors of COX-2.

Fig. 5.2 shows how increasing arachidonic acid concentration affects COX-2 activity.

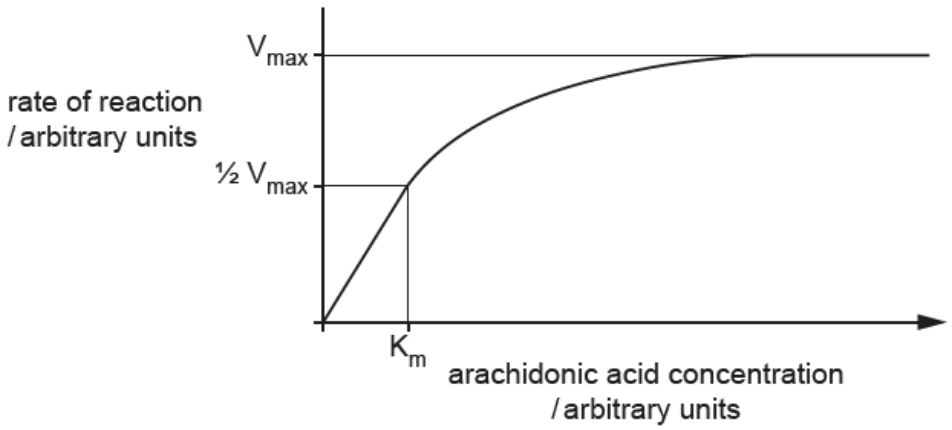


Fig. 5.2

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(i) Sketch on Fig. 5.2 the curve obtained if an anti-inflammatory drug, which is a **competitive** inhibitor, is present with arachidonic acid. [1]

(ii) Complete the statements to show whether the maximum rate of reaction (V_{max}) and the Michaelis-Menten constant (K_m) of COX-2 **increases**, **decreases**, or **stays the same** in the presence of a competitive inhibitor.

In the presence of a competitive inhibitor:

V_{max} of COX-2 .....

K_m of COX-2 ..... . [2]

(c) COX-2 is composed of two identical polypeptides. The enzyme is produced when a gene, *PTGS2*, located on chromosome 1, is switched on and transcription begins.

(i) Using gene *PTGS2* and enzyme COX-2 as examples, explain what is meant by a gene.

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..... [2]

(ii) Some mutations in *PTGS2* lead to an increased rate of transcription. These mutations have been linked to an increased risk of certain types of cancer.

Suggest why mutations in *PTGS2* may increase the risk of cancer.

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..... [2]

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(d) Fig. 5.3 shows the molecular structure of arachidonic acid. Not all hydrogen atoms are shown.

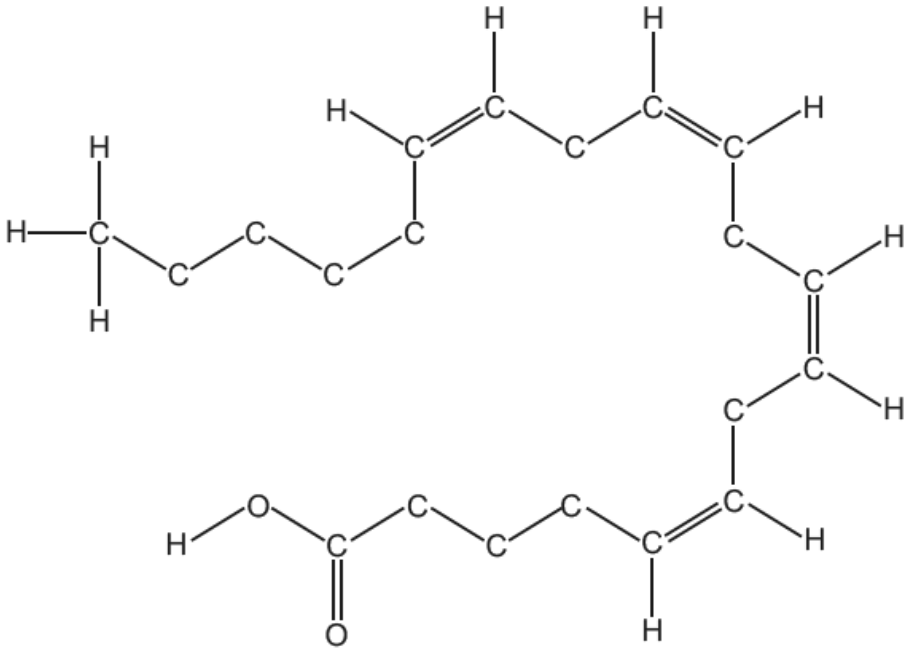


Fig. 5.3

With reference to Fig. 5.3, explain why increasing the proportion of phospholipids with arachidonic acid in a cell will increase the fluidity of the cell surface membrane of the cell.

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..... [3]

[Total: 12]

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Enzymes – AS 9700 Biology Nov 2022

1. Nov/2022/Paper_11/No.12

A student was provided with two test-tubes, one containing 10 cm^3 of solution P and one containing 10 cm^3 of solution Q. When these solutions were mixed together and left for 24 hours, the concentration of P decreased but the concentration of Q remained the same.

The student wrote the following conclusions.

1 P may break down over time.

2 Q may be a biological catalyst.

3 P may be the substrate for Q.

Which conclusions could be supported by the information?

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

2. Nov/2022/Paper_11/No.13

Which statements are correct for the lock and key hypothesis **and** the induced fit hypothesis of enzyme action?

1 The substrate is the same shape as the active site.

2 The substrate is held in place in the active site by temporary bonds.

3 The enzyme and sometimes the substrate change shape slightly as the substrate molecule enters the enzyme.

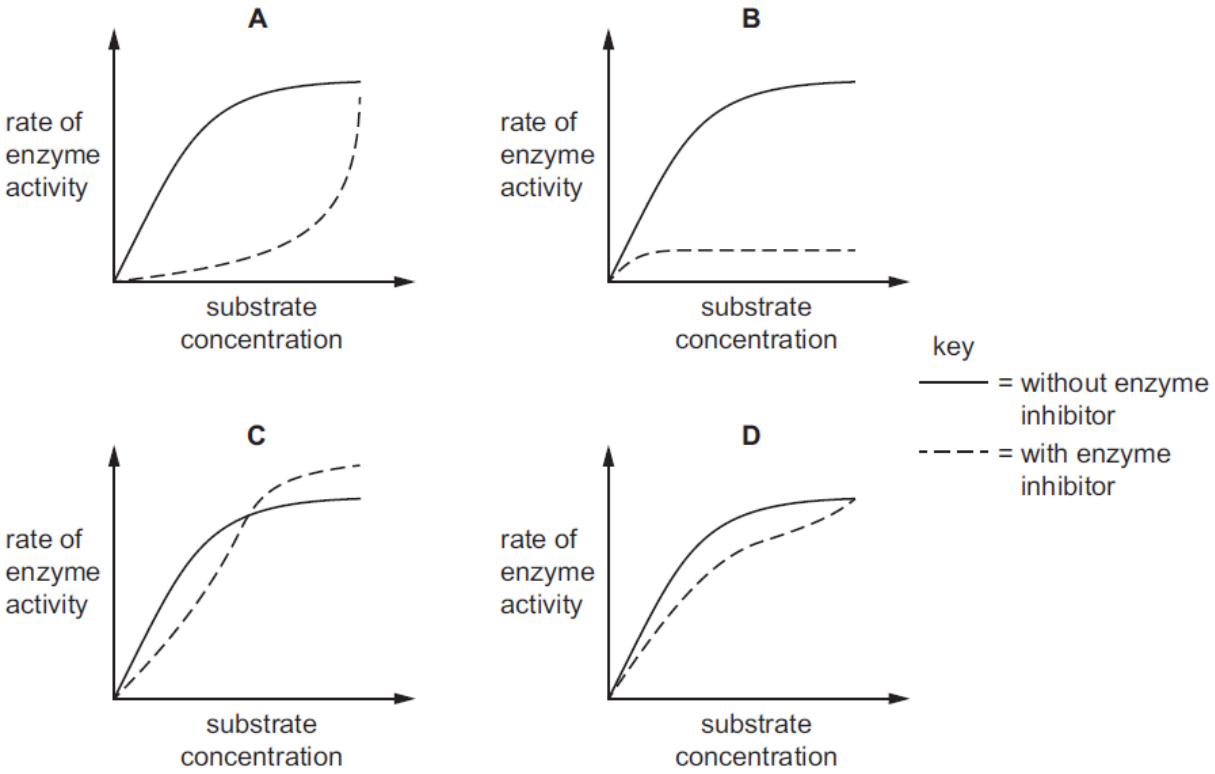
A 1 and 2 **B** 1 and 3 **C** 2 only **D** 3 only

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3. Nov/2022/Paper_11/No.14

A student investigated the rate of enzyme activity with increasing substrate concentration. The experiment was repeated with the addition of a reversible non-competitive enzyme inhibitor. A graph was plotted to show the results.

Which graph represents the results of the two experiments?

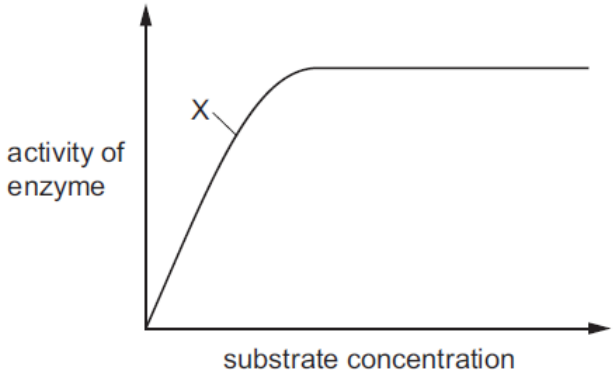


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4. Nov/2022/Paper_12/No.13

A student investigated the effect of substrate concentration on the activity of an enzyme.

The graph shows the results of this investigation.



An increase in which factors could lead to a change in the activity of the enzyme at point X on the graph?

1 pH

2 substrate concentration

3 temperature

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

5. Nov/2022/Paper_12/No.14

The Michaelis–Menten constant, K_m, is the substrate concentration at which an enzyme works at half its maximum rate.

What is correct when the K_m value is low?

A The enzyme has a low affinity for the substrate and the quicker the reaction will proceed to its maximum rate.

B The enzyme has a low affinity for the substrate and the slower the reaction will proceed to its maximum rate.

C The enzyme has a high affinity for the substrate and the quicker the reaction will proceed to its maximum rate.

D The enzyme has a high affinity for the substrate and the slower the reaction will proceed to its maximum rate.

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6. Nov/2022/Paper_13/No.13

Yeast contains the enzyme catalase which catalyses the breakdown of hydrogen peroxide (H_2O_2) as shown.

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

Yeast was added to a solution of hydrogen peroxide and the total volume of oxygen released was recorded every 30 seconds for 2 minutes. All other variables were standardised.

The data is shown in the table.

time / s	total volume of O_2 / cm^3
30	157
60	251
90	283
120	285

What explains the pattern of the data?

A The rate of reaction increases as more enzyme–substrate complexes are formed.

B The rate of reaction increases as the enzyme reaches its maximum velocity (V_{max}).

C The volume of oxygen released decreases as the enzymes begin to denature.

D The volume of oxygen released decreases as more substrate is converted into product.

7. Nov/2022/Paper_11/No.14

The Michaelis–Menten constant, K_m, is a measure of the affinity of an enzyme for its substrate.

1 The higher the affinity, the lower the K_m.

2 The lower the affinity, the slower the reaction will be.

3 At K_m, half the active sites of the enzyme are occupied by the substrate.

Which statements about K_m are correct?

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

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8. Nov/2022/Paper_11/No.1a(ii)

(a) Fig. 1.1 is a transmission electron micrograph showing a section of a human liver cell.

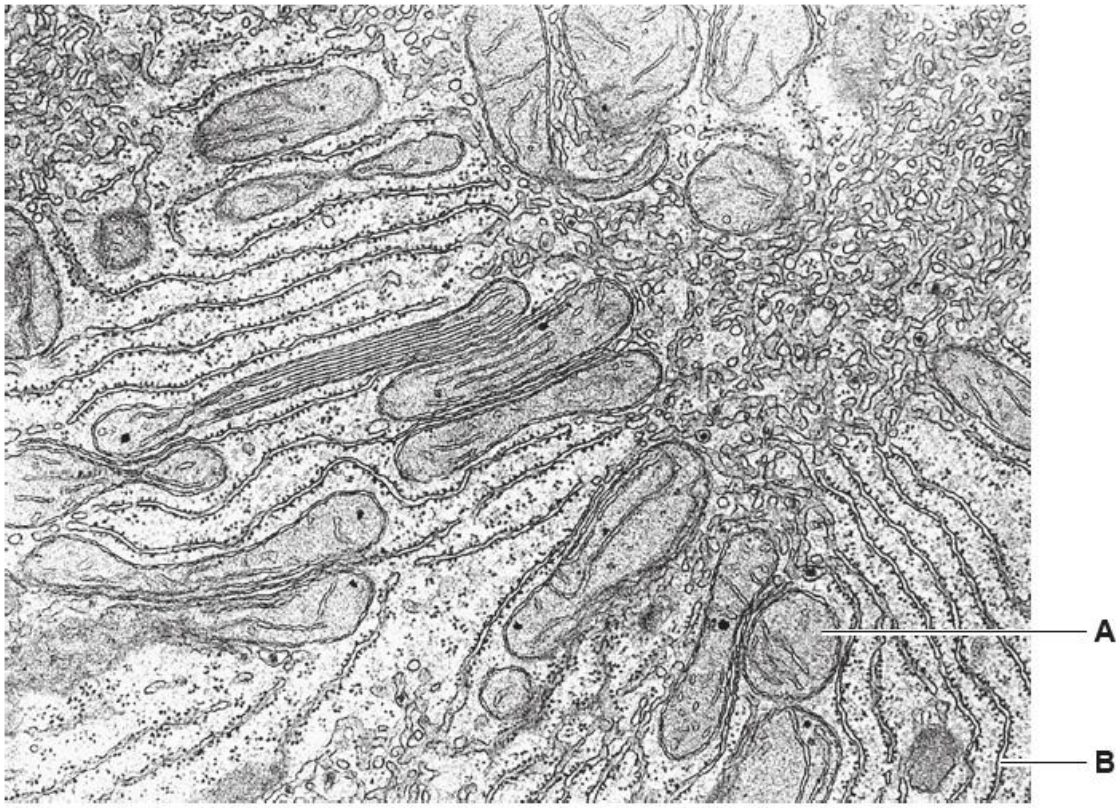


Fig. 1.1

(i) Name organelles **A** and **B** shown in Fig. 1.1.

A .....

B .....

[2]

(ii) In liver cells, enzymes are attached to the membrane of smooth endoplasmic reticulum.

With reference to the functions of smooth endoplasmic reticulum, suggest the advantages of having enzymes attached to the membrane rather than free in the lumen.

.....

.....

.....

.....

.....

..... [3]

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9. Nov/2022/Paper_22/No.5(c)

(c) Hydrolytic enzymes, known as collagenases, are secreted by cells in an inactive form.

Cells also secrete inhibitors of collagenases. The activity of the enzymes and inhibitors is regulated so that the development and maintenance of the extracellular matrix is controlled.

(i) State **and** explain what the outcome will be for the composition of the extracellular matrix if collagenase inhibitor activity is needed.

.....

.....

.....

.....

..... [2]

(ii) Synthetic inhibitors have been trialled as potential treatment for diseases caused by a lack of regulation of collagenase activity.

Research involves investigating the mechanism of action of an inhibitor.

State the effect that a **non-competitive** inhibitor will have on the maximum rate of reaction, V_{max}, and the Michaelis–Menten constant, K_m, of collagenase.

V_{max} .....

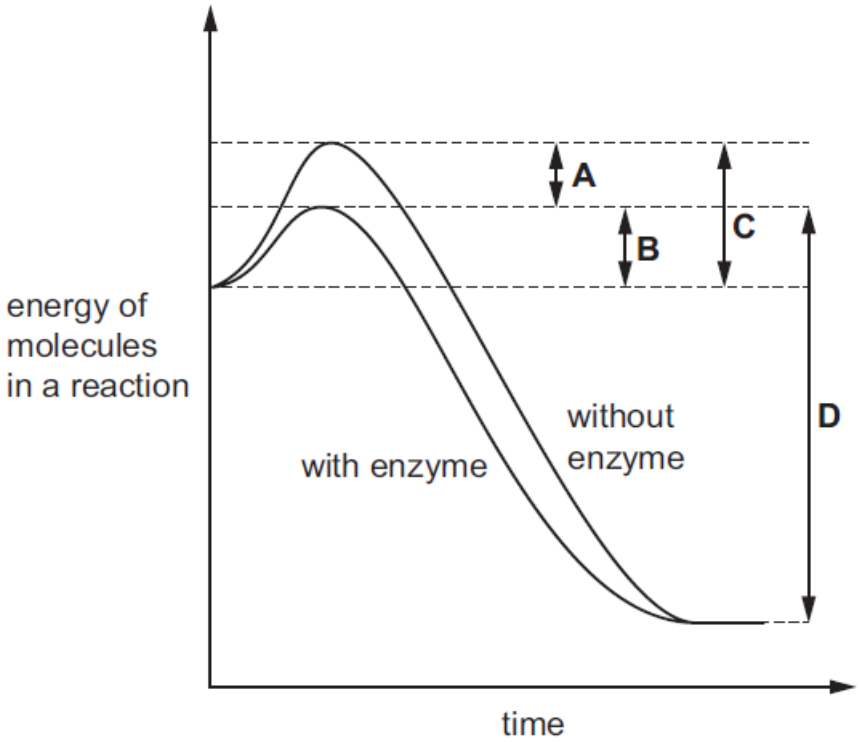
K_m .....
[2]

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Enzymes – AS 9700 June 2022

1. June/2023/Paper_9700/11/No.12

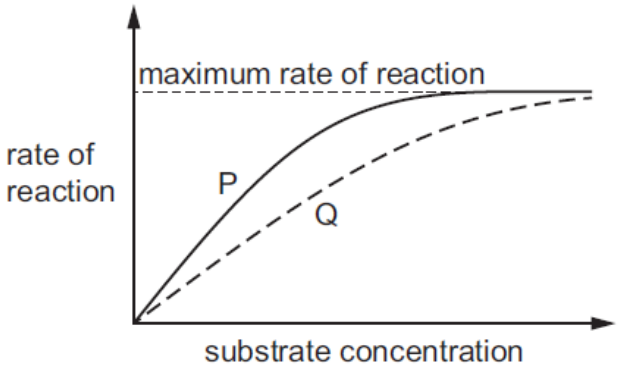
Which region on the graph shows the activation energy of an enzyme-catalysed reaction?



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2. June/2023/Paper_9700/11/No.13

The graph shows the effect of an increasing substrate concentration on the rate of an enzyme-catalysed reaction.



Line P represents the result when the enzyme is used at its optimum pH and optimum temperature and without an inhibitor.

Line Q represents the result when the reaction conditions are changed.

Which descriptions of changes to the reaction conditions could result in line Q if all other conditions were kept the same?

1 Add an inhibitor that attaches to a site other than the active site.

2 Add an inhibitor that has a similar shape to the substrate.

3 Add an inhibitor that blocks the active site of the enzyme.

4 Carry out the reaction at a higher temperature.

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

3. June/2023/Paper_9700/12/No.13

CYP3A4 is an important enzyme in the human digestive system where it is needed to break down a range of different toxins. The activity of CYP3A4 has been shown to be reduced by substances called furanocoumarins. Furanocoumarins are found in some fruits and so dangerous concentrations of toxins may develop in the human digestive system when fruits containing furanocoumarins are eaten.

From the information provided, what can be concluded about molecules of the enzyme CYP3A4?

A They lower the activation energy of the toxin breakdown reactions.

B They bind specifically through the active site to a substrate found in some fruits.

C They change permanently when acted upon by furanocoumarin molecules.

D They resume normal activity when concentrations of furanocoumarins decrease.

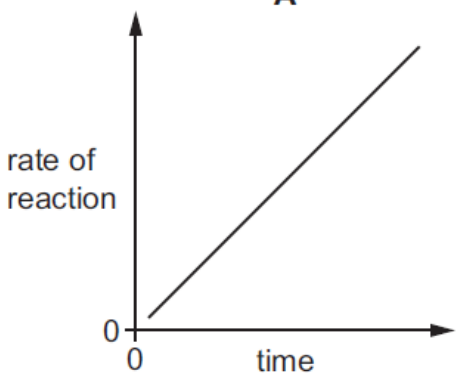
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4. June/2023/Paper_9700/12/No.14

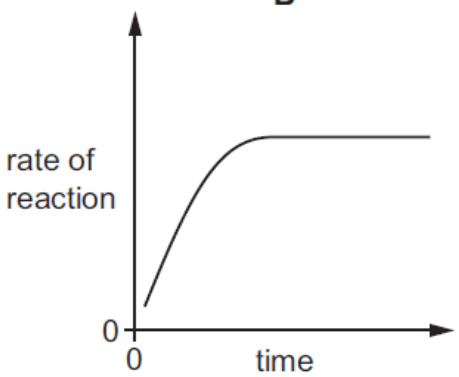
A fixed volume and concentration of substrate and enzyme were mixed. All other variables were kept constant. The enzyme-catalysed reaction was left until it was complete.

Which graph shows how the rate of reaction changes with time?

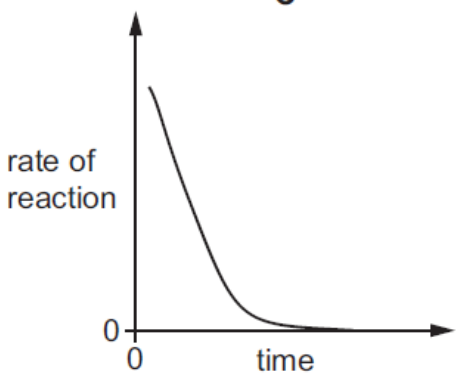
A



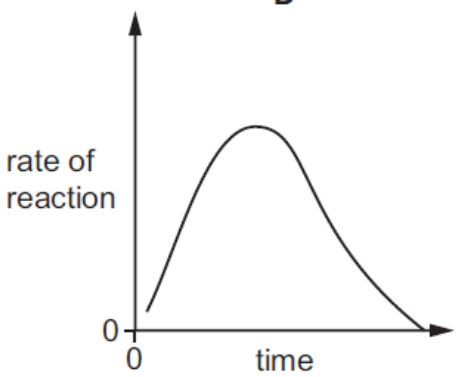
B



C



D



5. June/2023/Paper_9700/13/No.14

Some animals produce antimicrobial proteins which protect them from pathogens. These proteins could be used to kill human pathogens, however when used as a medicine they are broken down by protein-digesting enzymes.

Replacing one of the amino acids found in the protein with an amino acid that had been synthesised in the laboratory resulted in a modified protein that was **not** broken down.

What could explain why this modified protein was not broken down by the protein-digesting enzymes?

1 The modified protein has a different tertiary structure to the original protein.

2 The modified protein is **not** complementary in shape to the enzyme's active site.

3 The modified protein is unable to induce a fit with the protein-digesting enzyme.

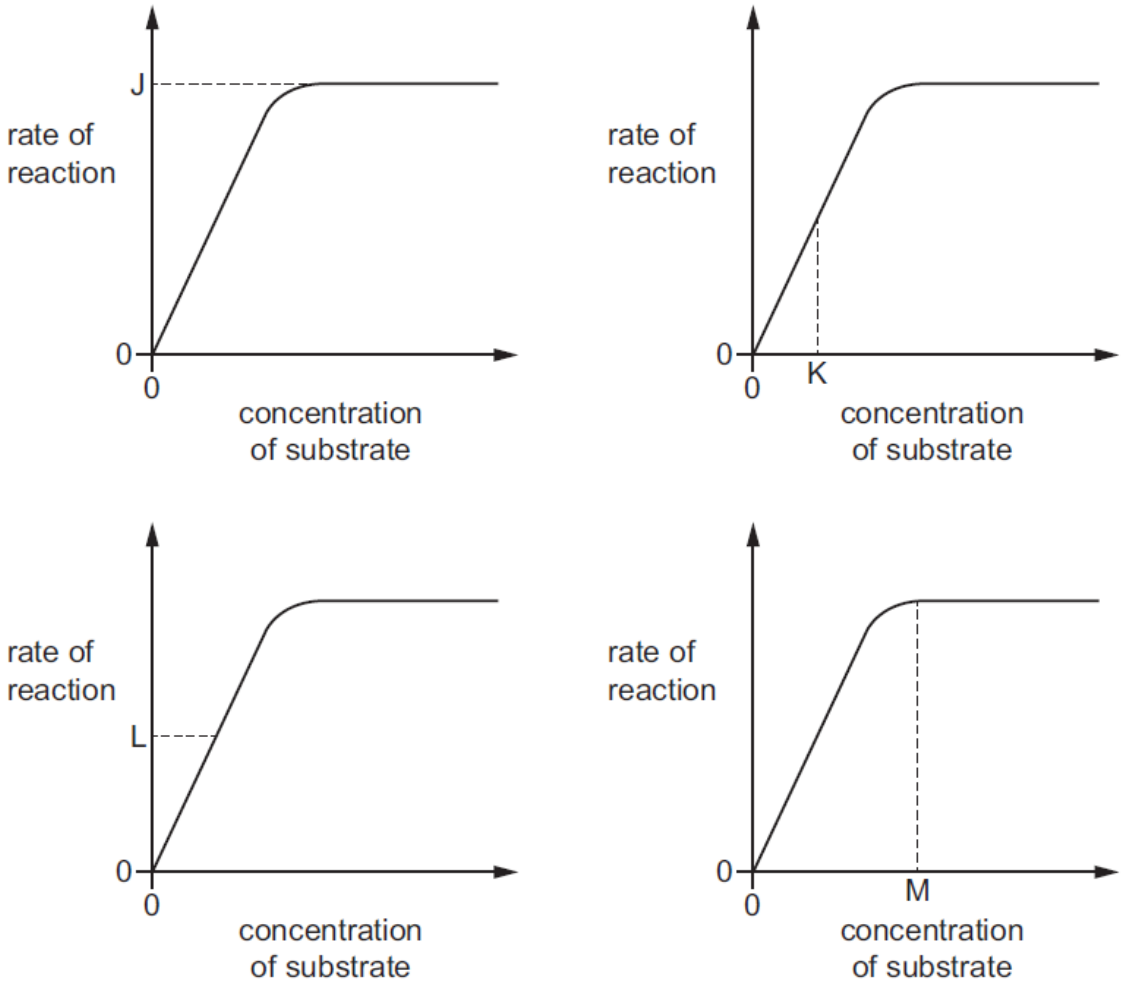
A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

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6. June/2023/Paper_9700/13/No.15

A student investigated the effect of substrate concentration on the rate of an enzyme-catalysed reaction. A graph was plotted to show the relationship between these two variables. The student was asked to take readings from the graph that could be used to determine the Michaelis–Menten constant, K_m, for this enzyme.

J, K, L and M show points read from the graphs which the student could use to determine the value of K_m.



Which two readings must the student use to determine the value of K_m?

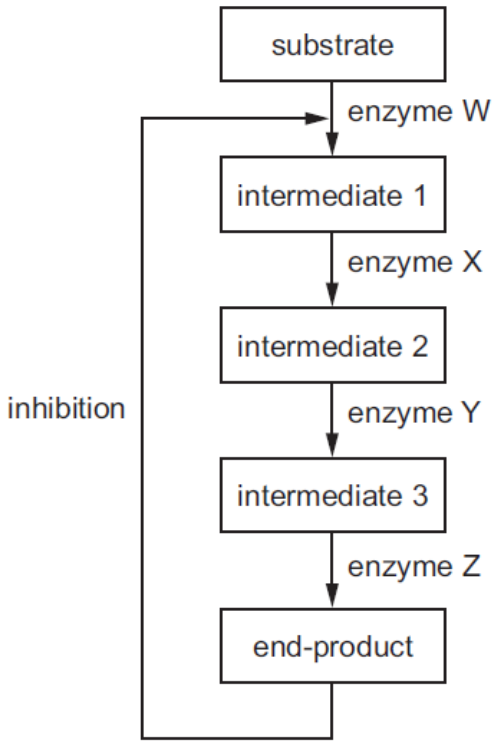
A J and K **B** J and M **C** K and L **D** L and M

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7. June/2023/Paper_9700/13/No.16

The end-product of a metabolic pathway can act as a competitive inhibitor. This is called end-product inhibition and allows a cell to control a metabolic pathway.

The diagram shows a metabolic pathway where the end-product could act as an inhibitor of enzyme W.



What would be the effect if enzyme Z was inhibited by the end-product instead of enzyme W?

	quantity of intermediate 1	quantity of end-product
A	increase	decrease
B	increase	unchanged
C	decrease	decrease
D	decrease	unchanged

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8. March/2023/Paper_9700/12/No.19

Which events are part of the mitotic cell cycle?

1 interphase

2 telophase

3 cytokinesis

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

9. March/2023/Paper_9700/22/No.16

(c) Mitogens are short chains of amino acids that function as cell-signalling molecules. Mitogens are released from secretory cells and travel in the blood to target cells, where the mitogens bind to cell surface receptors. The target cells respond by progressing from the G_1 phase to the S phase of the mitotic cell cycle.

(i) Outline what happens in the G_1 phase and S phase of the mitotic cell cycle.

G_1 phase .....

.....

.....

S phase .....

.....

.....

[2]

(ii) As a result of mutation, the production and release of mitogens into the blood can be greatly increased.

Suggest a possible consequence for target cells of increased concentrations of mitogens in the blood.

.....

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..... [1]

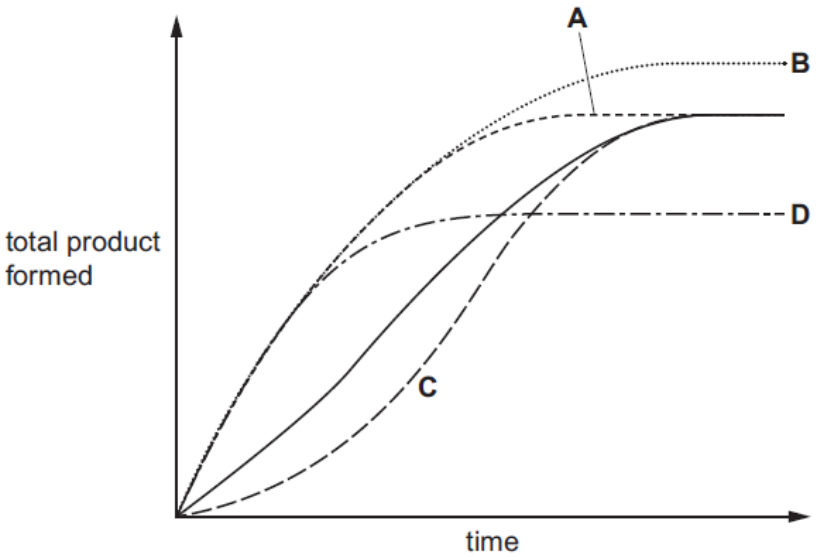
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Enzymes – AS 9700 November 2023

1. Nov/2023/Paper_ 9700/11/No.13

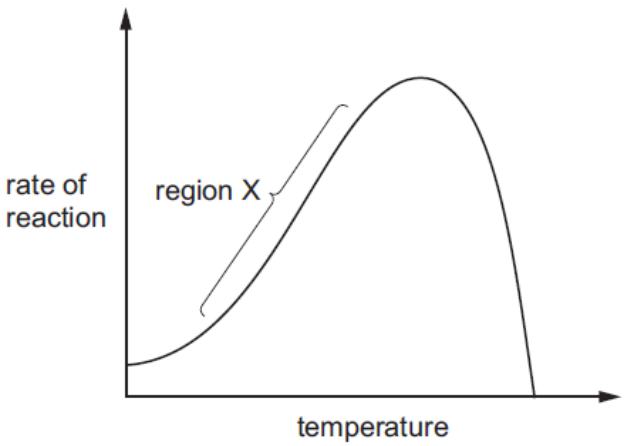
The solid line on the graph represents the product formed over time for a reaction in a cell.

Which other line represents the effect of adding the enzyme for this reaction?



2. Nov/2023/Paper_ 9700/11/No.14

The graph shows how the rate of an enzyme-controlled reaction is affected by the change in temperature. All other variables were standardised.



What is the factor limiting the rate in region X?

A substrate concentration

B enzyme concentration

C temperature

D number of empty active sites

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3. Nov/2023/Paper_ 9700/11/No.15

How will the removal of a reversible non-competitive enzyme inhibitor affect an enzyme-catalysed reaction?

A The K_m will decrease and the V_{max} will increase.

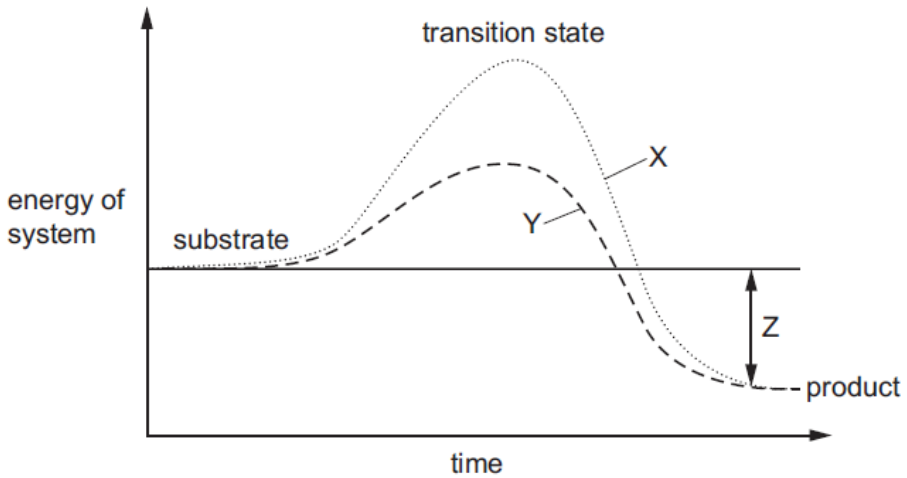
B The K_m will increase and the V_{max} will not change.

C The K_m will not change and the V_{max} will increase.

D The K_m will not change and the V_{max} will not change.

4. Nov/2023/Paper_ 9700/12/No.12

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



Which row identifies X, Y and Z?

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

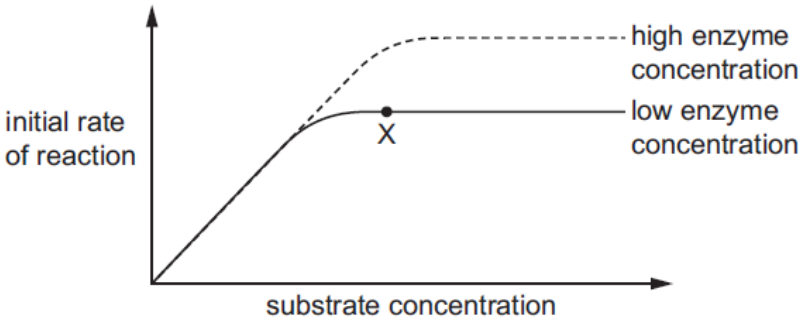
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5. Nov/2023/Paper_ 9700/12/No.13

The graph shows the results of two experiments on the effect of increasing substrate concentration on the rate of an enzyme-catalysed reaction.

One experiment was at a high concentration of enzyme and the second was at a low concentration of enzyme.

All other variables were standardised.



What would limit the initial rate of reaction at point X?

A enzyme concentration

B pH

C substrate concentration

D temperature

6. Nov/2023/Paper_ 9700/12/No.14

Which statements about the Michaelis–Menten constant (K_m) of an enzyme are correct?

1 At the K_m value, half the active sites of the enzyme should be occupied by the substrate.

2 K_m represents the substrate concentration at which the enzyme is working at half its maximum rate.

3 The lower the K_m value, the lower the affinity of the enzyme to its substrate.

4 When an enzyme has a high K_m value, the enzyme-catalysed reaction will proceed very slowly to its maximum rate.

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

7. Nov/2023/Paper_ 9700/13/No.14

Which statements describe some enzyme actions?

1 Enzymes hold reacting molecules so that their reactive groups are close together.

2 In an enzyme-catalysed reaction, more molecules have sufficient energy to react than without the enzyme.

3 Reactions catalysed by enzymes take place at a lower temperature than they would without the enzyme.

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

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8. Nov/2023/Paper_ 9700/13/No.15

Influenza virus has an enzyme called neuraminidase which breaks down glycoproteins in the surface membrane of the cell that the virus will infect. The glycoprotein binds to the active site of neuraminidase by induced fit.

Which statements about the induced fit hypothesis of enzyme action are correct?

1 The active site must have the same shape as the substrate for them to bind together.

2 This enzyme is less likely to be affected by non-competitive inhibitors than an enzyme working by the lock-and-key mechanism.

3 The substrate is converted to product by specific R-groups in the active site just like the lock-and-key mechanism.

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

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