

1. Question | 9700 Feb-March 2016 P1 V2 Q11

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

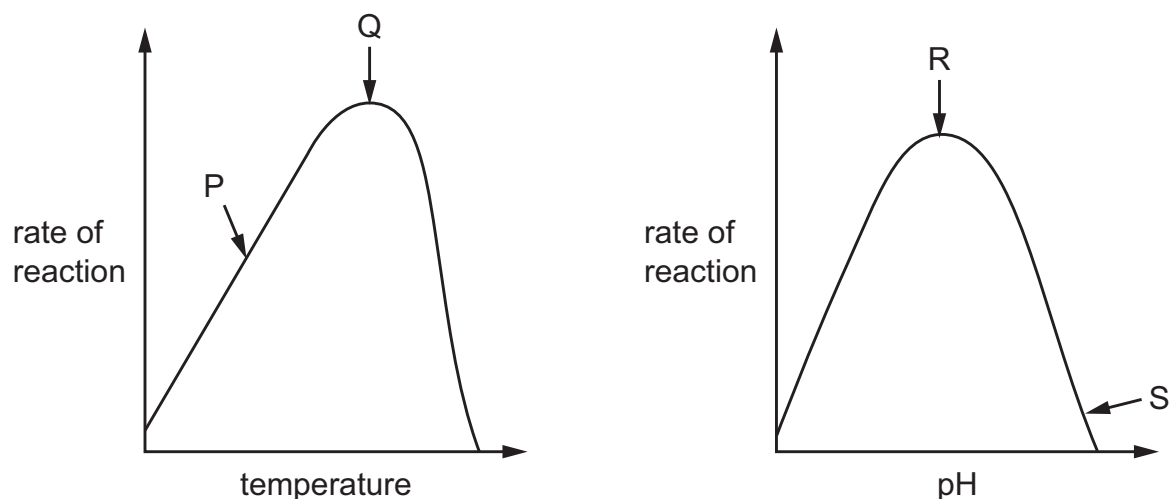
What may be involved in such regulation?

- 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

2. Question | 9700 Feb-March 2016 P1 V2 Q12

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.

3. Question | 9700 Feb-March 2016 P1 V2 Q13

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.

4. Question | 9700 May-June 2016 P1 V1 Q12

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

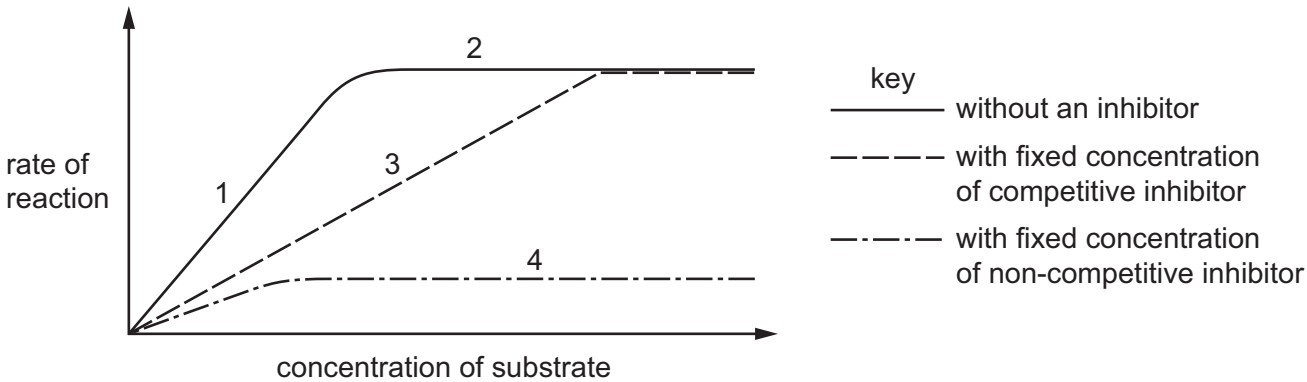
13 Which row about competitive inhibitors of enzymes is correct?

	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

6. Question | 9700 May-June 2016 P1 V1 Q14

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

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

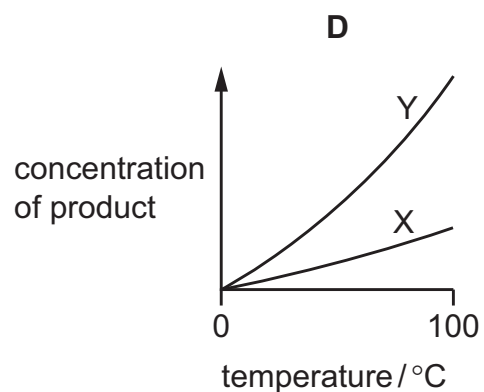
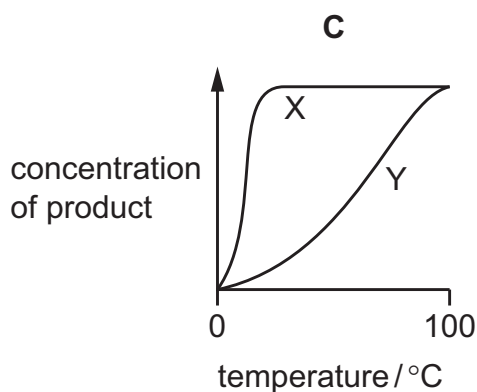
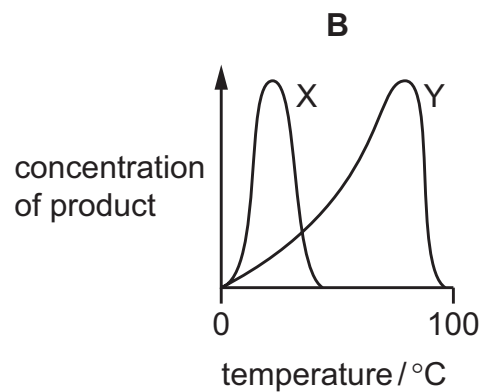
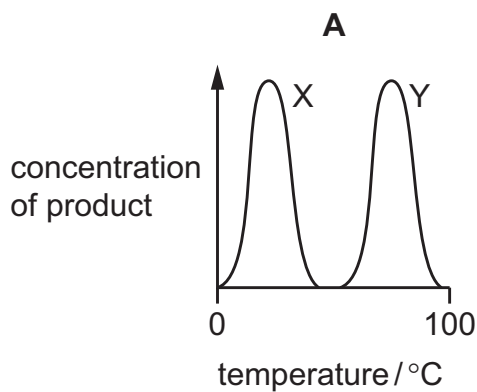
11 Two enzymes, X and Y, were used in an experiment.

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?



9. Question | 9700 May-June 2016 P1 V3 Q10

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

10. Question | 9700 May-June 2016 P1 V3 Q11

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

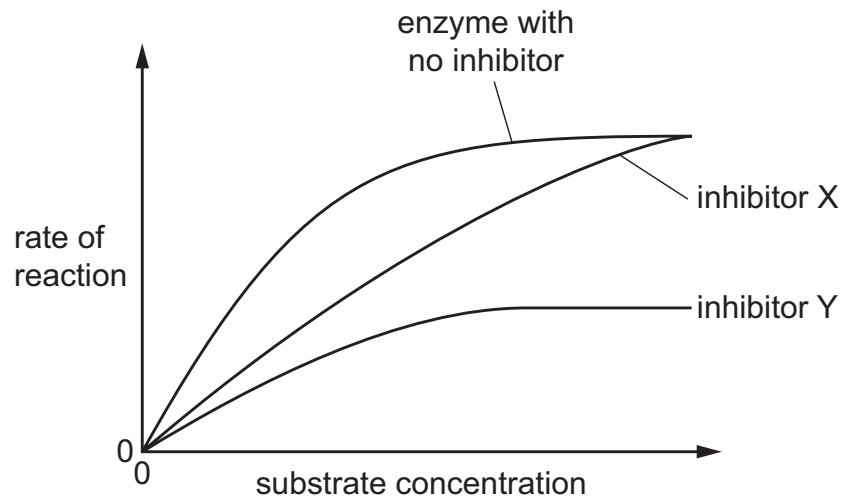
- A** A few amino acids give the active site a specific shape.
- B** An enzyme has a substrate with a specific shape.
- C** The enzyme changes shape in the presence of the substrate.
- D** The substrate molecules are complementary to the active site.

11. Question | 9700 May-June 2016 P1 V3 Q12

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.

12. Question | 9700 Oct-Nov 2016 P1 V1 Q12

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

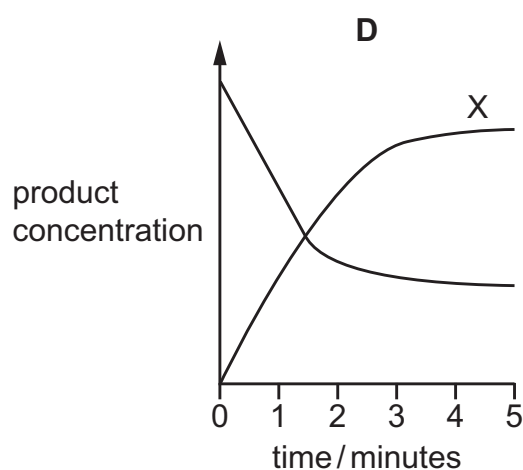
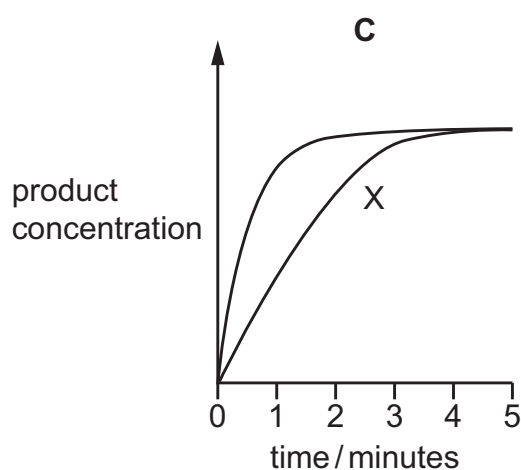
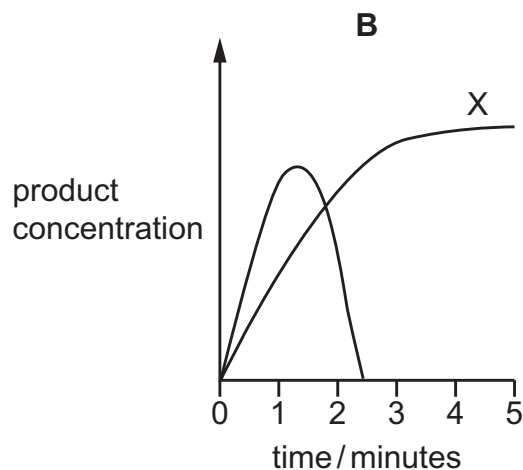
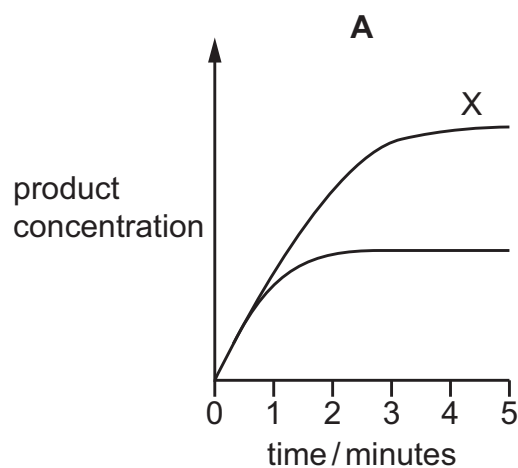
Which steps are required to obtain an estimate of lactate dehydrogenase activity in a sample of blood plasma?

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

key
✓ = step required
x = step not required

- 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?



14. Question | 9700 Oct-Nov 2016 P1 V2 Q13

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

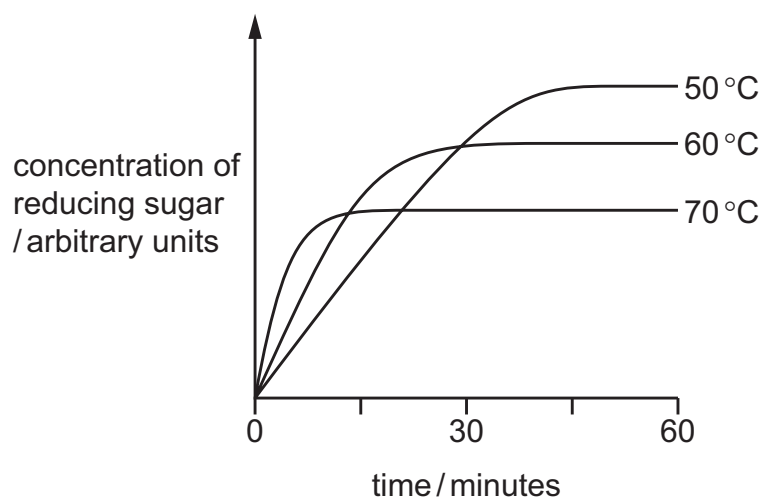
Two identical chains of 99 amino acids form the enzyme. In each chain, amino acids 25, 26 and 27 in the sequence form part of the active site.

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

- A** primary, secondary, tertiary and quaternary
- B** primary, secondary and tertiary only
- C** primary and quaternary only
- D** quaternary only

15. Question | 9700 Oct-Nov 2016 P1 V2 Q14

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

16. Question | 9700 Oct-Nov 2016 P1 V2 Q15

- 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.

17. Question | 9700 Oct-Nov 2016 P1 V3 Q11

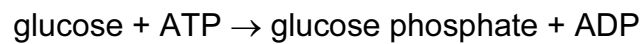
- 11** An investigation into the rate of an enzyme-catalysed reaction was carried out. During the investigation the concentration of the substrate was kept higher than the concentration of the enzyme.

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

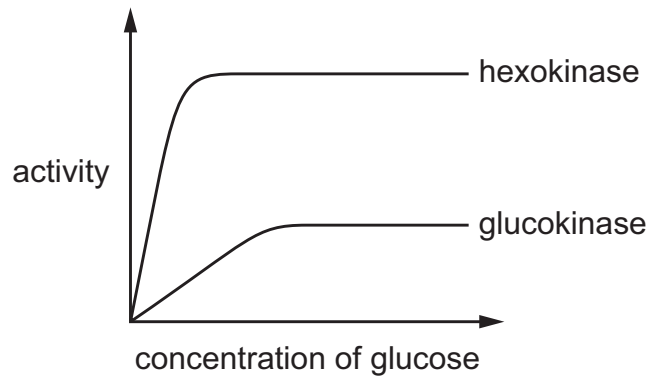
- 1 increase in enzyme concentration
- 2 increase in pH
- 3 increase in temperature

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

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



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

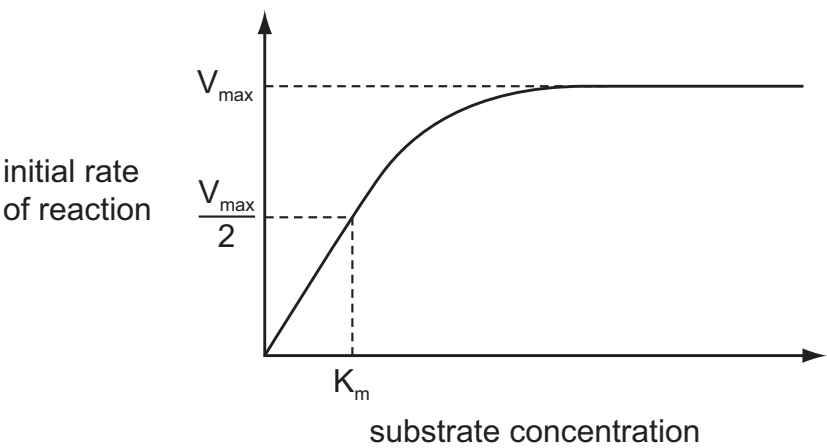


What describes the different activities of the two enzymes?

- 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.

19. Question | 9700 Oct-Nov 2016 P1 V3 Q13

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.

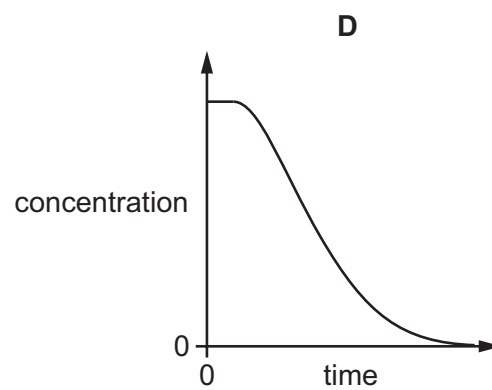
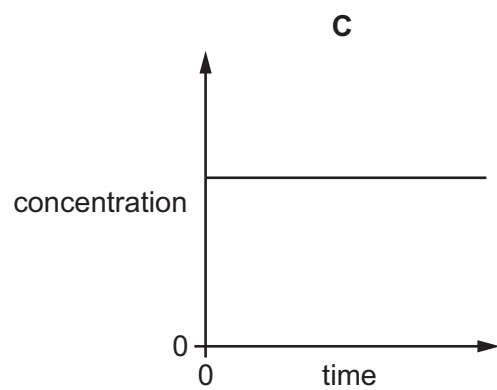
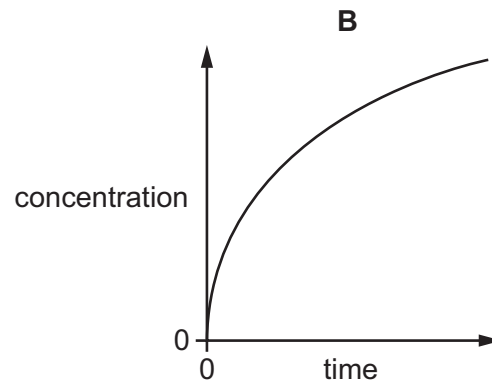
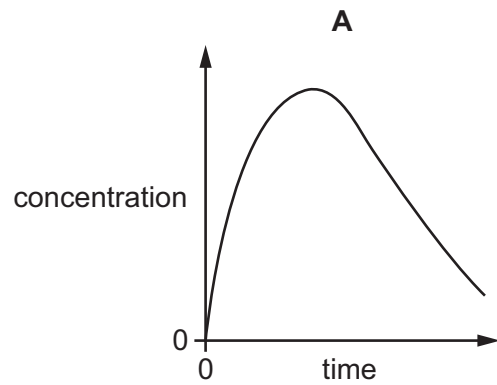
What could be the value of K_m with inhibitor compared to the value of K_m with no inhibitor?

	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

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?



21. Question | 9700 Feb-March 2017 P1 V2 Q15

- 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.

22. Question | 9700 May-June 2017 P1 V1 Q14

- 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?

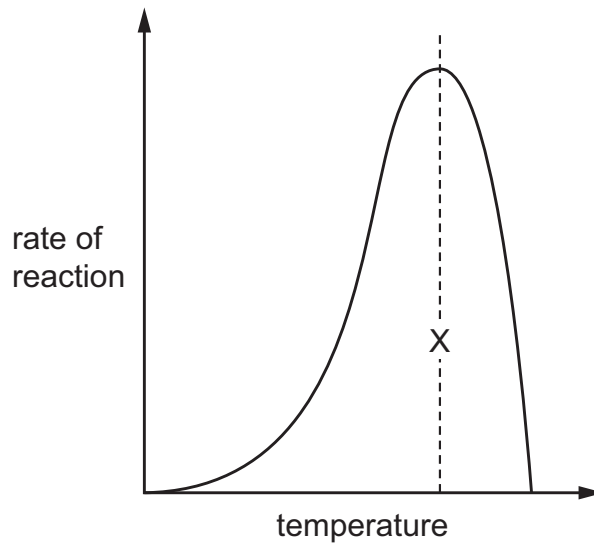
- A** Carrying out a further experiment where the enzyme solution is replaced with water.
- B** Carrying out each experiment in a thermostatically regulated water-bath at 35 °C.
- C** Performing three repeat experiments for each of the five enzyme concentrations.
- D** Using the same volume of enzyme solution for each of the five experiments.

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

- 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?

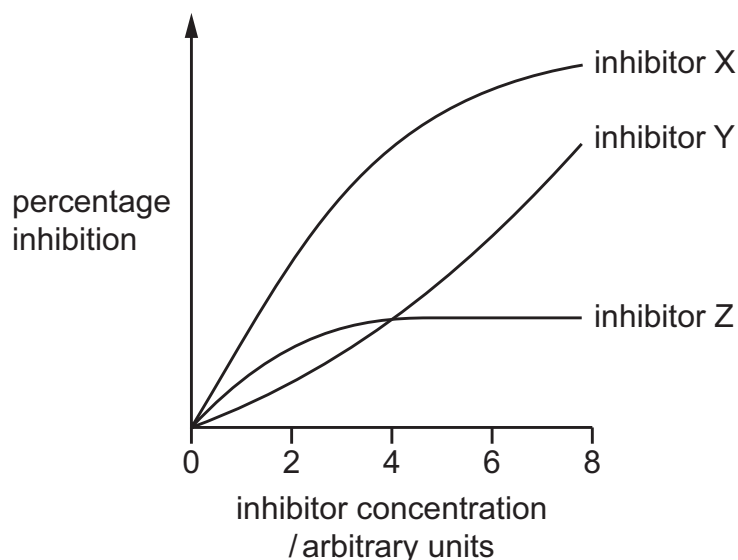
- 1 Bonds are broken between the R groups of the amino acids in the polypeptide chains of the enzyme.
- 2 There are more collisions between the enzyme and its substrate.
- 3 The tertiary structure of the enzyme is altered.
- 4 The shapes of the active site and the substrate are no longer complementary.

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

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

26. Question | 9700 May-June 2017 P1 V2 Q11

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?

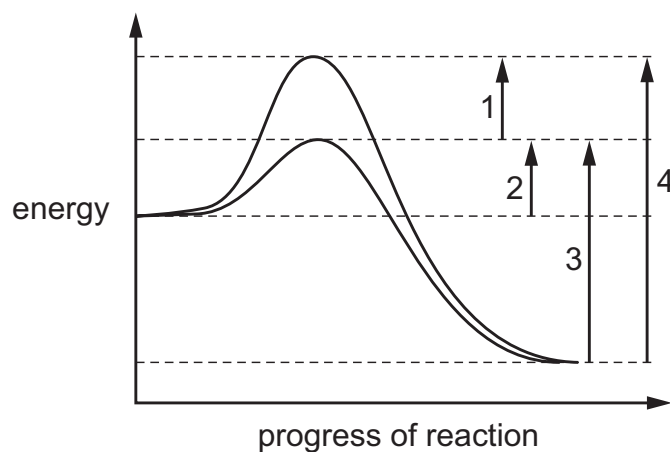
- A** 1 and 2 **B** 1 and 3 **C** 2, 3 and 4 **D** 2 and 4 only

27. Question | 9700 May-June 2017 P1 V2 Q12

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

10 The graph shows energy changes in a chemical reaction.

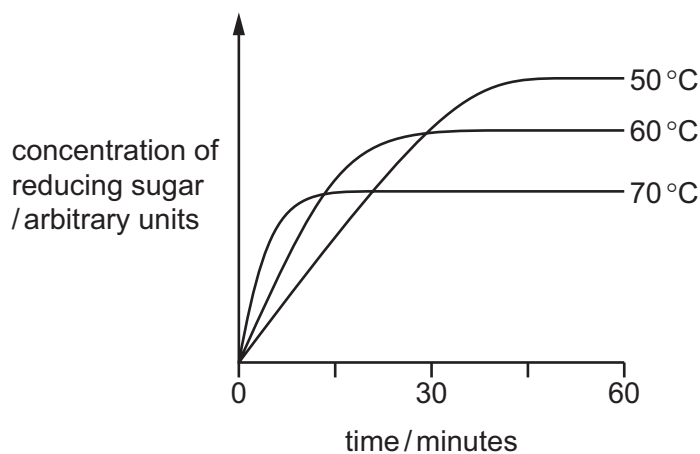


What is the activation energy when an enzyme is added?

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

29. Question | 9700 May-June 2017 P1 V3 Q11

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



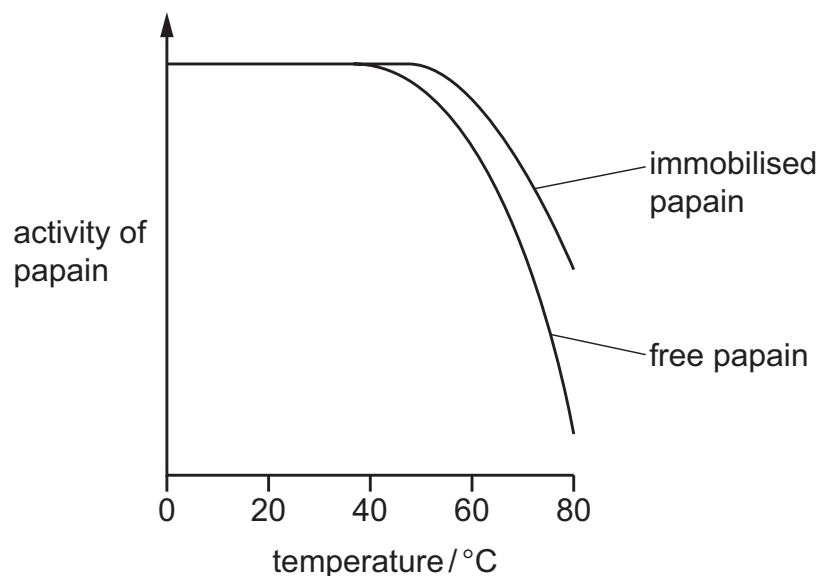
In each investigation the concentration and volume of the solutions was kept constant.

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.

30. Question | 9700 May-June 2017 P1 V3 Q12

- 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.

31. Question | 9700 Oct-Nov 2017 P1 V1 Q10

- 10** Lysozyme is an enzyme found in tears and saliva.

Which statement refers only to the tertiary structure of lysozyme?

- A** A section of the molecule consists of an α -helix.
- B** It consists of a single polypeptide.
- C** It is 129 amino acids long.
- D** The 35th and 52nd amino acids help form the active site.

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

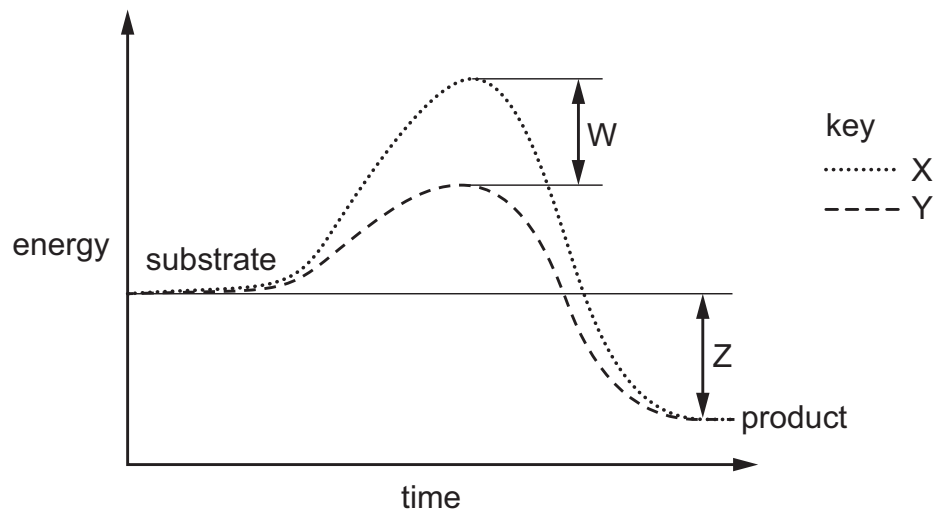
Most of these ribozymes have other RNA molecules as their substrates and catalyse reactions that break specific sugar phosphate bonds in the substrate molecules.

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

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.

34. Question | 9700 Oct-Nov 2017 P1 V1 Q13

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

35. Question | 9700 Oct-Nov 2017 P1 V2 Q14

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

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.

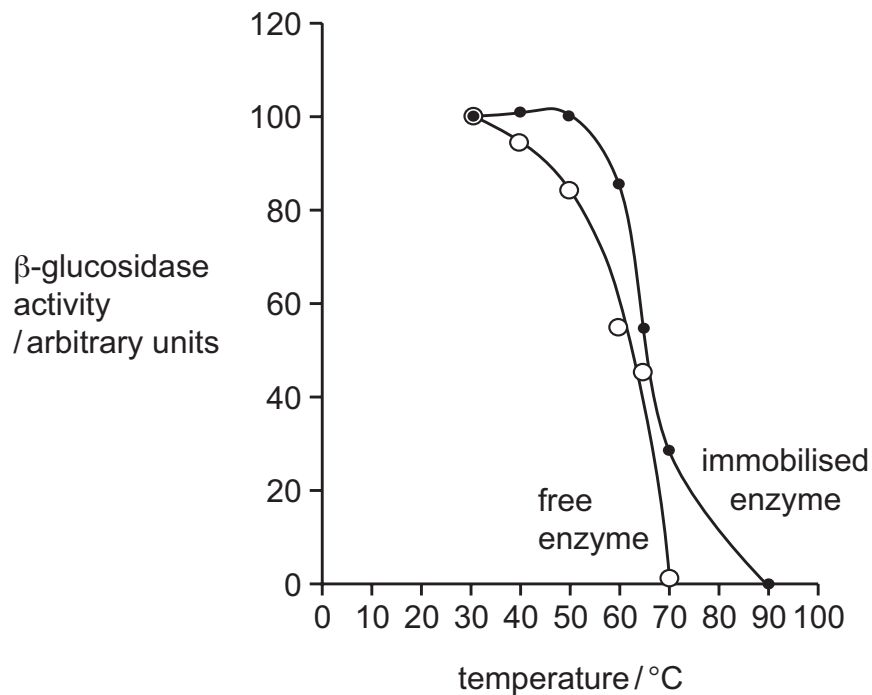
What explains the results after 10 minutes?

- 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.

- 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.

- 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.

39. Question | 9700 Oct-Nov 2017 P1 V3 Q14

- 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.

40. Question | 9700 Oct-Nov 2017 P1 V3 Q15

- 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

41. Question | 9700 Oct-Nov 2017 P1 V3 Q16

- 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.

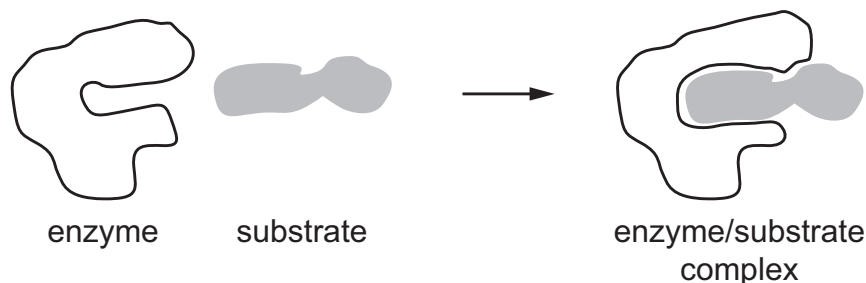
The liver that had been at –18 °C produced bubbles of oxygen more rapidly than the liver that had been at 5 °C.

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.

42. Question | 9700 Feb-March 2018 P1 V2 Q14

- 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.

43. Question | 9700 Feb-March 2018 P1 V2 Q15

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

44. Question | 9700 May-June 2018 P1 V1 Q12

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

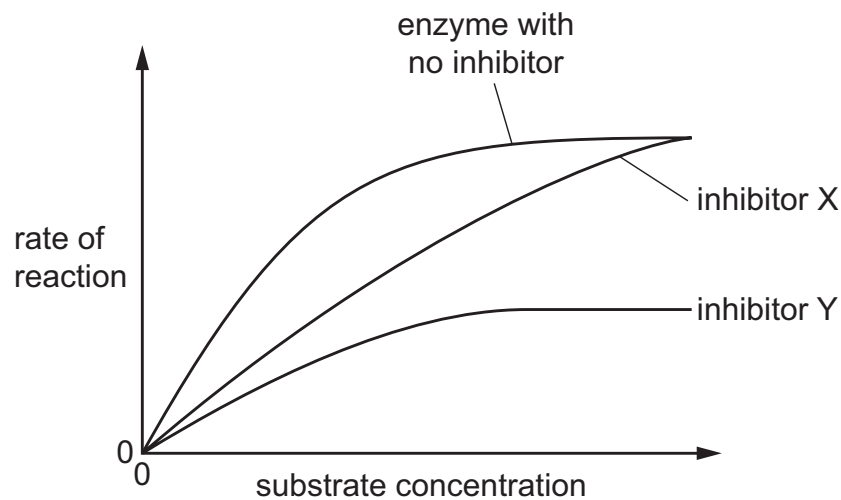
When the pH of an environment is decreased below the optimum pH of an enzyme, ...1..... bonds between adjacent 2..... groups, holding the 3..... structure, are disrupted.

	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

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.

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

- 1 cm³ of enzyme solution was added to 10 cm³ 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.

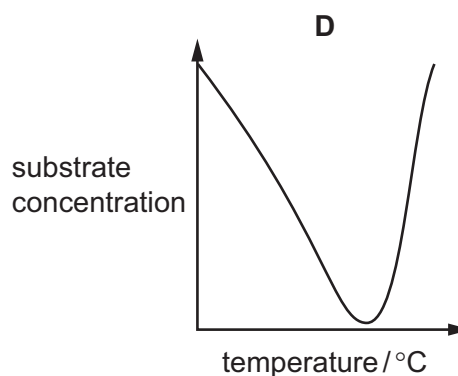
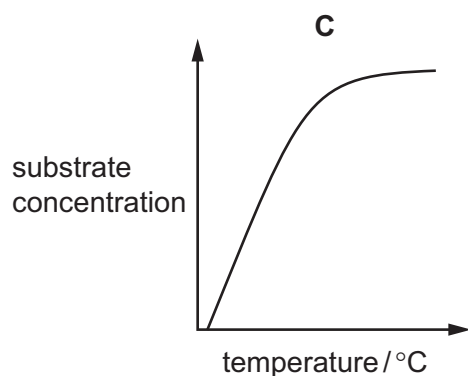
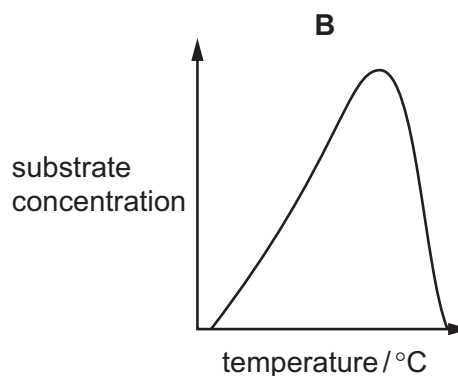
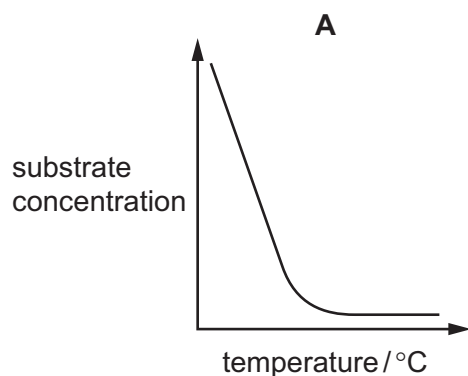
A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

47. Question | 9700 May-June 2018 P1 V2 Q13

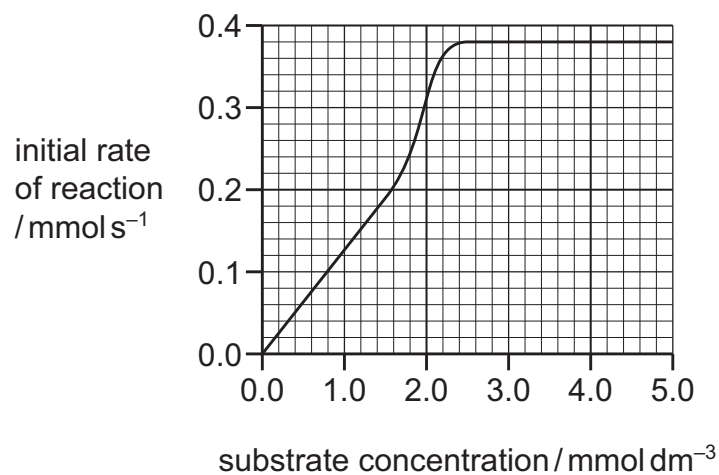
- 13** A student carried out an investigation into the effect of temperature on the rate of an enzyme-catalysed reaction.

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?



- 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}

49. Question | 9700 May-June 2018 P1 V3 Q13

- 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 parahydroxybenzoic 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

50. Question | 9700 May-June 2018 P1 V3 Q14

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

51. Question | 9700 May-June 2018 P1 V3 Q15

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

52. Question | 9700 Oct-Nov 2018 P1 V1 Q13

13 A mutation occurred within the DNA sequence coding for an enzyme, causing a decrease in the rate of a reaction catalysed by this enzyme.

Which statements could explain the decrease in the rate of reaction?

- 1 An inhibitor for this enzyme has an increased affinity for the enzyme and forms an enzyme–inhibitor complex more easily.
- 2 The active site of the enzyme might have changed shape and so is no longer complementary.
- 3 The activation energy for the reaction with the mutated enzyme is greater than with the non-mutated enzyme.

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

53. Question | 9700 Oct-Nov 2018 P1 V1 Q14

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

54. Question | 9700 Oct-Nov 2018 P1 V2 Q14

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

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

enzyme	$K_m / \text{mmol dm}^{-3}$
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 $6.0 \times 10^{-3} \text{ mmol dm}^{-3}$.

56. Question | 9700 Oct-Nov 2018 P1 V3 Q13

- 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 $V_{\max}$.

57. Question | 9700 Oct-Nov 2018 P1 V3 Q14

- 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 one 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** 2 and 3 only **D** 2 only

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?

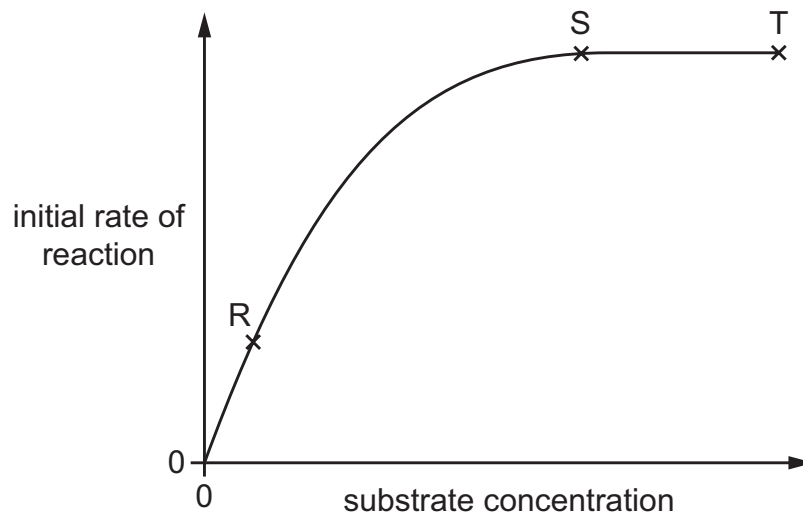
	incubation time / s	incubation temperature / °C	mass of product / μg
A	30	25	2.5
B	30	45	5.0
C	600	25	32.0
D	600	45	10.0

14 Which levels of protein structure can determine the specificity of an enzyme?

- 1 primary
- 2 secondary
- 3 tertiary
- 4 quaternary

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

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

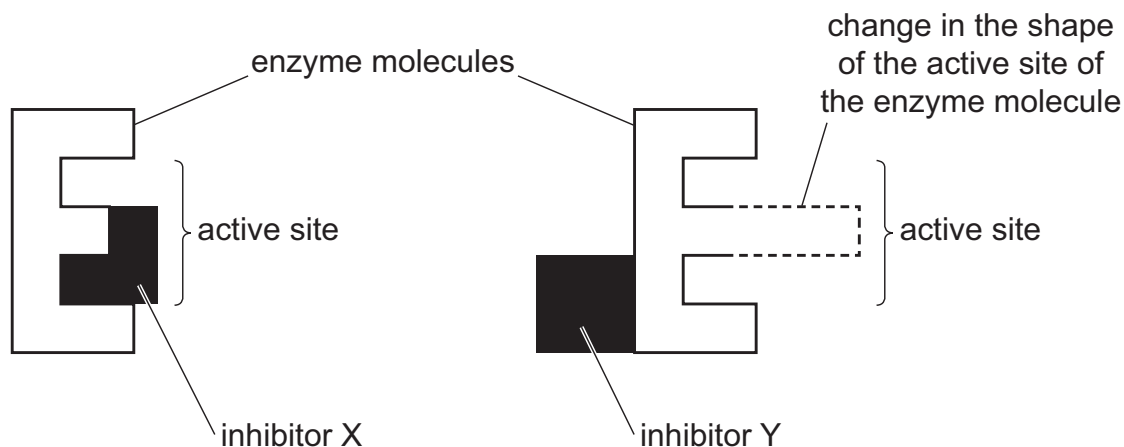


Which statement about the graph is correct?

- 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.

61. Question | 9700 Feb-March 2019 P1 V2 Q16

- 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

62. Question | 9700 May-June 2019 P1 V1 Q7

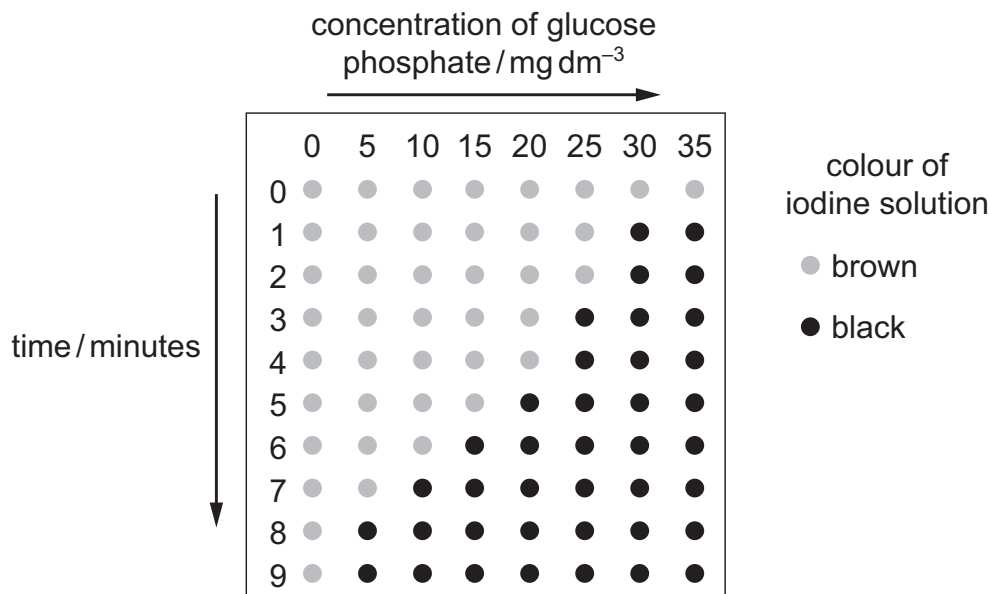
- 7** A solution of amylase was added to a suspension of starch. After 30 seconds, three samples of the mixture were tested with iodine solution, Benedict's solution or with biuret reagent.

Which are the expected results?

	colour with test reagent		
	iodine solution	Benedict's solution	biuret reagent
A	black	green	purple
B	black	red	blue
C	brown	blue	purple
D	brown	yellow	blue

- 13** In an investigation, the same concentration of the enzyme phosphorylase was added to different concentrations of glucose phosphate and incubated at 30 °C. At 1 minute intervals, one drop of the reaction mixture was removed and added to a drop of iodine solution on a white tile.

The diagram shows the results of this investigation.



What explains the trend in the results of this investigation?

- A** Phosphorylase catalyses a reaction converting glucose phosphate to starch.
- B** The maximum rate of reaction is reached at 20 mg dm⁻³ of glucose phosphate.
- C** Substrate concentration is limiting at concentrations of glucose phosphate 25 mg dm⁻³ or less.
- D** Enzyme concentration is limiting at concentrations of glucose phosphate 25 mg dm⁻³ or less.

64. Question | 9700 May-June 2019 P1 V1 Q14

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 $V_{\max}$

8 In enzyme-catalysed reactions, the position of the amino acids found at the active site is important.

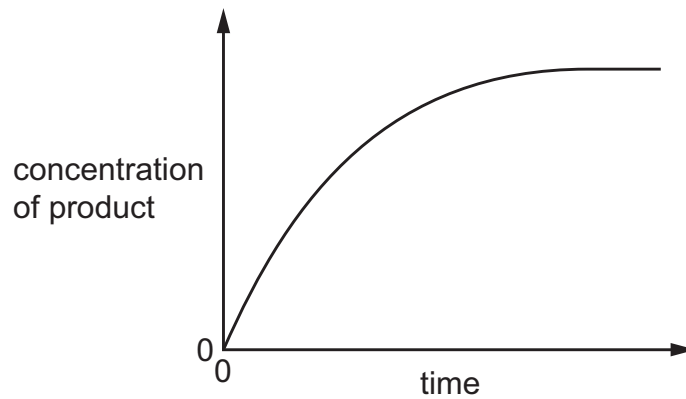
During the synthesis of enzymes, amino acids are brought together in the correct position to form the active site.

Which levels of protein structure **must** be involved in forming the active site?

	level of protein structure			
	primary	secondary	tertiary	quaternary
A	✓	✓	✓	✓
B	✓	✓	✓	x
C	x	✓	✓	✓
D	x	✓	x	✓

key
✓ = involved
x = not involved

- 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.

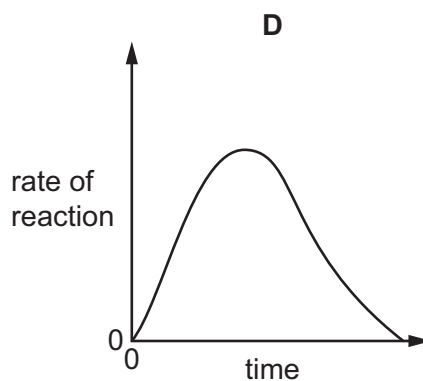
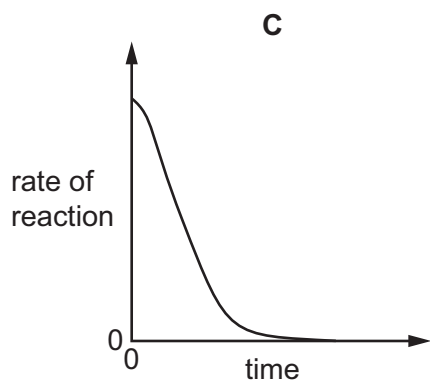
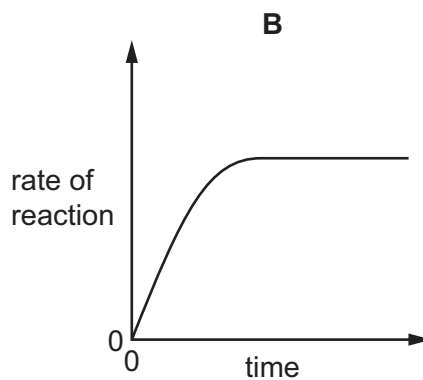
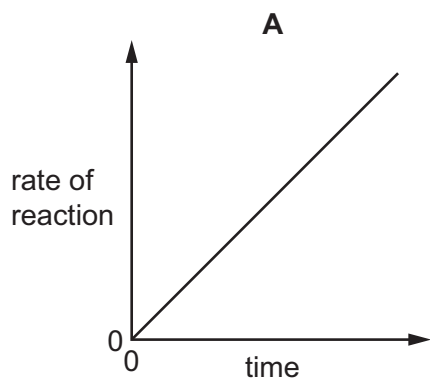


What explains the shape of this graph?

- 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.

- 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?



- 7** A solution of amylase was added to a suspension of starch. The mixture was stirred and kept at 40 °C for 45 minutes.

Samples were then tested with various reagents.

What is the expected set of results?

	test and resulting colour		
	iodine test	Benedict's test	biuret test
A	black	blue	blue
B	black	orange	purple
C	brown	blue	blue
D	brown	orange	purple

69. Question | 9700 May-June 2019 P1 V3 Q14

- 14** Which levels of protein structure would always be changed if an enzyme works by the induced fit hypothesis?

	primary	secondary	tertiary	quaternary
A	✓	✓	✓	✓
B	✓	✓	✗	✗
C	✗	✓	✗	✗
D	✗	✗	✓	✗

key

✓ = always changed

✗ = not changed

70. Question | 9700 May-June 2019 P1 V3 Q15

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

71. Question | 9700 May-June 2019 P1 V3 Q16

- 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.

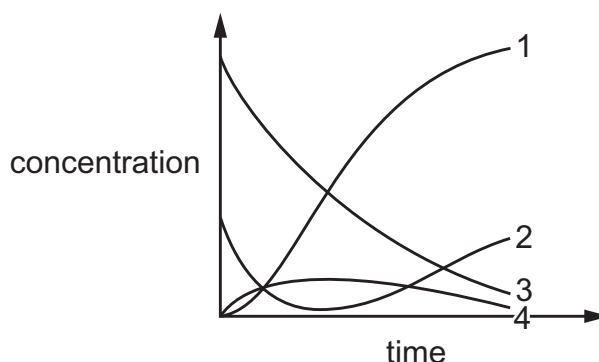
- A** 1, 2 and 3 **B** 1 and 3 only **C** 1 only **D** 2, 3 and 4

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

- 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

- 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.

- 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.

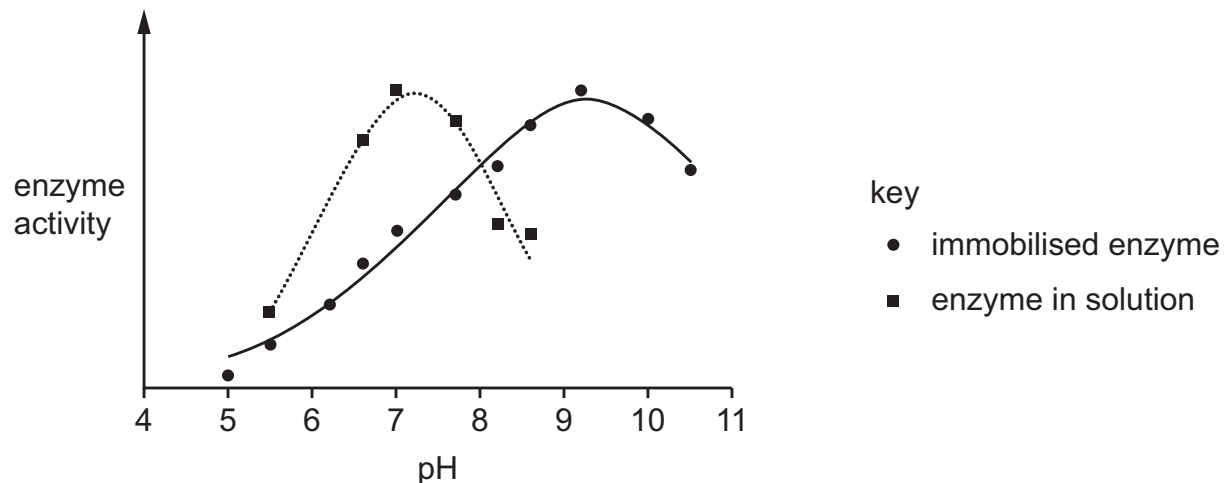
What is the reason for this?

- 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.

76. Question | 9700 Oct-Nov 2019 P1 V2 Q16

- 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.

77. Question | 9700 Oct-Nov 2019 P1 V3 Q11

- 11** Some extracellular protease enzymes are synthesised in an inactive form called zymogen.

Zymogen is converted to the active protease in the Golgi body.

What is the purpose of producing zymogen before converting it to the extracellular protease?

- A** to avoid unwanted digestion of proteins inside the cell
- B** to avoid unwanted digestion of proteins outside the cell
- C** to catalyse digestion of proteins in the cytoplasm
- D** to catalyse digestion of proteins in the rough endoplasmic reticulum

78. Question | 9700 Oct-Nov 2019 P1 V3 Q12

- 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.

79. Question | 9700 Feb-March 2020 P1 V2 Q13

- 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

80. Question | 9700 Feb-March 2020 P1 V2 Q14

- 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

81. Question | 9700 May-June 2020 P1 V1 Q12

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

82. Question | 9700 May-June 2020 P1 V1 Q13

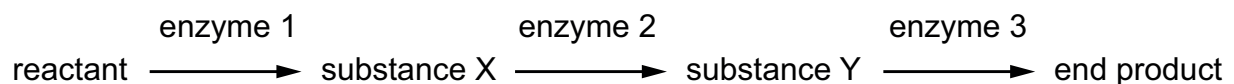
13 An enzyme is modified for industrial use. It has a lower Michaelis-Menten constant (K_m) than the unmodified enzyme.

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.

83. Question | 9700 May-June 2020 P1 V2 Q13

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.

84. Question | 9700 May-June 2020 P1 V2 Q14

- 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.

85. Question | 9700 May-June 2020 P1 V3 Q9

- 9** The enzyme trypsin hydrolyses proteins to amino acids. Trypsin does not function when the pH is very low as its 3D shape would be changed.

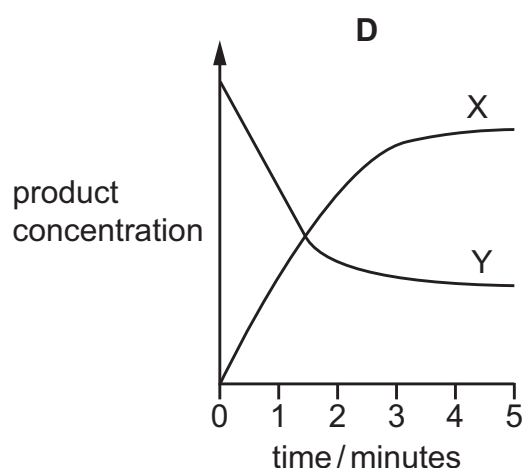
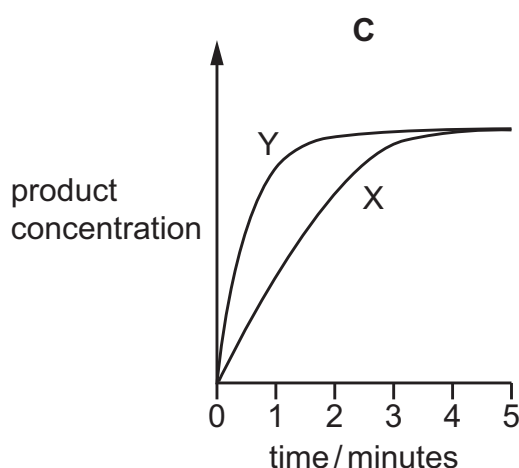
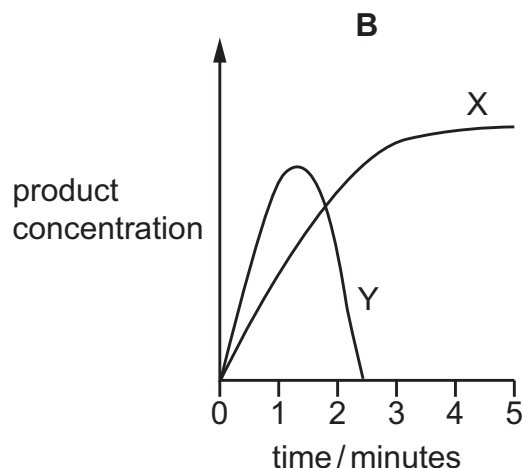
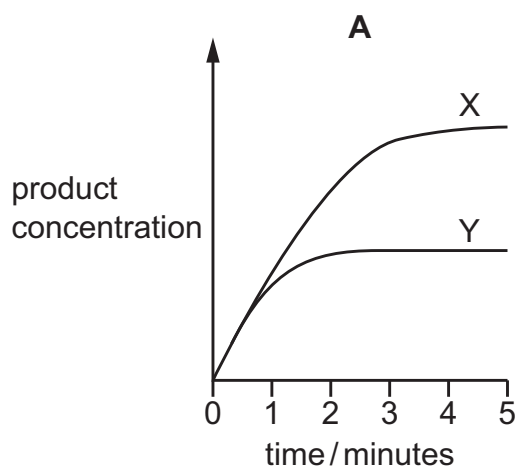
What explains this change in 3D shape?

- A** Hydrogen ions attach themselves to negatively charged R groups.
- B** Hydrogen ions disrupt disulfide bonds.
- C** Hydrogen ions increase hydrogen bonding between amino acids.
- D** Hydrogen ions reduce the affinity of hydrophilic R groups for water.

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?

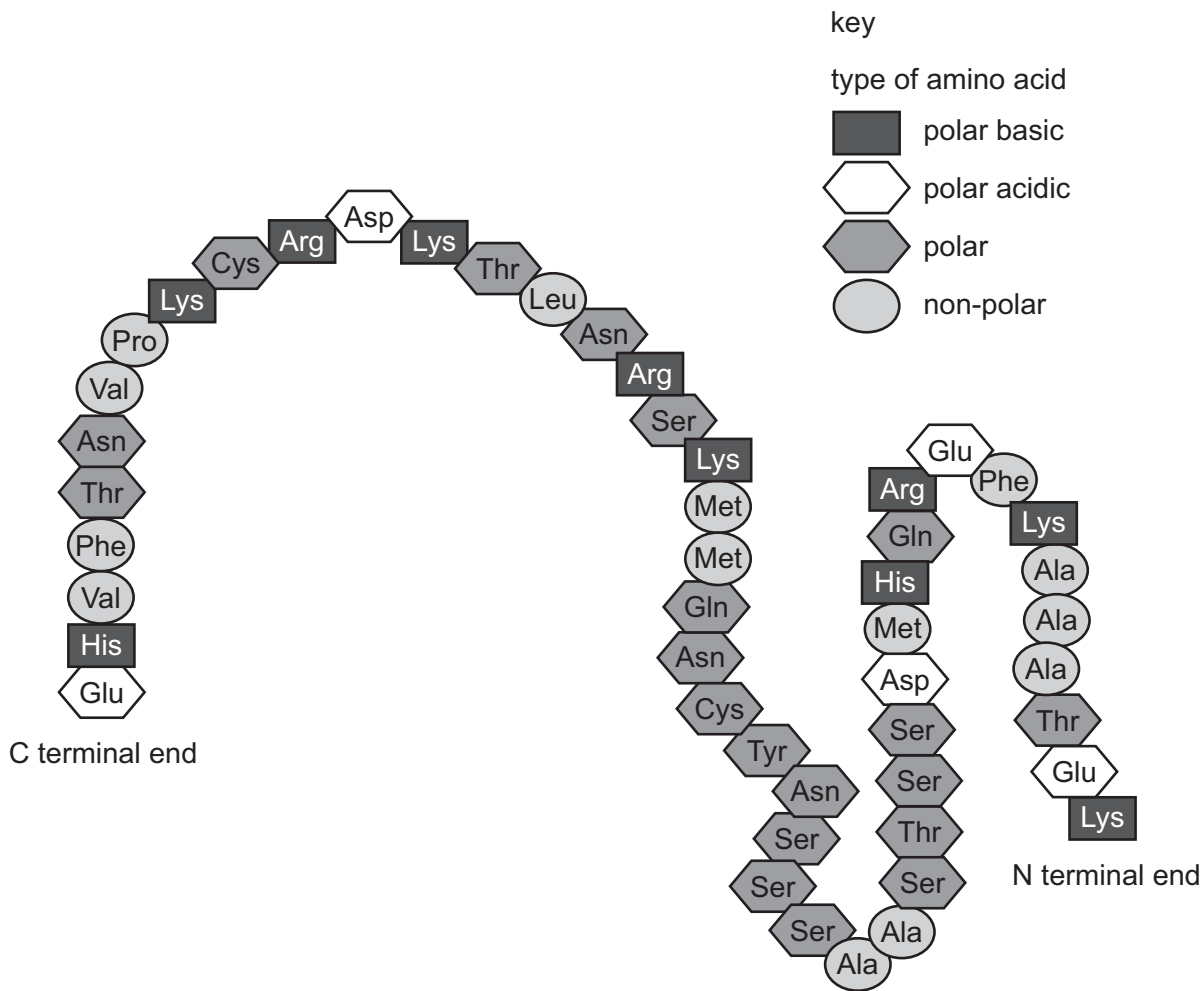


13 What affects the rate of an enzyme-catalysed reaction when in the presence of a non-competitive inhibitor?

- 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

11 The diagram shows the amino acids in a polypeptide.



An enzyme catalyses the hydrolysis of **any** peptide bond between a non-polar amino acid **and** any polar amino acid.

How many small peptides and single amino acids will be formed by the action of this enzyme?

	small peptides	single amino acids
A	6	1
B	8	1
C	12	3
D	13	4

89. Question | 9700 Oct-Nov 2020 P1 V1 Q13

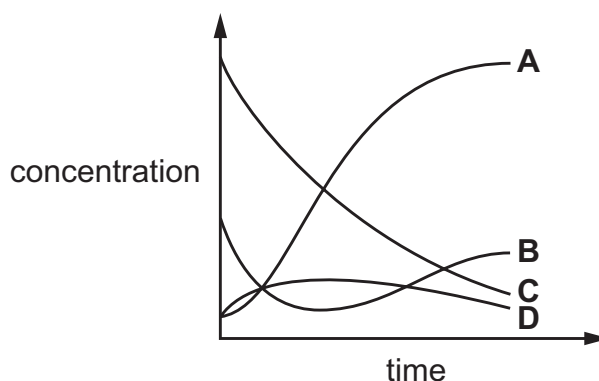
13 Which enzyme is extracellular?

- 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.

90. Question | 9700 Oct-Nov 2020 P1 V1 Q14

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?



91. Question | 9700 Oct-Nov 2020 P1 V1 Q15

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

7 Diastase is an enzyme that breaks down starch into maltose. Maltose is a reducing sugar.

A sample of starch is treated with boiled diastase and left for 15 minutes.

Samples of the mixture are then tested with iodine solution and with Benedict's reagent.

What are the results?

	iodine solution	Benedict's reagent
A	blue-black	blue
B	blue-black	red
C	brown	blue
D	brown	red

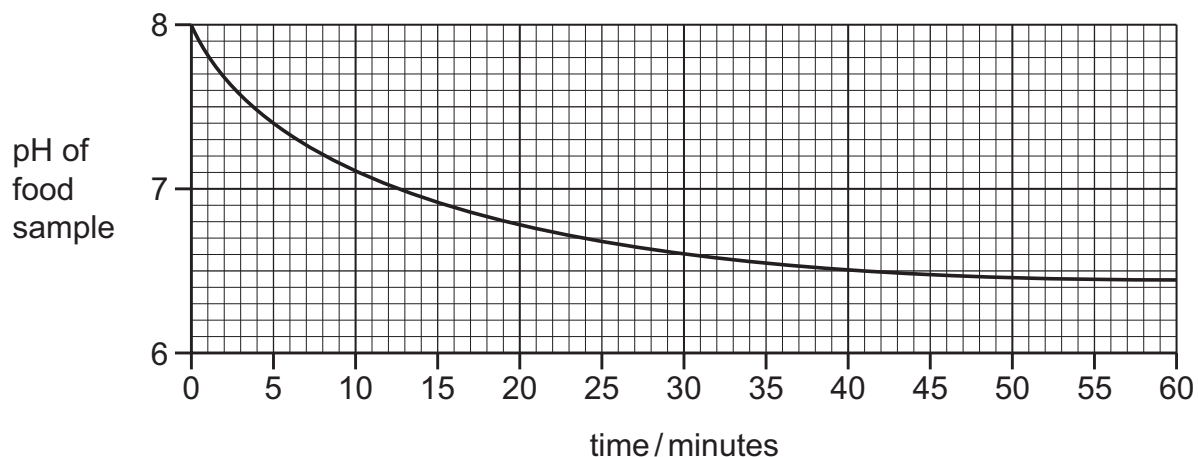
12 Which statements describe some enzyme actions?

- 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

- 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

95. Question | 9700 Oct-Nov 2020 P1 V2 Q14

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

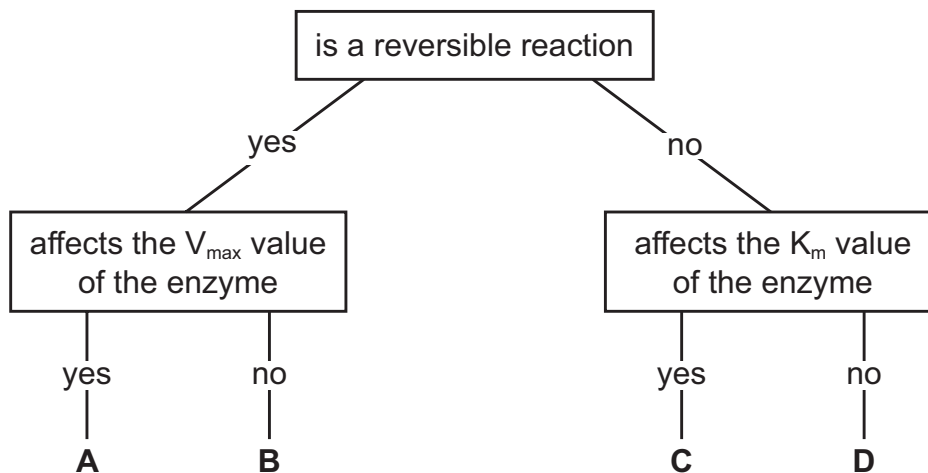
Ibuprofen binds reversibly to the active site of the enzyme.

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

96. Question | 9700 Oct-Nov 2020 P1 V3 Q14

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



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

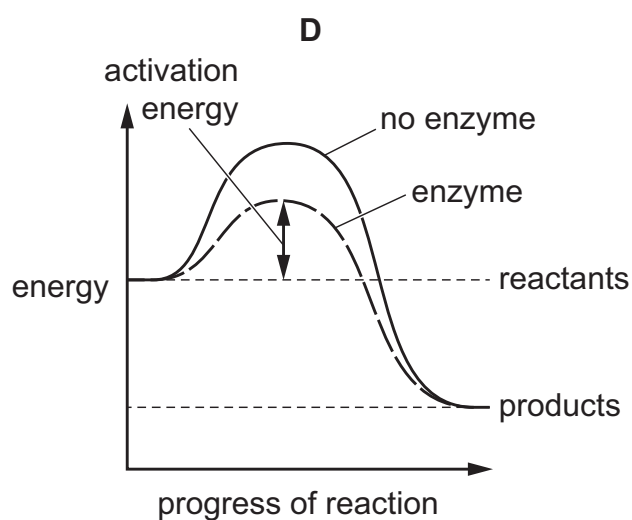
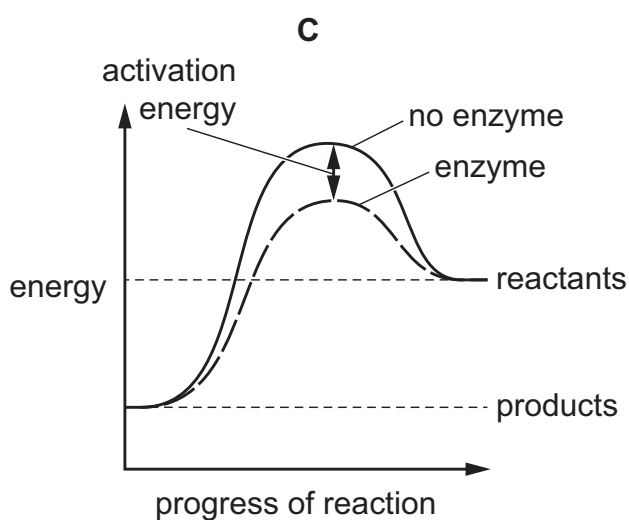
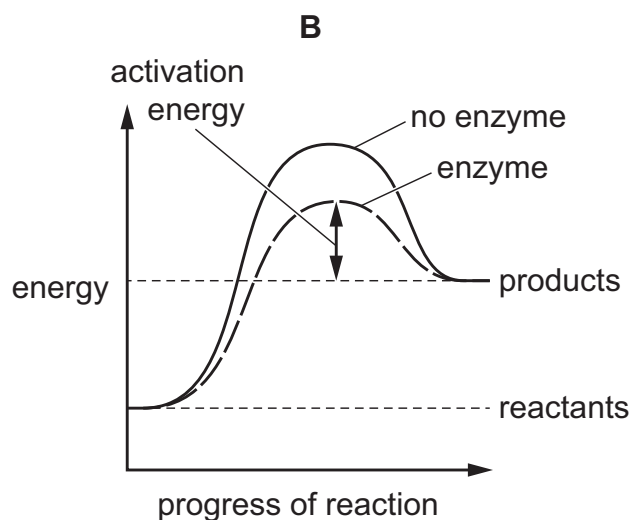
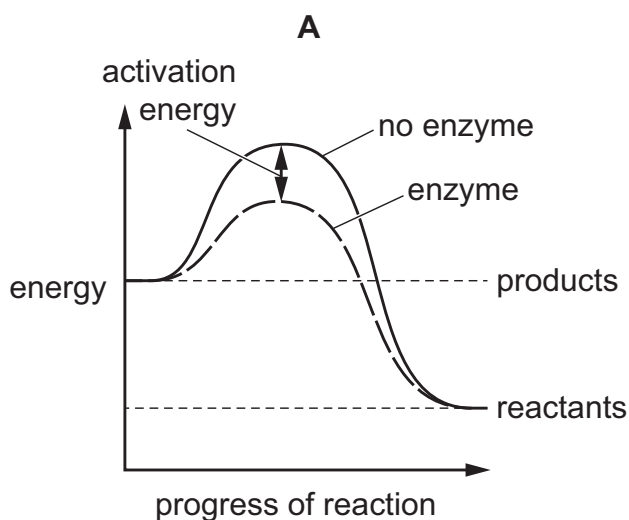
Catechol oxidase is inhibited by parahydroxybenzoic acid (PHBA), which is structurally similar to catechol. In the presence of PHBA, the Michaelis-Menten constant (K_m) for catechol oxidase increases.

How does PHBA inhibit catechol oxidase?

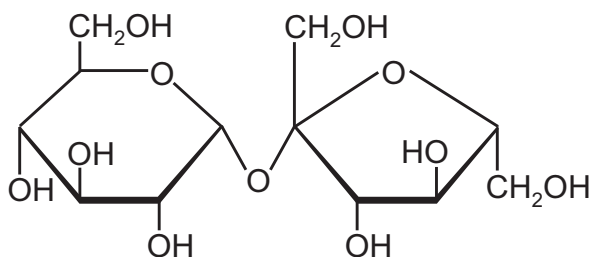
- 1 PHBA and catechol can both bind to the enzyme but not at the same time.
- 2 PHBA is a non-competitive inhibitor of catechol oxidase.
- 3 PHBA decreases the V_{max} of the reaction.

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

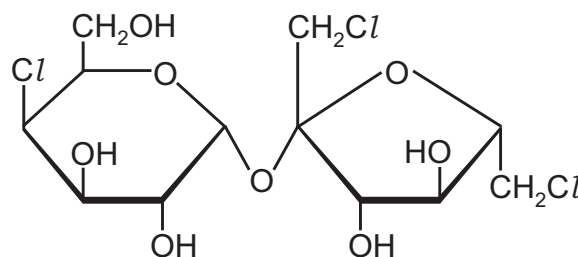
14 Which graph correctly shows the activation energy of a reaction when an enzyme is added?



12 The diagram shows sucrose and sucralose.



sucrose



sucralose

The enzyme sucrase breaks down sucrose but cannot break down sucralose. Four students were asked to suggest why sucrase can break down sucrose but not sucralose.

Three of the students gave correct suggestions.

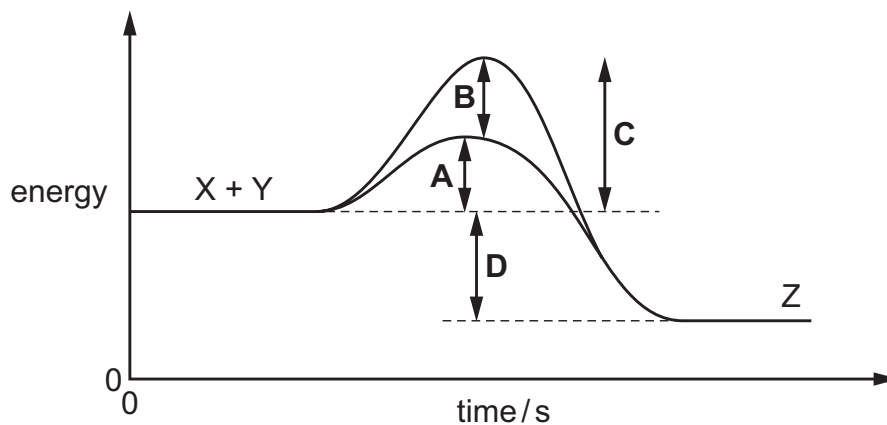
Which suggestion **cannot** be correct?

- A** The *Cl* atoms change the shape of the sucralose molecule so it is not the same shape as the active site of sucrase.
- B** The *Cl* atoms of the modified fructose cannot bind to the active site of sucrase.
- C** The *Cl* atoms cannot cause an induced fit, so sucralose does not enter the active site of sucrase.
- D** The *Cl* atoms cause fewer temporary hydrogen bonds between sucralose and the active site of sucrase.

100. Question | 9700 May-June 2021 P1 V2 Q13

- 13** 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?



101. Question | 9700 May-June 2021 P1 V3 Q14

- 14** The enzyme β -galactosidase can catalyse the hydrolysis of four substrates with similar structures.

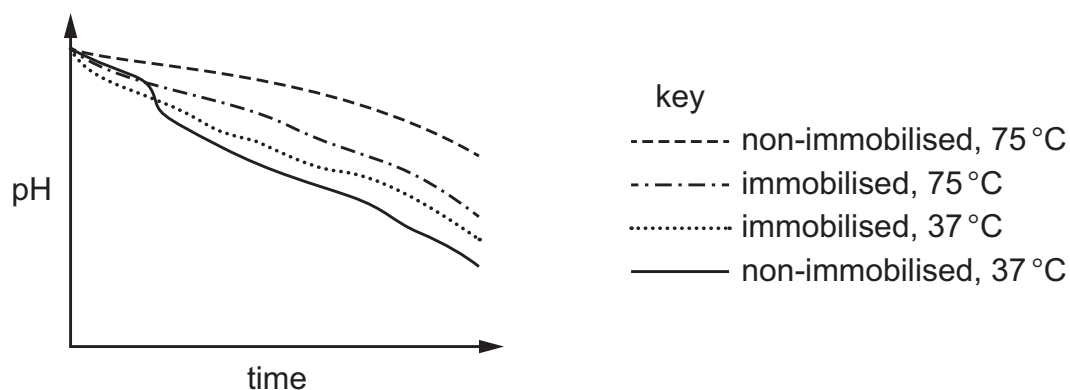
Each substrate gives a different K_m value.

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

	substrate	$K_m / \text{mol dm}^{-3}$
A	1	4×10^{-3}
B	2	1×10^{-3}
C	3	2×10^{-4}
D	4	1×10^{-4}

- 15** An investigation was carried out on the effect of temperature on the activity of an enzyme when it is immobilised and when it is non-immobilised (free in solution). The product of the enzyme-catalysed reaction causes a decrease in pH.

The graph shows the results of the investigation.

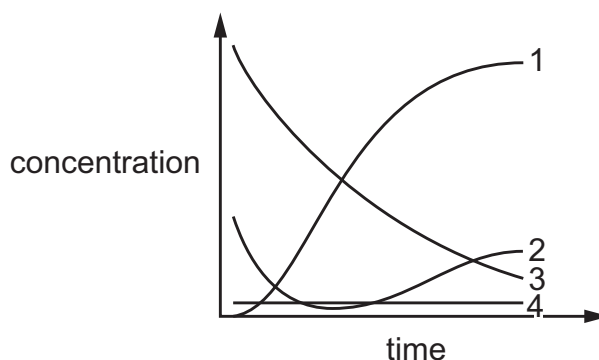


Which would give the highest yield of product?

- A** immobilised, 37 °C
- B** immobilised, 75 °C
- C** non-immobilised, 37 °C
- D** non-immobilised, 75 °C

103. Question | 9700 Oct-Nov 2021 P1 V1 Q12

- 12** The graph shows how the concentrations of four components, 1, 2, 3 and 4, of an enzyme-catalysed reaction change with time.



Which component is the enzyme–substrate complex?

- A** 1 **B** 2 **C** 3 **D** 4

104. Question | 9700 Oct-Nov 2021 P1 V1 Q13

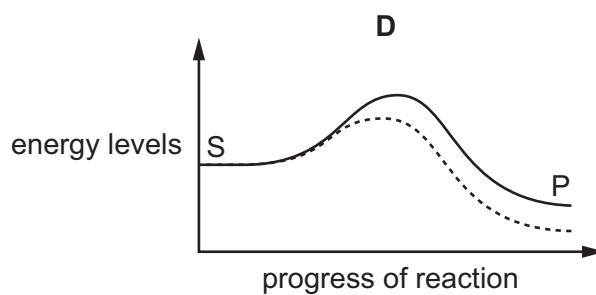
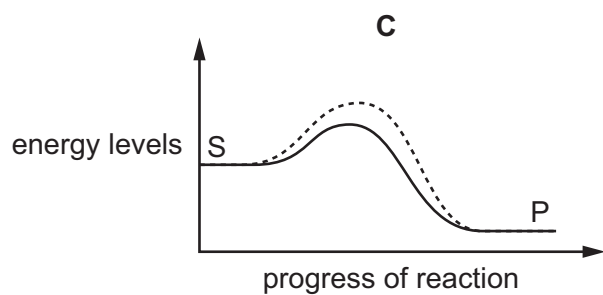
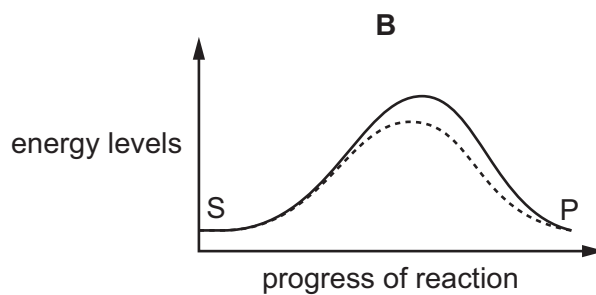
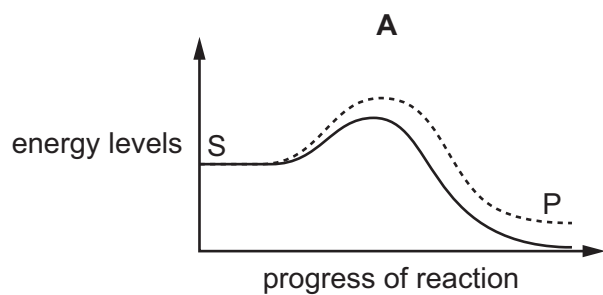
- 13** The table shows the Michaelis–Menten constant, K_m , for three enzymes.

enzyme	$K_m / \text{mmol dm}^{-3}$
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 $6.0 \times 10^{-3} \text{ mmol dm}^{-3}$.

- 14 Which graph correctly shows possible changes in energy levels as a chemical reaction progresses with or without an enzyme?



key

— with enzyme

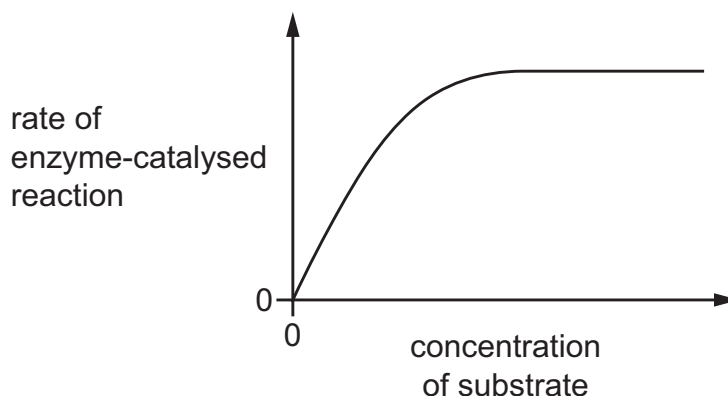
----- without enzyme

S substrate

P product

106. Question | 9700 Oct-Nov 2021 P1 V2 Q15

- 15** The graph shows the relationship between the concentration of substrate and the rate of an enzyme-catalysed reaction.



Which row shows how K_m and V_{max} for this enzyme would be affected if the same reaction was carried out in the presence of a competitive inhibitor?

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

107. Question | 9700 Oct-Nov 2021 P1 V3 Q14

- 14** Which descriptions about all enzymes are correct?

- 1 catalyse the breakdown of large molecules into smaller molecules
- 2 only function inside cells
- 3 form temporary bonds with the substrate
- 4 have a tertiary structure

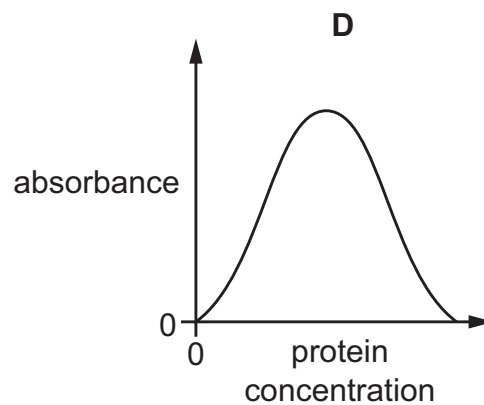
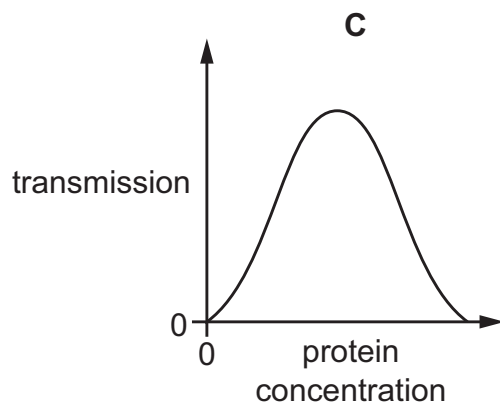
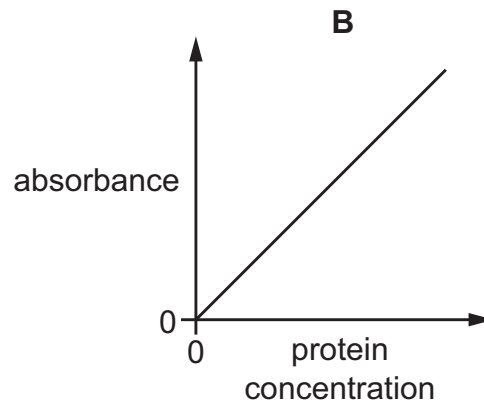
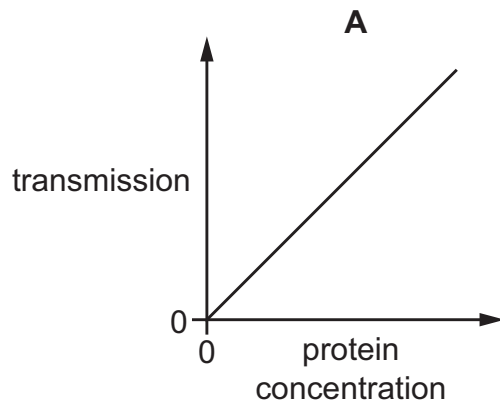
A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 3 and 4

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?



109. Question | 9700 May-June 2022 P1 V1 Q13

- 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

110. Question | 9700 May-June 2022 P1 V2 Q11

- 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

111. Question | 9700 May-June 2022 P1 V2 Q12

- 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.

112. Question | 9700 May-June 2022 P1 V3 Q12

12 RNA polymerase and peptidyl transferase are both enzymes involved in protein synthesis.

Which statements describe similarities between these two enzymes?

- 1 They are both globular proteins.
- 2 They both have the same tertiary structure.
- 3 They are both intracellular enzymes.

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

113. Question | 9700 May-June 2022 P1 V3 Q13

13 What is a feature of competitive enzyme inhibition?

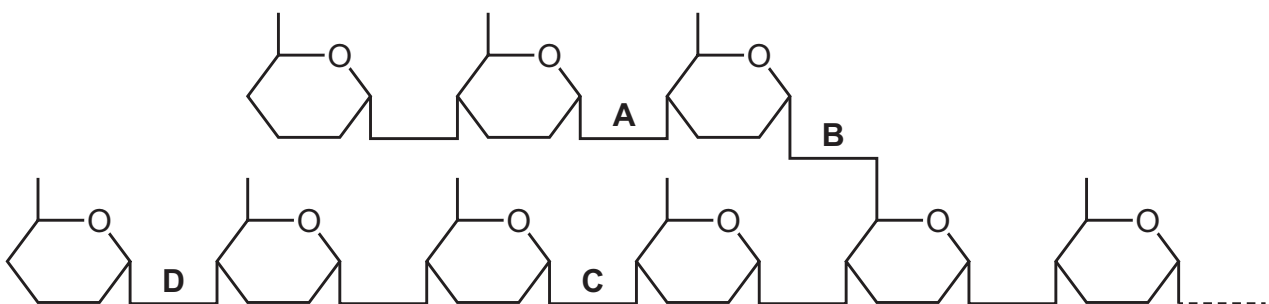
- A** The inhibitor binds permanently to the active site.
- B** Inhibition can be reversed by increasing the concentration of the substrate.
- C** The inhibitor molecule changes the secondary structure of the enzyme.
- D** The substrate and the inhibitor are the same shape.

114. Question | 9700 Oct-Nov 2022 P1 V1 Q9

9 The enzyme α -amylase hydrolyses amylopectin but it is not able to hydrolyse some of its glycosidic bonds.

- It only hydrolyses 1,4 glycosidic bonds.
- It is not able to hydrolyse the last bond of a chain.
- It is not able to hydrolyse the bonds in a chain of three units attached by a 1,6 glycosidic bond to another chain.

Which glycosidic bond can be hydrolysed by α -amylase?



115. Question | 9700 Oct-Nov 2022 P1 V1 Q12

- 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

116. Question | 9700 Oct-Nov 2022 P1 V1 Q13

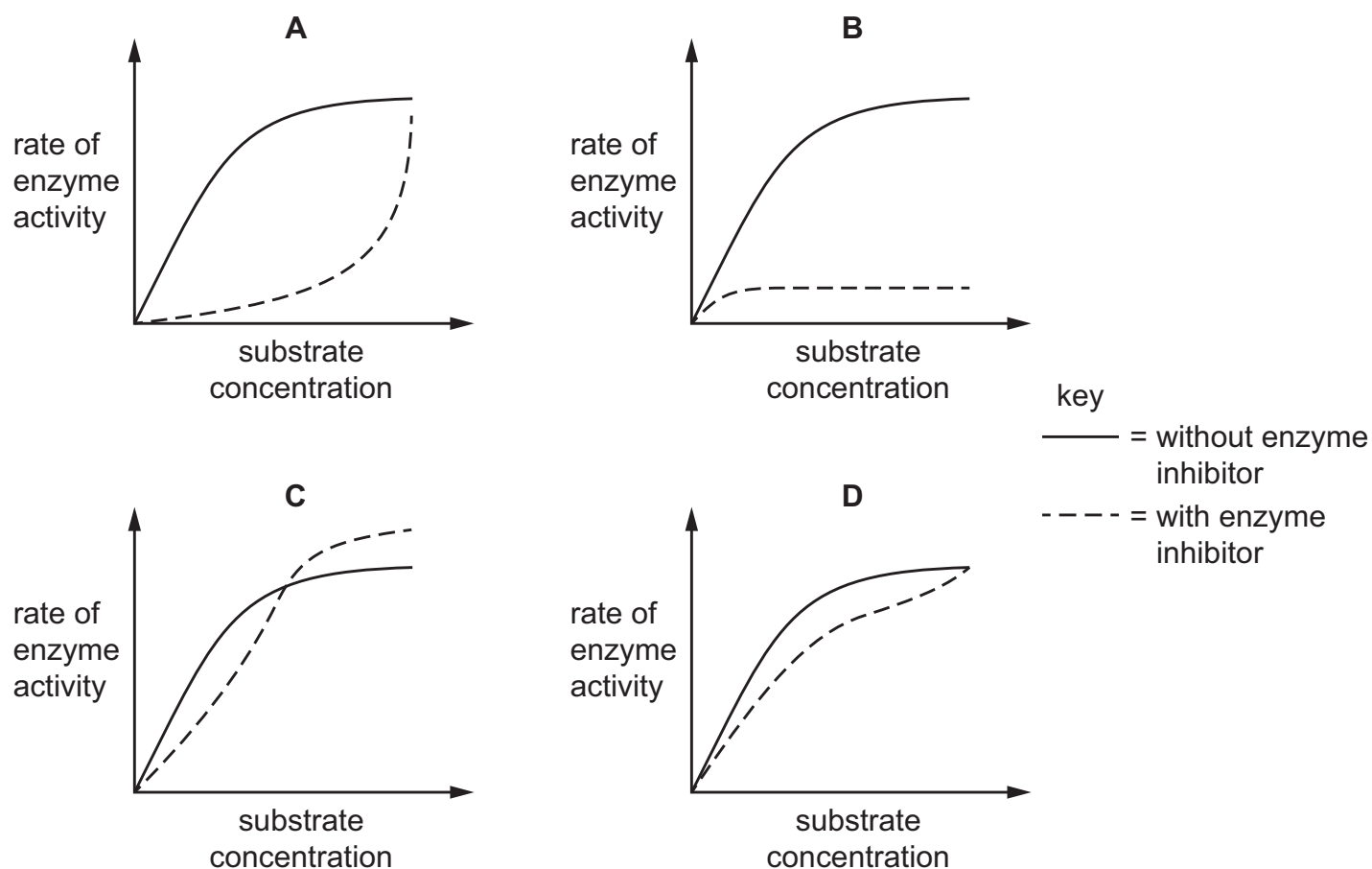
- 13** Which statements are correct for the lock and key hypothesis **and** the induced fit hypothesis of enzyme action?

- 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

- 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?

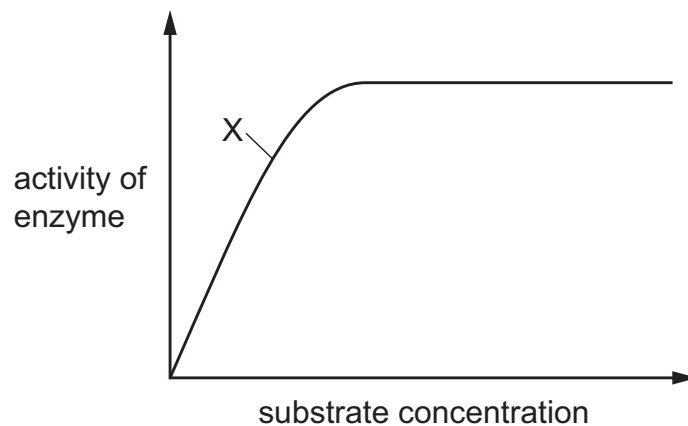


- 12** Which property of the tertiary structure of a globular protein enables it to catalyse a metabolic reaction?
- A** It has hydrophobic amino acid R groups on the outside.
 - B** It will be denatured by high temperatures.
 - C** The R groups of some amino acids form bonds with a substrate.
 - D** The three-dimensional shape depends on hydrogen bonding.

119. Question | 9700 Oct-Nov 2022 P1 V2 Q13

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

120. Question | 9700 Oct-Nov 2022 P1 V2 Q14

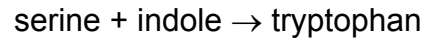
14 The Michaelis–Menten constant, K_m , is the substrate concentration at which an enzyme works at half its maximum rate.

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.

- 12** Some molecules fluoresce when illuminated with ultraviolet light. Changes in the structure or shape of such molecules can change the intensity of the fluorescence.

The enzyme tryptophan synthase fluoresces bluish-green because of a phosphate group associated with the active site. The enzyme catalyses the reaction shown.



Adding serine to the enzyme increases the intensity of the fluorescence, but when indole is also added the bluish-green fluorescence decreases in intensity.

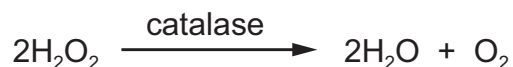
What may be concluded from these observations?

- 1 Serine and indole attach to the active site of the enzyme.
- 2 An enzyme–serine complex is formed.
- 3 An enzyme–serine–indole complex is formed.

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

122. Question | 9700 Oct-Nov 2022 P1 V3 Q13

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



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.

123. Question | 9700 Oct-Nov 2022 P1 V3 Q14

- 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

- 13** A student investigated the effect of enzyme concentration on the rate of hydrolysis 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 for the mixture to become clear.

What is an appropriate control for this investigation?

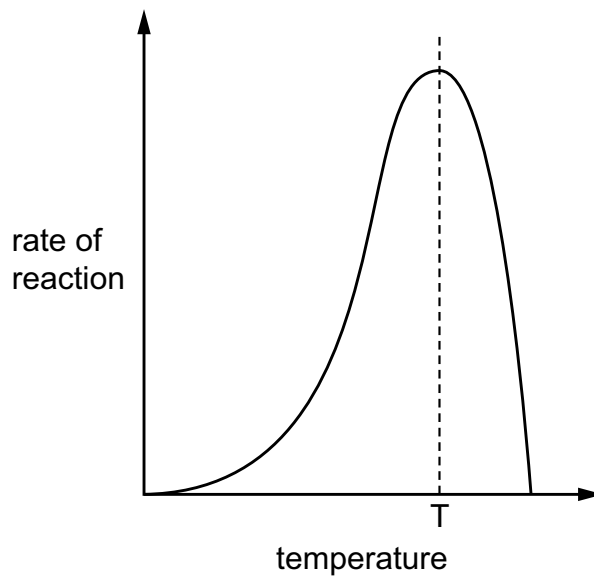
- A** Carrying out an experiment where the enzyme solution is replaced with water.
- B** Carrying out each experiment in a thermostatically controlled water-bath at 35 °C.
- C** Repeating each experiment three times for each of the five enzyme concentrations.
- D** Using the same volume of enzyme solution for each of the five experiments.

14 What determines the specificity of an enzyme?

- 1 the covalent and other bonding between R groups of the polypeptide
- 2 the optimum pH of the enzyme
- 3 the covalent 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

- 15** 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 T?

- 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

- 14** Which statement describes an example of an extracellular enzyme?
- A** Amylase in saliva is an enzyme that catalyses the breakdown of starch in the mouth.
 - B** Carbonic anhydrase is an enzyme that helps in the transport of carbon dioxide in blood.
 - C** DNA polymerase is an enzyme that helps build DNA molecules from nucleotides.
 - D** RNA polymerase is an enzyme involved in the process of gene transcription.

15 Which row is correct for enzymes that catalyse reactions using the lock-and-key hypothesis?

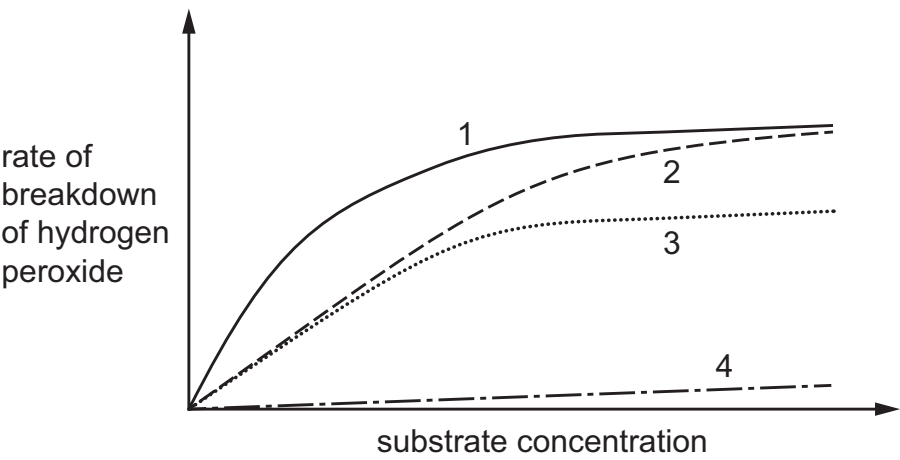
	effect of the enzyme on the activation energy of the reaction being catalysed	shape of active site in comparison to the substrate
A	lowers the activation energy	changes to become complementary as the enzyme–substrate complex forms
B	lowers the activation energy	complementary before, during and after the formation of an enzyme–substrate complex
C	raises the activation energy	changes to become complementary as the enzyme–substrate complex forms
D	raises the activation energy	complementary before, during and after the formation of an enzyme–substrate complex

16 A scientist investigated the rate of breakdown of hydrogen peroxide.

Four experiments were carried out using different mixtures.

- substrate only
- substrate + enzyme
- substrate + enzyme + competitive inhibitor
- substrate + enzyme + non-competitive inhibitor

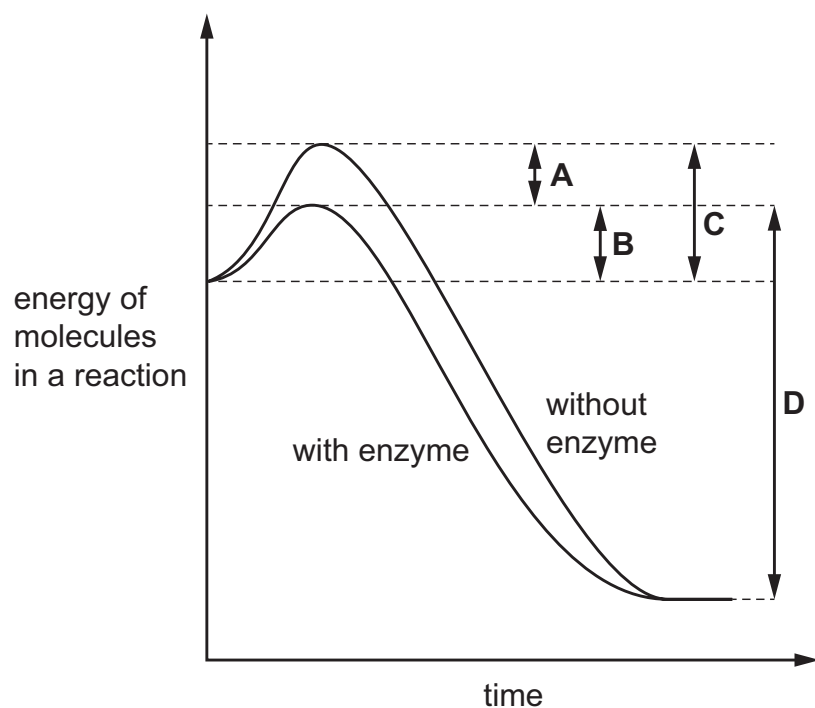
The results are sketched in the graph.



Which row shows the correct lines for two of the experimental mixtures?

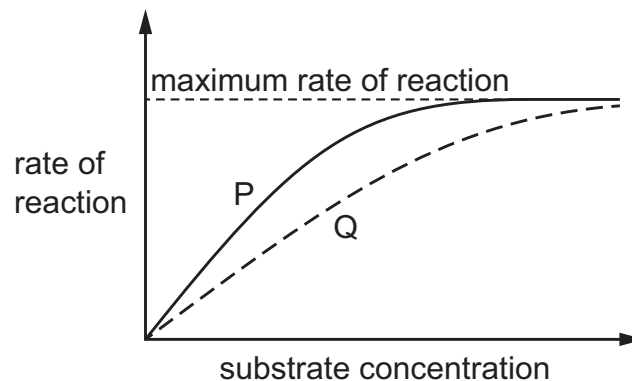
	substrate only	substrate + enzyme + competitive inhibitor
A	1	2
B	4	2
C	1	3
D	4	3

12 Which region on the graph shows the activation energy of an enzyme-catalysed reaction?



131. Question | 9700 May-June 2023 P1 V1 Q13

- 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

132. Question | 9700 May-June 2023 P1 V2 Q13

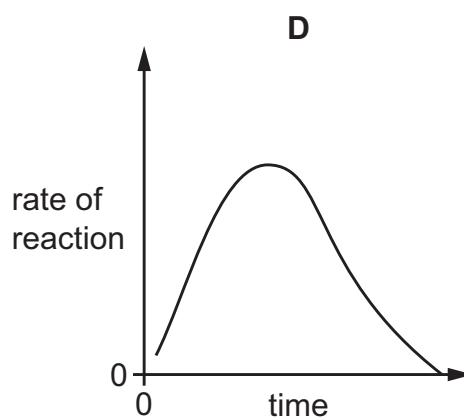
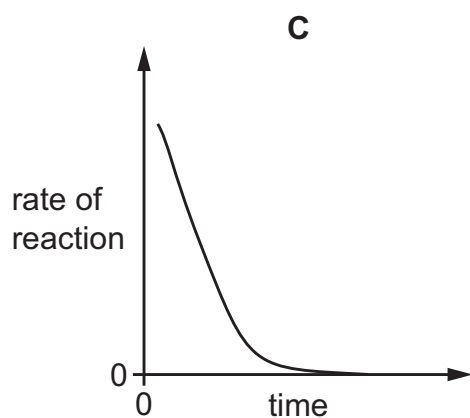
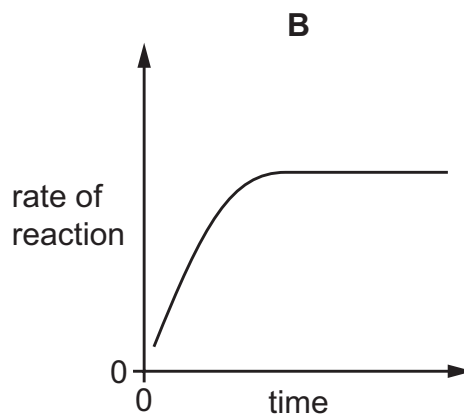
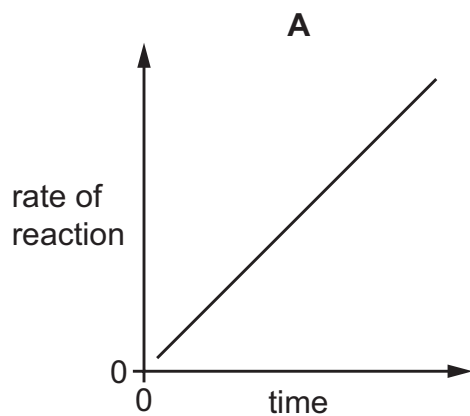
- 13** CYP3A4 is an important enzyme in the human digestive system where it is needed to break down a range of different toxins. The activity of CYP3A4 has been shown to be reduced by substances called furanocoumarins. Furanocoumarins are found in some fruits and so dangerous concentrations of toxins 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.

- 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?



134. Question | 9700 May-June 2023 P1 V3 Q14

- 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.

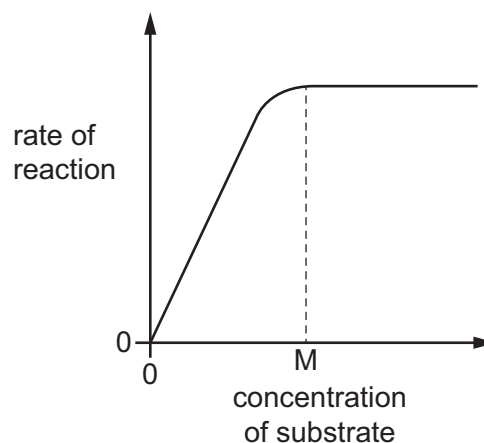
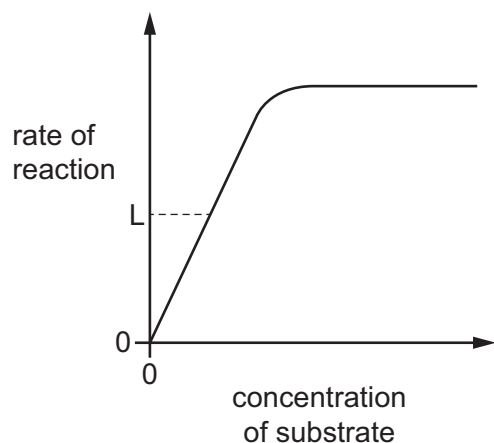
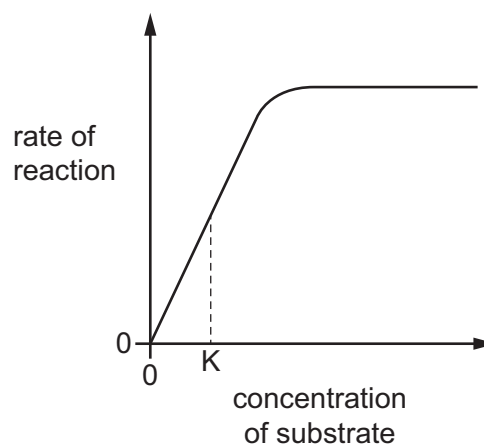
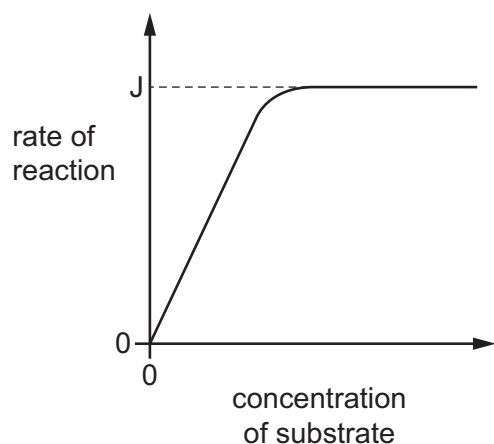
What could explain why this modified protein was not broken down by the protein-digesting enzymes?

- 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

- 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 .

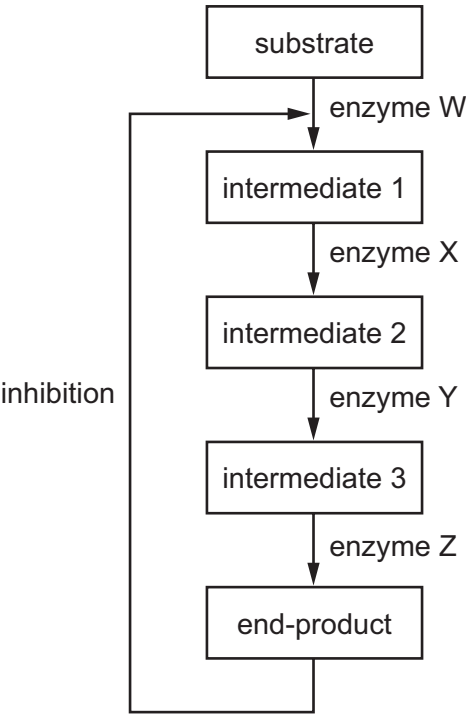


Which two readings must the student use to determine the value of K_m ?

- A** J and K **B** J and M **C** K and L **D** L and M

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.

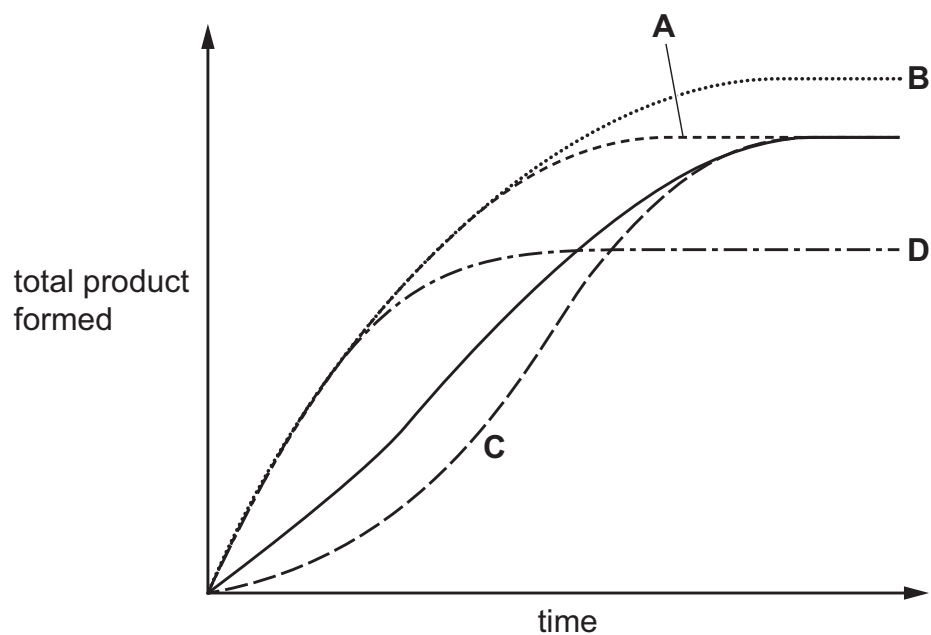


What would be the effect if enzyme Z was inhibited by the end-product instead of enzyme W?

	quantity of intermediate 1	quantity of end-product
A	increase	decrease
B	increase	unchanged
C	decrease	decrease
D	decrease	unchanged

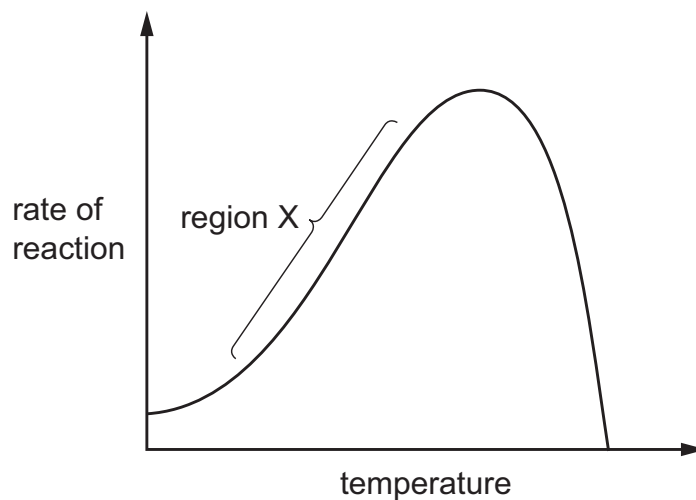
13 The solid line on the graph represents the product formed over time for a reaction in a cell.

Which other line represents the effect of adding the enzyme for this reaction?



138. Question | 9700 Oct-Nov 2023 P1 V1 Q14

- 14** The graph shows how the rate of an enzyme-controlled reaction is affected by the change in temperature. All other variables were standardised.



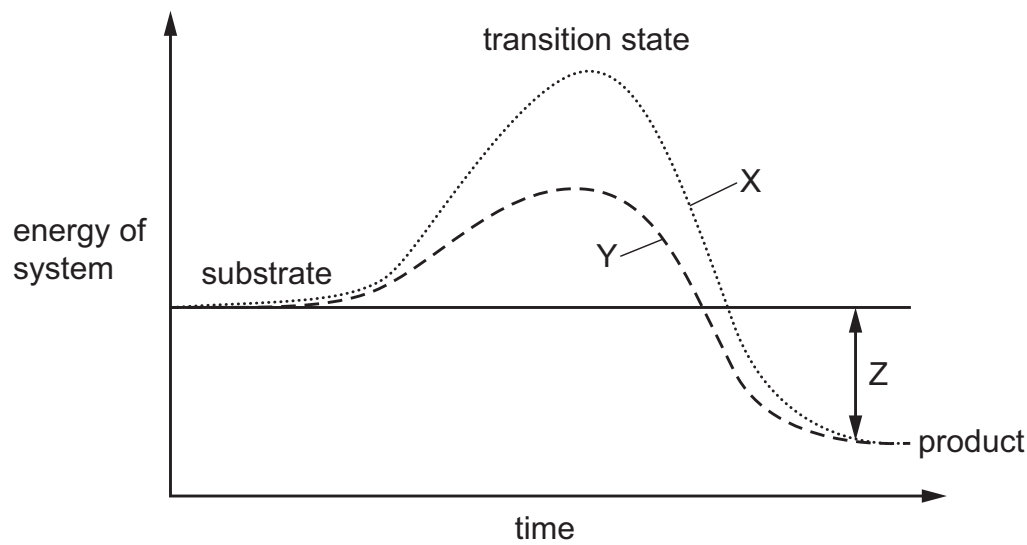
What is the factor limiting the rate in region X?

- A** substrate concentration
- B** enzyme concentration
- C** temperature
- D** number of empty active sites

139. Question | 9700 Oct-Nov 2023 P1 V1 Q15

- 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.

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



Which row identifies X, Y and Z?

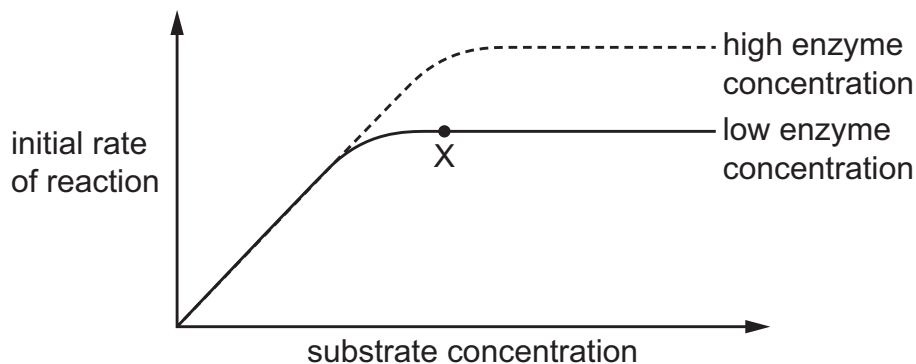
	X	Y	Z
A	catalysed reaction	uncatalysed reaction	energy lost by product
B	catalysed reaction	uncatalysed reaction	overall energy lost during reaction
C	uncatalysed reaction	catalysed reaction	energy gained by product
D	uncatalysed reaction	catalysed reaction	overall energy released during reaction

141. Question | 9700 Oct-Nov 2023 P1 V2 Q13

- 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

142. Question | 9700 Oct-Nov 2023 P1 V2 Q14

- 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

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

- 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.

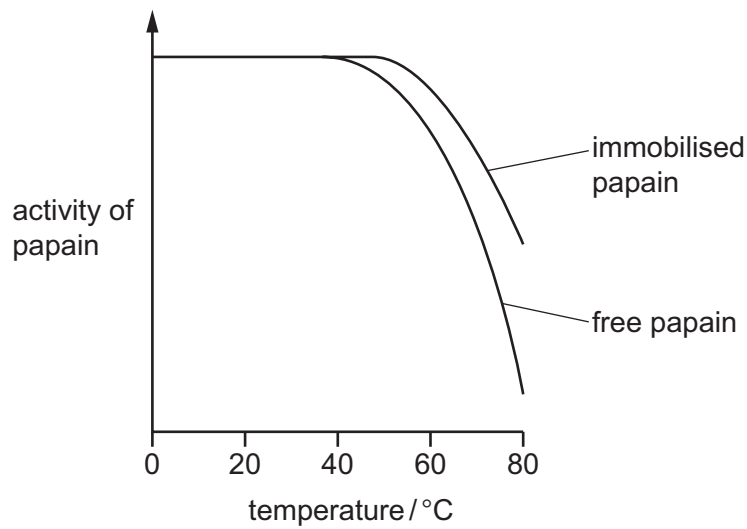
Which statements about the induced fit hypothesis of enzyme action are correct?

- 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

145. Question | 9700 Oct-Nov 2023 P1 V3 Q16

- 16** 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?

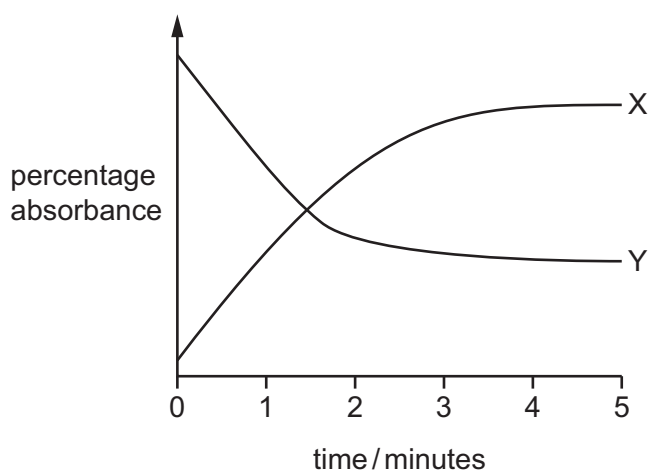
- A** It alters the shape of papain's active site at higher temperatures.
- B** It decreases the activity of papain at higher temperatures.
- C** It increases the stability of papain at higher temperatures.
- D** It reduces the number of collisions of papain with the substrate.

- 13** A scientist investigated the progress of two enzyme-catalysed reactions in separate test-tubes, X and Y. Both reactions result in colour changes that can be detected using colorimetry.

0.5 cm³ samples were taken from each test-tube at the start of the investigation and at regular intervals for the next 5 minutes. Copper ions were added to each sample as soon as the sample was collected to inactivate the enzymes and stop the reactions from progressing further.

The absorbance of each sample was measured using a colorimeter.

The graph shows the results of this investigation.



Which statement is consistent with the results shown in the graph?

- A** The substrate in test-tube X has a higher absorbance than the product.
- B** The product in test-tube Y has a lower absorbance than the substrate.
- C** The rate of the reaction in test-tube X increased with time.
- D** The rate of the reaction in test-tube Y increased with time.

147. Question | 9700 Feb-March 2024 P1 V2 Q14

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

- 1 cm³ of enzyme solution was added to 10 cm³ 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.

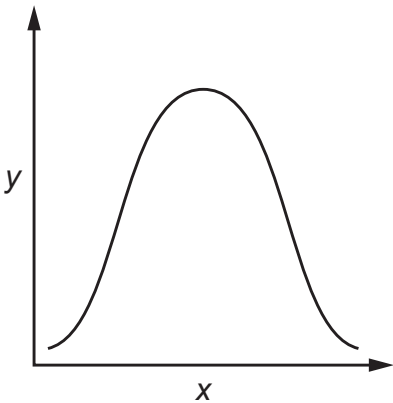
Which statements correctly describe the expected results of this investigation?

- 1 The product forms more slowly as time proceeds because the concentration of the substrate is decreasing.
- 2 The pH of the reaction mixture increases rapidly in the first few minutes and then increases less rapidly.
- 3 The increase in the concentration of product eventually causes the lipase molecules to denature.

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

148. Question | 9700 May-June 2024 P1 V1 Q11

11 The graph shows the trend from an enzyme-catalysed reaction.



Which labels are correct for the x-axis and y-axis?

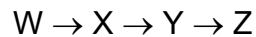
	x-axis	y-axis
A	rate of reaction	substrate concentration
B	enzyme concentration	temperature
C	pH	rate of reaction
D	substrate concentration	pH

12 Which statements about the Michaelis–Menten constant (K_m) are correct?

- 1 The higher the K_m , the higher the enzyme affinity for the substrate.
- 2 K_m is a measure of the degree of enzyme affinity for the substrate.
- 3 K_m is defined as the substrate concentration at which the enzyme functions at half its maximum rate.

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

14 The diagram shows a simple metabolic pathway.



The letters W, X, Y and Z represent four different substances. At each step in the diagram the substrate undergoes a chemical reaction catalysed by an enzyme. The reaction produces the next substance in the pathway.

Which statements correctly describe the enzymes taking part in this metabolic pathway?

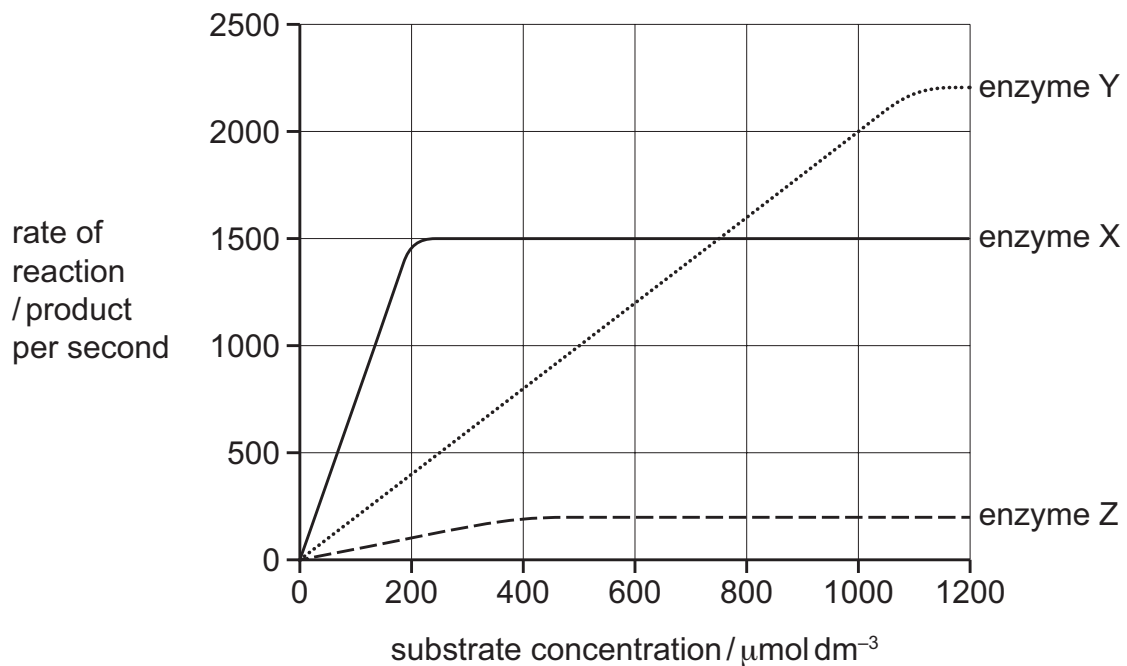
- 1 They are all globular proteins.
- 2 They all have the same tertiary structure.
- 3 They all contain hydrogen atoms in their structure.

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

10 Which row describes the expected effect on V_{max} and K_{m} when a competitive reversible inhibitor is added to an enzyme-catalysed reaction?

	effect on V_{max}	substrate concentration at K_{m}
A	no change	increases
B	no change	no change
C	decreases	increases
D	decreases	no change

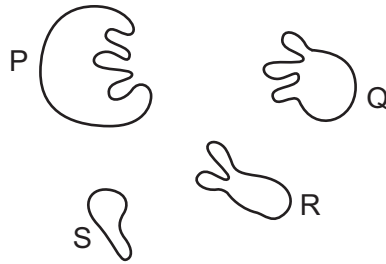
- 11** The graph shows the effect of substrate concentration on the rates of reaction of three enzymes, X, Y, and Z.



What is the correct order of affinity of these enzymes for their substrates, starting with the enzyme with the highest affinity?

- A** $X \rightarrow Y \rightarrow Z$ **B** $X \rightarrow Z \rightarrow Y$ **C** $Y \rightarrow X \rightarrow Z$ **D** $Z \rightarrow X \rightarrow Y$

10 The diagram shows different molecules in a solution.

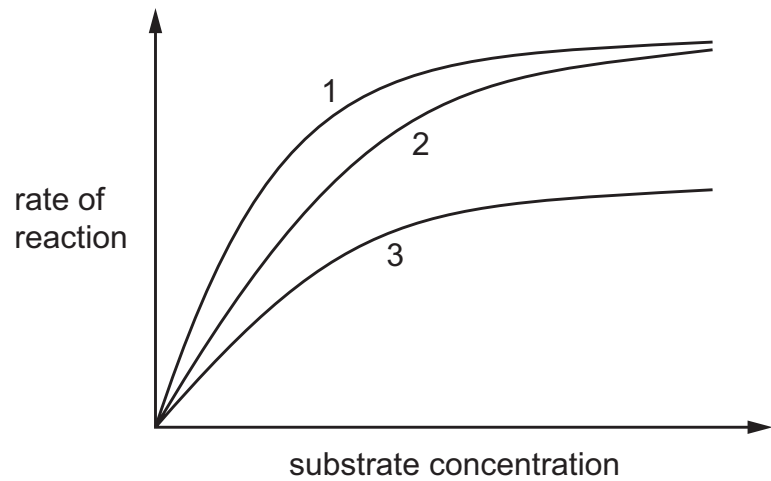


Which statement could explain what happens when some of the molecules are mixed together?

- A** Molecule P forms an enzyme–substrate complex with the non-competitive inhibitor molecule Q.
- B** Molecule Q binds to molecule P, increasing the activation energy.
- C** Molecules R and S bind to the active site of molecule P.
- D** Molecules S and R are the products of the breakdown of molecule P.

- 11 The effect of substrate concentration on an enzyme-catalysed reaction was measured in three different conditions:
- without an inhibitor
 - with a competitive inhibitor
 - with a non-competitive inhibitor.

The graph shows the results.



Which row is correct?

	without an inhibitor	with a competitive inhibitor	with a non-competitive inhibitor
A	1	2	3
B	1	3	2
C	3	1	2
D	3	2	1

155. Question | 9700 May-June 2024 P1 V3 Q12

- 12** Which aspect of enzyme activity can be compared by the Michaelis–Menten constant?
- A** activation energy of a reaction with or without an enzyme
 - B** affinity of different enzymes for their substrates
 - C** affinity of an enzyme at different substrate concentrations
 - D** maximum rate of reaction (V_{max}) at different temperatures

156. Question | 9700 May-June 2024 P1 V3 Q13

- 13** The number of substrate molecules one enzyme molecule can convert to product in a second is called the turnover number. This number is obtained when all conditions are optimum for the specific enzyme-catalysed reaction.

enzyme	turnover number /s ⁻¹
catalase	2 800 000
carbonic anhydrase	600 000
phosphatase	971
protease	100

How many times faster at converting substrate to product is catalase compared to phosphatase?

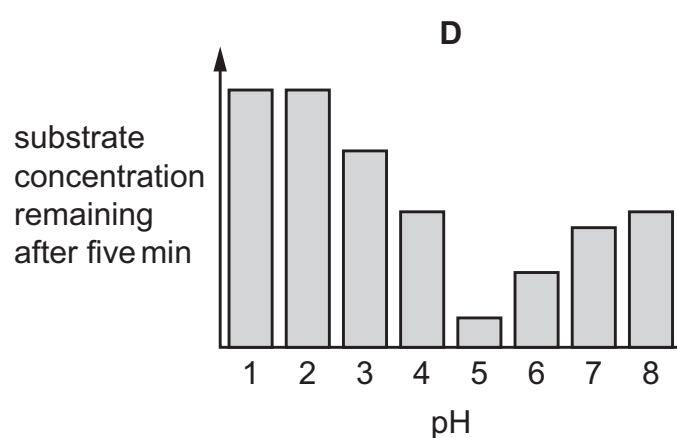
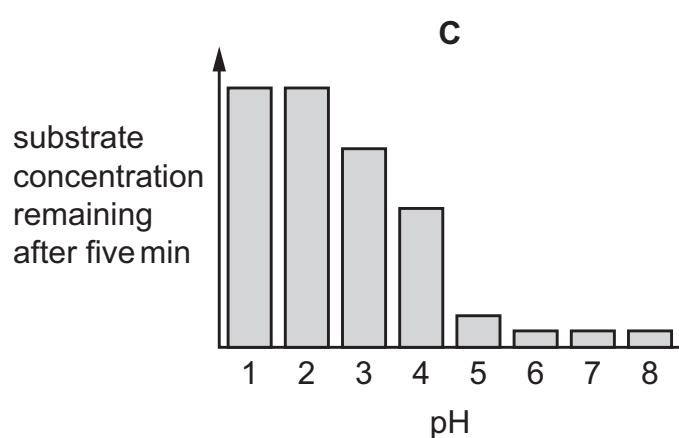
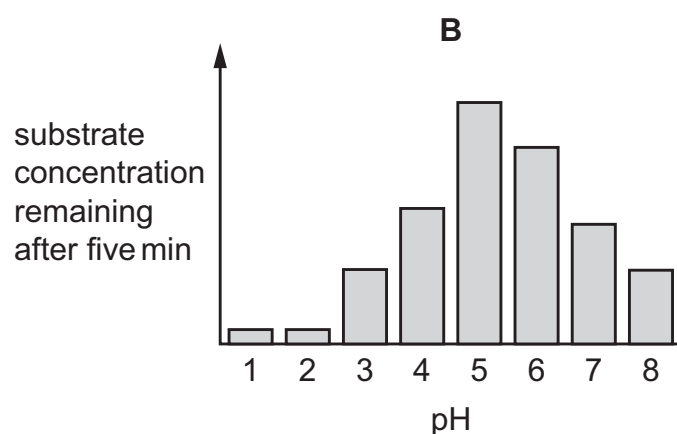
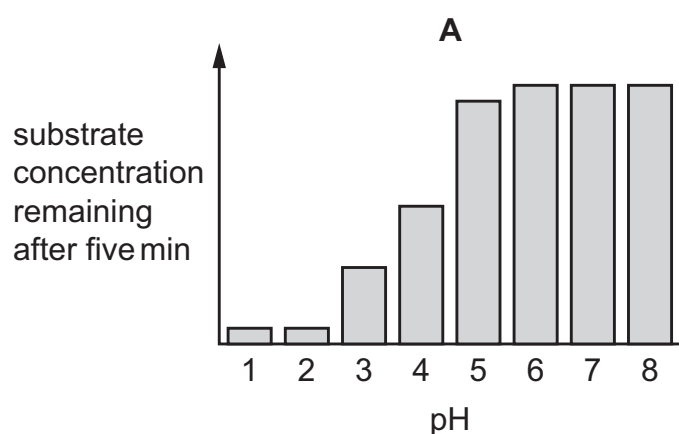
- A** 29 **B** 288 **C** 2884 **D** 28 836

- 12** A student carried out investigations at pH 1–8 to look at the effect of pH on an enzyme-catalysed reaction.

The optimum condition for this enzyme is the acidic environment of the stomach at pH 1–2.

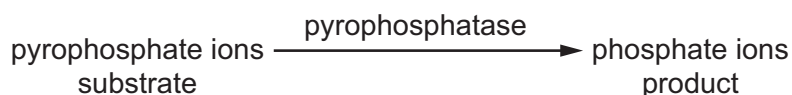
The remaining substrate concentration was measured after five minutes at each different pH.

Which graph shows the effect of increasing pH on substrate concentration remaining after five minutes?



- 13** Which statement is correct for a non-competitive inhibitor?
- A** The inhibitor binds to the active site of the enzyme and decreases $V_{\max}$.
 - B** The inhibitor binds away from the active site and increases the Michaelis–Menten constant.
 - C** The inhibitor decreases $V_{\max}$, but the Michaelis–Menten constant does **not** change.
 - D** The inhibitor does **not** change $V_{\max}$ but increases the Michaelis–Menten constant.

14 Pyrophosphatase enzymes catalyse a hydrolysis reaction.

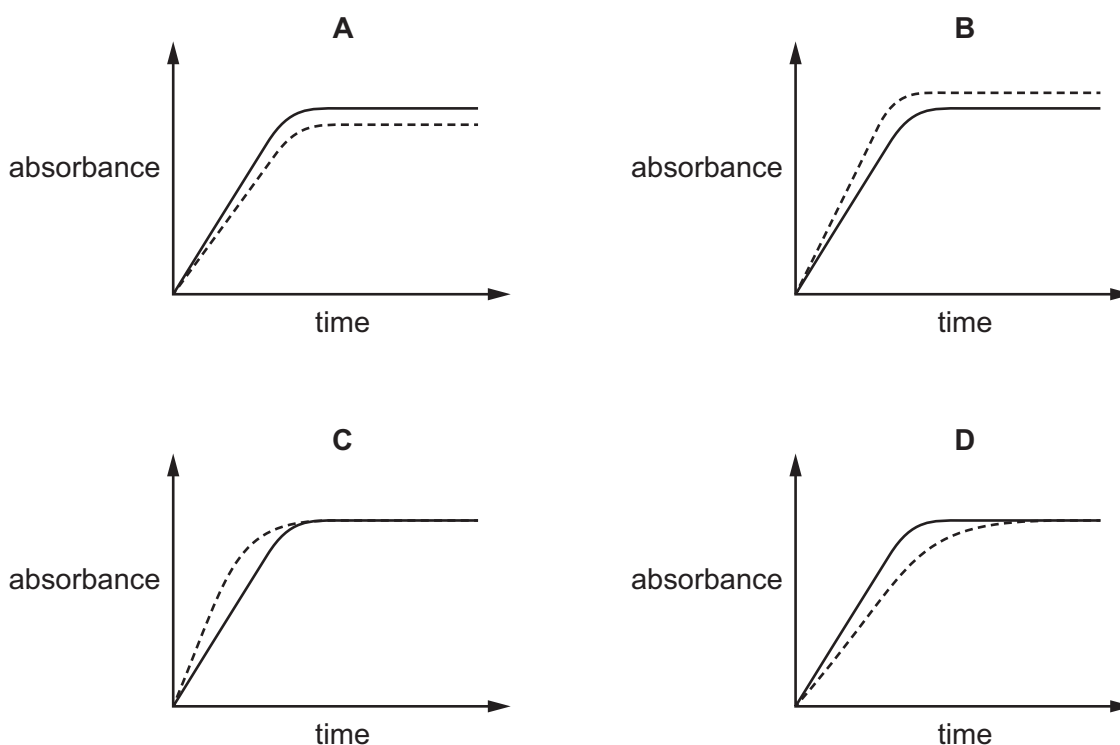


In experiment 1, a scientist studied the rate of this reaction, using a colorimeter.

The absorbance of the solution was measured at regular intervals until all of the pyrophosphate ions had been converted into phosphate ions.

In experiment 2, the scientist repeated the procedure with a higher concentration of pyrophosphatase. All other variables were standardised.

Which graph shows the effect of increasing the concentration of pyrophosphatase?



key
—— = experiment 1
----- = experiment 2

15 Proteases are a group of enzymes that digest proteins.

Which statements about proteases are correct?

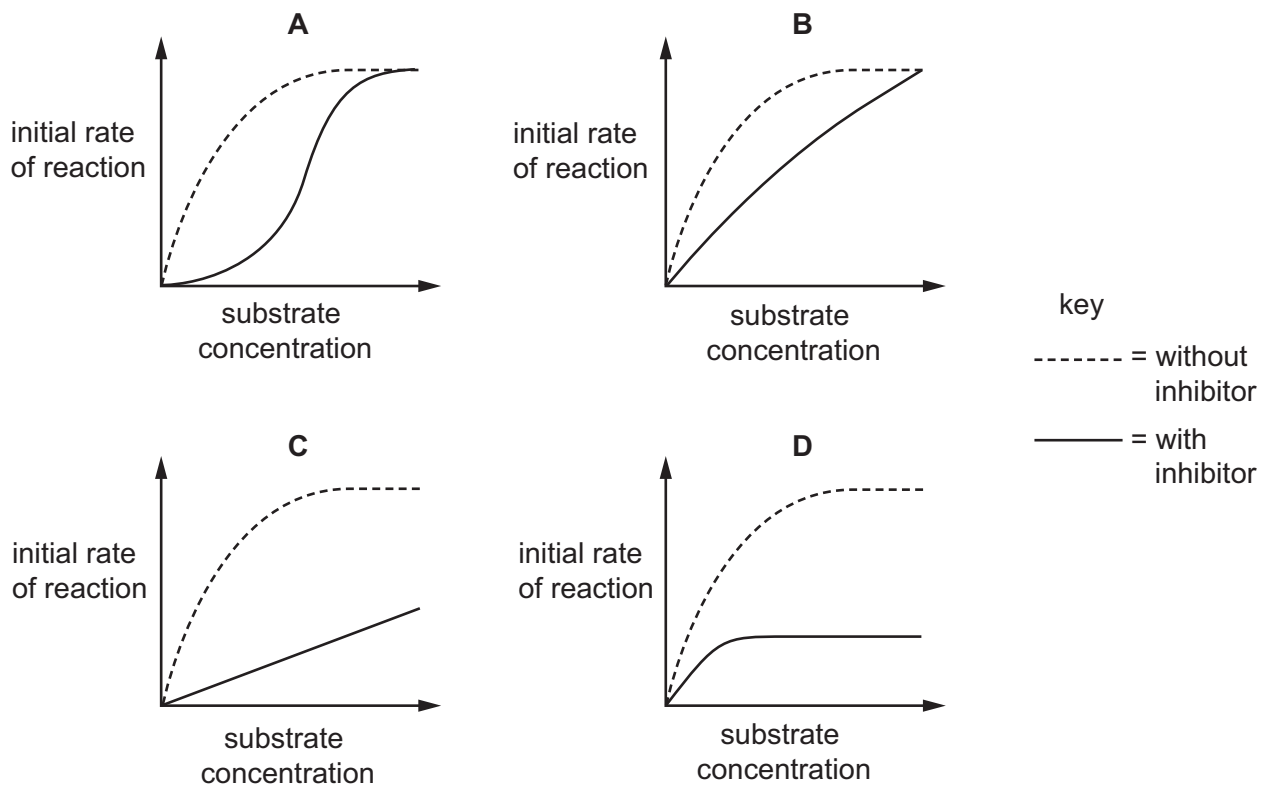
- 1 A bacterial protease that is secreted from a disease-causing bacterium could act as an antibody and cause the production of antigens against it.
- 2 Non-competitive inhibition of a protease that has an optimum condition of pH 2 can be overcome by increasing the substrate concentration and increasing the pH.
- 3 Water molecules are required when peptide bonds that link the monomers together are broken by the action of proteases in hydrolysis reactions.

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

161. Question | 9700 Oct-Nov 2024 P1 V2 Q12

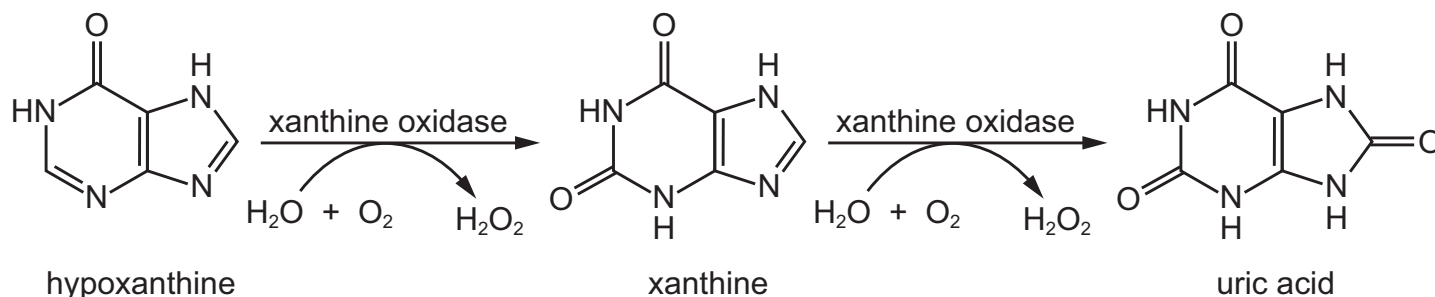
- 12** The initial rate of a reaction catalysed by an enzyme was measured at various substrate concentrations.

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

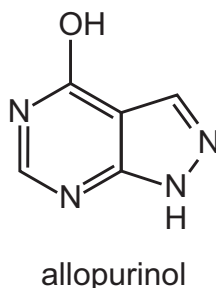


- 13** Gout is a type of arthritis in which small uric acid crystals form inside and around the joints. It causes sudden attacks of severe pain and swelling.

The diagram shows how uric acid is formed from hypoxanthine catalysed by the enzyme xanthine oxidase.



Gout can be treated using a drug called allopurinol which has a similar shape to hypoxanthine.



What can be concluded from this information about how allopurinol prevents the formation of uric acid?

- A** It binds to the active site of xanthine oxidase instead of hypoxanthine, resulting in reduced production of uric acid.
- B** It binds to another part of xanthine oxidase and this changes the shape of the active site.
- C** It disrupts the hydrogen bonds within xanthine oxidase so it denatures and the active site is no longer complementary to hypoxanthine and xanthine.
- D** It hydrolyses the peptide bonds within xanthine oxidase to change the shape of the active site.

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

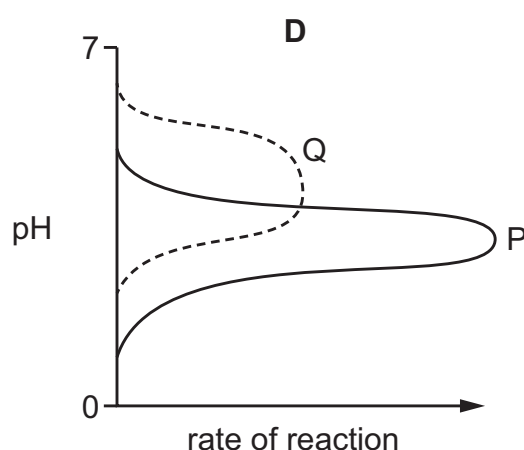
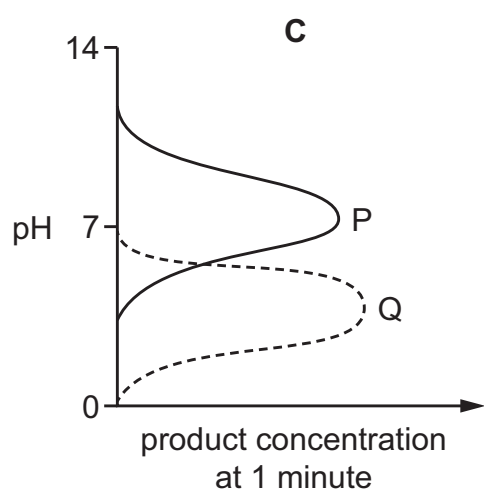
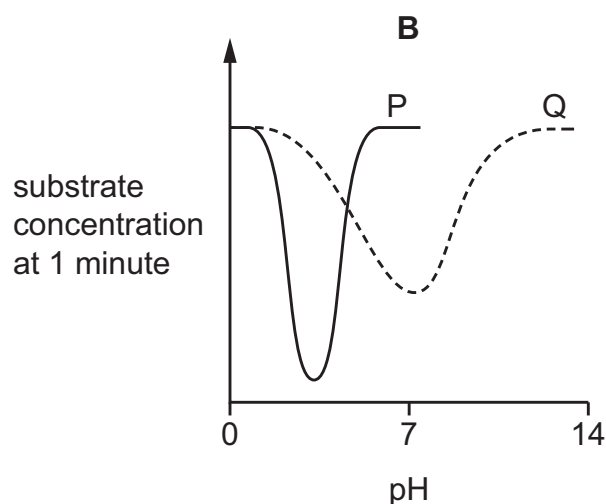
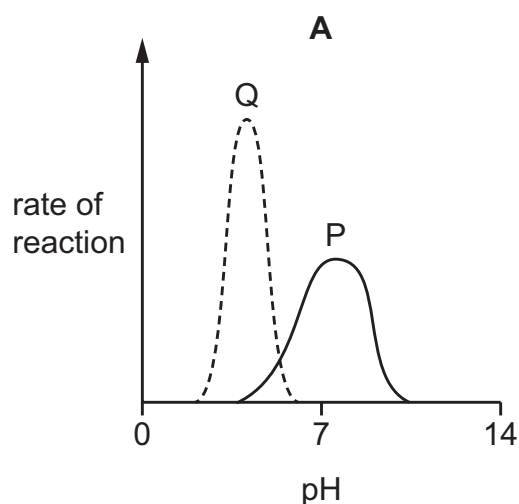
Two identical chains of 99 amino acids form the enzyme. In each chain, amino acids 25, 26 and 27 in the sequence form part of the active site.

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

- A** primary, secondary, tertiary and quaternary
- B** primary, secondary and tertiary only
- C** primary and quaternary only
- D** quaternary only

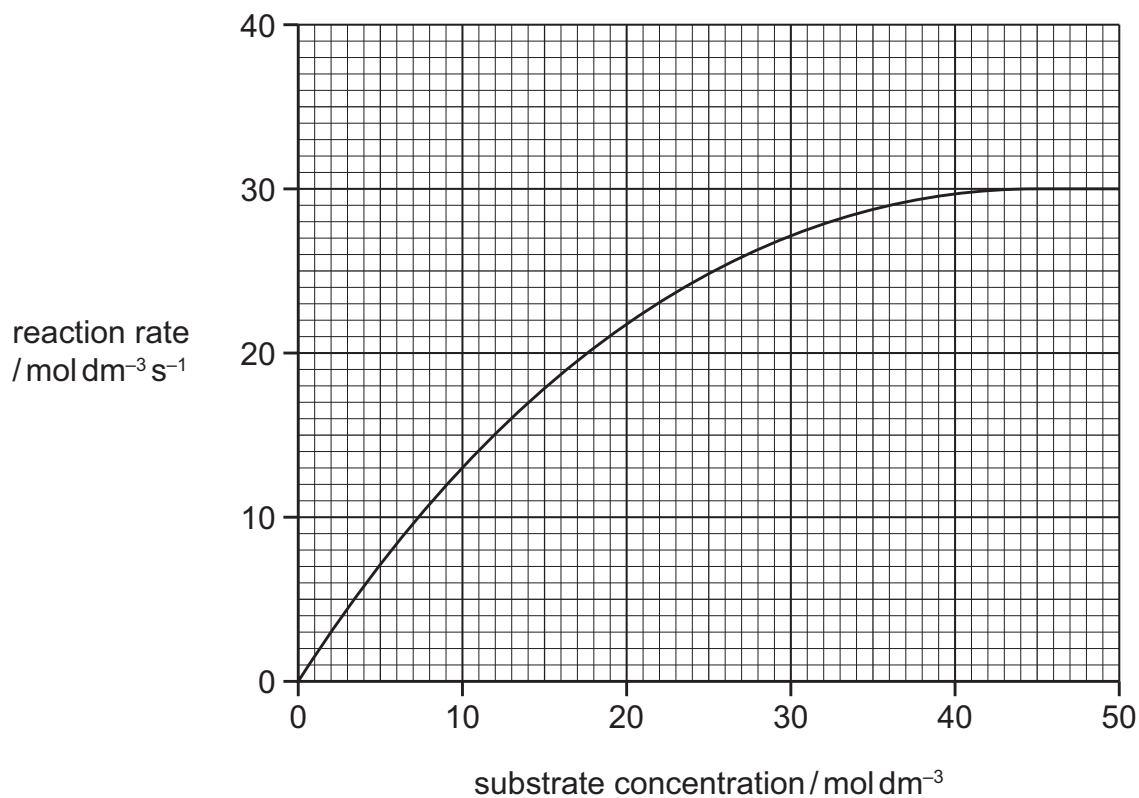
- 10** Two different enzymes, P and Q, are investigated to find the optimum pH for each enzyme. The results show that P works only in acidic conditions. Q has an optimum pH which is slightly alkaline.

Which graph shows the correct results for P and Q?



- 11** A student investigated the effect of substrate concentration on the rate of an enzyme-catalysed reaction.

The student plotted the results in a graph.



What is the K_m for this enzyme-catalysed reaction?

- A** 12 mol dm⁻³
- B** 15 mol dm⁻³ s⁻¹
- C** 30 mol dm⁻³ s⁻¹
- D** 50 mol dm⁻³

166. Question | 9700 Oct-Nov 2024 P1 V3 Q12

12 Which statements could be used to describe enzyme molecules **and** antibody molecules?

- 1 Hydrogen bonds stabilise the structure of the protein and are important for it to function efficiently.
- 2 Hydrophilic R-groups point in to the centre of the molecule and cause it to curl into a spherical shape.
- 3 The tertiary structure of the protein molecule plays an important role in the functioning of the protein.

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

167. Question | 9700 Oct-Nov 2024 P1 V3 Q13

13 Which description identifies a reversible, non-competitive enzyme inhibitor?

- A** It can attach to the active site.
- B** It can attach to a site other than the active site.
- C** It can attach to the active site and another site simultaneously.
- D** It can attach to either the active site or another site.

13 Which levels of protein structure are **always** involved in forming the active site of an enzyme?

	level of protein structure		
	primary	tertiary	quaternary
A	✓	✓	✓
B	✓	✓	✗
C	✗	✓	✓
D	✗	✗	✓

key
✓ = always involved
✗ = **not** always involved

- 14** Catalase is an enzyme that breaks down hydrogen peroxide into water and oxygen.

Catalase was added to a solution of hydrogen peroxide and the oxygen produced was collected in a gas syringe.

The total volume of oxygen produced from the start of the reaction was recorded every 10 seconds for 1 minute.

The results are shown in the table.

time / s	total volume of oxygen produced / cm ³
0	0
10	22
20	40
30	50
40	55
50	57
60	58

What can be concluded from these results?

- A** The reaction stopped after 60 seconds and no more oxygen was produced.
- B** The highest rate of oxygen production occurred 10 seconds after the start of the reaction.
- C** It took more than 20 seconds from the start of the reaction for half of the substrate to be converted to water and oxygen.
- D** The mean rate of reaction between 20 and 30 seconds was twice the mean rate of reaction between 30 and 40 seconds.

170. Question | 9700 Feb-March 2025 P1 V2 Q15

- 15** Succinic dehydrogenase is an enzyme that catalyses the conversion of succinate to fumarate in aerobic respiration.

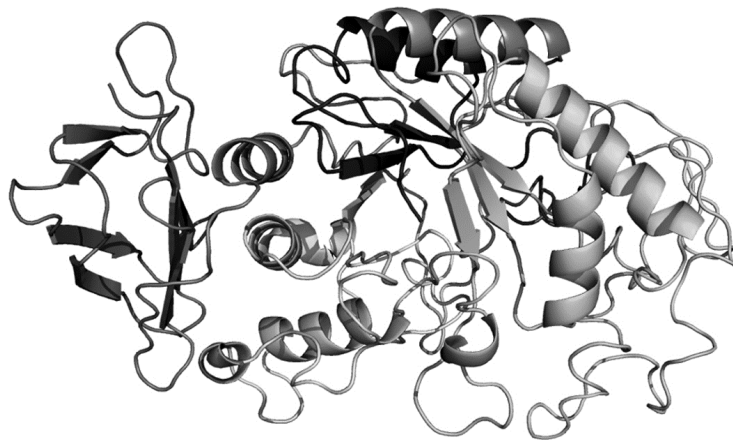
Malonate is a reversible inhibitor of succinic dehydrogenase. Malonate reduces the enzyme's activity by binding to its active site. Malonate and succinate **cannot** bind to the active site at the same time.

Which statement describes the effect of malonate on the activity of succinic dehydrogenase?

- A** In the presence of malonate, $V_{\max}$ can still be reached if the concentration of succinate is increased.
- B** Malonate has no effect on the K_m .
- C** In the presence of malonate, $V_{\max}$ can still be reached if the concentration of fumarate is increased.
- D** Malonate decreases the K_m .

171. Question | 9700 May-June 2025 P1 V1 Q13

- 13** The diagram shows the structure of the enzyme amylase.



Which level of protein structure results in the folding of amylase into its globular shape?

- A** primary
- B** secondary
- C** tertiary
- D** quaternary

172. Question | 9700 May-June 2025 P1 V1 Q15

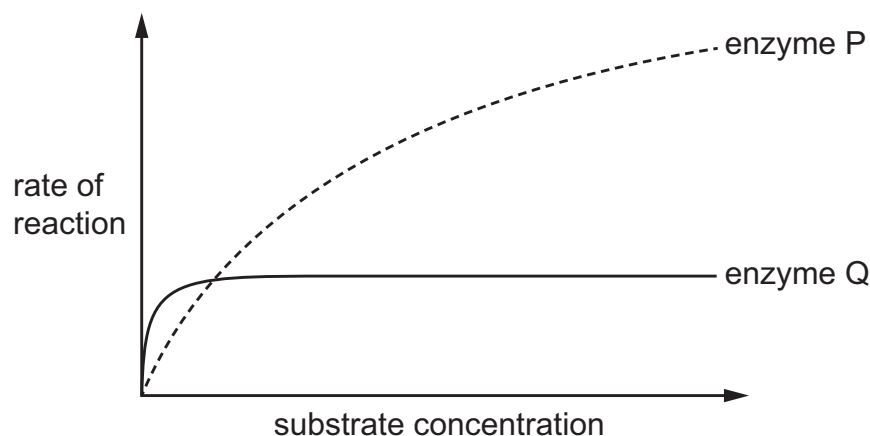
15 Which statements about the mode of action of an enzyme are correct?

- 1 Some enzymes have a region on their surface to which the substrate has a complementary shape.
- 2 Some enzymes and their substrates can change shape slightly as the substrate enters the active site.
- 3 Enzymes permanently change shape when they react with their substrates to form an enzyme–substrate complex.

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

173. Question | 9700 May-June 2025 P1 V1 Q16

16 The graph shows the effect of increasing substrate concentration on the rate of reaction of two enzymes that catalyse reactions with the same substrate.



Which statement is correct?

- A** Enzyme Q has a higher K_m and a higher affinity for the substrate than enzyme P.
- B** Enzyme Q has a higher K_m and a lower affinity for the substrate than enzyme P.
- C** Enzyme Q has a lower K_m and a higher affinity for the substrate than enzyme P.
- D** Enzyme Q has a lower K_m and a lower affinity for the substrate than enzyme P.

174. Question | 9700 May-June 2025 P1 V2 Q12

12 Prokaryotes and eukaryotes use extracellular enzymes.

Extracellular digestive enzymes are found in the external environments of some prokaryotes.

Some prokaryotes are digested by hydrolytic enzymes during phagocytosis by eukaryotic cells.

Which row shows the locations where extracellular enzymes are produced?

	site of production of digestive enzymes used by prokaryotes	site of production of hydrolytic enzymes used by eukaryotic phagocytes
A	inside cells	inside cells
B	inside cells	outside cells
C	outside cells	inside cells
D	outside cells	outside cells

175. Question | 9700 May-June 2025 P1 V2 Q13

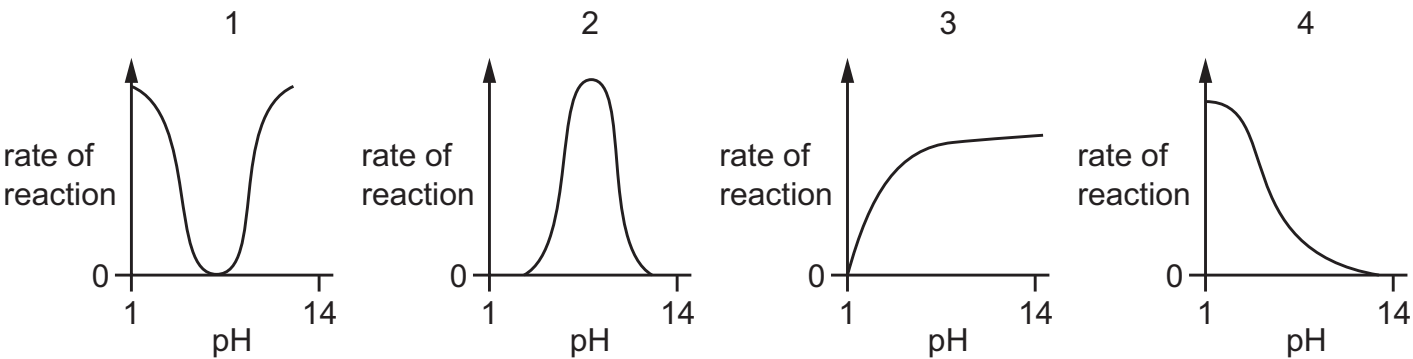
13 Amylase breaks down starch molecules.

Which substance will have the same number of molecules for the duration of this reaction?

- A** amylase
- B** water
- C** maltose
- D** amylose

176. Question | 9700 May-June 2025 P1 V2 Q14

14 Which graphs could show the effect of pH on the rate of enzyme-catalysed reactions?



- A 1 and 2 B 1 and 3 C 2 and 4 D 3 and 4

177. Question | 9700 May-June 2025 P1 V2 Q15

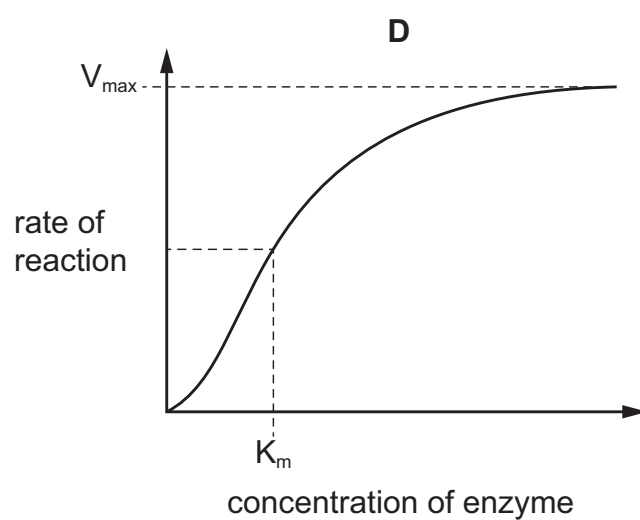
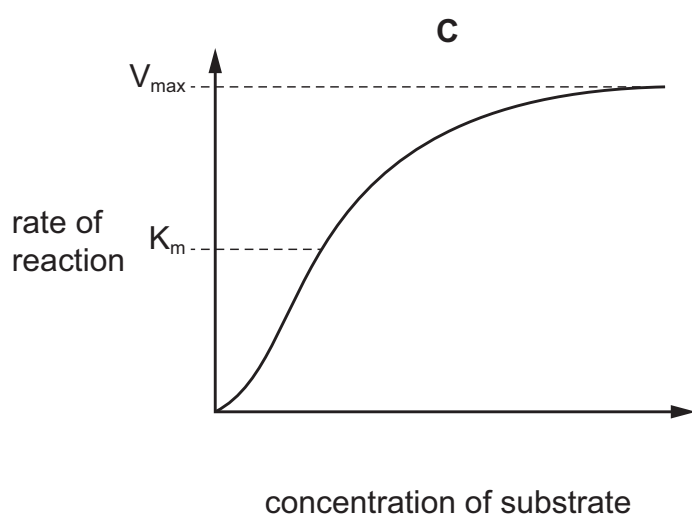
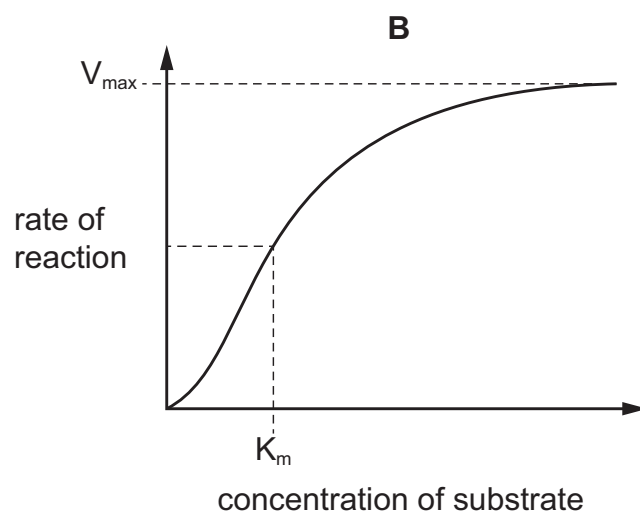
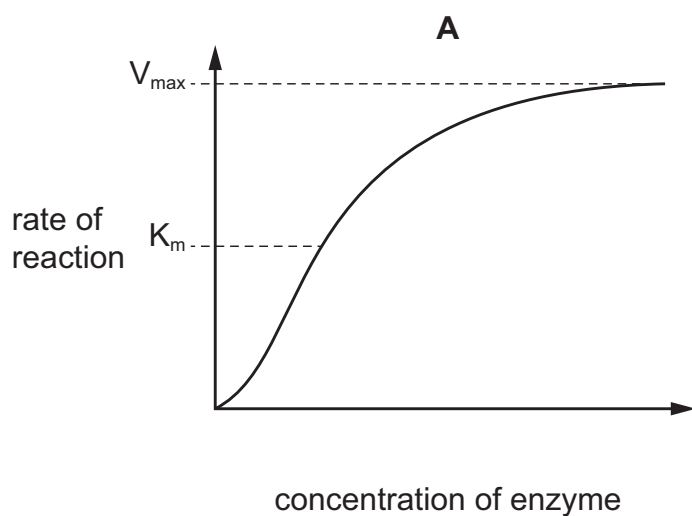
15 After a heart attack, the enzyme lactate dehydrogenase leaks into the blood plasma from damaged heart muscle.

What is required to measure the activity of lactate dehydrogenase activity in a sample of blood plasma?

	sterilisation of blood plasma by heating	incubation of sample with substrate for lactate dehydrogenase	incubation of sample with lactate dehydrogenase inhibitor
A	✓	✓	✓
B	x	✓	✓
C	x	✓	x
D	x	x	✓

key
✓ = required
x = not required

16 Which graph correctly shows K_m and V_{max} ?



179. Question | 9700 May-June 2025 P1 V3 Q15

15 Histidine and proline are two amino acids commonly found in enzymes.

Histidine has a polar R-group and proline has a non-polar R-group.

Where would most histidines and prolines be positioned?

	histidine	proline
A	inside an enzyme	on the surface of an enzyme
B	on the surface of an enzyme	on the surface of an enzyme
C	inside an enzyme	inside an enzyme
D	on the surface of an enzyme	inside an enzyme

180. Question | 9700 May-June 2025 P1 V3 Q16

16 The activity of an enzyme can be affected by a competitive inhibitor.

Which row is correct for the effect of a competitive inhibitor on the value of K_m and the reason for this?

	effect of a competitive inhibitor on the value of K_m	reason
A	increased	Few substrate molecules will bind to the active site when the substrate concentration is low because the active site is blocked by the inhibitor.
B	increased	V_{max} will increase because the substrate will only bind to the active site when the concentration of the substrate is high.
C	no effect	At high substrate concentrations, substrate molecules are still able to bind to the enzymes in the presence of a competitive inhibitor.
D	no effect	The inhibitor molecule does not bind to the active site; it binds to a site on another part of the enzyme.

8 Diastase is an enzyme that breaks down starch into maltose.

A sample of starch is treated with boiled diastase and left for 15 minutes.

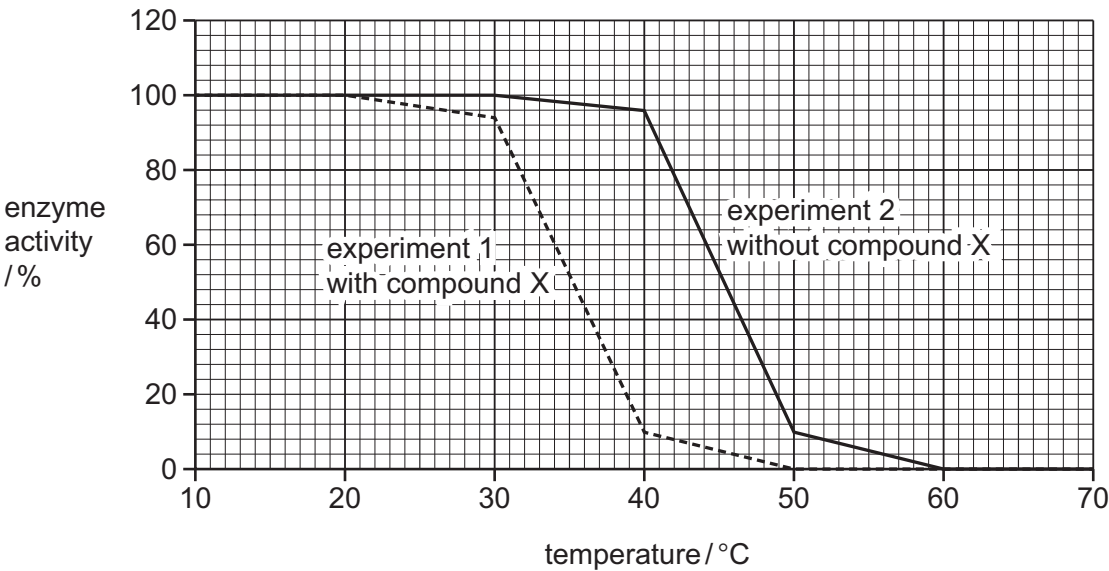
Samples of the mixture are then tested with iodine solution and with Benedict’s solution.

What is the correct result?

	iodine solution	Benedict’s solution
A	blue-black	blue
B	blue-black	red
C	brown	blue
D	brown	red

14 An investigation was carried out to see if compound X could improve the thermostability of an enzyme. Thermostable enzymes will function well at high temperatures.

The results of the investigation are shown.



Which row is correct?

	compound X makes the enzyme more thermostable	at 40 °C in experiment 1 most of the enzyme active sites will no longer be complementary to the substrate	at 45 °C in experiment 2 approximately half of the enzymes are forming enzyme–substrate complexes
A	✓	x	x
B	✓	✓	x
C	x	✓	✓
D	x	x	✓

key

✓ = correct

x = **not** correct

- 15** The table shows the results 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

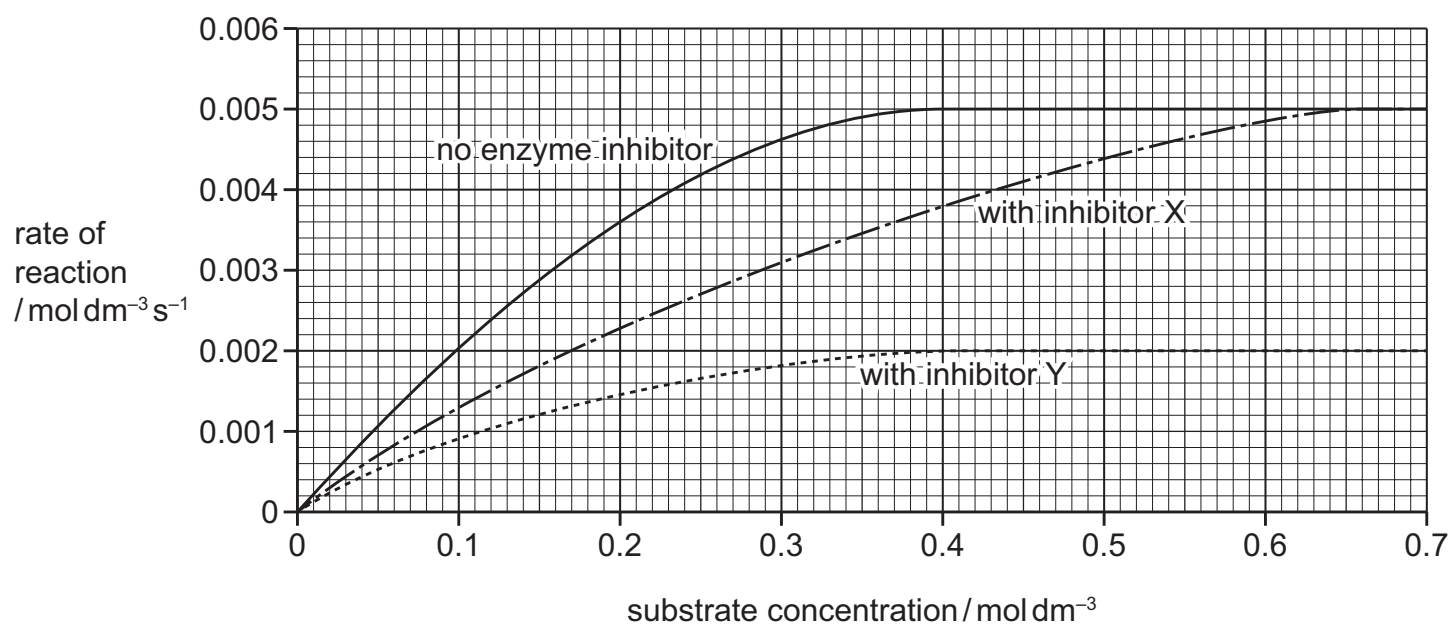
What is the correct conclusion?

- 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** All the enzymes denatured at 60 °C.

16 The graph shows how the rate of a reaction changes with substrate concentration in the presence of:

- no inhibitor
- inhibitor X
- inhibitor Y.

One of the inhibitors is competitive and the other inhibitor is non-competitive.

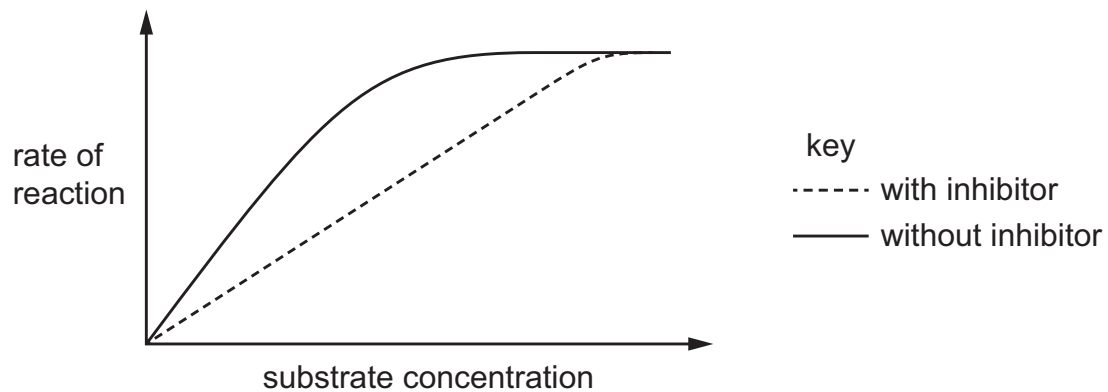


What is the correct estimate of K_m for the reaction shown when a competitive inhibitor is present?

- A** 0.11 mol dm^{-3}
- B** 0.23 mol dm^{-3}
- C** 0.38 mol dm^{-3}
- D** 0.65 mol dm^{-3}

185. Question | 9700 Oct-Nov 2025 P1 V1 Q12

- 12** The graph shows the effect of substrate concentration on an enzyme-catalysed reaction with and without a competitive inhibitor.

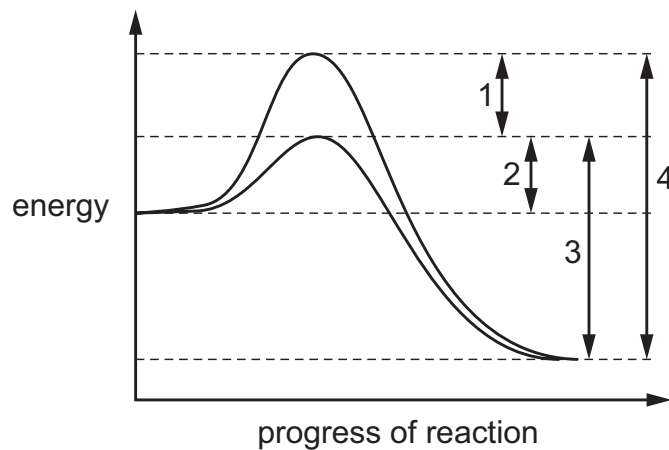


What is the effect of the competitive inhibitor on V_{max} and K_m ?

- A** V_{max} decreases and K_m decreases.
- B** V_{max} stays the same and K_m decreases.
- C** V_{max} stays the same and K_m increases.
- D** V_{max} decreases and K_m stays the same.

186. Question | 9700 Oct-Nov 2025 P1 V1 Q13

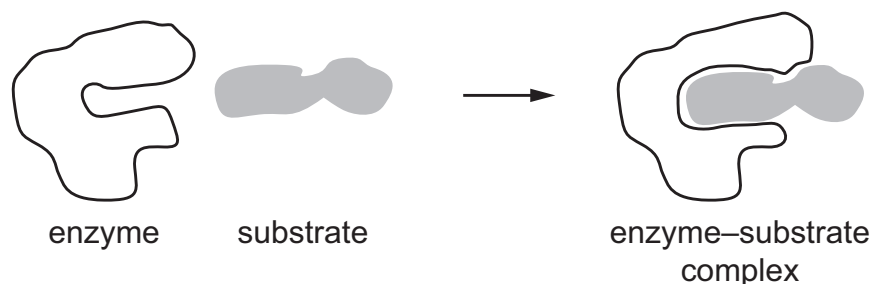
- 13** The graph shows energy changes in a chemical reaction.



What is the activation energy when an enzyme is added?

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

14 The diagram shows an enzyme, its substrate and an enzyme–substrate complex.



Which statement explains how this substrate is able to enter the active site of this 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.

9 Enzyme P has been found in a tropical grass.

- The enzyme catalyses the hydrolysis of the fungal polysaccharide, chitin, into amino sugars.
- It also inhibits the activity of an enzyme in locust guts which catalyses the digestion of amylose.

Which row describes the actions of enzyme P?

	reaction catalysed	reaction inhibited
A	hydrolysis of glycosidic bonds	condensation of glycosidic bonds
B	hydrolysis of glycosidic bonds	hydrolysis of glycosidic bonds
C	hydrolysis of peptide bonds	condensation of glycosidic bonds
D	hydrolysis of peptide bonds	hydrolysis of glycosidic bonds

189. Question | 9700 Oct-Nov 2025 P1 V2 Q11

- 11** Resilin is a protein found in the wings of insects. It is an elastic, fibrous protein and scientists have suggested that it may have an important role in allowing the wings of an insect to fold and unfold without damage.

Peptidyl transferase is an enzyme which catalyses the condensation of amino acids during translation to form resilin.

Which statements are correct?

- 1 Peptidyl transferase and resilin have structural roles in the insect.
- 2 Peptidyl transferase is a globular protein.
- 3 Peptidyl transferase is soluble in water.

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

190. Question | 9700 Oct-Nov 2025 P1 V2 Q13

- 13** 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** decreases the activation energy and increases the energy yield

- 14** How is the Michaelis–Menten constant (K_m) used?
- A** to determine the number of collisions between the enzyme and substrate
 - B** to compare the affinity of enzymes for their substrates
 - C** to find the maximum velocity of an enzyme (V_{max})
 - D** to find the optimum rate of reaction

15 Some students investigated the effect of pH on the rate of starch digestion by amylase at 20 °C.

- They added 2 cm³ of a 1% amylase solution and 1 cm³ of pH 4 buffer to a test-tube.
- They added 2 cm³ of a starch solution, containing 0.02 g of starch, to the test-tube.
- They measured the time taken for the starch to be digested (to disappear).

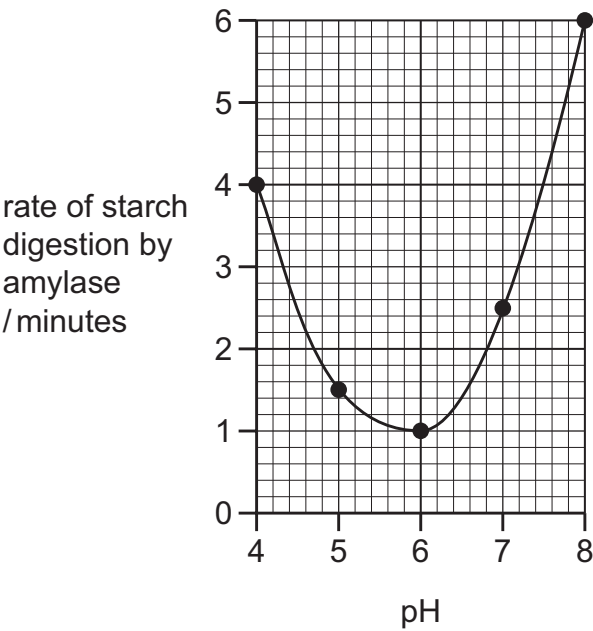
The students then repeated these steps with pH 5, pH 6, pH 7 and pH 8 buffers.

The table shows the results.

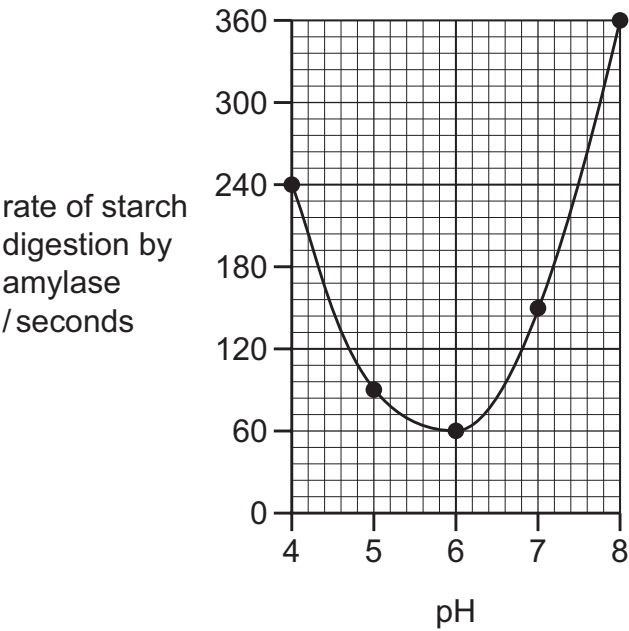
pH	time taken for starch to be digested / minutes
4	4.0
5	1.5
6	1.0
7	2.5
8	6.0

Which graph is correct for these data?

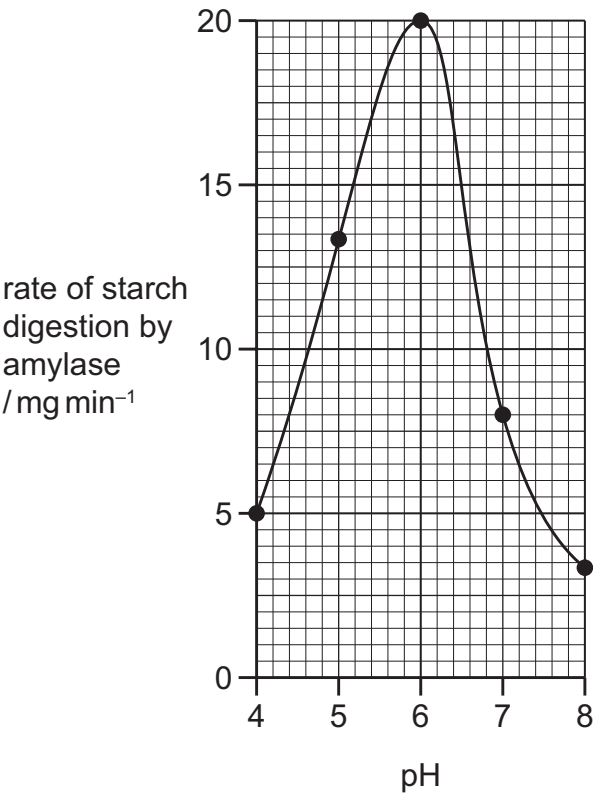
A



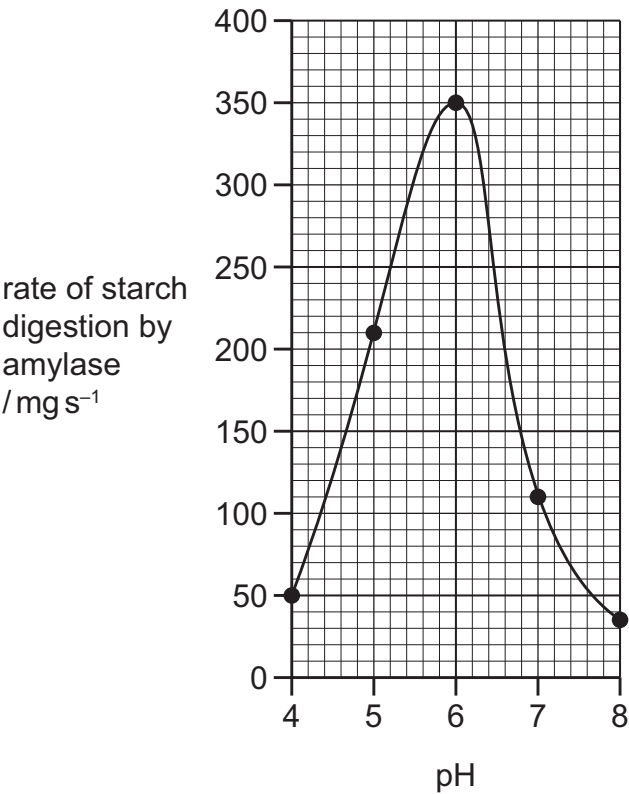
B



C



D



193. Question | 9700 Oct-Nov 2025 P1 V2 Q16

16 Which statements are correct for a non-competitive inhibitor of enzyme action?

- 1 Increasing the concentration of the enzyme's substrate will reduce its effect.
- 2 It reduces the activation energy required for a reaction to take place.
- 3 It reduces the maximum rate of reaction.

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

194. Question | 9700 Oct-Nov 2025 P1 V3 Q15

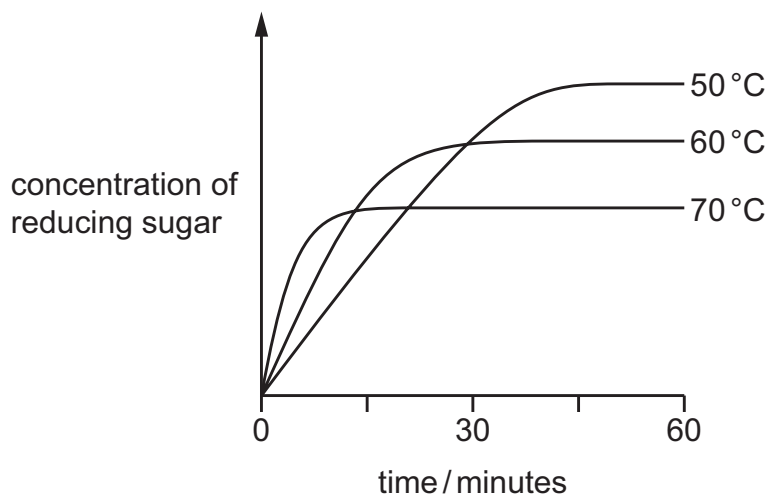
15 Which descriptions of enzymes that use the lock-and-key hypothesis are correct?

- 1 The active site is complementary to the substrate the enzyme acts on.
- 2 Bonds that form in the enzyme–substrate complex change the shape of the active site.
- 3 Most of the amino acids in an enzyme help to maintain the specific shape of the enzyme.

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

195. Question | 9700 Oct-Nov 2025 P1 V3 Q16

- 16** 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

196. Question | 9700 Oct-Nov 2025 P1 V3 Q17

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

What may be involved in this 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

11 Thermostable enzymes can maintain their tertiary structure at high temperatures.

Scientists studying the primary structure of a thermostable enzyme found that the enzyme contained:

- more charged amino acids
- fewer polar amino acids that are **not** charged
- more hydrophobic amino acids

than enzymes that are **not** thermostable.

Which row shows a correct comparison between this thermostable enzyme and an enzyme that is **not** thermostable?

	number of amino acids forming interactions at the centre of a thermostable enzyme compared to an enzyme that is not thermostable	number of ionic bonds in a thermostable enzyme compared to the number in an enzyme that is not thermostable
A	less than	more than
B	less than	less than
C	more than	less than
D	more than	more than

13 Which 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

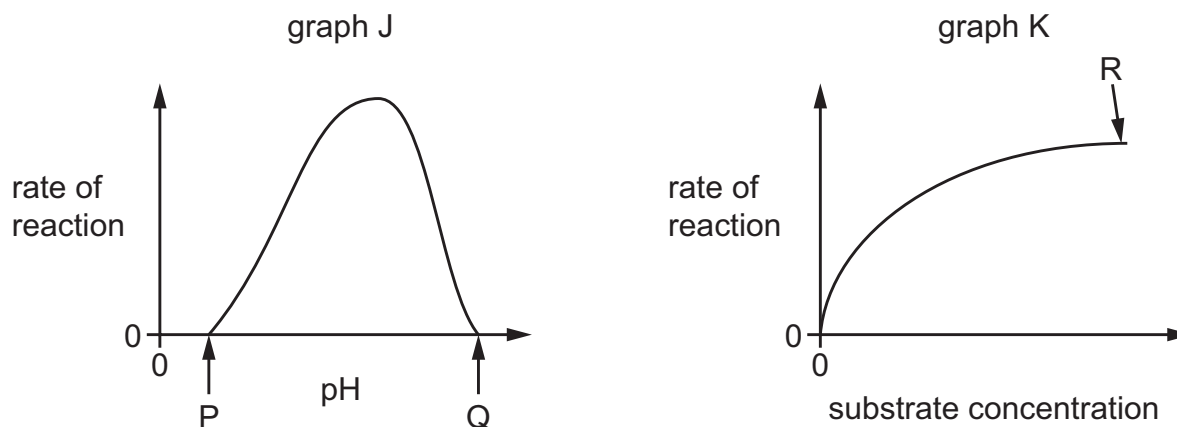
199. Question | 9700 Oct-Nov 2025 P1 V4 Q14

14 Which statement about the induced-fit hypothesis of enzyme action is correct?

- A** An enzyme that uses the induced-fit mechanism will increase the activation energy of a reaction.
- B** The binding of a substrate causes conformational changes in an enzyme.
- C** The active site of an enzyme changes to become the same shape as the substrate.
- D** An enzyme that uses an induced-fit mechanism has decreased specificity to the substrate.

200. Question | 9700 Oct-Nov 2025 P1 V4 Q15

15 Graph J shows the effect of pH on the rate of an enzyme reaction. Graph K shows the effect of substrate concentration on the rate of an enzyme reaction.



A student wrote four statements about the graphs.

- 1 In graph J, the enzyme is denatured at point Q.
- 2 In graph J, the enzyme is inactive at point P.
- 3 In graph K, the rate of reaction is directly proportional to the substrate concentration.
- 4 In graph K, $V_{\max}$ is reached at point R.

Which statements are correct?

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