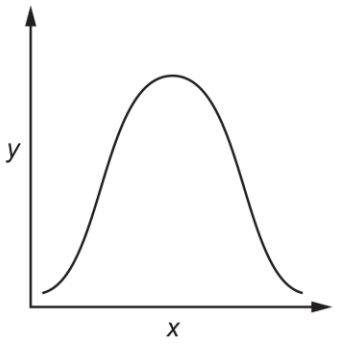
3. Enzymes

3.2 Factors that affect enzyme action

Paper 1

Question Paper

1 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

2 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.

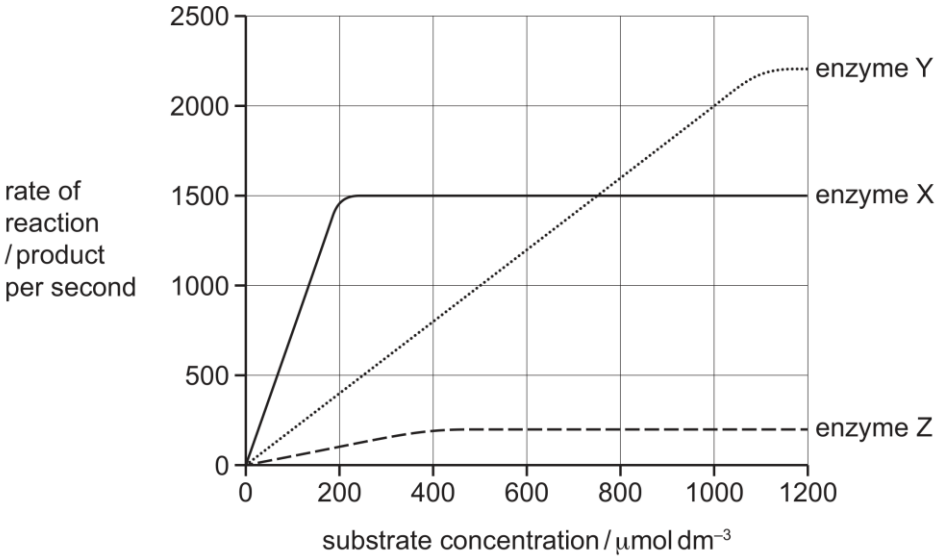
3 K_m is defined as the substrate concentration at which the enzyme functions at half its maximum rate.

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

3 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

4 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** $Z \rightarrow X \rightarrow Y$

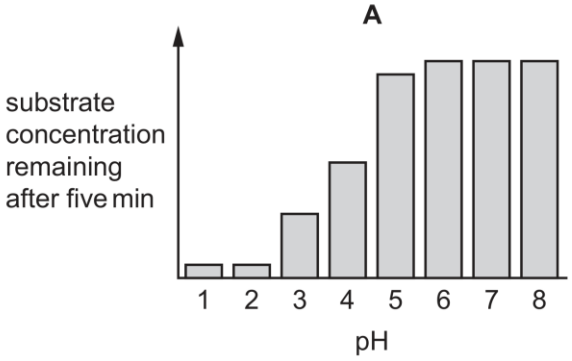
5 A student carried out investigations at pH 1–8 to look at the effect of pH on an enzyme-catalysed reaction.

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

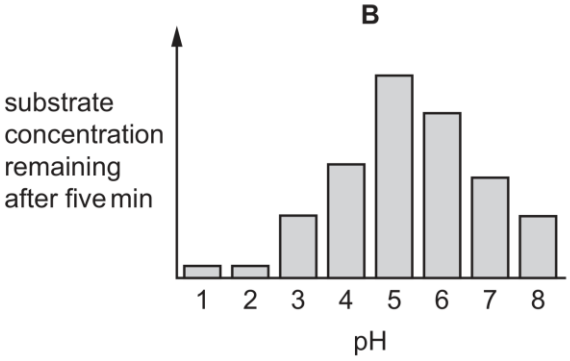
The remaining substrate concentration was measured after five minutes at each different pH.

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

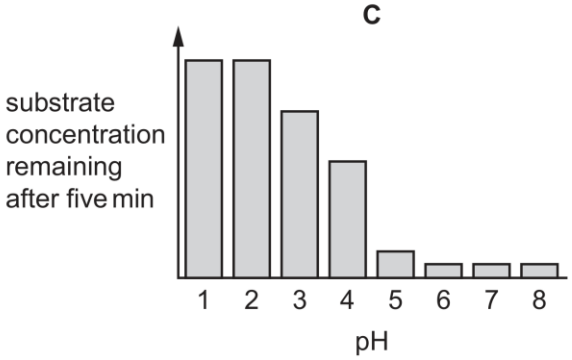
A



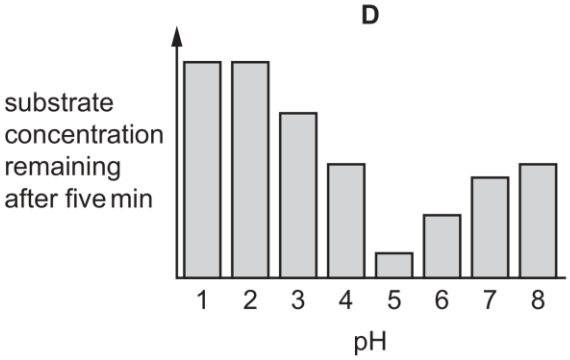
B



C



D



6 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.

7 Pyrophosphatase enzymes catalyse a hydrolysis reaction.

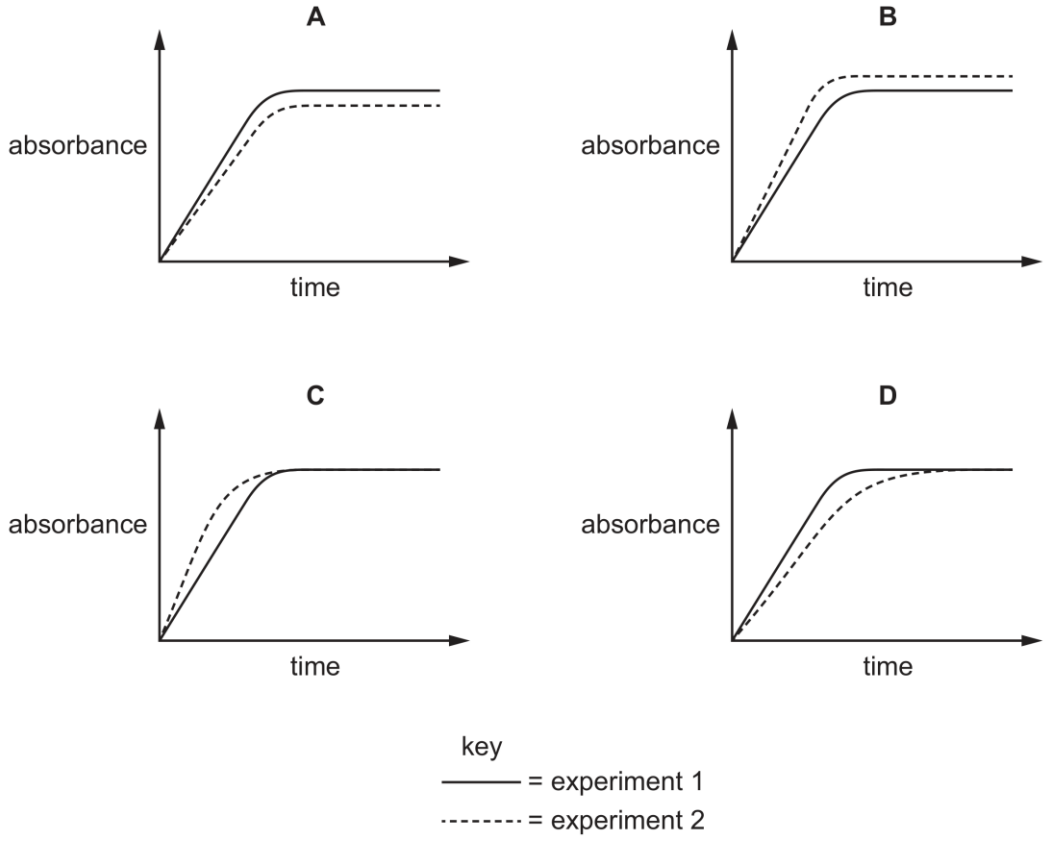
pyrophosphate ions (substrate) $\xrightarrow{\text{pyrophosphatase}}$ phosphate ions (product)

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?



8 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.

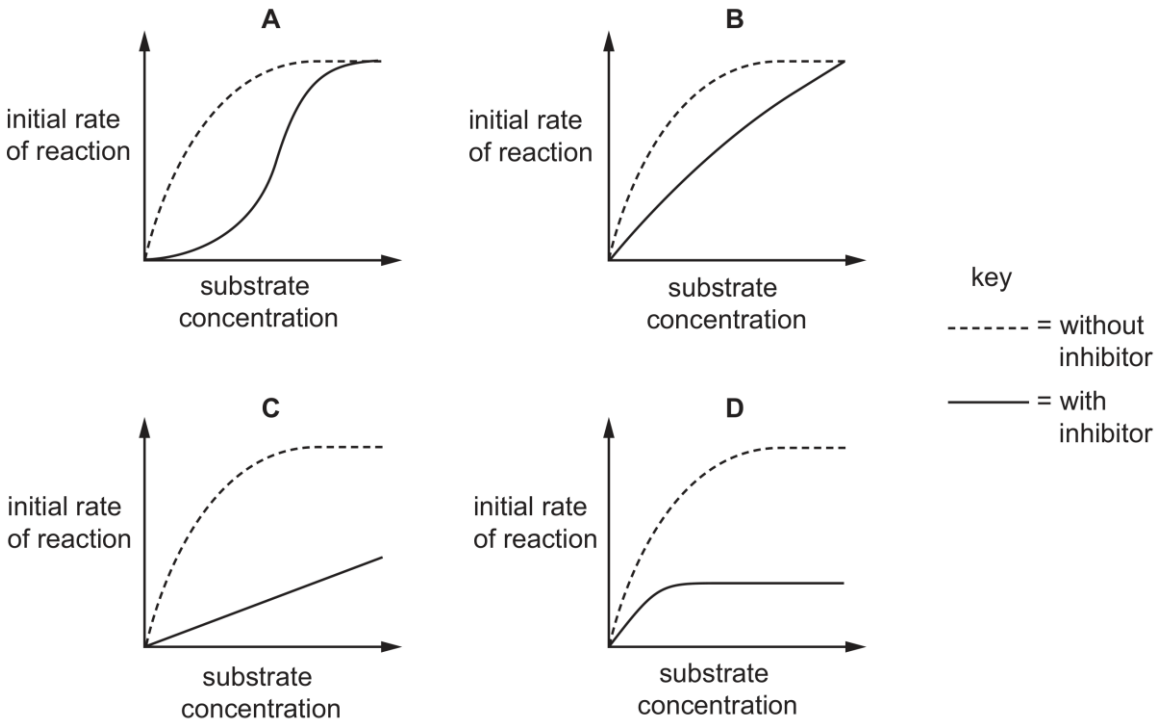
2 Non-competitive inhibition of a protease that has an optimum condition of pH 2 can be overcome by increasing the substrate concentration and increasing the pH.

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

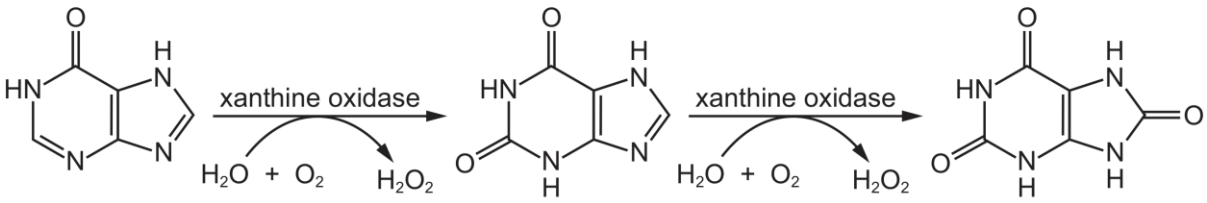
9 The initial rate of a reaction catalysed by an enzyme was measured at various substrate concentrations.

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



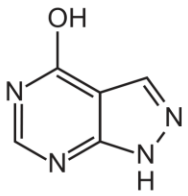
10 Gout is a type of arthritis in which small uric acid crystals form inside and around the joints. It causes sudden attacks of severe pain and swelling.

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



hypoxanthine xanthine uric acid

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



allopurinol

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

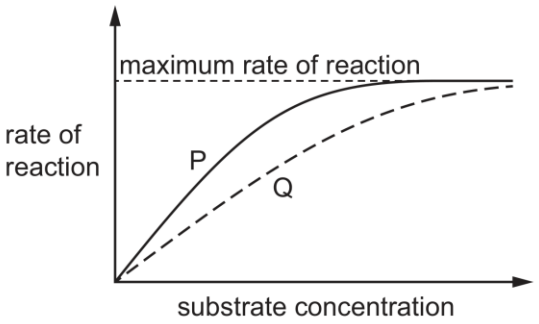
A It binds to the active site of xanthine oxidase instead of hypoxanthine, resulting in reduced production of uric acid.

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.

11 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.

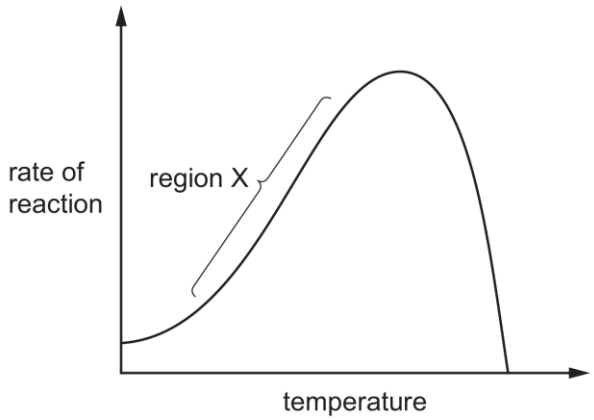
2 Add an inhibitor that has a similar shape to the substrate.

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

12 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

13 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.

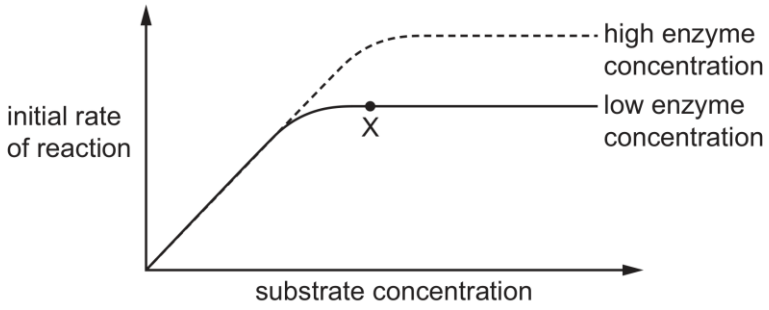
C The K_m will not change and the V_{max} will increase.

D The K_m will not change and the V_{max} will not change.

14 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

15 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

16 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

17 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.

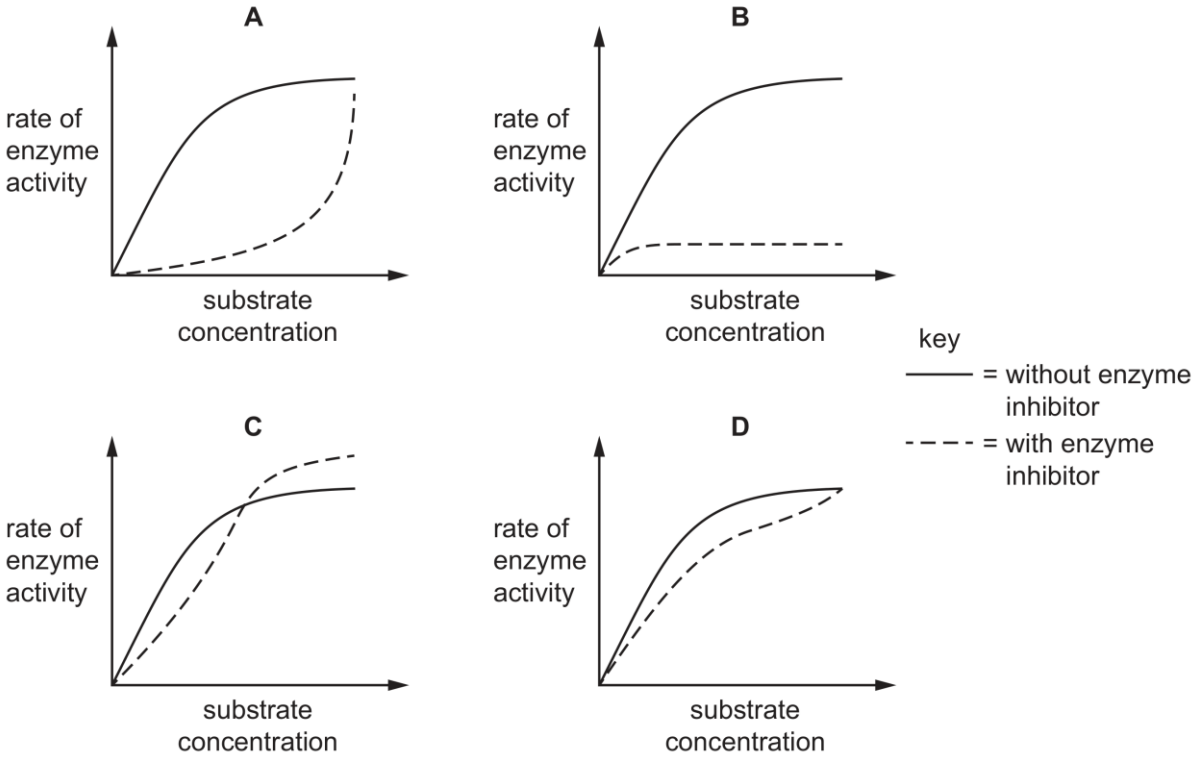
B It has a high K_m and reaches V_{max} at a low substrate concentration.

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.

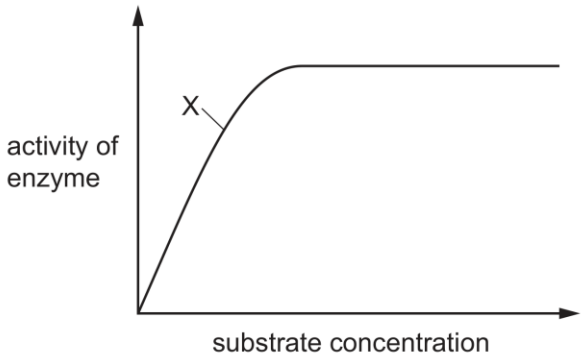
18 A student investigated the rate of enzyme activity with increasing substrate concentration. The experiment was repeated with the addition of a reversible non-competitive enzyme inhibitor. A graph was plotted to show the results.

Which graph represents the results of the two experiments?



19 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

20 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.

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

enzyme	K_m / 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?

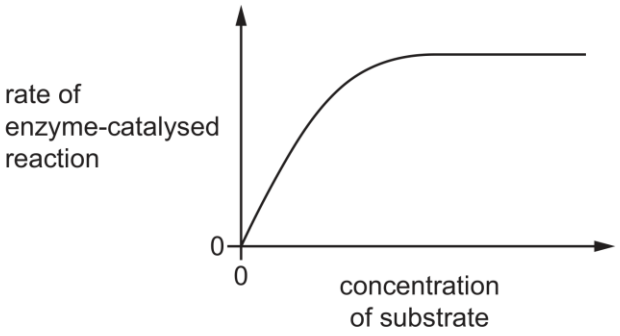
A Enzyme C has a V_{max} which is half that of enzyme P.

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 6.0×10^{-3} mmol dm^{-3}.

22 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

23 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?

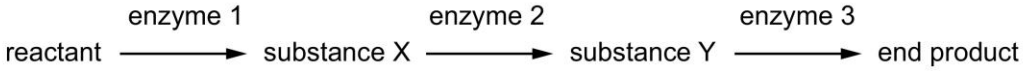
A It is more specific.

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.

24 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.

25 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.

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

1 lower the K_m value

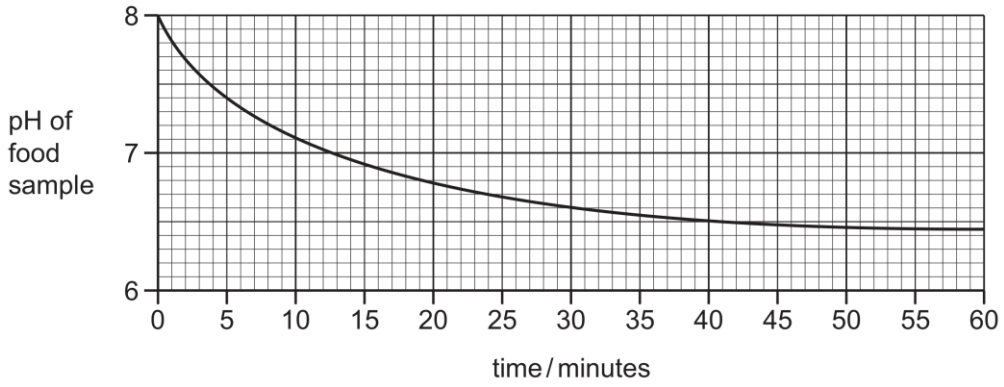
2 reduce the concentration of the product

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

27 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

28 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

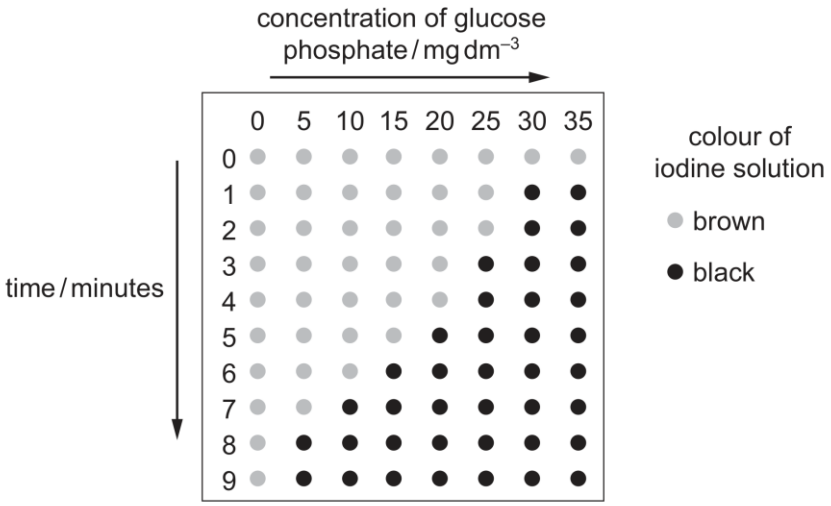
B competitive inhibition because ibuprofen and the substrate cannot bind at the same time

C non-competitive inhibition because ibuprofen blocks the active site

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

29 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.

30 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}

31 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

32 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.

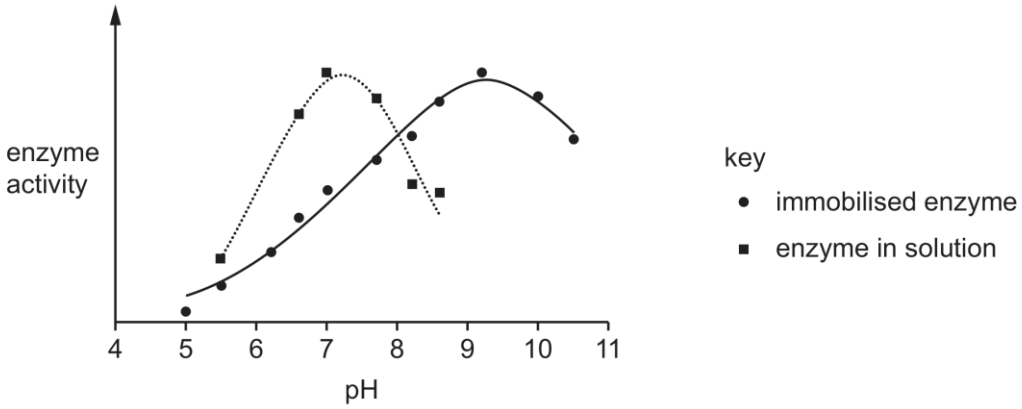
B The products of hydrolysis decrease the pH.

C The products of hydrolysis increase the pH.

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

33 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.

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

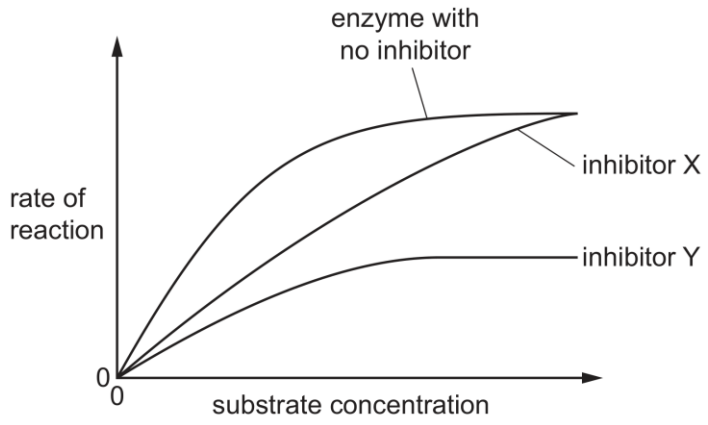
When the pH of an environment is decreased below the optimum pH of an enzyme, ……1…… bonds between adjacent ……2…… groups, holding the ……3…… structure, are disrupted.

	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

35 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.

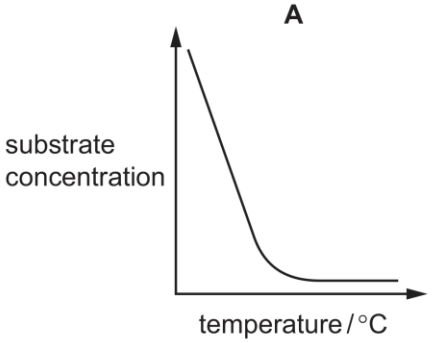
D Y is a non-competitive inhibitor which binds to a site other than the active site of the enzyme.

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

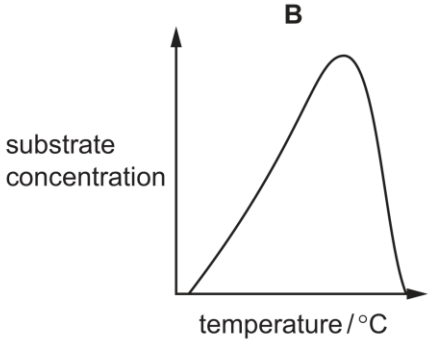
At each temperature, the substrate concentration was measured after 10 minutes. All the other variables were kept constant.

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

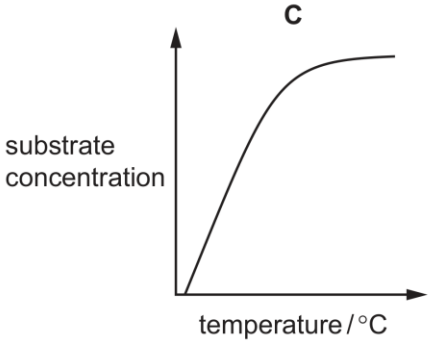
A



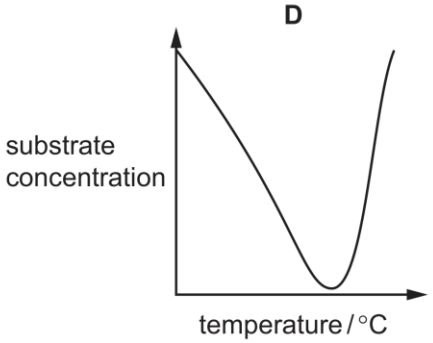
B



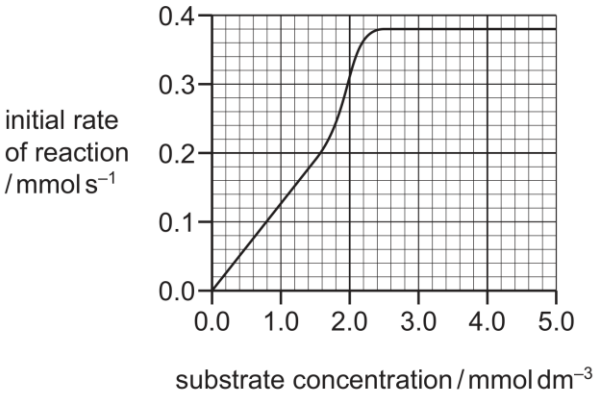
C



D



37 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}

38 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

39 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

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

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

Which interpretation of the information is correct?

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

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

C Enzyme F has the greatest affinity for its substrate.

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