

Metabolic Pathways & Enzymes

1 The diagram represents the conversion of starch into maltose.



Which row in the table identifies the type of reaction shown in the diagram and whether it requires or releases energy?

	Type of reaction	Energy required or released
A	catabolic	required
B	catabolic	released
C	anabolic	required
D	anabolic	released

2 The reaction below is part of a metabolic pathway in cells.

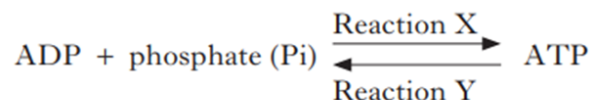


Which line in the table below correctly identifies the type of reaction and whether it releases or takes up energy?

	Type of reaction	Energy released or taken up
A	catabolic	released
B	anabolic	released
C	catabolic	taken up
D	anabolic	taken up

3

The diagram below shows the regeneration of ATP in a cell.



The following statements relate to this diagram.

- 1 Reaction X releases energy for anabolic pathways.
- 2 Reaction Y releases energy for anabolic pathways.
- 3 Reaction X is catalysed by ATP synthase.
- 4 Reaction Y is catalysed by ATP synthase.

Which statements are correct?

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

4 Which statement describes induced fit between an enzyme and its substrate?

- A The active site changes shape after the substrate binds.
B The substrate changes shape after the enzyme binds.
C The active site changes shape before the substrate binds.
D The substrate changes shape before the enzyme binds.

Metabolic Pathways & Enzymes

- 5 As part of a metabolic pathway substrate X is converted into product Y.

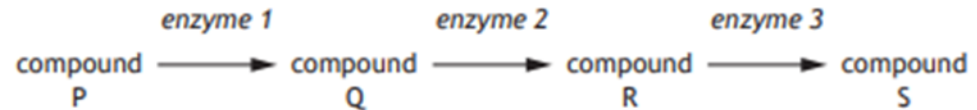


Under what circumstances would this reaction be reversed?

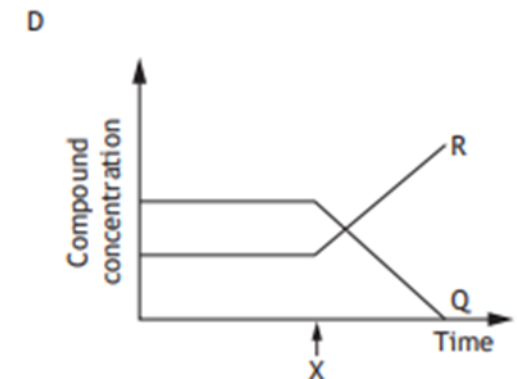
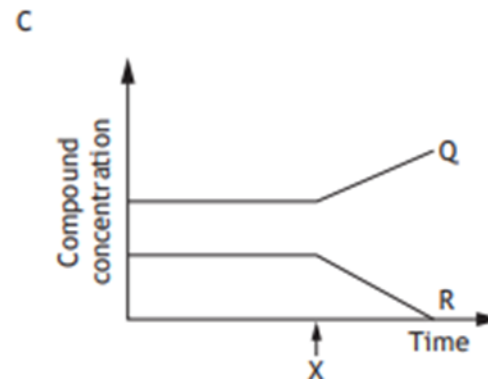
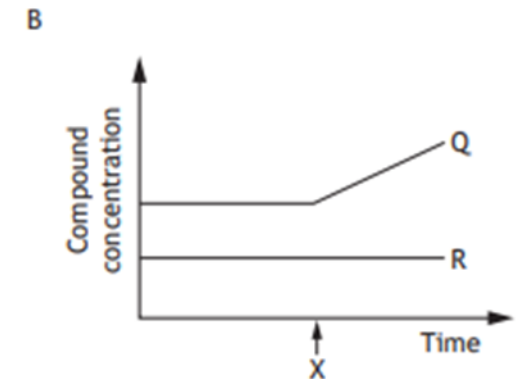
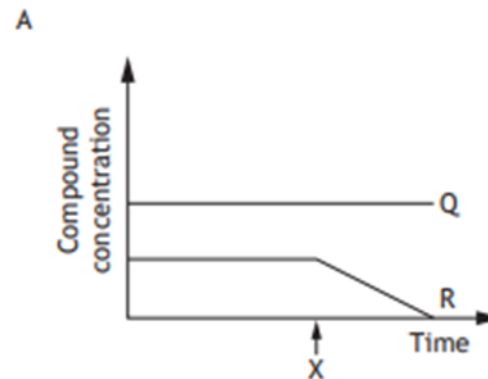
- A An increase in concentration of both X and Y
- B A decrease in concentration of both X and Y
- C An increase in concentration of X and removal of Y
- D An increase in concentration of Y and removal of X
- 6 Which line in the table below identifies correctly the change in activation energy brought about by an enzyme and the affinity of its product for the active site?

	<i>Change in activation energy</i>	<i>Affinity of product for the active site</i>
A	lowered	high
B	lowered	low
C	raised	low
D	raised	high

7. The following diagram shows an enzyme-controlled metabolic pathway.



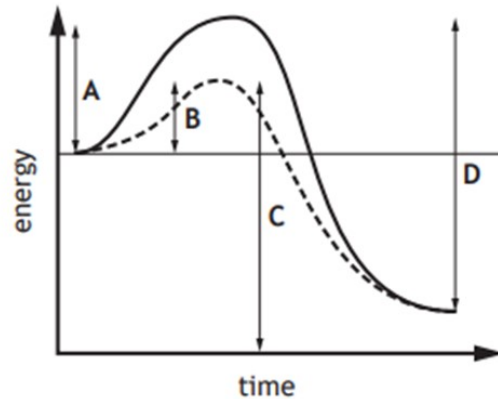
If enzyme 2 is inhibited at time X, which graph predicts the resulting concentrations of compounds Q and R?



Metabolic Pathways & Enzymes

- 8 The graph shows the energy at different times of a reaction in the presence and absence of an enzyme.

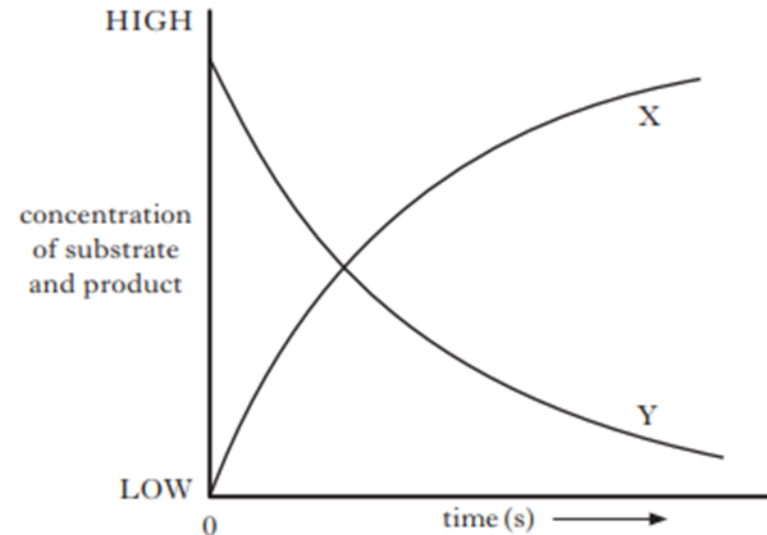
Which letter represents the activation energy for this reaction in the presence of an enzyme?



- 9 Metabolic pathways can be controlled by feedback inhibition where

- A an end product binds to an enzyme found at the start of the pathway
- B an end product binds to an enzyme found at the end of the pathway
- C an enzyme binds to a substrate found at the start of the pathway
- D an enzyme binds to a substrate found at the end of the pathway.

10. The graph below shows the changes to the concentrations of substrate and product during an enzyme-controlled reaction.

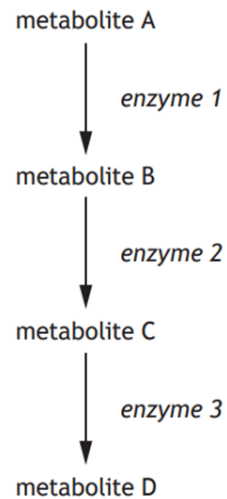


Which line in the table below correctly identifies the substrate, product and the change in the rate of the reaction during the process?

	Substrate	Product	Rate of reaction
A	X	Y	increasing
B	X	Y	decreasing
C	Y	X	increasing
D	Y	X	decreasing

Metabolic Pathways & Enzymes

11. The stages of an enzyme-controlled metabolic pathway are shown.



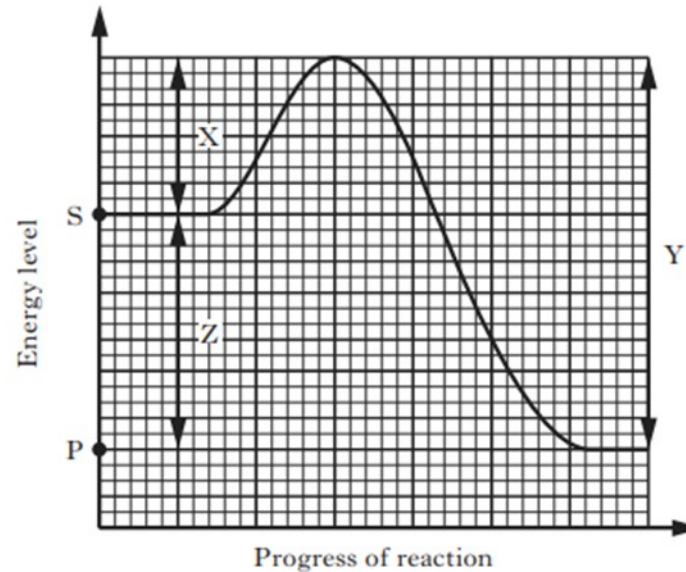
In feedback inhibition

- A enzyme 3 binds with enzyme 1
- B enzyme 3 binds with metabolite A
- C metabolite D binds with enzyme 1
- D metabolite D binds with metabolite A.

- 12 Non-competitive inhibitors affect enzyme action by

- A altering the shape of the active site of the enzyme
- B altering the shape of the substrate molecule
- C competing for the active site of the enzyme
- D acting as a co-enzyme for enzyme action.

13. S — substrate
P — product

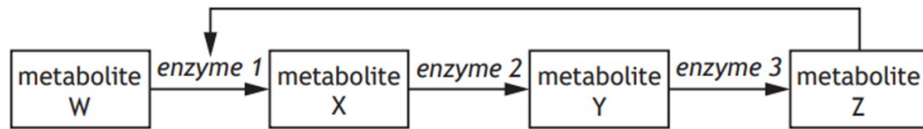


Which line in the table below identifies correctly the activation energy and the net energy released by the reaction?

	<i>Activation energy</i>	<i>Net energy released by the reaction</i>
A	X	Y
B	Y	Z
C	Y	X
D	X	Z

Metabolic Pathways & Enzymes

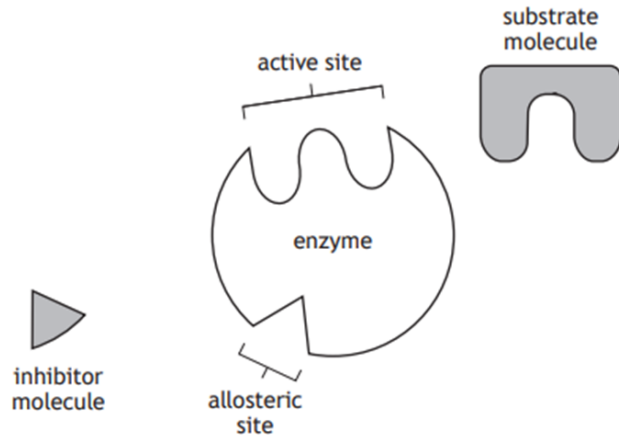
14. This metabolic pathway is regulated by feedback inhibition.



Which of the following would occur if a mutation caused enzyme 3 to be non-functional?

- A Metabolite Z would inhibit enzyme 1
- B Metabolite Z would increase in concentration
- C Metabolite Y would not be converted to metabolite Z
- D Metabolite W would not be converted to metabolite X

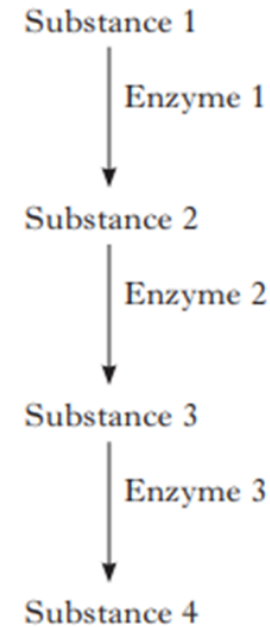
15. The diagram shows an enzyme and molecules that can bind to it.



Which of the following will change shape during induced fit?

- A Active site
- B Allosteric site
- C Substrate molecule
- D Inhibitor molecule

16. The diagram below shows a metabolic pathway that is controlled by end product inhibition.

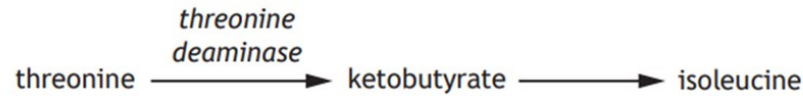


For Substance 4 to bring about end product inhibition, with which of the following would it interact?

- A Enzyme 1
- B Enzyme 3
- C Substance 1
- D Substance 3

Metabolic Pathways & Enzymes

17. Part of a metabolic pathway used to produce the amino acid isoleucine is shown.



Isoleucine is a feedback inhibitor of the enzyme threonine deaminase.

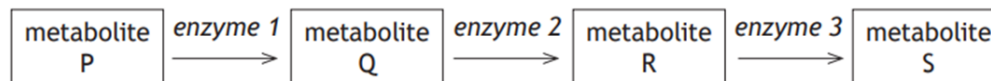
The statements refer to substances in the metabolic pathway.

1. Isoleucine binds to threonine deaminase.
2. Threonine deaminase lowers the activation energy required to convert threonine into ketobutyrate.
3. Ketobutyrate is the substrate of isoleucine.

Which of these statements are correct?

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

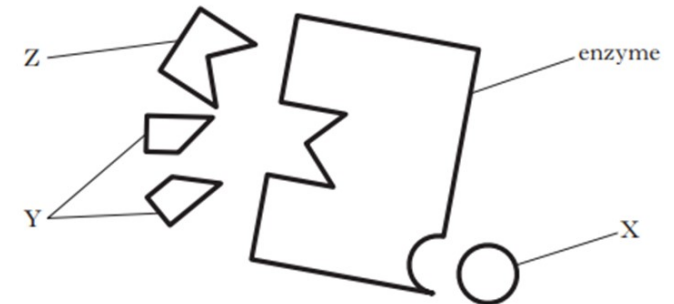
18. A metabolic pathway is shown.



In end-product inhibition

- A enzyme 3 binds to enzyme 1
B enzyme 3 binds to metabolite P
C metabolite S binds to enzyme 1
D metabolite S binds to metabolite P.

19. The diagram below represents various molecules involved in a synthesis reaction.



Which line in the table below correctly identifies the molecules?

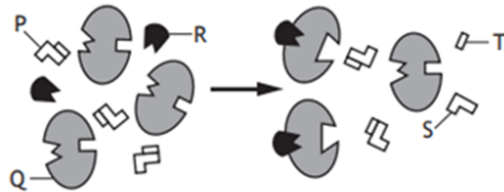
	X	Y	Z
A	competitive inhibitor	substrate	product
B	competitive inhibitor	product	substrate
C	non-competitive inhibitor	substrate	product
D	non-competitive inhibitor	product	substrate

20. Non-competitive inhibitors affect enzyme action by

- A acting as a co-enzyme for enzyme action
B altering the shape of the substrate molecule
C competing for the active site of the enzyme
D altering the shape of the active site of the enzyme.

Metabolic Pathways & Enzymes

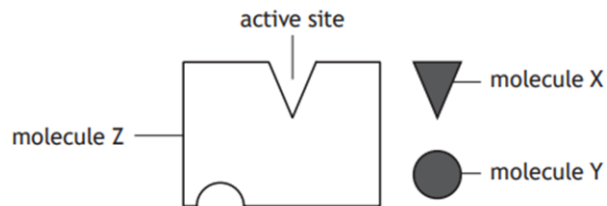
21. The diagram below shows an enzyme-catalysed reaction taking place in the presence of an inhibitor.



Which line in the table below identifies the molecules in the reaction?

	Inhibitor	Substrate	Product
A	P	R	S
B	Q	P	S
C	R	P	T
D	R	Q	T

22. The diagram shows molecules involved in an enzyme controlled reaction.



Which row in the table identifies these molecules?

	Molecule X	Molecule Y	Molecule Z
A	substrate	non-competitive inhibitor	enzyme
B	non-competitive inhibitor	enzyme	substrate
C	substrate	competitive inhibitor	enzyme
D	competitive inhibitor	non-competitive inhibitor	substrate

23. The diagrams below represent the shapes of an enzyme molecule and its substrate.

Enzyme molecule



Substrate molecule



Which row in the table below shows the possible shapes of two types of molecule that could inhibit the enzyme above?

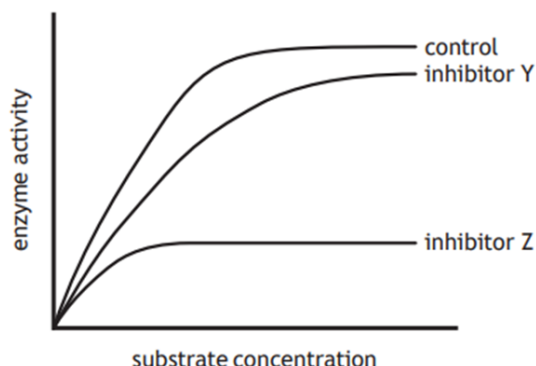
	Competitive Inhibitor	Non-competitive Inhibitor
A		
B		
C		
D		

24. Non-competitive inhibitors affect enzyme action by

- A altering the shape of the active site of the enzyme
- B altering the shape of the substrate molecule
- C competing for the active site of the enzyme
- D competing for the substrate molecule.

Metabolic Pathways & Enzymes

25. The graph shows the results of an investigation into the effects of two different inhibitors on enzyme activity.



Which of the following conclusions can be drawn from this graph?

- A Inhibitor Z is a competitive inhibitor
 B There is a steady increase in enzyme activity with no inhibitor
 C Inhibitor Y has less effect on enzyme activity than inhibitor Z
 D Increasing substrate concentration increases the effect of both inhibitors
26. An inhibitor of an enzyme-catalysed reaction can be described as competitive if
- A its effect is decreased by raising substrate concentrations
 B it is the final product in a metabolic pathway
 C it switches off the gene encoding the enzyme
 D it permanently changes the shape of the active site.

27. Test tubes each containing an enzyme solution with different concentrations of substrate were incubated. After 10 minutes enzyme activity was measured.

The results are shown in the table.

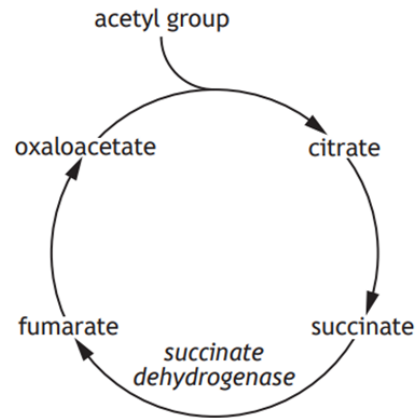
Substrate concentration (mol/l)	Enzyme activity (units)		
	No inhibitor	Inhibitor X	Inhibitor Y
0.0	0.0	0.0	0.0
0.2	0.2	0.1	0.1
0.4	0.3	0.1	0.2
0.6	0.4	0.2	0.4
0.8	0.5	0.2	0.4
1.0	0.5	0.2	0.5

Which of the following statements is supported by the data?

- A Inhibitor Y changes the shape of the active site.
 B The optimum substrate concentration is 1.0 mol/l.
 C Inhibitor X binds to the active site.
 D Inhibitor Y is a competitive inhibitor.

Metabolic Pathways & Enzymes

28. Succinate dehydrogenase is an enzyme that catalyses a reaction in the citric acid cycle as shown in the diagram.

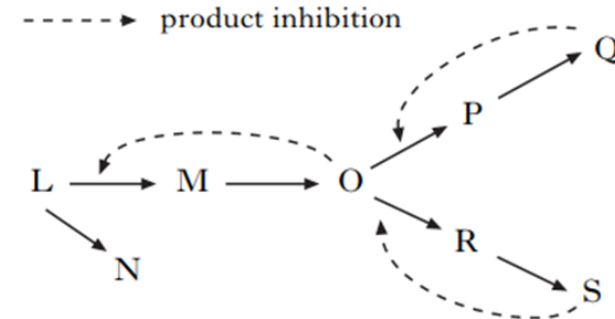


Malonate is a competitive inhibitor of succinate dehydrogenase.

Which statement about succinate dehydrogenase is correct?

- A Succinate and malonate have a higher affinity than fumarate for the active site of succinate dehydrogenase.
- B Increasing the concentration of fumarate would reverse the inhibition of succinate dehydrogenase.
- C Increasing the concentration of succinate would have no effect on the inhibition of succinate dehydrogenase.
- D Malonate and succinate bind to different sites on succinate dehydrogenase.

29. The following diagram shows a branched metabolic pathway.

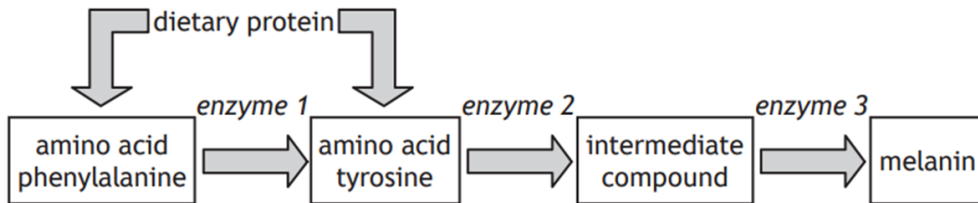


Which reaction would tend to occur if both Q and S are present in the cell in high concentrations?

- A $L \rightarrow M$
- B $R \rightarrow S$
- C $O \rightarrow P$
- D $L \rightarrow N$

Metabolic Pathways & Enzymes

1. Phenylketonuria (PKU) is an example of a genetic disorder which affects the following metabolic pathway.

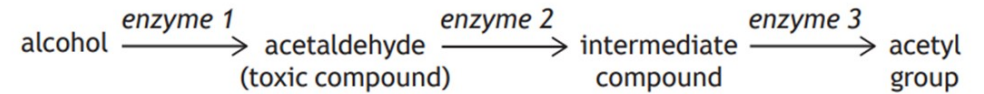


- a) Use the metabolic pathway above to suggest

(i) why PKU results in a build-up of phenylalanine;

(ii) why individuals with PKU can still produce melanin.

2. The diagram shows some of the stages in the breakdown of alcohol by the liver.



- a) Some individuals cannot produce enough fully functioning enzyme 2.

(i) In these individuals an altered form of enzyme 2 is produced due to a missense mutation.

1

Explain why these individuals are less tolerant of alcohol.

1

1

- b) A drug that acts as a competitive inhibitor of enzyme 2 can be prescribed to treat alcoholism.

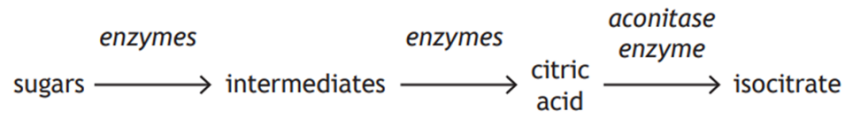
Explain how this drug will affect the enzyme.

1

Metabolic Pathways & Enzymes

3. The fungus *Aspergillus niger* (*A.niger*) is used to produce citric acid in fermenters using sugars as substrates.

Citric acid is an intermediate in a metabolic pathway as shown.



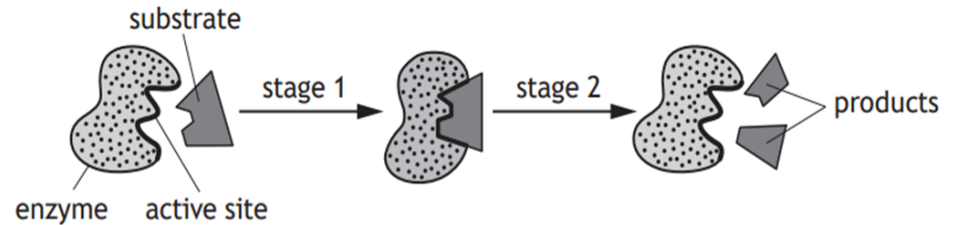
- (a) The aconitase enzyme requires iron to function.

Explain why the growth medium used to produce citric acid should not contain iron.

- (b) The optimum temperature for citric acid production by *A.niger* is 30 °C.

Explain why less citric acid would be produced if the temperature in the fermenter was reduced.

4. The diagram represents stages of an enzyme-catalysed reaction.



- (i) Use the diagram to explain why this reaction can be described as catabolic.

1

1

- (ii) The diagram shows induced fit occurring between the enzyme and its substrate molecule.

Describe what happens during induced fit.

1

1

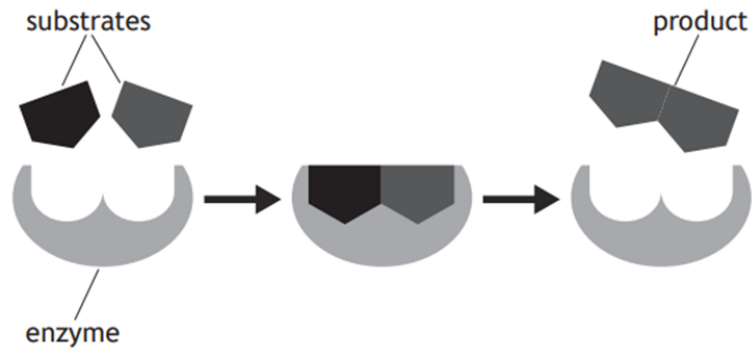
- (iii) Once the reaction is complete the products are released from the active site and the enzyme can be reused.

Explain why the products leave the active site.

1

Metabolic Pathways & Enzymes

5. The diagram represents a reaction in a metabolic pathway.



- (i) Name the type of reaction shown in the diagram and give a reason for your answer.

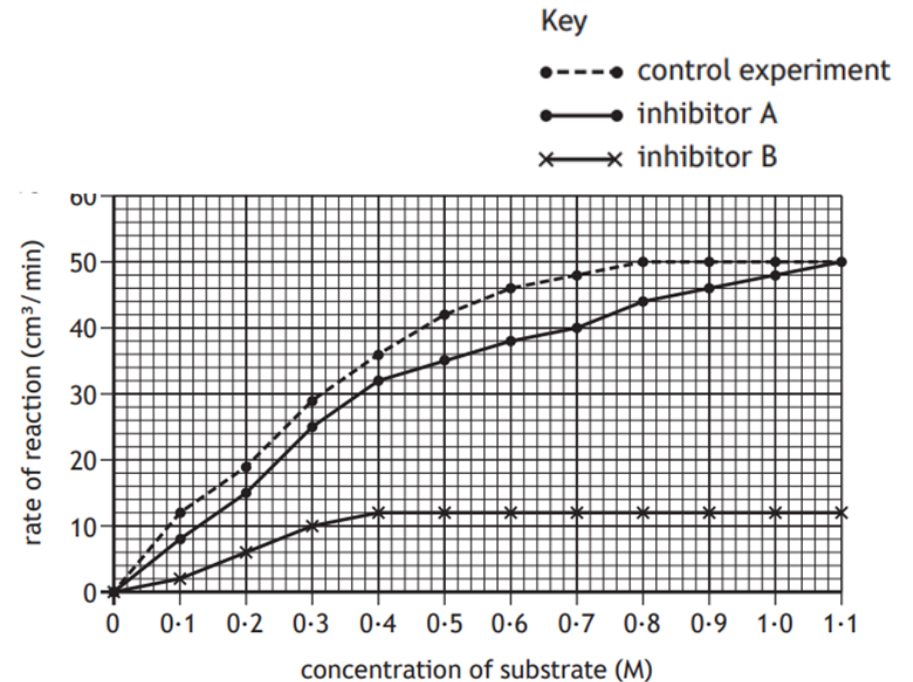
Type of reaction _____

Reason _____

- (ii) Describe the role of induced fit in this enzyme-catalysed reaction.

6. An investigation was carried out to show the effect of two different inhibitors on the rate of a reaction, catalysed by an enzyme.

The graph shows the results of this investigation.



- (a) Name the substances present in the control experiment.

1

- (b) Use the information in the graph to select which inhibitor is non-competitive and give a reason for your choice.

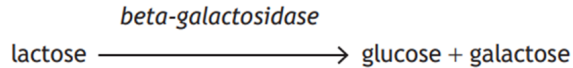
1

Inhibitor _____

Reason _____

Metabolic Pathways & Enzymes

7. *E.coli* breaks down lactose using the enzyme beta-galactosidase as shown.



- a) Suggest a benefit to *E.coli* of producing beta-galactosidase only when lactose is present.

- b) In terms of activation energy, state how enzymes increase the rates of reactions in living cells.

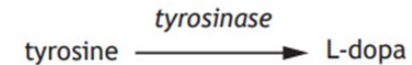
Metabolic pathways can be regulated by feedback inhibition.

- c) (i) Describe feedback inhibition of a metabolic pathway.

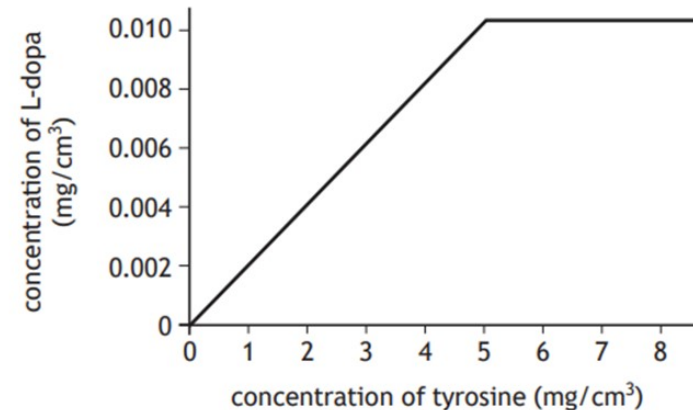
- (ii) Suggest **one** advantage to a cell of using feedback inhibition.

8. Parkinson's disease is caused by low levels of dopamine in the brain resulting in poor muscle co-ordination. Parkinson's disease can be treated using the drug L-dopa, which is converted to dopamine in the brain.

L-dopa is produced commercially in a reaction vessel using the enzyme tyrosinase as shown.



The graph shows the results of using different concentrations of the substrate tyrosine on the concentration of L-dopa produced in the reaction vessel.



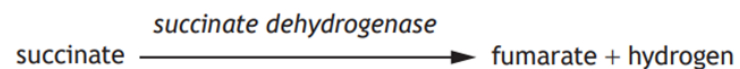
- a) Using information from the graph, suggest why a tyrosine concentration of 5 mg/cm³ is used in the commercial production of L-dopa.

- b) Many enzymes are used in commercial processes. When using enzymes in these processes the end-product is regularly removed.

Suggest why end-products are removed during production processes.

Metabolic Pathways & Enzymes

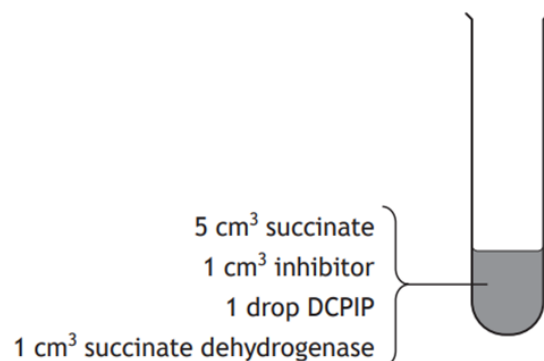
9. Succinate is converted to fumarate by a dehydrogenase enzyme as shown.



The rate of this reaction can be measured using the indicator DCPIP, which changes colour from blue to colourless when it combines with hydrogen.

An investigation was carried out into the effect of an inhibitor on the rate of this reaction at different concentrations of succinate.

Five test tubes were set up as shown in the diagram, each test tube contained a different concentration of succinate.



The time to decolourise the DCPIP indicator in each tube was measured.

The investigation was repeated without the inhibitor.

The results of the investigation are shown in the table.

Concentration of succinate (M)	Time to decolourise DCPIP (s)	
	With inhibitor	Without inhibitor
0.2	94	72
0.4	48	30
0.6	24	16
0.8	14	8
1.0	8	8

- a) Describe how the results show that the inhibitor used is a competitive inhibitor of succinate dehydrogenase.

1

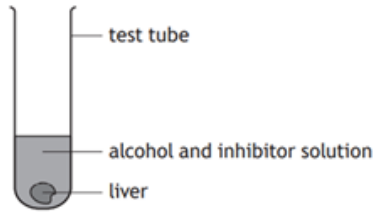
- b) Suggest how the results of this investigation would be different if a non-competitive inhibitor had been used.

1

Metabolic Pathways & Enzymes

10. An investigation was carried out into the effect of inhibitor concentration on the activity of an enzyme which breaks down alcohol in liver cells.

Six test tubes were set up, each containing a piece of liver, alcohol and different concentration of inhibitor, as shown in the diagram.



Inhibitor concentration (mM)	Final alcohol concentration (% of initial concentration)
0.5	20
1.5	28
2.5	60
3.5	96
4.5	100
5.5	100

- a) The inhibitor used in this investigation was non-competitive.

Describe how a non-competitive inhibitor works.

1

- b) A second experiment, using increasing concentrations of alcohol, was carried out to show that the inhibitor was non-competitive.

Six test tubes were set up, each containing a piece of liver, an inhibitor concentration of 4.5 mM and different concentrations of alcohol.

Suggest how the results would confirm that the inhibitor was non-competitive.

1

11. In an investigation, nitrogenase activity was measured at different concentrations of its substrate, nitrous oxide, in the presence and absence of two inhibitors P and Q.

The results are shown in the table.

Concentration of nitrous oxide (mol l ⁻¹)	Nitrogenase activity (units)		
	No inhibitor	Inhibitor P	Inhibitor Q
0	0	0	0
5	13	4	3
10	25	17	11
15	36	26	14
20	36	35	14
25	36	36	14

Name the type of inhibition shown by Q and use evidence from the table to justify your answer.

2

Type of inhibition _____

Justification _____

Metabolic Pathways & Enzymes

1. B
 2. D
 3. C
 4. A
 5. D
 6. B
 7. C
 8. B
 9. A
 10. D
 11. C
 12. A
 13. D
 14. A
 15. A
 16. A
 17. D
 18. C
 19. C
 20. D
 21. C
 22. A
 23. D
 24. A
 25. C
 26. A
 27. D
 28. A
 29. D
- 1a (I) enzyme 1 is not working/can't produce enough enzyme 1
- (ii) dietary protein can bypass this step and cause tyrosine to eventually make melanin
- 2a they cannot break down the acetaldehyde a toxic product into an intermediate
- b) The drug binds to the active site prevent acetaldehyde from binding.
- 3a citric acid will be turned into isocitrate
- b) enzyme activity would reduce
- Produce citric acid
- 4a (i) larger substrate broken down to smaller product
- (ii) active site changes shape to better fit substrate AFTER substrate binds
- (ii) product has low affinity for active site
- 5(i) anabolic
- (ii) when the active site change shape AFTER the substrate has bound.
- Smaller substrates are converted into larger product
- 6a substrate & enzyme & water (instead of inhibitor)
- b) Inhibitor B
- Inhibition is not reversible with increasing substrate concentration
- 7.a) saves energy/amino acids
- b) lower activation energy
- c(i) when the end product reaches a critical concentration it binds to an earlier enzyme to stop its own synthesis
- c(ii) saves ATP

Metabolic Pathways & Enzymes

8 a) lowest concentration of tyrosine that produces the maximum L Dopa.

b) to prevent feedback inhibition

9a increasing the substrate (succinate) concentration reverses the inhibition on the enzyme activity

b increasing the substrate concentration would not reverse the inhibition on the enzyme's activity

10a binds away from active site but changes shape of active site stopping substrate from binding

b increasing the substrate concentration would not reverse the inhibition of the alcohol on the enzyme's activity

11. competitive

Inhibition reversible by increasing substrate concentration