Past-paper walk-through

Mode of action of enzymes ▪ 3.1

eXercise

Questions in this set

- 9700/11 N25 Q13 ▪ 1 mark
- 9700/11 N25 Q14 ▪ 1 mark
- 9700/12 N25 Q9 ▪ 1 mark
- 9700/12 N25 Q13 ▪ 1 mark
- 9700/13 N25 Q15 ▪ 1 mark
- 9700/14 N25 Q13 ▪ 1 mark
- 9700/14 N25 Q14 ▪ 1 mark
- 9700/21 N25 Q3 ▪ 10 marks
- 9700/23 N25 Q3 ▪ 9 marks

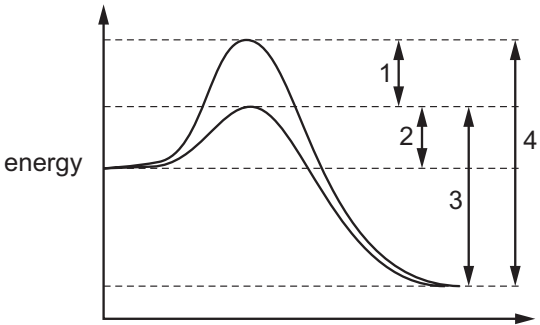
Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 13

9700/11 N25 ▪ Q13 ▪ 1 mark

13 The graph shows energy changes in a chemical reaction.



Question 13

What is the activation energy when an enzyme is added?

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

Solution 13

Answer: **B**

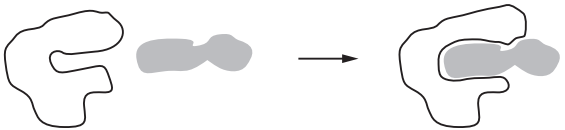
Why

- Activation energy is measured from the reactants up to the peak of the curve.
- Adding an enzyme lowers that peak, giving the smaller of the two humps.
- So the answer is the single rise from the reactant level to the lower peak.

Question 14

9700/11 N25 ▪ Q14 ▪ 1 mark

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.

Question 14

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.

Solution 14

Answer: **A**

Why

- A rigid active site would only fit a substrate that already matched it exactly.
- In the induced-fit model, the substrate binding *changes* the enzyme's shape.
- The active site moulds around the substrate, which is how it comes to fit.

Question 9

9700/12 N25 ▪ Q9 ▪ 1 mark

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

Question 9

D	hydrolysis of peptide bonds	hydrolysis of glycosidic bonds

Solution 9

Answer: **B**

Why

- The enzyme hydrolyses chitin, so it is a hydrolase acting on a polysaccharide.
- It also *inhibits* another enzyme, so towards that enzyme it acts as an inhibitor, not a catalyst.
- Read the two roles separately – one reaction it speeds up, one it blocks.

Question 13

9700/12 N25 ▪ Q13 ▪ 1 mark

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

Solution 13

Answer: **B**

Why

- An enzyme provides an alternative route with a lower activation energy.
- It does not change how much energy the reaction releases overall.
- So the activation energy falls and the energy yield is unchanged.

Question 15

9700/13 N25 ▪ Q15 ▪ 1 mark

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

Solution 15

Answer: **C**

Why

- Lock-and-key means the active site is already complementary to the substrate – statement 1 is right.
- A shape *change* on binding is the induced-fit model instead, so statement 2 does not belong here.
- Most of the amino acids are there to hold the tertiary structure that shapes the active site, so statement 3 is right.

Question 13

9700/14 N25 ▪ Q13 ▪ 1 mark

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

Solution 13

Answer: **D**

Why

- An extracellular enzyme works outside the cell that made it.
- Digestion in the lumen of the small intestine happens outside the cells, so statement 2 qualifies.
- DNA replication in the nucleus and ATP synthesis in mitochondria are both intracellular.

Question 14

9700/14 N25 ▪ Q14 ▪ 1 mark

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.

Solution 14

Answer: **B**

Why

- In the induced-fit model the active site is not already the exact shape of the substrate.
- Binding the substrate changes the enzyme's conformation.
- The active site moulds around the substrate; enzymes always *lower* the activation energy.

Question 3

9700/21 N25 ▪ Q3 ▪ 10 marks

3 **(a)** The lock-and-key hypothesis and the induced-fit hypothesis are used to describe the interaction of enzymes and their substrates.

Describe **one** similarity and **one** difference between the lock-and-key hypothesis and the induced-fit hypothesis.

Question 3

Question 3

[2]

(b) Phosphorylase enzymes can catalyse the synthesis of starch **and** the breakdown of starch in some plant tissues. A reaction catalysed by starch phosphorylase is shown in Fig. 3.1.

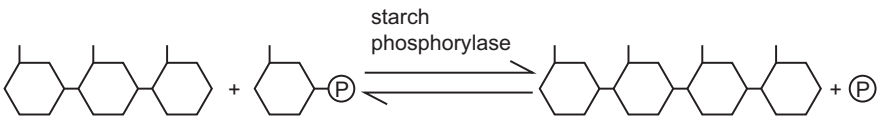


Fig. 3.1

A student carried out an experiment to study the synthesis of starch by phosphorylase found in potato tissue.

Question 3

The student was provided with a solution, **E**, extracted from potato tissue. The extract was

Question 3

The student was provided with a solution, **E**, extracted from potato tissue. The extract was filtered to remove all the starch grains.

Extract **E** contained biological molecules from the potato tissue including phosphorylase but **no** starch.

(i) Iodine solution was used to confirm that starch was **not** present in extract **E**.

State the colour observed when iodine solution was added to a sample of extract **E**.

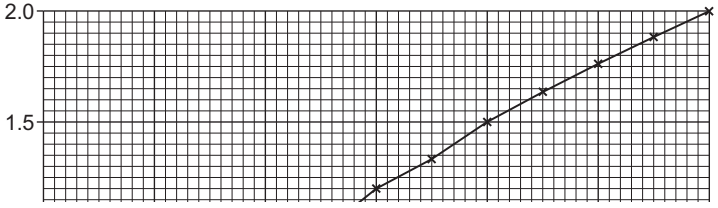
Question 3

The student added a small drop of a dilute starch solution and a solution of glucose 1-phosphate to a test-tube containing extract **E**.

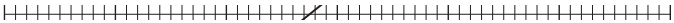
Samples of the reaction mixture in the test-tube were removed every minute and a drop of iodine solution was added to each.

The student used a colorimeter to measure the absorbance of the solution in each sample.

The results are shown in Fig. 3.2.



Question 3



Question 3

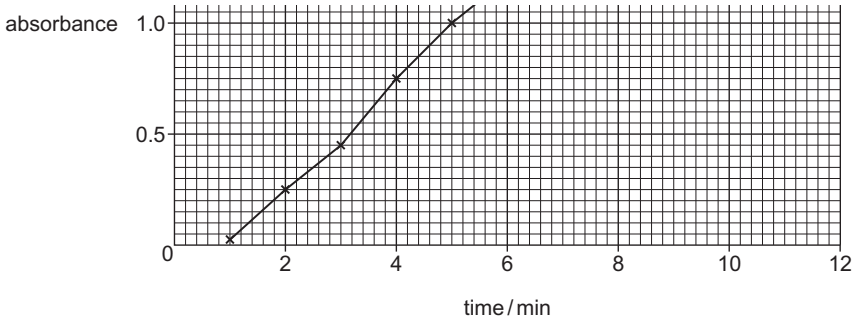


Fig. 3.2

(ii) Explain the results shown in Fig. 3.2.

Question 3

(iii) After 12 minutes, the student added a solution containing phosphate ions to the reaction mixture. The student continued taking samples every minute, adding iodine solution to each sample.

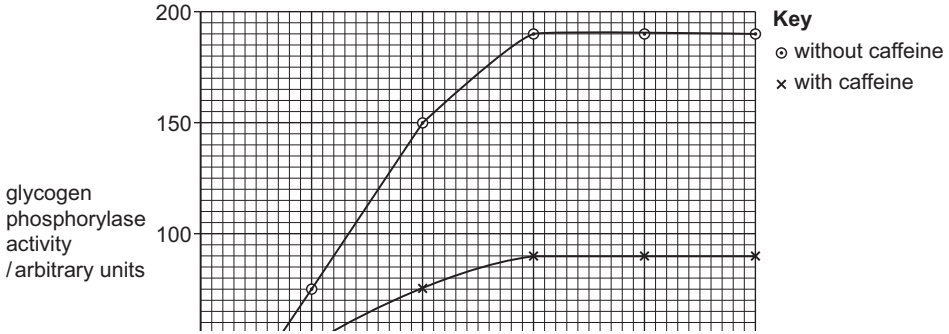
The absorbance of the solution in each of these samples was measured. The results showed that the absorbance decreased over time.

Suggest why the absorbance decreased.

Question 3

(c) Muscle cells contain glycogen phosphorylase.

Fig. 3.3 shows the effect of caffeine on the activity of glycogen phosphorylase at different concentrations of substrate.



Question 3

Question 3

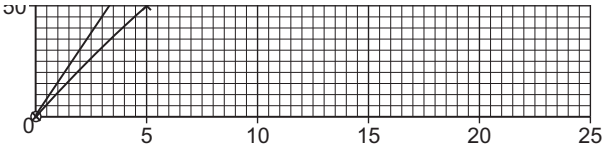


Fig. 3.3

A student concluded that caffeine acts as a non-competitive inhibitor of glycogen phosphorylase.

Explain how the results in Fig. 3.3 support this conclusion.

Question 3

[Total: 10]

Solution 3

(a) Mark scheme

- one similarity ;
- e.g. substrate binds to active site
- enzyme-substrate complex forms
- product leaves active site
- interaction does not alter enzyme for re-use
- lower activation energy
- specific to one or very similar substrate(s)
- interaction can be affected by, action of inhibitors / pH / AW

Solution 3

- one difference ;
- e.g. induced-fit ora for lock-and-key
- active site not fully complementary to substrate
- change in, conformation / shape, of active site / AW context of binding substrate or after product release
- less specificity to substrate
- 2

Solution 3

(b)(i)

Mark scheme

- orange / brown / amber ;
- A yellow-brown, yellow-orange
- 1

Solution 3

(b)(ii) Mark scheme

- any three from:
- phosphorylase (in extract) catalyses addition of glucose 1-phosphate to starch added to extract ;
- more starch is synthesised by phosphorylase as time progresses / AW ;
- iodine solution added to mixture turns a, blue / black / blue-black, colour (in the presence of starch) ;
- the more starch present in the mixture, the, darker / more intense, the, colour / shade ;

Solution 3

- the darker the colour (of the positive result) the less light passes through, mixture / sample ;
- the darker the colour / AW, the higher the absorbance (reading of the colorimeter) ;
- 3

Solution 3

(b)(iii) Mark scheme

- ref. to breakdown of starch catalysed by the enzyme / reaction in Fig. 3.1 goes in the opposite direction ;
- AVP ; e.g. ref to equilibrium shift
- ref. to glucose 1-phosphate has run out
- decrease in concentration of starch, qualified with ref. to iodine solution
- 1
- 9700/21
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Solution 3

(c) Mark scheme

- any three from:
- reduction in activity of phosphorylase (at all concentrations) ; ora higher throughout with caffeine
- Vmax not reached ;
- ref. to plateau at a (much) lower activity ;
- calculated Km value with caffeine is the same as without caffeine ;
- use of data from the graph to support conclusion ;
- 3

Question 3

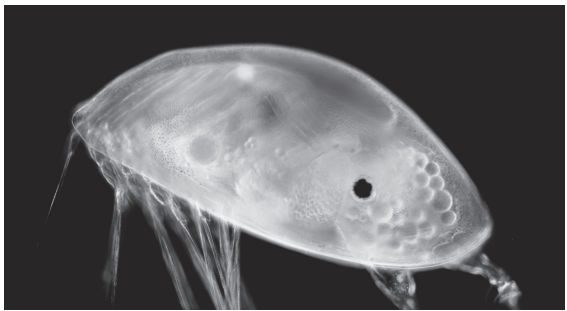
9700/23 N25 ▪ Q3 ▪ 9 marks

3 **(a)** Describe the induced-fit hypothesis of enzyme action.

Question 3

(b) Many marine organisms can become attached to hard surfaces such as rocks or the surfaces of ships. These organisms are known as fouling organisms.

The larva of the acorn barnacle, *Amphibalanus amphitrite*, is an example of a fouling organism. One of these barnacle larvae is shown in Fig. 3.1.



Question 3

magnification ×160

Fig. 3.1

The larvae of *A. amphitrite* use a protein to attach themselves to the surfaces of ships.

It is expensive to remove fouling organisms from ships. Scientists have developed substances to prevent the attachment of larvae. However, some of these substances are toxic and have been responsible for a decrease in marine biodiversity.

Scientists investigated the effect of using an immobilised protease, subtilisin A, to prevent the attachment of the larvae of *A. amphitrite* to surfaces.

The scientists used 4 different concentrations of subtilisin A which had been immobilised onto the surface of a polymer film. As a control they used denatured subtilisin A immobilised onto

Question 3

the surface of a polymer film. As a control they used denatured subtilisin A immobilised onto

Question 3

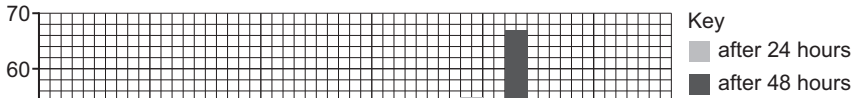
the surface of the same polymer. Glass slides were also used as a control.

The larvae were released into 6 tanks of artificial sea water:

- 4 tanks, each with a polymer surface and a different concentration of immobilised subtilisin A
- 1 tank with a polymer surface and denatured immobilised subtilisin A
- 1 tank with glass slides instead of a polymer surface.

The number of larvae that attached to the different surfaces in the tanks was counted after 24 hours and again after 48 hours.

The number of larvae attached in each tank was expressed as the percentage of the total number of larvae released in each tank. The results are shown in Fig. 3.2.



Question 3

Question 3

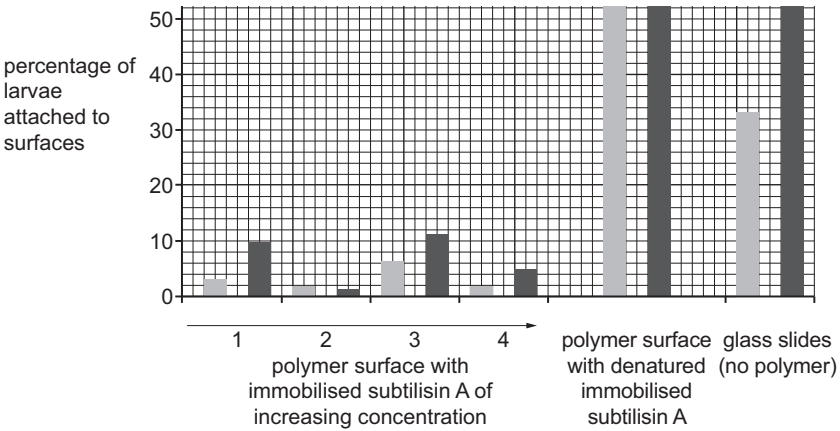


Fig. 3.2

Question 3

Question 3

(i) With reference to the data in Fig. 3.2, discuss whether subtilisin A is effective in preventing the attachment of the larvae.

Question 3

(ii) The scientists extended their investigation by applying the polymer with immobilised subtilisin A to the outside of the bottom of small ships.

Two factors that need to be taken into consideration in this type of investigation are the temperature and pH of the sea water.

Outline **two other** factors that need to be taken into consideration when investigating the suitability of immobilised subtilisin A as an anti-fouling agent for ships.

Question 3

[Total: 9]

Question 3

Question 3

Question 4 starts on page 12.

Solution 3

(a) Mark scheme

- any three from:
- to award MPs 2, 3 and 6 there must be reference to shape or conformation at least once in the answer
- if no reference to shape or conformation in the answer mark to max 2
- if lock and key described mark to max 2 from MP4 onwards
- 1
- idea that active site (of inactive enzyme) and substrate are, (only) partially / not, complementary ;

Solution 3

- 2
- as substrate enters active site there is a, change in shape / conformational change, (of active site / enzyme) ;
- A active site moulds around substrate
- R substrate changes shape / substrate active site
- 3
- so shape of active site becomes complementary to substrate ;
- A idea that there is a good fit between active site and substrate
- 4
- enzyme-substrate complex forms ;

Solution 3

- 5
- lowers activation energy ;
- 6
- product(s) leave and, enzyme / active site, returns to original, shape / conformation ;
- 7
- AVP ; e.g. catalytic sites move to be in correct position
- e.g. detail of lowering activation energy – putting strain on substrate / stress on bonds
- 3

Solution 3

(b)(i) Mark scheme

- allow enzyme or subtilisin for immobilised subtilisin A
- allow attachment for attachment of larvae
- I comparisons between controls
- any four from:
- 1
- effective because (much) lower percentage attachment with, the enzyme / AW, compared with the control(s) / AW ;
- ora for (both) controls

Solution 3

- 2
- any comparison between 24 and 48 hrs in the same experimental tank (1 to 4) ;
- e.g. tank 2 only one showing decrease at 48 hours
- 3
- any comparison between any two different tanks (1 to 4 or any experimental with control) at either 24 or 48 hours ;
- e.g. less attachment in tank 2 than in the others at 48 hours
- 4
- 48 hours is a short period of time / may not be effective after a few days ;
- 5

Solution 3

- not 100% effective ;
- 6
- (generally) becomes less effective at 48 hours (with exception of tank 2) ;
- 7
- immobilised enzyme, not stable / detached from surface ;
- 8
- ref. to no trend with increasing subtilisin concentration ;
- 9
- no repeats so data may not be valid / AW ;
- 10 AVP ;

Solution 3

- 4
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Solution 3

(b)(ii) Mark scheme

- I ref. to cost
- any two from:
- 1
- density / concentration of, enzyme / subtilisin A / polymer ;
- A way of attaching enzyme to polymer
- 2
- type of polymer ;
- 3

Solution 3

- check that all organisms are removed from ships before applying, enzyme / polymer ;
- 4
- way to fix polymer to surfaces of ships / material used to make surface of ships ;
- 5
- number of larvae put into tanks / experiment carried out at time of year when larvae are in sea water ;
- A idea that different places have different numbers of larvae
- 6
- length of time before taking measurements ;
- 7

Solution 3

- length of time, enzyme / anti-fouling agent, remains active ;
- A ref. to stability of immobilised enzyme
- 8
- idea of any interaction with other, fouling / marine, organisms ; A 'affect' as an interaction
- e.g. that could, graze / decompose, subtilisin A / polymer
- that could compete with A. amphitrite for attachment sites
- effectiveness against fouling organisms other than, A. amphitrite / barnacles
- subtilisin A / product of enzyme, may be, toxic / harmful, to marine organisms
- 9

Solution 3

- effect of immersion in sea water on, enzyme / polymer (not in artificial sea water) ;
- 10 effect of different types of sea water, e.g. salt content / mineral content / roughness ;
- A different, concentrations of sea water / salinities
- 11 effect of marine pollutants / something in sea water, as enzyme inhibitors ;
- 12 AVP ; e.g. ref. to surface area of ship exposed to sea water
- types of antifouling agents present in the seawater
- 2
- 9700/23
- October/November 2025