Enzymes

Model Answers 3

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Foundations in Biology
Topic	Enzymes
Booklet	Model Answers 3

Time allowed: **49 minutes**

Score: **/36**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

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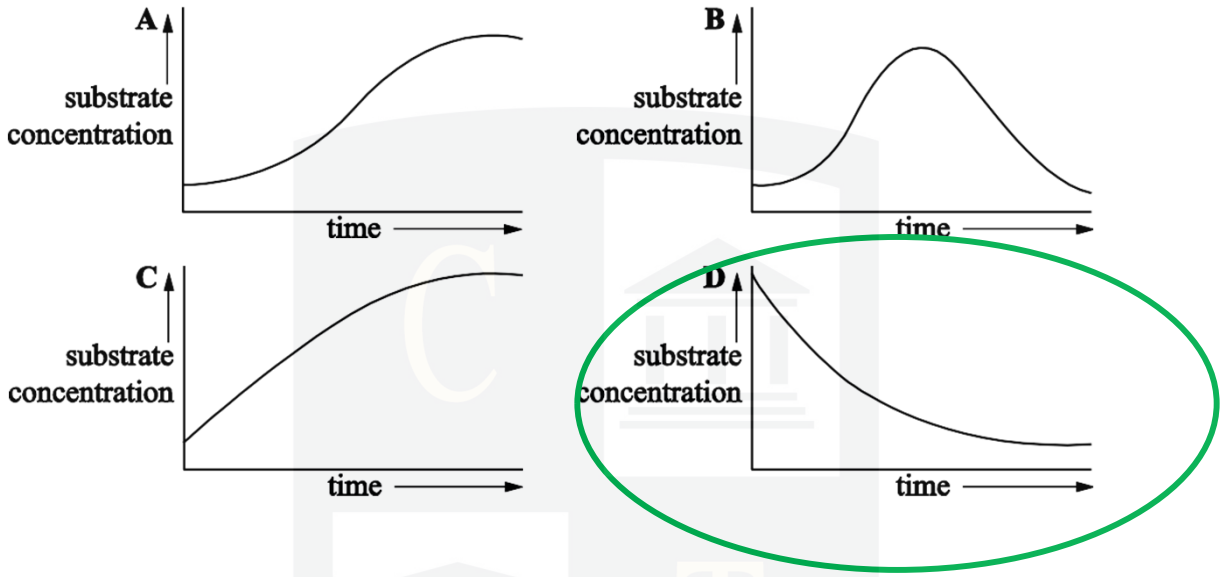
Question 1

A group of students monitored the **substrate** concentration during an enzyme-controlled reaction.

Select the graph that correctly shows how the substrate concentration changes during the course of the reaction.



[1]

The concentration of substrate will drop over a period of time as it is converted to product

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Question 2

A chemical produced by a metabolic pathway binds to the initial enzyme in the pathway. The chemical binds to the enzyme at a site away from the active site and inhibits the enzyme action.

Which of the following statements about the mode of action of the chemical is/are correct?

Statement 1: It is an end product inhibitor.

Statement 2: It is a competitive inhibitor.

Statement 3: It binds to the allosteric site of the enzyme.

A. 1, 2 and 3

B. Only 1 and 2

C. Only 1 and 3

D. Only 1

[1]

This is an end product inhibitor as it is produced after a metabolic pathway and inhibits one of the earlier enzymes. The product is also binding to the allosteric site of the enzyme as it states in the question that it binds to the enzyme at a site away from the active site.

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Question 3

(a) Alcohol dehydrogenase is a protein molecule that is present in the liver. The molecule breaks down alcohols and other chemicals that would otherwise be toxic to the body.

Name the group of biological molecules to which alcohol dehydrogenase belongs. **[1]**

- Alcohol dehydrogenase is an enzyme

Any molecule ending in the suffix 'ase' is definitely an enzyme

(b) In 1985, health concerns were raised when the compound diethylene glycol (DEG) was detected in samples of wine. The DEG had been added, illegally, to make the wine taste sweeter.

In the liver, DEG is broken down by alcohol dehydrogenase to form a toxic product. Alcohol dehydrogenase also breaks down ethanol, the key ingredient in alcoholic drinks such as wine, to form a non-toxic product.

Fig. 2.1 shows the structures of DEG and ethanol.

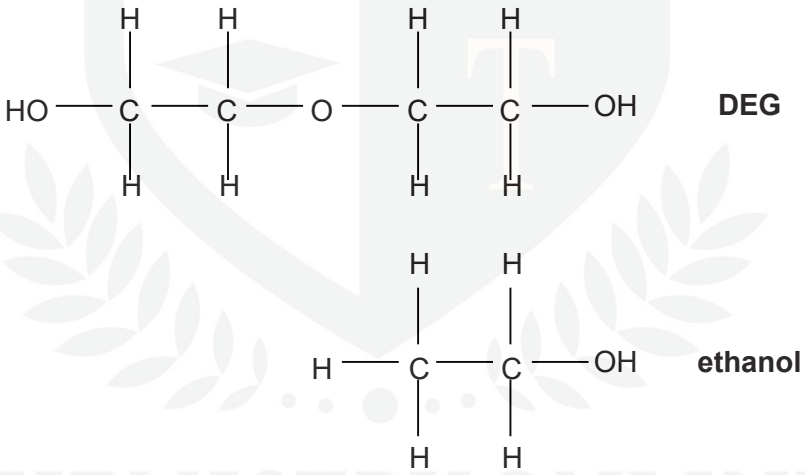
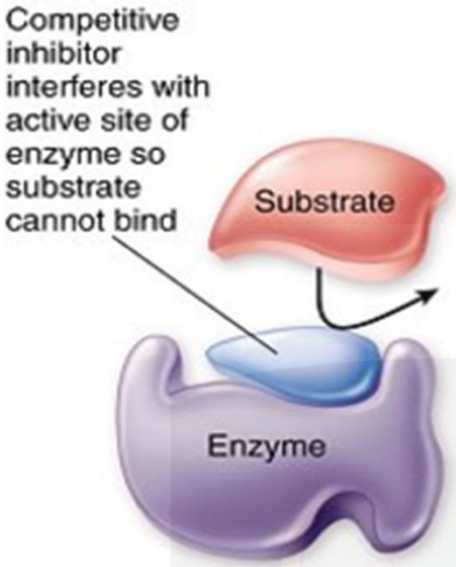


Fig. 2.1

(i) Using the information in Fig. 2.1, explain why alcohol dehydrogenase is able to break down **both** ethanol and DEG. **[3]**

- Alcohol dehydrogenase can break down both molecules because they have a similar shape
- Both molecules can fit into the active site because they have a complementary shape
- Ethanol has a similar shape to part of the DEG molecule



(ii) Suggest why DEG-contaminated wines with a high ethanol content may result in less DEG poisoning than contaminated wines with a low ethanol content. **[3]**

- Ethanol competes with DEG
- When ethanol is at a higher concentration it is more likely to collide with the active site of the enzyme
- If there is less DEG breakdown then there is a less of the toxic products

[Total: 7]

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Question 4

(a) Complete the passage below using the most appropriate terms.

Enzymes are ..... globular ..... proteins and are therefore soluble. They alter the rate of metabolic reactions and are described as biological ..... catalysts ..... .

Some enzymes, such as those found in cytoplasm, are described as

..... intracellular ..... enzymes. Other enzymes, such as those that digest food in the small intestine, are known as ..... extracellular ..... enzymes. Some medicinal drugs reduce enzyme activity. These are called enzyme ..... inhibitors. ..... . **[5]**

(b) Many enzymes are associated with non-protein molecules known as cofactors. Some cofactors are small inorganic ions.

Rennin is an enzyme that is involved in the digestion of milk. It converts soluble caseinogen in milk into insoluble casein. The cofactor Ca^{2+} is associated with this reaction.

A student wished to investigate the effect of Ca^{2+} on the action of rennin.

Describe how the student could carry out this investigation and produce valid results. **[5]**

- Five different concentrations of calcium ions should be used
- The concentration and volume of enzyme should be the same
- The concentration and volume of the substrate i.e. milk should be kept constant
- The temperature and pH should also be kept constant
- The appearance of the product or disappearance of the substrate should be measured. For example the turbidity cloudiness of the solution
- This should be measured over a fixed period of time
- Replicates, at least three, should also be carried out. These make the results more reliable and allow a statistical test to be performed
- A control should be included without any of the calcium ions, this allows a comparison to be made

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Don’t worry about the references to calcium ions and the enzyme rennin. This question may be an unfamiliar situation but it can be answered by simply using your knowledge of enzymes and how to design experiments with a view to obtaining valid results

(c) Enzyme cofactors are often derived from vitamins and minerals in the diet.

Proteins are required in large amounts in the diet whereas vitamins and minerals are required only in small amounts.

Suggest why. **[1]**

- Cofactors can be used over and over again so they are only needed in small amounts
- Cofactors are involved in enzyme action, so the total mass compared to the size of the enzyme is very small
- Proteins are used for other purposes in cells, such as channel or carrier proteins
- Some enzymes don’t need cofactors and can catalyse reactions without them

The question refers to the small amounts of vitamins and minerals needed in the diet, but the first sentence refers to cofactors as being derived from these. So the question could read, ‘proteins are required in large amounts in the diet whereas cofactors are required only in small amounts’. Cofactors are covered in topics such as respiration and photosynthesis. NAD and NADP are important cofactors involved in the transport of hydrogen atoms

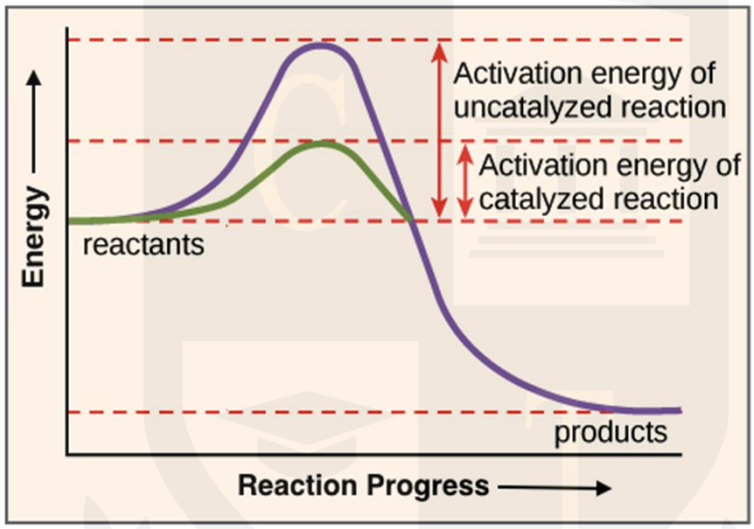
[Total: 11]

Question 5

(a) Enzymes are biological catalysts.

Explain the term *biological catalyst*. **[2]**

- The term biological catalyst refers to the fact that enzymes are proteins
- As catalysts they lower the activation energy of a reaction and are not changed or used up by the reaction(2)



(b) When the enzyme catalase is added to hydrogen peroxide, the following reaction occurs:

$$\underset{\text{hydrogen peroxide}}{H_2O_{2(l)}} \xrightarrow{\text{catalase}} 2\,H_2O_{(l)} + O_{2\,(g)}$$

In an investigation into the effect of temperature on the rate of this reaction, a student set up apparatus as shown in Fig. 2.1, using liquidised celery as a source of catalase.

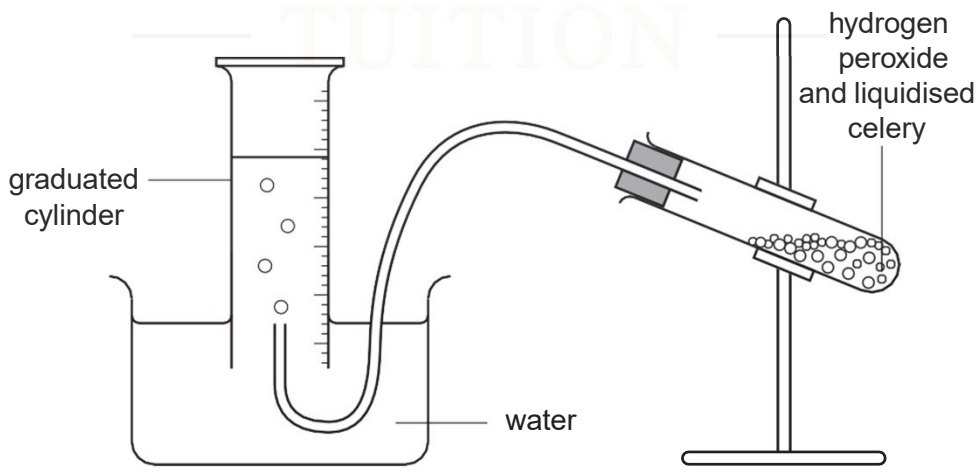


Fig. 2.1

The student measured the volume of oxygen produced at five different temperatures using samples of the liquidised celery.

(i) State the other variable that needs to be measured in order to calculate the **rate** of reaction. **[1]**

To calculate the rate you would need the time taken to measure the oxygen production at each temperature

(ii) Identify **one** potential problem with using samples of liquidised celery as a source of catalase in this investigation **and** suggest a way to minimise this problem. **[2]**

- Using samples of different extracts means they can have different concentrations of enzyme
- To overcome this problem prepare enough extract for the whole experiment
- Before removing mix the sample thoroughly
- Try to purify the extract or use a commercial source of the enzyme

Refer to the same batch of enzyme used at each temperature. Enzyme extracts are affected by the mass of tissue used and the volume of water it is in.

(iii) The student collected the data shown in Table 2.1.

Table 2.1

temperature (°C)	volume of oxygen (cm^3)
5	4
10	7
12	10
25	28
28	32

Suggest how the student could check the reliability of the data. **[2]**

- Reliability could be checked by the student carrying out more repeats
- The student could identify any anomalous results
- A mean could be calculated or a statistical test
- Error bars could be included on any graphical representation of the results

(c) Another student carried out a similar procedure and presented his results as a graph. The graph that he drew is shown in Fig. 2.2.

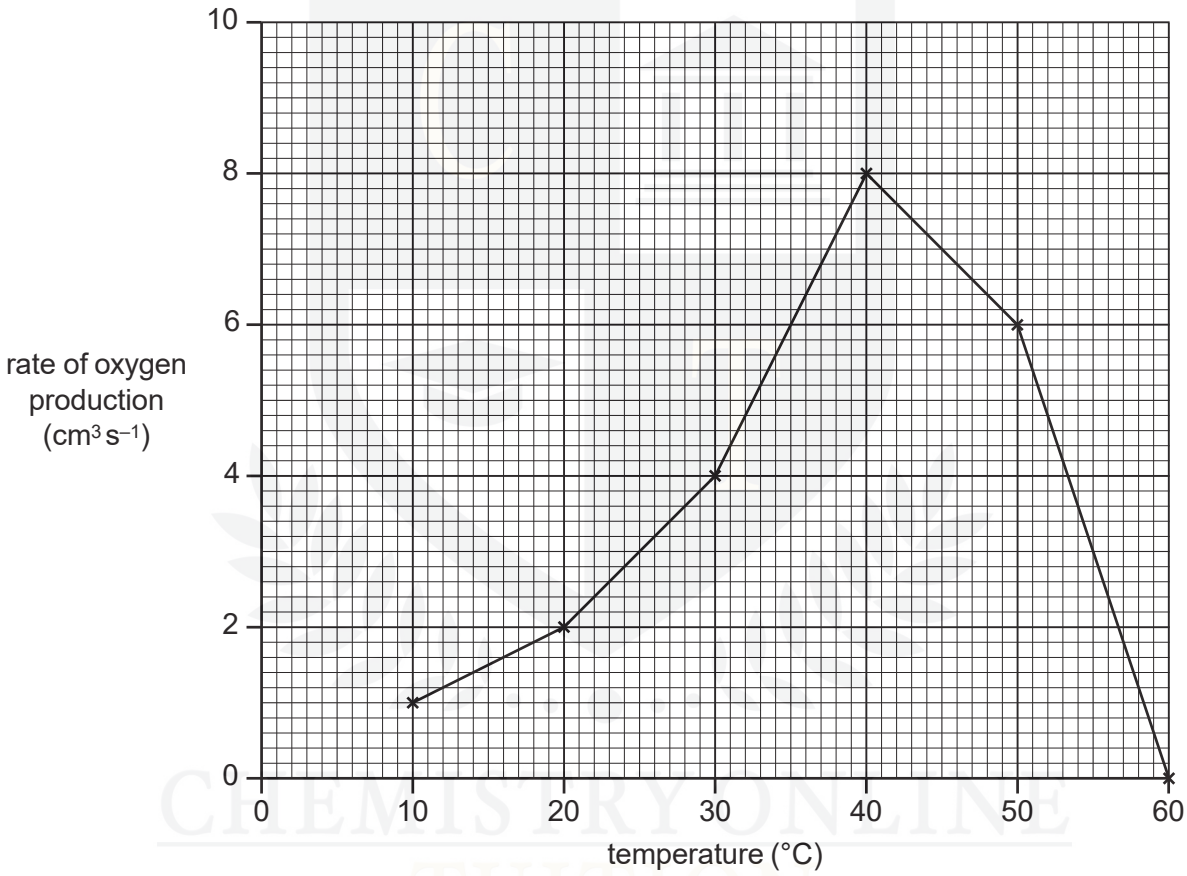


Fig. 2.2

(i) Describe the data shown in Fig. 2.2. **[4]**

- The rate of oxygen production increases as the temperature increases from 10 to 40° C
- The rate peaks or reaches a maximum at 40° C
- The drop in rate is more rapid than the rise
- There is no oxygen production at 60° C
- As the temperature increases from 10°C to 40°C the rate increases from 1 to 8 $cm^3\ s^{-1}$

If you look carefully at the graph, as the temperature increases by 10°C the rate doubles. For example at 20°C

the rate is 2 cm^3s^{-1} and doubles to 4 cm^3s^{-1} at 30°C. This is known as a Q_{10}. Note that the question is asking you to describe the data and not to explain it. You should not refer to enzyme activity, or enzymes denaturing in your answer.

***Exam tip**: **Analysing data**. Remember to annotate your graph, this will make it easier to build an answer. Read off values carefully and use a ruler, never approximate. Don't try to describe the graph all at once, better to break it down into sections. Some of the results in the graph will be subtle but deliberately put there by the examiner and, it may seem a bit laborious to keep referring to the units, but it's always safer to do so.*

(ii) Q_{10} is a measure of the increase in the rate of reaction for a 10 °C rise in temperature.

It is calculated using the following formula:

$$Q_{10} = \frac{\text{rate at } (t + 10\,°C)}{\text{rate at } t\,°C}$$

where t + 10 °C = rate at the higher temperature
t = rate at the lower temperature

Using the information in Fig. 2.2, calculate Q_{10} between 15 °C and 25 °C.

Show your working. **[1]**

- 2

The rate at 35°C is 6 cm^3s^{-1} and at 25°C it is 3 cm^3s^{-1}.

6 ÷ 3 = 2. For any enzyme catalysed reaction, up to 40°C for obvious reasons, the rate doubles for every 10°C rise

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(iii) In the conclusion to this experiment, the student wrote the following:

> **As the heat increased, the reaction went faster until it got to its highest. After this, the rate of reaction fell. This happened because the enzyme was killed and the hydrogen peroxide could not fit into the enzyme's key site.**

Suggest a more appropriate word to replace each of the underlined words.

heat should be replaced with ..... temperature .....

highest should be replaced with ..... maximum .....

killed should be replaced with ..... denatured .....

key should be replaced with ..... active ..... **[4]**

[Total: 16]

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