4 Enzymes

Structured Questions ▸▸

Level 2

1. Figure 4.1 shows the four stages in an enzyme-catalysed chemical reaction.

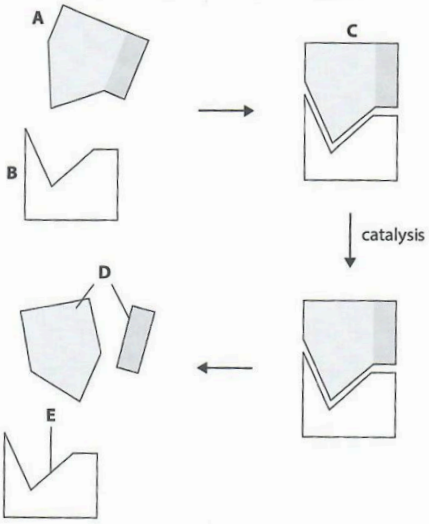

Figure 4.1

(a) Identify the molecules **A** to **D**. [4]

(b) (i) State the hypothesis used to describe the process shown. [1]

(ii) With reference to **E** in Figure 4.1, explain your answer in **(b)(i)**. [2]

Level 3

2. Every living organism is dependent on enzymes.

   (a) Define the term *enzyme* and describe the function of enzymes using a named example. [2]

   (b) Samples of the protease enzyme were incubated with proteins at different temperatures. The rate of protein digestion in each sample was recorded and plotted in Figure 4.2.

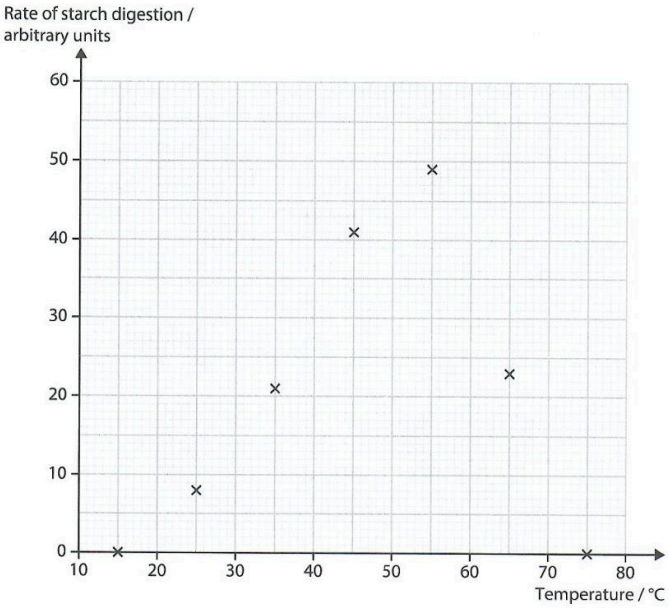

Figure 4.2

   (i) Complete the graph in Figure 4.2 by drawing a best fit curve to show the effect of temperature on the rate of protein digestion by the protease enzyme. [1]

   (ii) With reference to the graph in **(b)(i)**, state the optimum temperature for this enzyme. [1]

   (iii) Explain the effect of temperature on the rate of protein digestion. [3]

   (iv) Suggest the name of a suitable protease enzyme that could be involved in this experiment. [1]

(v) Using the protease enzyme named in **(b)(iv)**, sketch a graph in Figure 4.3 to show the effect of pH on enzyme activity. [1]

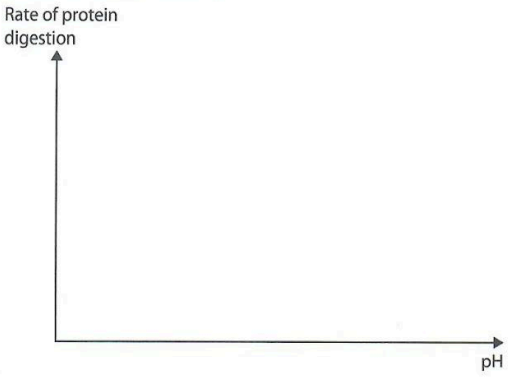

Figure 4.3

3. Egg albumen (egg white) contains proteins. Egg albumen would appear chalky in solution and will become clear when digested. An experiment is conducted to demonstrate the activity of enzymes in pancreatic juice on egg albumen under various conditions, as seen in Table 4.1.

Table 4.1

Test-tube	Contents	Observation
1	3 cm^3 of albumen + 3 cm^3 of pancreatic juice + 10 drops of distilled water	chalky
2	3 cm^3 of albumen + 3 cm^3 of pancreatic juice + 10 drops of dilute hydrochloric acid	chalky
3	3 cm^3 of albumen + 3 cm^3 of pancreatic juice + 10 drops of sodium hydrogencarbonate	clear
4	3 cm^3 of albumen + 3 cm^3 of boiled pancreatic juice + 10 drops of sodium hydrogencarbonate	chalky
5	3 cm^3 of albumen + 10 drops of distilled water	chalky
6	3 cm^3 of albumen + 10 drops of sodium hydrogencarbonate	chalky

(a) Suggest why the biuret test would be unsuitable to investigate if albumen has been digested. [1]

(b) State what can be deduced from observations shown in test-tubes **1** to **3**. Explain your answer. [3]

(c) State and explain which test-tube is suitable to serve as a control. [2]

(d) Account for the difference in observations for test-tubes **3** and **4**. [3]

(e) Suggest how the experiment can be modified to ensure that it is a fair one. [1]

4. A researcher conducted an experiment with amylase to investigate the digestion of starch in the human alimentary canal.

   The amylase was added to a starch suspension in a test-tube. The mixture was incubated at 40°C for 30 minutes.

   (a) A sample from the mixture was removed and some food tests were conducted.

   (i) Describe a reducing sugar test to be performed on the sample and state the observation you would expect from the sample. [2]

   (ii) A biuret test was carried out on the sample. It was found to form a violet colouration. Explain why. [1]

   (b) The experiment was repeated with the addition of concentrated sodium hydroxide. Another sample from the mixture was removed and the same reducing sugar test in **(a)(i)** was conducted.

   (i) State the expected observation from the reducing sugar test. [1]

   (ii) Explain your answer in **(b)(i)**. [2]

5. The enzyme catalase breaks down hydrogen peroxide into water and oxygen. An experiment is conducted at room temperature to find the effect of hydrogen peroxide concentration on the rate of reaction. The results are plotted in the graph shown in Figure 4.4.

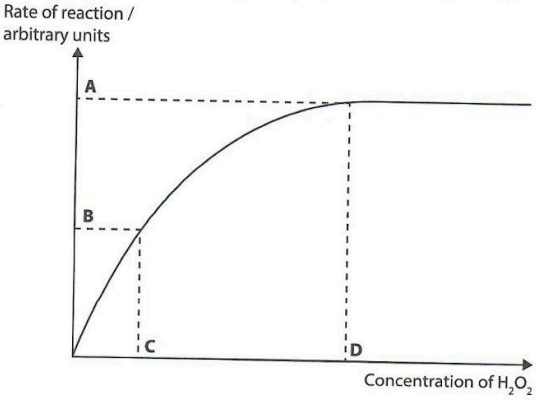

Figure 4.4

   (a) State **two** conditions that have to be kept constant to ensure a fair experiment. [2]

   (b) Account for the constant rate of reaction after point **D**. [2]

6. Figure 4.5 simulates the action of an enzyme.

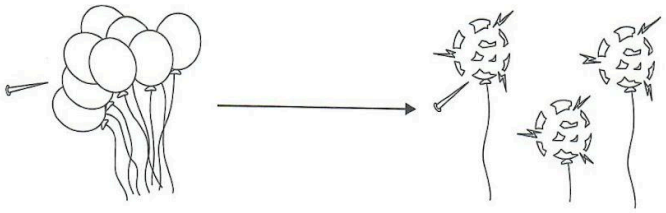

Figure 4.5

(a) With reference to Figure 4.5, state what the balloons, the sharp end of the pin and the fragments of the burst balloons represent in a typical enzyme-catalysed reaction. [3]

(b) State **one** property of enzymes the reaction in Figure 4.5 demonstrates. [1]

(c) State **two** ways in which the above model is **not** a good representation of an actual enzyme-catalysed reaction. [2]

7. A researcher conducted an investigation on the fat content of a milk sample. Figure 4.6 shows a sequence of steps in the experiment. The pH indicator used is colourless when the pH is 7 or less, and purple when the pH is over 7.

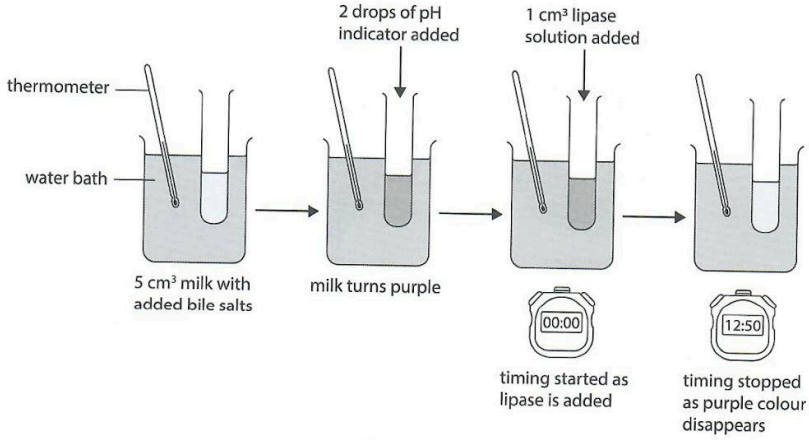

Figure 4.6

The experiment was carried out at various temperatures. The results of the experiment are shown in Table 4.2.

Table 4.2

Temperature / °C	Time Taken for Indicator to Change Colour / min
0	35
10	21
20	16
30	9
40	6
50	31

(a) Suggest what the initial colour of the pH indicator is. [1]

(b) With reference to Table 4.2, explain the trend observed in the time taken for the indicator to change colour from 0°C to 40°C. [3]

(c) Account for the time taken for the pH indicator to change colour at 50°C. [2]

(d) When another protease enzyme was used instead of lipase, there was no visible change in the colour of the pH indicator. With reference to the lock-and-key hypothesis, explain why this is so. [2]

Free-response Questions ▸▸

Level 3

8. Pepsin is an enzyme involved in the digestion of proteins. It is synthesised in the cells of the stomach as an inactive proenzyme known as pepsinogen. There is an extra peptide chain that is absent in active pepsin. Only the presence of an acidic environment of the stomach would activate pepsinogen to pepsin.

Figure 4.7 shows the structures of pepsinogen and pepsin.

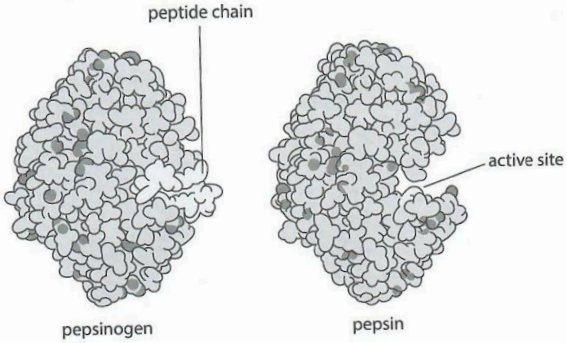

Figure 4.7

(a) With reference to Figure 4.7, use the lock-and-key hypothesis to explain why pepsinogen is unable to digest proteins. [3]

(b) Briefly describe an experiment to investigate the effect of pH on pepsin activity and how its optimum pH can be determined. [5]

(c) Predict and sketch a graph to show the effect of pH on pepsin activity and label the optimum pH. [2]

9. Thermophilic bacteria thrive in high temperatures such as hot springs. Some students investigated the effect of temperature on the rate of reaction by a lipase enzyme found in thermophilic bacteria.

Table 4.3 shows the results obtained by the students from the investigation. The rate of reaction is a measure of the amount of fatty acids produced per minute.

Table 4.3

Temperature / °C	38	43	49	63	70	76	82	87
Rate of Reaction / Arbitrary Unit per min	3	8	17	39	62	58	25	1

(a) Using the data in Table 4.3, plot a graph to show the relationship between the rate of reaction and temperature. [3]

(b) Describe and explain the shape of the graph obtained in **(a)**. [5]

(c) A person suffering from lysosomal acid lipase deficiency has a low level of lipase in the body. As a result, he is not able to break down fats and cholesterol in the body. State and explain if lipase from thermophilic bacteria is suitable to be injected into the person to help in fat digestion. [3]

10. Intestinal lipase is an enzyme found in the stomach of the human alimentary canal that digests fats into glycerol and fatty acids. An experiment was carried out to determine the effect of pH on the activity of lipase at 35°C. Table 4.4 shows the results of the experiment.

Table 4.4

pH	Time Taken for Methyl Orange Solution to Change Colour / min	Rate of Reaction / Arbitrary Unit per min
6	9	0.111
7	4	0.250
8	2	0.500
9	3	0.333
10	7	0.143
11	13	0.077

(a) (i) Using the information in Table 4.4, plot a graph of the rate of reaction against pH. [3]

(ii) Suggest the colour change of methyl orange. [1]

(iii) Using the graph obtained in **(a)(i)**, state and explain the optimum pH of this intestinal lipase. [2]

(b) In another experiment, the intestinal lipase is boiled and cooled to 30°C. Using your knowledge of the lock-and-key hypothesis, state and explain your expected results. [2]

11. A researcher conducted an experiment to investigate the effect of temperature on amylase activity. The enzyme amylase was extracted from a sample of digestive juices from the intestines of the human alimentary canal.

Six different test-tubes, each containing a mixture of cake, amylase and Benedict's solution, were placed in water baths of different temperatures. The colour of the mixture was recorded at 5-minute intervals and the results are shown in Table 4.5.

Table 4.5

Time / min	Water Bath Temperature / °C					
	5	15	25	35	45	55
5	blue	blue	blue	blue	blue	blue
10	blue	blue	blue	green	blue	blue
15	blue	blue	green	yellow	blue	blue
20	blue	green	yellow	red	green	blue
25	blue	yellow	red	red	yellow	blue

(a) Explain the colour change of the Benedict's solution. [2]

(b) With reference to Table 4.5, describe and explain the results in the test-tubes that were placed in 15°C and 35°C. [4]

(c) Explain why the test-tube at 55°C remained blue even after 25 minutes. [2]