

Exercise walk-through

5.1.1

Enzyme experiments: turning times into rates, and explaining the curve

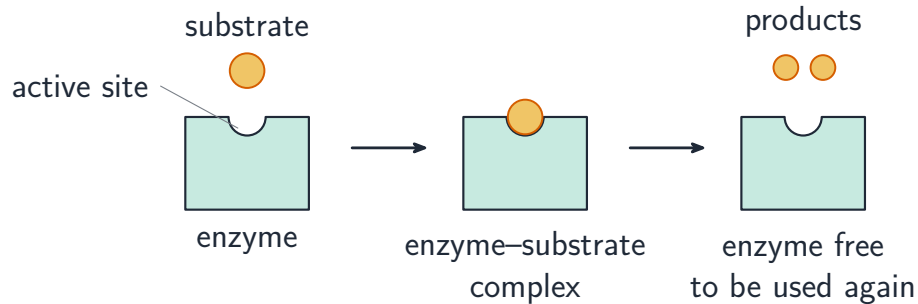
IGCSE Biology

What enzymes are



- The shape of the active site is **complementary** to the shape of the substrate – they fit together like a key in a lock.
- The substrate slots into the active site. **(Supplement)** This makes an **enzyme-substrate complex**.
- The reaction takes place, and the substrate is changed into one or more **products**.
- The products leave the active site, which is then free to be

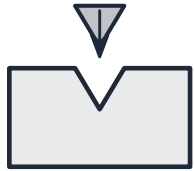
How an enzyme works



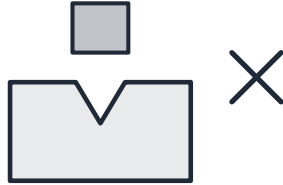
The **substrate** fits the **active site** like a key in a lock.

- shapes are **complementary**
- it forms an **enzyme-substrate complex**
- **products** leave; the enzyme is reused

Why enzymes are specific



right substrate
fits



wrong substrate
does not fit

Each enzyme is **specific** – it works on only **one** substrate. Only the right-shaped substrate fits the active site; the wrong key will not fit.

Exercise 2.1

2.1 A student timed how long amylase took to break down all the starch at three temperatures.

temperature / °C	time taken / s
20	100
30	50
40	40

Calculate the rate of reaction at each temperature, using $\text{rate} = 1000 \div \text{time}$. [3]

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Calculate the rate of reaction at each temperature, using $\text{rate} = 1000 \div \text{time}$. [3]

2.1

- divide 1000 by each time

$$\frac{1000}{100} = \mathbf{10} \quad \frac{1000}{50} = \mathbf{20} \quad \frac{1000}{40} = \mathbf{25}$$

- the units are “arbitrary units” here, because 1000 was only chosen to keep the numbers tidy

Exercises 2.2-2.4

2.2 State which temperature gave the fastest reaction, and explain how the times show this. [2]

2.3 Name the independent variable and the dependent variable in this investigation. [2]

2.4 State **two** variables the student must keep the same. [2]

Exercises 2.2-2.4

2.2 State which temperature gave the fastest reaction, and explain how the times show this. [2]

2.2

- 40 °C
- it took the **shortest time** (40 s), and a shorter time means a faster rate

2.3 Name the independent variable and the dependent variable in this investigation. [2]

2.3

- independent variable: the **temperature**
- dependent variable: the **time taken for the starch to be broken down**

2.4 State **two** variables the student must keep the same. [2]

2.4

- any **two** of: the volume or concentration of amylase; the volume or concentration of starch; the pH; the volume of iodine solution used for each test

Exercises 2.5-2.6

2.5 Explain why the reaction was faster at 40 °C than at 20 °C. Use the words *kinetic energy* and *collisions*. [3]

2.6 The student repeated the experiment at 70 °C. After 10 minutes the iodine solution was still blue-black. Explain this result. [3]

Exercises 2.5-2.6

2.5 Explain why the reaction was faster at 40 °C than at 20 °C. Use the words *kinetic energy* and *collisions*. [3]

2.5

- at 40 °C the molecules have more **kinetic energy**, so they move faster
- enzyme and substrate molecules **collide more often**, and more of those collisions are successful
- so more enzyme-substrate complexes form each second and the starch is broken down faster

2.6 The student repeated the experiment at 70 °C. After 10 minutes the iodine solution was still blue-black. Explain this result. [3]

2.6

- 70 °C is far **above the optimum temperature** for amylase
- the heat has **changed the shape of the active site**, so starch no longer fits it
- the enzyme is **denatured**, and the change is permanent, so no starch was broken down and the iodine stayed blue-black

Exercise 3.1

3.1 An enzyme breaks down its substrate in 250 s at 15 °C and in 50 s at 35 °C. How many times faster is the reaction at 35 °C? [1]

☐

A 0.2

B 5

C 200

D 300

Exercise 3.1

3.1 An enzyme breaks down its substrate in 250 s at 15 °C and in 50 s at 35 °C. How many times faster is the reaction at 35 °C? [1]

☐

A 0.2

B 5

C 200

D 300

3.1 B

- turn each time into a rate, or divide the longer time by the shorter one

$$\text{how many times faster} = \frac{\text{longer time}}{\text{shorter time}} = \frac{250 \text{ s}}{50 \text{ s}} = \mathbf{5} \text{ times faster}$$

- **A** is the division upside down, $50 \div 250$; **C** is the difference $250 - 50$; **D** is the sum $250 + 50$. None of those compares two rates.

Exercise 3.2 (a)

3.2 Pepsin digests protein in the stomach. A student timed how long pepsin took to digest a piece of cooked egg white at four pH values.

pH	time taken / s
1	120
2	60
4	200
7	no change after 600

(a) Calculate the rate of reaction at pH 2 and at pH 4, using $\text{rate} = 1000 \div \text{time}$. Give each answer to 2 significant figures. [2]

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(a) Calculate the rate of reaction at pH 2 and at pH 4, using $\text{rate} = 1000 \div \text{time}$. Give each answer to 2 significant figures. [2]

(a)

- divide 1000 by each time

$$\text{pH 2: } \frac{1000}{60} = \mathbf{17} \quad \text{pH 4: } \frac{1000}{200} = \mathbf{5.0}$$

Exercise 3.2 (b)

3.2 Pepsin digests protein in the stomach. A student timed how long pepsin took to digest a piece of cooked egg white at four pH values.

pH	time taken / s
1	120
2	60
4	200
7	no change after 600

(b) State the optimum pH of pepsin, and give the evidence from the table.

[2]

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3.2 Pepsin digests protein in the stomach. A student timed how long pepsin took to digest a piece of cooked egg white at four pH values.

pH	time taken / s
1	120
2	60
4	200
7	no change after 600

(b) State the optimum pH of pepsin, and give the evidence from the table.

[2]

(b)

- **pH 2**
- it gave the **shortest time**, 60 s, so the fastest rate; the times get longer on both sides of it

Exercise 3.2 (c)

3.2 Pepsin digests protein in the stomach. A student timed how long pepsin took to digest a piece of cooked egg white at four pH values.

pH	time taken / s
1	120
2	60
4	200
7	no change after 600

(c) Explain why no protein was digested at pH 7.

[2]

Exercise 3.2 (c)

3.2 Pepsin digests protein in the stomach. A student timed how long pepsin took to digest a piece of cooked egg white at four pH values.

pH	time taken / s
1	120
2	60
4	200
7	no change after 600

(c) Explain why no protein was digested at pH 7.

[2]

(c)

- pH 7 is far from pepsin's optimum pH, so the **shape of the active site has changed** and the protein no longer fits
- the enzyme is **denatured**, so no enzyme-substrate complexes can form

Setup for exercise 3.3

3.3 A food company uses the enzyme **pectinase** to get more juice out of crushed apples. A student investigated how temperature affects pectinase.

She put 20 g of crushed apple and 2 cm³ of pectinase into each of six test tubes. She kept each tube at a different temperature for 20 minutes, then filtered the mixture and measured the volume of juice collected.

temperature / °C	volume of juice / cm ³
10	3.0
20	5.5
30	9.0
40	12.5
50	6.0
60	0.5

Exercise 3.3 (a)

(a) Name the independent variable and the dependent variable.

[2]

Exercise 3.3 (a)

(a) Name the independent variable and the dependent variable.

[2]

(a)

- independent variable: the **temperature**
- dependent variable: the **volume of juice collected**

Exercise 3.3 (b)

(b) State **two** variables that were kept the same.

[2]

Exercise 3.3 (b)

(b) State **two** variables that were kept the same.

[2]

(b)

- any **two** of: the mass of crushed apple (20 g); the volume of pectinase (2 cm³); the time the tubes were left (20 minutes); the same apple variety; the same filter paper

Exercise 3.3 (c)

(c) Describe the results shown in the table.

[3]

Exercise 3.3 (c)

(c) Describe the results shown in the table.

[3]

(c)

- the volume of juice **rises** as the temperature rises from 10 °C to 40 °C, from 3.0 cm³ to 12.5 cm³
- the **maximum** volume is at 40 °C
- above 40 °C the volume **falls sharply**, to only 0.5 cm³ at 60 °C
- a description quotes figures off the table; it gives no reasons

Exercise 3.3 (d)

(d) Explain the results between 10 °C and 40 °C.

[3]

Exercise 3.3 (d)

(d) Explain the results between 10 °C and 40 °C.

[3]

(d)

- as the temperature rises the molecules gain **kinetic energy** and move faster
- pectinase and its substrate **collide more often**, and more of the collisions are successful
- so more of the pectin is broken down in the 20 minutes, releasing more juice

Exercise 3.3 (e)

(e) Explain why almost no juice was collected at 60 °C.

[3]

Exercise 3.3 (e)

(e) Explain why almost no juice was collected at 60 °C. [3]

(e)

- 60 °C is far **above the optimum temperature** of pectinase
- the heat has **changed the shape of the active site**, so the substrate no longer fits
- the enzyme is **denatured**, so almost no pectin was broken down and almost no extra juice was released

Exercise 3.3 (f)

(f) Suggest one change the student could make so that her results are more reliable. [1]

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(f)

- **repeat** each temperature at least three times and take a **mean** volume