

Exercise walk-through

3.1

Mode of action of enzymes

A-Level Biology

How enzymes work

Enzymes are **globular proteins** that **catalyse** reactions – **intracellular** ones work inside the cell, **extracellular** ones are **secreted** to work outside it, like amylase in the gut. The **active site** is complementary to the **substrate** .

lock and key

the site is a rigid match
for one substrate

induced fit

the site moulds around
the substrate as it binds

Both form an enzyme–substrate complex that lowers activation energy. Induced fit is the better model.

Two models of the active site

Lock-and-key

The **lock-and-key hypothesis** : the active site is a fixed shape, and only a substrate with the matching shape fits.

Induced fit

The **induced-fit hypothesis** : the site is not quite the right shape at first, and moulds itself around the substrate as it binds.

The complex

Either way the substrate forms an **enzyme–substrate complex** ; the reaction happens, the **products** leave, and the site is free again.

Specificity

An example is **amylase** , released into the gut to **digest starch** – and nothing else.

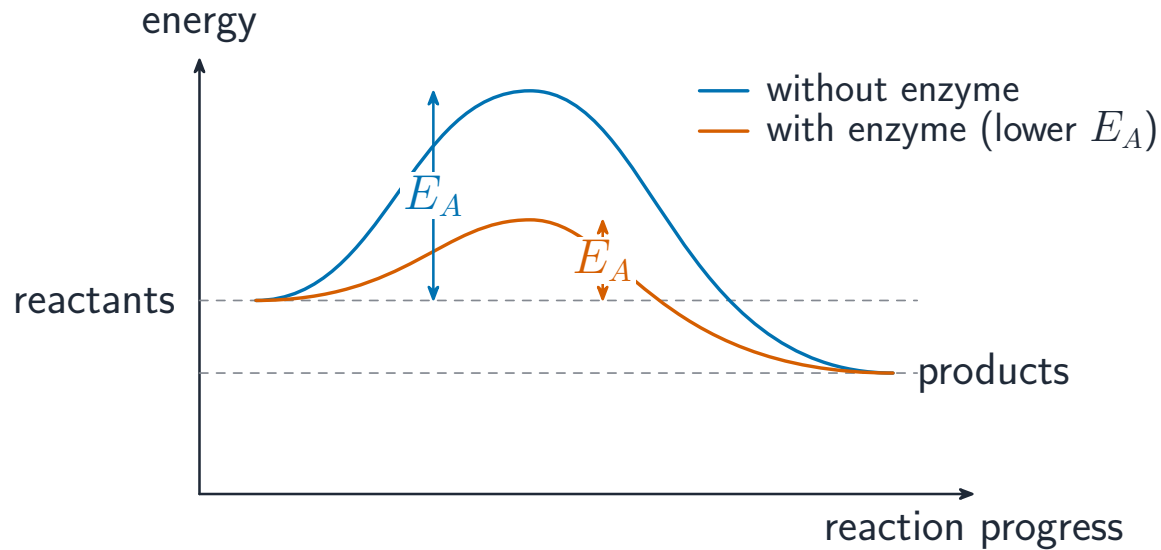
Induced fit explains what lock-and-key cannot: why binding itself strains the substrate's bonds and lowers the activation energy.

Lowering activation energy

Every reaction needs an **activation energy** to start.

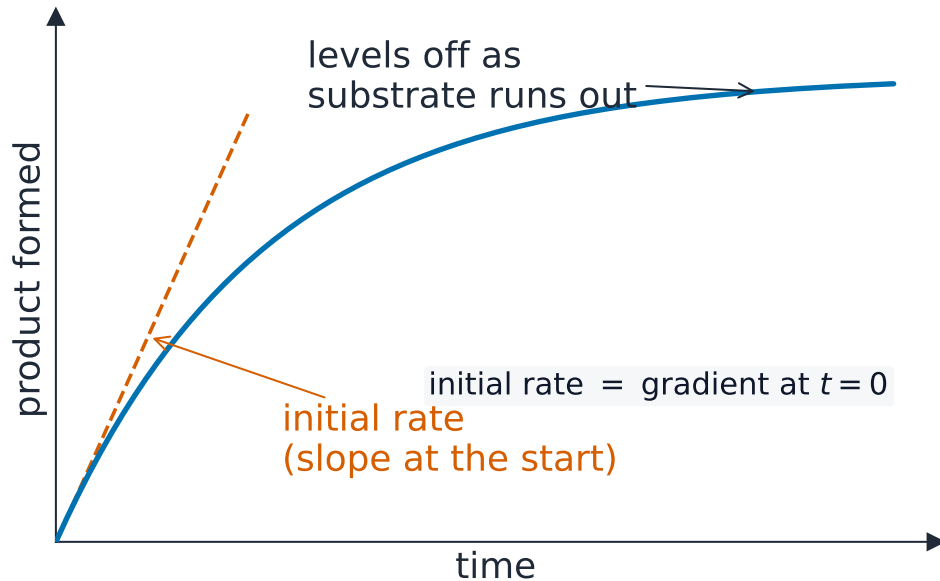
An enzyme **lowers** it, so the reaction runs fast at the cell's normal temperature – no high heat needed.

Lowering activation energy, in detail



Every reaction needs an **activation energy** to start.

Measuring the rate



Follow the product made, or the substrate used up – with amylase, the iodine test's blue-black fades. A **colorimeter** measures the absorbance, turning a colour change into a number you can plot.

Product builds fastest at the start, so the **initial rate** (slope at time zero) is the fairest value to compare.

Exercises 2.1·2.2

2.1 Put these steps of enzyme action in order: products leave · substrate enters the active site · enzyme–substrate complex forms · reaction occurs. [2]

2.2 State **one** reason the induced-fit hypothesis is preferred to the lock-and-key hypothesis. [1]

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- substrate enters the active site
- enzyme–substrate complex forms
- reaction occurs
- products leave

2.2 State **one** reason the induced-fit hypothesis is preferred to the lock-and-key hypothesis. [1]

2.2

- the active site changes shape as the substrate binds, which matches experimental evidence

Exercises 3.1-3.2

3.1 An enzyme lowers the activation energy of a reaction. This means that: [1]

☐

- A** more product is made overall
- B** the reaction releases more energy
- C** the reaction can proceed faster at a given temperature
- D** the enzyme is used up in the reaction

3.2 Why does one type of enzyme catalyse only one reaction? [1]

☐

- A** there is only one enzyme in each cell
- B** the active site is complementary to only one substrate
- C** enzymes are used up after one reaction
- D** the substrate lowers the activation energy

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- A more product is made overall
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3.1 C

- Lowering activation energy speeds the reaction; it does not change the amount of product or energy released, and the enzyme is not used up

3.2 Why does one type of enzyme catalyse only one reaction? [1]

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- A there is only one enzyme in each cell
- B the active site is complementary to only one substrate
- C enzymes are used up after one reaction
- D the substrate lowers the activation energy

3.2 B

- The active site is complementary in shape to only one substrate

Exercise 3.3 (a)

3.3 Catalase breaks down hydrogen peroxide into water and oxygen. A student collects the oxygen given off.

time / s	0	30	60	90
volume of O ₂ / cm ³	0	12	18	20

(a) Calculate the mean rate of oxygen production during the first 30 s. Give the unit.[2]

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(a) Calculate the mean rate of oxygen production during the first 30 s. Give the unit.[2]

(a)

- rate = $\frac{\text{volume}}{\text{time}} = \frac{12 \text{ cm}^3}{30 \text{ s}} = 0.40 \text{ cm}^3 \text{ s}^{-1}$

Exercise 3.3 (b)

3.3 Catalase breaks down hydrogen peroxide into water and oxygen. A student collects the oxygen given off.

time / s	0	30	60	90
volume of O ₂ / cm ³	0	12	18	20

(b) The rate between 60 s and 90 s is lower than during the first 30 s. Explain why. [2]

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(b) The rate between 60 s and 90 s is lower than during the first 30 s. Explain why. [2]

(b)

- substrate (hydrogen peroxide) has been used up / its concentration is lower, so fewer enzyme–substrate complexes form per second

Exercise 3.3 (c)

3.3 Catalase breaks down hydrogen peroxide into water and oxygen. A student collects the oxygen given off.

time / s	0	30	60	90
volume of O ₂ / cm ³	0	12	18	20

(c) Explain why the **initial rate** is the fairest measurement to use when comparing reactions. [2]

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(c) Explain why the **initial rate** is the fairest measurement to use when comparing reactions. [2]

(c)

- at the start the substrate concentration is highest, so the rate is at its true maximum and not yet slowed by substrate running out; this makes comparisons fair

Exercise 3.4

3.4 Describe how a colorimeter could be used to follow the breakdown of starch by amylase. [3]

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- prepare a colour series / calibrate with known starch concentrations using the iodine test; take samples over time and measure the absorbance/colour in the colorimeter; the blue-black colour fades as starch is digested, so absorbance falls – plot against time