Exercise walk-through

Mode of action of enzymes ▪ 3.1

eXercise

You must be able to

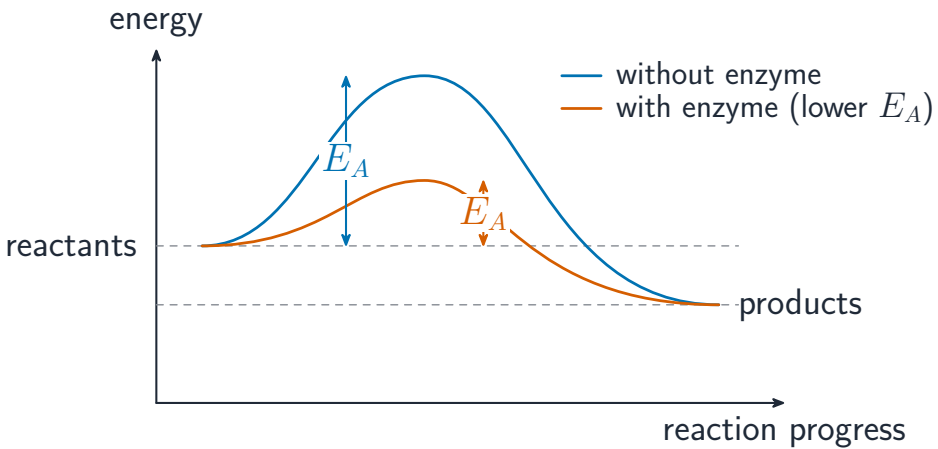
- explain how an enzyme works using active site, enzyme–substrate complex and lowering of activation energy
- compare the lock-and-key and induced-fit hypotheses
- describe how to follow a reaction (catalase, amylase, colorimeter) and calculate an initial rate

Method — How enzymes lower activation energy

Every reaction needs a "push" of energy to start — the **activation energy** (E_A). An enzyme provides a route with a **lower** E_A, so the reaction goes quickly at the cell's normal temperature.

The **substrate** 底物 binds in the active site to form an **enzyme–substrate complex**; the reaction happens, the **products** 产物 leave, and the active site is free again.

Method — How enzymes lower activation energy

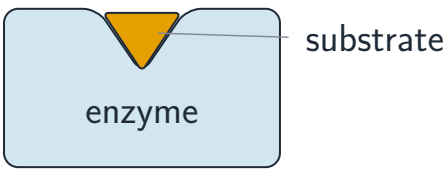


Method — Specificity: lock-and-key vs induced fit

An enzyme is **specific** — its active site is **complementary** 互补 to only one substrate. The **induced-fit** hypothesis fits the evidence better: the active site changes shape slightly as the substrate binds.

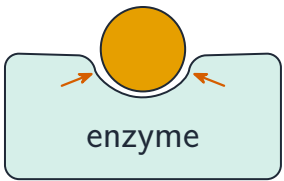
Method — Specificity: lock-and-key vs induced fit

lock-and-key



active site is a fixed shape

induced fit

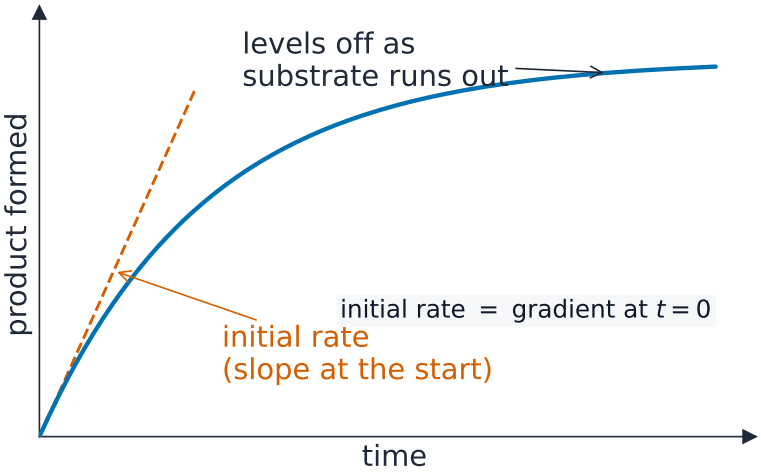


active site moulds to fit the substrate

Method — Measuring rate — the initial rate

Follow product made (e.g. O_2 from **catalase** 过氧化氢酶) or substrate lost (e.g. starch with **amylase** 淀粉酶, using the iodine test or a **colorimeter** 比色计). The reaction is fastest at the start, so the **initial rate** (slope of the tangent at time zero) is the fairest value to compare.

Method — Measuring rate — the initial rate



Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: How enzymes lower activation energy

Worked steps

substrate enters the active site → enzyme–substrate complex forms → reaction occurs → products leave **M1** **A1** *correct first/last, fully correct.*

Practice 2.2 ▪ 1 mark

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

Solution 2.2

Method: Specificity: lock-and-key vs induced fit

Worked steps

the active site changes shape as the substrate binds, which matches experimental evidence B1.

Exam-style 3.1 ▪ 1 mark

An enzyme lowers the activation energy of a reaction. This means that:

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

Solution 3.1

Method: How enzymes lower activation energy

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

Worked steps

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.

Exam-style 3.2 ▪ 1 mark

Why does one type of enzyme catalyse only one reaction?

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

Solution 3.2

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

Worked steps

B. The active site is complementary in shape to only one substrate.

Exam-style 3.3 ▪ 2 marks

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 / cm^3	0	12	18	20

(a) Calculate the mean rate of oxygen production during the first 30 s. Give the unit.
(b) The rate between 60 s and 90 s is lower than during the first 30 s. Explain why.
(c) Explain why the **initial rate** is the fairest measurement to use when comparing reactions.

Solution 3.3

Method: Measuring rate — the initial rate

Worked steps

(a) $\dfrac{12\ \text{cm}^3}{30\ \text{s}} = 0.40\ \text{cm}^3\,\text{s}^{-1}$ **M1** **A1** *with unit.*

(b) substrate (hydrogen peroxide) has been used up / its concentration is lower **M1**, so fewer enzyme–substrate complexes form per second **A1**.

(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 **M1**; this makes comparisons fair **A1**.

Exam-style 3.4 ▪ 3 marks

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

Solution 3.4

Method: Measuring rate — the initial rate

Worked steps

prepare a colour series / calibrate with known starch concentrations using the iodine test B1; take samples over time and measure the absorbance/colour in the colorimeter B1; the blue-black colour fades as starch is digested, so absorbance falls — plot against time B1.