A-LEVEL BIOLOGY • EXERCISE SHEET

3.1 Mode of action of enzymes

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS enzyme 酶 • substrate 底物 • colorimeter 比色计 • induced-fit hypothesis 诱导契合学说 • active site 活性位点

Objective

Build the skills to answer exam questions on the **mode of action of enzymes** — the **active site** 活性位点, the **enzyme–substrate complex** 酶底物复合物, lowering of **activation energy** 活化能, **specificity** 专一性, and measuring reaction rate.

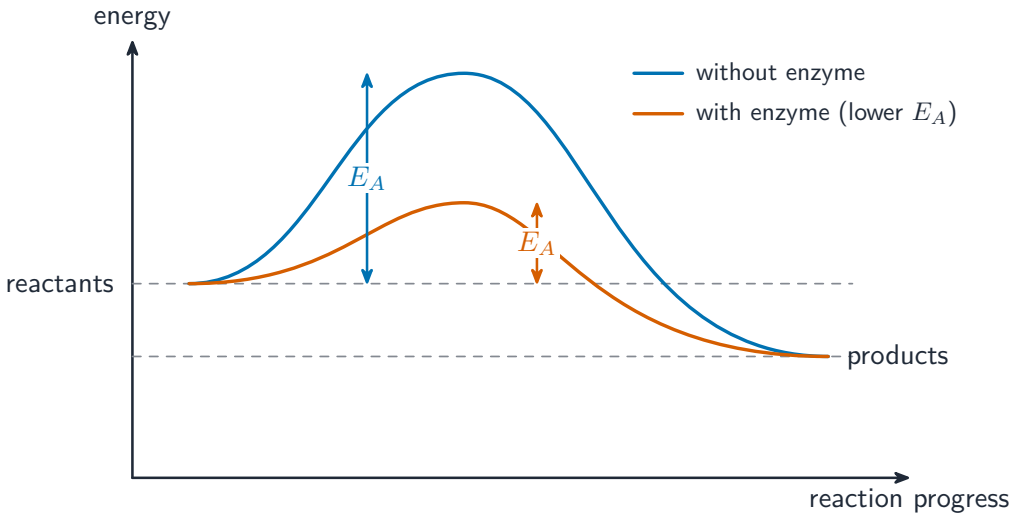
You must be able to:

- 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

1 Worked examples

■ 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.

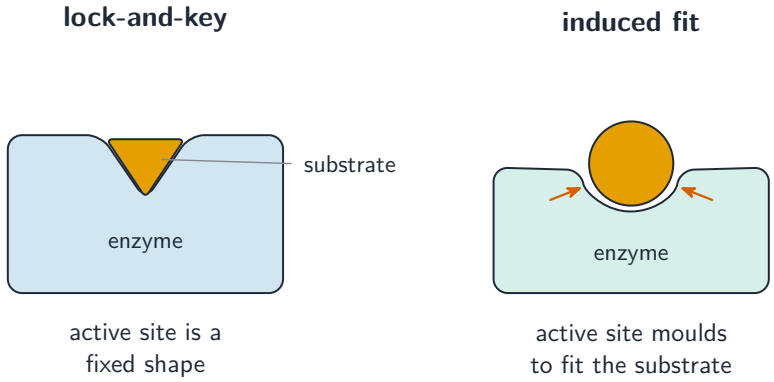


The enzyme route has a lower E_A, so more molecules have enough energy to react

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.

Specificity: lock-and-key vs induced fit

An enzyme is **specific** — its active site is **complementary** 互补 to only one substrate.

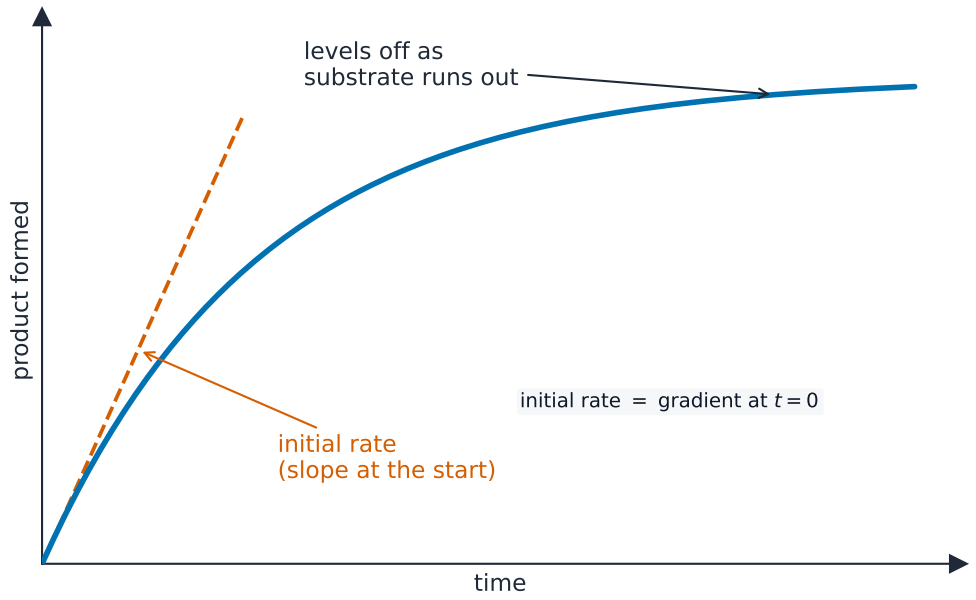


Lock-and-key: a fixed active site. Induced fit: the active site changes shape to grip the substrate

The **induced-fit** hypothesis fits the evidence better: the active site changes shape slightly as the substrate binds.

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.



Product builds fastest at the start; the initial rate is the slope of the tangent at time zero

2 Practice

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]

3 Exam-style questions

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

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]

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

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

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

Solutions

2.1 substrate enters the active site → enzyme–substrate complex forms → reaction occurs → products leave.

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

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

3.3 (a) $\dfrac{12\ \text{cm}^3}{30\ \text{s}} = 0.40\ \text{cm}^3\,\text{s}^{-1}$.
(b) substrate (hydrogen peroxide) has been used up / its concentration is lower, so fewer enzyme–substrate complexes form per second.
(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.

3.4 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.