

3.1 Mode of action of enzymes

Name: _____ Class: _____ Date: _____

Total: 14 marks

KEY WORDS enzyme • substrate • colorimeter
 • induced-fit hypothesis • active site

Objective

Build the skills to answer exam questions on the **mode of action of enzymes** – the **active site**, the **enzyme–substrate complex**, lowering of **activation energy**, **specificity**, and measuring reaction rate.

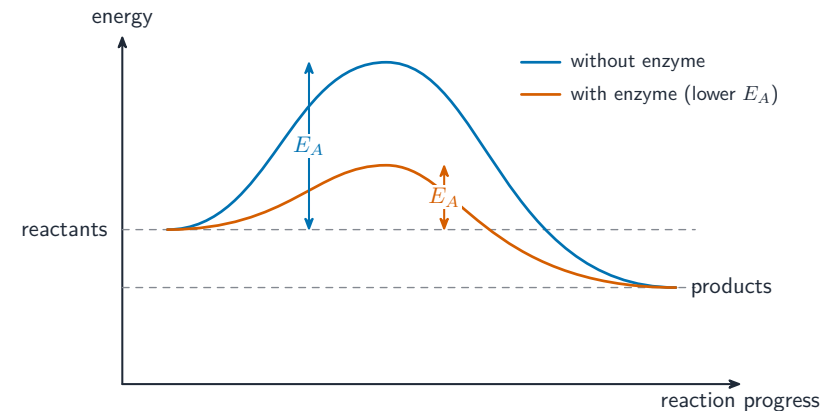
You must be able to:

- 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 Key knowledge and 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.

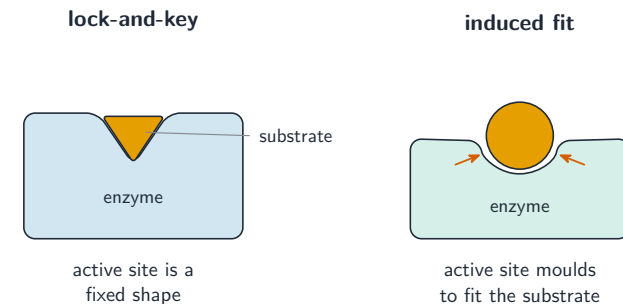


The enzyme route has a lower E_A , so more molecules have enough energy to react

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

■ Specificity: lock-and-key vs induced fit

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

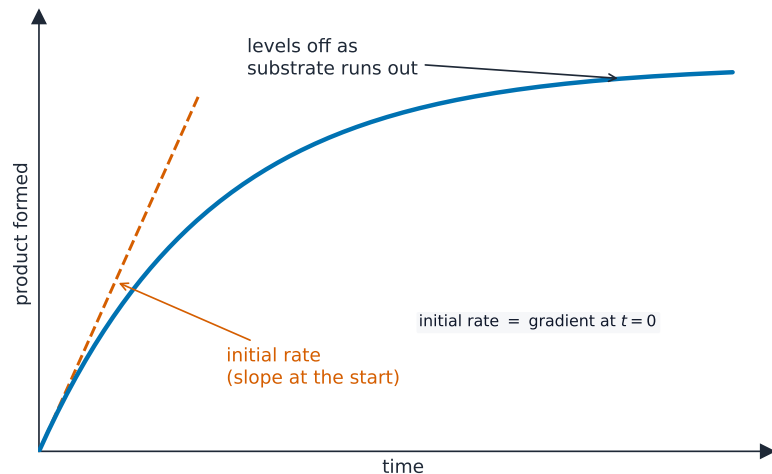


Lock-and-key: a fixed active site. Induced fit: the active site changes shape to grip the substrate

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**) or substrate lost (e.g. starch with **amylase**, using the iodine test or a **colorimeter**). 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

Each answer shows the steps, then the **result**.

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)

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

(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