

Enzymes

A-Level Biology 9700 · Topic 3 revision notes

Everything from the 2 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. How enzymes work

2. Factors that affect enzyme action

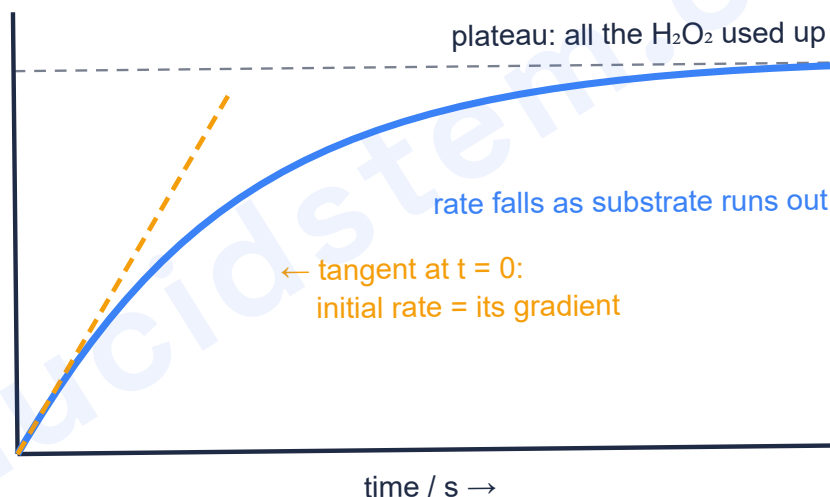
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1 How enzymes work

Syllabus 3.1

Enzymes are **globular proteins** that catalyse reactions either inside cells (**intracellular**, such as catalase) or after being secreted (**extracellular**, such as amylase in saliva). The substrate binds to the **active site**, a small region whose shape and charges are complementary to it, forming an **enzyme-substrate complex**. That makes the enzyme **specific**. In the **lock-and-key** hypothesis the site is rigid; in the **induced-fit** hypothesis it changes shape slightly as the substrate binds, straining its bonds. Either way the enzyme **lowers the activation energy**, so more collisions succeed at the same temperature, and it leaves the reaction unchanged. Reaction progress is followed by measuring **product formed** (oxygen from catalase) or **substrate lost** (starch with amylase), and the **initial rate** is used to compare conditions.

volume of O_2 collected / cm^3



catalase + hydrogen peroxide: product formed against time

Fig. 1: a progress curve for catalase; the gradient of the tangent at the start gives the initial rate

Shape, barrier, rate.

- ✓ **Active site** is complementary to the substrate, not the same shape.
- ✓ **Enzymes lower activation energy**; they do not supply energy.
- ✓ **Initial rate** = gradient of the tangent at $t = 0$.
- ✓ **Plateau** means substrate used up, not enzyme used up.

Watch out!

Say **complementary**, not the same shape. The substrate and active site fit together like a key and lock, so their shapes are complementary. Also, the enzyme is not used up: it is released unchanged and can bind another substrate molecule.

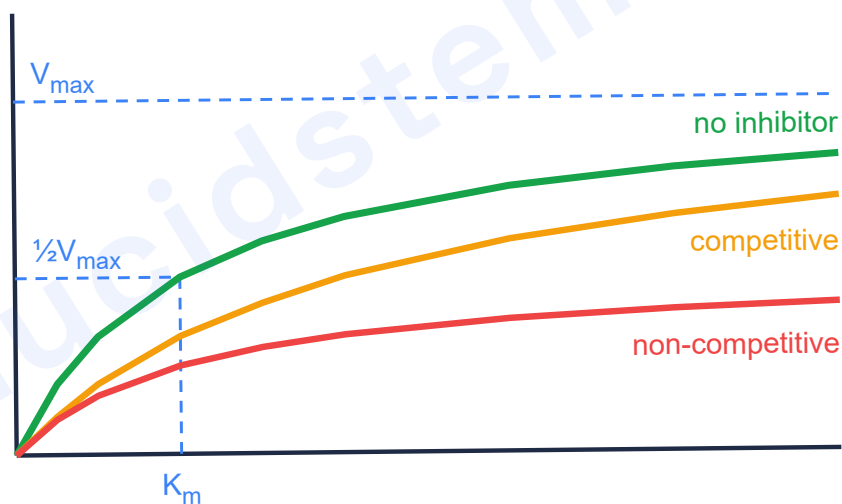
The curve levels off because the **substrate has run out**, not because the enzyme has been used up or denatured. If you add more substrate the reaction carries on at once.

2 Factors that affect enzyme action

Syllabus 3.2

Raising the **temperature** increases kinetic energy and successful collisions until the **optimum**; above it, hydrogen and ionic bonds break, the active site loses its shape and the enzyme is **denatured**. Each enzyme has an optimum **pH**, kept constant in experiments with **buffer solutions**; other pH values alter the charges on R groups in the active site. Rate rises with **enzyme concentration** while substrate is in excess, and with **substrate concentration** until every active site is occupied and the rate reaches V_{max} . The **Michaelis-Menten constant** K_m is the substrate concentration giving $\frac{1}{2}V_{max}$; a **low K_m means high affinity**. A **competitive** inhibitor competes for the active site (V_{max} unchanged, K_m raised); a **non-competitive** inhibitor binds elsewhere and changes the active site (V_{max} lowered). Enzymes **immobilised in alginate** can be reused, do not contaminate the product and are more stable.

rate of reaction



substrate concentration →

low K_m : half of the top rate is reached at a low [S], so high affinity

Fig. 1: rate against substrate concentration with no inhibitor, a competitive inhibitor and a non-competitive inhibitor

Collisions, shape, sites.

- ✓ **Temperature and pH:** explain via collisions and active site shape.
- ✓ **K_m** = $[S]$ at $\frac{1}{2}V_{max}$: low K_m = high affinity.
- ✓ **Competitive:** V_{max} same, K_m up. **Non-competitive:** V_{max} down.
- ✓ **Immobilised:** reusable, pure product, more stable.

Watch out!

Do not write that enzymes are killed: they are not alive. Say the enzyme is **denatured** and explain it: bonds in the tertiary structure break, the active site loses its complementary shape, and fewer enzyme-substrate complexes form.

A competitive inhibitor does **not** lower V_{max} : at a very high substrate concentration the substrate out-competes it. Only a non-competitive inhibitor lowers V_{max} . And K_m is a substrate concentration, read on the x-axis, not a rate.