

# Enzymes

## IGCSE Biology

### What enzymes are



*Biological washing powders contain enzymes that break down stains.*

Image: Kritzolina, CC BY-SA 4.0 (commons.wikimedia.org)

A **catalyst** 催化剂 is a substance that speeds up the **rate** 速率 of a **chemical reaction** 化学反应 but is **not** used up or changed by the reaction. The same catalyst can be used again and again.

**Enzymes** 酶 are biological catalysts —catalysts made by living cells. They are **proteins** 蛋白质. Enzymes take part in all the reactions of **metabolism** 新陈代谢, so they control almost every chemical reaction in a living thing.

Enzymes are vital. Without them, the reactions that keep you alive would be far too slow. Enzymes raise the reaction rate enough to keep the organism alive.

## How an enzyme works

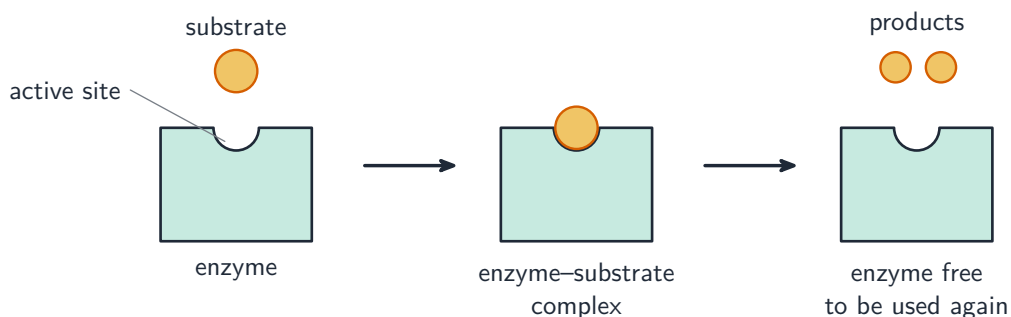


*Kiwi fruit contains a protease enzyme that breaks down protein.*

Image: Luc Viatour, CC BY-SA 2.5 (commons.wikimedia.org)

Each enzyme has a special pocket called its **active site** 活性位点. The **molecule** 分子 it works on is called the **substrate** 底物.

- The shape of the active site is **complementary** 互补 to the shape of the substrate—they fit together like a key in a lock.
- The substrate slots into the active site. **(Supplement)** This makes an **enzyme-substrate complex** 酶底物复合物.
- The reaction takes place, and the substrate is changed into one or more **products** 产物.
- The products leave the active site, which is then free to be used again.



*The substrate fits the active site like a key in a lock, then leaves as products*

## Why enzymes are specific (Supplement)

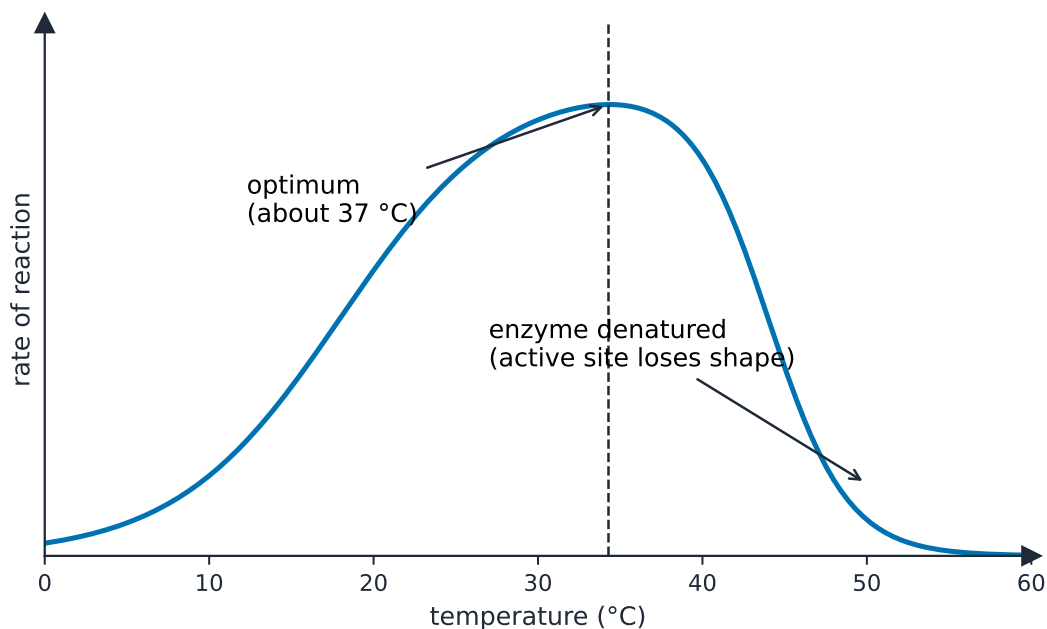
Each enzyme is **specific** 专一—it works on only one kind of substrate. This is because only that substrate has the right shape to fit the active site. A substrate of a different shape will not fit, just as the wrong key will not open a lock.

## The effect of temperature and pH

The activity of an enzyme depends on **temperature** 温度 and pH. You can investigate this by measuring how fast the reaction goes at different temperatures or pH values.

### Temperature

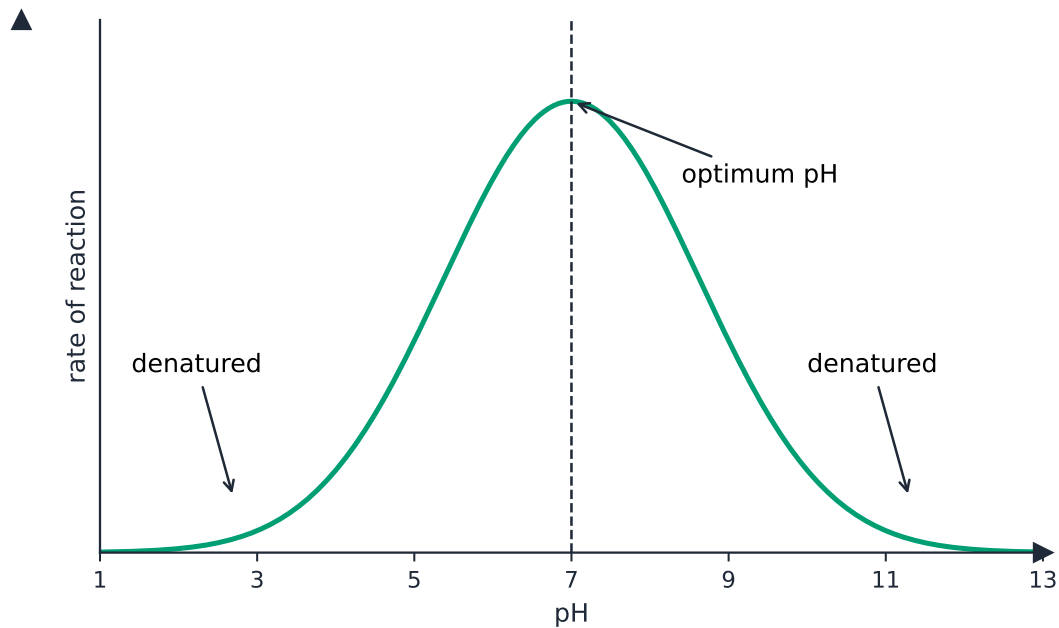
- As the temperature rises from cold, enzyme activity speeds up. The enzyme and substrate molecules have more **kinetic energy** 动能, so they move faster and meet more often. (**Supplement**) There are more useful **collisions** 碰撞 each second.
- Activity is highest at the **optimum temperature** 最适温度 (about 37 °C in the human body).
- Above the optimum, activity falls fast. The heat changes the shape of the active site, so the substrate no longer fits. The enzyme is **denatured** 变性. Denaturation is permanent —the enzyme cannot recover.



*Activity peaks at the optimum temperature, then falls sharply as the enzyme denatures*

### pH

- Each enzyme works best at one particular pH.
- If the pH is too high or too low, the shape of the active site changes, the substrate stops fitting, and the enzyme is denatured.



*Each enzyme has one optimum pH; far from it the enzyme is denatured*

## Exam tips

- An enzyme is both a **protein** and a biological catalyst: it speeds up a reaction and is **not** used up.
- Describe the shape: the active site is **complementary** to the substrate (the lock-and-key idea). Each enzyme is **specific** to one substrate.
- Low temperature → slow (too little kinetic energy). Optimum → fastest. Too hot → **denatured** (the active site loses its shape, permanently).
- The wrong pH also **denatures** the enzyme by changing the shape of the active site.
- "Denatured" does **not** mean "killed" —enzymes are not alive. Say that the shape of the active site has changed so the substrate no longer fits.