

# 3 Enzymes – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary

*Write each word three times.*

| English                   | Write it 3 times (English) |       |       |
|---------------------------|----------------------------|-------|-------|
| enzyme                    | _____                      | _____ | _____ |
| active site               | _____                      | _____ | _____ |
| substrate                 | _____                      | _____ | _____ |
| rate                      | _____                      | _____ | _____ |
| kinetic energy            | _____                      | _____ | _____ |
| collide                   | _____                      | _____ | _____ |
| optimum temperature       | _____                      | _____ | _____ |
| denatures                 | _____                      | _____ | _____ |
| optimum pH                | _____                      | _____ | _____ |
| buffer solution           | _____                      | _____ | _____ |
| Michaelis–Menten constant | _____                      | _____ | _____ |
| high affinity             | _____                      | _____ | _____ |
| inhibitor                 | _____                      | _____ | _____ |
| competitive inhibitor     | _____                      | _____ | _____ |
| non-competitive inhibitor | _____                      | _____ | _____ |

**Write it 3 times** (English)

|             |     |
|-------------|-----|
| immobilised | en- |
| zyme        |     |

## Recall

From Part 1 you know an **enzyme** has an **active site** that fits its **substrate**. Here we look at what changes the **rate** of an enzyme reaction.

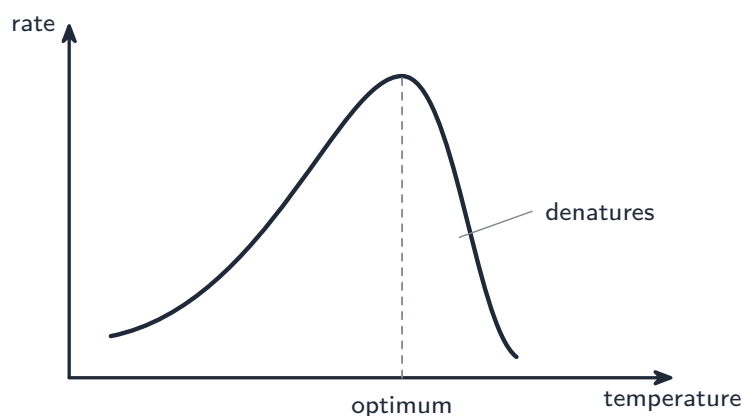
- At IGCSE you saw enzymes have a best (optimum) temperature and pH.
- Now we add the idea of *denaturing* and how to read the graphs.

## New ideas

Read these first, then do the Practice.

- 1 Temperature

As temperature rises, molecules gain **kinetic energy** and **collide** more often, so the rate rises. But above the **optimum temperature** the heat breaks the bonds holding the enzyme's shape – it **denatures**. The active site changes, the substrate no longer fits, and the rate falls fast.



■ 2 pH

Each enzyme has an **optimum pH** pH. Move the pH too far from it and the enzyme denatures, so the rate drops. A **buffer solution** is used to keep pH steady in an experiment.

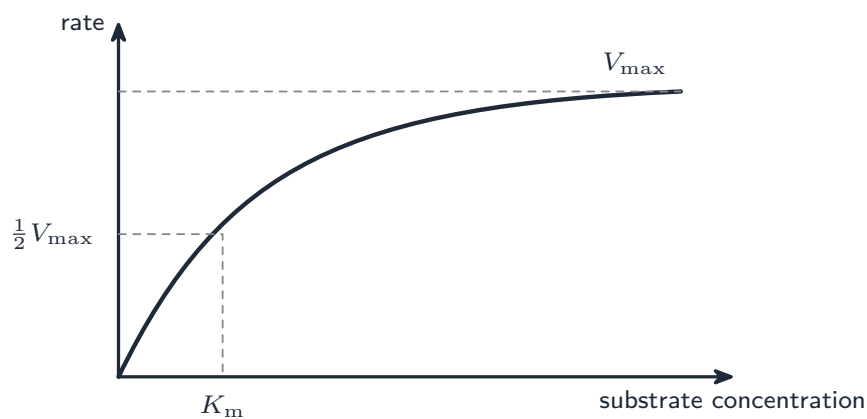
### ■ 3 Concentration

- more **enzyme** (with plenty of substrate) → more active sites → faster, in proportion.
- more **substrate** → faster at first, then it levels off once every active site is busy.

### ■ 4 $V_{\max}$ and $K_m$

The levelling-off rate, when all active sites are full, is the maximum rate,  $V_{\max}$ .

The **Michaelis–Menten constant** ( $K_m$ ) is the substrate concentration that gives **half** of  $V_{\max}$ . A **low**  $K_m$  means a **high affinity** (the enzyme grips its substrate strongly).



### ■ 5 Inhibitors

An **inhibitor** slows an enzyme. Two reversible types:

- **competitive inhibitor** – binds in the active site; more substrate out-competes it.
- **non-competitive inhibitor** – binds elsewhere and changes the active site; more substrate does not help.

An **immobilised enzyme** is fixed in place (e.g. trapped in beads) so it can be reused and is not washed away.

**Watch out:** above the optimum, heat *denatures* the enzyme – the shape change is *permanent*, so the rate does *not* recover on cooling. A competitive inhibitor (in the active site) is overcome by *more* substrate; a non-competitive one is not.

## Practice

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Try these in order.

**3.1** Explain why an enzyme reaction speeds up as temperature rises from 10 °C to its optimum. [2]

**3.2** What is meant by *denature*? [1]

**3.3** Why is a buffer solution used when studying the effect of temperature on an enzyme? [1]

**3.4** Adding more substrate speeds the reaction at first, then has no effect. Explain why it has no effect at high concentration. [2]

**3.5** Define the Michaelis–Menten constant,  $K_m$ . [1]

**3.6** State where (a) a competitive and (b) a non-competitive inhibitor bind on an enzyme. [2]

**3.7 Challenge.** Adding more substrate reverses the effect of a competitive inhibitor, but not a non-competitive one. Explain why. [2]

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