IGCSE BIOLOGY • EXERCISE SHEET

5.1 Enzymes

Name: ____________ Class: ________ Date: __________ **Total: 29 marks**

KEY WORDS enzyme 酶 • temperature 温度 • rate 速率 • catalyst 催化剂 • biological catalyst 生物催化剂

Objective

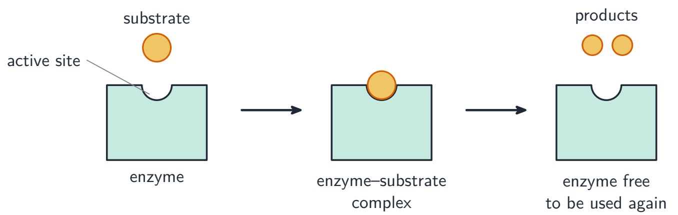
Build the skills to answer exam questions on **enzymes** 酶 — what they are, the **active site** 活性位点 and lock-and-key model, and the effects of **temperature** 温度 and **pH**.

You must be able to:

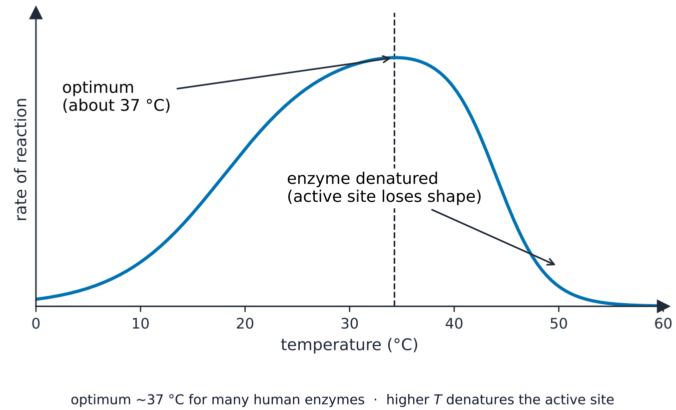
- describe enzymes as biological catalysts (proteins, not used up)
- explain enzyme action with the active site/substrate (specificity)
- explain the effect of temperature and pH, including denaturation

1 Worked examples

■ Lock-and-key and temperature



The substrate fits the active site (complementary shape); each enzyme is specific to one substrate



Above the optimum the active site loses its shape — the enzyme is denatured (permanent)

■ Enzymes: the model, the graphs, and the words that earn marks

An **enzyme** 酶 is a **biological catalyst** 生物催化剂 — a protein that speeds up a reaction and is not used up, so one molecule works over and over. Each enzyme has an **active site** 活性位点 whose shape is **complementary** to its **substrate** 底物; that is why an enzyme is **specific** 专一的 and works on one substrate only. This is the **lock-and-key** model.

Temperature. Below the optimum, raising the temperature raises the rate: molecules have more **kinetic energy**, so enzyme and substrate collide more often and more successfully. Above the optimum the rate falls **sharply**: bonds holding the enzyme's shape break, the active site **changes shape**, the substrate no longer fits, and the enzyme is **denatured** 变性 — permanently, so cooling it does not restore activity.

pH. Each enzyme has an optimum pH; either side of it the rate falls, and far from it the enzyme is denatured for the same reason. Pepsin works best at about pH 2 in the stomach; amylase at about pH 7 in the mouth.

△ **Three words that lose marks.** An enzyme is **denatured**, never *killed* — it is not alive. It is the **active site** that changes shape, not "the enzyme stops working". And an enzyme is **not used up**, so "it runs out" is wrong.

Worked example. A reaction is run at 20 °C, 37 °C and 60 °C. Describe and explain the rates.

1. At 20 °C the rate is slow: little kinetic energy, so few successful collisions.
2. At 37 °C the rate is fastest: this is near the optimum for a human enzyme, with the most successful collisions per second.

3. At 60 °C the rate is very low: the enzyme has been denatured, its active site no longer fits the substrate, and the change is permanent.

2 Practice

2.1 Define a catalyst. [1]

2.2 State the type of molecule that all enzymes are made of. [1]

2.3 State two conditions that can denature an enzyme. [2]

2.4 Explain why an enzyme works on only one substrate. [2]

2.5 Predict what happens to the rate if the substrate concentration is raised while enzyme concentration stays the same. [2]

3 Exam-style questions

3.1 Above its optimum temperature, an enzyme's rate falls because the enzyme is: [1]

- **A** used up
- **B** denatured (active site changes shape)
- **C** killed
- **D** diluted

3.2 An enzyme has a specific substrate.

(a) Explain, using the lock-and-key model, why an enzyme is specific. [2]

(b) Explain why a very low pH reduces the enzyme's activity. [2]

3.3 Explain why enzyme activity increases as the temperature rises from 10 °C to 37 °C. [2]

3.4 A student measures how fast the enzyme catalase breaks down hydrogen peroxide, by counting the oxygen bubbles released each minute at different temperatures.

(a) Complete the table by predicting the relative rate at each temperature. [3]

Temperature / °C	Predicted rate (high / medium / very low)
10	
40	
70	

(b) Explain the rate you predicted at 10 °C. [2]

(c) Explain, in terms of the active site, why the rate at 70 °C is very low and does not recover on cooling. [3]

(d) State two variables the student must keep constant. [2]

(e) The student repeats the experiment at pH 3 and pH 7 at 40 °C, and finds the rate is much lower at pH 3. Explain this result. [2]

(f) State why the enzyme does not need replacing after each reaction. [2]

Solutions

2.1 a substance that speeds up a reaction but is not used up (changed) by it.

2.2 protein.

2.3 A temperature above the optimum; a pH far from the optimum.

2.4 The active site has a shape complementary to one particular substrate; a different substrate does not fit into it, so no reaction is catalysed.

2.5 The rate increases at first, then levels off because all the active sites are occupied and the enzyme concentration becomes the limiting factor.

3.1 B. The active site changes shape — the enzyme is denatured.

3.2 (a) the active site has a shape complementary to one substrate; only that substrate fits, so the enzyme works on only one reaction.
(b) the wrong pH changes the shape of the active site; so the substrate no longer fits and the enzyme is denatured.

3.3 the molecules gain kinetic energy and move faster; so enzyme and substrate collide more often (giving more successful reactions).

3.4 (a) 10 °C: medium, or low; 40 °C: high; 70 °C: very low.
(b) The molecules have little kinetic energy at 10 °C, so enzyme and substrate collide less often and fewer collisions are successful.
(c) At 70 °C the bonds holding the enzyme's shape are broken; the active site changes shape so the substrate no longer fits; the enzyme is denatured, and the change is permanent, so cooling does not restore its activity.
(d) Any two of: the concentration and volume of hydrogen peroxide; the mass or concentration of catalase; the pH; the time counted.
(e) pH 3 is far from catalase's optimum of about pH 7; the active site's shape is altered, so fewer substrate molecules fit and the rate falls.
(f) An enzyme is a catalyst and is not used up in the reaction, so the same molecule catalyses the reaction again and again.