Week 8

A-Level Biology

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Biology Name: _____ Score: _____

1. Which best describes an enzyme?
   - ☐ a globular protein that catalyses a reaction and is not used up
   - ☐ a carbohydrate that is broken down in the reaction
   - ☐ a lipid used up as the reaction goes
   - ☐ a fibrous protein that gives support
2. Why is the initial rate (slope at time zero) the fairest value to compare?
   - ☐ the reaction is fastest then, with the most substrate present
   - ☐ the reaction has stopped
   - ☐ the enzyme has denatured
   - ☐ all product has been made
3. What does V_max represent?
   - ☐ the maximum rate, reached when all active sites are occupied
   - ☐ the substrate concentration at the start
   - ☐ the rate with no enzyme
   - ☐ the optimum temperature
4. Select **all** the correct statements about where enzymes work.
   - ☐ Catalase breaks down hydrogen peroxide **inside** the cell (intracellular)
   - ☐ Amylase is **secreted** to digest starch outside the cell (extracellular)
   - ☐ An extracellular enzyme works inside the cell that made it
   - ☐ Because it is a catalyst, an enzyme is not used up and works repeatedly

   Tick every correct option.
5. Above the optimum temperature, the rate falls steeply because the enzyme:
   - ☐ denatures — its shape changes so the active site no longer fits the substrate
   - ☐ is used up
   - ☐ gains more kinetic energy
   - ☐ becomes a substrate
6. An enzyme has V_max = 80 units. At a substrate concentration equal to its Km, what is the rate?

_____ units

7. An enzyme is specific because:

   ☐ its active site is complementary in shape to only one substrate

   ☐ it can bind any molecule

   ☐ it is made of carbohydrate

   ☐ it is used up by its substrate

8. To stop pH changing while you vary temperature, keep it constant with a _____ solution.

   _____

9. A LOW Km means the enzyme only reaches half its maximum rate at a HIGH substrate concentration.

   ☐ True ☐ False

10. In the induced-fit model the active site is completely rigid and never changes shape.

    ☐ True ☐ False

3. Enzymes

Answers · 答案

A-Level Biology

1. **a globular protein that catalyses a reaction and is not used up**

   Enzymes are globular protein catalysts: they speed reactions and are not used up, so each one works again and again.

2. **the reaction is fastest then, with the most substrate present**

   At the start the most substrate is present, so the rate is highest and not yet limited by substrate running out.

3. **the maximum rate, reached when all active sites are occupied**

   V_max is the top rate; the curve flattens there because every active site is busy.

4. **Catalase breaks down hydrogen peroxide inside the cell (intracellular); Amylase is secreted to digest starch outside the cell (extracellular); Because it is a catalyst, an enzyme is not used up and works repeatedly**

   Catalase is intracellular and amylase is extracellular. Extracellular means it works **outside** the cell, so the third statement is false.

5. **denatures — its shape changes so the active site no longer fits the substrate**

   Heat breaks the bonds holding the enzyme's shape; the active site changes and can no longer bind the substrate.

6. **40 units**

   By definition Km is the substrate concentration that gives **half** of V_max, so the rate is $80 \div 2 = 40$ units.

7. **its active site is complementary in shape to only one substrate**

   Specificity comes from the active site's shape being complementary to one substrate and no other.

8. **buffer**

   A buffer resists pH change, so pH stays controlled while temperature is the only variable.

9. **False**

   The opposite: low Km means half-speed is reached at LOW substrate — a high affinity, gripping the substrate tightly.

10. **False**

    That describes lock-and-key. In induced fit the active site moulds around the substrate as it binds — a tighter grip that fits the evidence better.

A-LEVEL BIOLOGY • EXERCISE SHEET

3.1 Mode of action of enzymes

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS enzyme 酶 • substrate 底物 • colorimeter 比色计 • induced-fit hypothesis 诱导契合学说 • active site 活性位点

Objective

Build the skills to answer exam questions on the **mode of action of enzymes** — the **active site** 活性位点, the **enzyme–substrate complex** 酶底物复合物, lowering of **activation energy** 活化能, **specificity** 专一性, and measuring reaction rate.

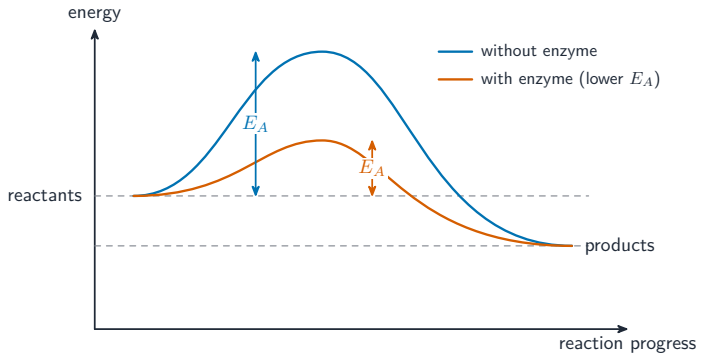
You must be able to:

- 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 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.

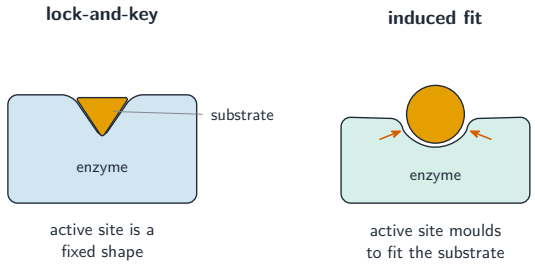


The enzyme route has a lower E_A, so more molecules have enough energy to react

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

■ Specificity: lock-and-key vs induced fit

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

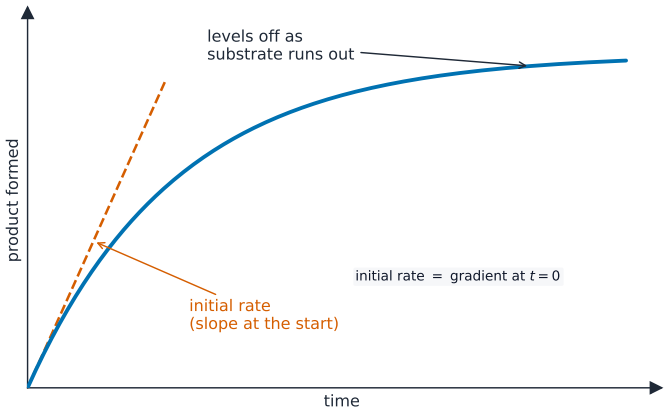


Lock-and-key: a fixed active site. Induced fit: the active site changes shape to grip the substrate

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** 过氧化氢酶) or substrate lost (e.g. starch with **amylase** 淀粉酶, using the iodine test or a **colorimeter** 比色计). 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

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.

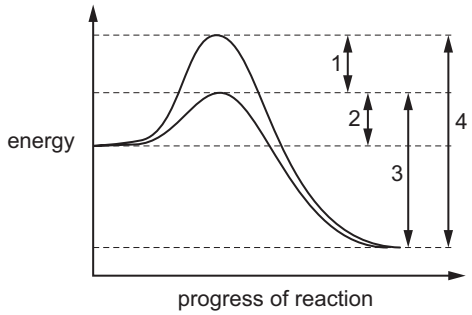
3.1 C. Lowering activation energy speeds the reaction; it does not change the amount of product or energy released, and the enzyme is not used up.

3.2 B. The active site is complementary in shape to only one substrate.

3.3 (a) $\dfrac{12\ \text{cm}^3}{30\ \text{s}} = 0.40\ \text{cm}^3\,\text{s}^{-1}$.
(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.

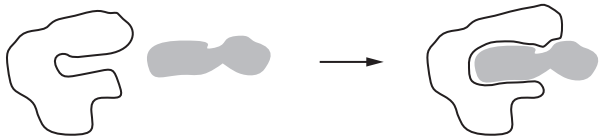
13 The graph shows energy changes in a chemical reaction.



What is the activation energy when an enzyme is added?

A 1 + 2 **B** 2 only **C** 3 – 2 **D** 4

14 The diagram shows an enzyme, its substrate and an enzyme–substrate complex.



Which statement explains how this substrate is able to enter the active site of this enzyme?

A Contact between the substrate and the enzyme causes a change in the enzyme shape.

B The shape of the active site and the shape of the substrate are complementary.

C The substrate within the active site forms hydrogen bonds with amino acids.

D When the enzyme–substrate complex forms, the tertiary structure of the enzyme changes.

9 Enzyme P has been found in a tropical grass.

- The enzyme catalyses the hydrolysis of the fungal polysaccharide, chitin, into amino sugars.
- It also inhibits the activity of an enzyme in locust guts which catalyses the digestion of amylose.

Which row describes the actions of enzyme P?

	reaction catalysed	reaction inhibited
A	hydrolysis of glycosidic bonds	condensation of glycosidic bonds
B	hydrolysis of glycosidic bonds	hydrolysis of glycosidic bonds
C	hydrolysis of peptide bonds	condensation of glycosidic bonds
D	hydrolysis of peptide bonds	hydrolysis of glycosidic bonds

13 What is the effect of an enzyme in an enzyme-catalysed reaction?

A decreases the activation energy and decreases the energy yield

B decreases the activation energy and has **no** effect on the energy yield

C increases the activation energy and increases the energy yield

D decreases the activation energy and increases the energy yield

15 Which descriptions of enzymes that use the lock-and-key hypothesis are correct?

1 The active site is complementary to the substrate the enzyme acts on.

2 Bonds that form in the enzyme–substrate complex change the shape of the active site.

3 Most of the amino acids in an enzyme help to maintain the specific shape of the enzyme.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 3 only

13 Which statements describe the action of an extracellular enzyme?

1 synthesis of a polynucleotide in the nucleus during DNA replication

2 digestion of macromolecules in the lumen of the small intestine

3 synthesis of ATP molecules in the mitochondria

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 2 only

14 Which statement about the induced-fit hypothesis of enzyme action is correct?

A An enzyme that uses the induced-fit mechanism will increase the activation energy of a reaction.

B The binding of a substrate causes conformational changes in an enzyme.

C The active site of an enzyme changes to become the same shape as the substrate.

D An enzyme that uses an induced-fit mechanism has decreased specificity to the substrate.

3 **(a)** The lock-and-key hypothesis and the induced-fit hypothesis are used to describe the interaction of enzymes and their substrates.

Describe **one** similarity and **one** difference between the lock-and-key hypothesis and the induced-fit hypothesis.

similarity .....

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difference .....

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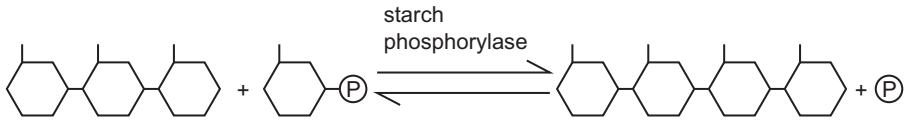
[2]

(b) Phosphorylase enzymes can catalyse the synthesis of starch **and** the breakdown of starch in some plant tissues. A reaction catalysed by starch phosphorylase is shown in Fig. 3.1.



part of a starch molecule | glucose 1-phosphate | phosphate ion

Fig. 3.1

A student carried out an experiment to study the synthesis of starch by phosphorylase found in potato tissue.

The student was provided with a solution, **E**, extracted from potato tissue. The extract was filtered to remove all the starch grains.

Extract **E** contained biological molecules from the potato tissue including phosphorylase but **no** starch.

(i) Iodine solution was used to confirm that starch was **not** present in extract **E**.

State the colour observed when iodine solution was added to a sample of extract **E**.

..... [1]

The student added a small drop of a dilute starch solution and a solution of glucose 1-phosphate to a test-tube containing extract **E**.

Samples of the reaction mixture in the test-tube were removed every minute and a drop of iodine solution was added to each.

The student used a colorimeter to measure the absorbance of the solution in each sample.

The results are shown in Fig. 3.2.

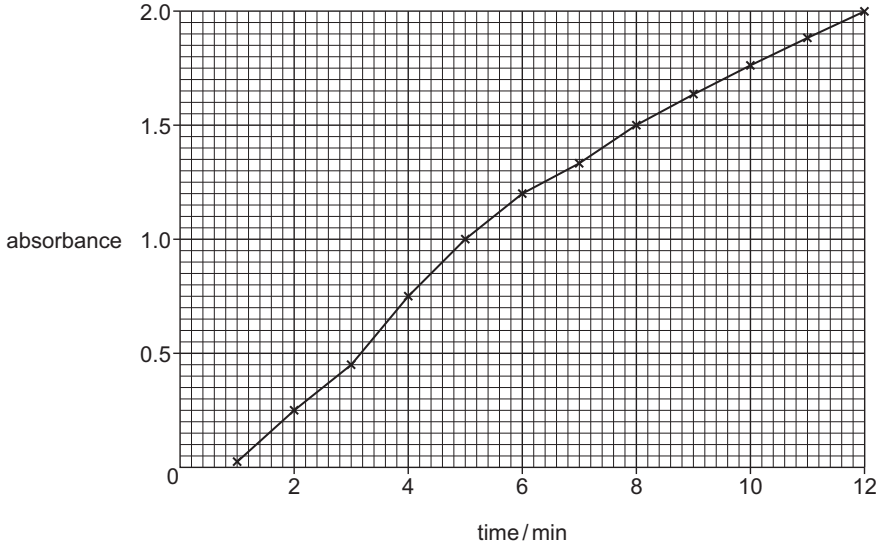


Fig. 3.2

(ii) Explain the results shown in Fig. 3.2.

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..... [3]

(iii) After 12 minutes, the student added a solution containing phosphate ions to the reaction mixture. The student continued taking samples every minute, adding iodine solution to each sample.

The absorbance of the solution in each of these samples was measured. The results showed that the absorbance decreased over time.

Suggest why the absorbance decreased.

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..... [1]

(c) Muscle cells contain glycogen phosphorylase.

Fig. 3.3 shows the effect of caffeine on the activity of glycogen phosphorylase at different concentrations of substrate.

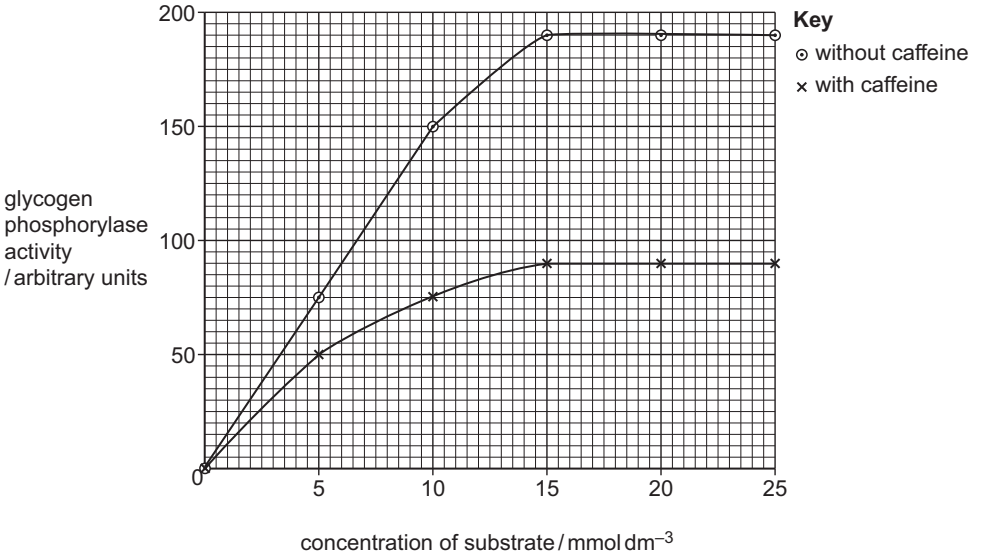

Fig. 3.3

A student concluded that caffeine acts as a non-competitive inhibitor of glycogen phosphorylase.

Explain how the results in Fig. 3.3 support this conclusion.

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..... [3]

[Total: 10]

3 **(a)** Describe the induced-fit hypothesis of enzyme action.

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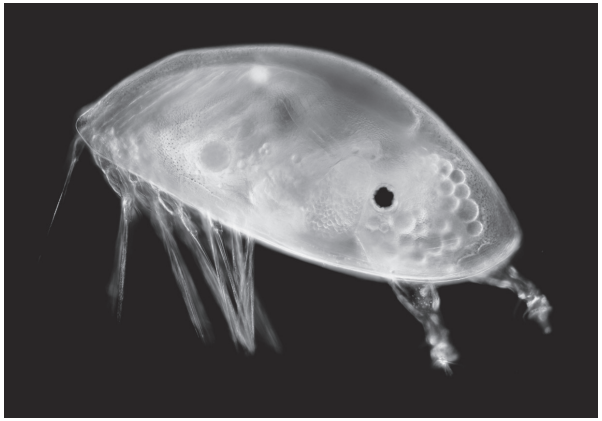
..... [3]

(b) Many marine organisms can become attached to hard surfaces such as rocks or the surfaces of ships. These organisms are known as fouling organisms.

The larva of the acorn barnacle, *Amphibalanus amphitrite*, is an example of a fouling organism. One of these barnacle larvae is shown in Fig. 3.1.



magnification ×160

Fig. 3.1

The larvae of *A. amphitrite* use a protein to attach themselves to the surfaces of ships.

It is expensive to remove fouling organisms from ships. Scientists have developed substances to prevent the attachment of larvae. However, some of these substances are toxic and have been responsible for a decrease in marine biodiversity.

Scientists investigated the effect of using an immobilised protease, subtilisin A, to prevent the attachment of the larvae of *A. amphitrite* to surfaces.

The scientists used 4 different concentrations of subtilisin A which had been immobilised onto the surface of a polymer film. As a control they used denatured subtilisin A immobilised onto the surface of the same polymer. Glass slides were also used as a control.

The larvae were released into 6 tanks of artificial sea water:

- 4 tanks, each with a polymer surface and a different concentration of immobilised subtilisin A
- 1 tank with a polymer surface and denatured immobilised subtilisin A
- 1 tank with glass slides instead of a polymer surface.

The number of larvae that attached to the different surfaces in the tanks was counted after 24 hours and again after 48 hours.

The number of larvae attached in each tank was expressed as the percentage of the total number of larvae released in each tank. The results are shown in Fig. 3.2.

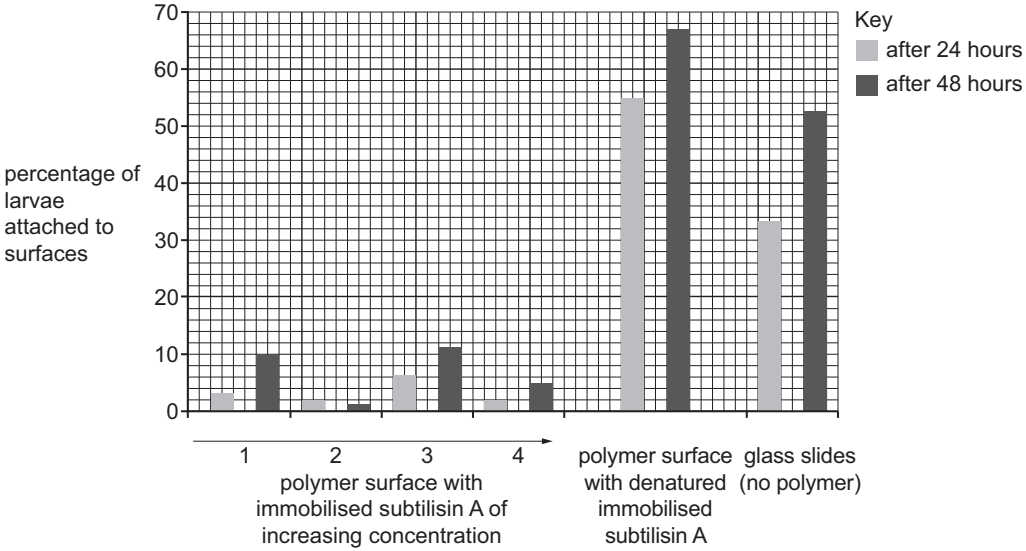


Fig. 3.2

(i) With reference to the data in Fig. 3.2, discuss whether subtilisin A is effective in preventing the attachment of the larvae.

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..... [4]

(ii) The scientists extended their investigation by applying the polymer with immobilised subtilisin A to the outside of the bottom of small ships.

Two factors that need to be taken into consideration in this type of investigation are the temperature and pH of the sea water.

Outline **two other** factors that need to be taken into consideration when investigating the suitability of immobilised subtilisin A as an anti-fouling agent for ships.

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..... [2]

[Total: 9]

Question 4 starts on page 12.

A-LEVEL BIOLOGY • EXERCISE SHEET

3.2 Factors that affect enzyme action

Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS michaelis–menten constant 米氏常数 • competitive 竞争性 • inhibitor 抑制剂 • competitive inhibitor 竞争性抑制剂 • non-competitive 非竞争性

Objective

Build the skills to answer exam questions on the **factors that affect enzyme action** — temperature, pH, enzyme and substrate concentration, **inhibitors** 抑制剂, the **Michaelis–Menten constant** 米氏常数, and **immobilised enzymes** 固定化酶.

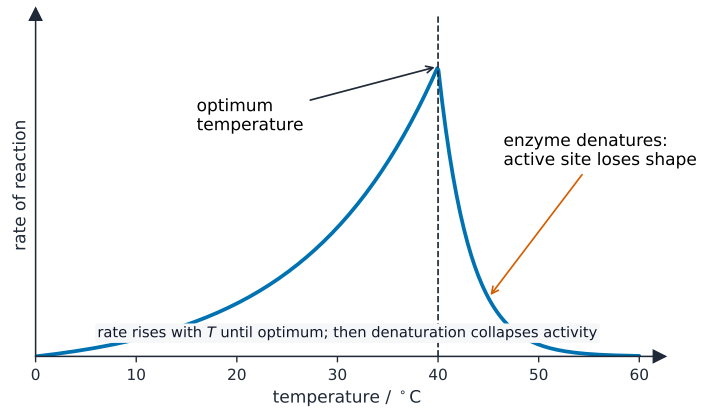
You must be able to:

- explain the effect of temperature, pH, enzyme concentration and substrate concentration on rate
- explain V_{max} and K_m and use K_m to compare affinity
- explain competitive and non-competitive inhibition, and state the advantages of immobilised enzymes

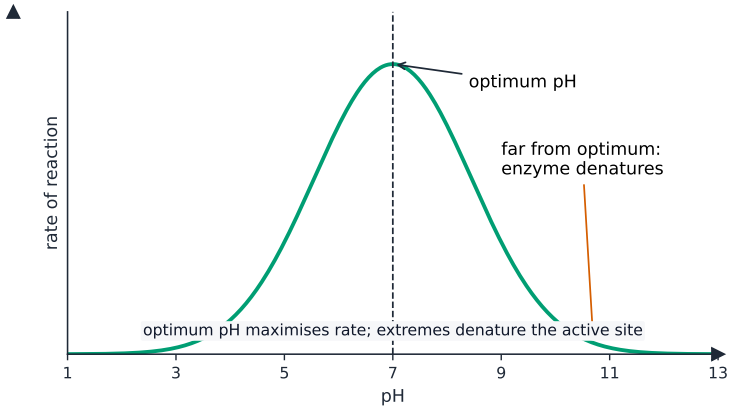
1 Worked examples

■ Temperature and pH

Rate rises with temperature (more **kinetic energy** 动能, more collisions) up to the **optimum**; above it the enzyme **denatures** 变性 — bonds holding its shape break, the active site changes, and rate falls fast. Each enzyme also has an optimum pH; far from it the enzyme denatures.



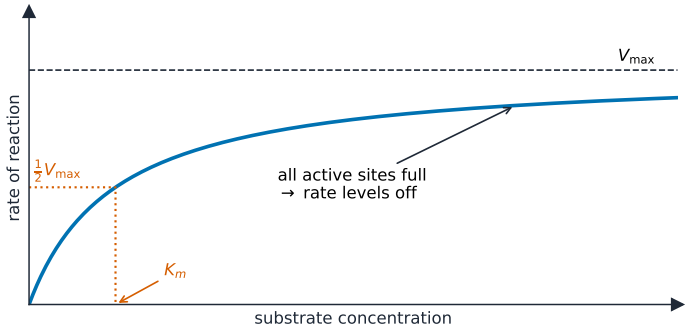
Rate rises to the optimum, then falls fast as the enzyme denatures



The rate peaks at the optimum pH and falls away on either side

Substrate concentration, V_max and K_m

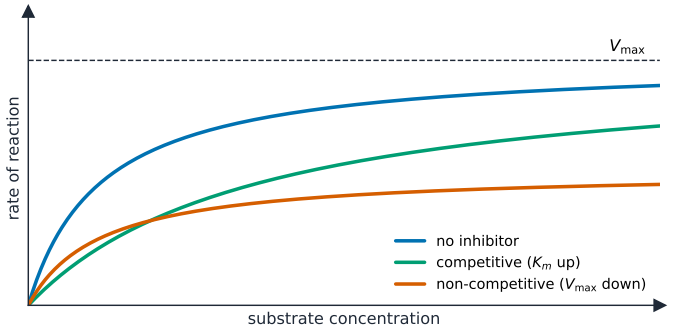
Adding substrate speeds the reaction until every active site is busy; then rate levels off at the maximum, V_{max}. The **Michaelis–Menten constant** K_m is the substrate concentration that gives **half** of V_{max}. A **low** K_m = **high affinity** 亲和力 (reaches half-speed at low substrate).



$v = \frac{V_{max}[S]}{K_m + [S]}$ · K_m = [S] at half V_{max}

K_m is the substrate concentration giving half V_{max} — a lower K_m means higher affinity

Reversible inhibitors



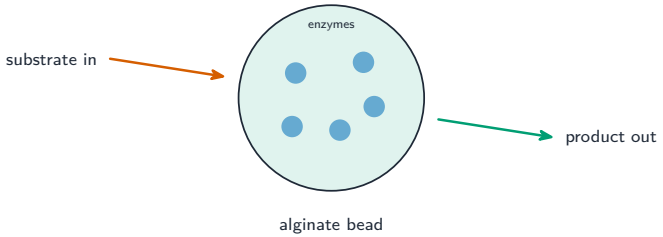
competitive: ↑ K_m, same V_{max} · non-competitive: ↓ V_{max}

Competitive inhibition raises K_m (more substrate overcomes it); non-competitive lowers V_{max}

- **competitive** 竞争性: binds the active site (similar shape to substrate); more substrate overcomes it → V_{max} unchanged, K_m rises.
- **non-competitive** 非竞争性: binds elsewhere, changing the active site; more substrate does not help → V_{max} falls.

■ Immobilised enzymes

An **immobilised enzyme** is fixed in place (e.g. trapped in **alginate** 海藻酸盐 beads).



Enzymes stay trapped while substrate flows in and product out — so they are not washed away

Advantages: re-used many times; pure product; more stable to temperature/pH; can run continuously.

2 Practice

2.1 Explain why the rate of an enzyme reaction falls above the optimum temperature. [3]

2.2 State **two** advantages of using an immobilised enzyme rather than a free one. [2]

3 Exam-style questions

3.1 A competitive inhibitor is added to an enzyme reaction. Compared with no inhibitor, what happens to V_{max} and K_m? [1]

- **A** V_{max} unchanged; K_m increases
- **B** V_{max} decreases; K_m unchanged
- **C** both increase
- **D** both decrease

3.2 Enzyme Y has a lower K_m than enzyme Z for the same substrate. This means that enzyme Y: [1]

- **A** has a higher affinity for the substrate
- **B** has a higher V_{max}
- **C** is denatured more easily
- **D** works at a higher optimum pH

3.3 A student investigates how temperature affects the rate at which catalase breaks down hydrogen peroxide. She measures the volume of oxygen produced in the first minute at five temperatures.

(a) State **two** variables she must control to make this a fair test. [2]

(b) Describe and explain the results she would expect between 10 °C and 60 °C. [4]

(c) Explain why a buffer solution would be used in a similar experiment that varied pH. [2]

3.4 The graph of rate against substrate concentration for an enzyme levels off at high substrate concentration. Explain why. [2]

Solutions

2.1 heat breaks the bonds (hydrogen/ionic) holding the enzyme's shape; the active site changes shape / denatures; so the substrate no longer fits and fewer enzyme–substrate complexes form.

2.2 Any two: re-used many times / product is pure (no enzyme) / more stable to temperature and pH / allows continuous flow.

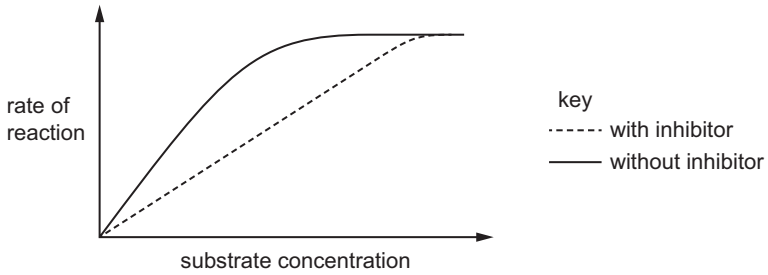
3.1 A. A competitive inhibitor raises K_m but leaves V_{max} unchanged (more substrate overcomes it).

3.2 A. A lower K_m means half V_{max} is reached at lower substrate concentration — higher affinity.

3.3 (a) any two: substrate (hydrogen peroxide) concentration / volume / enzyme concentration / pH / time.
(b) rate rises from 10 °C towards the optimum as molecules gain kinetic energy and collide more often; above the optimum the enzyme denatures, so the rate falls.
(c) a buffer keeps pH constant so that pH is not an uncontrolled variable affecting the rate.

3.4 at high substrate concentration every active site is occupied / saturated, so adding more substrate cannot increase the rate further — it is at V_{max}.

12 The graph shows the effect of substrate concentration on an enzyme-catalysed reaction with and without a competitive inhibitor.



What is the effect of the competitive inhibitor on V_{max} and K_m?

A V_{max} decreases and K_m decreases.

B V_{max} stays the same and K_m decreases.

C V_{max} stays the same and K_m increases.

D V_{max} decreases and K_m stays the same.

14 How is the Michaelis–Menten constant (K_m) used?

A to determine the number of collisions between the enzyme and substrate

B to compare the affinity of enzymes for their substrates

C to find the maximum velocity of an enzyme (V_{max})

D to find the optimum rate of reaction

15 Some students investigated the effect of pH on the rate of starch digestion by amylase at 20 °C.

- They added 2 cm^3 of a 1% amylase solution and 1 cm^3 of pH 4 buffer to a test-tube.
- They added 2 cm^3 of a starch solution, containing 0.02 g of starch, to the test-tube.
- They measured the time taken for the starch to be digested (to disappear).

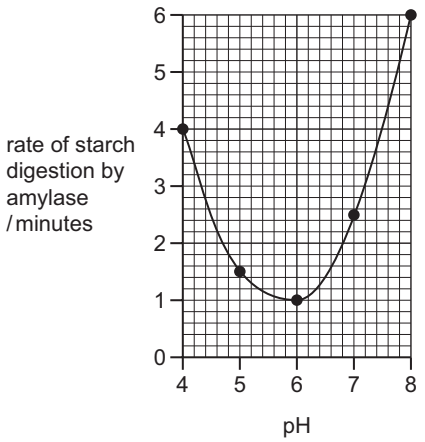
The students then repeated these steps with pH 5, pH 6, pH 7 and pH 8 buffers.

The table shows the results.

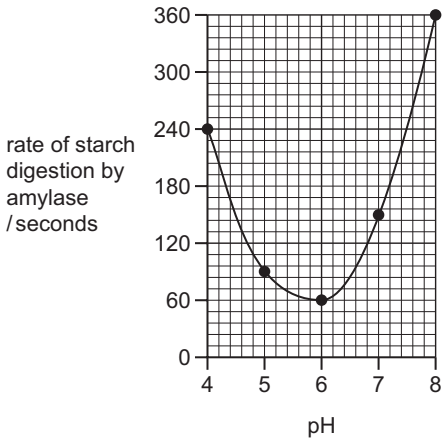
pH	time taken for starch to be digested / minutes
4	4.0
5	1.5
6	1.0
7	2.5
8	6.0

Which graph is correct for these data?

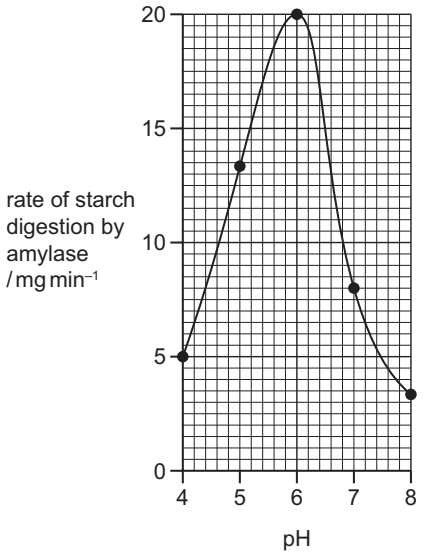
A



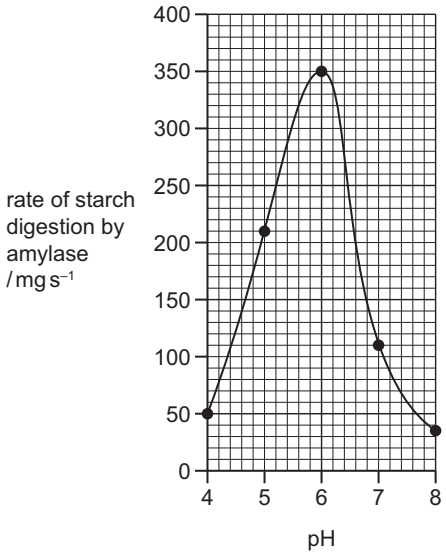
B



C



D



16 Which statements are correct for a non-competitive inhibitor of enzyme action?

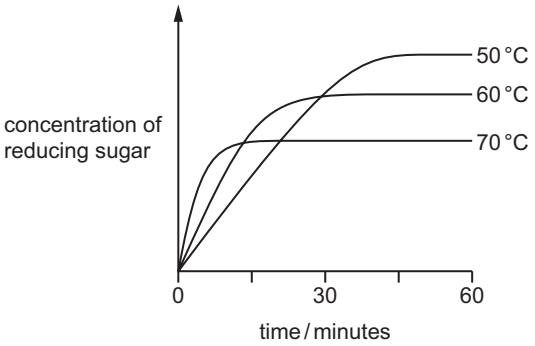
1 Increasing the concentration of the enzyme's substrate will reduce its effect.

2 It reduces the activation energy required for a reaction to take place.

3 It reduces the maximum rate of reaction.

A 1 and 3 **B** 1 only **C** 2 and 3 **D** 3 only

16 The graph shows the results of an investigation into the effect of amylase on starch at three different temperatures.



Which statements are correct conclusions using these results?

1 The optimum temperature is 50 °C.

2 The initial rate of reaction is highest at 70 °C.

3 The higher the temperature the more quickly the enzyme denatures.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

17 The rate of enzyme-catalysed reactions in human cells is regulated.

What may be involved in this regulation?

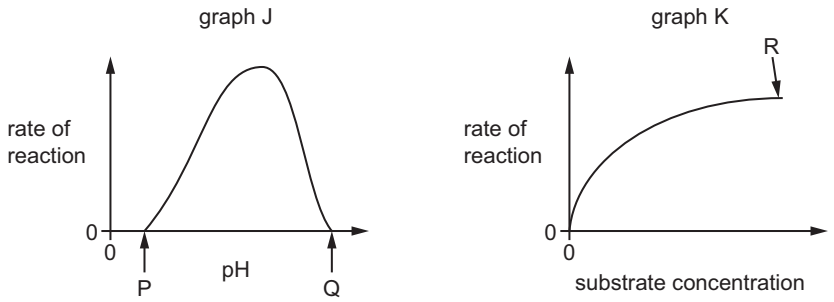
1 a change in enzyme concentration

2 a change in substrate concentration

3 inhibition by the final product of the reaction

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

15 Graph J shows the effect of pH on the rate of an enzyme reaction. Graph K shows the effect of substrate concentration on the rate of an enzyme reaction.



A student wrote four statements about the graphs.

1 In graph J, the enzyme is denatured at point Q.

2 In graph J, the enzyme is inactive at point P.

3 In graph K, the rate of reaction is directly proportional to the substrate concentration.

4 In graph K, V_{max} is reached at point R.

Which statements are correct?

A 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

1 The bacterium *Streptococcus pneumoniae* is commonly found in the throat. *S. pneumoniae* produces hydrogen peroxide as it grows. A sample can be taken from a patient's throat and tested to measure the concentration of hydrogen peroxide. This can be used as a measure of the growth of the bacteria.

You will determine the growth of bacteria by measuring the concentration of hydrogen peroxide in a solution that represents a sample taken from a patient. You will do this by measuring how long it takes for a sample of hydrogen peroxide to cause a colour change in a reaction mixture. The faster the mixture changes to a blue-black colour, the higher the concentration of hydrogen peroxide, and the greater the growth of bacteria.

You will use a range of known concentrations of hydrogen peroxide to estimate the concentration of hydrogen peroxide in a sample.

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	volume / cm^3
R1	dilute sulfuric acid	irritant	100
R2	starch solution	low	10
R3	potassium iodide solution	low	10
R4	sodium thiosulfate solution	low	10
H	2.0% hydrogen peroxide solution	irritant	25
U	solution representing patient sample	irritant	10
W	distilled water	low	100

If any solution comes into contact with your skin, wash off immediately with cold water.

It is recommended that you wear suitable eye protection.

You will need to carry out a **serial** dilution of the 2.0% hydrogen peroxide solution, **H**, to reduce the concentration by **half** between each successive dilution.

You will need to prepare **four** concentrations of hydrogen peroxide solution in addition to the 2.0% hydrogen peroxide solution, **H**.

After the serial dilution is completed, you will need to have 10 cm^3 of each concentration available to use.

(a) (i) Complete Fig. 1.1 to show how you will prepare your serial dilution.

Each beaker should have:

- a labelled arrow to show the volume of hydrogen peroxide solution transferred
- a labelled arrow to show the volume of distilled water, **W**, added
- a label under the beaker to show oncentration of the hydrogen peroxide solution.

0 cm^3 of **W**