Exercise walk-through

12.1.1

Investigating the effect of temperature on respiration in yeast

IGCSE Biology

You must be able to

- state the uses of energy in living organisms, including **muscle contraction**, **protein
- **investigate and describe the effect of temperature on respiration in yeast**

1 The method

Method — Why yeast, and what is actually being measured

Yeast 酵母 is a single-celled fungus that respires quickly and releases **carbon dioxide**. You cannot see respiration, but you can count the gas it produces – so the **number of bubbles per minute** stands in for the **rate of respiration**.

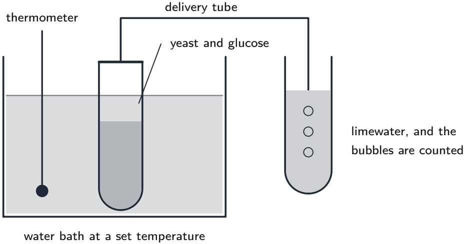
Method — Why yeast, and what is actually being measured

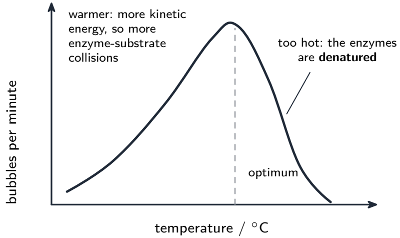
The three variable types, which a Paper 6 question asks about by name:

	in this investigation
independent (what you change)	the **temperature** of the water bath
dependent (what you measure)	the number of **bubbles per minute**
control (what you keep the same)	the volume and concentration of the yeast suspension, the concentration of glucose, the time counted, and the same yeast

Method — Why yeast, and what is actually being measured

Yeast 酵母 is a single-celled fungus that respires quickly and releases carbon dioxide .





Respiring yeast releases **carbon dioxide**, so the *rate of respiration* can be measured as the **number of bubbles per minute** – the dependent variable. Temperature is the independent variable; the volume and concentration of the yeast suspension, the glucose concentration and the time counted must all be **kept the same**, or the comparison means nothing.

Method — The method, step by step

1. Mix a fixed volume of **yeast suspension** with a fixed volume of **glucose solution** in a boiling tube.
2. Seal it with a bung carrying a **delivery tube** that leads into a second tube of **limewater**.
3. Stand the boiling tube in a **water bath** at the first temperature and leave it for a few minutes to reach that temperature.
4. **Count the bubbles** entering the limewater for a fixed time, for example one minute.
5. Repeat at each temperature, **changing nothing else**.
6. Repeat the whole set and take a **mean** at each temperature.

Two method marks that are easy to lose:

Method — The method, step by step

- **Leave time to equilibrate.** The mixture is not at the water-bath temperature the instant the tube goes in, and counting too early gives a rate for the wrong temperature.
- **Use a water bath, not a flame.** A water bath holds the whole tube at one known, steady temperature; direct heating makes it hotter at the bottom than the top, so the temperature is neither uniform nor controlled.

The limewater has a second job: it **turns milky**, which confirms that the gas really is carbon dioxide.

Method — The curve, and the two different reasons for its two halves

- **From low temperature up to the optimum**, the rate **increases**. The molecules have more **kinetic energy**, so enzyme and substrate collide more often and with enough energy, and more successful reactions happen per second.
- **Above the optimum**, the rate **falls sharply** to zero. The heat changes the **shape of the enzyme's active site** – the enzyme is **denatured 变性** – so the substrate no longer fits and the reaction stops.

△ These are **not** the same explanation with a sign change, and writing "the enzymes work less well" for both halves earns one mark at most. The rise is about **collisions**; the fall is about **shape**. Denaturing is also **permanent**: cooling a denatured enzyme does not restore it, which is why the curve falls much more steeply than it rose.

2 Practice

Practice 2.1 ▪ 2 marks

Name the gas produced by respiring yeast, and state how the rate at which it is produced can be measured.

Solution 2.1

Method: Why yeast, and what is actually being measured — p.4

Worked steps

- **carbon dioxide** B1
- by counting the **number of bubbles produced per minute**, passed through a delivery tube into limewater B1

Practice 2.2 ▪ 3 marks

State **three** variables that must be kept the same in this investigation.

Solution 2.2

Method: Why yeast, and what is actually being measured — p.4

Worked steps

any **three** of: **B1** *each*

- the volume of yeast suspension; the concentration of the yeast suspension; the concentration or volume of glucose solution; the length of time the bubbles are counted for; the same yeast, from the same culture

Practice 2.3 ▪ 3 marks

Explain why the number of bubbles per minute increases as the temperature is raised from $20\ ^{\circ}\mathrm{C}$ to $40\ ^{\circ}\mathrm{C}$.

Solution 2.3

Method: Why yeast, and what is actually being measured — p.4

Worked steps

- raising the temperature gives the molecules more **kinetic energy**, so they move faster **B1**
- so enzyme and substrate molecules **collide more often**, and with enough energy to react **B1**
- more successful reactions happen each second, so more carbon dioxide is produced per minute **B1**

Practice 2.4 ▪ 2 marks

Explain why the number of bubbles per minute falls to zero above about 60 °C.

Solution 2.4

Worked steps

- above the optimum the heat changes the shape of the **active site** of the respiration enzymes, so they are **denatured** **B1**
- the substrate no longer fits the active site, so the reaction stops and no carbon dioxide is produced **B1**

Practice 2.5 ▪ 2 marks

Explain why a water bath is used rather than heating the boiling tube directly with a flame.

Solution 2.5

Method: The method, step by step — p.7

Worked steps

- a water bath holds the **whole tube** at one known, steady temperature **B1**
- heating directly with a flame makes the mixture hotter at the bottom than the top and the temperature is not controlled, so it is not known what temperature the result belongs to **B1**

3 Exam-style

Exam-style 3.1 ▪ 1 mark

In an investigation into the effect of temperature on respiration in yeast, which is the **dependent** variable?

A the temperature of the water bath

B the volume of yeast suspension used

C the number of bubbles produced per minute

D the concentration of the glucose solution

Solution 3.1

Method: Why yeast, and what is actually being measured — p.4

A the temperature of the water bath

B the volume of yeast suspension used

C the number of bubbles produced per minute ✓

D the concentration of the glucose solution

Worked steps

C

- the dependent variable is what is **measured**: the number of bubbles per minute **B1**

Exam-style 3.2 ▪ 7 marks

A student is asked to investigate the effect of temperature on respiration in yeast.

Exam-style 3.2 (a) ▪ 4 marks

Describe a method the student could use, including how the rate of respiration is measured.

Solution 3.2 (a)

> Method: Why yeast, and what is actually being measured — p.4

Worked steps

- mix a **fixed volume** of yeast suspension with a **fixed volume** of glucose solution in a boiling tube, and seal it with a bung and delivery tube **B1**
- stand the tube in a **water bath** at a set temperature, and leave it long enough to reach that temperature **B1**
- **count the bubbles** passing into the limewater for a **fixed time**, for example one minute **B1**
- repeat at a range of temperatures, changing nothing else, and repeat the whole set to take a **mean** at each temperature **B1**

Exam-style 3.2 (b) ▪ 3 marks

State **two** variables the student must control, and explain why **one** of them would affect the results if it were not controlled.

Solution 3.2 (b)

Worked steps

- any two of: the volume and concentration of the yeast suspension; the concentration of glucose; the counting time; the same yeast culture **B1** *for two*
- an explanation for one of them, for example: more yeast means more cells respiring, so more bubbles per minute **B1**
- which would appear as a change in rate even though the temperature caused none of it, so the comparison between temperatures would be meaningless **B1**

Exam-style 3.3 ▪ 10 marks

A student obtains these results.

temperature / °C	**10**	**20**	**30**	**40**	**50**	**60**
bubbles per minute	4	11	26	41	18	0

Exam-style 3.3 (a) ▪ 2 marks

State the temperature at which the rate of respiration was highest, and describe the shape of the graph these results would give.

Solution 3.3 (a)

Worked steps

- the rate was highest at $40\ ^\circ$**C** **B1**
- the graph rises to a **peak** at $40\ ^\circ$C and then falls steeply to zero – the fall is much steeper than the rise **B1**

Exam-style 3.3 (b) ▪ 3 marks

Explain the results between $10\ ^\circ C$ and $40\ ^\circ C$.

Solution 3.3 (b)

Worked steps

- as the temperature rises the molecules gain **kinetic energy** and move faster **B1**
- so enzyme and substrate **collide more often** and with enough energy to react **B1**
- so the rate of respiration increases, from 4 to 41 bubbles per minute **B1**

Exam-style 3.3 (c) ▪ 3 marks

Explain the result at $60\ ^\circ C$.

Solution 3.3 (c)

Worked steps

- at $60\ ^{\circ}\mathrm{C}$ the temperature is far above the optimum **B1**
- the respiration **enzymes** have been **denatured** – the shape of the active site has changed permanently **B1**
- so the substrate can no longer bind, respiration stops, and no carbon dioxide is produced **B1**

Exam-style 3.3 (d) ▪ 2 marks

Suggest **one** improvement the student could make to this method, and explain how it would make the results more reliable.

Solution 3.3 (d)

Worked steps

any **one**, with its explanation:

- **repeat each temperature several times and take a mean** B1 – this reduces the effect of any one anomalous count, so the mean is closer to the true rate B1
- or use **more temperatures**, especially between 40 and 50, to locate the optimum more precisely
- or use a **gas syringe** to measure the volume of gas rather than counting bubbles, since bubbles are not all the same size