

12.1.1 Investigating the effect of temperature on respiration in yeast

Name: _____ Class: _____ Date: _____ Total: 30 marks

KEY WORDS temperature 温度 • respiration 呼吸作用 • yeast 酵母 • energy 能量
• carbon dioxide 二氧化碳

Objective

Sheet 12.1 is 20 marks on the **uses** of energy. It never touches the unit's other Core statement, which is a **practical**: investigate and describe the effect of temperature on respiration in yeast. That investigation is where Paper 6 meets this unit, and it is the reason this topic carries more exam weight than a two-statement unit looks as though it should. This sheet covers syllabus 12.1.

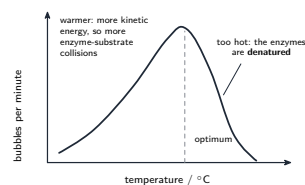
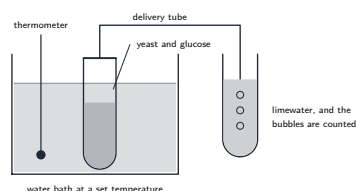
You must be able to:

- state the uses of energy in living organisms, including **muscle contraction**, **protein synthesis**, **cell division**, **active transport**, **growth**, the passage of **nerve impulses** and the maintenance of a **constant body temperature**
- investigate and describe the effect of temperature on respiration in yeast**

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

■ Why yeast, and what is actually being measured



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.

Yeast 酵母 is a single-celled fungus that respire 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**.

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

■ The method, step by step

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

Two method marks that are easy to lose:

- 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.

■ 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

Now use the methods above.

2.1 Name the gas produced by respiring yeast, and state how the rate at which it is produced can be measured. [2]

2.2 State **three** variables that must be kept the same in this investigation. [3]

2.3 Explain why the number of bubbles per minute increases as the temperature is raised from 20 °C to 40 °C. [3]

2.4 Explain why the number of bubbles per minute falls to zero above about 60 °C. [2]

2.5 Explain why a water bath is used rather than heating the boiling tube directly with a flame. [2]

3 Exam-style questions

3.1 In an investigation into the effect of temperature on respiration in yeast, which is the **dependent** variable? [1]

A	B
C	D

- 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

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

(a) Describe a method the student could use, including how the rate of respiration is measured. [4]

(b) State **two** variables the student must control, and explain why **one** of them would affect the results if it were not controlled. [3]

3.3 A student obtains these results.

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

(a) State the temperature at which the rate of respiration was highest, and describe the shape of the graph these results would give. [2]

(b) Explain the results between 10 °C and 40 °C. [3]

(c) Explain the result at 60 °C. [3]

(d) Suggest **one** improvement the student could make to this method, and explain how it would make the results more reliable. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

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

2.2 any **three** of:

- 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

2.3

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

2.4

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

2.5

- a water bath holds the **whole tube** at one known, steady temperature
- 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

3.1 C

- the dependent variable is what is **measured**: the number of bubbles per minute
- **A** is the independent variable, and **B** and **D** are control variables

3.2

(a)

- 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
- stand the tube in a **water bath** at a set temperature, and leave it long enough to reach that temperature
- **count the bubbles** passing into the limewater for a **fixed time**, for example one minute

- repeat at a range of temperatures, changing nothing else, and repeat the whole set to take a **mean** at each temperature

(b)

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

3.3

(a)

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

(b)

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

(c)

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

(d) any **one**, with its explanation:

- **repeat each temperature several times and take a mean** – this reduces the effect of any one anomalous count, so the mean is closer to the true rate
- 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