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.

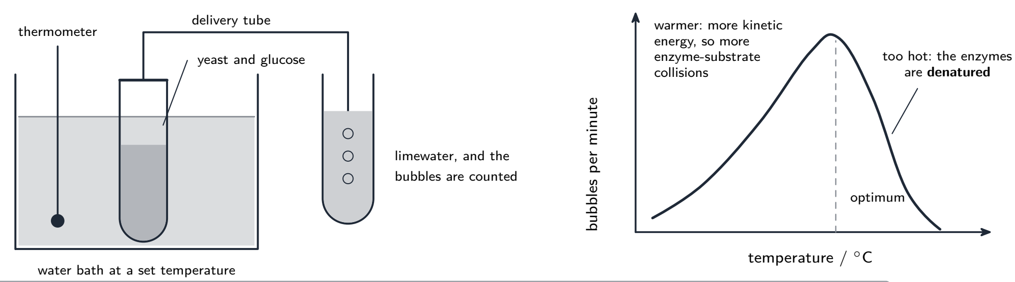
You must be able to:

- 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 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**.

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

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:

- **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 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