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