# 2023 Bi H2 Q9

## Section: Metabolism and Survival

## Topic: Metabolic Rate

## Question Summary

The investigation measured metabolic rate by recording the temperature rise of water in a calorimeter as two individuals exercised at different intensities — one walking and one running. Temperature change was measured at 5-minute intervals over 30 minutes.

## Worked Solution

(a) The calorimeter measures heat energy released by the individual during exercise. This heat increases the temperature of water circulating around the chamber. Since metabolic rate is proportional to heat energy produced, the temperature rise allows it to be calculated.

■ Answer (a): Heat from respiration warms the water; the temperature rise measures metabolic energy output.

(b) The independent variable is the intensity of exercise (walking or running).

■ Answer (b): Intensity of exercise.

(c) Two variables that must be controlled:
1. Duration of exercise (30 minutes).
2. Mass or body size of the individual.
Other valid answers could include: same calorimeter, same initial water temperature, or same environmental temperature.

■ Answer (c): Duration of exercise and body mass of subject (or equivalent).

(d)(i) On the graph, the running line should start at (0, 0) and rise more steeply than the walking line: by 30 minutes, temperature increase is 1.6°C compared to 1.4°C for walking.

■ Answer (d)(i): The running curve lies above the walking curve, reaching 1.6°C at 30 minutes.

(d)(ii) By extending the trend, the temperature after 35 minutes of walking would be about 1.7°C.

■ Answer (d)(ii): 1.7°C

(e) Running produces a greater increase in water temperature than walking, showing a higher metabolic rate. This is because higher exercise intensity requires more energy and therefore releases more heat.

■ Answer (e): Metabolic rate increases with exercise intensity.

## Revision Tips

• Metabolic rate can be measured by oxygen uptake, $CO_2$ output, or heat production.
• A calorimeter measures energy output as heat.
• Always identify:
- Independent variable → what's changed.
- Dependent variable → what's measured.
- Controlled variables → kept constant.
• Exercise increases respiration rate → more ATP used → higher heat output.

# Calorimeter