

Exercise walk-through

4.1

Thermal measurements and particle models

International Baccalaureate · IB Diploma · Physics · SL

4.1 Thermal measurements and particle models

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS specific heat capacity • latent heat

Objective

Thermal measurements and particle models. Original classroom practice for IB SL; not an official IB paper.

1 Key knowledge and worked examples

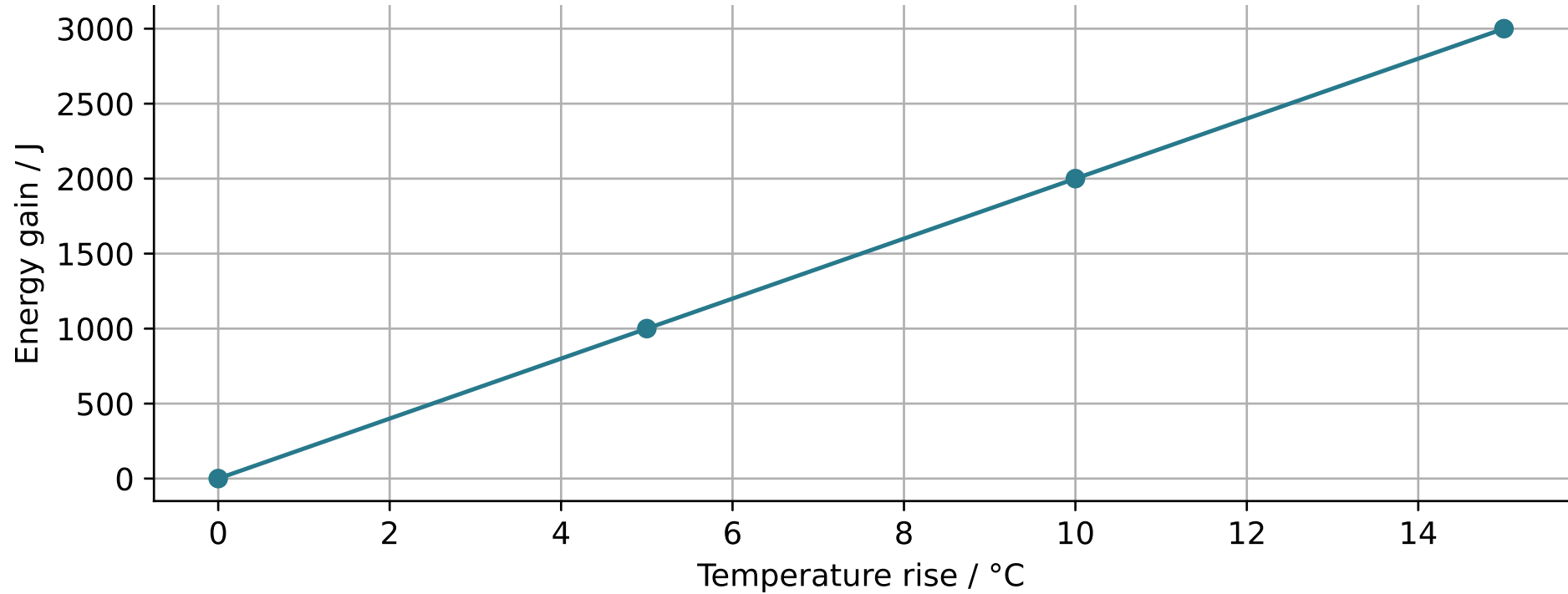
■ What would explain this observation?

- Two equal masses receive the same energy but show different temperature rises. Material properties determine how energy transfer changes temperature.

■ **Build the model**

- **Specific heat capacity** is energy needed to raise the temperature of unit mass by one degree.
- **Specific latent heat** relates energy to change of state without temperature change for the idealized process.

- specific heat capacity: Energy per mass per temperature rise.
- latent heat: Energy associated with a change of state.



■ Choose evidence that can test it

- Temperature relates to particle motion in a model; internal energy includes kinetic and potential contributions.
- During a change of state, energy can change particle arrangements rather than temperature.

In the lab: Measure mass, electrical input and temperature change for an insulated block. Ensure the temperature sensor has good contact, allow time for equilibration, and consider energy transferred to the surroundings.

■ Work from known quantities

- Known: a 0.50 kg block gains 2,000 J and rises 10 °C.

- Use $E = mc\Delta T$.
- Rearranging gives $c = E/(m\Delta T)$. $c = 2,000/(0.50 \times 10) = 400$ J per kilogram per degree.
- Heat loss would make the value inferred from electrical input too large.

Your turn: A 2 kg sample with $c=500$ J per kilogram per degree warms by 3 °C. Find energy gain.

■ Check the conclusion and its limits

- A flat section of a heating curve can show a phase change, not absence of energy transfer.
- Do not substitute temperature for a temperature difference in $E = mc\Delta T$.

Not true: A temperature plateau always means zero energy transfer. A plateau on a heating curve marks a phase change, where energy goes into changing particle arrangement as latent heat. Energy transfer continues; only the temperature pauses.

Key:

- Specific heat capacity is energy needed to raise the temperature of unit mass by one degree.
- Temperature relates to particle motion in a model; internal energy includes kinetic and potential contributions.
- Watch for: A flat section of a heating curve can show a phase change, not absence of energy transfer.

■ Write from an energy gain of 4000 J

- A 0.40 kg sample with specific heat capacity 2000 J per kilogram per degree warms by 5 degrees.
 - Find the energy gain. A temperature plateau can still transfer energy.
-

Exercises 2.1·2.2

2.1 Why can temperature stay constant while a pure substance melts? Choose one answer.

- **A** Energy changes particle arrangement
- **B** The thermometer must be broken
- **C** No energy enters

[1]

2.2 A 2 kg sample with $c=500$ J per kilogram per degree warms by $3\text{ }^{\circ}\text{C}$. Find energy gain. Show the relation, substitution and units.

[2]

Exercises 2.1·2.2

2.1 Why can temperature stay constant while a pure substance melts? Choose one answer.

- **A** Energy changes particle arrangement
- **B** The thermometer must be broken
- **C** No energy enters

[1]

2.1 A During melting the incoming energy does work separating particles against their attractions - the latent heat - rather than raising kinetic energy, so temperature stays constant. Energy is still entering; it changes arrangement, not temperature.

2.2 A 2 kg sample with $c=500$ J per kilogram per degree warms by $3\text{ }^{\circ}\text{C}$. Find energy gain. Show the relation, substitution and units.

[2]

2.2 $E=mc\Delta T=2\times 500\times 3=3,000\text{ J}$.

Exercises 2.3-3.1

2.3 Decide whether this claim is true and justify: A temperature plateau always means zero energy transfer. [2]

2.4 Energy per mass per temperature rise: write the technical term. [1]

3.1 A fictional 0.50 kg block receives 2,000 J electrical energy and warms 8 K; 200 J heats its container and 200 J escapes. Find c and compare using all input. [4]

Exercises 2.3-3.1

2.3 Decide whether this claim is true and justify: A temperature plateau always means zero energy transfer. [2]

2.3 False. A plateau on a heating curve marks a phase change, where energy goes into changing particle arrangement as latent heat. Energy transfer continues; only the temperature pauses.

2.4 Energy per mass per temperature rise: write the technical term. [1]

2.4 specific heat capacity. specific heat capacity means Energy per mass per temperature rise.

3.1 A fictional 0.50 kg block receives 2,000 J electrical energy and warms 8 K; 200 J heats its container and 200 J escapes. Find c and compare using all input. [4]

3.1 Block energy=1,600 J; $c=1,600/(0.50 \times 8)=400 \text{ J}/(\text{kg K})$. The uncorrected 500 J/(kg K) is too high. State the system boundary and loss assumptions.