

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. Supported SL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

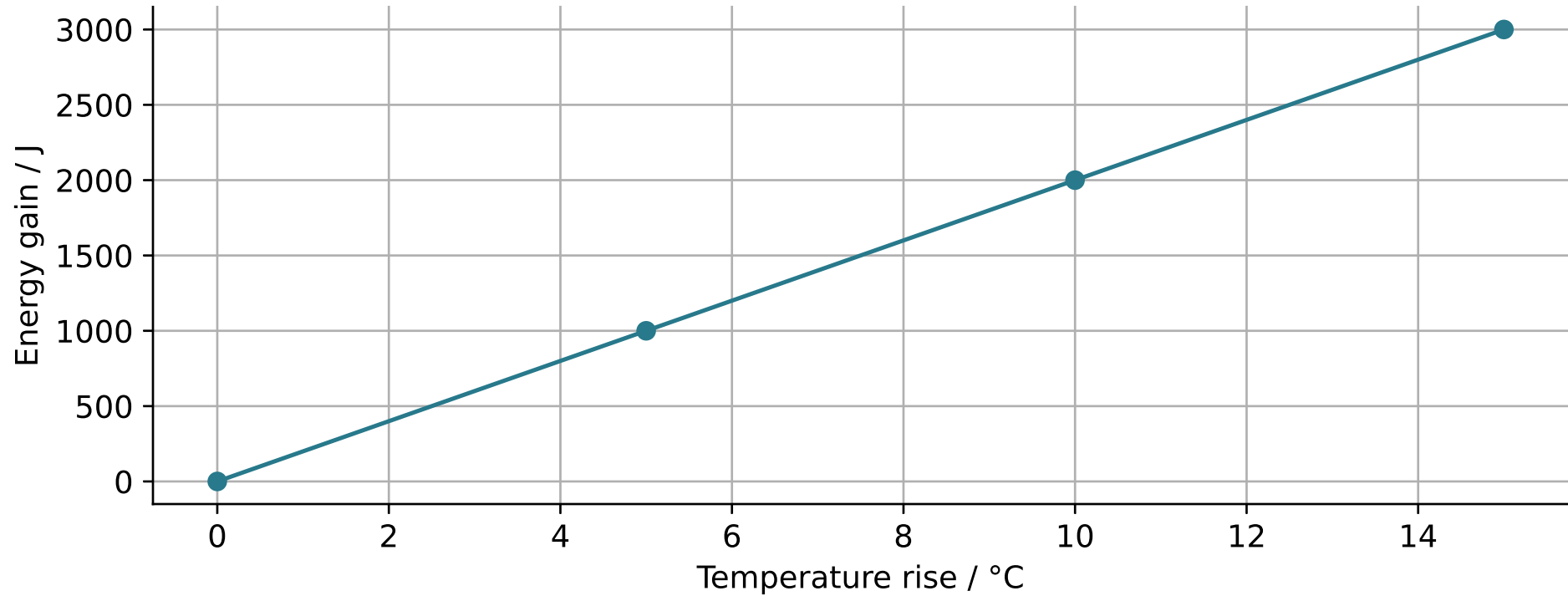
■ What would explain this observation?

- Two equal masses receive the same energy but show different temperature rises. Material properties determine how energy transfer changes temperature.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ 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.
- 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

- State the known values and their units. Choose the relation because its assumptions

fit this case, then rearrange before substitution.

- 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.

Example:

A 2 kg sample with $c=500$ J per kilogram per degree warms by 3 °C. Find energy gain. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ 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 $E = mc\Delta T$.

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A temperature plateau always means zero energy transfer. This claim is false: 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 $E = mc\Delta T$.

Key:

Thermal measurements and particle models: 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.

Exercises 2.1·2.3

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

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

[1]

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

[2]

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

[2]

Exercises 2.1·2.3

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

- **A** No energy enters
- **B** Energy changes particle arrangement
- **C** The thermometer must be broken [1]

2.1 B 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.

2.2 A 2 kg sample with $c=500$ J per kilogram per degree warms by 3°C . Find energy gain. Show the relation, substitution and units. [2]

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

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

2.3 False. 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 $E = mc\Delta T$.

Exercises 2.4·3.1

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

[1]

3 Exam-style questions

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 2.4·3.1

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

3 Exam-style questions

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.