

Exercise walk-through

# 6.1

## Thermal measurements and particle models

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International Baccalaureate · IB Diploma · Physics · HL

# 6.1 Thermal measurements and particle models

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 10 marks**

**KEY WORDS** specific heat capacity • latent heat

# Objective

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Thermal measurements and particle models. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

## 1 Key knowledge and worked examples

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### ■ What would explain this observation?

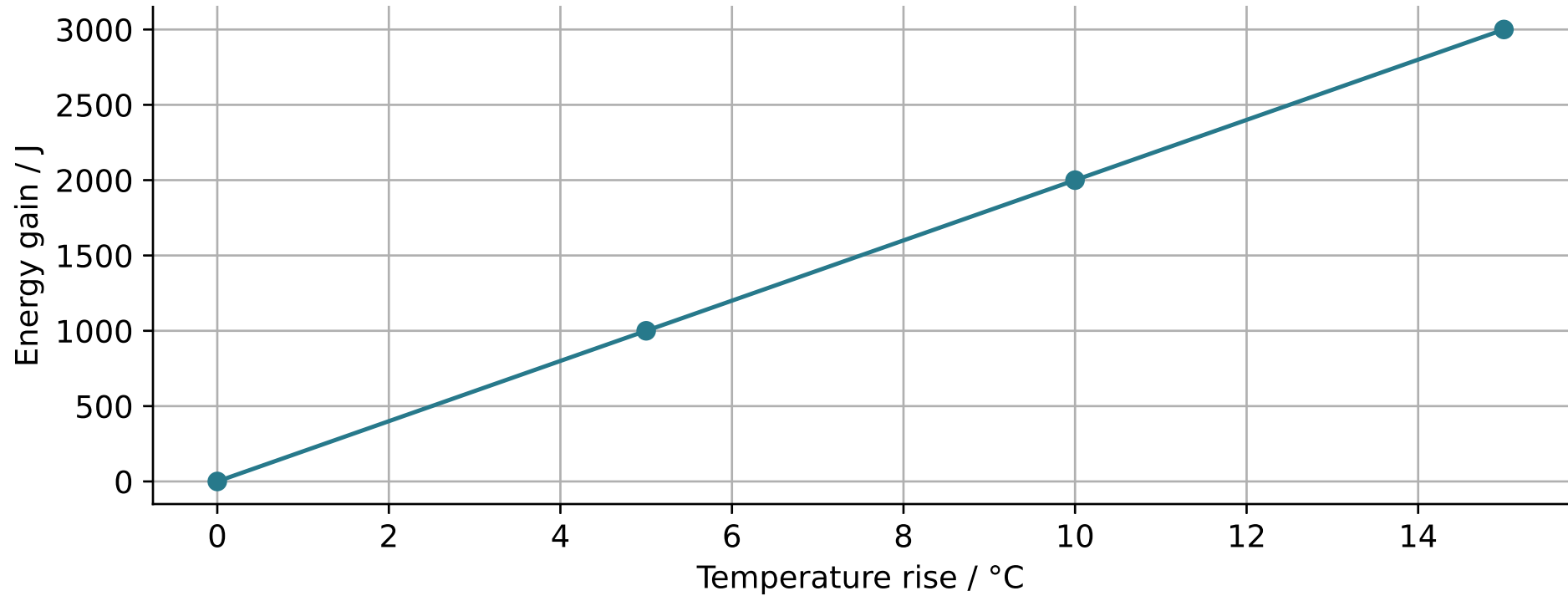
- Two equal masses receive the same energy but show different temperature rises. Material properties determine how energy transfer changes temperature.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

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## ■ 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.



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## ■ 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.

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## ■ 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.

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### **■ 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.

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## Exercises 2.1·2.3

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**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]

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

[2]

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

[2]

## Exercises 2.1·2.3

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**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.

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

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

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**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

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

[1]

### 3 Exam-style questions

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**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

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

### 3 Exam-style questions

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

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**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.