

Thermal energy transfers

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

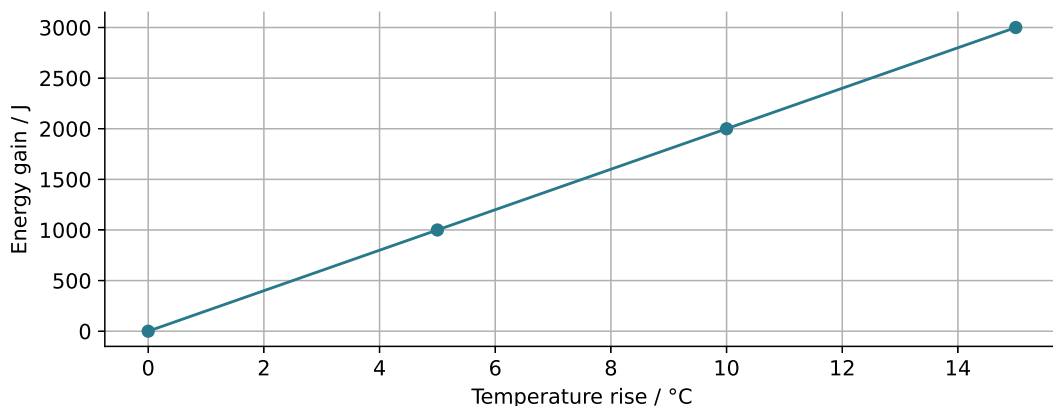
Thermal measurements and particle models

■ 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.



$Q = mc\Delta T$: energy is proportional to temperature rise, here 200 J per °C

■ 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 1800 J

- A 0.20 kg sample with specific heat capacity 1500 J per kilogram per degree warms by 6 degrees.
- Find the energy gain. A temperature plateau can still transfer energy.

■ **Write from a mixing final temperature**

- 0.20 kg of water at 80 °C mixes with 0.20 kg at 20 °C ($c = 4,200 \text{ J per kg per degree}$).
- Equal masses, same c : the final temperature is the mean, 50 °C – hot loses $0.20 \times 4,200 \times 30 = 25,200 \text{ J}$, cold gains the same.

■ **Write from a latent step hidden in the account**

- Ice at 0 °C becomes water at 0 °C: the temperature never moves.
- Energy still enters – as latent heat, breaking bonds: a temperature graph with a flat step is an energy account, not an idle thermometer.