

Temperature changes in a system and specific heat capacity

6.3.2.2 · Physics · revision notes

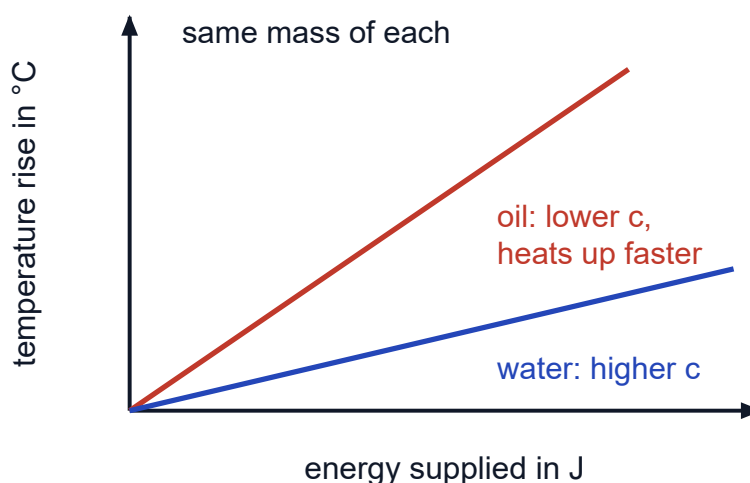
Specific heat capacity tells you how much energy is needed to raise the temperature of 1 kg of a material by 1 °C. You need to define it and use $\Delta E = m c \Delta\theta$, which is on the Physics equation sheet. Expect 2 to 4 mark calculations, often with a rearrangement, unit conversions or a link to power, plus explanations of why one material heats up faster than another.

Key facts

- $\Delta E = m c \Delta\theta$ (on the equation sheet)
- Specific heat capacity: energy to raise the temperature of 1 kg by 1 °C
- $c = \Delta E \div (m \times \Delta\theta)$
- High c: more energy needed per °C, so it heats up and cools down more slowly
- ΔE in J, m in kg, c in J/kg °C, $\Delta\theta$ in °C
- $\Delta\theta$ = final temperature – starting temperature
- Energy from a heater: $E = P t$ (P in W, t in s)

What specific heat capacity means

- When you heat a substance without changing its state, its temperature rise depends on the **mass** heated, the **type of material** and the **energy** supplied.
- The **specific heat capacity** (c) of a substance is the amount of energy needed to raise the temperature of **1 kg** of the substance by **1 °C**.
- Its unit is J/kg °C. Water has a high specific heat capacity (about 4200 J/kg °C); metals such as copper and aluminium have much lower values.
- A material with a high specific heat capacity needs more energy for each °C rise, so with the same heating it warms up more slowly. It also transfers more energy to the surroundings for each °C that it cools.



Same mass, same energy: the lower the specific heat capacity, the bigger the temperature rise.

The equation

- change in thermal energy = mass $\times$ specific heat capacity $\times$ temperature change: $\Delta E = m c \Delta\theta$ (on the equation sheet).
- ΔE in joules (J), m in kilograms (kg), c in J/kg °C, $\Delta\theta$ in degrees Celsius (°C).
- $\Delta\theta$ is a **change**: a rise from 15 °C to 40 °C is $\Delta\theta = 25$ °C.
- Rearranged: $c = \Delta E \div (m \Delta\theta)$; $m = \Delta E \div (c \Delta\theta)$; $\Delta\theta = \Delta E \div (m c)$.
- Convert first: grams to kg ($\div 1000$) and kJ to J ($\times 1000$).
- The same equation gives the energy transferred away when an object cools down.

Finding c by experiment

- The required practical to measure specific heat capacity is in the Energy topic: you heat a block of known mass with an electric heater and record its temperature rise.
- Energy supplied: read it from a joulemeter, or use $E = P t$ (P = power in W, t = time in s).
- Then calculate $c = E \div (m \Delta\theta)$.

How to answer each type of question

Calculate the energy needed to heat something

2 to 3 marks

Grade 5

1. Choose $\Delta E = m c \Delta\theta$ from the equation sheet.
2. Work out $\Delta\theta = \text{final} - \text{starting temperature}$, and make sure the mass is in kg.
3. Substitute, calculate and give the unit (J).

Example. An electric kettle heats 0.80 kg of water from 20 °C to 100 °C.

specific heat capacity of water = 4200 J/kg °C

Calculate the energy transferred to the water.

Model answer. $\Delta\theta = 100 - 20 = 80$ °C (1)

$\Delta E = 0.80 \times 4200 \times 80$ (1)

$\Delta E = 268\,800$ J (1)

Don't lose marks

- ✗ Using the final temperature instead of the temperature change for $\Delta\theta$.
- ✗ Leaving the mass in grams, which makes the answer 1000 times out.
- ✗ Leaving the time in minutes when using $E = P t$.
- ✗ Using $\Delta E = m c \Delta\theta$ during a change of state. The temperature does not change then: use $E = m L$ instead.
- ✗ Rearranging wrongly, e.g. $c = \Delta E \times m \div \Delta\theta$. You must divide by both m and $\Delta\theta$.

More tips

Memory tricks

- Both Δ s in $\Delta E = m c \Delta\theta$ stand for 'change': a change in energy and a change in temperature.
- Sense check with water: about 4200 J warms 1 kg by 1 °C, so heating 1 kg of water by 80 °C needs roughly 340 000 J.
- Double the mass or double the temperature rise and you double the energy needed.
- The unit J/kg °C reminds you of the rearrangement: $c = \text{joules} \div (\text{kg} \times \text{°C})$.
- Calculator tip: for $c = \Delta E \div (m \Delta\theta)$, put brackets round $m \times \Delta\theta$, or divide twice: $\Delta E \div m \div \Delta\theta$.

Exam technique

- The equation is on the equation sheet, but you must choose it and know what each symbol means.
- Always write the substitution line with numbers: it usually earns a mark even if the final answer goes wrong.
- Give J/kg °C as the unit of specific heat capacity, and round to the significant figures asked for.
- In practical questions, describe the error precisely: energy is transferred to the surroundings (so the measured temperature rise is too small).

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Define specific heat capacity

The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C.

Grade 4

Substitute into $\Delta E = m c \Delta\theta$

Calculate the change in thermal energy with m in kg, c in J/kg °C and $\Delta\theta$ in °C.

Grade 5

Work out the temperature change $\Delta\theta$

$\Delta\theta$ is the difference between the final and starting temperatures, not the final temperature.

Free notes, worksheets, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers.
Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.