

Energy changes in systems

4.1.1.3 · Energy · revision notes

How much energy it takes to change the temperature of a material. You need to know what specific heat capacity means, use $\Delta E = m c \Delta\theta$, and know the required practical in which you measure the specific heat capacity of a material. Expect 2 to 4 mark calculations and practical questions, including 6-mark method questions.

Key facts

- $\Delta E = m c \Delta\theta$ (on the equations sheet)
- Specific heat capacity: the energy needed to raise the temperature of 1 kg of a substance by 1 °C
- Units: ΔE in J, m in kg, c in J/kg °C, $\Delta\theta$ in °C
- $\Delta\theta$ = final temperature – starting temperature
- Water: $c \approx 4200$ J/kg °C (given when you need it)
- Energy from a heater: $E = P t$ (t in seconds)
- Practical: $c = \text{energy supplied} \div (\text{mass} \times \text{temperature rise})$

Notes

Specific heat capacity

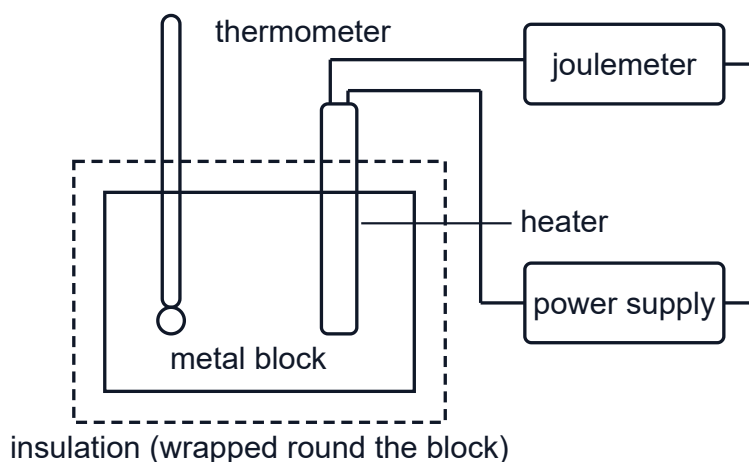
- When you heat a substance, energy goes into its thermal (internal) store and its temperature rises. When it cools, energy is released.
- The **specific heat capacity** (c) of a substance is the amount of energy needed to raise the temperature of 1 kg of the substance by 1 °C.
- Water has a high specific heat capacity (about 4200 J/kg °C), so it takes a lot of energy to heat up and releases a lot as it cools. Most metals have much lower values, so they heat up quickly.

The equation

- $\Delta E = m c \Delta\theta$ (on the equations sheet)
- ΔE = change in thermal energy (J), m = mass (kg), c = specific heat capacity (J/kg °C), $\Delta\theta$ = temperature change (°C).
- $\Delta\theta$ = final temperature – starting temperature.
- Rearranged: $c = \Delta E \div (m \times \Delta\theta)$ and $\Delta\theta = \Delta E \div (m \times c)$.
- The energy often comes from an electric heater: $E = P t$, with P in watts and t in seconds.

Required practical: measuring specific heat capacity

- Measure the mass of a metal block with a balance.
- Put an electric heater and a thermometer into the holes in the block. Wrap the block in insulation.



Required practical set-up: the joulemeter measures the energy supplied to the block.

- Record the starting temperature, then switch on the heater. Measure the energy supplied with a joulemeter (or record the power and the time and use $E = P t$).
- After a set time (e.g. 10 minutes), switch off. Record the energy supplied and the highest temperature the block reaches.
- Calculate $c = \text{energy supplied} \div (\text{mass} \times \text{temperature rise})$.

How to answer each type of question

Calculate the energy needed to heat something

2 marks

Grade 5

1. Work out the temperature change first.
2. Substitute into $\Delta E = m c \Delta \theta$.
3. Give the answer in J (or in kJ if the question asks).

Example. A saucepan contains 1.5 kg of water at 18 °C. The water is heated to 78 °C.
specific heat capacity of water = 4200 J/kg °C
Calculate the energy transferred to the water.

Model answer. $\Delta \theta = 78 - 18 = 60$ °C

$$\Delta E = 1.5 \times 4200 \times 60 \text{ (1)}$$

$$\Delta E = 378\,000 \text{ J (1)}$$

Don't lose marks

- ✗ Using the final temperature instead of the temperature change.
- ✗ Forgetting to change minutes to seconds in $E = P t$.

- ✗ Using the mass in grams instead of kilograms.
- ✗ Confusing specific heat capacity (temperature change) with specific latent heat (change of state, no temperature change).
- ✗ Writing that 'heat is lost' without saying it is dissipated to the surroundings or how this affects the value of c .

More tips

Memory tricks

- The definition has three parts: energy needed, 1 kg, 1 °C.
- Sense check: 1 kg of water needs about 4200 J for each 1 °C rise, so heating a kettle of water takes hundreds of thousands of joules.
- Calculator: for $c = \Delta E \div (m \times \Delta\theta)$ use brackets, or divide by m and then by $\Delta\theta$.
- In this practical, a value that is too high is almost always due to energy dissipated to the surroundings.

Exam technique

- In method questions, name the equipment: balance, thermometer, electric heater, joulemeter (or power supply and stopwatch), insulation.
- Give c the unit J/kg °C.
- If a question gives a power and a time, you almost always need $E = P t$ first.

What each grade needs

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

Grade 3

Name what affects the energy needed to heat

The energy needed depends on the mass, the material and the temperature rise.

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 5

Calculate energy using $\Delta E = m c \Delta\theta$

Find the temperature change first, then multiply mass $\times$ specific heat capacity $\times$ temperature change.

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