3.3 Specific heat capacity and temperature changes

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS specific heat capacity

Objective

Consolidate $\Delta E = mc\Delta\theta$ from the particle view and read temperature data from graphs and tables. Original questions consolidating spec statement 4.3.2.2 (the RP1 practical itself is on sheet 1.3).

1 Key knowledge and worked examples

$$\Delta E = m\,c\,\Delta\theta$$

Symbol	Meaning	Unit
ΔE	energy transferred to the thermal store	J
m	mass	kg
c	specific heat capacity	J/kg °C
$\Delta\theta$	temperature **change**	°C

From the particle view: c measures how much energy the particles store per kilogram for each degree of temperature rise. Water's large c (4200 J/kg °C) means its particles take a lot of energy to speed up – hence kettles are the most powerful appliance in a home.

Facts that earn quick marks:

- $\Delta\theta$ is a **difference** – subtract the two readings, never insert an absolute temperature.
- The temperature rise depends on the **mass**, the **material** and the **energy input** – the three factors the spec names.
- Equal masses, equal energy: the smaller c, the bigger the temperature rise.

Worked example. A 0.20 kg aluminium heating pad (c = 900 J/kg °C) receives 3240 J. Find the temperature rise.

$$\Delta\theta = \frac{\Delta E}{mc} = \frac{3240\ \text{J}}{0.20\ \text{kg} \times 900\ \text{J/kg °C}} = 18\ \text{°C}$$

Worked example (comparison with graph data). A heater supplies 9000 J to 0.50 kg of a liquid; its graph shows a rise from 22 °C to 40 °C.

$$c = \frac{9000}{0.50 \times 18} = 1000 \text{ J/kg °C}$$

- If a second liquid, same mass and energy, rose further, its c is smaller – check such comparisons against the numbers, not the picture alone.

2 Practice

2.1 0.030 kg of olive oil ($c = 1800$ J/kg °C) warms from 21 °C to 96 °C. Calculate the energy transferred. [3]

2.2 6300 J raises 0.25 kg of oil by 15 °C. Calculate c. [2]

2.3 Equal masses of water ($c = 4200$) and copper ($c = 385$) each receive the same energy. State which rises in temperature more, and by roughly what factor. [2]

3 Exam-style questions

3.1 A hand warmer's pad has mass 0.20 kg and $c = 900$ J/kg °C. When switched on it warms from 22 °C to 46 °C.

(a) Calculate the energy transferred to the pad. [3]

(b) The pad is replaced by one with the same mass but a larger specific heat capacity. State and explain the change in temperature rise for the same energy. [2]

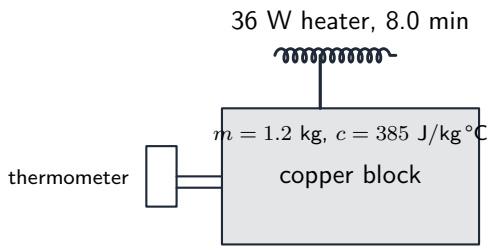
3.2 A student plots temperature against energy supplied for 0.50 kg of a liquid. The graph is a straight line rising 9 °C for every 4500 J.

(a) Use the gradient to calculate the liquid's specific heat capacity. [3]

(b) State two factors, other than the material, that the temperature rise depends on. [2]

3.3 A heater of power 36 W runs for 8.0 minutes inside a 1.2 kg copper block ($c = 385$ J/kg °C). The block warms from 21 °C to 37 °C.

(a) Calculate the energy supplied by the heater. [3]

(b) Calculate the energy that raised the block's thermal store. [2]

(c) A reactor has a heat-absorbing pad. Explain how a high specific heat capacity helps limit its temperature rise for a given absorbed energy and pad mass. [2]