

Specific Heat Capacity 2

Mark Scheme



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1. Specific heat capacity explains how much energy different substances need to change temperature. For each of the following questions **circle** the letter of the correct answer.

- a) What is the standard GCSE unit for specific heat capacity?

C – is the only correct answer.	1 mark
	Total: 1 mark

- b) Water has a very high specific heat capacity compared to most metals. What does this mean in practice?

B – is the only correct answer.	1 mark
	Total: 1 mark

- c) Which of the following is the correct equation for calculating the energy transferred when a substance is heated?

D – is the only correct answer.	1 mark
	Total: 1 mark

- d) A 2 kg block of copper is heated, increasing its temperature by 10°C. If the specific heat capacity of copper is 390 J/kg°C, how much energy was transferred?

D – is the only correct answer.	1 mark
	Total: 1 mark

- e) A heater supplies 9,000 J of thermal energy to 1.5 kg of a liquid. If the specific heat capacity of the liquid is 2,000 J/kg°C, what is the temperature increase of the liquid?

A – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. A student is calculating the thermal energy required to heat different materials in a physics lab.

Use the equation:

$$\text{Change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

- a) A 2.0 kg block of iron is heated, and its temperature increases by 15 °C. The specific heat capacity of iron is 450 J/kg °C. Calculate the change in thermal energy of the iron block.

$\Delta E = m \times c \times \Delta\theta$	1 mark
$\Delta E = 2.0 \times 450 \times 15$	
$\Delta E = 13\,500\text{ J}$	1 mark
	Total: 2 marks

- b) The student then heats 0.5 kg of water in a kettle.

Calculate the change in thermal energy needed to increase the temperature of the water by 40 °C. The specific heat capacity of water is 4,200 J/kg °C.

$\Delta E = m \times c \times \Delta\theta$	1 mark
$\Delta E = 0.50 \times 4200 \times 40$	
$\Delta E = 84\,000\text{ J}$	1 mark
	Total: 2 marks

- c) Finally, a 4.0 kg aluminium saucepan is heated from 20 °C to 70 °C. Calculate the change in thermal energy of the saucepan. The specific heat capacity of aluminium is 900 J/kg °C.

$\Delta\theta = 70 - 20$	
$\Delta\theta = 50$	1 mark
$\Delta E = m \times c \times \Delta\theta$	1 mark
$\Delta E = 4.0 \times 900 \times 50$	
$\Delta E = 180\,000\text{ J}$	1 mark
	Total: 3 marks

(Total for Question 2 is 6 marks)

3. A student investigates the specific heat capacity of an aluminium block. They use an electrical immersion heater to heat the block and a thermometer to measure the temperature change.

a) State what is meant by the term specific heat capacity.

A statement to include:	
The amount of energy required to raise the temperature	1 mark
of 1 kg of a substance by 1 °C.	1 mark
	Total: 2 marks

- b) The student supplies 10 800 J of thermal energy to a 1.0 kg block of aluminium.
The temperature of the block increases from 22 °C to 34 °C.

Calculate the specific heat capacity of the aluminium block based on the student's results.

$\Delta\theta = 34 - 22$	
$\Delta\theta = 12$	1 mark
$c = \Delta E(m \times \Delta\theta)$	
$c = 10\,800(1.0 \times 12)$	1 mark
$c = 900$	1 mark
	Total: 3 marks

- c) The immersion heater has a power output of 50 W.

Calculate how long the heater was switched on to supply the 10 800 J of thermal energy.

Use the equation: Energy transferred = power $\times$ time

$E = P \times t$	1 mark
$10\,800 = 50 \times t$	
$t = 10\,800 \div 50$	1 mark
$t = 216$	1 mark
	Total: 3 marks

- d) The specific heat capacity calculated by the student in part (b) is higher than the true value for aluminium.

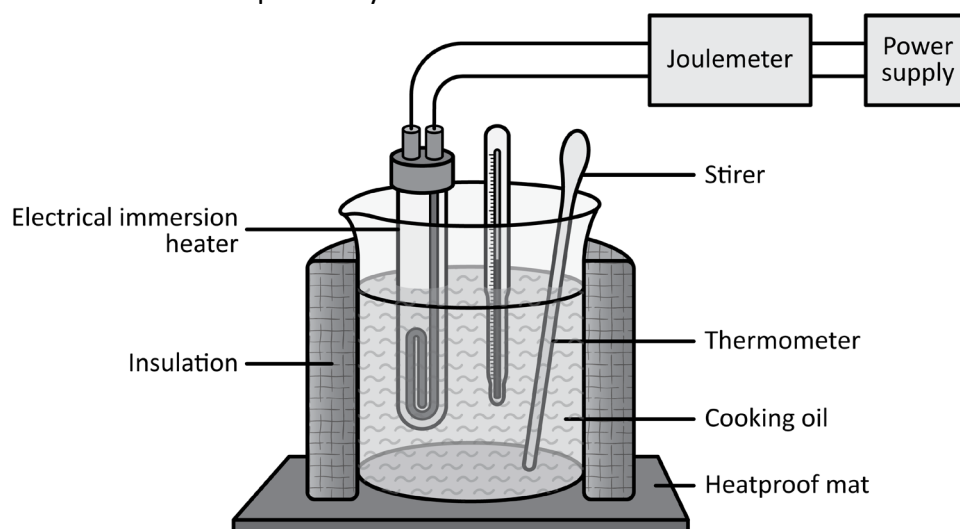
Suggest **one** reason why this happened and how the student could improve their experiment to get a more accurate result.

Reason: thermal energy is dissipated / lost to the surroundings (rather than heating the block).	1 mark
Allow: heat escapes into the air for the 1st mark.	
Improvement: wrap the block in insulation / insulating material.	1 mark
	Total: 2 marks

(Total for Question 3 is 10 marks)

4. A student investigates the specific heat capacity of cooking oil. They place the oil in a beaker wrapped in insulation and heat it using an electrical immersion heater.

The figure below shows the setup used by the student.



- a) State the standard unit for specific heat capacity and name the piece of equipment the student should use to measure the electrical energy supplied to the heater.

Unit: J / kg °C	1 mark
Equipment: Joulemeter	1 mark
	Total: 2 marks

- b) The student heats 0.8 kg of the cooking oil. The temperature of the oil increases from 20 °C to 65 °C. The specific heat capacity of the oil is 2100 J/kg °C.

Calculate the thermal energy transferred to the oil.

$\Delta\theta = 65 - 20$	
$\Delta\theta = 45$	1 mark
$\Delta E = m \times c \times \Delta\theta$	
$\Delta E = 0.8 \times 2100 \times 45$	1 mark
$\Delta E = 75\,600 \text{ J}$	1 mark
	Total: 3 marks

- c) The heater was switched on for 5 minutes to transfer this energy. Calculate the power output of the heater in Watts (W).

Use the equation: Power = Energy transferred ÷ time

$t = 5 \times 60$	
$t = 300$	1 mark
$P = E \div t$	
$P = 75\,600 \div 300$	1 mark
$P = 252 \text{ W}$	1 mark
	Total: 3 marks

(Total for Question 4 is 8 marks)

5. A student uses a 2.4 kW electric kettle to heat 1500 cm³ of water.
 The water is initially at 20 °C and is heated until it boils at 100 °C.
 The specific heat capacity of water is 4200 J/kg °C. The density of water is 1.0 g/cm³.

The kettle is 80 % efficient at transferring electrical energy into thermal energy in the water.

Calculate the time taken, in seconds, for the water to reach 100 °C.

Give your final answer to 3 significant figures.

Calculate the mass of the water: $m = \text{density} \times \text{volume}$ $m = 1.0 \times 1500 = 1500 \text{ g} = 1.5 \text{ kg}$	1 mark
Calculate thermal energy needed: $\Delta\theta = 100 - 20$ $\Delta\theta = 80$ $\Delta E = m \times c \times \Delta\theta$ $\Delta E = 1.5 \times 4200 \times 80$ $\Delta E = 504\,000 \text{ J}$	1 mark
Take the efficiency into account: $\text{Total energy required} = 504\,000 \times 0.80$ $\text{Total energy required} = 630\,000 \text{ J}$	1 mark
Determine the time taken: $\text{Power} = 2.4 \text{ kW} = 2400 \text{ W}$ $t = 630\,000 \div 2400$ $t = 262.5$	1 mark
Round to 3 sig figs: 263 seconds	1 mark
	Total: 6 marks

(Total for Question 5 is 6 marks)

6. A car of mass 1.4 tonnes is travelling at a speed of 31 m/s.
 The driver applies the brakes and the car comes to a complete stop.
 The car has 4 brake discs. Each brake disc has a mass of 1.5 kg.
 The specific heat capacity of the material used to make the brake discs is 450 J/kg °C.

Assume that all the kinetic energy of the car is transferred into the thermal store of the 4 brake discs equally. Calculate the maximum temperature increase of the brake discs.
 Give your answer to 2 significant figures.

Calculate kinetic energy of the car: $\text{Mass} = 1.4 \text{ tonnes} = 1400 \text{ kg}$ $E_k = 0.5 \times m \times v^2$ $E_k = 0.5 \times 1400 \times 31^2$	 1 mark 1 mark
Calculate thermal energy per brake disc: $E = 672\,700 \div 4$ $E = 168\,175 \text{ J}$	 1 mark
Calculate temperature increase: $\Delta\theta = \Delta E \div (m \times c)$ $\Delta\theta = 168\,175 \div (1.5 \times 450)$ $\Delta\theta = 249.148$	 1 mark 1 mark
Round to 2 significant figures: 250	 1 mark
	Total: 6 marks

(Total for Question 6 is 6 marks)

7. A sports car of mass 1200 kg is travelling at a speed of 108 km/h.
The driver applies the brakes and the car comes to a complete stop.

Only 60% of the car's initial kinetic energy is transferred into the thermal store of the two front brake discs. The mass of each front brake disc is 1.2 kg.

The specific heat capacity of the brake disc material is 460 J/kg °C.

Before the driver applied the brakes, the temperature of the brake discs was already 45 °C.

Calculate the maximum final temperature of the front brake discs.

Give your answer to 3 significant figures.

Convert speed to m/s: $108 \text{ km/h} = 108,000 \text{ m/h}$ $108,000 \div 3600 = 30 \text{ m/s}$	1 mark
Calculate kinetic energy: $E_k = 0.5 \times m \times v^2$ $E_k = 0.5 \times 1200 \times 30^2$ $E_k = 540,000 \text{ J}$	1 mark
Apply efficiency and split energy: Thermal energy to both of the front brakes = $540,000 \times 0.60 = 324,000 \text{ J}$ Energy to one brake disc = $324,000 \div 2 = 162,000 \text{ J}$	1 mark
Calculate temperature increase: $\Delta\theta = \Delta E \div (m \times c)$ $\Delta\theta = 162000 \div (1.2 \times 460)$ $\Delta\theta = 293.478$ Final temperature: $293.478 + 45$ $= 338.478$	1 mark
Round to 3 significant figures: 338	1 mark
	Total: 6 marks

(Total for Question 7 is 6 marks)