

Specific heat capacity required practical

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Paper 1 | Foundation and Higher

Worked solutions and teaching prompts | 26 parts | 48 marks

Specification points covered

Specific heat capacity and energy changes: 8463 4.1.1.3 / 8464 6.1.1.3. Required practical: 8463 RP1 / 8464 RP14.

Electrical power and energy: 8463 4.2.4.1–4.2.4.2 / 8464 6.2.4.1–6.2.4.2; power and time: 4.1.1.4 / 6.1.1.4.

Unwanted energy transfers and insulation: 8463 4.1.2.1 / 8464 6.1.2.1. Analyse data and evaluate a practical method.

A manufacturer tests metal heat-spreader blocks for a temperature-controlled food delivery box. Your job is to check the measurements, evaluate the test and select a block. All data and design limits are supplied for this exercise.

Original PhysicsUK questions, not an official AQA paper or mark scheme. Accept valid alternative methods and consistent follow-through without double penalising an earlier error. Use the levels guidance for 6(a). Timing is an estimate, not classroom-tested.

1 Checking the heating calculations

Each part describes a separate test or design change at the factory.

1(a) A block warms from 19.0 °C to 34.0 °C. Calculate its temperature rise. **[1 mark]**

Answer / mark points: $\Delta\theta = 34.0 - 19.0 = 15.0$ °C. [1]

Teacher prompt: Use final temperature minus initial temperature, not the final reading alone.

1(b) A 24 W heater operates for 150 s. Calculate the electrical energy it supplies. **[1 mark]**

Answer / mark points: $E = P t = 24 \times 150 = 3600$ J. [1]

1(c) An aluminium block has mass 0.400 kg and $c = 900 \text{ J kg}^{-1} \text{ °C}^{-1}$. Calculate its energy gain for a 10.0 °C rise. **[1 mark]**

Answer / mark points: $\Delta E = m c \Delta\theta = 0.400 \times 900 \times 10.0 = 3600$ J. [1]



1 Checking the heating calculations continued

1(d) A smaller aluminium insert has mass 250 g and $c = 900 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$. Calculate the energy needed to raise its temperature from $20.0 \text{ }^{\circ}\text{C}$ to $36.0 \text{ }^{\circ}\text{C}$. **[2 marks]**

Answer / mark points: $m = 0.250 \text{ kg}$ and $\Delta\theta = 16.0 \text{ }^{\circ}\text{C}$; correct substitution $\Delta E = 0.250 \times 900 \times 16.0$. [1] $\Delta E = 3600 \text{ J}$. [1]

1(e) A 0.600 kg steel block has $c = 500 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$. It gains 4500 J. It starts at $22.0 \text{ }^{\circ}\text{C}$. Calculate its final temperature. **[2 marks]**

Answer / mark points: $\Delta\theta = \Delta E / (m c) = 4500 / (0.600 \times 500) = 15.0 \text{ }^{\circ}\text{C}$. [1] Final temperature = $22.0 + 15.0 = 37.0 \text{ }^{\circ}\text{C}$. [1]

1(f) An aluminium block must gain 7200 J while warming by $20.0 \text{ }^{\circ}\text{C}$. Its specific heat capacity is $900 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$. Calculate the mass needed. **[2 marks]**

Answer / mark points: $m = \Delta E / (c \Delta\theta) = 7200 / (900 \times 20.0)$. [1] $m = 0.400 \text{ kg}$. [1]

1(g) A test heater supplies 12 000 J in 4.0 minutes. Calculate its mean power. **[2 marks]**

Answer / mark points: $t = 4.0 \times 60 = 240 \text{ s}$; $P = E / t = 12\,000 / 240$. [1] $P = 50 \text{ W}$. [1]

Teacher prompt: Convert minutes to seconds before using joules and watts.

1(h) A heater operates at 12.0 V with a current of 2.00 A. Calculate the energy it supplies during a 200 s block test. **[2 marks]**

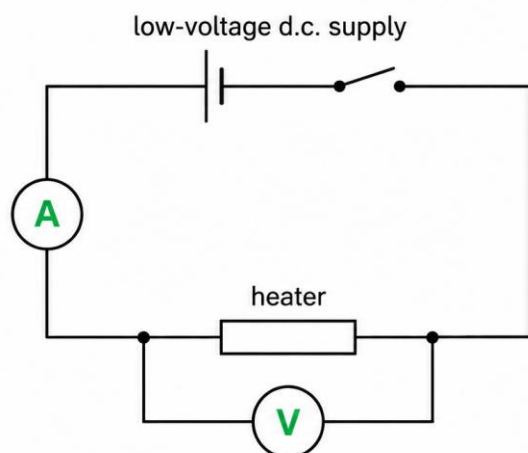
Answer / mark points: $P = V I = 12.0 \times 2.00 = 24.0 \text{ W}$. [1] $E = P t = 24.0 \times 200 = 4800 \text{ J}$. [1]
Alternatively $E = V I t$.



2 Setting up the block test

Figure 1 shows the circuit and a cross-section of the block. The heater symbol represents the heater in the block. The switch is open during setup.

Circuit



Block cross-section

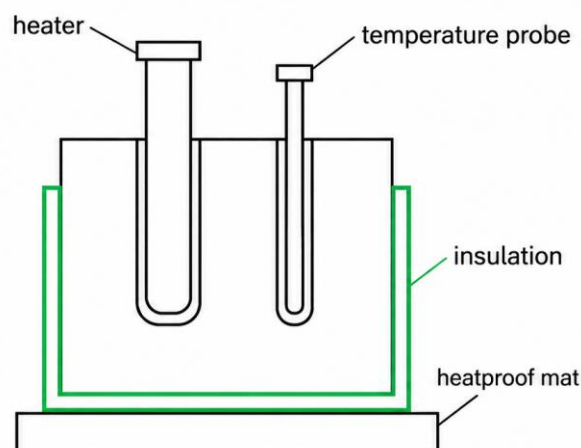


Figure 1

2(a) Name the meters needed at P and Q in Figure 1. **[2 marks]**

Answer / mark points: P: ammeter, to measure current through the heater. [1] Q: voltmeter, to measure potential difference across the heater. [1] The teacher figure replaces P and Q with A and V.

Teacher prompt: An ammeter is connected in series. A voltmeter is connected in parallel across the component.

2(b) Name the instrument used to measure the block's mass before insulation is added. **[1 mark]**

Answer / mark points: A balance (digital/top-pan balance). [1] Record mass in kg. A newtonmeter measures weight, not mass directly.

2(c) Why should the probe be left in the unheated block until its reading is steady before the initial temperature is recorded? **[1 mark]**

Answer / mark points: To allow the probe to reach the block's temperature / thermal equilibrium with the block. [1] A steady room-temperature reading before insertion is not sufficient.

2(d) A probe fits loosely in its hole. Suggest one improvement to obtain a temperature reading closer to the block's temperature. **[1 mark]**

Answer / mark points: Add a small amount of suitable thermal contact paste/oil in the probe hole, or use a close-fitting probe, to improve thermal contact. [1] Keep any liquid away from electrical connections.

2(e) Give one precaution that reduces the risk of burns when dismantling the apparatus. **[1 mark]**

Answer / mark points: Switch off the supply and allow the block/heater to cool before handling. [1] Accept an appropriate heat-resistant handling tool with a clear link to avoiding hot surfaces.



3 Plotting and using the test results

A 0.500 kg block starts at 20.0 °C. Table 1 gives electrical energy supplied and the measured block temperature. Do not assume yet that all this energy reaches the block.

Table 1

Energy supplied E / J	Block temperature / °C
0	20.0
1000	22.0
2000	24.0
3000	26.0
4000	28.0
5000	30.0

3(a) Use Table 1. What temperature rises correspond to 26.0 °C and 30.0 °C? [1 mark]

Answer / mark points: $\Delta\theta = 26.0 - 20.0 = 6.0$ °C; $\Delta\theta = 30.0 - 20.0 = 10.0$ °C. [1 for both]

3(b) Plot all six readings from Table 1 on Figure 2, with electrical energy against temperature rise. Draw a straight line of best fit. [3 marks]

Answer / mark points: Plot ($\Delta\theta$, E): (0,0), (2,1000), (4,2000), (6,3000), (8,4000), (10,5000). [2 for all six; 1 for four or five correct] Draw one straight best-fit line through the plotted trend/origin. [1] Plot tolerance: half a small grid division. Axes are already provided; do not award a separate axes mark.

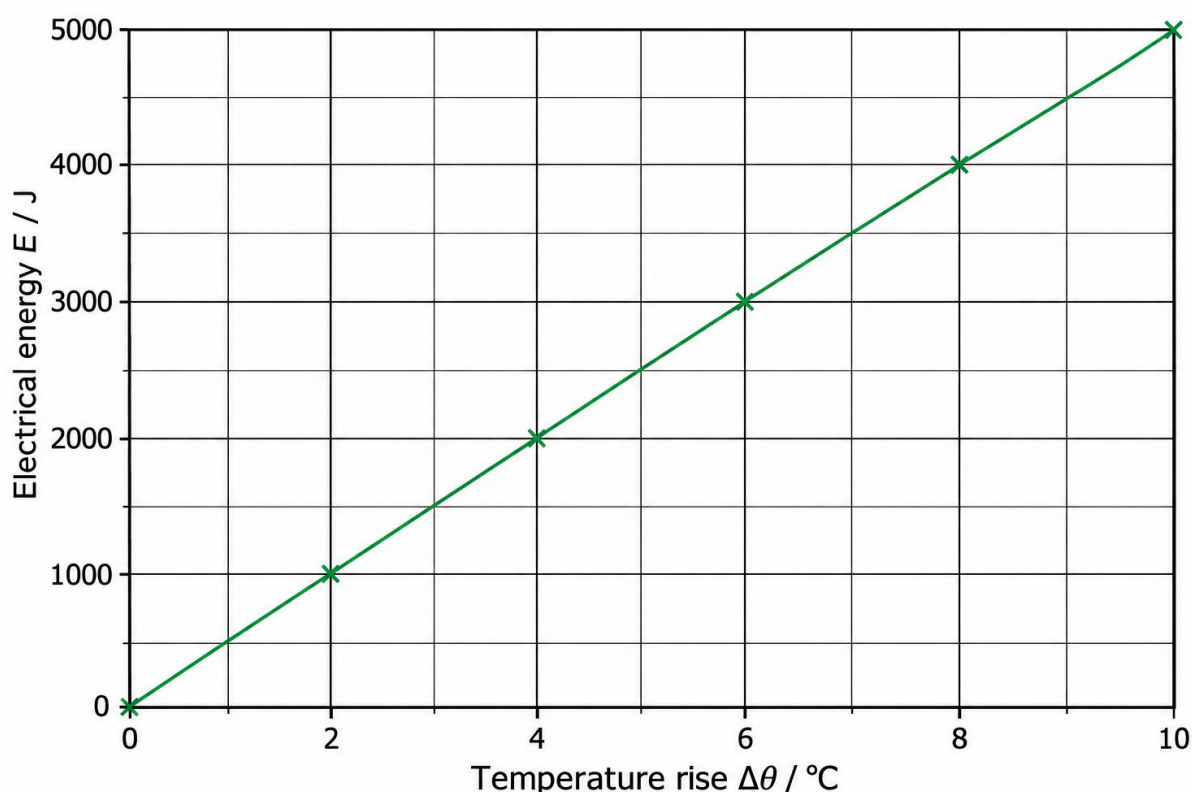


Figure 2

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3 Plotting and using the test results continued

3(c) Calculate the gradient of your graph using two widely separated points. Use gradient = change in energy / change in temperature rise. Give its unit. **[2 marks]**

Answer / mark points: For example gradient = $(5000 - 0) / (10.0 - 0) = 500$. [1] Unit J per °C. [1] Accept a suitable pair of separated points and consistent readings; do not divide temperature rise by energy.

3(d) For this graph, c = gradient / mass. Use your gradient and the 0.500 kg block mass to estimate its specific heat capacity. **[1 mark]**

Answer / mark points: c = gradient / m = $500 / 0.500 = 1000 \text{ J kg}^{-1} \text{ °C}^{-1}$. [1] Accept consistent follow-through from 3(c).

3(e) Use your line to estimate the electrical energy supplied for a temperature rise of 7.0 °C. **[1 mark]**

Answer / mark points: 3500 J. [1] Allow 3250–3750 J, or a read-off consistent with the pupil's valid best-fit line.

4 Checking whether the result is trustworthy

The team investigates why the measured value differs from the reference value for this metal.

4(a) The calculation in 3(d) treats all electrical energy supplied as energy gained by the block. Explain why energy transferred to the surroundings makes this calculated c too high. **[2 marks]**

Answer / mark points: The electrical energy supplied is greater than the energy actually gained by the block. [1] Using this larger energy in $c = E / (m \Delta\theta)$, for the measured mass and temperature rise, gives a value that is too high. [1]

Teacher prompt: "Heat is lost" alone identifies an issue but does not explain the direction of the error. Energy is transferred, not destroyed.

4(b) A separate check shows that when 5000 J is supplied, 500 J is transferred elsewhere. The 0.500 kg block warms by 10.0 °C. Calculate its corrected specific heat capacity. **[2 marks]**

Answer / mark points: Energy gained by block = $5000 - 500 = 4500 \text{ J}$. [1] $c = 4500 / (0.500 \times 10.0) = 900 \text{ J kg}^{-1} \text{ °C}^{-1}$. [1]

4(c) Three repeats using the original method give c values of 960, 1000 and $1040 \text{ J kg}^{-1} \text{ °C}^{-1}$. Calculate the mean. Does taking this mean remove a systematic heat-loss error? Explain. **[2 marks]**

Answer / mark points: Mean = $(960 + 1000 + 1040) / 3 = 1000 \text{ J kg}^{-1} \text{ °C}^{-1}$. [1] No: heat loss biases all repeats in the same direction; averaging can reduce random variation, not remove this systematic error. [1]

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4 Checking whether the result is trustworthy continued

4(d) The team compares two insulation jackets on the SAME block, using temperature rise after a fixed heating time. Choose one other variable to keep constant and explain why it matters. **[2 marks]**

Answer / mark points: For example, keep heater power constant [1] so the same electrical energy is supplied in the fixed time [1]. Or keep initial block and room temperatures the same [1] so the starting temperature difference, and hence initial heat-loss conditions, are comparable [1]. Accept another valid control with a linked reason; not insulation thickness if thickness is the variable being compared.

5 Selecting a delivery-box block

Table 2 gives reference values for two candidate blocks. Both fit the box. For this comparison, neglect energy transfers to the surroundings.

Table 2

Block	Mass / kg	c / J kg ⁻¹ °C ⁻¹
A	0.500	900
B	0.750	500

5(a) Each candidate block cools from 65.0 °C to 45.0 °C. Calculate the energy released by block A and by block B. **[2 marks]**

Answer / mark points: A: $\Delta E = 0.500 \times 900 \times 20.0 = 9000 \text{ J}$. [1] B: $\Delta E = 0.750 \times 500 \times 20.0 = 7500 \text{ J}$. [1] Values are magnitudes of energy released.

5(b) The box needs at least 8000 J released over this temperature drop and the block mass must not exceed 0.800 kg. Which candidate meets BOTH requirements? Use the data to justify your answer. **[2 marks]**

Answer / mark points: A meets both: 9000 J is at least 8000 J and 0.500 kg is below 0.800 kg. [1] B satisfies the mass limit (0.750 kg) but releases only 7500 J, below 8000 J, so fails. [1] Accept consistent comparison following an earlier arithmetic error.

5(c) For a different product, block B is heated from 20.0 °C to 65.0 °C by a 25 W heater. Calculate the minimum heating time and decide whether it can be ready within 12 minutes. **[3 marks]**

Answer / mark points: $E = 0.750 \times 500 \times (65.0 - 20.0) = 16\,875 \text{ J}$. [1] $t = E / P = 16\,875 / 25 = 675 \text{ s}$ (11.25 min). [1] Yes: 675 s is less than 720 s / 11.25 min is less than 12 min. [1] Real heating may take longer because losses were neglected.

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6 Writing a complete practical method

A new supplier sends an unlabelled metal block with two holes. The team must measure its specific heat capacity before considering it for the box.

6(a) Describe a method to determine the specific heat capacity of the new metal block using an electrical heater. Explain how you would obtain the necessary measurements, calculate c and reduce important errors. Include one safety precaution. Use these planning headings: mass and setup → energy input → temperature rise → calculation → checks and safety. **[6 marks]**

Answer / mark points: Model method: Measure the dry, bare block's mass using a checked/zeroed balance and record it in kg. Put it on a heatproof mat, wrap the sides/top with suitable insulation and insert the heater and temperature probe fully into their separate holes. Improve thermal contact with a small amount of suitable contact paste/oil, kept away from electrical connections. Use a low-voltage supply; connect an ammeter in series and a voltmeter across the heater, or use a correctly connected joulemeter.

Let the probe reach the block's temperature and record the initial temperature. Switch on the heater and start the timer together. Record V and I and check they remain steady; record heating time in seconds and temperature readings at suitable intervals. Calculate $E = V I t$ for steady readings (or obtain the energy change from a joulemeter), and $\Delta\theta$ = final minus initial temperature. Choose a temperature rise large enough to measure reliably without overheating.

Calculate $c = E / (m \Delta\theta)$, in $\text{J kg}^{-1} \text{ } ^\circ\text{C}^{-1}$, noting that some input energy also heats the apparatus/surroundings. Insulation and good contact reduce important errors but do not guarantee zero heat loss. Repeat after returning the block to a comparable initial temperature and take a mean of consistent c values. Switch off and allow hot equipment to cool before handling.

Holistic levels: 5–6 marks for a clear, logically sequenced, usable method measuring mass, electrical energy and temperature change, with a correct calculation and relevant error reduction; use completeness, measurement detail and safety to choose within the level. 3–4 for a mostly usable account with an important omission or incomplete links. 1–2 for relevant isolated steps that do not form a usable method. 0 for no relevant content. Do not allocate six automatic keyword ticks. Accept a valid joulemeter method or an energy-versus-temperature-rise graph with $c = \text{gradient} / \text{mass}$.

Teacher prompt: This is a scaffolded six-mark practice response, not an independently standardised AQA mark scheme. Do not require every optional improvement in the model to award full marks.

Review and improve

Distinguish temperature from temperature rise, energy supplied from energy gained by the block, and random variation from systematic heat loss. A specific heat capacity is not an amount of energy.

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