Heating Matter

Questions

Q1.

A student uses the apparatus in Figure 17 to determine the specific heat capacity of water.

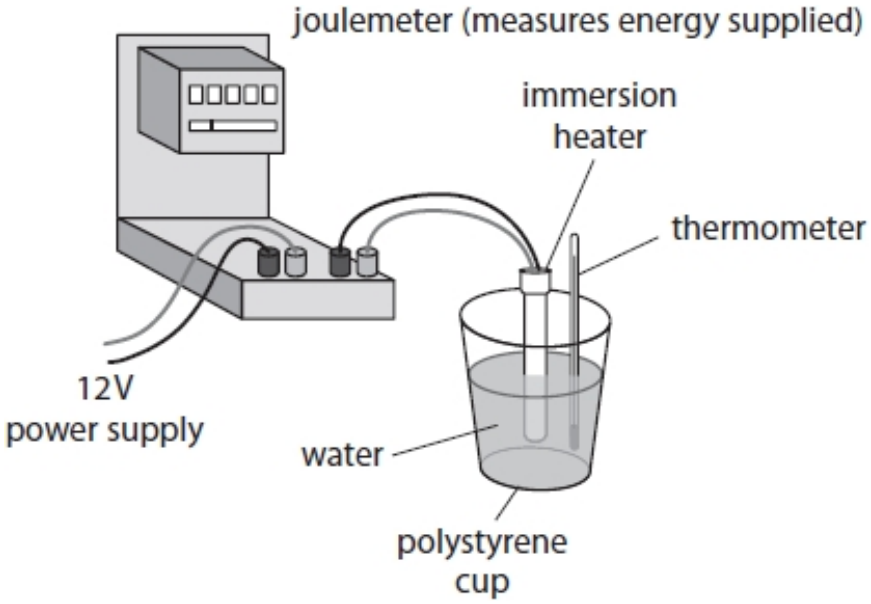

Figure 17

(i) State the measurements needed to calculate the specific heat capacity of water.

(4)

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(ii) State **two** ways that the apparatus could be adapted to improve the procedure.

(2)

1 .....

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2 .....

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(Total for question = 6 marks)

Q2.

A student wants to determine the specific heat capacity of copper.

Figure 20 shows a piece of copper, with a thread tied around it, in a glass beaker of boiling water.

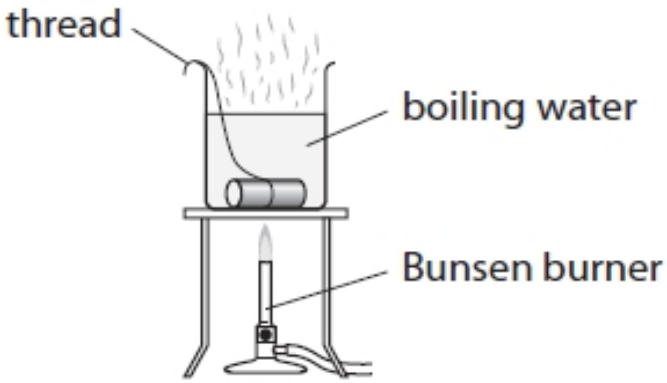

Figure 20

The student leaves the piece of copper in the boiling water so that the copper reaches a temperature of 100 °C.

The student uses the thread to take the piece of copper out of the boiling water.

The student puts the hot piece of copper into a different beaker of cold water at 20 °C.

The apparatus is shown in Figure 21.

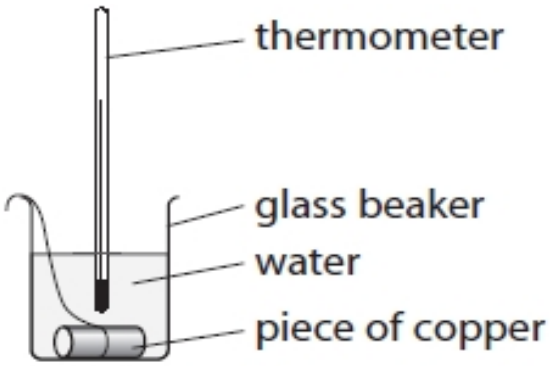

Figure 21

The student assumes that the thermal energy gained by the water equals the thermal energy lost by the piece of copper.

The water and copper both reach a temperature of 22 °C.

The cold water gains 1050 J of energy.

The mass of the piece of copper is 0.058 kg.

(i) Calculate a value for the specific heat capacity of copper, using these results.

Use the equation

change in thermal energy = mass × specific heat capacity × change in temperature

$$\Delta Q = m \times c \times \Delta\theta$$

(2)

specific heat capacity of copper from these results = ...
J/kg °C

(ii) The value for the specific heat capacity of copper obtained from the student's results is lower than the correct value.

State **two** ways that the experiment could be improved to give a value that is closer to the correct value.

(2)

1 .....

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2 .....

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(Total for question = 4 marks)

Q3.

A beaker contains 0.25 kg of water at room temperature.
The beaker of water is heated until the water reaches boiling point (100 °C).
The specific heat capacity of water is 4200 J/kg °C.
The total amount of thermal energy supplied to the water is 84 000 J.

(i) Calculate the temperature of the water before it was heated.

Use an equation selected from the list of equations at the end of this paper.

(3)

temperature before heating = ... °C

(ii) The heating continues until 0.15 kg of the water has turned into steam.

The thermal energy needed to turn the boiling water into steam is 0.34 MJ.
Calculate the specific latent heat of vapourisation of water.
Use an equation selected from the list of equations at the end of this paper.

(2)

specific latent heat = ... MJ/kg

(iii) The graph in Figure 13 shows how the **volume** of 1 kg of water changes with temperature.

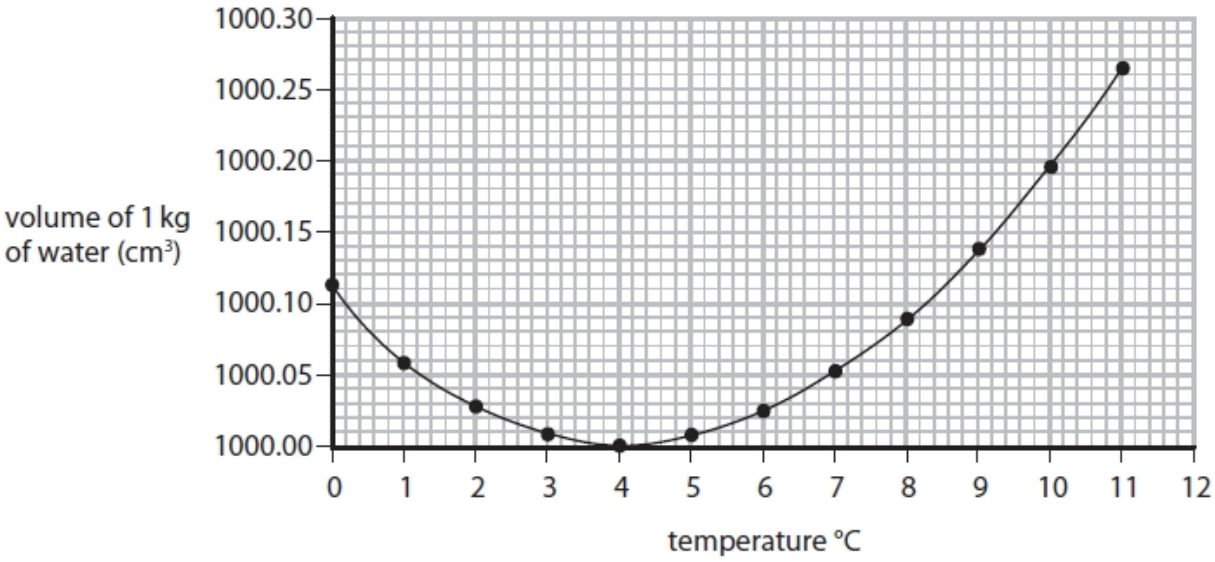

Figure 13

Describe how the **density** of water changes with temperature over the range of temperature shown in Figure 13.
Calculations are not required.

(2)

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(Total for question = 7 marks)

Q4.

(i) Figure 11 shows an electric kettle.

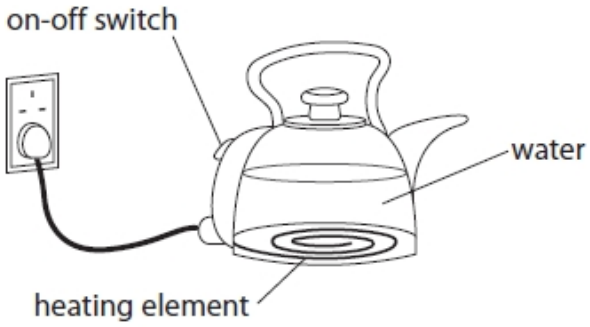

Figure 11

The kettle contains 1.5 kg of water.
The kettle is switched on.
Calculate the energy needed to raise the temperature of the water by 50 °C.
Specific heat capacity of water = 4200 J/kg °C
Use the equation

$$\Delta Q = m \times c \times \Delta\theta$$

(2)

energy needed = ... J

(ii) The amount of energy, *E*, needed to bring the water to boiling point is 670 000 J.

The kettle has a power of 3500 W.
Calculate the time, *t*, it takes to bring the water to boiling point.
Use the equation

$$P = \frac{E}{t}$$

(3)

time to bring the water to boiling point = ... s

(Total for question = 5 marks)

Q5.

A digital thermometer gives a temperature reading of 23 °C.

Calculate the value of this temperature in kelvin.

(1)

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.....

(Total for question = 1 mark)

Q6.

An electric kettle contains 1.41 kg of water at 25 °C.

The kettle is switched on.

After a while, the water reaches boiling point at 100 °C.

The specific heat capacity of water is 4200 J / kg °C.

(i) Calculate the amount of thermal energy supplied to the water by the kettle.
Give your answer to the appropriate number of significant figures.

Use an equation selected from the list of equations at the end of the paper.

(3)

energy supplied = ... J

(ii) The kettle is kept switched on and the water continues to boil.

After a while, the mass of the water in the kettle has decreased to 1.21 kg.
The thermal energy supplied to the water during this time was 450 000 J.
Calculate the specific latent heat of vaporisation of water.
Use an equation selected from the list of equations at the end of the paper.

(3)

specific latent heat of vaporisation = ... J / kg

(Total for question = 6 marks)

Q7.

Another student decides to melt some ice.

The student melts 380 g of ice at 0 °C.

The specific latent heat of fusion of ice is 3.34×10^5 J/kg.

Calculate the thermal energy needed to melt the ice.

Select an equation from the list of equations at the end of this paper.

(2)

thermal energy needed = ... J

(Total for question = 2 marks)

Q8.

On a very cold day, the temperature of the air is −4 °C.

Calculate the value of this temperature on the kelvin scale.

(1)

temperature = ... K

(Total for question = 1 mark)

Q9.

Describe, in terms of particles, **two** differences between a solid and a liquid of the same substance.

(2)

1 .....

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2 .....

.....

(Total for question = 2 marks)

Q10.

* This question is about determining the specific heat capacity of aluminium.
An aluminium block is placed in boiling water as shown in Figure 21.

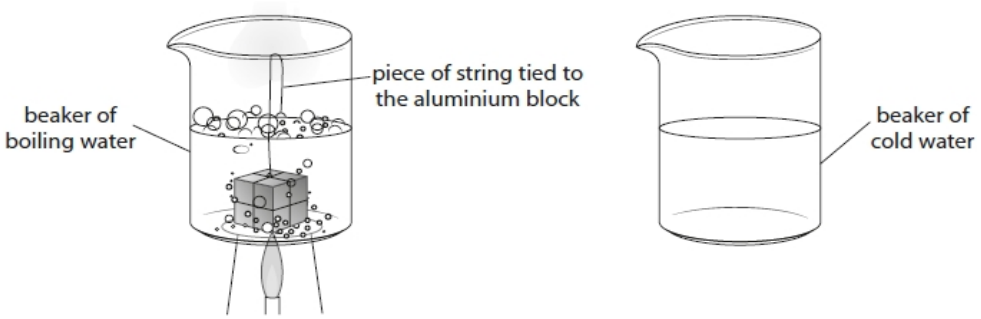

Figure 21

The piece of string is tied to the aluminium block so the block can be transferred from the boiling water to the cold water.

Describe how a student could use this apparatus, and any additional items needed, to determine the specific heat capacity of aluminium.

Your answer should include how the student would

- obtain the necessary measurements
- use the measurements to calculate the specific heat capacity of aluminium.

(6)

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(Total for question = 6 marks)

Q11.

The student decides to measure the temperature of the water every minute while it is being heated.

Figure 18 shows a graph of the student's results.

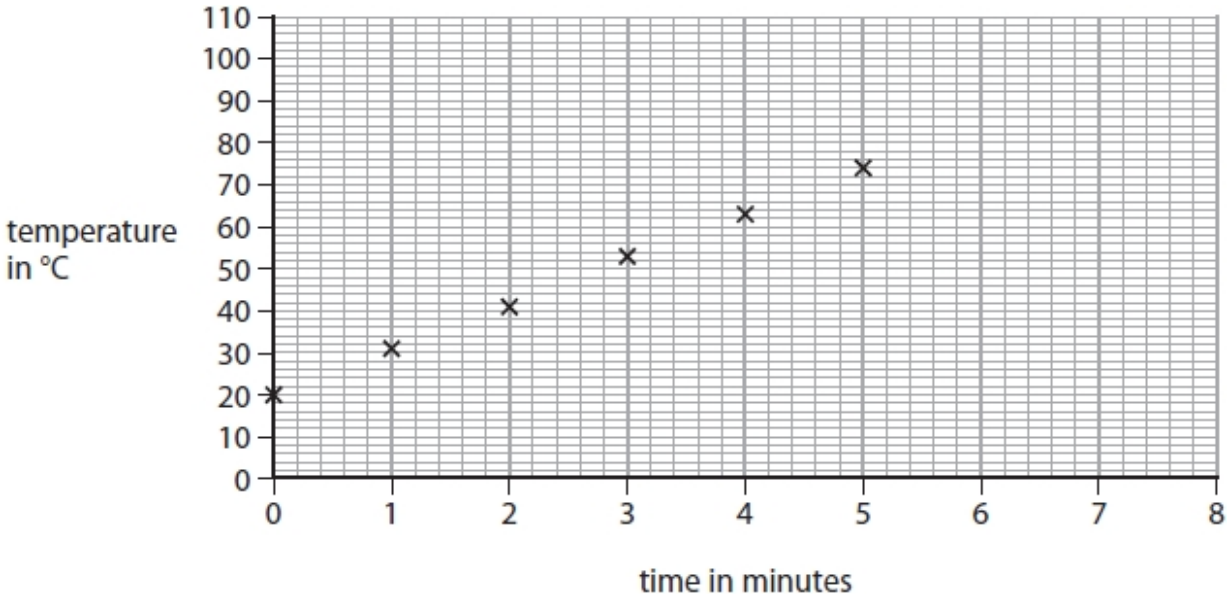

Figure 18

Predict the temperature of the water if the heating continues up to 8 minutes.

(1)

temperature of the water = ... °C

(Total for question = 1 mark)

Q12.

Figure 21 shows a shed made mostly of concrete blocks.

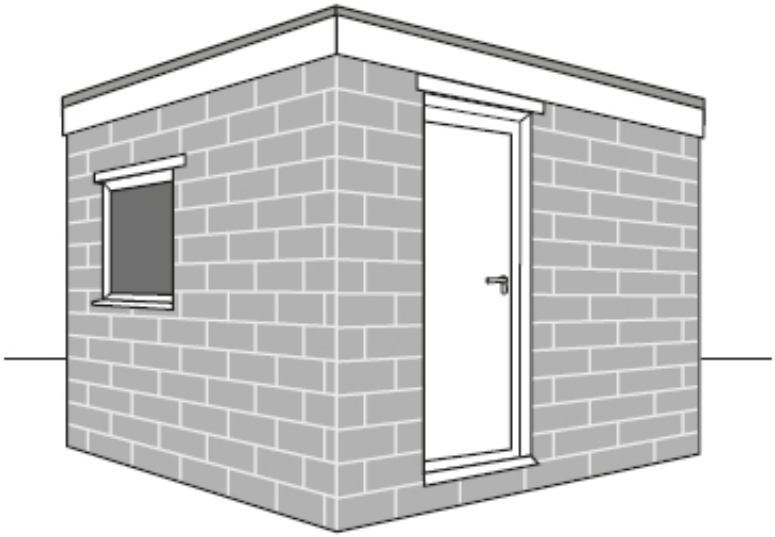

Figure 21

State **two** practical ways to reduce heat loss from this shed.

(2)

1 .....

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2 .....

.....

(Total for question = 2 marks)

Mark Scheme – Heating Matter

Q1.

Question number:	Answer	Additional guidance	Mark
(i)			(4) AO 1 2
	(measurement of) the mass of water (1)	accept volume / weight of water ignore amount	
	(measurement of) the temperature (rise/change) (1)	accept (take) thermometer reading	
	(measurement of) the energy supplied / from heater (1)	accept (take) reading of the joulemeter ignore 'change in thermal energy' (from equation)	
	detail of any of the above (1)	e.g. measure temp at the start and end or measure mass of empty cup or start and end readings on the meter	

Question Number:	Answer	Additional guidance	Mark
(ii)	any two improvements from:	both marks can be scored in one answer space ignore repeating readings ignore increase voltage / power / energy ignore use of clamp to hold thermometer / heater	(2) AO 3 3b
	add lid /cover (1)		
	add lagging / insulation (1)	accept use better insulator or better insulated / thicker cup accept use calorimeter ignore use glass beaker unless cup is inside it ignore different type of cup	
	add a stirrer (1)		
	use a more sensitive thermometer (1)	accept use digital / electric thermometer / data logger	
	ensure heater fully submerged (1)		

Q2.

Question number	Answer	Additional guidance	Mark
(i)	rearrangement (and substitution) (1) (c) = $\frac{1050}{0.058 \times 78}$ evaluation (1) 230 (J/kg °C)	$c = \frac{\Delta Q}{m \times \Delta\theta}$ award 1 mark if 78 seen accept 232(J/kg °C) award full marks for correct answer without working.	**(2)**

Question number	Answer	Additional guidance	Mark
(ii)	any two of the following reduce heat loss from water/insulate beaker/add cover (1) make the temperature rise larger/use a larger piece of copper/ use a smaller amount of water (1) (use)a stirrer (1) account for heat gained by glass beaker (1) transfer the hot copper faster (1) use a different heating method (1) measure the temperature of the boiling water (1)	ignore more accurate measurements e.g. thermometer, balance etc. ignore taking repeats start with colder water	**(2)**

Q3.

Question Number	Answer	Additional guidance	Mark
(i)	substitution into $\Delta Q = m \times c \times \Delta\theta$ (1) $84\,000 = 0.25 \times 4200 \times \Delta\theta$ rearrangement $\frac{\Delta Q}{m \times c}$ (1) $(\Delta\theta =) \frac{84\,000}{0.25 \times 4200}$ $(= 80)$ evaluation (1) (temperature before heating =) 20 (°C)	accept substitution and rearrangement in either order answer of 80 (°C) scores 2 marks award full marks for the correct answer without working	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $Q = m \times L$ (1) $0.34 = 0.15 \times L$ re-arrangement and evaluation (1) $(L = \frac{0.34}{0.15} =)$ 2.3 (MJ/kg)	allow values that round to 2.3 (MJ/kg) allow 1 mark for POT error award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(iii)	A description that makes reference to any **two** of the following (density) increases between 0°C and 4 °C (1) reaches a maximum at 4 °C (1) (density) decreases above 4 °C (1)	 increases initially / at first / up to 4 °C then decreases if no other marks scored then credit reference to large volume means low density (OWTTE) for 1 mark only	(2)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $(\Delta Q) = 1.5 \times 4200 \times 50$ evaluation (1) 320 000 (J)	 accept 315 000 (J) 310 000 (J) award full marks for the correct answer without working 320 000 000 315 000 000 310 000 000 score 1 mark (mass in grams)	**(2)**

Question Number	Answer	Additional guidance	Mark
(ii)	substitution (1) $3500 = \frac{670\,000}{t}$ rearrangement (1) $(t=) \frac{670\,000}{3500}$ evaluation (1) 190(s)	accept substitution and rearrangement in either order accept any answer that round to 190(s) power of ten error award 2 marks maximum award full marks for the correct answer without working	**(3)**

Q5.

Question Number	Answer	Additional guidance	Mark
	296 (°C)	accept 23 + 273	**(1)**

Q6.

Question number	Answer	Additional guidance	Mark
i	substitution into $\Delta Q = m \times s \times \Delta T$ (1) $(\Delta Q) = 1.41 \times 4200 \times (100-25)$		**(3)** **AO2**
	evaluation (1) (energy =) 444,150 (J) answer to 2 sf (1) 440,000 (J)	ignore POT error for this mark independent mark allow 3 sf 444,000 award full marks for the correct answer without working award 1 mark for answers with values 148,050 or 592,200 (incorrect temp and sf) award 2 marks for answers with values 150,000 or 148,000 or 590,000 or 592,000 (incorrect temp but allowed sf)	

Question number	Answer	Additional guidance	Mark
ii	substitution into $\Delta Q = m \times L$ $450{,}000 = (1.41 - 1.21) \times L$ (1) rearrangment $L = \frac{450{,}000}{0.2}$ (1) evaluation (L) = 2 200 000 (J/kg) (1)	allow substitution and rearrangement in either order accept 2 250 000 award full marks for the correct answer without working award 1 mark for answers that round to 330,000 or 370,000 (incorrect mass used)	**(3)** **AO2**

Q7.

Question Number:	Answer	Additional guidance	Mark
	substitution (1) $(Q =) \frac{380 \times 3.34\ (\times 10^5)}{(1000)}$ evaluation (1) 1.27×10^5 (J)	 127 kJ 126920 (J) accept answers that round to 1.27×10^5 e.g. 1.2692×10^5 accept 130 kJ or 1.3×10^5 (J) POT error max. 1 mark award full marks for correct answer without working	**(2)** AO 2 1

Q8.

Question number	Answer	Additional guidance	Mark
	269 (K)	allow use of 273.14? 269.14 (K)	**(1)** **AO2**

Q9.

Question number	Answer	Additional guidance	Mark
	descriptions to include any **two** of • particles / atoms in solid close(r) together (1)	reverse argument difference asked for, so **must compare** for subsequent marking points	**(2) AO1**
	• particles / atoms in solid (vibrate) in fixed positions but particles in liquid move (freely) (1)		
	• particles in a solid in regular arrangement but particles in liquid are randomly arranged (1)		
	• particles in a liquid have more (kinetic) energy (than in a solid) (1)	allow answers in terms of forces between particles	

Q10.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Procedure • Measure the temperature of the boiling water • Allow sufficient time for block to reach temperature of boiling water • Measure temperature of cold water in beaker • Using a thermometer • Transfer (hot) aluminium block to cold water in the beaker. • Work quickly to avoid thermal energy loss during transfer • Measure temperature of water • Stir to ensure even distribution • Measure maximum temperature reached by water • Calculate temp rise of water by subtracting initial from final temperature. • Calculate temp drop of aluminium by subtracting final temperature from 100. • Find mass of beaker and water and aluminium • Use a balance • Empty water from beaker and dry beaker and block • Weigh beaker and block alone • Find mass of water by subtraction. • Allow plausible method of finding mass of water before putting block in.	**(6)** **AO2 and AO3**
	Process results • Calculate thermal energy gained water using $\Delta Q = m \times c \times \Delta\theta$ • Thermal energy gained by water = thermal energy lost by aluminium • Specific heat capacity of aluminium = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$	

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1–2	• The plan attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. (AO2) • Analyses the scientific information but understanding and connections are flawed. An incomplete plan that provides limited synthesis of understanding. (AO3)
Level 2	3–4	• The plan is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. (AO2) • Analyses the scientific information and provides some logical connections between scientific enquiry, techniques and procedures. A partially completed plan that synthesises mostly relevant understanding, but not entirely coherently. (AO3)
Level 3	5–6	• The plan is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. (AO2) • Analyses the scientific information and provide logical connections between scientific concepts throughout. A well-developed plan that synthesises relevant understanding

Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Partially complete description of a suitable procedure with at least one measurement	Possible candidate responses Heat up the block in the boiling water. Then put the block into the cold water. Measure the temperature reached by the water.
Level 2	3–4	Additional guidance Mostly complete description of a suitable procedure with at least two measurements and some description of processing the results.	Possible candidate responses As above with Measure mass of water. Use $\Delta Q = m \times c \times \Delta\theta$ to find thermal energy transferred
Level 3	5–6	Additional guidance Detailed description of a suitable procedure with most of the necessary measurements and a clear description of processing the results.	Possible candidate responses As above with Calculate temperature changes by subtraction. Calculate thermal energy lost by Al as being equal to thermal energy gained by water. Specific heat capacity of Al = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$

Q11.

Question Number:	Answer	Additional guidance	Mark
	100 (°C) (1)	accept any answer between and including 95 and 102 (possibility that it is not pure water and possibility of heat loss prevents reaching boiling point)	**(1)** AO 2 1

Q12.

Question number	Answer	Additional guidance	Mark
	statements to include any **two** from use cladding / (extra) insulation (1) use double thicknesses of the concrete (1) use silver / reflective / white (paint) (1) plant trees around (wind break) (1) use double glazed windows (1) (properly) close window(s)/door	 create cavity draft exclusion	**(2)** **AO1**