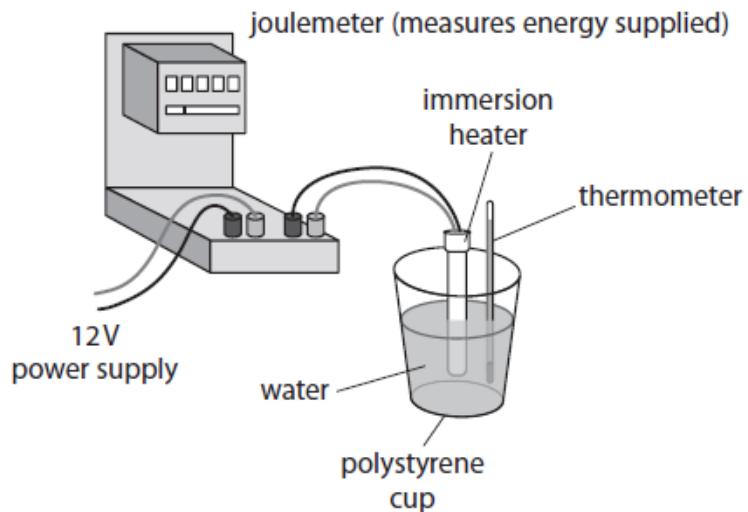


## Questions

Q1.

A student uses the apparatus in Figure 3 to determine the specific heat capacity of water.



**Figure 3**

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

(4)

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.....  
.....  
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.....  
.....

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

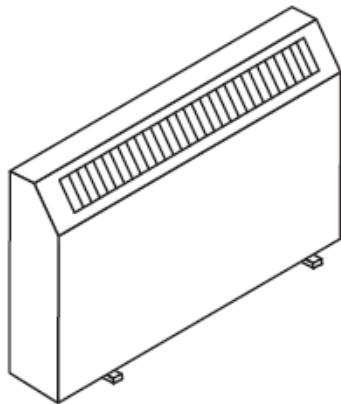
(2)

1 .....  
.....  
.....  
2 .....

**(Total for question = 6 marks)**

Q2.

Figure 22 shows a storage heater.



**Figure 22**

The storage heater contains bricks.

The bricks are heated electrically.

The electrical heater supplies 210 kJ of energy to each brick in the storage heater.

One brick has a mass of 5.8 kg.

The specific heat capacity for the brick is 860 J/kg K.

(i) Use this data to calculate the increase in temperature of the brick.

**(2)**

temperature increase = ..... °C

(ii) The actual temperature increase will be smaller than you calculated in (i).

Explain why the actual temperature increase will be smaller than the value in (i).

**(2)**

.....

.....

.....

(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.

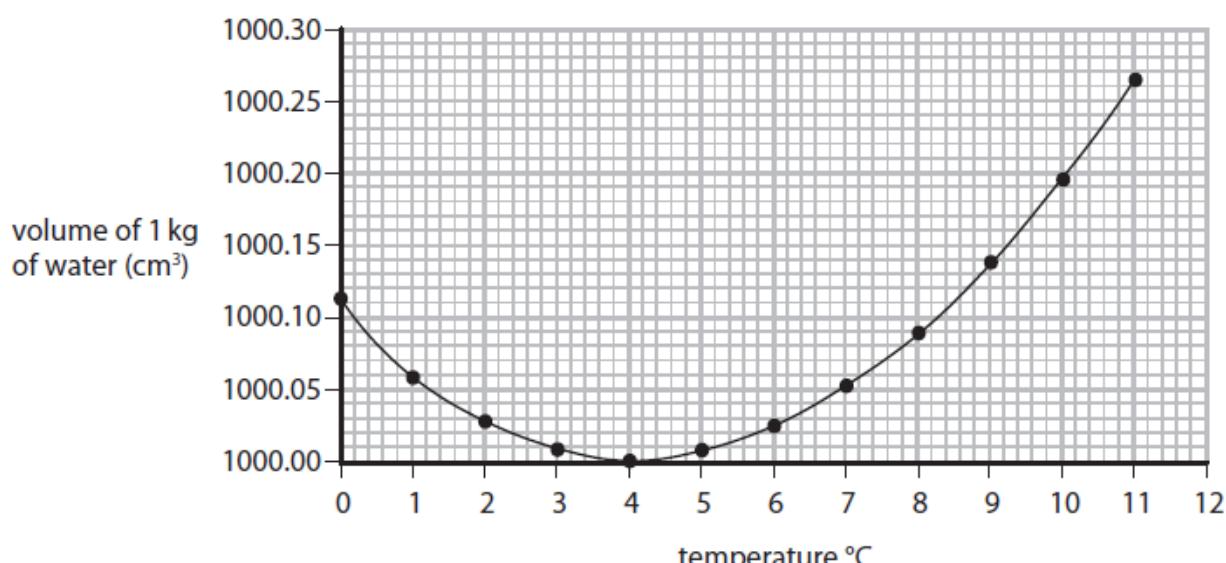


Figure 13

Describe how the **density** of water changes with temperature over the range of temperature shown in Figure 13.

Calculations are not required.

(2)

.....  
.....  
.....  
.....

**(Total for question = 7 marks)**

Q4.

A student boils some water.

Calculate the amount of thermal energy needed to change 60.0 g of water to steam at its boiling point.

The specific latent heat of vaporisation of water, L, is  $2.26 \times 10^6$  J/kg.

Use the equation

$$Q = m \times L$$

(2)

amount of thermal energy = ..... J

**(Total for question = 2 marks)**

Q5.

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)

$$\text{energy supplied} = \dots \text{J}$$

- (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)

$$\text{specific latent heat of vaporisation} = \dots \text{J / kg}$$

**(Total for question = 6 marks)**

Q6.

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  $3.34 \times 10^5$  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)

$$\text{thermal energy needed} = \dots \text{J}$$

**(Total for question = 2 marks)**

Q7.

Describe an investigation to determine the value for the specific heat capacity of water.

Your answer should include details of

- the apparatus needed
  - the experimental procedure
  - how the value may be calculated from the measurements taken.

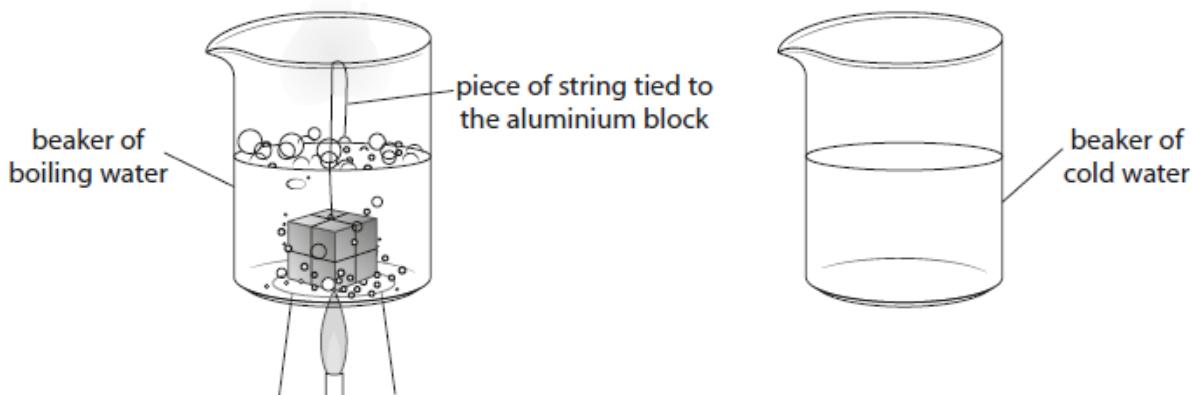
You may draw a diagram to help your answer.

(6)

**(Total for question = 6 marks)**

Q8.

\* 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)

.....  
.....  
.....  
**(Total for question = 6 marks)**

Q9.

Describe what happens when a substance experiences sublimation.

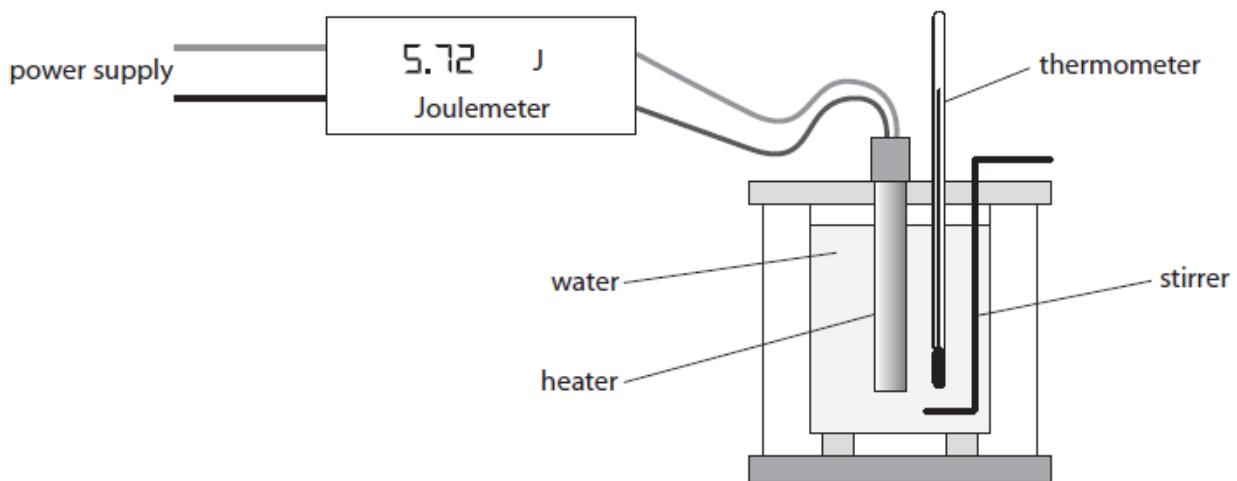
(2)

.....  
.....  
.....  
.....

**(Total for question = 2 marks)**

Q10.

Figure 19 shows some apparatus that may be used to determine the specific heat capacity of water.



**Figure 19**

A student measures the initial temperature of the water.

The power supply is switched on for 10 minutes and then switched off.

Explain how the student should then obtain an accurate reading for the final temperature of the water, to be used in the calculation of the specific heat capacity.

(3)

.....  
.....  
.....  
.....  
.....

**(Total for question = 3 marks)**

Q11.

Explain the difference between the term 'specific heat capacity' and the term 'specific latent heat' when applied to heating substances.

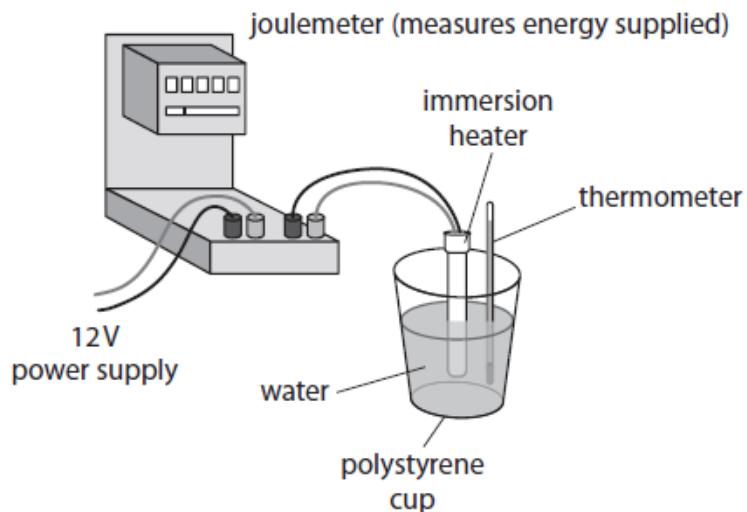
(2)

.....  
.....  
.....

**(Total for question = 2 marks)**

Q12.

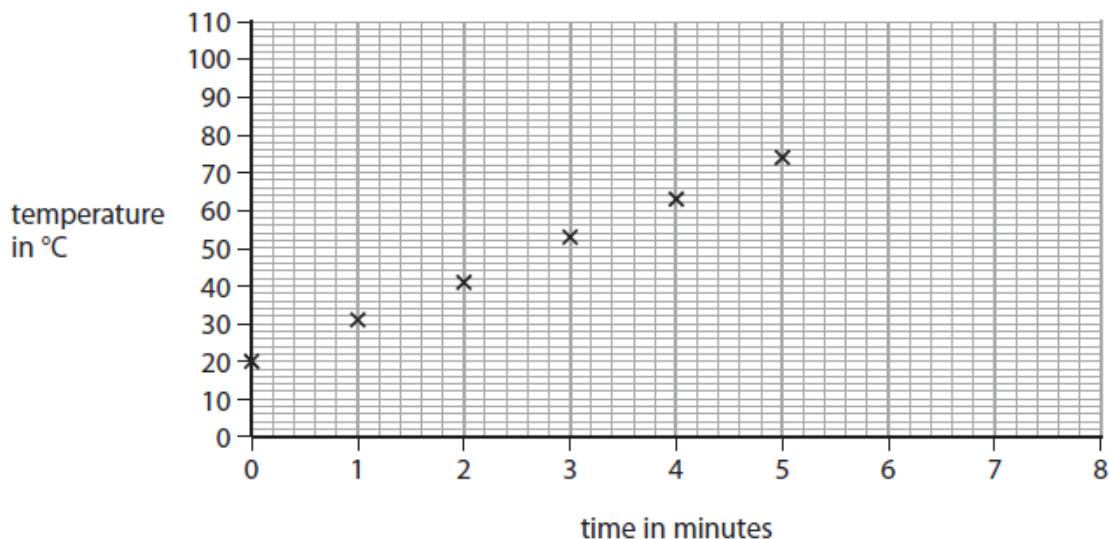
A student uses the apparatus in Figure 3 to determine the specific heat capacity of water.



**Figure 3**

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

Figure 4 shows a graph of the student's results.



**Figure 4**

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)**

## **Mark Scheme**

Q1.

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

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

Q2.

Question number	Answer	Additional guidance	Mark
i	<p>rearrangement and substitution (1)</p> $(\Delta\theta = ) \underline{210} (\times 10^3)$ $5.8 \times 860$ <p>evaluation (1)</p> <p>42 (°C)</p>	$(\Delta\theta = ) \underline{210} (\times 10^3)$ $4988$ <p>accept any value which rounds to 42 e.g. 42.10</p> <p>award full marks for the correct answer without working</p> <p>4.2 to any other power of 10 scores 1 mark</p>	(2) AO2.1

Question number	Answer	Additional guidance	Mark
ii	<p>an explanation linking any two from</p> <p>not all the energy supplied goes to the <u>brick</u> (1)</p> <p>not all the energy supplied stays in the <u>brick</u> (1)</p> <p>energy transferred to the storage heater parts (1)</p>	<p>ignore:</p> <ul style="list-style-type: none"> <li>• energy is lost / wasted, unqualified</li> <li>• not 100% efficient</li> <li>• arguments about sound energy</li> </ul> <p>accept heat for energy throughout</p> <p>less (thermal) energy given to <u>brick</u></p> <p>energy transfers from the <u>brick</u></p>	(2) AO2.1

	<p>energy transferred to the surroundings (1)</p> <p>argument linking <math>\Delta\theta</math> to <math>\Delta Q</math> using <math>\Delta\theta = \frac{\Delta Q}{m \times c}</math> (1)</p>	<p>energy dissipated</p> <p>from the equation, if energy supplied to the block is smaller the change of temperature will be smaller</p> <p>'brick transfers (thermal) energy to the surroundings' scores 2 marks</p>	
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Q3.

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

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

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

Q4.

	Answer	Additional guidance	Mark
	<p>substitution into <math>Q = m \times L</math> (1)</p> <p>(<math>Q =) 60 (\times 10^{-3}) \times 2.26 (\times 10^6)</math></p> <p>evaluation (1)</p> <p><math>1.36 \times 10^5</math> (J)</p>	<p>136 000 (J) 135 600 (J)</p> <p>accept numbers that round to <math>1.4 \times 10^5</math> (J)</p> <p>award full marks for the correct answer without working</p> <p>any answer rounding to 1.4 to any other power of 10 scores 1 mark</p>	(2) AO2.1

Q5.

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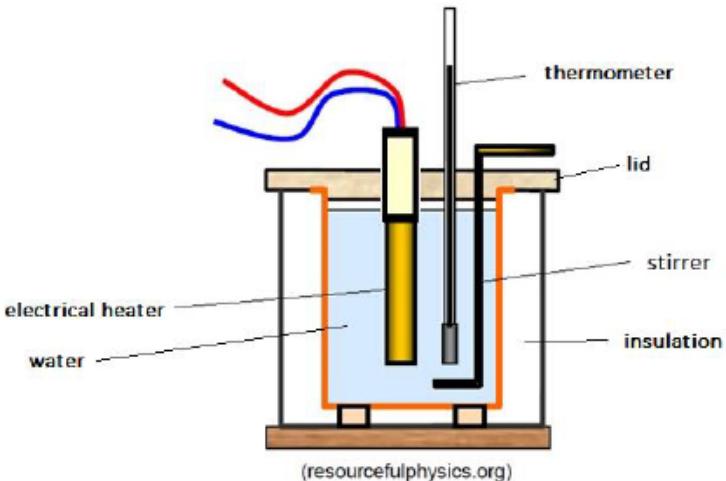
Question number	Answer	Additional guidance	Mark
ii	<p>substitution into  <math>\Delta Q = m \times L</math>  <math>450,000 = (1.41 - 1.21) \times L</math></p> <p style="text-align: center;">(1)</p> <p>rearrangement</p> $L = \frac{450,000}{0.2}$ <p style="text-align: center;">(1)</p> <p>evaluation  <math>(L)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

Q6.

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

Q7.

SSQ NO:	CS NO :	Answer	Mark
*		<p>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.</p> <p>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.</p> <p>(Accept the method of cooling a heated object in water but consult your TL.)</p> <p style="text-align: center;"><b>AO1 strand 2 (6 marks)</b></p> <p style="text-align: center;"><b>Details of the apparatus to include:</b></p>	(6)  AO1.2

		 <p>(resourcefulphysics.org)</p> <ul style="list-style-type: none"> <li>credit all elements seen in diagram or stated</li> <li>may also include power supply / electrical circuitry</li> <li>other apparatus – balance / scales ; stopwatch ; voltmeter / ammeter / joulemeter</li> </ul>	
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- ignore bunsen burner

(continued ...)

**Steps taken with the procedure and calculation including:**

- measure mass of water (with a balance)
- measure initial temperature (with thermometer)
- switch on for a (set) time / use of stopwatch
- measure final / highest temperature (reached)
- measure energy input on joulemeter / measure V, I and t
- extra detail e.g. stirring / how to get final maximum temperature
- rearrange  $\Delta Q = m \times c \times \Delta\theta$  to find  $c$      $c = \frac{\Delta Q}{m \times \Delta\theta}$
- correct use of graph to determine  $c$

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>• No rewardable material.</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1)</li> <li>• Presents a description which is not logically ordered and with significant gaps. (AO1)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1)</li> </ul>

		<ul style="list-style-type: none"> <li>• Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1)</li> <li>• Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)</li> </ul>

## Summary for guidance

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	<u>Additional guidance</u> list of relevant apparatus: at least 2 items  AND at least one reasonable step described  OR  gives equation to find c	<u>Possible candidate responses</u> some apparatus named e.g. thermometer, balance, stirrer, joulemeter, ammeter, voltmeter, beaker diagram with some labels  measure mass of water use a thermometer   use of $\Delta Q = m \times c \times \Delta\theta$

Level 2	3–4	<u>Additional guidance</u> list of apparatus for measurements  AND logical steps including how to find $\Delta\theta$ OR $\Delta Q$	<u>Possible candidate responses</u> balance / thermometer together with joulemeter / stopwatch etc.  measure initial and final temperatures with a thermometer  realistic use of joulemeter
Level 3	5–6	<u>Additional guidance</u> understanding is detailed and fully developed. includes detail about apparatus used to obtain measurements  AND details in steps taken, including how to find $\Delta\theta$ AND $\Delta Q$	<u>Possible candidate responses</u>  (use of) balance / thermometer / stopwatch / insulated can / electrical heater etc.   measure mass of water (with a balance) / measure initial and final temperatures with a thermometer + electrical heating applied

		AND how to determine c	for a (set) time + realistic use of joulemeter (or power (VI) and time) $c = \frac{\Delta Q}{m \times \Delta\theta}$
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Question number	Indicative content	Mark
*	<p>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.</p> <p>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.</p> <p>Procedure</p> <ul style="list-style-type: none"> <li>• Measure the temperature of the boiling water</li> <li>• Allow sufficient time for block to reach temperature of boiling water</li> <li>• Measure temperature of cold water in beaker</li> <li>• Using a thermometer</li> <li>• Transfer (hot) aluminium block to cold water in the beaker.</li> <li>• Work quickly to avoid thermal energy loss during transfer</li> <li>• Measure temperature of water</li> <li>• Stir to ensure even distribution</li> <li>• Measure maximum temperature reached by water</li> <li>• Calculate temp rise of water by subtracting initial from final temperature.</li> <li>• Calculate temp drop of aluminium by subtracting final temperature from 100.</li> <li>• Find mass of beaker and water and aluminium</li> <li>• Use a balance</li> <li>• Empty water from beaker and dry beaker and block</li> <li>• Weigh beaker and block alone</li> <li>• Find mass of water by subtraction.</li> <li>• Allow plausible method of finding mass of water before putting block in.</li> </ul>	(6) AO2 and AO3

	<p>Process results</p> <ul style="list-style-type: none"> <li>• Calculate thermal energy gained water using  <math display="block">\Delta Q = m \times c \times \Delta\theta</math> </li> <li>• Thermal energy gained by water = thermal energy lost by aluminium</li> <li>• Specific heat capacity of aluminium =  <math display="block">\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}</math> </li> </ul>	
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Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>No awardable content</li> </ul>
Level 1	1–2	<ul style="list-style-type: none"> <li>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)</li> <li>Analyses the scientific information but understanding and connections are flawed. An incomplete plan that provides limited synthesis of understanding. (AO3)</li> </ul>
Level 2	3–4	<ul style="list-style-type: none"> <li>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)</li> <li>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)</li> </ul>
Level 3	5–6	<ul style="list-style-type: none"> <li>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)</li> <li>Analyses the scientific information and provide logical connections between scientific concepts throughout. A well-developed plan that synthesises relevant understanding coherently. (AO3)</li> </ul>

## Summary for guidance

<b>Level</b>	<b>Mark</b>	<b>Additional Guidance</b>	<b>General additional guidance – the decision within levels</b>
	0	No rewardable material.	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.
Level 1	1–2	<u>Additional guidance</u> Partially complete description of a suitable procedure with at least one measurement	<u>Possible candidate responses</u> 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	<u>Additional guidance</u> Mostly complete description of a suitable procedure with at least two measurements and some description of processing the results.	<u>Possible candidate responses</u> 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	<u>Additional guidance</u> Detailed description of a suitable procedure with most of the necessary measurements and a clear description of processing the results.	<u>Possible candidate responses</u> As above with Calculate temperature changes by subtraction. Calculate thermal energy lost by Al as being equal to thermal energy gained by water. $\text{Specific heat capacity of Al} = \frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$

Q9.

Question number	Answer	Additional guidance	Mark
	<p>A description including idea of change of state / solid <b>changes</b> (1)</p> <p>to gas / vapour (directly) (1)</p>	<p>accept equivalents e.g. turns into / goes from to</p> <p>allow reverse i.e. gas → solid</p> <p>may be via appropriate example e.g. ice → water vapour / steam or reverse (2 marks)</p>	(2) <b>AO1.1</b>

Q10.

Question number	Answer	Additional guidance	Mark
	<p>an explanation linking any <b>three</b> from:</p> <p>stir the water before taking a reading of temperature (1)</p> <p>(continue to) observe temperatures after switching off (1)</p> <p>record the maximum / highest / peak temperature reached (1)</p> <p>take temperature reading at eye level (1)</p> <p>conduction (and convection) take time (1)</p>	<p>allow "for <b>longer</b> than 10 minutes"</p> <p>allow wait(ing period) in correct context</p> <p>until the temperature stops changing</p> <p>takes time (for water / thermometer) to heat through</p>	(3) <b>AO1.2</b>

Q11.

Question number	Answer	Additional guidance	Mark
	<p>an explanation linking specific heat capacity concerns change in temperature (1)</p> <p>whereas</p> <p>specific latent heat concerns change of state (1)</p>	<p>accept specific heat capacity concerns heating <u>up</u> / cooling</p> <p>accept any named change of state e.g. melting / freezing / evaporating /boiling</p> <p>accept specific latent heat related to no change in temperature</p>	<b>(2)</b> <b>A01.1</b>

Q12.

Question Number:	Answer	Additional Guidance	Mark
	100 ( $^{\circ}\text{C}$ ) (1)	<p>accept any answer between and including 95 and 102</p> <p>(possibility that it is not pure water and possibility of heat loss prevents reaching boiling point)</p>	<b>(1)</b> AO 2 1