Mark Scheme

Q1.

Question Number:	Answer	Additional Guidance	Mark
(i)	a description to include:		(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: add lid /cover (1) add lagging / insulation (1) add a stirrer (1) use a more sensitive thermometer (1) ensure heater fully submerged (1)	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 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 accept use digital / electric thermometer / data logger	(2) AO 3 3b

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: Density = mass/ volume (1) = 28 x10^{-3}/ 3.6 x 10^{-6} (1) Evaluation = 7777 kg / m^3 (1)	 (recalled / used) ignore any power of ten (pot) error here do not penalise any sf errors (7.77 etc. would get 2 marks: losing the pot mark in the evaluation)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	(Use $\Delta Q = m \times c \times \Delta \theta$) substitution thermal energy gained = 0.028 x 510 x 80 (1) evaluation = 1100 (J) (1)	 ignore any pot error here 1142 (J)	(2)

Question number	Answer	Mark
(iii)	An explanation that combines identification – knowledge (2 marks) and reasoning / justification (1 mark) Solid state → particles vibrate (1) → about fixed positions (1) Liquid state → particles move randomly / freely (1)	(3)

Q4.

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 × L (1) 0.34 = 0.15 × 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)**

Q5.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking any three of the following : use a measuring cylinder / beaker or use a eureka can /displacement can/container with spout (1) (partly) fill measuring cylinder / beaker (with water) note the reading or fill (eureka) can to spout (1) immerse piece of copper (in water) (1) note difference in readings of water level (in measuring cylinder / beaker) or collect water from spout in a measuring cylinder / beaker (1)	give credit for other acceptable methods If no other marks scored then allow 1 mark for attempt to measure volume directly: e.g. fill copper tube with water, tip out and measure volume or measure dimension(s) of copper tube	(3)

Question number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) density= $\frac{m}{V}$ (density=) $\frac{0.058}{6.5 (\times 10^{-6})}$ evaluation (1) 8.9×10^3 (kg/m³)	 accept values that round to 8900 e.g. 8923(kg/m³) or 9000 8.9 to any other power of ten gains 1 mark award full marks for correct answer without working.	(2)

Q6.

Question number	Answer	Additional guidance	Mark
	volume substitution (1) 1.5 x 1.0 x 0.2(0) (= 0.3) substitution in equation (1) mass = 2100 x (0.3(0)) evaluation (1) = 630 (kg)	 ecf from calculated value of volume for this mark only award 2 marks for 6.3 x any other power of 10 5670 gains 1 mark from use of 1.5+1.0+0.2=2.7 award full marks for correct answer without working	**(3)** **AO2**

Q7.

Question number	Answer	Additional guidance	Mark
	calculation of change in volume (1) (530 cm^3 – 490 cm^3) = 40 (cm^3) substitution (1) $7.9 = \frac{mass}{40}$ rearrangement and evaluation (1) (mass = 7.9 x 40) (mass =) 316 (g) evaluation to 2 sig fig (1) 320 (g)	measurement mark – using scale allow use of incorrect volume answers without working 316 (g) scores 3 marks 0.316 kg scores 3 marks 316 to any other power of 10 scores 2 marks 4187 or 3871 scores 2 marks (incorrect volume) **any answer** written to 2sf independent mark answers without working 320 scores 4 marks 320 to any other power of ten scores 3 marks 4200 scores 3 marks 3900 scores 3 mark	**(4)** **AO2.2**

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
(i)	substitution into $\Delta Q = m \times s \times \Delta T$ (1) $(\Delta Q) = 1.41 \times 4200 \times (100-25)$ 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)	**(3)** **AO2**

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**

Q10.

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

Q11.

Question number	Answer	Mark
(i)	C	**(1)**

Question number	Answer	Additional guidance	Mark
(ii)	Equating the same variable in both equations (1) $\Delta Q = m \times c \times \Delta\theta = P \times t$ Rearrangement (1) $t = \frac{(m \times c \times \Delta\theta)}{P}$ Substitution and evaluation (1) $t = \frac{(1 \times 4200 \times 77)}{3500}$ = 92 s	 allow $\Delta\theta$ seen as 95 – 18 92.4 evaluation must be seen to at least 2 s.f. at some point in the working	**(3)**

Q12.

Question number	Answer		Mark
(i)	An answer that combines the following points of understanding to provide a logical description: • when steam condenses, its molecules move closer together, so the internal energy decreases (1) • when the water from the condensed steam cools, its molecules move more slowly, therefore storing less kinetic energy (1)	allow as water cools, the distance between the particles decreases which increases the intermolecular forces	(2)

Question number	Answer	Additional guidance	Mark
(ii)	equating the variables in the three equations/principle of conservation of energy (1) $(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w) = (m_m \times c_m \times \Delta\theta_m)$ rearrangement (1) $m_m = \frac{(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w)}{(c_m \times \Delta\theta_m)}$ substitution of correctly calculated quantities (1) $= \left(\frac{\left(\left(\frac{25}{1000}\right) \times 2260000\right) + \left(\left(\frac{25}{1000}\right) \times 4200 \times 35\right)}{3840 \times 60} \right)$ evaluation (1) 0.26 (kg)	allow in words or with suitable alternative subscripts temperature changes and l_w must be correct allow maximum of 3 marks for calculations that omit the energy from cooling of water	(4)

Question number	Answer	Mark
(iii)	Any two of the following reasons: • more steam must condense and transfer the energy that is dissipated to the jug during the process (1) • more steam must condense and transfer the energy that is dissipated to the surroundings during the process (1) • more steam must condense and transfer the energy needed to cause the milk to froth (1) • more steam must condense to replace any steam that might leave the milk without condensing (1)	(2)

Q13.

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 coherently. (AO3)

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	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 = $\frac{\text{thermal energy transferred}}{\text{mass of Al} \times \text{temp drop of Al}}$

Q14.

Question Number	Answer	Additional guidance	Mark
	A description including: find mass of marble(s) (1) put marble(s) into water (in cylinder) and measure **change** in water level (1) divide mass by volume (1) suitable idea to improve accuracy such as use several marbles (1)	 weigh marble(s) accept volume for water level note level before and after marble(s) added find **volume** of water displaced density = mass/volume in words or symbols subtract mass of bag from total mass of marbles and bag ensure water measured at eye level use appropriately sized measuring cylinder ignore reference to repeating and taking average	**(4)**

Q15.

Question number	Answer	Additional guidance	Mark
	descriptions to include any **two** of particles / atoms in solid close(r) together (1) 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)	reverse argument difference asked for so **must compare** for subsequent marking points allow answers in terms of forces between particles	**(2)** **AO1**

Q16.

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

Q17.

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

Q18.

SSQ NO:	CS NO:	Answer	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. **AO1 strand 1 (6 marks)** • particles move faster (at a higher temperature) • greater velocity / speed means greater kinetic energy • since KE = ½ m v^2 • heating increases KE (store) • KE (store) increase leads to higher (average) speeds • faster particles (at higher temperature so) hit container with more force / momentum exchange • bigger pressure because p = F / A • particles hit container more frequently (at higher temperature) • so **more** force exerted on (walls of) container	**(6)** **AO1.1**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - 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 isolated idea(s) of physics e.g. recognising the speed-temperature relationship or the pressure temperature relationship	Possible candidate responses particles faster (at higher temperature) KE increases pressure increases (at a higher temperature)
Level 2	3–4	Additional guidance limited details about KE **or** limited details about pressure **or** linked ideas about kinetic energy and pressure	Possible candidate responses faster particles have greater kinetic energy (store) (particles) hitting container more often causes greater pressure faster particles cause greater force bigger pressure because force increased
Level 3	5–6	Additional guidance understanding is detailed and fully developed. includes detail about **both** kinetic energy **and** force involvement in pressure, but one aspect may be covered in greater detail than the other one	Possible candidate responses greater speed means greater kinetic energy since KE = ½ m v^2 **AND** bigger pressure because more frequent collisions causes an increase in force greater speed means greater kinetic energy **AND** bigger pressure because p = F / A and (total) force increased because of hitting container walls with bigger momentum (changes)

Q19.

Question number	Answer	Additional guidance	Mark
	an explanation linking specific heat capacity concerns change in temperature (1) whereas specific latent heat concerns change of state (1)	 accept specific heat capacity concerns heating up / cooling accept any named change of state e.g. melting / freezing / evaporating /boiling accept specific latent heat related to no change in temperature	**(2)** **AO1.1**

Q20.

Question number	Answer	Additional guidance	Mark
	an explanation linking density of wood less (than that of water) (1) less (volume of) water displaced (than volume of wood) (1)	 allow wood floats / should be submerged allow wood absorbing water allow (idea of) incorrect volume reading allow (idea that) the volume cannot be measured this way	**(2)** **AO2.2**

Q21.

Question Number	Answer	Acceptable answers	Mark
(a) (i)	10.8 + or – 0.2 (cm)	Any value between 10.6(cm) and 11.0 (cm) Accept 11 cm	**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	B $2.1 \times 10^{-2}\,cm^3$		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(iii)	Temperature conversion to K 50°C to 323K **OR** 100°C to 373K (1) Substitution $V_1 = \frac{2.31 \times 10^{-2} \times 373}{323}$ (1) Evaluation $2.67 \times 10^{-2}\,(cm^3)$ (1)	If equation is transformed to give V_2, allow correct substitution mark. $0.0267(cm^3)$, $2.7 \times 10^{-2}\,(cm^3)$, $0.027(cm^3)$, $2.67 \times 10^{-8}\,m^3$, $2.7 \times 10^{-8}\,m^3$ Allow power of ten error for 2 marks e.g. 267 Allow 2.6×10^{-2} for 3 marks Full marks for correct answer with no working If temperature is not converted to Kelvin, maximum two marks e.g. $V_1 = \frac{2.31 \times 10^{-2} \times 100}{50}$ $4.62 \times 10^{-2}(cm^3)$ Allow power of ten error for 1 mark e.g. 4.62 2 marks for $4.62 \times 10^{-2}\,(cm^3)$ with no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
(b)	A description including: (Average) KE/it increases as the temperature increases (1) Idea of proportionality / KE doubles when the temperature doubles (1) (when) temperature in Kelvin /K (1)	Allow energy for kinetic energy Or reverse argument - (Average) KE/it is (directly) proportional to the Kelvin temperature gets all three marks (Average) KE/it is (directly) proportional to the temperature gets first two marks Allow absolute scale	**(3)**

Q22.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	C stationary		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	(Average KE/it is) halved	divided by 2,multiplied by 0.5	**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)	Explanation in terms of particles linking the following:- • particles collide with / hit /strike / bombard (1) • the wall / sides of the balloon (1) • (causing a) force / (rate of) change in momentum (1)	 Accept "molecules/atoms" for particles Must mention particles etc to gain this mark Ignore "push"	**(3)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	-46 + 273 (1)	273-46 / any use of 273	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii)	substitution: (1) $\frac{101 \times 9.1}{273} = \frac{1.12 \times V_2}{227}$ Transposition (1) $V_2 = \frac{101 \times 9.1 \times 227}{273 \times 1.12}$ evaluation: (1) 682 (m^3)	Accept either Pa or kPa for substitution substitution and transposition in any order ignore power of ten error until evaluation 680 (m^3), 682.4 (m^3), 682.35 (m^3) full marks for the correct numerical answer without working	**(3)**

Question Number	Answer	Acceptable answers	Mark
(c)(iii)	bursts/explodes or words to that effect		**(1)**

(Total marks for question = 10 marks)

Q23.

Question number	Answer	Additional guidance	Mark
	An answer that combines **any four** of the following points of understanding to provide a logical description: • chooses either thermocouple or infra-red thermometer (1) • molten steel is poured into a crucible (1) • a stopwatch is started (1) • the crucible + contents are allowed to cool down (in the room) (1) • temperatures are taken at regular intervals (e.g. every minute) (1)	any interval with steel – every 10 minutes etc.	**(4)**

Q24.

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

Q25.

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**

Q26.

Question number	Answer			Mark
	[x] **B**	bigger than in water	less than water	**(1) AO1.1**

A is incorrect because the density of steam is less than water.
C is incorrect because the space between the particles increases.
D is incorrect because the space between the particles increases and density of steam is less than water.