1)

Question	Expected Answers	Marks	Additional guidance
(a)(i)	(1 kWh is) the **energy** used/provided by a 1 kW device in 1 hour	B1	Allow 1 kWh = 60x60x1000 = 3.6 x 10^6 J
(a)(ii)	Energy used in kWh = (70/1000) x (7 x 24) = 11.8 kWh Cost = 11.8 x 0.12 = **£1.41 (or £1.4)**	C1 A1	Any arithmetic error loses one mark
(b)(i)	use of E = mc Δθ e.g. E = 2 x 3800 x (18-3) = **1.14 x 10^5 J**	C1 A1	
(b)(ii)	Rate of energy loss = 1.14 x 10^5 /100x60 = **19** W	B1	Allow ecf for cand's (b)(i) value
(c)	1. 18 °C to 0 °C negative gradient line 2. horizontal line on time axis 3. 0°C to -18 °C line of **steeper –ve gradient** (judged by eye) than in 1	B1 B1 B1	
	Total	**9**	

2)

Question			Expected Answers	Marks	Additional guidance
	a	i	correct substitution in E = mcΔθ: eg E = 0.08x4180x40 ratio = 0.08x4180x40/5 x 10^{-5} x2460x40 = **2.7(2) x 10^3**	C1 A1	Allow 80x4180/0.05x2460 (13376/4.92) for this C1 mark. 1: 2700 does not score the second mark.
		ii	*Any valid advantage: eg* car cooling systems because it absorbs large amounts of heat for a small rise in temp OR ideal fluid for central heating systems because it releases large amounts of heat for a small drop in temp. OR helps to maintain constant body temperature since body is mainly water which absorbs lots of heat for small temp rise	 B1 B1	 First mark for valid situation Second mark for correct explanation of why the high value of the shc is helpful.
	b		***labelled diagram (2 marks)***: liquid in vessel with electrical heater (submerged) and thermometer ammeter connected in series between supply and heater AND voltmeter connected across heater. ***list of measurements (3 marks):*** mass of liquid, initial and final temperature/change of temp (of the liquid) I, V and t values OR energy meter readings OR power and time ***explanation (1 mark):*** E = mcΔθ rearranged to c = E/mΔθ ***uncertainties (2 marks) each stated with explanation of remedy:*** e.g. - heat losses (makes E or Δθ uncertain) *(solved by)* insulating beaker/use lid - false temp reading *(solved by)* stir the liquid - temp continues to rise after heater switched off measure highest value - thermal capacity of vessel (*solved by*) take this into account in calculation	 B1 B1 B1 B1 B1 B1 B1 B1 max 2	 Allow use of joule meter if convincingly connected to heater and power supply i.e. 2 wires from power supply two wires to heater Allow such things as "find mass", "known mass", "10K temp rise", "time for 2 minutes" "known power", etc. Allow ItV/mΔθ. Do not allow "repeat the experiment". Give credit for valid suggestions if mentioned anywhere in the description of the experiment.
			Total	**12**	

3)

Question			Answer	Marks	Guidance
	(a)		latent heat of **fusion** ✎**The term fusion to be included and spelled correctly to gain the B1 mark**	B1	**Allow**: Specific latent heat of fusion **Allow**: (Specific) latent energy of fusion **Must use tick or cross on Scoris to show if the mark is awarded**
	(b)	(i)	Total / sum of randomly (distributed) kinetic energy and potential energy of molecules/atoms	B2	**Allow**: 1 mark only if molecules / atoms and/or randomly are omitted
		(ii)	Potential energy of the molecules increases Kinetic energy of molecules is the same for water and steam (since the temperature is the same) / work is done in moving molecules apart	B1 B1	**Allow** : work is done to break the bonds (between molecules)
	(c)	(i)	Mass of air = volume x density = 15 x 1.2 (= 18 kg) Heat energy transferred to air in one hour Q = 12 x 60 x 60 (= 43200 J) $\Delta\theta = Q / mc$ = 12 x 60 x 60 / 18 x 990 Temperature rise in one hour = 2.4 K	C1 C1 A1	 **Allow**: any subject Treat a transcription error as one AE. **Allow**: 2 K as question asks for an estimate
		(ii)	Any **two** from • Heat lost to structure of greenhouse / contents • Heat lost through glass / from the greenhouse / surroundings • Average rate of loss of heat reduces (as temperature falls)	B1 x 2	
			Total	**10**	

4)

Question			Answer	Marks	Guidance
	(a)	(i)	vibrate (about their 'fixed' positions)	B1	**Allow:** molecules vibrate
		(ii)	greater amplitude / greater frequency (of vibration)	B1	**Not:** faster / more / bigger /more vigorous (vibrations)
		(iii)	**Either** internal energy increases **Or** potential energy (of molecules) increases and the kinetic energy remains constant temperature remains constant	B1 B1	
	(b)	(i)	$P t = m c \Delta\theta$ 48 x 720 = 0.98 x c x (54 - 18) + 0.027 x 850 x (38-18) c = 970 (J kg^{-1} K^{-1})	C1 C1 C1 A1	**Note:** mark is for correct substitution for total energy input **and** heat gained by **metal** **Note:** mark is for adding a correct substitution for heat gained by insulation into this equation **Note:** answer to 3 sf = 967 Calculation of c = 980 ignoring energy used to heat insulation scores 2 marks
		(ii)	Without the insulation there will be **more** heat lost to the surroundings / air (AW) final temperature will be **lower** **OR** a **lower** temperature rise **OR** more energy will be required to give the **same** temperature rise / final temperature **AND** hence c is **higher** than that calculated in (i)	M1 A1	**Not:** lost to wires / data logger
			Total	**10**	

5)

Question	Expected Answers	Marks	Additional guidance
(a) (i)	Initial KE of car = $0.5 \times 970 \times 27^2$ = **3.5×10^5 J** (353565J)	B1	
(a) (ii)	Work done = Av Force x distance moved Av Force = 3.5×10^5 J/40 = **8.8×10^3 N** (or 8750 N) (or 353565/40 = 8836.7 N) Assumption: **no air resistance**	C1 A1 B1	If $v^2 = u^2 + 2as$ is used. accept $a = 0-27^2/(2\times40) = 9.113\ ms^{-2}$ C1 $F = ma = 970 \times 9.11 = 8.84 \times 10^3$ N A1 Allow air friction or drag
(b) (i)	correct use of $E = mc\Delta\theta$: $3.5 \times 10^5/4 = 1.2 \times 520 \times \Delta\theta$ $\Delta\theta$ = **140°C** (if 353565 is used $\Delta\theta = 142^{\circ}C$)	C1 A1	If cand. forgets to divide by 4 allow any value between 560 and 570 for 1 mark.
(b) (ii)	Air resistance will be acting (slowing down the car) (hence) reducing the KE of the car (WTTE) The discs are hotter than the surroundings (hence) energy/heat will be lost from discs/brakes (WTTE)	M1 A1 B1 B1	Do not allow sound since only a tiny proportion of energy is lost in this way. Allow other valid comments as alternative ways of scoring one or both of the 'B' marks: e.g. 'hot spots' on discs; discs are different. Try to credit a well argued case based upon correct physics- e.g. wheels locking.
(b) (iii)	Any valid suggestion: e.g. use a material with a higher s.h.c use a disc with a higher heat capacity Use discs of greater mass put holes in the discs (to increase air flow)	B1	Confusion between shc and heat capacity should not be penalised.
	Total	11	

6)

	Expected Answers	Mark	Additional guidance
(a)(i)	Latent heat of fusion.	B1	QWC fusion spelled correctly ignore any reference to specific.
(a)(ii)	Latent heat of vaporisation.	B1	QWC Vaporisation spelled correctly. **Accept** vaporization but not vapourisation.
(b)(i)	$E = mc\Delta\theta$ used correctly e.g. $0.8 \times 4200 \times 82$ $= 2.8 \times 10^5$ (J) (275520)	C1 A1	$0.8 \times 4200 \times (82+273)$ scores zero
(b)(ii)	Any two from: Some heat/energy used to heat kettle Some heat/energy lost to surroundings/air/environment. Some heat/energy used to boil water before kettle switches off	B1 B1	Do **not allow** "some heat lost" i.e. they must state where/how Do **not allow** "kettle if not 100% efficient". Do not allow "energy lost as sound/light"
(b)(iii)	1 kWh = $1000 \times 3600 = 3.6 \times 10^6$ J Wastage per year = $(2.8 \times 10^5 \times 365) / 3.6 \times 10^6 = 28$ kWh (27.9)	C1 A1	**Allow** 1 mark for energy lost per year = 1.02×10^8 Joules Allow ecf from (b)(i)
	Total	**8**	

7)

Question			Answer	Marks	Guidance
	(a)	(i)	Energy required to raise the temperature of a unit mass of a substance by unit temperature rise.	B1	**Allow:** $c = \frac{Q}{m\Delta\theta}$ with all symbols defined.
		(ii)	LH of fusion is energy needed to change (a substance) from solid to liquid LH of vaporisation is energy needed to change (a substance) from liquid to gas/vapour	B1	Allow: a single reference to energy (either statement acceptable)
	(b)	(i)	**A to B**: KE of molecules increases AND PE of molecules (small) increases **B to C**: KE of molecules remain constant AND PE of molecules increases	B1 B1	
		(ii)	c_{solid} is **less than** c_{liquid} Correct reason **Eg** gradient for solid is greater than gradient for liquid AND gradient is inversely proportional to specific heat capacity (AW}	B1 B1	
	(c)	(i)	In one second volume flowing through = (3.6 x 10^{-3} /60) = 6.0 x 10^{-5} mass flowing through = 6.0 x 10^{-5} x 1000 = (6.0 x 10^{-2}) Energy gained by water $E = mc\,\Delta\theta$ = 0.060 x 4200 x (36.7 – 17.4) (= 4864) Power of heater = E / t = 4864 /1 Power of heater = 4.9 x 10^3 ≈ 5 kW	C1 C1 C1 A1 A0	**Alternative** In one minute volume flowing through = 3.6 x 10^{-3} mass flowing through = 3.6 (C1) Energy gained $E = mc\,\Delta\theta$ = 3.6 x 4200 x (36.7 – 17.4) (C1) (= 2.92 x 10^5 J) Power = E / t = 2.92 x 10^5 /60 (C1) Power of heater = 4.9 x 10^3 (A1) ≈ 5 kW (A0)
		(ii)	EITHER rate of flow of water changes **because** water pressure changes OR Inlet temperature changes **because** ambient temperature changes	M1 A1	
			Total	**12**	

8)

Question			Answer	Marks	Guidance
	(a)		Mass of air = 4.5 x 4 x 2.4 x 1.3 (= 56.2) $Q = mc\Delta\theta$ = 56.2 x 990 x (21 – 12) Q = 5.0 x 10^5 (J)	B1 C1 A1	**Allow:** follow through (FT) for mass of air **Note:** Max 1 mark out of 3 if temperature **rise** is given as 282 K.
	(b)	**(i)**	$t = \frac{Q}{P} = \frac{5.0\times10^5}{2300}$ $t = 220$ (s)	C1 A1	Possible **ecf** from **(a)** Answer is 217 (s) or 218 (s) to 3 sf depending on accuracy of Q used from (a)
		(ii)	Volume of gas, $V = \frac{5.0\times10^5}{39\times10^6}$ (= 0.0128 (m^3)) Mass of gas $= V\rho = 0.0128\times0.72$ Mass $= 9.2\times10^{-3}$ (kg)	C1 A1	Possible **ecf** from **(a)**
	(c)		Any **two** from the following : • thermal energy/heat is lost through or to walls / ceiling / floor/windows /door of room (AW) • other objects within the room (AW) • warm air may escape from room / cold air or draughts may enter the room	B1 B1	**Not:** Bald 'Heat lost to surrounding' **Ignore** any references to heater
			Total	**9**	