Q1.

2	**(a)**	✗ ✗ ✓ ✓ (-1 for each error or omission)	B2	[2]
	(b)	heat lost by liquid gold = 0.95m x 129 x ΔT	C1	
		heat gained (silver) = 0.05m x 235 x (1340 – 300) + 0.05m x 105 000	C1, C1	
		122.5$m\Delta T$ = 17 470m		
		ΔT = 143 K	C1	
		temperature = 143 + 1340 = 1483 K	A1	[5]
	(c)	e.g. thermocouple/resistance thermometer	B1	[1]

Q2.

6	0	-	+	(-1 for each error)	B2	
	+	+	0	(-1 for each error)	B2	
	+	+	0	(-1 for each error)	B2	**[6]**
				Total		**[6]**

Q3.

3	**(a)**		(thermal) energy/heat required to convert unit mass/1 kg of solid to liquid	**M1**	
			with no change in temperature/at melting point	**A1**	**[2]**
	(b)	**(i)**	energy required to warm ice = 24 × 10^{-3} × 2.1 × 10^{3} × 15 (= 756 J)	**C1**	
			energy required to melt ice at 0 °C = 24 × 10^{-3} × 330 × 10^{3} (= 7920 J)	**C1**	
			total energy = 8700 J	**A1**	**[3]**
		(ii)	energy lost by warm water = 200 × 10^{-3} × 4.2 × 10^{3} × (28 - T)	**C1**	
			200 × 4.2 × (28 - T) = 24 × 4.2 × T + 8676	**C1**	
			T = 16 °C	**A1**	**[3]**
			[allow 2 marks if ΔT calculated]		
			[allow 2 marks if (24 x 4.2 x T) omitted]		
			[allow 1 mark for 224 x 4.2 x (28 - T) = 8676, T - 19 °C]		

Q4.

3	**(a)**	gradient of graph is (a measure of) the sensitivity	M1	
		the gradient varies with temperature	A1	**[2]**
	(b)	2040 ± 20 Ω corresponds to 15.0 ± 0.2 °C	C1	
		T / K = T / °C + 273.15 (allow 273.2)	C1	
		temperature is 288.2 K	A1	**[3]**

Q5.

2 **(a)** (on melting,) bonds between molecules are broken/weakened
or molecules further apart/are able to slide over one another B1
kinetic energy unchanged so no temperature change B1
potential energy increased/changed so energy required B1 [3]

(b) thermal energy/heat required to convert unit mass of solid to liquid M1
with no change in temperature/ at its normal boiling point A1 [2]

(c) **(i)** thermal energy lost by water = $0.16 \times 4.2 \times 100$
= 67.2 kJ C1
$67.2 = 0.205 \times L$ C1
$L = 328\ \text{kJ kg}^{-1}$ A1 [3]

(ii) more energy (than calculated) melts ice M1
so, (calculated) L is lower than the accepted value A1 [2]

Q6.

3 **(a)** increasing separation of molecules / breaking bonds between molecules B1
(allow atoms/molecules, overcome forces)
doing work against atmosphere (during expansion) B1 [2]

(b) **(i)** **1** *either* bubbles produced at a constant rate / mass evaporates/lost at constant rate
or find mass loss more than once and this rate should be constant
or temperature of liquid remains constant B1 [1]
2 to allow/cancel out/eliminate/compensate for heat losses (to atmosphere) B1 [1]
(do not allow 'prevent'/'stop')

(ii) use of *power* × *time* = *mass* × *specific latent heat* C1
$(70 - 50) \times 5 \times 60 = (13.6 - 6.5) \times L$ C1
$L = 845\ \text{J g}^{-1}$ A1 [3]

Q7.

3 **(a)** **(i)** 1 deg C corresponds to (3840 – 190) / 100 Ω C1
for resistance 2300 Ω, temperature is $100 \times (2300 - 3840) / (190 - 3840)$
temperature is 42 °C A1 [2]

(ii) *either* 286 K ≡ 13 °C *or* 42 °C ≡ 315 K B1
thermodynamic scale does not depend on the property of a substance M1
so change in resistance (of thermistor) with temperature is non-linear A1 [3]

(b) heat gained by ice in melting = $0.012 \times 3.3 \times 10^5$ J C1
= 3960 J
heat lost by water = $0.095 \times 4.2 \times 10^3 \times (28 - \theta)$ C1
$3960 + (0.012 \times 4.2 \times 10^3 \times \theta) = 0.095 \times 4.2 \times 10^3 \times (28 - \theta)$ C1
$\theta = 16°\text{C}$ A1 [4]
(answer 18°C – melted ice omitted – allow max 2 marks)
(use of $(\theta - \text{T})$ then allow max 1 mark)

Q8.

4	(a)	$+\Delta U$: increase in internal energy	B1	
		$+q$: thermal energy / heat supplied to the system	B1	
		$+w$: work done on the system	B1	[3]
	(b) (i)	(thermal) energy required to change the state of a substance	M1	
		per unit mass	A1	
		without any change of temperature	A1	[3]
	(ii)	when evaporating		
		greater change in separation of atoms/molecules	M1	
		greater change in volume	M1	
		identifies each difference correctly with ΔU and w	A1	[3]

Q9.

3	(a)	(numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance	M1	
		without any change of temperature	A1	[2]
		(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)		
	(b) *either*	energy supplied = 2400 × 2 × 60 = 288000 J	C1	
		energy required for evaporation = 106 × 2260 = 240000 J	C1	
		difference = 48000 J		
		rate of loss = 48000 / 120 = 400 W	A1	
	or	energy required for evaporation = 106 × 2260 = 240000 J	(C1)	
		power required for evaporation = 240000 / (2 × 60) = 2000 W	(C1)	
		rate of loss = 2400 – 2000 = 400 W	(A1)	[3]

Q10.

3	(a)	sum of potential energy and kinetic energy of atoms/molecules/particles	M1	
		reference to random (distribution)	A1	[2]
	(b) (i)	as lattice structure is 'broken'/bonds broken/forces between molecules reduced (not molecules separate)	B1	
		no change in kinetic energy, potential energy increases	M1	
		internal energy increases	A1	[3]
	(ii)	*either* molecules/atoms/particles move faster/ $<c^2>$ is increasing		
		or kinetic energy increases with temperature (increases)	B1	
		no change in potential energy, kinetic energy increases	M1	
		internal energy increases	A1	[3]

Q11.

1 (a) (i) $Q = mc\Delta\theta$ C1
$2300 = 0.75 \times c \times (100 - 20) / 120$ …(if uses ±273, then −2)…… C1
$c = 4600\ \mathrm{J\ kg^{-1}\ K^{-1}}$ …(allow 1 sf).. A1
(ii) $Q = mL$ C1
$2300 = (0.375 / 420) \times L$
$L = 2.6 \times 10^{6}\ \mathrm{J\ kg^{-1}}$ …(allow 1 sf).. A1 [5]

(b) e.g. heat losses, power not constant etc M1
(do not allow if releated to s.h.c., rather than l.h.c.)
effect on value for L .... A1 [2]

Q12.

3 (a) pV/T = constant.. C1
$T = (6.5 \times 10^{6} \times 30 \times 300)/(1.1 \times 10^{5} \times 540)$.................................. C1
$= 985$ K... A1 [3]
(*if uses °C, allow 1/3 marks for clear formula*)

3 (b) (i) $\Delta U = q + w$
symbols identified correctly M1
directions correct... A1 [2]

(ii) q is zero B1
w is positive OR $\Delta U = w$ and U increases B1
ΔU is rise in kinetic energy of atoms M1
and mean kinetic energy $\propto T$ .... A1 [4]
(*allow one of the last two marks if states 'U increases so T rises'*)

Q13.

7 (a) variation is non-linear 1
two possible temperatures 1 **[2]**

(b) e.g. 1. small thermal capacity/measure $\Delta\theta$ of small object /short response time
2 readings taken at a point/physically small
3 can be used to measure temperature difference
4 no power supply required
etc. (any two, 1 mark each) 2 **[2]**

Q14.

3	**(a)**	correct statement, words or symbols ……………………………………	B1	**[1]**
	(b)(i)	$w = p\Delta V$ …………………………………………………………………	C1	
		$= 1.03 \times 10^5 \times (2.96 \times 10^{-2} - 1.87 \times 10^{-5})$		
		= (–) 3050 J …………………………………………………………………	A1	**[2]**
	(ii)	$q = 4.05 \times 10^4$ J ………………………………………………………	B1	**[1]**
	(iii)	$\Delta U = 4.05 \times 10^4 - 3050 = 37500$ J …no e.c.f. from **(a)**…………………	A1	**[1]**
		penalise 2 sig.fig. once only		
	(c)	number of molecules = N_A ………………………………………………	C1	
		energy $= 37500 / (6.02 \times 10^{23})$		
		$= 6.2 \times 10^{-20}$ J (accept 1 sig.fig.) ………………………………	A1	**[2]**

Q15.

2	**(a)**	**(i)**	idea of heat lost (by oil) = heat gained (by thermometer)	C1	
			32 x 1.4 x (54 – *t*) = 12 x 0.18 x (*t* – 19)	C1	
			t = 52.4°C	A1	[3]
		(ii)	*either* ratio (= 1.6/54) = 0.030 *or* (=1.6/327) = 0.0049	A1	[1]
	(b)		thermistor thermometer (allow 'resistance thermometer')	B1	
			because small mass/thermal capacity	B1	[2]
	(c)		boiling point temperature is constant	M1	
			further comment		
			e.g. heating of bulb would affect only rate of boiling	A1	[2]

Q16.

2	**(a)**		(Thermal) energy / heat required to convert unit mass of solid to liquid	M1	
			at its normal melting point / without any change in temperature	A1	[2]
			(*reference to 1 kg or to ice → water scores max 1 mark*)		
	(b)	**(i)**	To make allowance for heat gains from the atmosphere	B1	[1]
		(ii)	e.g. constant rate of production of droplets from funnel		
			constant mass of water collected per minute in beaker		
			(*any sensible suggestion, 1 mark*)	B1	[1]
		(iii)	mass melted by heater in 5 minutes = 64.7 – ½ × 16.6 = 56.4 g	C1	
			$56.4 \times 10^{-3} \times L = 18$	C1	
			$L = 320$ kJ kg^{-1}	A1	[3]
			(*Use of m = 64.7, giving L = 278 kJ kg*$^{-1}$*, scores max 1 mark*		
			use of m = 48.1, giving L = 374 kJ kg^{-1}*, scores max 2 marks*)		

Q17.

4 (a) $\Delta U = q + w$ (*allow correct word equation*) B1 [1]

(b) *either* kinetic energy constant because temperature constant M1
potential energy constant because no intermolecular forces M1
so no change in internal energy A1 [3]
or kinetic energy and potential energy both constant (M1)
so no change in internal energy (A1)
reason for *either* constant k.e. *or* constant p.e. given (A1)

Q18.

3 (a) e.g. two objects of different masses at same temperature (M1)
same material would have different amount of heat (A1)
e.g. temperature shows direction of heat transfer (M1)
from high to low regardless of objects (A1)
e.g. when substance melts/boils (M1)
heat input but no temperature change (A1)
any two, M1 + A1 each, max 4 ………………………………………………… [4]

(b) (i) energy losses (to the surroundings) M1
either increase as the temperature rises
or rise is zero when heat loss = heat input ....A1 [2]

(ii) idea of input <u>power</u> = maximum <u>rate</u> of heat loss C1
power = $m \times c \times \Delta\theta / \Delta t$
$54 = 0.96 \times c \times 3.7 / 60$ C1
$c = 910\ \text{J kg}^{-1}\ \text{K}^{-1}$ ....A1 [3]

[Total: 9]

Q19.

2 (a) sum of kinetic and potential energies of molecules / particles / atoms M1
random (distribution) ....A1 [2]

(b) $+\Delta U$: increase in internal energy B1
$+q$: heating of / heat supplied to system B1
$+w$: work done on system ....B1 [3]

(c) (i) work done = $p\Delta V$ C1
$= 1.0 \times 10^5 \times (2.1 - 1.8) \times 10^{-3}$
$= 30$ J M1
$w = 30$ J, $q = 0$ so $\Delta U = 30$ J ....A1 [3]

(ii) these three marks were removed, as insufficient data was given in the question.

[Total: 8]

Q20.

2 **(a)**	temperature scale calibrated assuming linear change of property with temperature	B1	
	neither property varies linearly with temperature	B1	[2]
(b) **(i)**	does not depend on the property of a substance	B1	[1]
(ii)	temperature at which atoms have minimum/zero energy	B1	[1]
(c) **(i)**	323.15 K	A1	[1]
(ii)	30.00 K	A1	[1]

Q21.

3 **(a)**	temperature of the spheres is the same	B1	
	no (net) transfer of energy between the spheres	B1	[2]
(b) **(i)**	power $= m \times c \times \Delta\theta$ where m is mass per second	C1	
	$3800 = m \times 4.2 \times (42 - 18)$	C1	
	$m = 38\,\mathrm{g\,s^{-1}}$	A1	[3]
(ii)	some thermal energy is lost to the surroundings	M1	
	so rate is an overestimate	A1	[2]

Q22.

3 **(a)**	*either* change in volume = $(1.69 - 1.00 \times 10^{-3})$		
	or liquid volume << volume of vapour	M1	
	work done = $1.01 \times 10^5 \times 1.69 = 1.71 \times 10^5$ (J)	A1	[2]
(b) **(i)**	**1.** heating of system/thermal energy supplied to the system	B1	[1]
	2. work done on the system	B1	[1]
(ii)	$\Delta U = (2.26 \times 10^6) - (1.71 \times 10^5)$	C1	
	$= 2.09 \times 10^6$ J (*3 s.f. needed*)	A1	[2]

Q23.

3 **(a)** resonance B1 [1]

(b) $Pt = mc\,\Delta\theta$ C1
$750 \times 2 \times 60 = 0.28 \times c \times (98 - 25)$ C1
$c = 4400\,\mathrm{J\,kg^{-1}\,K^{-1}}$ A1 [3]

(*use of* $\Delta\theta = 73 + 273$ *max. 1/3*)
(*use of* $t = 2\,\mathrm{s}$ *not* $120\,\mathrm{s}$ *max. 2/3*)

(c) e.g. some microwave leakage from the cooker
e.g. container for the water is also heated
(*any sensible suggestion*) B1 [1]

Q24.

3 **(a)** initially, $pV/T = (2.40 \times 10^5 \times 5.00 \times 10^{-4})/288 = 0.417$ M1
finally, $pV/T = (2.40 \times 10^5 \times 14.5 \times 10^{-4})/835 = 0.417$ M1
ideal gas because pV/T is constant A1 [3]
(*allow 2 marks for two determinations of V / T and then 1 mark for V / T* <u>*and*</u> *p constant, so ideal*)

(b) **(i)** work done $= p\Delta V$
$= 2.40 \times 10^5 \times (14.5 - 5.00) \times 10^{-4}$ C1
$= 228\,\mathrm{J}$ (*ignore sign, not 2 s.f.*) A1 [2]

(ii) $\Delta U = q + w = 569 - 228$
$= 341\,\mathrm{J}$ M1
increase A1 [2]