

Q1.

- 2 (a) $\begin{matrix} \times \\ \times \\ \checkmark \\ \checkmark \end{matrix}$ (-1 for each error or omission) B2 [2]
- (b) heat lost by liquid gold = $0.95m \times 129 \times \Delta T$ C1
 heat gained (silver) = $0.05m \times 235 \times (1340 - 300) + 0.05m \times 105\,000$..C1, C1
 $122.5m\Delta T = 17\,470m$
 $\Delta T = 143\text{ K}$ C1
 temperature = $143 + 1340 = 1483\text{ K}$ 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 with no change in temperature/at melting point M1 A1 [2]
- (b) (i) energy required to warm ice = $24 \times 10^{-3} \times 2.1 \times 10^3 \times 15$ (= 756 J) C1
 energy required to melt ice at 0°C = $24 \times 10^{-3} \times 330 \times 10^3$ (= 7920 J) C1
 total energy = 8700 J A1 [3]
- (ii) energy lost by warm water = $200 \times 10^{-3} \times 4.2 \times 10^3 \times (28 - T)$ C1
 $200 \times 4.2 \times (28 - T) = 24 \times 4.2 \times T + 8676$ C1
 $T = 16^\circ\text{C}$ A1 [3]
 [allow 2 marks if ΔT calculated]
 [allow 2 marks if $(24 \times 4.2 \times T)$ omitted]
 [allow 1 mark for $224 \times 4.2 \times (28 - T) = 8676$, $T = 19^\circ\text{C}$]

Q4.

- 3 (a) gradient of graph is (a measure of) the sensitivity the gradient varies with temperature M1 A1 [2]
- (b) $2040 \pm 20\ \Omega$ corresponds to $15.0 \pm 0.2^\circ\text{C}$ C1
 $T/\text{K} = T/^\circ\text{C} + 273.15$ (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
kinetic energy unchanged so no temperature change
potential energy increased/changed so energy required
- (b) thermal energy/heat required to convert unit mass of solid to liquid
with no change in temperature/ at its normal boiling point
- (c) (i) thermal energy lost by water = $0.16 \times 4.2 \times 100$
= 67.2 kJ
 $67.2 = 0.205 \times L$
 $L = 328 \text{ kJ kg}^{-1}$
- (ii) more energy (than calculated) melts ice
so, (calculated) L is lower than the accepted value

B1
B1
B1 [3]

M1
A1 [2]

C1
C1
A1 [3]

M1
A1 [2]

Q6.

- 3 (a) increasing separation of molecules / breaking bonds between molecules
(allow atoms/molecules, overcome forces)
doing work against atmosphere (during expansion)
- (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
- 2 to allow/cancel out/eliminate/compensate for heat losses (to atmosphere)
(do not allow 'prevent'/'stop')
- (ii) use of $\text{power} \times \text{time} = \text{mass} \times \text{specific latent heat}$
 $(70 - 50) \times 5 \times 60 = (13.6 - 6.5) \times L$
 $L = 845 \text{ J g}^{-1}$

B1
B1 [2]

B1 [1]
B1 [1]

C1
C1
A1 [3]

Q7.

- 3 (a) (i) 1 deg C corresponds to $(3840 - 190) / 100 \Omega$
for resistance 2300Ω , temperature is $100 \times (2300 - 3840) / (190 - 3840)$
temperature is 42°C
- (ii) either $286 \text{ K} \equiv 13^\circ\text{C}$ or $42^\circ\text{C} \equiv 315 \text{ K}$
thermodynamic scale does not depend on the property of a substance
so change in resistance (of thermistor) with temperature is non-linear
- (b) heat gained by ice in melting = $0.012 \times 3.3 \times 10^5 \text{ J}$
= 3960 J
heat lost by water = $0.095 \times 4.2 \times 10^3 \times (28 - \theta)$
 $3960 + (0.012 \times 4.2 \times 10^3 \times \theta) = 0.095 \times 4.2 \times 10^3 \times (28 - \theta)$
 $\theta = 16^\circ\text{C}$
(answer 18°C – melted ice omitted – allow max 2 marks)
(use of $(\theta - T)$ then allow max 1 mark)

C1
A1 [2]

B1
M1
A1 [3]

C1
C1
A1 [4]

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 M1
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 M1
the state of unit mass of a substance A1
without any change of temperature [2]
(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)
- (b) *either* energy supplied = $2400 \times 2 \times 60 = 288000 \text{ J}$ C1
energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$ C1
difference = 48000 J
rate of loss = $48000 / 120 = 400 \text{ W}$ A1
or energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$ (C1)
power required for evaporation = $240000 / (2 \times 60) = 2000 \text{ W}$ (C1)
rate of loss = $2400 - 2000 = 400 \text{ W}$ (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 B1
molecules reduced (not molecules separate) M1
no change in kinetic energy, potential energy increases A1 [3]
internal energy increases
- (ii) *either* molecules/atoms/particles move faster/ $\langle c^2 \rangle$ is increasing B1
or kinetic energy increases with temperature (increases) M1
no change in potential energy, kinetic energy increases A1 [3]
internal energy increases

Q11.

- 1 (a) (i) $Q = mc\Delta\theta$ C1
 $2300 = 0.75 \times c \times (100 - 20) / 120$... (if uses ± 273 , then -2)..... C1
 $c = 4600 \text{ J kg}^{-1} \text{ K}^{-1}$... (allow 1 sf)..... A1
- (ii) $Q = mL$ C1
 $2300 = (0.375 / 420) \times L$
 $L = 2.6 \times 10^6 \text{ J kg}^{-1}$... (allow 1 sf)..... A1 [5]
- (b) e.g. heat losses, power not constant etc M1
(do not allow if related to s.h.c., rather than l.h.c.)
effect on value for L A1 [2]

Q12.

- 3 (a) $pV/T = \text{constant}$ C1
 $T = (6.5 \times 10^6 \times 30 \times 300) / (1.1 \times 10^5 \times 540)$ C1
 $= 985 \text{ K}$ 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)	$w = \rho \Delta V$	C1	
		$= 1.03 \times 10^5 \times (2.96 \times 10^{-2} - 1.87 \times 10^{-5})$		
		$= (-) 3050 \text{ J}$	A1	[2]
	(ii)	$q = 4.05 \times 10^4 \text{ J}$	B1	[1]
	(iii)	$\Delta U = 4.05 \times 10^4 - 3050 = 37500 \text{ J}$...no e.c.f. from (a).....	A1	[1]
		penalise 2 sig.fig. once only		
	(c)	number of molecules = N_A	C1	
		energy = $37500 / (6.02 \times 10^{23})$		
		$= 6.2 \times 10^{-20} \text{ J}$ (accept 1 sig.fig.)	A1	[2]

Q15.

2	(a)	(i)	idea of heat lost (by oil) = heat gained (by thermometer)	C1	
			$32 \times 1.4 \times (54 - t) = 12 \times 0.18 \times (t - 19)$	C1	
			$t = 52.4^\circ\text{C}$	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 at its normal melting point / without any change in temperature	M1		
		(reference to 1 kg or to ice → water scores max 1 mark)	A1	[2]	
	(b)	(i)	To <u>make allowance</u> 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 = $64.7 - \frac{1}{2} \times 16.6 = 56.4 \text{ g}$	C1	
			$56.4 \times 10^{-3} \times L = 18$	C1	
			$L = 320 \text{ kJ kg}^{-1}$	A1	[3]
			(Use of $m = 64.7$, giving $L = 278 \text{ kJ kg}^{-1}$, scores max 1 mark		
			use of $m = 48.1$, giving $L = 374 \text{ kJ kg}^{-1}$, 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 power = maximum rate 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 / atomsM1
 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
 $= 1.0 \times 10^5 \times (2.1 - 1.8) \times 10^{-3}$
 $= 30 \text{ J}$ M1
 $w = 30 \text{ J}, q = 0$ so $\Delta U = 30 \text{ J}$ 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
neither property varies linearly with temperature B1 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
no (net) transfer of energy between the spheres B1 B1 [2]
- (b) (i) power = $m \times c \times \Delta\theta$ where m is mass per second
 $3800 = m \times 4.2 \times (42 - 18)$
 $m = 38 \text{ gs}^{-1}$ C1 C1 A1 [3]
- (ii) some thermal energy is lost to the surroundings
so rate is an overestimate M1 A1 [2]

Q22.

- 3 (a) *either* change in volume = $(1.69 - 1.00 \times 10^{-3})$
or liquid volume \ll volume of vapour
work done = $1.01 \times 10^5 \times 1.69 = 1.71 \times 10^5 \text{ (J)}$ M1 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) $\Delta U = (2.26 \times 10^6) - (1.71 \times 10^5)$
 $= 2.09 \times 10^6 \text{ J (3 s.f. needed)}$ C1 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
 $c = 4400 \text{ J kg}^{-1} \text{ K}^{-1}$ A1 [3]

(use of $\Delta\theta = 73 + 273$ max. 1/3)

(use of $t = 2 \text{ s}$ not 120 s max. 2/3)

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(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 and p constant, so ideal)

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

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

