TEMPERATURE WORKSHEET
A-Level Physics 9702

MJ25/41/Q3

1 **(a)** Define specific latent heat.

....

....

.... [2]

(b) Explain why, for a substance, the specific latent heat of vaporisation is usually greater than the specific latent heat of fusion.

....

....

....

....

.... [3]

(c) An ice cube of mass 37.0 g at temperature 0.0 °C is placed in a beaker containing water of mass 208 g at temperature 26.4 °C.

When all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is 10.3 °C.

The specific heat capacity of water is 4.18 $J\,g^{-1}\,°C^{-1}$.

The beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

Determine a value, to three significant figures, for the specific latent heat of fusion of water.

specific latent heat of fusion = ... $J\,g^{-1}$ [4]

[Total: 9]

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2 **(a)** State what is meant by two objects being in thermal equilibrium.

....

....

.... [2]

(b) A mass X of ice at 0°C is placed in a beaker containing a mass M of water at Celsius temperature t. The beaker is perfectly insulated and has negligible heat capacity. After some time, the ice that was added reaches thermal equilibrium with the original water in the beaker.

The specific latent heat of fusion of water is L. The specific heat capacity of water is c. The final Celsius temperature of the system is θ.

Give expressions, in terms of some or all of X, M, t, θ, L and c, for the thermal energy:

(i) E_1, gained by the ice as it melts to become water at 0°C

E_1 = ... [1]

(ii) E_2, lost by the water as its Celsius temperature decreases from t to θ

E_2 = ... [1]

(iii) E_3, gained by the melted ice as its Celsius temperature increases from 0°C to θ.

E_3 = ... [1]

(c) Use your answers in **(b)** to show that the final Celsius temperature θ of the system is given by

$$\theta = \frac{Mct - XL}{c(M + X)}.$$

[2]

[Total: 7]

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3 **(a)** Two metal cuboids P and Q are in thermal contact with each other.

(i) P and Q are in thermal equilibrium.

State what is meant by the term thermal equilibrium.

....

....

.... [2]

(ii) Data for P and Q are given in Table 3.1.

Table 3.1

	P	Q
specific heat capacity / $\text{J kg}^{-1}\text{K}^{-1}$	390	910
mass / kg	0.54	0.37

P and Q are initially both at the same temperature.

P is supplied with 24 kJ of thermal energy. After some time, P and Q are once again both at the same temperature as each other.

P and Q are perfectly insulated from the surroundings.

Determine the change in temperature ΔT of Q.

ΔT = ... K [3]

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4 **(a)** Define specific heat capacity.

....

....

.... [2]

(b) Two solid blocks X and Y are made from different metals. The blocks have different initial temperatures. Block Y is initially at room temperature.

The blocks are placed in direct thermal contact with each other at time $t = 0$. Fig. 2.1 shows the variation with t of the temperatures of the two blocks.

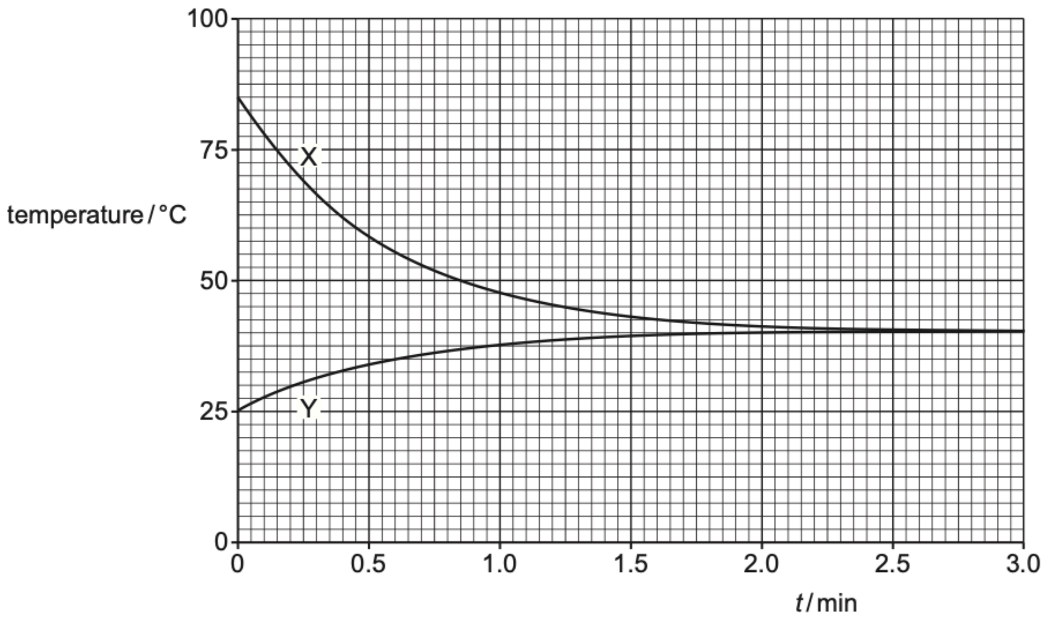

Fig. 2.1

(i) State **three** conclusions that may be drawn from Fig. 2.1. The conclusions may be qualitative or quantitative.

1 ....

....

2 ....

....

3 ....

....
[3]

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(ii) The ratio $\frac{\text{mass of block Y}}{\text{mass of block X}}$ is equal to 1.3.

The metal in block Y has a specific heat capacity of $901\,J\,kg^{-1}\,K^{-1}$.

Determine the specific heat capacity of the metal in block X.

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ [3]

[Total: 8]

5 **(a)** Define specific latent heat. **ON24/42/Q3**

....

....

.... [2]

(b) A dish containing $7.2 \times 10^{-5}\,m^3$ of a substance rests on a laboratory bench. The substance is initially a liquid of density $710\,kg\,m^{-3}$. Atmospheric pressure is $1.0 \times 10^5\,Pa$.

The liquid is heated at its boiling point so that it completely vaporises. The increase in the internal energy of the substance during this process is 17.6 kJ. The final volume of the vapour is $0.017\,m^3$.

(i) Show that the magnitude of the work done on the substance when it vaporises is 1.7 kJ.

[2]

(ii) Use the information in **(b)(i)** to calculate the thermal energy Q, in kJ, supplied to the substance to cause it to vaporise.

Q = ... kJ [2]

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(iii) Use your answer in **(b)(ii)** to determine a value for the specific latent heat of vaporisation L_V, in $kJ\,kg^{-1}$, of the substance.

L_V = ... $kJ\,kg^{-1}$ [2]

MJ24/41/Q2

6 (a) (i) State the magnitude and unit of absolute zero on the thermodynamic temperature scale.

.... [1]

(ii) Explain why temperature measured using a laboratory liquid-in-glass thermometer does **not** give a measurement of thermodynamic temperature.

....

.... [1]

(b) Fig. 2.1 shows a simplified diagram of a type of thermometer called a platinum resistance thermometer.

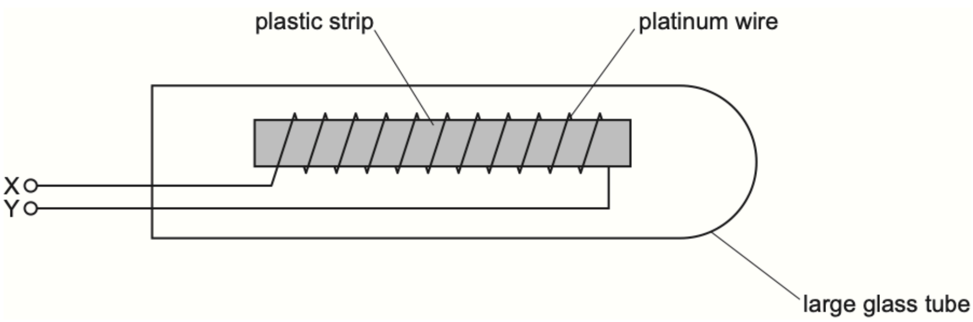

Fig. 2.1

The glass tube is immersed in the environment for which the temperature is to be determined. The resistance between the terminals X and Y is measured.

Fig. 2.2 shows the variation of the resistivity ρ of platinum with thermodynamic temperature T.

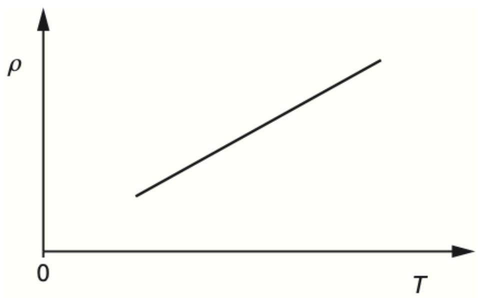

Fig. 2.2

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.

(i) Explain how Fig. 2.2 shows that platinum is a suitable metal for use in a resistance thermometer.

....

....

.... [2]

(ii) Suggest a reason why a platinum resistance thermometer is **not** suitable for measuring a rapidly changing temperature.

....

....

.... [1]

(iii) Suggest a type of thermometer that is suitable for measuring a rapidly changing temperature.

.... [1]

(c) A negative temperature coefficient thermistor may be used as a type of resistance thermometer.

State **one** way in which the variation with temperature of the resistance of a thermistor differs from that of a platinum wire.

....

.... [1]

[Total: 7]

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7 **(a)** State the reason why two objects that are at the same temperature are described as being in thermal equilibrium.

....

.... [1]

(b) Fig. 3.1 shows the variations with temperature of the densities of mercury and of water between 0 °C and 100 °C.

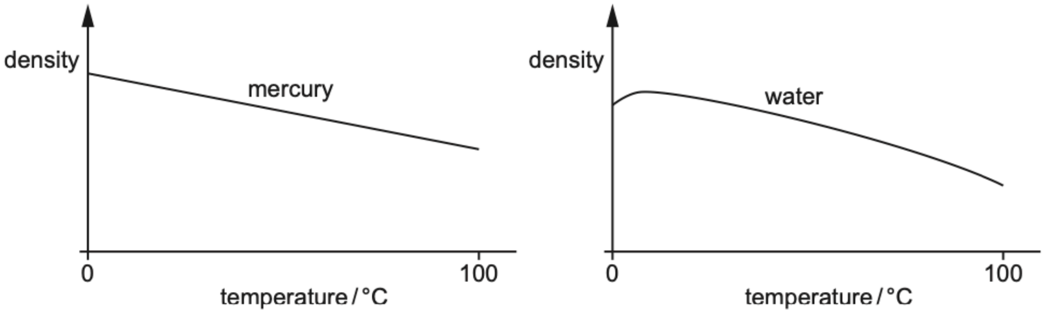

Fig. 3.1

Temperature may be measured using the variation with temperature of the density of a liquid.

Suggest why, for measuring temperature over this temperature range:

(i) mercury is a suitable liquid

....

.... [1]

(ii) water is not a suitable liquid.

....

....

.... [2]

(c) A beaker contains a liquid of mass 120 g. The liquid is supplied with thermal energy at a rate of 810 W. The beaker has a mass of 42 g and a specific heat capacity of 0.84 J g^{-1} K^{-1}. The beaker and the liquid are in thermal equilibrium with each other at all times and are insulated from the surroundings.

Fig. 3.2 shows the variation with time *t* of the temperature of the liquid.

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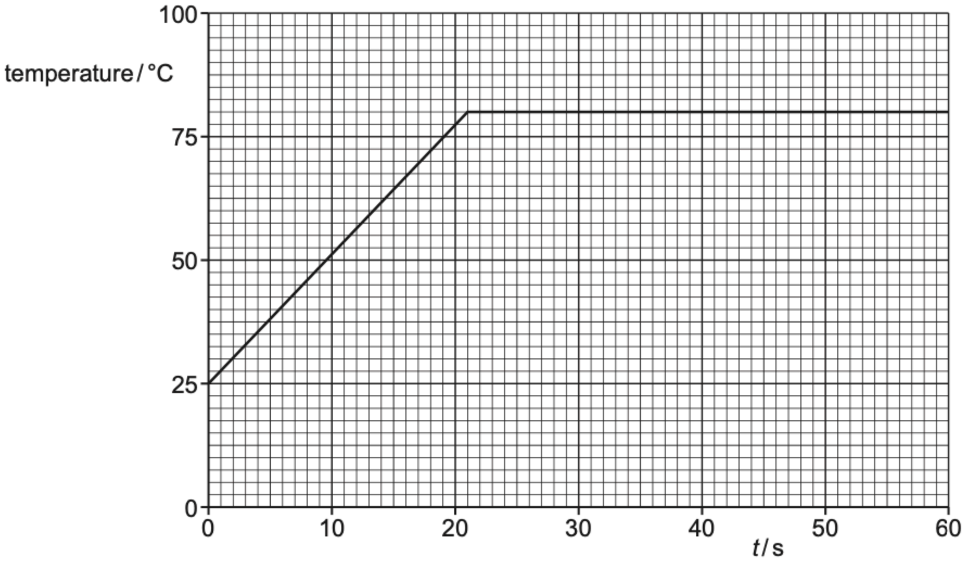

Fig. 3.2

(i) State the boiling temperature, in °C, of the liquid.

temperature = ... °C [1]

(ii) Determine the specific heat capacity, in $J\,g^{-1}\,K^{-1}$, of the liquid.

specific heat capacity = ... $J\,g^{-1}\,K^{-1}$ [4]

(d) The experiment in **(c)** is repeated using water instead of the liquid in **(c)**. The mass of liquid used, the power supplied, and the initial temperature are all unchanged.
The specific heat capacity of water is approximately twice that of the liquid in **(c)**.
The boiling temperature of water is 100 °C.

On Fig. 3.2, sketch the variation with time t of the temperature of the water between t = 0 and t = 60 s. Numerical calculations are not required. [2]

[Total: 11]

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8 Fig. 2.1 shows a laboratory thermometer that is calibrated to measure temperature in degrees Celsius.

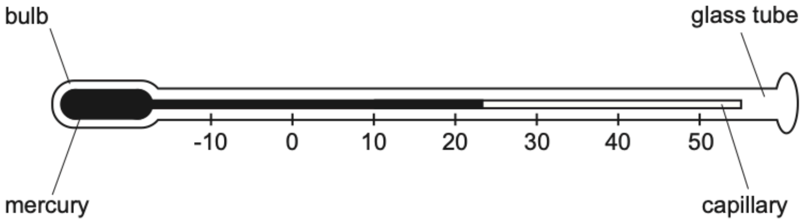

Fig. 2.1

The thermometer makes use of the fact that the density of mercury varies with temperature.

(a) State **two** other physical properties of materials, apart from the density of a liquid, that can be used for measuring temperature.

1 ....

2 ....
[2]

(b) The thermometer is initially at 23.0 °C, as shown in Fig. 2.1. It is used to measure the temperature of an insulated beaker of water that is at 37.4 °C. The bulb of the thermometer is inserted into the water, and the water is stirred until the reading on the thermometer becomes steady.

The mass of water in the beaker is 18.7 g.
The mass of mercury in the thermometer is 6.94 g.
The specific heat capacity of water is 4.18 $J g^{-1} K^{-1}$.
The specific heat capacity of mercury is 0.140 $J g^{-1} K^{-1}$.
The glass of the thermometer and the beaker containing the water can be considered to have negligible heat capacity.

(i) Calculate, to three significant figures, the final steady temperature indicated by the thermometer in the water.

temperature = ... °C [4]

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(ii) Suggest **one** change that could be made to the design of the thermometer that would enable it to give a more accurate measurement of temperature.

....

.... [1]

(c) (i) Explain why the thermometer in Fig. 2.1 does **not** provide a direct measurement of thermodynamic temperature.

....

....

.... [2]

(ii) Thermodynamic temperature *T* may be determined by the behaviour of a type of substance for which *T* is proportional to the product of pressure and volume.

State the name of this type of substance.

.... [1]

[Total: 10]

MJ22/42/Q3

9 (a) Define specific latent heat of vaporisation.

....

....

.... [2]

(b) The specific latent heat of vaporisation of water at atmospheric pressure of 1.0×10^5 Pa is 2.3×10^6 J kg^{-1}. A mass of 0.37 kg of liquid water at 100 °C is provided with the thermal energy needed to vaporise all of the water at atmospheric pressure.

(i) Calculate the thermal energy *q* supplied to the water.

q = ... J [1]

(ii) The mass of 1.0 mol of water is 18 g. Assume that water vapour can be considered to behave as an ideal gas.

Show that the volume of water vapour produced is $0.64\,m^3$.

[3]

(iii) Assume that the initial volume of the liquid water is negligible compared with the volume of water vapour produced.

Determine the magnitude of the work done by the water in expanding against the atmosphere when it vaporises.

work done = ... J [2]

(iv) Use your answers in **(b)(i)** and **(b)(iii)** to determine the increase in internal energy of the water when it vaporises at 100 °C. Explain your reasoning.

increase in internal energy = ... J [2]

(c) Use the first law of thermodynamics to suggest, with a reason, how the specific latent heat of vaporisation of water at a pressure greater than atmospheric pressure compares with its value at atmospheric pressure.

....

....

.... [2]

[Total: 12]

10 (a) State what is meant by *specific latent heat*.

....

....

.... [2]

(b) A student uses the apparatus illustrated in Fig. 3.1 to determine a value for the specific latent heat of fusion of ice.

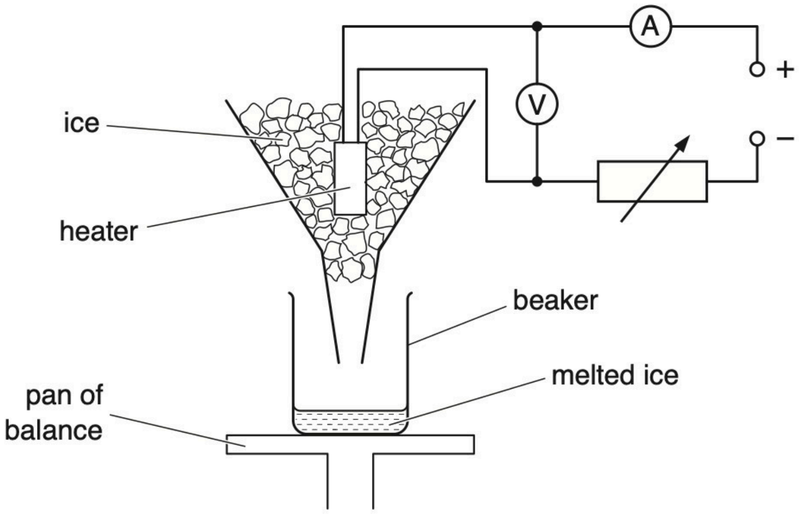

Fig. 3.1

The balance reading measures the mass of the beaker and the melted ice (water) in the beaker.

The heater is switched on and pieces of ice at 0 °C are added continuously to the funnel so that the heater is always surrounded by ice.

When water drips out of the funnel at a constant rate, the balance reading is noted at 2.0 minute intervals. After 10 minutes, the current in the heater is increased and the balance readings are taken for a further 12 minutes.

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The variation with time of the balance reading is shown in Fig. 3.2.

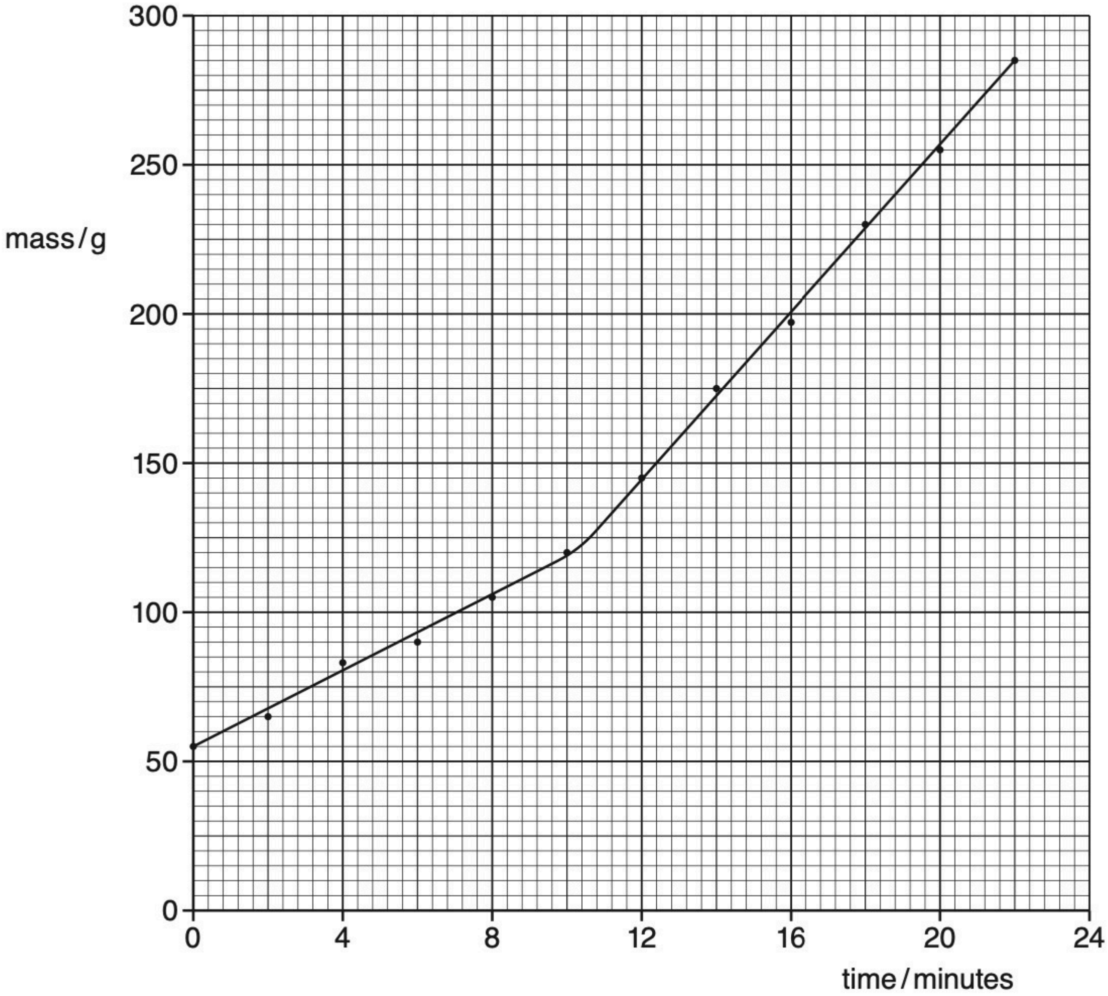

Fig. 3.2

The readings of the ammeter and of the voltmeter are shown in Fig. 3.3.

	ammeter reading / A	voltmeter reading / V
from time 0 to time 10 minutes after time 10 minutes	1.8 3.6	7.3 15.1

Fig. 3.3

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(i) From time 0 to time 10.0 minutes, 65 g of ice is melted.

Use Fig. 3.2 to determine the mass of ice melted from time 12.0 minutes to time 22.0 minutes.

mass = ... g [1]

(ii) Explain why, although the power of the heater is changed, the rate at which thermal energy is transferred from the surroundings to the ice is constant.

....

.... [1]

(iii) Determine a value for the specific latent heat of fusion *L* of ice.

L = ... $J g^{-1}$ [4]

(iv) Calculate the rate at which thermal energy is transferred from the surroundings to the ice.

rate = ... W [2]

[Total: 10]

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11 **(a)** State what is meant by *specific latent heat*.

....

....

.... [2]

(b) A student determines the specific latent heat of vaporisation of a liquid using the apparatus illustrated in Fig. 3.1.

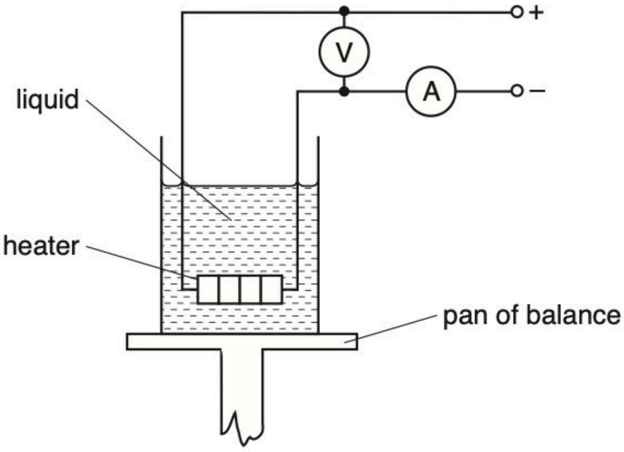

Fig. 3.1

The heater is switched on. When the liquid is boiling at a constant rate, the balance reading is noted at 2.0 minute intervals.

After 10 minutes, the current in the heater is reduced and the balance readings are taken for a further 12 minutes.

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The readings of the ammeter and of the voltmeter are given in Fig. 3.2.

	ammeter reading /A	voltmeter reading /V
from time 0 to time 10 minutes	1.2	230
after time 10 minutes	1.0	190

Fig. 3.2

The variation with time of the balance reading is shown in Fig. 3.3.

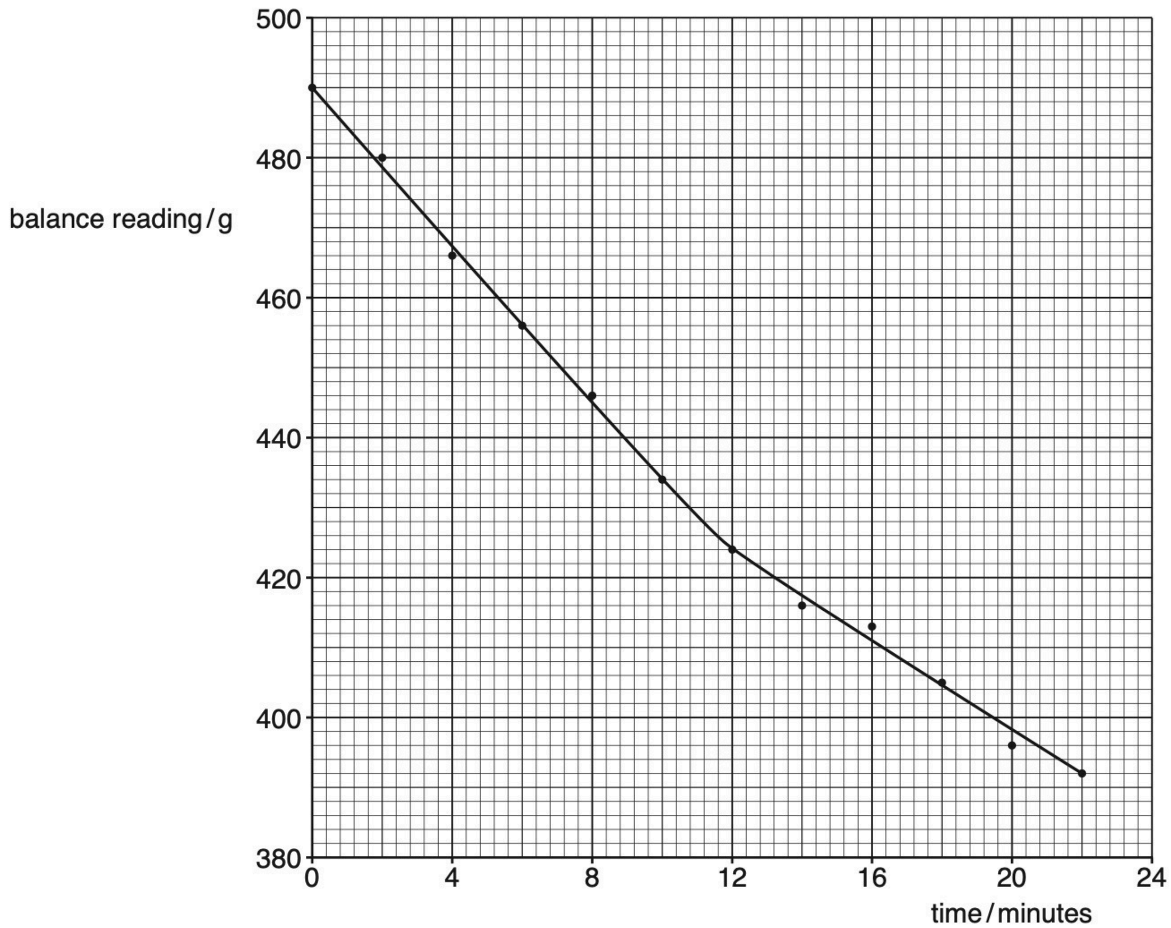

Fig. 3.3

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(i) From time 0 to time 10.0 minutes, the mass of liquid evaporated is 56 g.

Use Fig. 3.3 to determine the mass of liquid evaporated from time 12.0 minutes to time 22.0 minutes.

mass = ... g [1]

(ii) Explain why, although the power of the heater is changed, the rate of loss of thermal energy to the surroundings may be assumed to be constant.

....

.... [1]

(iii) Determine a value for the specific latent heat of vaporisation *L* of the liquid.

L = ... $J g^{-1}$ [4]

(iv) Calculate the rate at which thermal energy is transferred to the surroundings.

rate = ... W [2]

[Total: 10]

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12 **(a)** Define *specific latent heat of fusion*. **ON18/42/Q3**

....

....

....[2]

(b) A student sets up the apparatus shown in Fig. 3.1 in order to investigate the melting of ice.

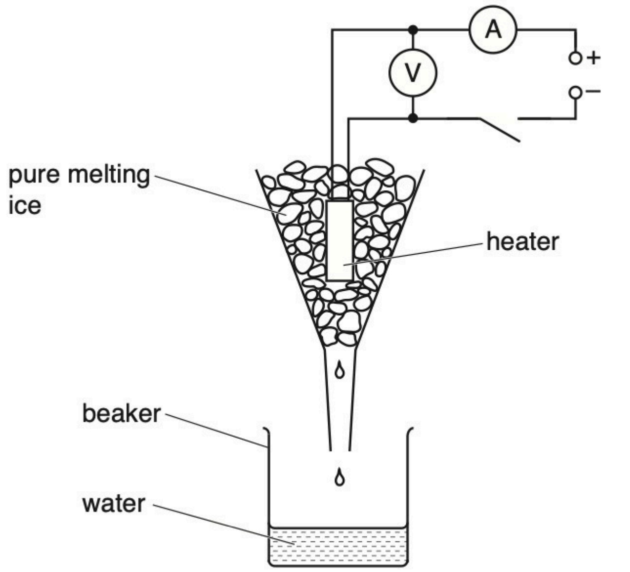

Fig. 3.1

The heater is switched on.
When the pure ice is melting at a constant rate, the data shown in Fig. 3.2 are collected.

voltmeter reading /V	ammeter reading /A	initial mass of beaker plus water/g	final mass of beaker plus water/g	time of collection /minutes
12.8	4.60	121.5	185.0	5.00

Fig. 3.2

The specific latent heat of fusion of ice is $332\,\mathrm{J\,g^{-1}}$.

(i) State what is observed by the student that shows that the ice is melting at a constant rate.

....

....[1]

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(ii) Use the data in Fig. 3.2 to determine the rate at which

1. thermal energy is transferred to the melting ice,

rate = ... W

2. thermal energy is gained from the surroundings.

rate = ... W
[4]

[Total: 7]

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13 **(a)** During melting, a solid becomes liquid with little or no change in volume. **MJ18/42/Q3**

Use kinetic theory to explain why, during the melting process, thermal energy is required although there is no change in temperature.

....

....

....

....

....[3]

(b) An aluminium can of mass 160 g contains a mass of 330 g of warm water at a temperature of 38 °C, as illustrated in Fig. 3.1.

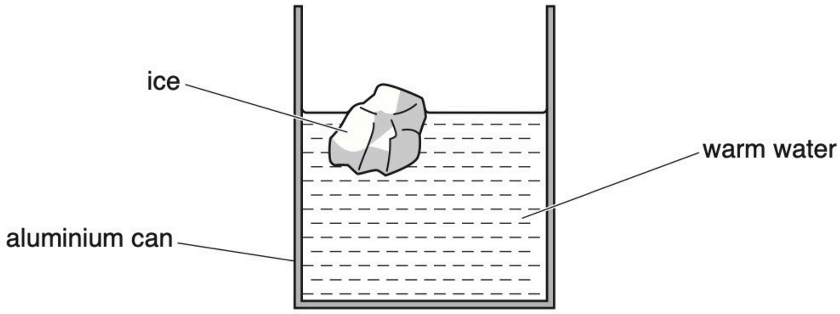

Fig. 3.1

A mass of 48 g of ice at –18 °C is taken from a freezer and put in to the water. The ice melts and the final temperature of the can and its contents is 23 °C.

Data for the specific heat capacity *c* of aluminium, ice and water are given in Fig. 3.2.

	c / J g^{-1} K^{-1}
aluminium	0.910
ice	2.10
water	4.18

Fig. 3.2

Assuming no exchange of thermal energy with the surroundings,

(i) show that the loss in thermal energy of the can and the warm water is 2.3×10^4 J,

[2]

(ii) use the information in **(i)** to calculate a value *L* for the specific latent heat of fusion of ice.

L = ... $J\,g^{-1}$ [2]

[Total: 7]

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14 **(a)** State **ON17/42/Q1**

(i) what may be deduced from the difference in the temperatures of two objects,

....

.... [1]

(ii) the basic principle by which temperature is measured.

....

.... [1]

(b) By reference to your answer in **(a)(ii)**, explain why two thermometers may not give the same temperature reading for an object.

....

....

.... [2]

(c) A block of aluminium of mass 670 g is heated at a constant rate of 95 W for 6.0 minutes.
The specific heat capacity of aluminium is $910\,\mathrm{J\,kg^{-1}\,K^{-1}}$.
The initial temperature of the block is 24 °C.

(i) Assuming that no thermal energy is lost to the surroundings, show that the final temperature of the block is 80 °C.

[3]

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(ii) In practice, there are energy losses to the surroundings.
The actual variation with time t of the temperature θ of the block is shown in Fig. 1.1.

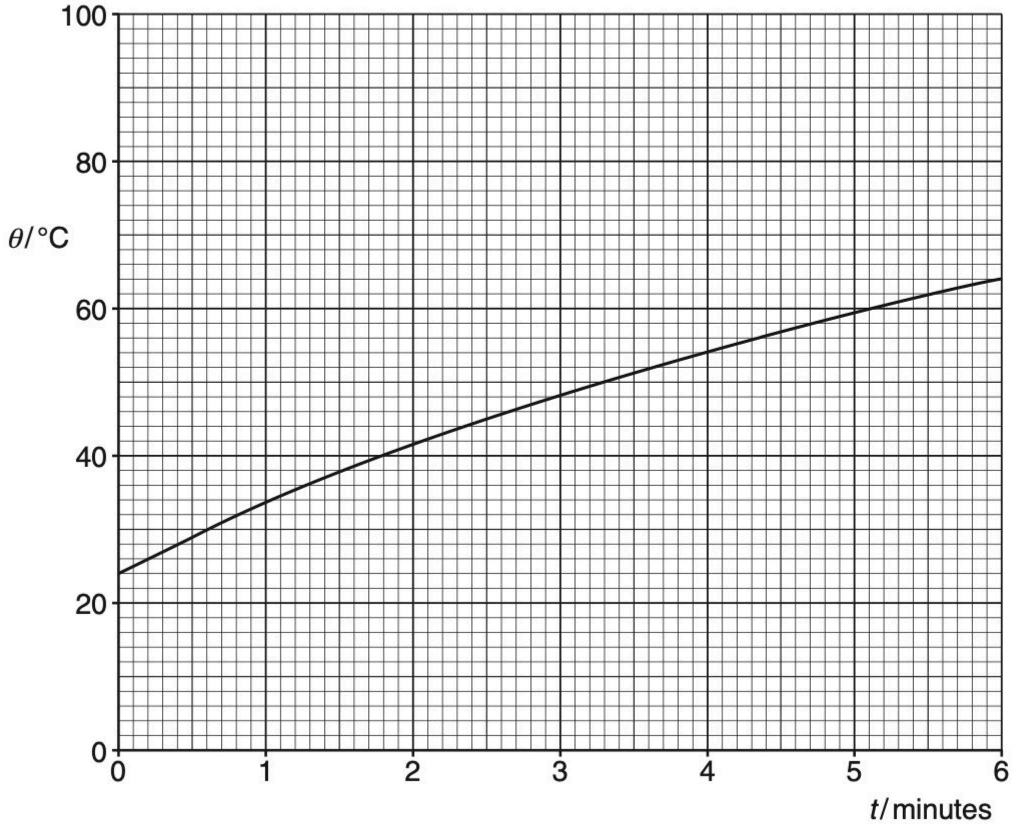

Fig. 1.1

1. Use the information in **(i)** to draw, on Fig. 1.1, a line to represent the temperature of the block, assuming no energy losses to the surroundings. [1]

2. Using Fig. 1.1, calculate the total energy loss to the surroundings during the heating process.

energy loss = ... J [2]

[Total: 10]

15 **(a)** The resistance of a thermistor at 0 °C is 3840 Ω. At 100 °C the resistance is 190 Ω. When the thermistor is placed in water at a particular constant temperature, its resistance is 2300 Ω.

(i) Assuming that the resistance of the thermistor varies linearly with temperature, calculate the temperature of the water.

temperature = ... °C [2]

(ii) The temperature of the water, as measured on the thermodynamic scale of temperature, is 286 K.

By reference to what is meant by the thermodynamic scale of temperature, comment on your answer in **(i)**.

....

....

....

.... [3]

(b) A polystyrene cup contains a mass of 95 g of water at 28 °C.

A cube of ice of mass 12 g is put into the water. Initially, the ice is at 0 °C. The water, of specific heat capacity $4.2 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$, is stirred until all the ice melts.

Assuming that the cup has negligible mass and that there is no heat exchange with the atmosphere, calculate the final temperature of the water.

The specific latent heat of fusion of ice is $3.3 \times 10^5\ \text{J kg}^{-1}$.

temperature = ... °C [4]

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1 (a)	(thermal) energy per unit mass (to cause state change) (thermal) energy to change state at constant temperature	B1 B1	Ratio must be clear. **Ignore** symbols unless they are defined. **Ignore** any reference to units. **Do not allow** 'work' for 'thermal energy'. **Allow** any named state change.
3(b)	(for vaporisation): *either*: involves much greater change in volume (of substance) *or*: involves much greater increase in separation of molecules *either*: much more work has to be done on molecules (to separate them) *or*: much greater increase in potential energy of molecules kinetic energy of molecules unchanged, so much more thermal energy needed	 B1 M1 A1	**Allow** reverse argument for fusion throughout.
3(c)	$Q = mc\Delta\theta$ and $Q = mL$ $\Delta\theta$ for the water = 26.4 – 10.3 $(37.0 \times L) + (37.0 \times 4.18 \times 10.3) = (208 \times 4.18 \times 16.1)$ L = **335 J g^{-1}**	C1 C1 C1 A1	First two C1 marks are independent of each other. $\Delta\theta$ = 16.1°C. This C1 mark implies all three C1 marks. Must be to three significant figures. AFC. Not the paper SF penalty.

2 (a)	no transfer of thermal energy (between them) if placed in (thermal) contact same temperature (as each other)	B1 B1	
2(b)(i)	$E_1 = XL$	B1	
2(b)(ii)	$E_2 = Mc(t - \theta)$	A1	Sign must be correct.
2(b)(iii)	$E_3 = Xc\theta$	B1	
2(c)	$E_2 = E_1 + E_3$ $Mc(t - \theta) = XL + Xc\theta$ …. …. <u>and</u> completion of algebra to reach $\theta = (Mct - XL) / c(M + X)$	C1 A1	Can be implied by the substitution into the equation of the expressions in **(b)**, as required in the A1 mark. However, use of $E_2 = Mc(\theta - t)$ does **not** imply this mark, unless the wrong sign is corrected at this point. This part of the A1 mark implies the C1 mark. Full substitution, algebra and answer needed for A1.

3 (a)(i)	(P and Q are at the) same temperature	**B1**
	no net transfer of thermal energy (between P and Q)	**B1**
3(a)(ii)	$Q = mc\Delta T$	**C1**
	$24 \times 10^3 = (0.54 \times 390 \times \Delta T) + (0.37 \times 910 \times \Delta T)$	**C1**
	$\Delta T = 44$ K	**A1**

4 (a)	(thermal) energy per unit mass (to change temperature)	**B1**
	(thermal) energy per unit change in temperature	**B1**
2(b)(i)	*Any three bulleted points from:* • the blocks end up in thermal equilibrium • heat capacity of Y is larger than heat capacity of X • no heat loss to the surroundings *Up to 2 points from these six:* • initial temperature of X = 85 °C • initial temperature of Y = 25 °C • the temperature change of X = 45 °C • the temperature change of Y = 15 °C • the temperature change in X is three times that in Y • final temperature of both = 40 °C	**B3**
2(b)(ii)	$\Delta\theta$ = 45 °C for X **and** 15 °C for Y	**C1**
	$mc \times 45 = 1.3 \times m \times 901 \times 15$	**C1**
	$c = 390$ J kg K^{-1}	**A1**

5 (a)	(thermal) energy per unit mass (to cause change of state)	**B1**
	(thermal) energy to change state at constant temperature	**B1**
3(b)(i)	$W = p\Delta V$	**C1**
	$= 1.0 \times 10^5 \times 0.017 = 1700$ J = 1.7 kJ	**A1**
3(b)(ii)	$\Delta U = Q + W$	**C1**
	$Q = 17.6 + 1.7$ $= 19.3$ kJ	**A1**
3(b)(iii)	mass $= 710 \times 7.2 \times 10^{-5}$ (= 0.051 kg)	**C1**
	$L = 19.3 / 0.051$ = 380 kJ kg^{-1}	**A1**
3(c)	fusion involves (much) smaller volume change (than vaporisation)	**B1**
	smaller change in intermolecular spacing so smaller change in internal energy	**B1**
	negligible work done (by substance during fusion) so L_F is less (than L_V)	**B1**

6 a)(i)	0 K	**B1**
2(a)(ii)	(measurement) depends on properties of the liquid	**B1**
2(b)(i)	• resistivity varies with temperature • variation with temperature is linear • unique value of resistivity for each (different value of) temperature *Any two points, 1 mark each*	**B2**
2(b)(ii)	thermometer has high heat capacity/specific heat capacity **or** energy transfer needed for thermometer to reach correct temperature **or** thermometer takes time to reach the correct temperature	**B1**
2(b)(iii)	thermocouple	**B1**
2(c)	(variation is) inverse **or** (variation is) non-linear	**B1**

7 3(a)	no <u>net</u> thermal energy is transferred (between them)	**B1**
3(b)(i)	variation (of density with temperature) is linear **or** each temperature has a unique value of density	**B1**
3(b)(ii)	• variation (of density with temperature) is not linear • region where the density does not vary with temperature • different temperatures have the same density *Any two points, 1 mark each*	**B2**
3(c)(i)	boiling point = 80 °C	**A1**
3(c)(ii)	$Q = Pt$ **and** $t = 21$ s (thermal energy supplied = 810 × 21 = 17000 J)	**C1**
	$c = Q / m\Delta\theta$	**C1**
	thermal energy absorbed by beaker = 42 × 0.84 × (80 – 25) (= 1940 J)	**C1**
	s.h.c. of liquid = [(810 × 21) – (42 × 0.84 × (80 – 25))] / [120 × (80 – 25)] = 2.3 J g^{-1} K^{-1}	**A1**
3(d)	sketch: straight diagonal line from 25 °C to 100 °C **and** then horizontal at 100 °C	**B1**
	straight diagonal line starting at 25 °C with gradient approximately half that of the original line	**B1**

8 (a)	• resistance of a metal • volume of a gas at constant pressure • e.m.f. of a thermocouple *Any two points, 1 mark each*	**B2**
2(b)(i)	$Q = mc\Delta T$	**C1**
	evidence of realisation that Q lost by water = Q gained by mercury	**C1**
	18.7 × 4.18 × (37.4 – T) = 6.94 × 0.140 × (T – 23.0)	**C1**
	T = 37.2 °C	**A1**
2(b)(ii)	use a liquid with a lower (specific) heat capacity (than mercury) **or** use a smaller mass of mercury	**B1**
2(c)(i)	depends on properties of a real substance	**B1**
	0 °C is not absolute zero	**B1**
2(c)(ii)	ideal gas	**B1**

9 (a)	(thermal) energy per unit mass	**B1**
	energy to change state between liquid and gas at constant temperature	**B1**
3(b)(i)	$q = mL = 0.37 \times 2.3 \times 10^6$ $= 8.5 \times 10^5$ J	**A1**
3(b)(ii)	$pV = nRT$ **and** $T = 373$ K	**C1**
	$n = 370 / 18$	**C1**
	$V = [(370 / 18) \times 8.31 \times 373] / (1.0 \times 10^5) = 0.64$ m^3	**A1**
3(b)(iii)	$w = p\Delta V$	**C1**
	$= 1.0 \times 10^5 \times 0.64$ $= 6.4 \times 10^4$ J	**A1**
3(b)(iv)	(water does work against atmosphere so) work done on water is negative	**B1**
	increase in internal energy = $(8.5 - 0.64) \times 10^5 = 7.9 \times 10^5$ J	**A1**
3(c)	valid reasoning of how work done by water is affected	**M1**
	correct use of first law to draw conclusion about effect on specific latent heat that is consistent with work done	**A1**

Question	Answer	Marks
10)	(thermal) energy per unit mass (to change state)	**B1**
	change of state without any change of temperature	**B1**
3(b)(i)	140 g	**A1**
3(b)(ii)	temperature difference (between apparatus and surroundings) does not change	**B1**
3(b)(iii)	$VIt = mL$	**C1**
	$(\{15.1 \times 3.6\} + R) \times 600 = 140 \times L$ **or** $(\{7.3 \times 1.8\} + R) \times 600 = 65 \times L$	**C1**
	$41.22 \times 600 = 75 \times L$	**C1**
	$L = 330$ J g^{-1}	**A1**
3(b)(iv)	$15.1 \times 3.6 \times 600 = (140 \times 330) - H$ **or** $7.3 \times 1.8 \times 600 = (65 \times 330) - H$	**C1**
	$H = 13\,600$ rate of gain = 13 600 / 600 = 23 W	**A1**

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Question	Answer	Marks
11 ı)	(thermal) energy per (unit) mass (to change state)	B1
	(heat transfer during) change of state at constant temperature	B1
3(b)(i)	32 g	A1
3(b)(ii)	temperature difference (between liquid and surroundings) does not change	B1
3(b)(iii)	$VIt = mL$	C1
	$230 \times 1.2 \times 60 \times 10 = (56 \times L) + H$ **or** $190 \times 1.0 \times 60 \times 10 = (32 \times L) + H$	C1
	$86 \times 600 = (56 - 32) \times L$	C1
	or	
	$230 \times 1.2 = (56 \times L) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times L) / (60 \times 10) + P$	(C1)
	$276 - 190 = (24 \times L) / 600$	(C1)
	$L = 2200\ \text{J g}^{-1}$	A1
3(b)(iv)	$230 \times 1.2 \times 600 = (56 \times 2150) + H$ **or** $190 \times 1.0 \times 600 = (32 \times 2150) + H$	C1
	$H = 45\,200$ rate $= 45\,200 / 600$ $= 75$ W	A1
	or	
	$230 \times 1.2 = (56 \times 2150) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times 2150) / (60 \times 10) + P$	(C1)
	rate (= P) = 75 W	(A1)

Question	Answer	Marks
12 3(a)	(thermal) energy per unit mass (to cause change of state)	B1
	(energy transfer during) change of state between solid and liquid at constant temperature	B1
3(b)(i)	Any one from: • rate of increase in mass (of beaker and water) is constant • level of water rises at a constant rate • volume of water (in beaker) increases at a constant rate • constant time between drops • constant rate of dripping	B1
3(b)(ii)	(electrical power supplied =) 12.8×4.60 (= 58.9 W)	C1
	(rate of transfer to ice =) $[(185.0 - 121.5) \times 332] / [5.00 \times 60]$ (= 70.3 W)	C1
	1. rate = 70.3 W	A1
	2. rate = 70.3 – 58.9 = 11.4 W	A1

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Question	Answer	Marks
13 (a)	(during melting,) bonds between atoms/molecules are broken	B1
	potential energy of atoms/molecules is increased	B1
	no/little work done so required input of energy is thermal	B1
3(b)(i)	(ΔQ =) $mc\Delta\theta$	C1
	loss = (160 × 0.910 × 15) + (330 × 4.18 × 15) = 2.3×10^4 J	A1
3(b)(ii)	2.3×10^4 = (48 × 2.10 × 18) + 48L + (48 × 4.18 × 23)	C1
	48L = 1.66×10^4 L = 350 J g^{-1}	A1

Question	Answer	Marks
14 (a)(i)	direction or rate of transfer of (thermal) energy **or** (if different,) not in thermal equilibrium/energy is transferred	B1
1(a)(ii)	uses a property (of a substance) that changes with temperature	B1
1(b)	• temperature scale assumes linear change of property with temperature • physical properties may not vary linearly with temperature • agrees only at fixed points *Any 2 points.*	B2
1(c)(i)	$Pt = mc(\Delta)\theta$	C1
	95 × 6 × 60 = 0.670 × 910 × $\Delta\theta$	M1
	$\Delta\theta$ = 56 °C so final temperature = 56 + 24 = 80 °C	A1
	or	
	95 × 6 × 60 = 0.67 × 910 × (θ – 24)	(M1)
	so final temperature or θ = 80 °C	(A1)

15 **(a)** **(i)** 1 deg C corresponds to (3840 – 190) / 100 Ω — C1
for resistance 2300 Ω, temperature is 100 × (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 × 3.3 × 10^5 J — C1
= 3960 J
heat lost by water = 0.095 × 4.2 × 10^3 × (28 – θ) — C1
3960 + (0.012 × 4.2 × 10^3 × θ) = 0.095 × 4.2 × 10^3 × (28 – θ) — C1
θ = 16°C — A1 [4]
(answer 18°C – melted ice omitted – allow max 2 marks)
(use of (θ – T) then allow max 1 mark)

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