

1

A liquid flows continuously through a chamber that contains an electric heater. When the steady state is reached, the liquid leaving the chamber is at a higher temperature than the liquid entering the chamber. The difference in temperature is Δt .

Which of the following will increase Δt with no other change?

A Increasing the volume flow rate of the liquid

☐

B Changing the liquid to one with a lower specific heat capacity

☐

C Using a heating element with a higher resistance

☐

D Changing the liquid to one that has a higher density

☐

(Total 1 mark)

2

The temperature of a hot liquid in a container falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which time all the liquid has all solidified.

What is the quantity $\frac{\text{Specific heat capacity of the liquid}}{\text{Specific latent heat of fusion}}$?

A $\frac{1}{40} \text{ K}^{-1}$

☐

B $\frac{1}{10} \text{ K}^{-1}$

☐

C 10 K^{-1}

☐

D 40 K^{-1}

☐

(Total 1 mark)

3

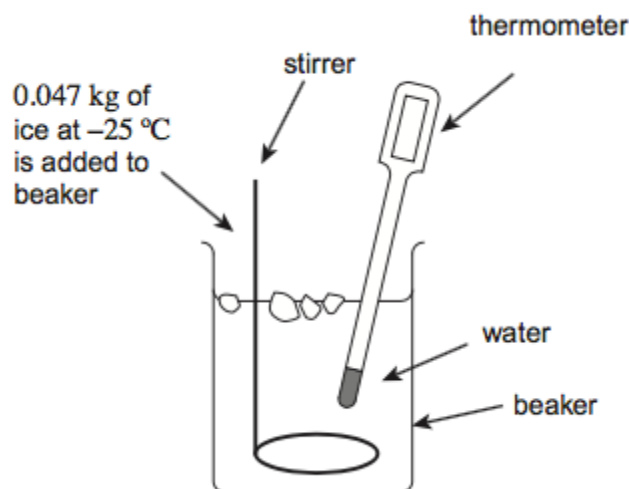
- (a) Which statement explains why energy is needed to melt ice at 0°C to water at 0°C ?

Place a tick (✓) in the right-hand column to show the correct answer.

	✓ if correct
It provides the water with energy for its molecules to move faster.	
It breaks all the intermolecular bonds.	
It allows the molecules to vibrate with more kinetic energy.	
It breaks some intermolecular bonds.	

(1)

- (b) The diagram shows an experiment to measure the specific heat capacity of ice.



A student adds ice at a temperature of -25°C to water. The water is stirred continuously. Ice is added slowly until all the ice has melted and the temperature of the water decreases to 0°C . The mass of ice added during the experiment is 0.047 kg .

- (i) Calculate the energy required to melt the ice at a temperature of 0°C .
The specific latent heat of fusion of water is $3.3 \times 10^5\text{ J kg}^{-1}$.

energy = _____ J

(1)

- (ii) The water loses 1.8×10^4 J of energy to the ice during the experiment. Calculate the energy given to the ice to raise its temperature to 0°C . Assume that no energy is transferred to or from the surroundings and beaker.

energy = _____ J

(1)

- (iii) Calculate the specific heat capacity of the ice.
State an appropriate unit for your answer.

specific heat capacity = _____ unit = _____

(2)

(Total 5 marks)

4

- (a) Define the specific latent heat of vaporisation of water.

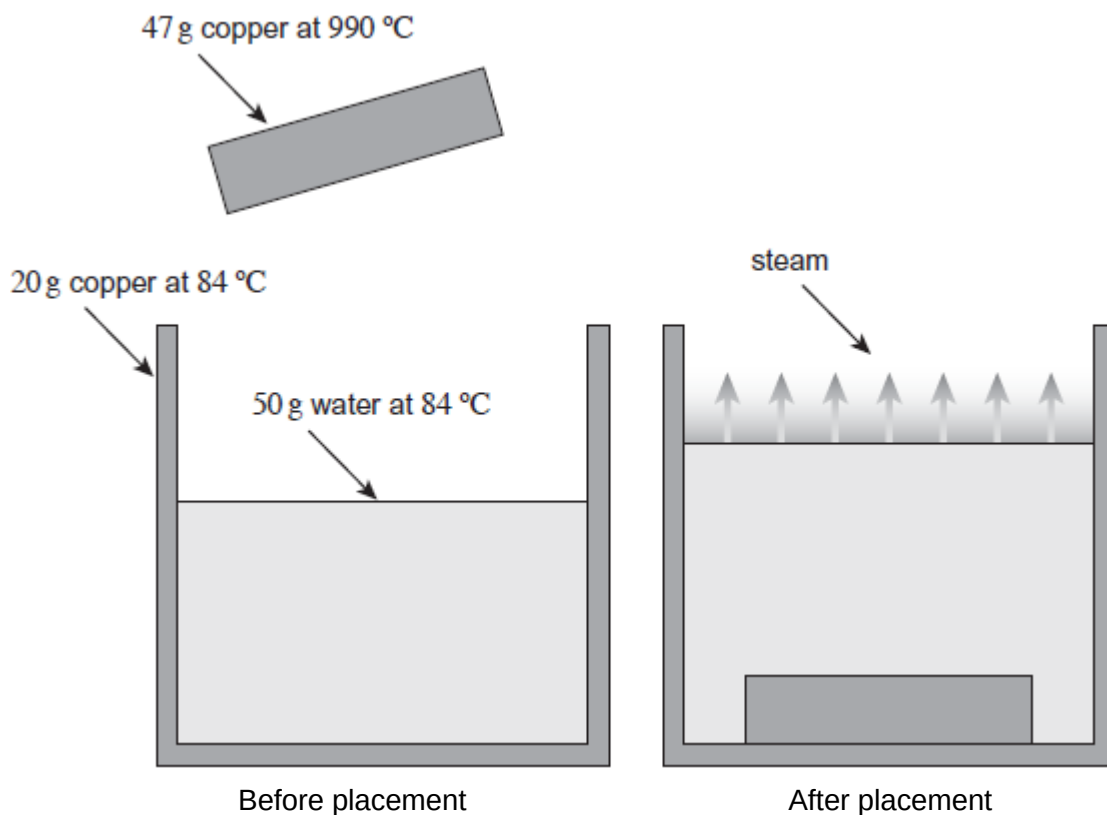
(2)

- (b) An insulated copper can of mass 20 g contains 50 g of water both at a temperature of 84 °C. A block of copper of mass 47 g at a temperature of 990 °C is lowered into the water as shown in the figure below. As a result, the temperature of the can and its contents reaches 100 °C and some of the water turns to steam.

specific heat capacity of copper = $390 \text{ J kg}^{-1} \text{ K}^{-1}$

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

specific latent heat of vaporisation of water = $2.3 \times 10^6 \text{ J kg}^{-1}$



- (i) Calculate how much thermal energy is transferred from the copper block as it cools to 100 °C.
Give your answer to an appropriate number of significant figures.

thermal energy transferred _____ J

(2)

- (ii) Calculate how much of this thermal energy is available to make steam.
Assume no heat is lost to the surroundings.

available thermal energy _____ J

(2)

- (iii) Calculate the maximum mass of steam that may be produced.

mass _____ kg

(1)

(Total 7 marks)

5

A cola drink of mass 0.200 kg at a temperature of 3.0 °C is poured into a glass beaker. The beaker has a mass of 0.250 kg and is initially at a temperature of 30.0 °C.

specific heat capacity of glass = 840 J kg⁻¹K⁻¹

specific heat capacity of cola = 4190 J kg⁻¹K⁻¹

- (i) Show that the final temperature, T_f , of the cola drink is about 8 °C when it reaches thermal equilibrium with the beaker.
Assume no heat is gained from or lost to the surroundings.

(2)

- (ii) The cola drink and beaker are cooled from T_f to a temperature of $3.0\text{ }^{\circ}\text{C}$ by adding ice at a temperature of $0\text{ }^{\circ}\text{C}$.
Calculate the mass of ice added.
Assume no heat is gained from or lost to the surroundings.

specific heat capacity of water = $4190\text{ J kg}^{-1}\text{ K}^{-1}$

specific latent heat of fusion of ice = $3.34 \times 10^5\text{ J kg}^{-1}$

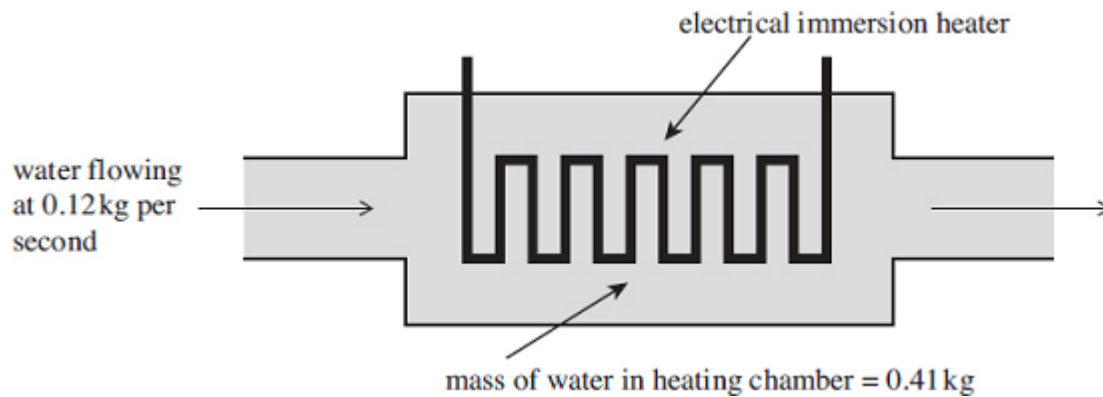
mass _____ kg

(3)

(Total 5 marks)

6

An electrical immersion heater supplies 8.5 kJ of energy every second. Water flows through the heater at a rate of 0.12 kg s^{-1} as shown in the figure below.



- (a) Assuming all the energy is transferred to the water, calculate the rise in temperature of the water as it flows through the heater.

specific heat capacity of water = $4200\text{ J kg}^{-1}\text{ K}^{-1}$

answer = _____ K

(2)

- (b) The water suddenly stops flowing at the instant when its average temperature is 26°C . The mass of water trapped in the heater is 0.41 kg . Calculate the time taken for the water to reach 100°C if the immersion heater continues supplying energy at the same rate.

answer = _____ s

(2)

(Total 4 marks)

7

Molten lead at its melting temperature of 327°C is poured into an iron mould where it solidifies. The temperature of the iron mould rises from 27°C to 84°C , at which the mould is in thermal equilibrium with the now solid lead.

mass of lead = 1.20 kg

specific latent heat of fusion of lead = $2.5 \times 10^4\text{ J kg}^{-1}$

mass of iron mould = 3.00 kg

specific heat capacity of iron = $440\text{ J kg}^{-1}\text{K}^{-1}$

- (a) Calculate the heat energy absorbed by the iron mould.

answer = _____ J

(2)

- (b) Calculate the heat energy given out by the lead while it is changing state.

answer = _____ J

(1)

- (c) Calculate the specific heat capacity of lead.

answer = _____ J kg⁻¹ K⁻¹

(3)

- (d) State **one** reason why the answer to part (c) is only an approximation.

(1)

(Total 7 marks)

8

An electrical heater is placed in an insulated container holding 100 g of ice at a temperature of $-14\text{ }^{\circ}\text{C}$. The heater supplies energy at a rate of 98 joules per second.

- (a) After an interval of 30 s, all the ice has reached a temperature of $0\text{ }^{\circ}\text{C}$. Calculate the specific heat capacity of ice.

answer = _____ J kg⁻¹ K⁻¹

(2)

- (b) Show that the final temperature of the water formed when the heater is left on for a further 500 s is about $40\text{ }^{\circ}\text{C}$.

specific heat capacity of water = $4200\text{ J kg}^{-1}\text{K}^{-1}$

specific latent heat of fusion of water = $3.3 \times 10^5\text{ J kg}^{-1}$

(3)

- (c) The whole procedure is repeated in an uninsulated container in a room at a temperature of 25 °C.

State and explain whether the final temperature of the water formed would be higher or lower than that calculated in part (b).

(2)

(Total 7 marks)

9

- (a) Calculate the energy released when 1.5 kg of water at 18 °C cools to 0 °C and then freezes to form ice, also at 0 °C.

specific heat capacity of water = 4200 J kg⁻¹ K⁻¹

specific latent heat of fusion of ice = 3.4×10^5 J kg⁻¹

(4)

- (b) Explain why it is more effective to cool cans of drinks by placing them in a bucket full of melting ice rather than in a bucket of water at an initial temperature of 0 °C.

(2)

(Total 6 marks)

10

In an experiment to measure the temperature of the flame of a Bunsen burner, a lump of copper of mass 0.12 kg is heated in the flame for several minutes. The copper is then transferred quickly to a beaker, of negligible heat capacity, containing 0.45 kg of water, and the temperature rise of the water measured.

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

specific heat capacity of copper = $390 \text{ J kg}^{-1} \text{ K}^{-1}$

- (a) If the temperature of the water rises from 15°C to 35°C , calculate the thermal energy gained by the water.

(2)

- (b) (i) State the thermal energy lost by the copper, assuming no heat is lost during its transfer.

- (ii) Calculate the fall in temperature of the copper.

- (iii) Hence calculate the temperature reached by the copper while in the flame.

(4)**(Total 6 marks)****11**

- (a) A 3.0 kW electric kettle heats 2.4 kg of water from 16°C to 100°C in 320 seconds.

- (i) Calculate the electrical energy supplied to the kettle.

- (ii) Calculate the heat energy supplied to the water.

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

- (iii) Give **one** reason why not all the electrical energy supplied to the kettle is transferred to the water.

(4)

- (b) The potential difference supplied to the kettle in part (a) is 230 V.

- (i) Calculate the resistance of the heating element of the kettle.

- (ii) The heating element consists of an insulated conductor of length 0.25 m and diameter 0.65 mm. Calculate the resistivity of the conductor.

(5)

(Total 9 marks)

12

A bicycle and its rider have a total mass of 95 kg. The bicycle is travelling along a horizontal road at a constant speed of 8.0 m s^{-1} .

- (a) Calculate the kinetic energy of the bicycle and rider.

(2)

- (b) The brakes are applied until the bicycle and rider come to rest. During braking, 60% of the kinetic energy of the bicycle and rider is converted to thermal energy in the brake blocks. The brake blocks have a total mass of 0.12 kg and the material from which they are made has a specific heat capacity of $1200 \text{ J kg}^{-1} \text{ K}^{-1}$.

- (i) Calculate the maximum rise in temperature of the brake blocks.

- (ii) State an assumption you have made in part (b)(i).

(4)

(Total 6 marks)

13

An electric shower heats the water flowing through it from 10°C to 42°C when the volume flow rate is $5.2 \times 10^{-5} \text{ m}^3 \text{ s}^{-1}$.

- (a) (i) Calculate the mass of water flowing through the shower each second.

density of water = 1000 kg m^{-3}

- (ii) Calculate the power supplied to the shower, assuming all the electrical energy supplied to it is gained by the water as thermal energy.

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$.

(4)

- (b) A jet of water emerges horizontally at a speed of 2.5 m s^{-1} from a hole in the shower head. The hole is 2.0 m above the floor of the shower. Calculate the horizontal distance travelled by this jet. Assume air resistance is negligible.

(3)

(Total 7 marks)

14

- (a) A 2.0 kW heater is used to heat a room from 5°C to 20°C . The mass of air in the room is 30 kg. Under these conditions the specific heat capacity of air = $1000 \text{ J kg}^{-1} \text{ K}^{-1}$.

Calculate

- (i) the gain in thermal energy of the air,

- (ii) the minimum time required to heat the room.

(4)

- (b) State and explain **one** reason why the actual time taken to heat the room is longer than the value calculated in part (a)(ii).

(2)

(Total 6 marks)

15

A tray containing 0.20 kg of water at 20 °C is placed in a freezer.

- (a) The temperature of the water drops to 0 °C in 10 minutes.

specific heat capacity of water = 4200 J kg⁻¹ K⁻¹

Calculate

- (i) the energy lost by the water as it cools to 0 °C,

- (ii) the average rate at which the water is losing energy, in J s⁻¹.

(3)

- (b) (i) Estimate the time taken for the water at 0 °C to turn completely into ice.

specific latent heat of fusion of water = 3.3×10^5 J kg⁻¹

- (ii) State any assumptions you make.

(3)

(Total 6 marks)

16

- (a) An electric shower heats water from 15°C to 47°C when water flows through it at a rate of 0.045 kg s^{-1} .

- (i) Calculate the energy supplied to the water each second by the heating element in the shower.

specific heat capacity of water = $4200\text{ J kg}^{-1}\text{ K}^{-1}$

- (ii) Show that the power of the heating element is 6.0 kW . Assume there is no heat loss to the surroundings.

(3)

- (b) (i) The heating element in part (a) is connected to an alternating supply at 230 V rms . Calculate the rms current passing through the heating element in normal operation.

- (ii) The live wire and the neutral wire in the connecting cable are insulated copper wires of diameter 2.4 mm . Calculate the resistance per metre length of copper wire of this diameter.

resistivity of copper = $1.7 \times 10^{-8}\text{ }\Omega\text{m}$

- (iii) Show that in normal operation, the potential drop per metre along the cable is 0.20 V m^{-1} .

- (iv) Electrical safety regulations require the potential drop along the cable to be less than 6.0 V .

Calculate the maximum safe distance along the cable from the distribution board to the heating element.

(9)

(Total 12 marks)

17

The following data refer to a dishwasher.

power of heating element	2.5 kW
time to heat water	360 s
mass of water used	3.0 kg
initial temperature of water	20°C
final temperature of water	60°C

- (a) Taking the specific heat capacity of water to be $4200 \text{ J kg}^{-1} \text{ K}^{-1}$, calculate

- (i) the energy provided by the heating element,

- (ii) the energy required to heat the water.

(4)

(b) Give **two** reasons why your answers in part (a) differ from each other.

(2)

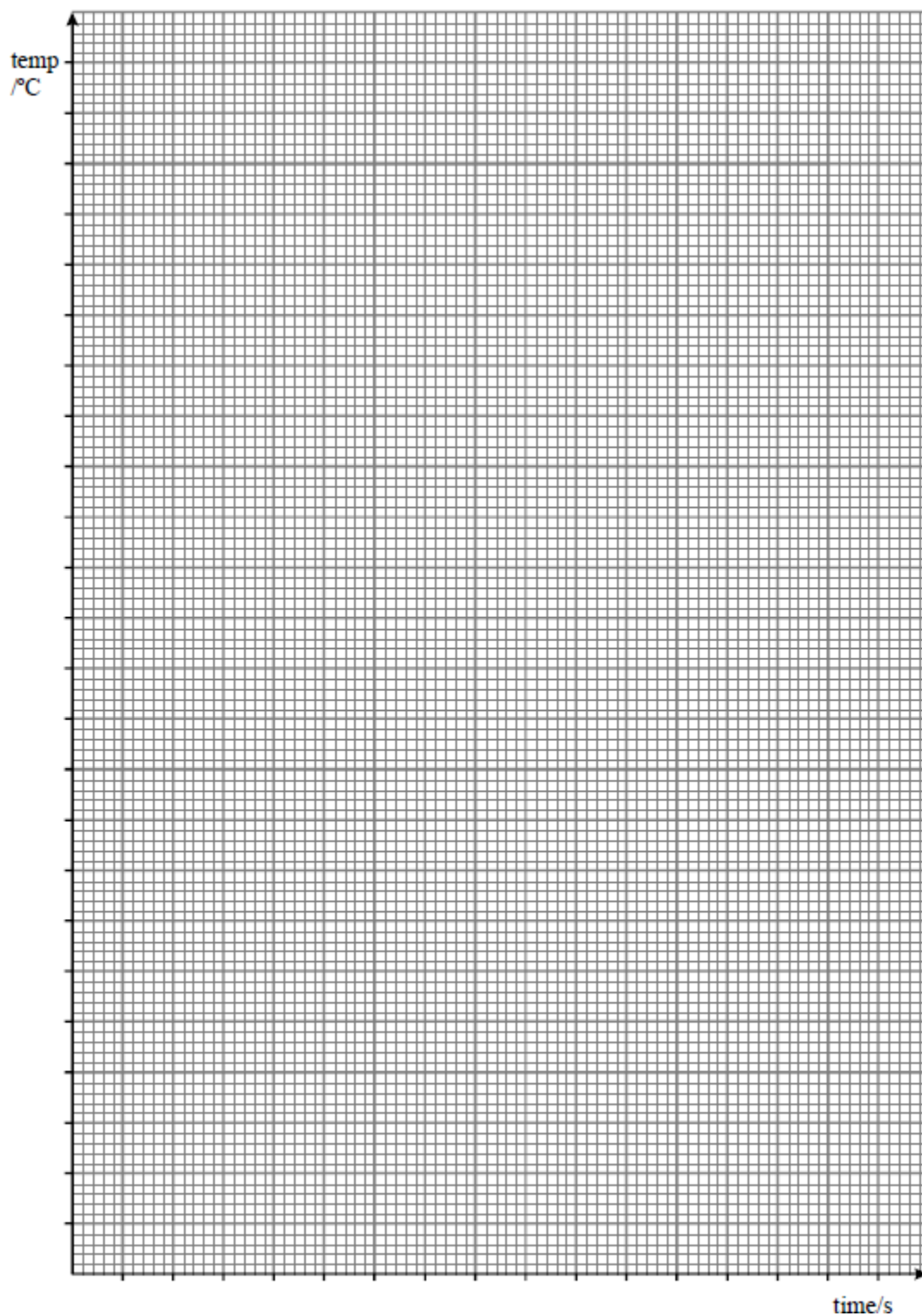
(Total 6 marks)

18

An electrical heater is used to heat a 1.0 kg block of metal, which is well lagged. The table shows how the temperature of the block increased with time.

temp / °C	20.1	23.0	26.9	30.0	33.1	36.9
time / s	0	60	120	180	240	300

- (a) Plot a graph of temperature against time on the grid provided.



(3)

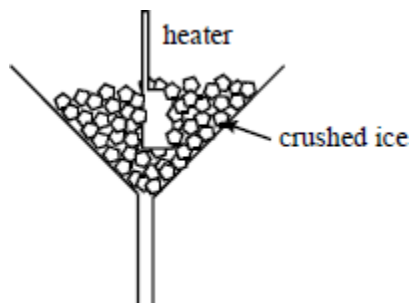
- (b) Determine the gradient of the graph.

(2)

- (c) The heater provides thermal energy at the rate of 48 W. Use your value for the gradient of the graph to determine a value for the specific heat capacity of the metal in the block.

(2)

- (d) The heater in part (c) is placed in some crushed ice that has been placed in a funnel as shown.



The heater is switched on for 200 s and 32 g of ice are found to have melted during this time. Use this information to calculate a value for the specific latent heat of fusion for water, stating **one** assumption made.

(3)

(Total 10 marks)

19

Use the following data to answer the question below.

specific latent heat of fusion of lead = 23 kJ kg⁻¹

molar mass of lead = 0.21 kg mol⁻¹

- (a) Estimate the mass of a lead atom.

- (b) Estimate the energy supplied to an atom of lead when solid lead melts.

- (c) Calculate the speed of a lead atom with the same kinetic energy as the energy supplied in part (b).

(Total 5 marks)

20

- (a) A student immerses a 2.0 kW electric heater in an insulated beaker of water. The heater is switched on and after 120 s the water reaches boiling point.

The table below gives data collected during the experiment.

initial mass of beaker	25 g
initial mass of beaker and water	750 g
initial temperature of water	20 °C
final temperature of water	100 °C

Calculate the specific heat capacity of water if the thermal capacity of the beaker is negligible.

(4)

- (b) The student in part (a) continues to heat the water so that it boils for 105 s. When the mass of the beaker and water is measured again, it is found that it has decreased by 94 g.

- (i) Calculate a value for the specific latent heat of vaporisation of water.

- (ii) State **two** assumptions made in your calculation.

(4)

(Total 8 marks)

21

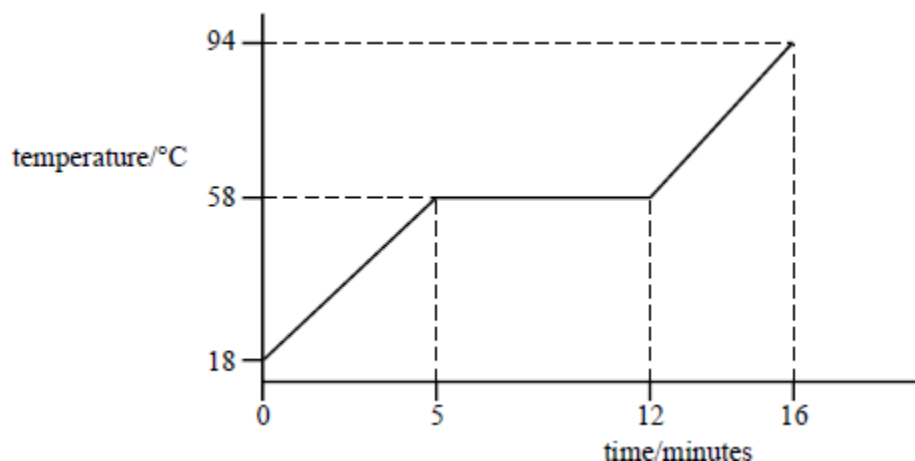
- (a) Explain what is meant by

- (i) the specific heat capacity of water,

- (ii) the specific latent heat of fusion of ice.

(4)

- (b) A sample of solid material, which has a mass of 0.15 kg, is supplied with energy at a constant rate. The specific heat capacity of the material is $1200 \text{ J kg}^{-1} \text{ K}^{-1}$ when in the solid state. During heating, its temperature is recorded at various times and the following graph is plotted.



Assume there is no heat exchange with the surroundings.

- (i) Show that energy is supplied to the material at a rate of 24 W.

- (ii) Calculate the specific latent heat of fusion of the material.

- (iii) Calculate the specific heat capacity of the material when in the liquid state.

(6)

(Total 10 marks)

22

- (a) (i) Explain what is meant by the *specific latent heat of vaporisation* of a liquid.

- (ii) Suggest why the specific latent heat of vaporisation of water is much greater than the specific latent heat of fusion of water.

(3)

- (b) A cup contains 0.25 kg of water at a temperature of 15 °C. The water is heated by passing steam at 100 °C into it.

specific heat capacity of water $= 4200 \text{ J kg}^{-1} \text{ K}^{-1}$

specific latent heat of vaporisation of water $= 2.3 \times 10^6 \text{ J kg}^{-1}$

boiling point of water $= 100 \text{ °C}$

- (i) Use the above data to calculate the minimum mass of water that is in the cup when the temperature of the water reaches its boiling point.

- (ii) Explain why there is likely to be a greater mass of water in the cup than you have calculated in part (b)(i).

(4)

(Total 7 marks)

23

A raindrop of mass m falls to the ground at its terminal speed v . The specific heat capacity of water is c and the acceleration of free fall is g . Given that 25% of the energy is retained in the raindrop when it strikes the ground, what is the rise in temperature of the raindrop?

A $\frac{mv^2}{8c}$

B $\frac{v^2}{4mc}$

C $\frac{mg}{4c}$

D $\frac{v^2}{8c}$

(Total 1 mark)

Mark schemes

1	B																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						</
---	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	----

- (b) (i) thermal energy given by copper block ($= mc\Delta T$)
 $= 0.047 \times 390 \times (990 - 100)$
 $= 1.6 \times 10^4 \text{ (J) } \checkmark$
 2 sig figs $\checkmark$

can gain full marks without showing working
a negative answer is not given credit
sig fig mark stands alone

2

- (ii) thermal energy gained by water and copper container
 $(= mc\Delta T_{\text{water}} + mc\Delta T_{\text{copper}})$
 $= 0.050 \times 4200 \times (100 - 84) + 0.020 \times 390 \times (100 - 84)$
 or
 $= 3500 \text{ (J) } \checkmark \text{ (3485 J)}$
 available heat energy ($= 1.6 \times 10^4 - 3500$) $= 1.3 \times 10^4 \text{ (J) } \checkmark$

allow both 12000 J and 13000 J

allow CE from (i)
working must be shown for a CE
take care in awarding full marks for the final answer – missing out
the copper container may result in the correct answer but not be
worth any marks because of a physics error
(3485 is a mark in itself)
ignore sign of final answer in CE
(many CE's should result in a negative answer)

2

- (iii) (using $Q = ml$)
 $m = 1.3 \times 10^4 / 2.3 \times 10^6$
 $= 0.0057 \text{ (kg) } \checkmark$
 Allow 0.006 but not 0.0060 (kg)

allow CE from (ii)
answers between 0.0052 $\rightarrow$ 0.0057 kg resulting from use of 12000
and 13000 J

1

[7]

5

- (i) (heat supplied by glass = heat gained by cola)

(use of $m_g c_g \Delta T_g = m_c c_c \Delta T_c$)*1st mark for RHS or LHS of substituted equation*

$$0.250 \times 840 \times (30.0 - T_f) = 0.200 \times 4190 \times (T_f - 3.0) \quad \checkmark$$

2nd mark for 8.4°C

$$(210 \times 30 - 210 t_f = 838 T_f - 838 \times 3)$$

$$T_f = 8.4(1) \quad (^\circ\text{C}) \quad \checkmark$$

*Alternatives:**8°C is substituted into equation (on either side shown will get mark)**✓**resulting in 4620J~4190J ✓**or**8°C substituted into LHS ✓ (produces $\Delta T = 5.5^\circ\text{C}$ and hence)*

$$= 8.5^\circ\text{C} \sim 8^\circ\text{C} \quad \checkmark$$

*8°C substituted into RHS ✓**(produces $\Delta T = 20^\circ\text{C}$ and hence)*

$$= 10^\circ\text{C} \sim 8^\circ\text{C} \quad \checkmark$$

- (ii) (heat gained by ice = heat lost by glass + heat lost by cola)

NB correct answer does not necessarily get full marks

(heat gained by ice = $mc\Delta T + ml$)

heat gained by ice = $m \times 4190 \times 3.0 + m \times 3.34 \times 10^5$ ✓

(heat gained by ice = $m \times 346600$)

3rd mark is only given if the previous 2 marks are awarded

heat lost by glass + heat lost by cola

= $0.250 \times 840 \times (8.41 - 3.0) + 0.200 \times 4190 \times (8.41 - 3.0)$ ✓

(= 5670 J)

(especially look for $m \times 4190 \times 3.0$)

the first two marks are given for the formation of the substituted equation not the calculated values

$m (=5670 / 346600) = 0.016$ (kg) ✓

if 8°C is used the final answer is 0.015 kg

or (using cola returning to its original temperature)

(heat supplied by glass = heat gained by ice)

(heat gained by glass = $0.250 \times 840 \times (30.0 - 3.0)$)

heat gained by glass = 5670 (J) ✓

(heat used by ice = $mc\Delta T + ml$)

heat used by ice = $m(4190 \times 3.0 + 3.34 \times 10^5)$ ✓ (= $m(346600)$)

$m (=5670 / 346600) = 0.016$ (kg) ✓

3

[5]

6

(a) $\Delta T = \left(\frac{\Delta Q}{mc} \right) = \frac{8.5 \times 10^3}{4200 \times 0.12}$ ✓
17 K ✓

2

(b) $\left(\frac{\Delta T}{\Delta t} = \frac{\frac{\Delta Q}{\Delta t}}{mc} \right) = \frac{100 - 26}{\Delta t} = \frac{8.5 \times 10^3}{0.41 \times 4200}$ ✓

$t = 15$ s ✓

2

[4]

7

(a) using $Q = mc\Delta\theta$

= $3.00 \times 440 \times (84-27)$ (1)

7.5×10^4 (J) (1)

2

(b) using $Q = ml$
 $= 1.20 \times 2.5 \times 10^4$
 $= 3.0 \times 10^4 \text{ (J) (1)}$

1

(c) (heat supplied by lead changing state + heat supplied by cooling lead = heat gained by iron)

$$3.0 \times 10^4 + \text{heat supplied by cooling lead} = 7.5 \times 10^4 \text{ (1)}$$

$$\text{heat supplied by cooling lead} = 4.5 \times 10^4 = mc\Delta\theta$$

$$c = 4.5 \times 10^4 / (1.2 \times (327 - 84)) \text{ (1)}$$

$$c = 154 \text{ (J kg}^{-1} \text{ K}^{-1}) \text{ (1)}$$

3

(d) any **one** idea (1)

no allowance has been made for heat loss to the surroundings

or the specific heats may not be a constant over the range of temperatures calculated

1

[7]

8

(a) (use of $\Delta Q = m c \Delta T$)

$$30 \times 98 = 0.100 \times c \times 14 \checkmark$$

$$c = 2100 \text{ (J kg}^{-1} \text{ K}^{-1}) \checkmark$$

2

(b) (use of $\Delta Q = m l + m c \Delta T$)

$$500 \times 98 = 0.100 \times 3.3 \times 10^5 \checkmark + 0.100 \times 4200 \times \Delta T \checkmark$$

$$(\Delta T = 38 \text{ }^\circ\text{C})$$

$$T = 38^\circ\text{C} \checkmark$$

3

(c) the temperature would be higher $\checkmark$

as the ice/water spends more time below 25°C

or heat travels in the direction from hot to cold

or ice/water first gains heat then loses heat

any **one** line $\checkmark$

2

[7]

9

- (a) (use of $\Delta Q = mcT$ gives)
 $\Delta Q_1 = 1.5 \times 4200 \times 18$ **(1)**
 $= 1.134 \times 10^5 \text{ (J)}$ **(1)**
 $\Delta Q_2 = 1.5 \times 3.4 \times 10^5 = 5.1 \times 10^5 \text{ (J)}$ **(1)**
 total energy released ($= 1.134 \times 10^5 + 5.1 \times 10^5$)
 $= 6.2 \times 10^5 \text{ J}$ **(1)**
 $(6.23 \times 10^5 \text{ J})$

4

- (b) (ice) requires energy to melt [or mention of latent heat] **(1)**
 stays at 0°C (for longer) (or cools for longer) **(1)**
 (or extracts more energy from the drink)

2

[6]**10**

- (a) (use of $\Delta Q = mc\Delta T$ gives) $\Delta Q = 0.45 \times 4200 \times (35 - 15)$ **(1)**
 $= 3.8 \times 10^4 \text{ J}$ $(3.78 \times 10^4 \text{ J})$ **(1)**

2

- (b) (i) $3.8 \times 10^4 \text{ J}$ **(1)**
 (allow C.E. for incorrect value of ΔQ from (a))
 (ii) ($mc\Delta T = \Delta Q$ gives) $0.12 \times 390 \times \Delta T = 3.8 \times 10^4$ **(1)**
 $\Delta T = 812 \text{ K}$ **(1)**
 (use of $\Delta Q = 3.78$ gives $\Delta T = 808 \text{ K}$
 (allow C.E. for incorrect value of ΔQ from (i))
 (iii) $(812 + 35) = 847^\circ \text{C}$ **(1)**
 (use of 808 gives 843°C)
 (allow C.E. from (ii))

4

[6]**11**

- (a) (i) (use of $E = Pt$ gives) $E = 3000 \times 320 = 960 \text{ kJ}$ **(1)**
 (ii) (use of $Q = mc\Delta\theta$ gives) $Q = 2.4 \times 4200 (100 - 16)$ **(1)**
 $= 850 \text{ kJ}$ **(1)**
 (iii) energy needed to heat the kettle material **(1)**
 [or heat loss to surroundings]

4

(b) (i) (use of $I = \frac{P}{V}$ gives) $I = \frac{3000}{230} = 13 \text{ (A) (1)}$

(use of $V = IR$ gives) $R \left(= \frac{230}{13} \right) = 18 \Omega \text{ (1) } (17.7 \Omega)$

(allow C.E. for value of I)

[or correct use of $R = \frac{V^2}{P}$ to give correct R]

(ii) $A = \pi \frac{(0.65 \times 10^{-3})^2}{4} \text{ (m}^2\text{) (1) } (= 3.32 \times 10^{-7} \text{ (m}^2\text{)})$

(use of $\rho = \frac{AR}{l}$ gives) $\rho = \frac{3.32 \times 10^{-7} \times 17.7}{0.25} \text{ (1)}$

$= 2.3 \times 10^{-5} \Omega \text{ m (1) } (2.35 \times 10^{-5} \Omega \text{ m})$

(use of $R = 18 \Omega$ gives $\rho = 2.4 \times 10^{-5} \Omega \text{ m}$)

(allow C.E. for value of R from (i) and value of A)

5

[9]

12 (a) (use of $E_k = \frac{1}{2}mv^2$ gives) $E_k = \frac{1}{2} \times 95 \times 8.0^2 \text{ (1)}$

$= 3040 \text{ J (1)}$

2

(b) (i) $\Delta Q = 0.60 \times 3040 = 1824 \text{ (J) (1)}$

(allow C.E. for E_k from (a))

(use of $\Delta Q = mc \Delta \theta$ gives) $1824 = 0.12 \times 1200 \Delta \theta \text{ (1)}$

$\Delta \theta = 13 \text{ K (1) } (12.7 \text{ K})$

(allow C.E. for ΔQ)

(ii) no heat is lost to the surroundings (1)

4

[6]

13 (a) (i) mass each sec $[=(\text{vol} / \text{sec}) \times \text{density}] = 5.2 \times 10^{-5} \times 1000 \text{ (1)}$
 $= 0.052 \text{ kg (s}^{-1}\text{) (1)}$

(ii) power (= energy supplied per sec = $mc\Delta\theta$) $= 0.052 \times 4200 \times (42 - 10) \text{ (1)}$
 $= 7.0 \times 10^3 \text{ W (1) } (6.99 \times 10^3 \text{ W})$

(allow C.E. for value of mass each sec from (i))

4

- (b) $h = \frac{1}{2}gt^2$ gives the time to reach the floor **(1)**

$$t \left(= \left(\frac{2h}{g} \right)^{1/2} \right) = \left(\frac{2 \times 2.0}{9.8} \right)^{1/2} = 0.64 \text{ s } \mathbf{(1)} \quad (0.639 \text{ s})$$

range = (horizontal) speed of projection $\times$ time = $2.5 \times 0.64 = 1.6 \text{ m } \mathbf{(1)}$
(allow C.E. for value of t)

3

[7]

14

- (a) (i) (use of $\Delta Q = mc\Delta\theta$ gives) $Q = 30 \times 1000 \times 15 \mathbf{(1)}$
 $= 4.5 \times 10^5 \text{ J } \mathbf{(1)}$

- (ii) $P \times t = 4.5 \times 10^5 \mathbf{(1)}$

$$t = \frac{4.5 \times 10^5}{2000} = 225 \text{ s } \mathbf{(1)}$$

(allow C.E. for value of Q from (i))

4

- (b) heat is lost to surroundings or other objects in room or to heater itself **(1)**
more (thermal) energy required from heater **(1)**

[or because convection currents cause uneven heating]
[or rate of heat transfer decreases as temperature increases]

2

[6]

15

- (a) (i) (use of $\Delta Q = mc\Delta\theta$ gives) energy lost by water
 $= 0.20 \times 4200 \times 20 \mathbf{(1)}$
 $= 1.7 \times 10^4 \text{ J } \mathbf{(1)}$ ($1.68 \times 10^4 \text{ J}$)

- (ii) rate of loss of energy = $\frac{1.68 \times 10^4}{10 \times 60} = 28 \text{ (W) } \mathbf{(1)}$

(allow C.E. for value of energy lost in (i))

3

- (b) (i) (use of $\Delta Q = ml$ gives) $(28 \times t) = 0.20 \times 3.3 \times 10^5 \mathbf{(1)}$
 $t = 2.4 \times 10^3 \text{ s } \mathbf{(1)}$ ($2.36 \times 10^3 \text{ s}$)
(allow C.E. for value of rate of loss of energy in (a)(ii))
- (ii) e.g. constant rate of heat loss **(1)**
ice remains at $0^\circ\text{C} \mathbf{(1)}$

max 3

[6]

16

(a) (i) (in 1 s), $E = 0.045 \times 4200 \times (47 - 15)$ **(1)**
 $= 6050 \text{ J}$

(ii) $P\left(= \frac{E}{t}\right) = 6.0 \text{ kW}$ **(1)**

3

(b) (i) (use of $P = VI$ gives) $I = \left(= \frac{6050}{230}\right) = 26 \text{ A}$ **(1)** (26.3 A)
 (allow C.E. for value of P from (a))

(ii) radius $= 1.2 \times 10^{-3} \text{ (m)}$ **(1)**
 cross-sectional area $= \pi(1.2 \times 10^{-3})^2$ (or $4.5 \times 10^{-6} \text{ (m}^2\text{)})$ **(1)**

$$\frac{R}{l} = \frac{\rho}{A} \text{ (1)}$$

$$= \frac{1.7 \times 10^{-8}}{4.5 \times 10^{-6}} \text{ (1)}$$

$$= 3.8 \times 10^{-3} \Omega \text{ m}^{-1}$$

(allow C.E. for value of A)

(iii) $\frac{V}{l} \left(= \frac{IR}{l} = 26 \times 3.8 \times 10^{-3}\right) = 0.1 \text{ (V m}^{-1}\text{)}$ (per wire)

two wires per cable gives pd per metre $= 2 \times 0.1$ **(1)**
 $(= 0.20 \text{ V m}^{-1})$ **(1)**

(iv) maximum length $= \left(= \frac{6}{0.2}\right) = 30 \text{ m}$ **(1)**

9

[12]**17**

(a) (i) ($P = VI$ gives) $P = 2500 \times 360$ **(1)**
 $= 9.0 \times 10^5 \text{ kJ}$ **(1)**

(ii) ($Q = mc\Delta t$ gives) $Q = 3 \times 4200 \times 40$ **(1)**
 $= 5.0 \times 10^5 \text{ J}$ **(1)**

(4)

(b) heat is lost to the surroundings
 the dishwasher is heated any two **(1) (1)**
 evaporation of the water

(2)

[6]

18

- (a) adequate scale **(1)**
 points plotted correctly **(1)**
 best fit line (at least a point to right and left of line) **(1)**

3

- (b) use of triangle for at least half line **(1)**

$$\text{gradient} \left(= \frac{11.6}{208} \right) = 0.056 \pm 0.004 \text{ (}^\circ\text{C / s)} \text{ (1)}$$

2

- (c) $(P = \frac{Q}{t} = \frac{mc\Delta T}{t})$ gives $48 = c \times (1.0) \times 0.056$ **(1)**

$$c = 860 \pm 60 \text{ J kg}^{-1}\text{K}^{-1} \text{ (or J kg}^{-1} \text{ }^\circ\text{C}^{-1}) \text{ (1)}$$

2

- (d) (use of $E_{\text{th}} = ml$ gives) $48 \times 200 = 32 \times 10^{-3} \times l$ **(1)**

$$l = 3.0 \times 10^5 \text{ J kg}^{-1} \text{ (1)}$$

sensible assumption, e.g. no heat lost to surroundings or temperature does not change or heat is transferred to ice **(1)**

3

[10]**19**

- (a) mass of one atom = $\frac{0.21}{6.0 \times 10^{23}} = 3.5 \times 10^{-25} \text{ kg}$ **(1)**

- (b) energy supplied = $23 \times 10^3 \times 3.5 \times 10^{-25}$ **(1)**
 $= 8.1 \times 10^{-21} \text{ J}$ **(1)** ($8.05 \times 10^{-21} \text{ J}$
 (allow C.E. for value from (i))

- (c) (use of $\frac{1}{2}mv^2 = E_K$ gives) $\frac{1}{2} \times 3.5 \times 10^{-25} \times v^2 = 8.1 \times 10^{-21}$

$$v = \left(\frac{2.0 \times 8.1 \times 10^{-21}}{3.5 \times 10^{-25}} \right)^{1/2} = 220 \text{ m s}^{-1} \text{ (1)} \quad (215 \text{ m s}^{-1})$$

$$(E_K = 8.05 \times 10^{-21} \text{ gives } v = 214 \text{ m s}^{-1}) \text{ (allow C.E. for value of } E_K \text{ from (ii))}$$

[5]**20**

- (a) (use of $mc\Delta\theta = Pt$ gives)

$$0.725 \times c \times (100 - 20) \text{ (1)} = 2000 \times 120 \text{ (1)}$$

$$c = 41 \text{ 00 (1) J kg}^{-1} \text{ (1)} \text{ (4140 J kg}^{-1})$$

- (b) (i) (use of $mL = Pt$ gives) $94 \times 10^{-3} L = 2000 \times 105$ **(1)**
 $L = 2.2 \times 10^6 \text{ J kg}^{-1}$ **(1)**
- (ii) no evaporation (before water heated to boiling point)
 no heat lost (to the surroundings)
 heater 100% efficient any two **(1) (1)**

4

[8]

21

- (a) (i) quantity of energy supplied to unit mass **(1)**
 which raises temperature by 1°C [or 1K] **(1)**
- (ii) quantity of energy required to change state of unit mass **(1)**
 solid to liquid [or ice to water] **(1)**
 without change of temperature **(1)**

(max 4)

- (b) (i) $Q (= mc\Delta\theta) = 0.15 \times 1200 \times (58 - 18) = 7200 \text{ (J)}$ **(1)**

$$P = \frac{7200}{5 \times 60} = 24 \text{ W}$$
 (1)

- (ii) $Q = 24 \times 7 \times 60 = 10080 \text{ (J)}$ **(1)**
 $0.15l = 10080$ gives $l = 67200 \text{ J kg}^{-1}$ **(1)**

- (iii) $24 \times 4 \times 60 = 0.15 \times s_L \times (94 - 58)$ **(1)**
 gives $s_L = 1070 \text{ J kg}^{-1} \text{ K}^{-1}$ **(1)**

(6)

[10]

22

- (a) (i) energy/heat input needed to change liquid into gas/vapour
 when at its boiling point/without change of temperature
- energy per unit mass/1 kg
- (ii) idea that more energy has to be supplied to separate
 molecules than to break solid bond
or
 for vaporisation work is done against atmospheric pressure
or
 Idea that there is a greater change in PE in L-G than S-L

M1

A1

B1

- (b) (i) $ml = Mc\Delta\theta$ or energy gain by water = 89250 (J)
 $m \times 2.3 \times 10^6 = 0.25 \times 4200 \times 85$

C1

$$m = 0.0388 \text{ kg}$$

A1

$$\text{total mass} = 0.289 \text{ (0.29) kg (0.25 + their } m)$$

B1

- (ii) energy from steam is needed to raise temperature of the cup

or

energy/heat will be lost to the surroundings/cup/tube during the heating

B1

4

[7]

23

D

[1]