Answer 1

(18 marks)

(a) Define the term 'internal energy'. (2 marks)

Description	Marks
In a closed system (the tea in the cup) internal energy is the sum of the potential and kinetic energies of the particles.	1–2
Total	**2**

(b) Calculate the heat energy lost to the environment as 0.250 kg of tea in the cup cooled down from 90.0 °C to 65.0 °C. Assume that the specific heat capacity of tea is the same as that for water. (2 marks)

Description	Marks
$\Delta T = 90 - 65 = 25$ $Q = mc\Delta T$ $= 0.25 \times 4.18 \times 10^3 \times 25$ $Q = 2.61 \times 10^4$ J	1–2
Total	**2**

(c) Use the kinetic theory to explain why blowing on the surface of the tea helps the tea to cool down quickly. (5 marks)

Description	Marks
Blowing removes the hot saturated air from above the tea	1
This allows more water to evaporate into the air	1
The process of evaporation removes energy from the tea	1
Causing the average kinetic energy to decrease	1
and hence the temperature decreases	1
Total	**5**

On hot days, Pat makes ice tea by adding ice cubes at 0.00 °C to the pot of freshly brewed tea, cooling it from 90.0 ° to 0.00 °C.

(d) If the amount of liquid in the teapot was 0.250 kg, calculate the difference in internal energy between tea at 90.0 °C and iced tea at 0.00 °C. (2 marks)

Description	Marks
Difference in temperature is 90.0° $Q = mc\Delta T$ $= 0.250 \times 4.18 \times 10^3 \times 90.0$	1
$Q = 9.41 \times 10^4$ J	1
Total	**2**

(e) Calculate the mass of ice, in kilograms, that has to be added to the tea in the pot in Part (d) to bring the temperature of the liquid down to 0.00 °C. Assume no loss of heat to the surroundings, and show **all** workings. (4 marks)

Description	Marks
Energy lost from the tea = $0.25 \times 4.18 \times 10^3 \times 90$ (from part (d)) = 94050 J	1
Energy absorbed by ice, Q = 94050 J	1
$Q = mL$ $m = Q \div L$ $= 94050 \div 3.34 \times 10^5$	1
m = 0.282 kg	1
Total	**4**

Answer 1 cont

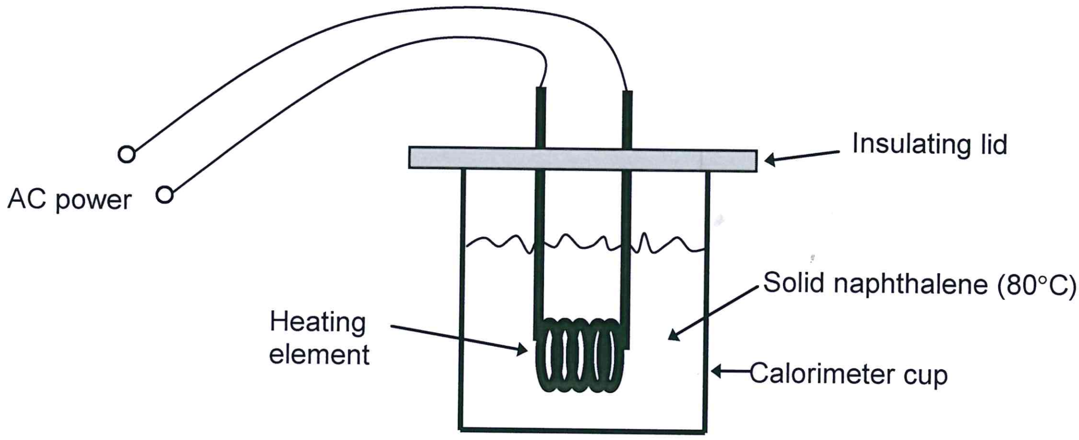
(f) In the real world, Pat would not need to add as much ice to the tea as calculated in Part (e) above. Using your understanding of heat transfer, explain why this is so. (3 marks)

Description	Marks
Energy would be lost to the environment Conduction to the cup/radiation/convection to the air	1–2
So not as much energy needs to be absorbed by the ice	1
Total	**3**

Answer 2

(17 marks)

Hayley investigated the accuracy of the stated power rating on a heating element that was marked '100 W'. She placed solid naphthalene at its melting point of 80.0°C in a calorimeter cup at 80.0°C together with the heating element, and timed how long it took to melt varying amounts of naphthalene.



She collected the following results:

Mass of naphthalene (kg)	Time to melt (s)
0.150	288
0.250	480
0.350	670
0.450	865
0.550	1055

L_f (Naphthalene) = 1.48×10^5 J kg^{-1}

She then used the following relationship to decide how to plot the data:

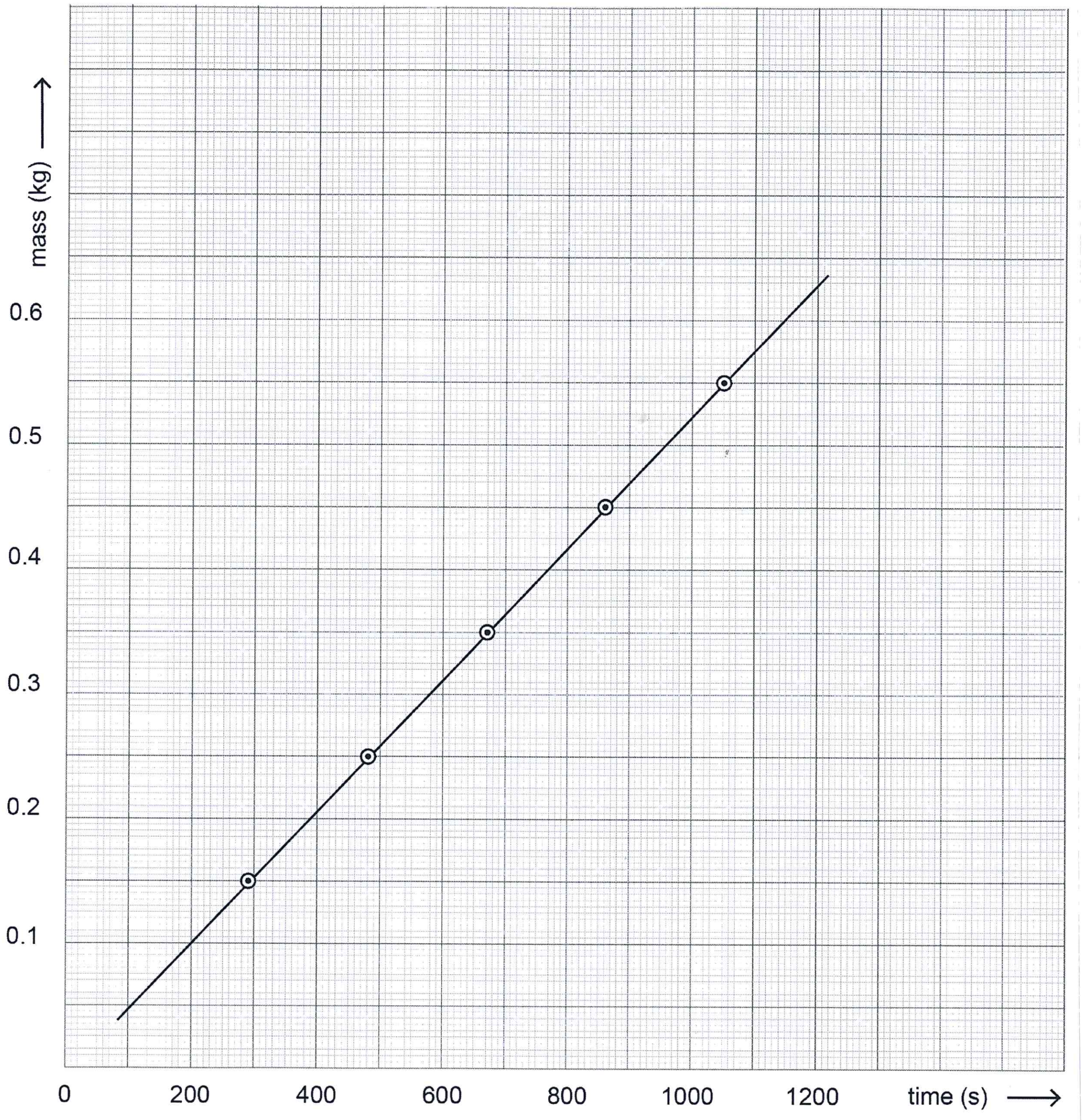
$$P = \frac{Q}{t} = \frac{mL_f}{t}$$

She used the gradient of the line from her plot to calculate the actual power output of the heating element.

Answer 2 cont

(a) Draw a clearly-labelled graph on the graph paper provided on page 19. Plot time on the x-axis and mass on the y-axis. (5 marks)

Description	Marks
Correct scale on axes, correct labels and orientation of axes follows instructions	1–3
Data plotted accurately	1
Line of best fit drawn accurately	1
	Total 5



Answer 2 cont

(b) From the graph, obtain the gradient of the line you have plotted. Show all workings and include the units in your answer. (5 marks)

Description	Marks
Gradient is derived from the graph. $\left(\frac{\text{rise}}{\text{run}}\right)$	1
Substitute values	2
gradient = 5.24×10^{-4} kg s^{-1}	1
Correct units	1
	Total 5

(c) Use the gradient of the graph and the equation to calculate the power output of the heating element. (3 marks)

Description	Marks
$P = \frac{mL}{t}$ = gradient × L	1
$= 5.24 \times 10^{-4} \times 1.48 \times 10^{5}$	1
= 77.6 W	1
	Total 3

(d) From the graph, determine the time taken to melt 0.300 kg of naphthalene. (2 marks)

Description	Marks
560 - 580s	2
Or 550 - 559 or 581 - 590	1
	Total 2

(e) Would you expect the calculated power rating to be higher or lower than the true power rating (not the rating printed on the heating element)? Explain your answer. (2 marks)

Description	Marks
As Q can only be lost from the system, input Q needs to be much larger than measured	1
Therefore power rating is really higher	1
	Total 2

Answer 3

(4 marks)

A plastic iceblock tray containing 250 mL of water, initially at 18°C, is placed in the freezer compartment of a refrigerator. How much heat must be lost from this water when it has all become ice at 0°C?

Description	Marks
$Q = mc\Delta T + mL_f$	1
$= 0.25 \times 4.18 \times 10^{3} \times 18 + 0.25 \times 3.34 \times 10^{5}$	2
$= 1.02\times10^{5}$ J	1
If $mc\Delta T$ or mL_f omitted max 2	**Total 4**

Answer 4

(16 marks)

A 0.680 kg solid sample of an unknown substance is heated slowly while inside an insulated container. The graph below illustrates the heating curve of this substance.

(a) State the temperature at which

(i) the substance boils. (1 mark)

Description	Marks
84 °C	1
Total	**1**

(ii) the substance melts. (1 mark)

Description	Marks
22 °C (accept from 21°C to 23 °C)	1
Total	**1**

(b) Explain why the temperature remains constant between Points A and B on the graph even though energy has been added. Your answer should demonstrate your understanding of phase change and temperature at a particle level. (6 marks)

Description	Marks
Between these points the substance is melting	1
The energy added is used move particles further apart	1
This is an increase in potential energy	1
Temperature is a measure of the average kinetic energy	1
As there is no change in kinetic energy	1
There is no change in temperature.	1
Total	**6**

(c) Calculate the latent heat of vaporisation of this substance, and give the correct units. (4 marks)

Description	Marks
$Q = 13 \times 10^4 - 8 \times 10^4 = 5 \times 10^4$ J	1
$L_v = Q/m = 5 \times 10^4 / 0.680$	1
$L_v = 7.35 \times 10^4$	1
J kg^{-1}	1
Total	**4**

(d) Calculate the specific heat capacity of this substance in the liquid phase. (4 marks)

Description	Marks
$\Delta T = 84 - 22 = 62$ °C	1
$Q = (8 - 4) \times 10^4 = 4 \times 10^4$ J	1
$c = Q / (m \times \Delta T) = 4 \times 10^4 / (0.68 \times 62)$	1
$c = 949$ J kg^{-1} K^{-1}	1
No penalty for using incorrect temperature values from (a) or incorrect or missing units	
Total	**4**

Answer 5

(4 marks)

One of the original theories of heat involved the concept of heat being contained in an object and, when the object was cut, the heat contained in the object being released. Drilling holes in cannons challenged this theory. As the drill bit becomes duller, the cannon and drill bit get hotter and it takes longer to drill a hole to the right depth.

(a) Explain why the cannon gets hotter when the drill becomes less sharp. (2 marks)

(b) Water is used when drilling holes through rock during mining operations to keep the drill bit from overheating. If 0.150 litres of the cooling water (initially at 100°C) was evaporated, how much energy was removed from the drill? (2 marks)

Description	Marks
(a) Less cutting means more friction or more repeated collisions	1
Kinetic theory, more movement from collisions then more heat	1
(b) $Q_{lost} = mL_v = 0.150 \times 2.26 \times 10^6$	1
$= 3.39 \times 10^5$ joules	1
	Total 4

Answer 6

(4 marks)

A 25.0 gram cube of ice, initially at 0.00°C, fell on a bench and melted.

(a) Calculate the energy required to change the ice cube from a solid to a liquid. (2 marks)

(b) Describe briefly what happened to the particles of the bench that were in contact with the ice cube as it melted. (2 marks)

Description	Marks
(a) $Q = mL_f = .025 \times 3.34 \times 10^5$	1
Q = 8350 J	1
(b) The kinetic energy decreases as the energy of the bench is transferred to the ice cube. (Mentioning 'energy transfer' is acceptable.)	1
so the particles slow down.	1
	Total 4