Thermal Energy Transfer and Temperature

Q1.

Aluminium is one of the most widely recycled metals. Aluminium cans are heated from room temperature until all the aluminium has melted. The molten aluminium is then used to make new cans. This process uses only 5% of the energy needed to extract aluminium from raw materials.

On a website it is claimed that recycling one aluminium can of mass 14 g saves enough energy to listen to music on a mobile phone continuously for 7 days.

Assess the validity of this claim.

melting point of aluminium = 660 K
specific heat capacity of aluminium = 902 J kg^{-1} K^{-1}
specific latent heat of aluminium = 396 kJ kg^{-1}
room temperature = 293 K
mobile phone p.d. = 3.7 V
mobile phone current = 120 mA

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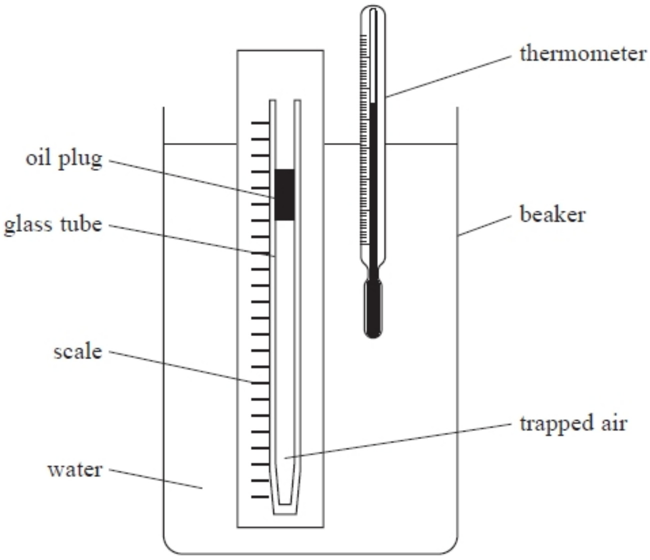
(Total for question = 6 marks)

Q2.

A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



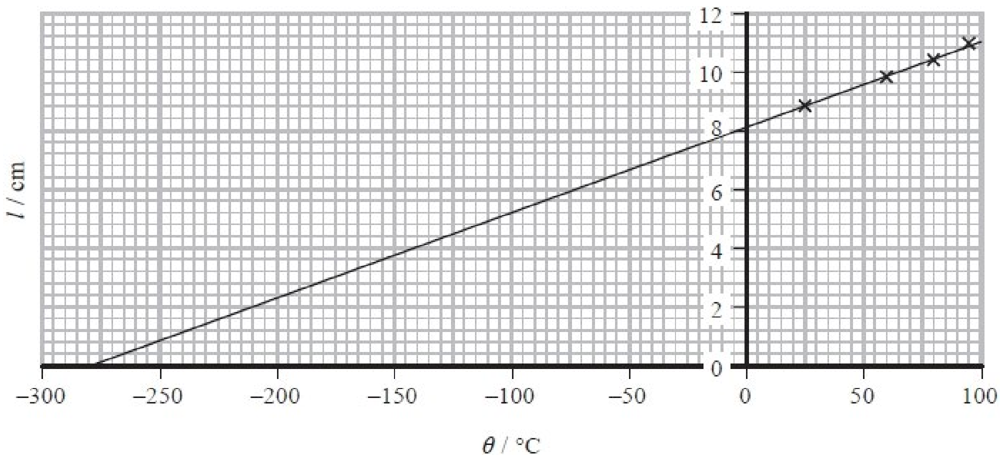
A glass tube was sealed at one end. A plug of oil trapped a length *l* of air in the tube. The water in the beaker was heated to a temperature *θ*. The corresponding value of *l* was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5 °C. The scale had mm divisions.

The student's results are shown in the table.

θ / °C	l / cm
24	8.8
60	9.8
78.5	10.3
95.5	10.9

The student plotted a graph of *l* against *θ* as shown.



(i) Explain the significance of the intercept on the *x*-axis.

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(ii) The student wrote a report of the investigation in her lab book. In the conclusion she wrote:

"In this investigation uncertainties were minimised by selecting measuring instruments with a high resolution. The points lie on a perfect straight line, indicating that the investigation is accurate."

Discuss the student's conclusion.

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(Total for question = 7 marks)

Q3.

Latte is a type of coffee made with hot frothy milk. The milk is heated by pumping steam into it.

Calculate the maximum mass of milk that could be warmed to a temperature of 65 °C by absorbing 15 g of steam at 100 °C.

initial temperature of milk = 4.0 °C
specific heat capacity of milk = 3900 J kg^{-1} K^{-1}
specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of vaporisation of water = 2.3×10^6 J kg^{-1}

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Maximum mass = ...

(Total for question = 4 marks)

Q4.

A data book contains the following information for ethanol.

latent heat of fusion = 109 kJ kg^{-1}

latent heat of vaporisation = 838 kJ kg^{-1}

545 J is transferred from a sample of ethanol when it condenses.

Which of the following shows how to calculate the mass of ethanol that condenses?

(1)

- ☐ **A** 545 ÷ 109 000
- ☐ **B** 545 ÷ 838 000
- ☐ **C** 109 000 ÷ 545
- ☐ **D** 838 000 ÷ 545

(Total for question = 1 mark)

Q5.

It was suggested on an online forum that it would be possible to cook a chicken by repeatedly slapping the chicken with one hand.

It was claimed that the energy transferred to a chicken in 8000 slaps would be sufficient to raise the temperature of the chicken from 23 °C to 165 °C.

In an investigation to test the claim, the effective mass of the hand was taken as 1.75 kg and the speed of the hand just before impact with the chicken as 6.25 m s^{-1}.

Deduce whether the data confirms that 8000 slaps would be sufficient.

Assume that no energy is transferred from the chicken to the surroundings.

mass of chicken = 0.875 kg

specific heat capacity of chicken = 1770 J kg^{-1} K^{-1}

efficiency of energy transfer from the hand = 65%

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(Total for question = 5 marks)

Q6.

An electric iron rated at 2600 W contains a steel plate which is heated to a working temperature of 215°C. Room temperature is 18°C.

Deduce whether the plate could reach its working temperature in less than 1 minute.

mass of steel plate = 890 g

specific heat capacity of steel = 450 J kg^{-1} K^{-1}

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(Total for question = 3 marks)

Q7.

A cup contains 180 g of black coffee at a temperature of 82 °C. 68 g of milk at a temperature of 2.7 °C is added to the coffee. An ideal temperature range for drinking coffee is said to be 50 °C to 60 °C.

Deduce whether the coffee will be within the ideal temperature range when the milk is added.

initial temperature of milk = 2.7 °C

specific heat capacity of black coffee = 4.2×10^3 J kg^{-1} K^{-1}

specific heat capacity of milk = 3.9×10^3 J kg^{-1} K^{-1}

(3)

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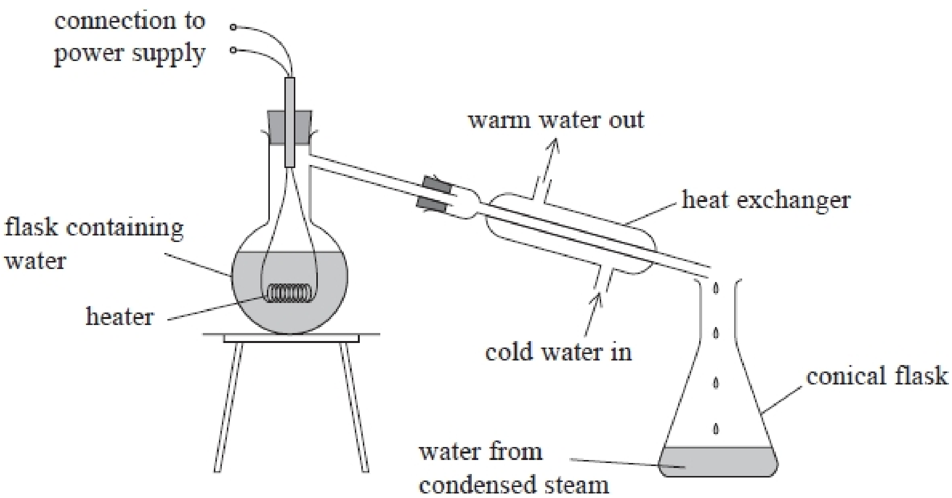
(Total for question = 3 marks)

Q8.

The apparatus shown can be used to determine a value for the specific latent heat of vaporisation of water.



(a) In one experiment the current in the heater was 8.20 A, and the potential difference across the heater was 230 V.

(i) Show that the power of the heater was about 2 kW.

(2)

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(ii) There was 0.655 kg of water in the flask at an initial temperature of 22.5 °C.
The heater was switched on, and the water in the flask was heated to boiling point.
Calculate the minimum time taken for the water to be heated to 100.0 °C.
specific heat capacity of water = 4190 J kg^{-1} K^{-1}

(3)

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Minimum time taken for water to be heated = ...

(b) The heater was left on and water continued to boil in the flask. The water was allowed to boil for a few minutes. The conical flask was then placed under the heat exchanger and water was collected in it.

(i) Give a reason why the water was left boiling for a few minutes before the conical flask was put in place.

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(ii) Water with a mass of 95.0 g was collected in a time of 125 s.
Calculate the rate of energy transfer in the heat exchanger.
specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

(3)

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Rate of energy transfer in the heat exchanger = ...

(iii) Discuss your answers to (a)(i) and (b)(ii).

(3)

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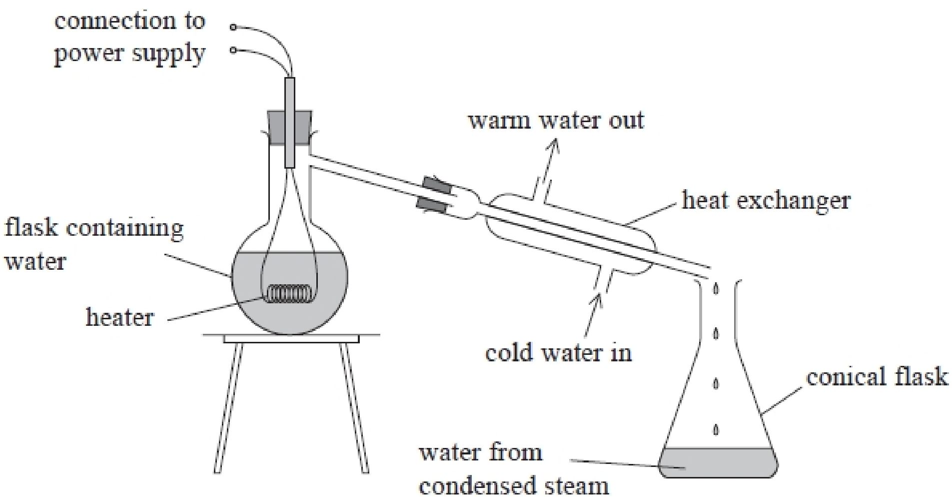
(Total for question = 12 marks)

Q9.

The apparatus shown can be used to determine a value for the specific latent heat of vaporisation of water.



State how the apparatus could be modified to minimise the effect of a significant source of error.

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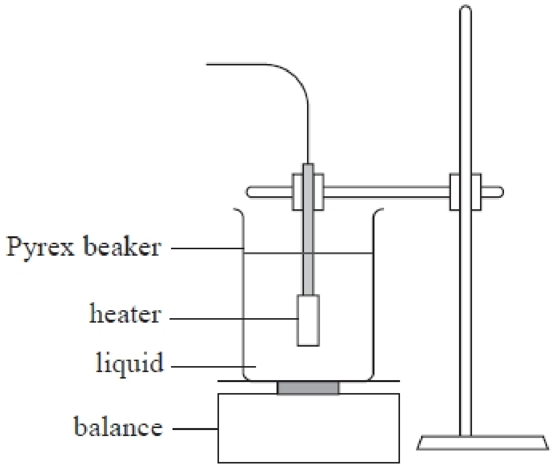
(Total for question = 1 mark)

Q10.

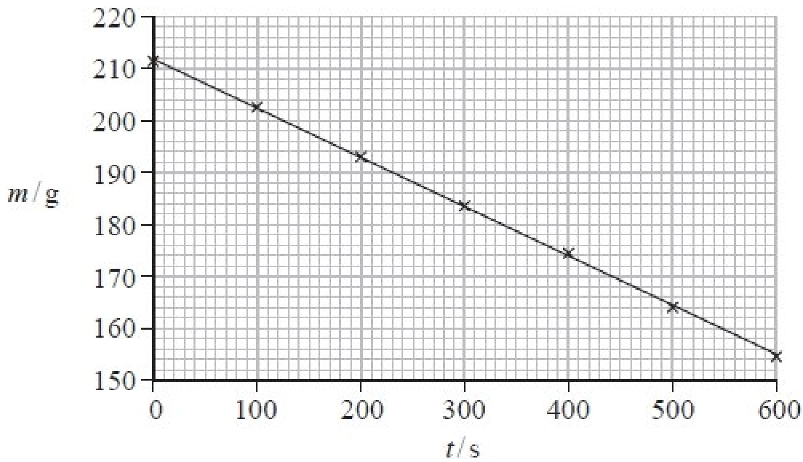
A student determined the latent heat of vaporisation of a liquid using an electrical heater to boil the liquid in a Pyrex beaker.

The apparatus used is shown below.



She connected the heater into a circuit and took measurements of the potential difference *V* and the current *I* for the heater.

The student monitored the mass of the beaker and the liquid *m* over the time *t* for which the liquid was boiling. Her results are plotted on the graph.



The student used her graph to determine a value for the latent heat of the liquid in the beaker. She concluded that the liquid was pure water.

Liquid	Latent heat of vaporisation / MJ kg^{-1}
Pure water	2.26
Weak salt water solution	2.10
Strong salt water solution	2.00

The student's conclusion was

V = 20.5 *V*

I = 10.5 A

Explain how this method might be modified to improve the accuracy of the student's conclusion.

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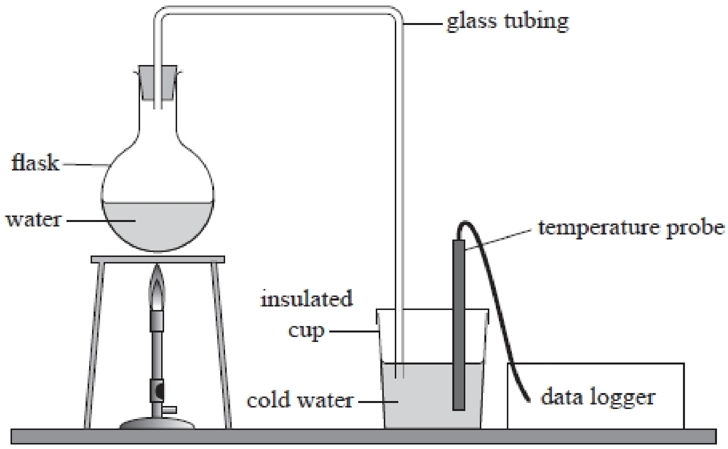
(Total for question = 2 marks)

Q11.

A student carried out an experiment to determine the specific latent heat of vaporisation of water using the apparatus shown.



The water in the flask was heated and steam was forced out of the flask and through the glass tubing into the cold water in the insulated cup. The steam condensed as it passed into the cold water.

(i) Explain why the water was heated to boiling point and left boiling for a few minutes before the insulated cup of cold water was put in place.

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(ii) Identify a significant source of error in this experiment and the steps that should be taken to minimise its effect on the calculated value of the specific latent heat of vaporisation of water.

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(Total for question = 4 marks)

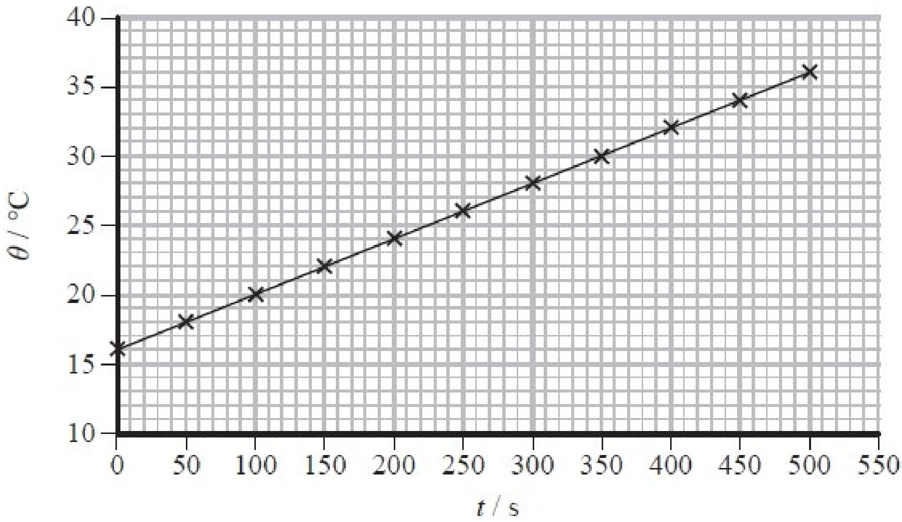
Q12.

A student determined the specific heat capacity of aluminium.

She used an electrical heater to heat an aluminium block and measured the temperature of the block with a digital thermometer.

The student monitored the temperature *θ* of the aluminium block over the time *t* for which the heater was switched on.

Her results are plotted on the graph.



(i) Determine the specific heat capacity of aluminium.

power of heater = 37.5 W
mass of aluminium block = 0.986 kg

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Specific heat capacity of aluminium = ...

(ii) The student looked up the accepted value for the specific heat capacity of aluminium. Using this value, the student predicted that it should have taken 240 s for the temperature of the aluminium block to increase by 10 °C.

Explain the difference between the predicted time and the student's actual observations.

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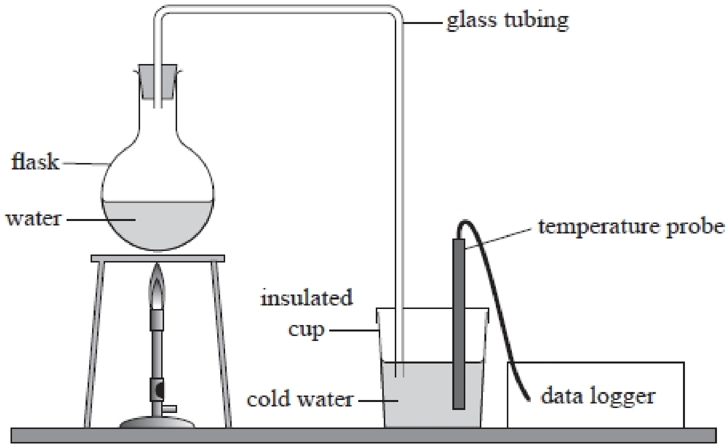
(Total for question = 5 marks)

Q13.

A student carried out an experiment to determine the specific latent heat of vaporisation of water using the apparatus shown.



The water in the flask was heated and steam was forced out of the flask and through the glass tubing into the cold water in the insulated cup. The steam condensed as it passed into the cold water.

The initial temperature of the cold water was 18.5°C and the mass of water in the cup was 255.0 g. After steam had been passed through the water for some time the temperature had risen to 26.0 °C and the mass of the water in the cup was 258.3 g.

the specific latent heat of vaporisation of water.

(3)

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

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Specific latent heat of vaporisation of water = ...

(Total for question = 3 marks)

Q14.

A wet handkerchief is dried in 56 s using a hot iron rated at 2400 W.

Determine whether energy is transferred to the water in the handkerchief at a greater rate than it is transferred to the iron.

initial temperature of wet handkerchief = 18 °C

initial mass of wet handkerchief = 35.9 g

final mass of dry handkerchief = 18.2 g

specific heat capacity of water = 4.19×10^3 J kg^{-1} K^{-1}

specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

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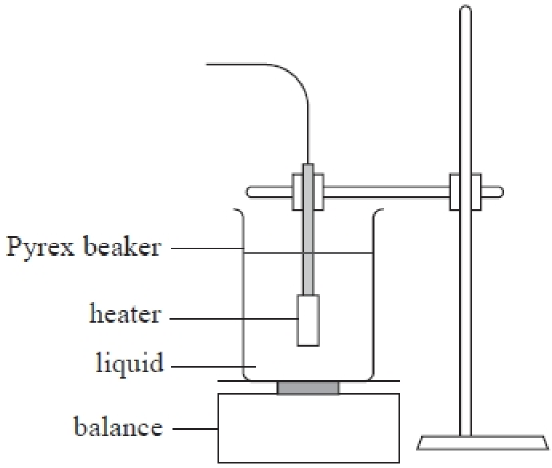
(Total for question = 5 marks)

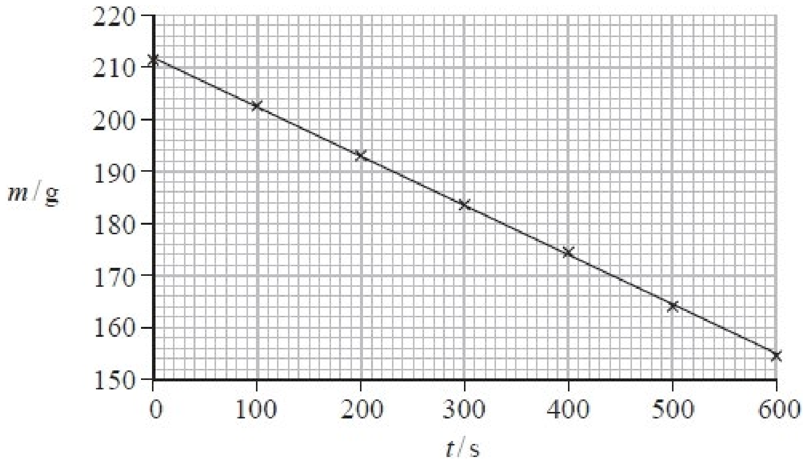
Q15.

A student determined the latent heat of vaporisation of a liquid using an electrical heater to boil the liquid in a Pyrex beaker.

The apparatus used is shown below.



The student monitored the mass of the beaker and the liquid *m* over the time *t* for which the liquid was boiling. Her results are plotted on the graph.



The student used her graph to determine a value for the latent heat of the liquid in the beaker. She concluded that the liquid was pure water.

Liquid	Latent heat of vaporisation / MJ kg^{-1}
Pure water	2.26
Weak salt water solution	2.10
Strong salt water solution	2.00

Comment on the validity of the student's conclusion.

V = 20.5 *V*

I = 10.5 A

(7)

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(Total for question = 7 marks)

Mark Scheme – Thermal Energy and Temperature

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $\Delta E = mc\Delta\theta$ (1) • Use of $\Delta E = L\Delta m$ (1) • Apply 5% to calculate energy saved (1) • Use of $P = VI$ or Use of $Q = It$ (1) • Use of $P = \frac{W}{t}$ or Use of $E = QV$ (1) • 2.69×10^5 J compared with 1.93×10^5 J (1) for energy saved, and concludes claim invalid. **Or** a phone could run for 5 days compared to 7 days and conclusion claim invalid **Or** a phone could run for 433 900 s compared to 604 800 s and conclusion claim invalid	<u>Example of calculation:</u> For aluminium when being heated up to m.pt.: $\Delta E = 14 \times 10^{-3}\text{ kg} \times 902\text{ J kg}^{-1}\text{K}^{-1} \times (660 - 293)\text{K}$ $\Delta E = 4.63 \times 10^3$ J For aluminium when melting: $\Delta E = 14 \times 10^{-3}\text{ kg} \times 396 \times 10^3\text{ J kg}^{-1} = 5.54 \times 10^3$ J Energy saved $= \frac{0.95}{0.05} \times (4630 + 5540)$J Energy saved $= 1.93 \times 10^5$ J $P = 3.7\text{ V} \times 120 \times 10^{-3}\text{ A} = 0.444$ W $\Delta E = 0.444\text{ W} \times 7 \times 24 \times (60 \times 60)\text{s} = 2.69 \times 10^5$ J	6

Q2.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • The intercept represents the temperature of the air at which the volume occupied would be zero • This is the absolute zero (of temperature) • Absolute zero is the lowest attainable temperature **Or** absolute zero is the temperature at which the atoms/molecules of the gas have zero kinetic energy	(1) (1) (1)	For MP3 accept atoms/molecules stop moving	3
(ii)	**MAX 4** **Resolution:** • It is correct that uncertainties would be reduced by using high resolution instruments • But the instruments are not high resolution • There could be a systematic error (in the measurements) **Graph:** • The points do not lie on a perfect straight line **Or** the true relationship may not linear • Temperature intercept may not be accurate **Or** there may be extrapolation errors • More points are needed **Or** a wider range is needed	(1) (1) (1) (1) (1) (1)		4

Q3.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use ofincrease in thermal energy of milk = latent heat energy released by steam + decrease in thermal energy of condensed steam • Use of $\Delta Q = mc\Delta\theta$ • Use of $\Delta Q = L\Delta m$ • m = 0.15 kg (150 g)	(1) (1) (1) (1)	Example of calculation $(mc\Delta\theta)_{milk} = (mc\Delta\theta)_{water} + L\Delta m_{steam}$ $m \times 3900\ \text{J kg}^{-1}\ \text{K}^{-1} \times (65.0\ °\text{C} - 4.00\ °\text{C})$ $= (0.015\ \text{kg} \times 4200\ \text{J kg}^{-1}\ \text{K}^{-1} \times (100\ °\text{C} - 65.0\ °\text{C})) + (2.3 \times 10^6\ \text{J kg}^{-1} \times 0.015\ \text{kg})$ $m = 0.15$ kg	4

Q4.

Question Number	Answer	Mark
	B – 545 ÷ 838 000	**1**
	Incorrect Answers: Correct method: mass = energy transfer ÷ latent heat of vaporisation A – uses energy transfer ÷ latent heat of fusion C – uses latent heat of fusion ÷ energy transfer D – uses latent heat of vaporisation ÷ energy transfer	

Q5.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $E_K = \frac{1}{2}mv^2$ **(1)** • Use of $\Delta E = mc\Delta\theta$ **(1)** • Use of 8000 **Or** use of (energy required) / (energy per slap) **(1)** • Use of 65% with input energy **(1)** • Energy from 8000 slaps would be 1.78×10^5 J which is less than the energy required to raise the temperature to 165 °C (2.20×10^5 J) **Or** final temperature would be 138 °C, so not enough **Or** 9900 slaps would be needed, so not enough **Or** temperature rise from 8000 slaps is 115 K which is less than required temperature rise of 142 K **(1)**	Example of calculation $E_K = \frac{1}{2} \times 1.75\ \text{kg} \times (6.25\ \text{m s}^{-1})^2 = 34.2\ \text{J}$ $\Delta E = 0.65 \times 8000 \times 34.2\ \text{J} = 1.78 \times 10^5\ \text{J}$ $\Delta E = 0.875\ \text{kg} \times 1770\ \text{J kg}^{-1}\text{K}^{-1} \times (165 - 23)\text{K}$ $\therefore \Delta E = 2.20 \times 10^5\ \text{J}$ $E_K = \frac{1}{2} \times 1.75\ \text{kg} \times (6.25\ \text{m s}^{-1})^2 = 34.2\ \text{J}$ $\Delta E = 0.65 \times 34.2\ \text{J} = 22.2\ \text{J}$ $\Delta E = 0.875\ \text{kg} \times 1770\ \text{J kg}^{-1}\text{K}^{-1} \times (165 - 23)\text{K}$ $\therefore \Delta E = 2.20 \times 10^5\ \text{J}$ Number of slaps $= \frac{2.20 \times 10^5\ \text{J}}{22.2\ \text{J}} = 9910$ $E_K = \frac{1}{2} \times 1.75\ \text{kg} \times (6.25\ \text{m s}^{-1})^2 = 34.2\ \text{J}$ $\Delta E = 0.65 \times 8000 \times 34.2\ \text{J} = 1.78 \times 10^5\ \text{J}$ $1.78 \times 10^5\text{J} = 0.875\ \text{kg} \times 1770\ \text{J kg}^{-1}\text{K}^{-1} \times (T_f - 296)\text{K}$ $\therefore T_f = \frac{1.78 \times 10^5\ \text{J}}{1.55 \times 10^3\ \text{J K}^{-1}} + 296\ \text{K} = 411\ \text{K}$ $\therefore \theta_f = (411 - 273)\ \text{K} = 138\ ^\circ\text{C}$ MP5: must see a correct value as part of the conclusion	5

Q6.

Question Number	Acceptable answers		Additional guidance	Mark
	• use of $\Delta E = mc\Delta\theta$ • use of $P = E/t$ • Correct calculation of an appropriate quantity **and** comment consistent with their value.	(1) (1) (1)	**MP2** Candidates need to calculate either a time, a final temperature, an energy or a power Examples: Yes, because t = 30 s, which is less than one minute **Or** Yes, because it could reach temperature of 408 °C in one minute **Or** Yes, because it would transfer 156 000 J in one minute **Or** Yes, because the power required is 1.3 kW Example of calculation ΔE = 0.89 kg × 450 J kg^{-1} K^{-1} × (215 °C - 18 °C) = 78 900 J t = 78 900 J ÷ 2600 W = 30 s	3

Q7.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use of $\Delta Q = mc\Delta\theta$ • … for correct temperature differences • Final temperature is 61.4 °C which is above range	(1) (1) (1)	Example of calculation 0.180 kg × 4200 J kg^{-1} K^{-1} × (82 °C – θ_f) = 0.068 kg × 3900 J kg^{-1} K^{-1} × (θ_f – 2.7 °C) θ_f = 61.4 °C Answers making comparisons based on equivalent Physics may be awarded MP3 e.g. 16 600 J must be transferred from coffee to reach 60°C but required energy transfer to milk is only 15 200 J	3

Q8.

Question Number	Acceptable Answer		Additional Guidance	Mark
(a)(i)	• Use of $P = VI$ • $P = 1900$ W (1.9 kW)	(1) (1)	Example of calculation $P = 230\text{ V} \times 8.20\text{ A} = 1890\text{ W}$	2
(a)(ii)	• Use of $\Delta E = mc\Delta\theta$ • Use of $P = \frac{\Delta E}{\Delta t}$ • $\Delta t = 112$ s or 113 s [106 s or 107 s if show that value used] ECF from (a)(i)	(1) (1) (1)	Example of calculation $\Delta E = 0.655\text{ kg} \times 4190\text{ J kg}^{-1}\text{K}^{-1} \times (100 - 22.5)\text{K}$ $\Delta E = 2.13 \times 10^5\text{ J}$ $\Delta t = \frac{2.13 \times 10^5\text{J}}{1890\text{ W}} = 112.5\text{ s}$	3

Question Number	Acceptable Answer		Additional Guidance	Mark
(b)(i)	• After a short time of boiling in the flask, all the apparatus would be at 100 °C. **Or** so energy is not being used to heat up the flask **Or** so steam won't condense in the flask	(1)		1
(b)(ii)	• Use of $\Delta E = mL$ • Use of $P = \frac{\Delta E}{\Delta t}$ • 1720 W (1.72 kW)	(1) (1) (1)	Example of calculation $\frac{\Delta m}{\Delta t} = \frac{95 \times 10^{-3}\text{ kg}}{125\text{ s}}$ $= 7.6 \times 10^{-4}\text{ kg s}^{-1}$ $\frac{\Delta E}{\Delta t} = 7.6 \times 10^{-4}\text{ kg s}^{-1} \times 2.26 \times 10^6\text{J kg}^{-1}$ $P = 1720\text{ J s}^{-1}$	3
(b)(iii)	• Comparison of answer to (a)(i) with answer to (b)(ii) • Not all of the energy from the heater is used to turn water from liquid state into vapour **Or** energy is being used to heat the heat exchanger **Or** not all the steam condenses in the heat exchanger • Some energy is transferred to the surroundings	(1) (1) (1)	e.g. rate at which thermal energy is supplied to the water in the flask is greater than rate at which thermal energy is removed from the water in the heat exchanger. If answer for (b)(ii) is bigger than 2 kW,1 mark for correct comparison can be scored.	3

Q9.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• By lagging the flask (to reduce energy transfer to the surroundings)	(1)		1

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use lagging to insulate the container from the surroundings (1) • So that a greater proportion of the energy supplied is used to boil the liquid (1) **Or** • Use a heater with a higher electrical power (1) • So that a shorter time is needed to boil the liquid (1)	Accept "to minimise heat loss to the surroundings"	2

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • To bring tubing up to temperature (of steam) (1) • So steam only condenses in the cup (1) **Or** steam doesn't condense in the tubing		2
(ii)	• Thermal energy will be transferred from the steam/tubing to the surroundings (1) • Lagging/insulating/shortening the tubing (1)	Accept: • Thermal energy is transferred to the cup/ probe • These should have a small a heat capacity	2

Q12.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• Change in temperature and corresponding time • Use of $P = \Delta E/\Delta t$ and $\Delta E = mc\Delta\theta$ • $c = 950\ \text{J kg}^{-1}\ \text{K}^{-1}$	(1) (1) (1)	Example of calculation: $\frac{\Delta\theta}{\Delta t} = \frac{(36 - 16)\ \text{K}}{(500 - 0)\ \text{s}} = 0.04\ \text{K s}^{-1}$ $37.5\ \text{W} = 0.986\ \text{kg} \times c \times 0.04\ \text{K s}^{-1}$ $c = 951\ \text{J kg}^{-1}\ \text{K}^{-1}$	3
(ii)	An explanation that makes reference to the following points: • In 240 s the temperature of the block rose by only 9.6 °C **Or** It took 250 s for the temperature of the block to rise by 10 °C. • Hence there must have been energy transfer to the surroundings (by heating)	(1) (1)	For MP1 accept 9.5 °C Accept it took 10 s longer For MP2 accept energy dissipated to the surroundings	2

Q13.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• Use of $\Delta E = L\Delta m$ • Use of $\Delta E = mc\Delta\theta$ • $L = 2.1 \times 10^6\ \text{J kg}^{-1}$	(1) (1) (1)	In MP1 Δm must be an attempt at a mass difference In MP2 allow any m, $\Delta\theta$ from the question data <u>Example of calculation</u> heat transfer as steam condens $(258.3\text{-}255.0)\times10^{-3}\text{kg} \times L$ heat transfer as steam cools = $3.3\times10^{-3}\text{kg}\times4190\ \text{J kg}^{-1}\ \text{K}^{-1}\times(100\text{-}26)\text{K}$ heat transfer as water is heated $0.255\ \text{kg}\times4190\ \text{J kg}^{-1}\ \text{K}^{-1}\times(26\text{-}18.5)\text{K}$ $\therefore 3.3\times10^{-3}\text{kg} \times L + 1023\ \text{J} = 80$ $\therefore L = \frac{8013\ \text{J} - 1023\ \text{J}}{3.3\times10^{-3}\ \text{kg}} = 2.12 \times 10^6\ \text{J kg}^{-1}$	3

Q14.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $\Delta Q = mc\Delta\theta$ (1) • … for correct temperature change (1) • Use of $\Delta Q = L\Delta m$ (1) • Use of $P = E/t$ (1) • It is not transferred faster because: (1) 823 (W to water) < 2400 (W to iron) **Or** 46 100 (J to water) < 134 400 (J to iron) **Or** 19.2 (s to evaporate water at rate of 2400 W) < 56 (s taken)	Example of calculation mass of water = 0.0359 kg – 0.0182 kg = 0.0177 kg ΔQ = 0.0177 kg × 4190 J kg^{-1} K^{-1} × (100 °C – 18 °C) = 6100 J ΔQ = (0.0177 kg) × 2.26 × 10^{6} J kg^{-1} = 40 000 J P = (6100 J + 40 000 J) / 56 s = 823 W	5

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $P = VI$ (1) • Calculation of gradient (1) • Gradient $= \frac{\Delta m}{\Delta t}$ (1) • Use of $\Delta E = mL$ and $P = \frac{\Delta E}{\Delta t}$ (1) (1) • L = 2.30 × 10^{6} (J kg^{-1}) • Comparison of calculated value for L with values in table and appropriate conclusion. (1) (1)	For MP2 and MP3 credit Δm read from graph and used with corresponding Δt value For MP3 and MP4, credit $L = \frac{VI}{\text{gradient}}$ Answers in the range (2.26 – 2.34) × 10^{6} J kg^{-1}	
	• But not all of the energy supplied to the liquid will be used to boil the liquid **Or** thermal energy will be transferred to surroundings	Example of calculation: grad= $\frac{(211\text{-}155)\times 10^{-3}\text{ kg}}{(0\text{-}600)\text{ s}} = 9.33\times 10^{-5}$ kg s^{-1} $\therefore \frac{\Delta m}{\Delta t} = 9.33\times 10^{-5}$ kg s^{-1} P=20.5 V × 10.5 A = 215 W $\therefore L = \frac{215\text{ W}}{9.33\times 10^{-5}\text{ kg s}^{-1}} = 2.30\times 10^{6}$ J kg^{-1}	7