

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.3.2.2 TEMPERATURE CHANGES IN A SYSTEM AND SPECIFIC HEAT CAPACITY (PACK 2)

SCORE

/90

PERCENTAGE

%

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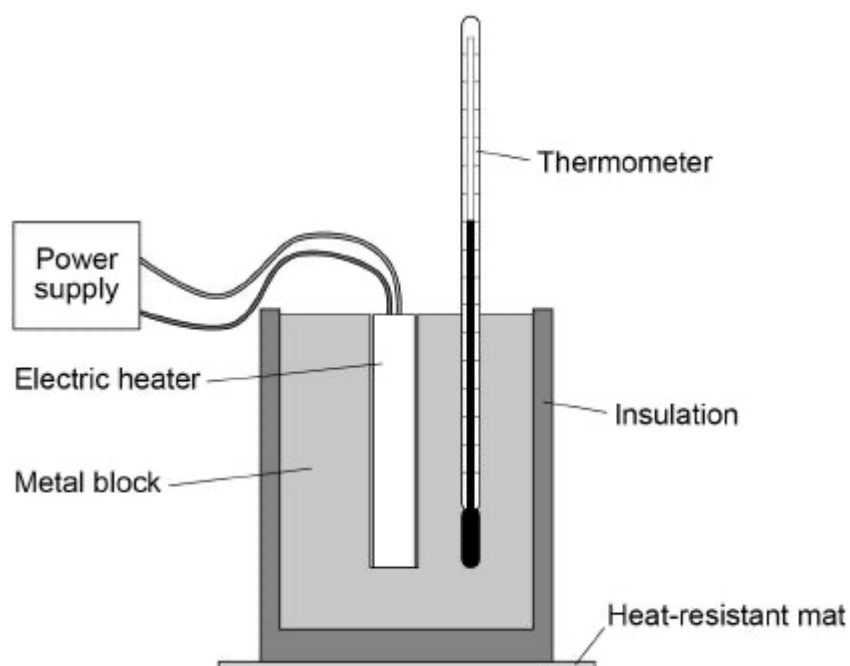
Q1.

A student investigated how the temperature of a metal block changed with time.

An electric heater was used to increase the temperature of the block.

The heater was placed in a hole drilled in the block as shown in **Figure 1**.

Figure 1



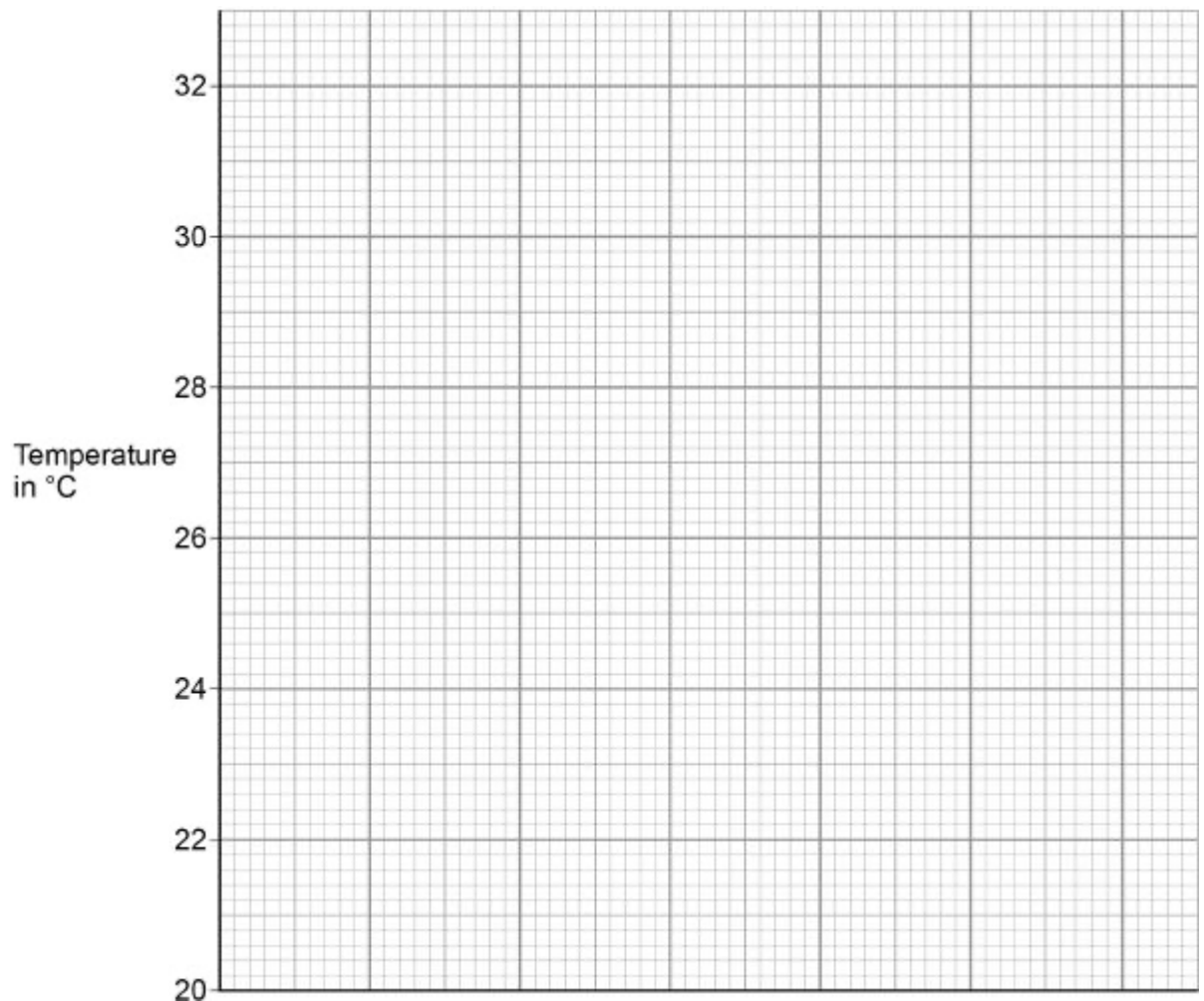
The student measured the temperature of the metal block every 60 seconds. The table below shows the student's results.

Time in s	Temperature in °C
0	20.0
60	24.5
120	29.0
180	31.0
240	31.5

(a) Complete the graph of the data from the table above on the graph below.

- Choose a suitable scale for the x-axis.
- Label the x-axis.
- Plot the student's results.
- Draw a line of best fit.

Figure 2



(4)

- (b) The rate of change of temperature of the block is given by the gradient of the graph.
Determine the gradient of the graph over the first 60 seconds.

Gradient = _____

(2)

- (c) The metal block had a mass of 1.50 kg
The specific heat capacity of the metal was 900 J/kg °C
Calculate the change in thermal energy of the metal during 240 seconds.
Use the Physics Equations Sheet.
Give your answer in kilojoules.

Change in thermal energy = _____ kJ

(4)

- (d) Another student repeated the investigation.

Give **two** variables this student would need to control to be able to compare their results with the results in the table above.

1. _____

2. _____

(2)

(Total 12 marks)

Q2.

Figure 1 shows a student making potato soup.

Figure 1



- (a) The student places 0.5 kg of potato into a pan of water.

During cooking, the temperature of the potato increases from 20 °C to 100 °C

The specific heat capacity of the potato is 3400 J/kg °C

Calculate the change in thermal energy of the potato.

Use the equation:

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

Change in thermal energy = _____ J (3)

- (b) Why is the energy supplied by the cooker greater than that calculated in part (a)?

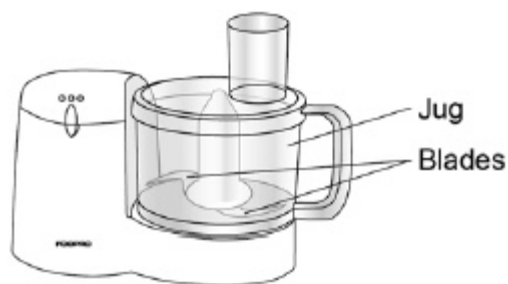
(1)

- (c) Suggest **one** way that the student could reduce the time to heat the potato to 100 °C

(1)

Figure 2 shows a food processor.

Figure 2



- (d) The student places the cooked potato into the jug of the food processor.

The food processor contains a motor that spins blades to chop the potato.

The total power input to the motor is 500 W

The useful power output from the motor is 300 W

Calculate the efficiency of the motor in the food processor.

Use the equation:

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Efficiency = _____

(2)

- (e) The jug is made of plastic with a low thermal conductivity.

Explain why this is an advantage.

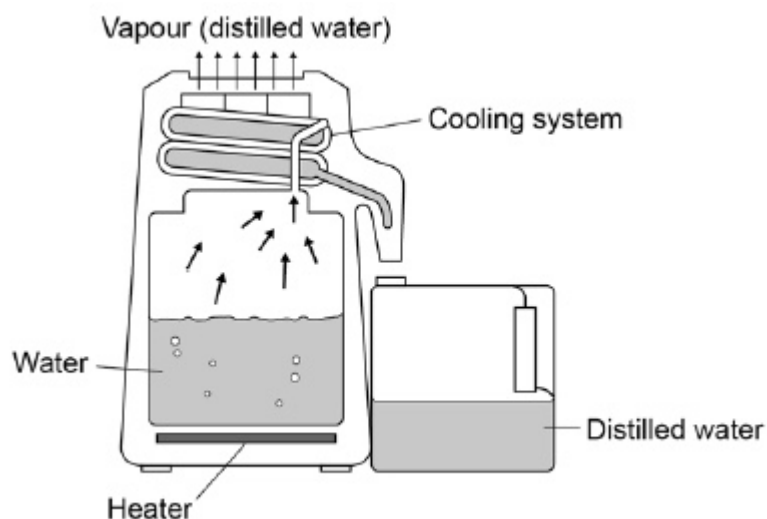
(2)

(Total 9 marks)

Q3.

Figure 1 shows a water distiller which is used to purify water.

Figure 1



The distiller boils water and then condenses most of the water vapour back to water.

- (a) The water distiller is filled with 5.0 kg of water at 20 °C

The specific heat capacity of water = 4 200 J/Kg °C

Calculate the energy needed to raise the temperature of the water to 100 °C

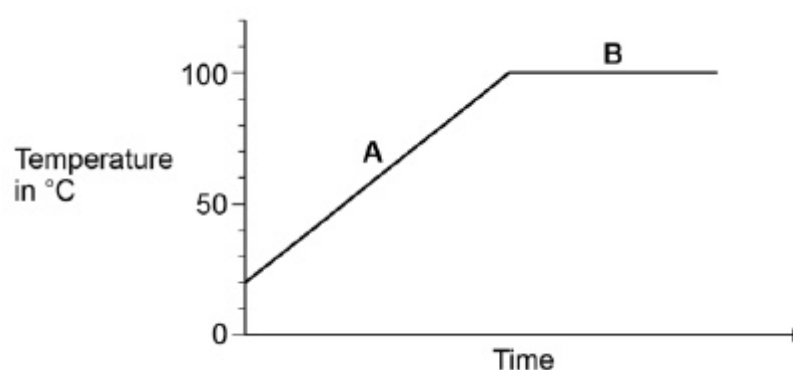
Use the Physics Equations sheet.

Energy = _____ J

(3)

Figure 2 shows how the temperature of the water in the distiller changes with time.

Figure 2



- (b) Energy is transferred to the water at a constant rate.

Explain why the graph is a different shape in parts **A** and **B**.

(3)

- (c) When the water drops to a low level, the heater automatically switches off.

Explain what problem would be caused if the heater did **not** automatically switch off.

(3)

- (d) The distiller is connected to the mains by a three-core cable.

The wires are covered by different coloured insulation.

What colour is the insulation covering each of the wires?

Live wire _____

Neutral wire _____

Earth wire _____

(2)

- (e) Which statement gives the purpose of the earth wire?

Tick **one** box.

It carries an alternating potential difference.

☐

It melts if the current in the circuit is too high.

☐

It provides a connection to complete the circuit.

☐

It stops the casing of the appliance becoming live.

☐

(1)

- (f) The heating element has a power of 2.5 kW

The resistance of the heating element is 17 Ω

Calculate the current in the heating element.

Give your answer to 2 significant figures.

Write any equations that you use.

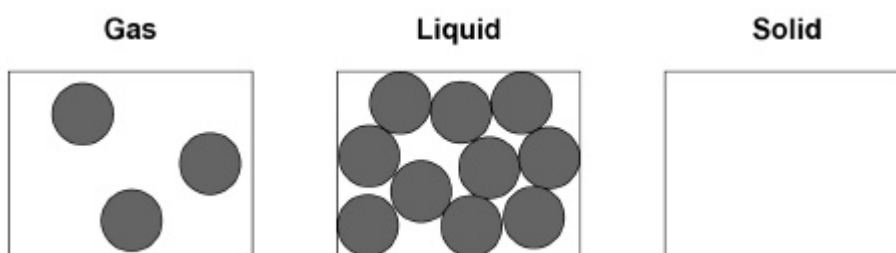
Current = _____ A

(5)

(Total 17 marks)

Q4.

The diagram shows a model of the particles in a gas and in a liquid.



- (a) Complete the diagram to show the arrangement of particles of the same substance as a solid.

(2)

- (b) What is the name of the process when a substance changes from a gas to a liquid?

Tick **one** box.

Condensing

☐

Evaporating

☐

Freezing

☐

Melting

☐

(1)

- (c) The substance in the diagram has a:

- melting point of 98 °C
- boiling point of 883 °C

What is the state of the substance at 20 °C?

Tick **one** box.

Gas

☐

Liquid

☐

Solid

☐

(1)

- (d) What type of change is a change of state?

Tick **one** box.

Chemical

☐

Kinetic

☐

Permanent

☐

Physical

☐

(1)

- (e) Which **two** statements are correct about the particles when a liquid turns into a gas?

Tick **two** boxes.

Particles are bigger

☐

Particles are lighter

☐

Particles have more chemical energy

☐

Particles have more kinetic energy

☐

Particles move faster

☐

(2)

- (f) Which **two** quantities are needed to calculate the energy required to turn a liquid into a gas with no change in temperature?

Tick **two** boxes.

Mass of the liquid

☐

Specific heat capacity of the gas

☐

Specific latent heat of vaporisation

☐

Time the liquid is heated

☐

(2)

- (g) A mass of 2.0 kg of water is heated.

The temperature increase of the water is 80 °C

The specific heat capacity of water is 4200 J / kg °C

Calculate the change in thermal energy when the water is heated.

Use the equation:

change in thermal energy = mass × specific heat capacity × temperature change

Change in thermal energy = _____ J

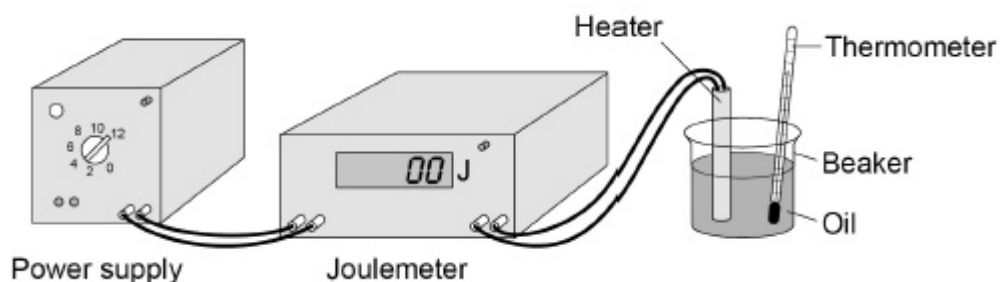
(2)

(Total 11 marks)

Q5.

Students investigated the specific heat capacity of different oils.

The diagram shows the equipment used.



This is the method used.

1. Put 200 g of an oil in a beaker.
2. Record the temperature of the oil.
3. Switch on the heater.
4. After 5 minutes, record the temperature of the oil and the reading on the joulemeter.
5. Repeat steps 1–4 with different oils.

- (a) Give **one** variable the students controlled in the investigation.

(1)

The table shows the students' results for one oil.

Temperature at start in °C	Temperature after 5 minutes in °C
21	68

- (b) What is the resolution of the thermometer used in the investigation?

Resolution = _____ °C

(1)

The students calculated the specific heat capacity of the oil as 2100 J/kg °C

The correct value for the specific heat capacity of the oil is 1630 J/kg °C

- (c) Calculate the percentage difference between the two values.

Percentage difference = _____ %

(2)

- (d) Suggest **two** improvements the students could make to obtain a more accurate value for the specific heat capacity.

1. _____

2. _____

(2)

- (e) A company is considering what metal to use to make saucepans.

They use data about the:

- cost of each metal
- specific heat capacity of each metal.

Suggest **two** other properties the company needs to consider when deciding which metal to use.

1. _____

2. _____

(2)

(Total 8 marks)

Q6.

The particle model can be used to explain the properties of gases.

- (a) Describe the direction of motion of the particles in a gas.

(1)

- (b) Explain why heating a gas increases the average speed of the gas particles.

(3)

- (c) Water can exist as either a liquid or a gas at 100 °C.

Explain why a mass of gaseous water at 100 °C contains more energy than an equal mass of liquid water at 100 °C.

(2)

- (d) Water vapour is a gas. Gases change state when they cool.

The figure below shows condensation on a cold bathroom mirror.



© Dwight Eschliman/Getty Images

A volume of $2.5 \times 10^{-5} \text{ m}^3$ of condensation forms on the mirror.

Density of water = 1000 kg / m^3

Specific latent heat of vaporisation of water = $2.26 \times 10^6 \text{ J / kg}$.

Calculate the energy released when the condensation forms.

Energy released = _____ J

(5)

- (e) Central heating boilers burn gas and use the energy released to heat water.

Modern condensing central heating boilers take advantage of the energy that is released when water condenses.

Waste water vapour produced when the water is heated in the boiler is used to preheat the cold water entering the boiler.

Give some of the arguments in favour of condensing boilers compared to older non-condensing boilers.

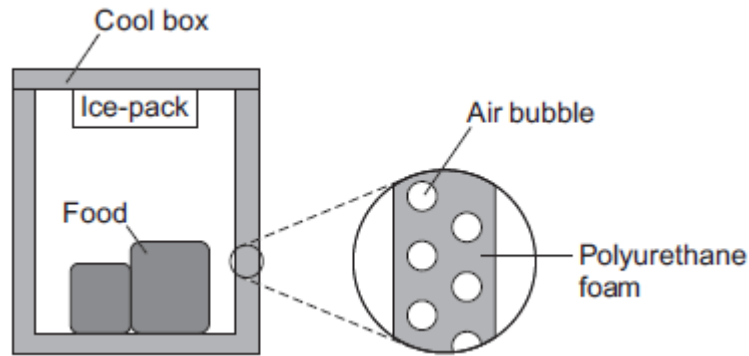
(4)

(Total 15 marks)

Q29.

The figure below shows a cool box.

A cool box is used to keep food colder than the surroundings. The cool box consists of plastic walls with a layer of polyurethane foam between them.



- (a) The polyurethane foam has a low U-value.

Why does the polyurethane foam need to have a low U-value?

(1)

- (b) The polyurethane foam contains air bubbles.

Explain how the air bubbles reduce energy transfer through the walls of the cool box.

You should refer to the processes of energy transfer in your answer.

(3)

- (c) An ice-pack can be placed inside the cool box. An ice-pack contains a material with a very high specific heat capacity. The ice-pack is frozen in a freezer and cooled to -18°C before being put in the cool box.

The ice-pack keeps the contents of the cool box cooler than the surroundings for a long time.

Describe how.

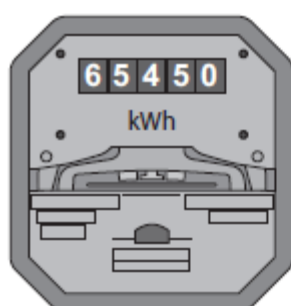
(3)
(Total 7 marks)

Q30.

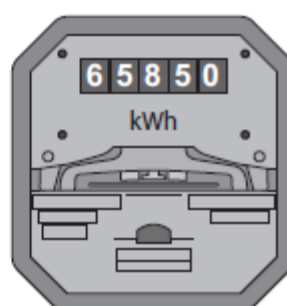
A householder wants to reduce her electricity bills.
The householder takes readings from her electricity meter to see how much electricity she is using.

The pictures show the electricity meter readings at the start and end of April in 2013.

At the start of April



At the end of April



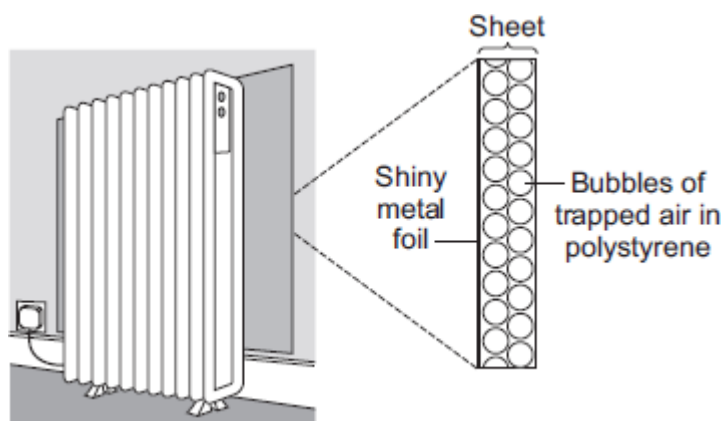
- (a) How many kilowatt-hours of electricity did she use in April?

Number of kilowatt-hours = _____

(2)

- (b) The householder wants to reduce energy transfer from a room so she puts a special sheet between a heater and the wall.

The side of the sheet facing the heater is shiny metal foil.
The side of the sheet facing the wall is polystyrene.
The polystyrene contains bubbles of trapped air.



What properties of the sheet make it good for reducing energy transfer from the room?

Draw a ring around each correct answer to complete the sentences.

- (i) Shiny surfaces are good

absorbers
emitters
reflectors

 of infrared radiation.

(1)

- (ii) The air in the polystyrene is a good

conductor.
insulator.
emitter.

(1)

- (c) The householder turns her heater thermostat down by 2°C so the temperature of the room is lower.

The specific heat capacity of air is $1000 \text{ J/kg}^{\circ}\text{C}$.

The mass of air in the room is 50 kg .

Calculate the energy needed to change the temperature of 50 kg of air by 2°C .

Use the correct equation from the Physics Equations Sheet.

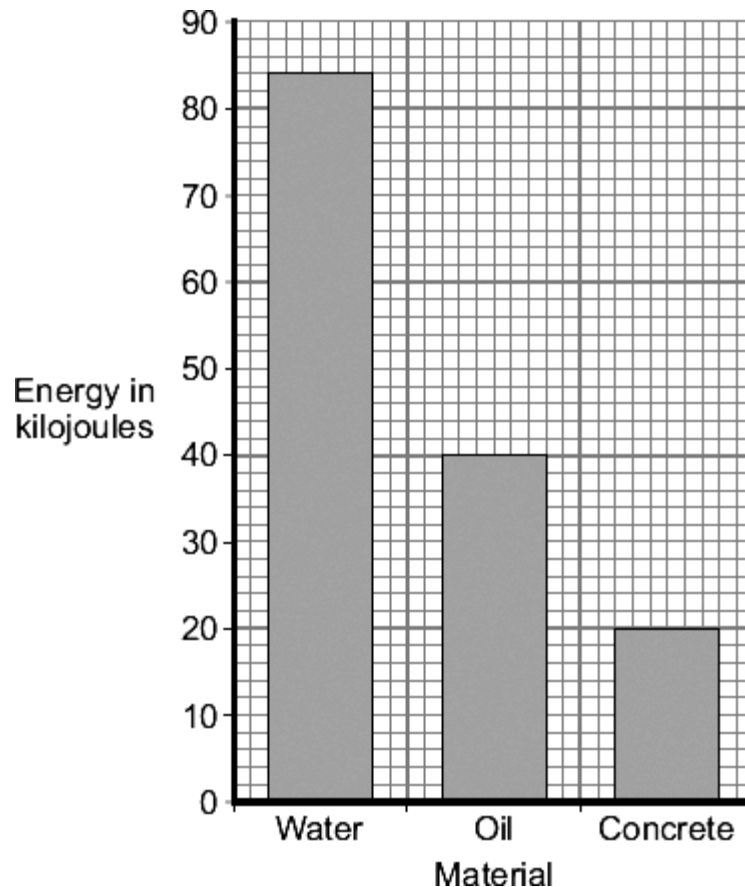
Energy = _____ J

(2)

(Total 6 marks)

Q31.

The bar chart shows the amount of energy needed to raise the temperature of 1 kg of three materials by 20°C . The materials are used inside heaters.

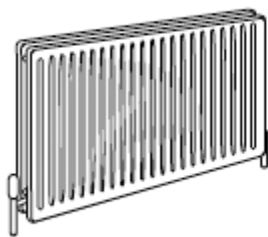


- (a) Which material stores most energy?

(1)

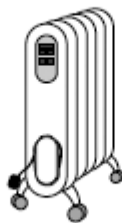
- (b) The heaters that use the different materials are shown below. The power output when the heaters are being used is shown below each picture.

Water-filled heater



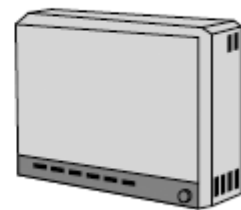
3kW

Oil-filled heater



1.5kW

Storage heater
(has concrete blocks inside)



1.7kW

Each heater is put in one of three identical rooms. Each room's temperature is 10 °C and the heaters are switched on for 5 hours.

Which heater would cause the biggest temperature rise in the room?

Give a reason for your answer.

Heater _____

Reason _____

(2)

- (c) Aluminium has a specific heat capacity of $900 \text{ J/kg } ^\circ\text{C}$.

Calculate how much energy is needed to raise the temperature of 2 kg of aluminium by $15 \text{ } ^\circ\text{C}$.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

Energy = _____ J

(2)

(Total 5 marks)

Mark schemes

Q1.

- (a) x-axis labelled **and** suitable scale 1
- points plotted correctly
*allow 5 correctly plotted for 2 marks, 3–4
 correctly plotted for 1 mark
 allow $\pm \frac{1}{2}$ square* 2
- line of best fit 1
- (b) $\frac{4.5}{60}$
allow ecf from line of best fit in part (a) 1
- 0.075 (°C/s) 1
an answer of 0.075 (°C/s) scores 2 marks
- (c) $\Delta\theta = 11.5$ (°C) 1
*a calculation using an incorrect temperature
 scores max 3 marks*
- $\Delta E = 1.50 \times 900 \times 11.5$ 1
- $\Delta E = 15\,525$ (J) 1
- $\Delta E = 15.525$ (kJ) 1
*an answer of 15.525 (kJ) or 15.53 (kJ) or 15.5
 (kJ) scores 4 marks
 an answer of 15 525 (kJ) scores 3 marks*
- (d) any **two** from:
- mass of block*
 - size / dimensions of block*
 - material of block*
**allow same block for 1 mark*
 - current through heater
allow power of heater
 - thickness of insulation*
 - material of insulation*
**allow same insulation for 1 mark*

- time interval
- starting temperature (of block / heater)

2

[12]

Q2.

- (a) 80 °C

1

$$\Delta E = 0.5 \times 3400 \times 80$$

1

$$\Delta E = 136\,000 \text{ (J)}$$

an answer of 136 000 (J) scores 3 marks

1

- (b) energy is dissipated into the surroundings
allow any correct description of wasted energy

1

- (c) put a lid on the pan
*allow any sensible practical suggestion
eg add salt to the water*

1

- (d) efficiency = 300/500

1

$$\text{efficiency} = 0.6$$

an answer of 0.6 or 60% scores 2 marks

allow efficiency = 60%

an answer of 0.6 with a unit scores 1 mark

an answer of 60 without a unit scores 1 mark

1

- (e) lower rate of energy transfer

1

(so) potato soup will remain at a higher temperature

1

[9]

Q3.

- (a) 80

1

$$E = 5.0 \times 4200 \times 80$$

1

$$E = 1\,700\,000 \text{ (J)}$$

an answer of 1 700 000 (J) or

1 680 000 (J) scores 3 marks

allow 1 680 000

1

(b)	in part A the increase in internal energy raises the temperature of the water	1
	in part B the increase in internal energy changes the state	1
	without changing the temperature	1
(c)	the heater would continue to transfer energy which would not be transferred to the water	1
	so would raise the temperature of the device	1
	causing it to be damaged	1
(d)	brown	
	blue	
	green and yellow stripes	
	<i>allow 1 mark for 2 correct</i>	2
(e)	it stops the casing of the appliance becoming live	1
(f)	$P = I^2 R$	
	$I = \sqrt{(P/R)}$	1
	$P = 2\,500 \text{ (W)}$	1
	$I = \sqrt{(2\,500 / 17)}$	1
	$I = 12.1267812$	1
	$I = 12 \text{ (A)}$	
	<i>an answer of 12 (A) scores 5 marks</i>	1
		[17]

Q4.

(a)	(approximate same size particles as each other and as liquid and gas) touching	
	<i>do not accept particles that overlap</i>	1
	regular arrangement (filling the square)	1
(b)	condensing	1

(c)	solid	1
(d)	physical	1
(e)	particles have more kinetic energy	1
	particles move faster	1
(f)	mass of the liquid	1
	specific latent heat of vaporisation	1
(g)	$2 \times 4\,200 \times 80$	1
	672 000 (J)	
	<i>an answer of 672 000 (J) scores 2 marks</i>	1
		[11]

Q5.

(a)	mass of oil	
	or	
	time the heater was turned on	1
(b)	1 (°C)	1
(c)	$\frac{470}{1630} \times 100$	
	28.8 (%)	1
	or	
	$\frac{470}{2100} \times 100$	
	22.4 (%)	1
(d)	insulate the beaker	
	or	
	add a lid	1

use a smaller heater

or

submerge heater fully in oil

1

(e) any **two** from:

- density / mass (of the metal)
- reactivity (of the metal)
- toxicity (of the metal)
- strength / hardness (of the metal)
- thermal conductivity (of the metal)
- corrosion resistance (of the metal)

2

[8]

Q6.

(a) random

accept in all directions

1

description must be of random motion

(b) heating increases the temperature of the gas

1

temperature is proportional to kinetic energy

1

if kinetic energy increases speed increases

1

(c) energy is needed to change the state of the water

1

to break the bonds

1

(d) $1000 = m / 2.5 \times 10^{-5}$

1

$m = 2.5 \times 10^{-5} \times 1000$

1

$m = 0.025 \text{ (kg)}$

1

$E = 0.025 \times 2\,260\,000$

1

$E = 56\,500 \text{ (J)}$

1

allow 56 500 (J) without working shown for 5 marks

0 marks awarded for $E = m \times L$

(e) any **four** from:

- because the water is preheated) the change in temperature of the

water
is less

- so less energy is used to heat the water ($E=mc\Delta\theta$)
- therefore they (condensing boilers) are more efficient
- so less energy is wasted
- less gas is burned to heat the same amount of water
- less waste gas (CO_2) is produced by the boiler **or** (because less gas is used) they are cheaper to run / save money

4

[15]

Q29.

- (a) so it is a good insulator

ignore references to efficiency

allow low (rate of) energy / 'heat' transfer

*do **not** accept prevents energy transfer*

1

- (b) air is a(n) (good) insulator

allow air is a poor conductor

1

(so) air reduces conduction

*do **not** allow stops conduction*

1

trapped air / air bubbles reduce(s) / stop(s) convection

1

- (c) any **three** from:

- ice-pack is (much) colder than the cool box contents
- ice-pack reduces the (overall) temperature of the cool box / air (in the cool box)
- ice pack requires a lot of energy to heat up / increase temperature / change temperature
allow 'heat' for energy
- ice-pack requires heating up before the cool box contents warm up
allow 'heat' for energy
allow ice-pack takes a long time to heat up / increase temperature / change temperature
- ice-pack cools the air which becomes more dense and sinks
allow ice-pack cools the air and causes (a) convection (current)
accept energy / 'heat' is needed to melt the (contents of the) ice-pack

3

[7]

Q30.

- (a) 400(kWh)

65850 – 65450 gains 1 mark provided no subsequent step shown

- 2
- (b) (i) reflectors
- 1
- (ii) insulator
- 1
- (c) 100 000(J)
- 2
- correct substitution i.e. $50 \times 1000 \times 2$ gains 1 mark provided no subsequent step shown*

[6]

Q31.

- (a) water
- 1
- allow H_2O / OH_2*
- (b) water (filled heater)
- 1
- allow 3kW*
- highest power (output) / most powerful / highest number of watts
- only scores if first marking point correct*
- allow highest energy / heat output*
- allow has more power*
- ignore stores most energy / references to heat*
- 1

- (c) $E = m \times c \times \theta$
- 27 000
- 2
- allow 1 mark for correct substitution into correct equation:*
- $2 \times 900 \times 15$
- or**
- $2000 \times 900 \times 15$
- or**
- $27\ 000\ 000$

[5]

Examiner reports

Q1.

Foundation

- (a) Most students made a good attempt at selecting a linear scale and labelling the x-axis. The label should include the unit.

Plotting was generally correct on major gridlines, but many plotting mistakes were seen. The line of best fit was a smooth curve in this instance. Straight lines of best fit and dot-to-dot did not gain the fourth marking point.

This question discriminated well with 82% of students achieving some credit, and 42% achieving three or four marks.

- (b) 2% of students could calculate the gradient of the graph. Students need to ensure they bring a calculator to the exam so as not to be disadvantaged in these calculation questions. When attempted, a single value was often read from each axis, and then divided.

Students did not appear to notice that the y-axis does not begin at zero, requiring a difference between two points on each axis to be determined before dividing.

- (c) Many students used the final temperature, rather than calculating the temperature change. Three out of four marks were still available for subsequent stages if the correct method was used. Answers frequently used the time in seconds, rather than the temperature change. Again, subsequent marks were available.

Most students did not attempt the unit conversion from joules to kilojoules. Of those who attempted the unit conversion, as many multiplied by 1000, as divided by 1000.

- (d) Students could generally give one control variable (29% of students), but few (11%) gave two correctly. Many incorrect answers of 'temperature' unqualified were seen. At this level, simple statements to keep it a fair test, or to use the same equipment, with no detail given, are insufficient.

Higher

- (a) Most students could choose a sensible linear scale and label the x-axis. Some errors in plotting were seen. The line of best fit was a smooth curve in this instance. Straight lines of best fit and dot-to-dot did not gain the fourth marking point. 75% of students achieved three or four marks.

- (b) 79% of students could not calculate the gradient. Some students attempted to count the squares of the graph paper to calculate the gradient, rather than use the appropriate scale.

Students were expected to calculate the gradient in '°C/second' because seconds were the unit of time provided, however, some students calculated the gradient in '°C/minute'. This could achieve full marks if the method was clear. Just calculating the change in temperature was insufficient.

- (c) 53% of students could calculate the change in thermal energy using the equation on the Physics Equations Sheet, although some did attempt to use an incorrect equation. Errors in calculating the temperature change were frequent. Unit

conversion from joules to kilojoules was generally correct when attempted.

- (d) 32% of students could state two control variables. however students should be aware that general statements regarding keeping equipment the same are insufficient. The answer should apply to the investigation given in the question.

Q29.

- (a) Some students lost marks because the response needed to specify a good insulator, rather than insulator alone. Many students implied that no energy would be transferred, which is incorrect. There were many poorly phrased responses such as "To keep heat out", "To stay cool" or "To increase efficiency", all of which were ignored.
- (b) The question instructed students to refer to the processes of heat transfer in their answer. Some students mentioned all three processes, whilst others mentioned none. Comments relating to infrared radiation were ignored as there was no mention of surface colour in the question. "Air is a poor conductor" was frequently seen, but was often followed by air stopping conduction, which is incorrect. Several students thought heat transfer would be stopped or that particles of energy were trapped, both of which were ignored. Few students referred to convection, but "Convection is stopped" was credited, as the trapped air cannot move even though convection would still occur within the air bubbles themselves. There were several references to air being a vacuum.
- (c) Only a fifth of students scored any marks on this question. Many students made no reference to the ice-pack but instead continued with the ideas in part(b) about insulation. Many of these answers included confused descriptions of the insulation preventing the cold, or cold energy escaping. A few students gained a mark for saying that its high specific heat capacity would mean a lot of energy would be needed to increase the temperature of the ice-pack. Others gave a description of convection within the cool box, although some thought the ice-pack released cold air or cool particles. Many misconceptions related to energy transfer were seen.

Q30.

- (a) Three quarters of the students correctly calculated the number of kilowatt-hours of electricity used in April. Some just gave the reading for the end of April, without carrying out a subtraction. A common error was to add the two readings together, instead of subtracting them.
- (b)
 - (i) Around three quarters of the students said shiny surfaces are good reflectors of infrared radiation.
 - (ii) Around three quarters of the students knew that air is a good insulator.
- (c) Almost half of the students gained full marks for this calculation. A few students gained 1 mark for showing the correct working. Often students made an error when writing their final answer by missing a zero off. A few multiplied the mass of the air by its specific heat capacity, but then divided this by the temperature change instead of multiplying.

Q31.

- (a) Most students correctly selected water as storing the most energy.

- (b) Whilst most students correctly chose the water-filled heater, many students failed to identify the highest power output as the reason, despite the stem of the question stating that the power output was shown. Many students answered in terms of it having the most energy. Some students just gave the heater as being a radiator, rather than naming it, which could not be credited. Students should be encouraged to use the language given in the question.
- (c) Almost a third of students gained full marks for this question. Students who presumably did not have a calculator often gave an incorrect number of zeros, but had attempted to use the correct equation.