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EDEXCEL INTERNATIONAL GCSE PHYSICS: QUESTIONS BY TOPIC

Energy Resources and Energy Transfers (4)

IGCSE Physics Topic 4

39 questions · 334 marks · Mark schemes included

Pearson Edexcel International GCSE (9-1) Physics 4PH1, Papers 1P/1PR & 2P/2PR, 2019-2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

39 questions · 334 marks · 4 sub-topics



SUB-TOPIC 4.1

ENERGY STORES, TRANSFERS, WORK AND EFFICIENCY

Sub-topic 4.1 · 11 questions · 103 marks · lowest tariff first



5 A toaster is an electrical device used for toasting bread.



© Levent Konuk/Shutterstock

The toaster contains thin metal wires.

These wires get hot when there is a current in them.

The wires transfer energy to the bread by heating and by radiation.

(a) Give a reason why the wires in the toaster are connected in parallel.

(1)

(b) (i) State the formula linking power, current and voltage.

(1)

(ii) The power rating of the toaster is 2.8 kW.

Calculate the total current in the toaster.

[mains voltage = 230V]

(3)

current = ... A

(iii) The toaster contains 48 thin metal wires.

Calculate the current in each of the thin metal wires.

(1)

current = ... A

(Total for Question 5 = 6 marks)



- 1 (a) The boxes give some situations and some energy stores.

Draw one straight line from each situation to the energy store that decreases for that situation.

The first one has been done for you.

(4)

Situation	Energy store
a beaker of water cooling down	elastic
a car moving horizontally and slowing down	kinetic
a ball falling towards the ground	thermal
a nucleus splitting due to fission	nuclear
a stretched rubber band decreasing in length	gravitational



(b) Energy is transferred when a filament lamp is connected to a battery.

(i) Which method of energy transfer takes place between the battery and the lamp?

(1)

- ☐ **A** electrical
- ☐ **B** heating
- ☐ **C** mechanical
- ☐ **D** radiation

(ii) Which method of energy transfer takes place between the lamp and the surroundings?

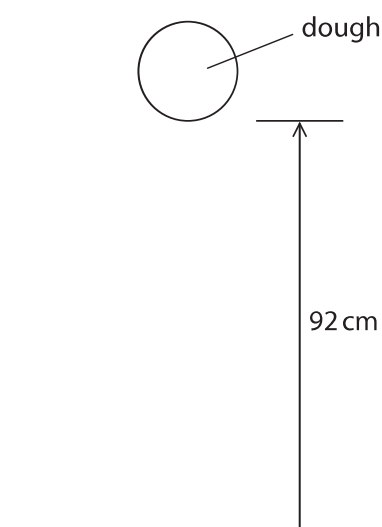
(1)

- ☐ **A** electrical
- ☐ **B** light radiation
- ☐ **C** mechanical
- ☐ **D** sound radiation

(Total for Question 1 = 6 marks)



- 12** (a) The diagram shows a ball of dough, of mass 580 g, held at a height of 92 cm above the floor.



Calculate the increase in gravitational potential energy (GPE) stored in the ball of dough when it is above the floor.

(3)

GPE = ... J



(b) The ball of dough hits the floor and does not rebound.

Describe the energy transfers taking place from when the dough is dropped to after it has hit the floor.

You should refer to energy stores as well as transfers between energy stores at these stages.

- before the dough is dropped
- just before the dough hits the floor
- after the dough has hit the floor

(4)

(Total for Question 12 = 7 marks)



3 A family has a television set.

(a) The television set has a low power mode called standby.

When on standby, the power rating of the television set is 0.27 W.

Calculate the energy transferred to the television set on standby in 12 hours.

(3)

energy transferred = ... J

(b) In normal use, the current in the television set is 0.31 A.

(i) Explain how a fuse works to protect the television set if there is a fault.

(3)

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(ii) Explain why a 13 A fuse is not an appropriate choice of fuse to use in the plug of this television set.

(2)

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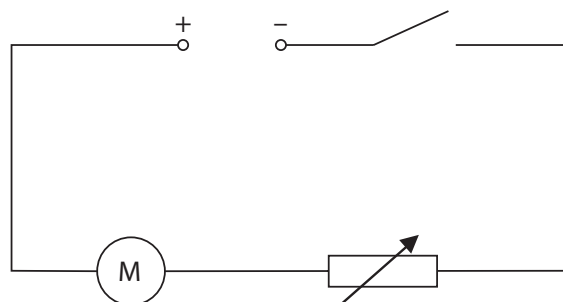
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(Total for Question 3 = 8 marks)



- 7 The circuit diagram shows a motor, power supply, switch and variable resistor connected in series.



- (a) The switch is open and the motor is not moving.

State how much energy is in the kinetic energy store of the motor.

(1)

kinetic energy = ... J

- (b) The switch is closed.

The motor takes 0.42 seconds to reach its maximum speed of rotation.

The mean current in the motor is 3.9 A.

The voltage across the motor is 7.1 V.

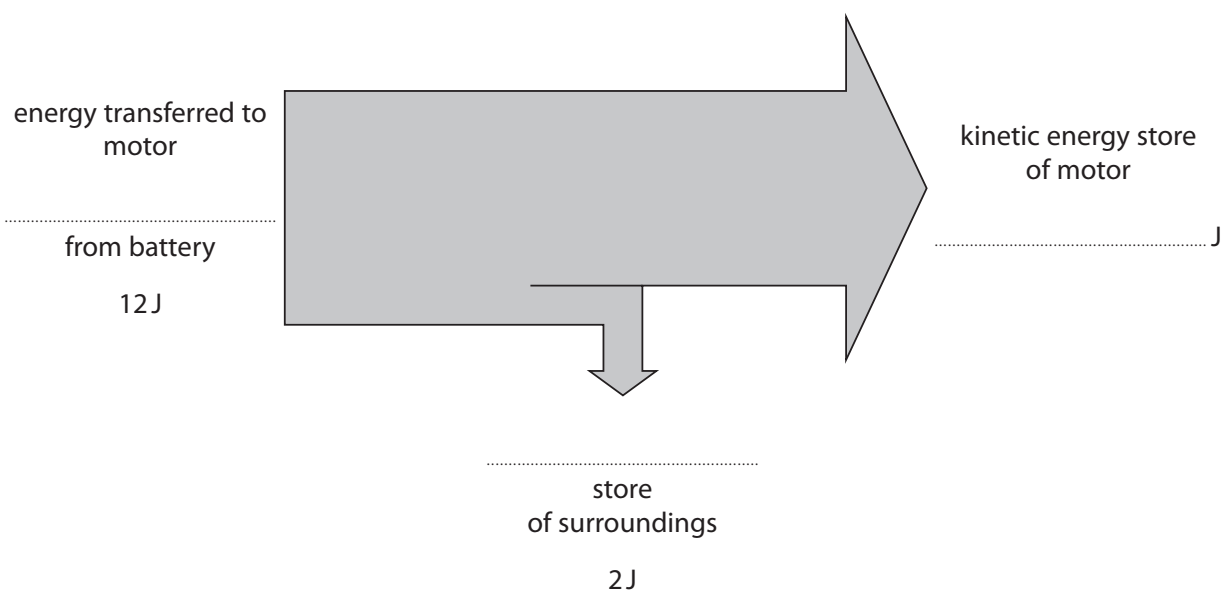
Show that the work done on the motor during the 0.42 seconds is about 12 J.

(2)

work done = ... J

- (c) Complete the Sankey diagram for the electric motor during the 0.42 seconds by giving the missing information.

(3)



- (d) Use the Sankey diagram to calculate the efficiency of the process of bringing the motor to its maximum speed of rotation.

(3)

efficiency = ... %

(Total for Question 7 = 9 marks)

- 9 The driver of a racing car makes a pit stop during a race to change the tyres on the racing car.

The area where the tyres are changed is called the pit lane.



(Source: © Hafiz Johari/Shutterstock)

- (a) Before entering the pit lane, the speed of the car must decrease for safety reasons.

- (i) The mass of the racing car is 830 kg.

The maximum braking force is 41 000 N.

Show that the maximum deceleration of the racing car is approximately 50 m/s^2 .

(3)

- (ii) The racing car is travelling at an initial speed of 72 m/s .

Calculate the minimum distance needed to decrease the speed of the racing car from 72 m/s to 26 m/s .

(3)

distance = ... m

(b) The racing car slows down using its brakes.

The brakes work using friction.

The brakes become very hot when the racing car slows down.

Using ideas about energy, explain why the brakes become hot.

(3)

(c) The tyres of the racing car also get very hot during a race.

A mechanic has to handle the hot tyres during the pit stop.

They wear protective gloves which have several layers of insulating materials.

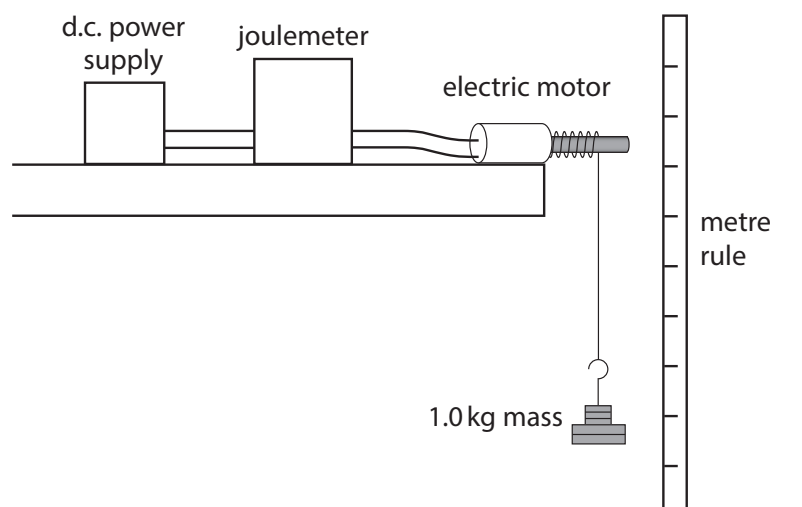
Explain how the layers of insulating materials in the gloves reduce the risk of the mechanic burning their hands on the hot tyres.

(2)

(Total for Question 9 = 11 marks)



- 8 A student uses this apparatus to investigate how the efficiency of an electric motor varies with its input voltage.



This is the student's method.

- connect the electric motor to a d.c. power supply and a joulemeter
- attach a 1.0 kg mass to the electric motor using a length of string
- set the voltage of the power supply to 10V and switch on the power supply
- switch off the power supply when the mass has been lifted through a distance of 50 cm
- record the input energy to the motor from the joulemeter
- calculate the energy transferred to the gravitational store of the mass
- calculate the efficiency of the motor

The student repeats this process, setting the power supply to a different voltage each time.

- (a) State how the student could improve the reliability of her results.

(1)

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- (b) Give two control variables for the investigation.

(2)

1

2

- (c) Show that the gravitational store of the 1.0 kg mass increases by 5.0 J when it is lifted through a distance of 50 cm.

(2)

- (d) The table shows the student's results.

Power supply voltage in V	Joulemeter reading in J	Motor efficiency (%)
3.0	99.4	5.0
3.5	25.5	19.6
4.0	16.5	30.3
5.0	13.5	37.0
6.0	12.6	39.7
8.0	12.8	39.1
10.0	12.7	

- (i) Calculate the motor efficiency when the power supply is set to a voltage of 10 V.

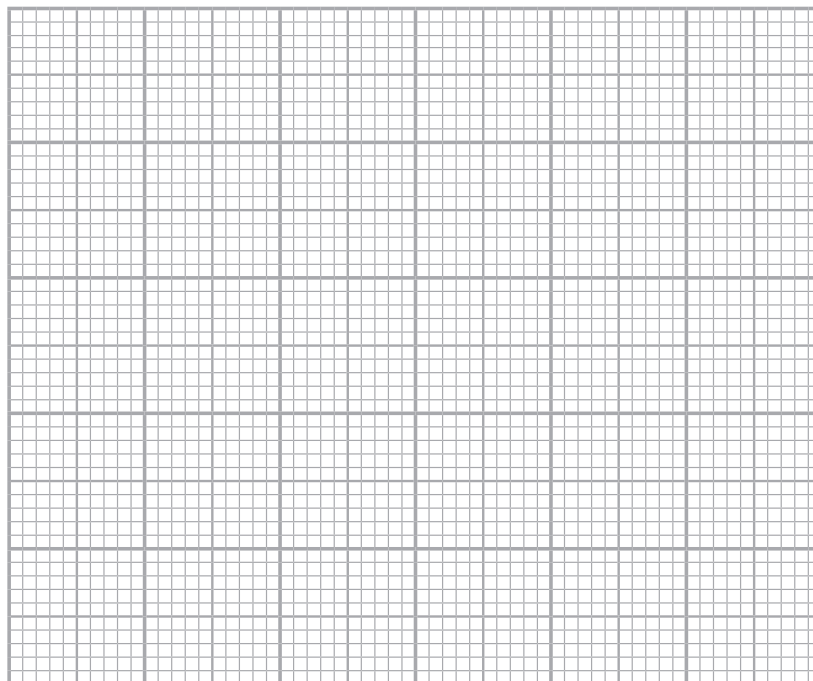
(3)

efficiency = ... %



- (ii) Plot a graph of the motor efficiency on the y-axis against the power supply voltage on the x-axis.

(3)



- (iii) Draw a curve of best fit.

(2)

- (iv) Using the graph, determine the minimum power supply voltage that will allow the electric motor to operate at maximum efficiency.

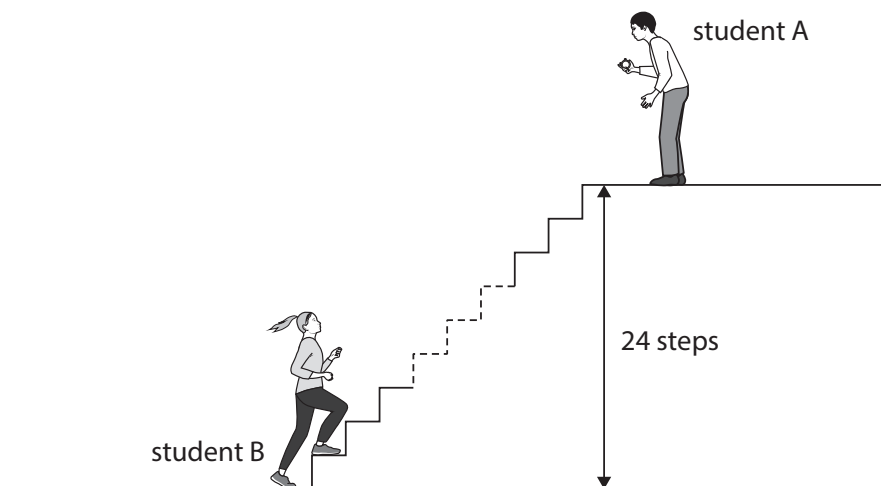
(1)

power supply voltage = ... V

(Total for Question 8 = 14 marks)

- 6 Two students do an experiment to determine their power when running up a set of steps.

The diagram shows how they set up their experiment. Not all of the steps are shown in the diagram.



This is the students' method.

- student A stands with a stopwatch at the top of the steps
- student A starts timing on the stopwatch and shouts "go" at the same time
- student B begins to run up the steps when she hears student A shout
- student A stops timing when student B reaches the top of the steps

The students repeat their method two more times.

- (a) Give a reason why the times recorded may not be accurate.

(1)

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(b) There are 24 steps in total and each step has a height of 19 cm.

(i) Student B has a mass of 67 kg.

Show that student B gains about 3000 J of energy in her gravitational store when she runs up the set of steps.

(3)

(ii) The table shows the times recorded for student B.

Time in s
4.28
4.95
4.65

Calculate the mean time from this data.

Give your answer to three significant figures.

(2)

mean time = ... s

(iii) Calculate the mean power of student B transferring energy to her gravitational store as she runs up the steps.

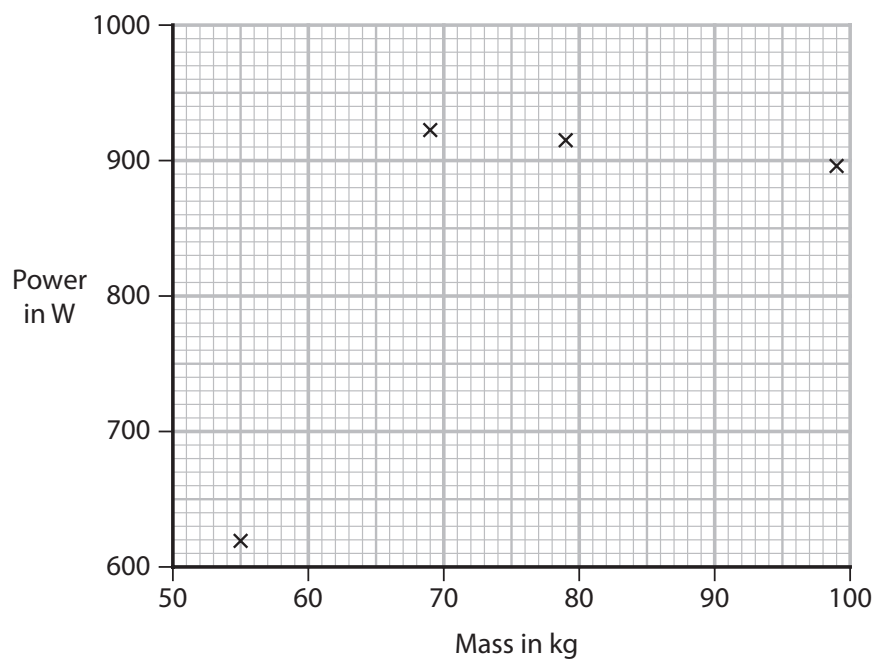
(2)

mean power = ... W



- (c) The students extend their investigation by calculating the power for students of different masses running up the steps.

The graph shows their results.



The students conclude that the greater the mass of the person, the greater the power of the person when running up the steps.

Comment on the students' conclusion.

(4)

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(Total for Question 6 = 12 marks)



9 (a) The diagrams show a spring hanging from a nail.

- diagram 1 shows the spring with no weight added
- diagram 2 shows the spring stationary, after a weight has been added
- diagram 3 shows the spring after the weight has been pulled down

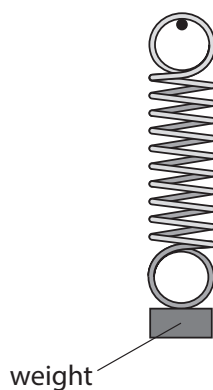


Diagram 1

Diagram 2

Diagram 3

(i) Which energy store has increased for the spring in diagram 2 compared to the spring in diagram 1?

(1)

- ☐ **A** chemical
- ☐ **B** elastic
- ☐ **C** gravitational potential
- ☐ **D** kinetic

(ii) The spring is released from the position shown in diagram 3.

Describe the energy transfers that take place until the spring stops vibrating.

(6)

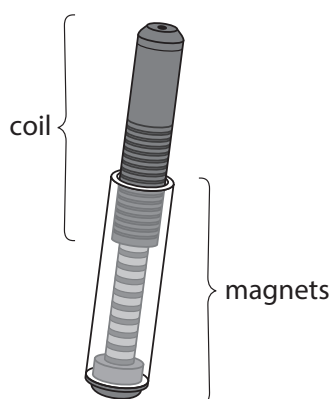


- (b) Shock absorbers containing springs are used on motorcycles.

Shock absorbers are designed to compress and expand as the motorcycle moves across a rough surface.

A new type of shock absorber has been developed to generate electricity from the movement of the motorcycle.

This new type of shock absorber consists of magnets that slide inside a coil when the motorcycle goes over a bump.



Some of the energy that would normally be wasted can be recovered, so fuel is saved.

- (i) Which of these statements best describes the advantage of this new type of shock absorber?

(1)

- ☐ **A** it increases the energy transferred to a thermal store from the fuel
- ☐ **B** it increases the efficiency of the motorcycle
- ☐ **C** it decreases the speed of the motorcycle
- ☐ **D** it decreases the braking power of the motorcycle

- (ii) Explain how this new type of shock absorber can generate electricity.

(3)

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(iii) Road X has a rough surface.

Road Y has a smooth surface.



(Source: © MikhailSh / Shutterstock)

Road X



(Source: © BearFotos / Shutterstock)

Road Y

A motorcycle travels at the same speed along road X and road Y.

Explain why the new type of shock absorber will generate more electricity for this motorcycle on road X than on road Y.

(3)

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(Total for Question 9 = 14 marks)

11 A ball is moving through the air with a speed of 54.8 m/s. The ball has a mass of 159 g.

(a) Calculate the energy in the kinetic store of the ball.

Give your answer to 3 significant figures.

(4)

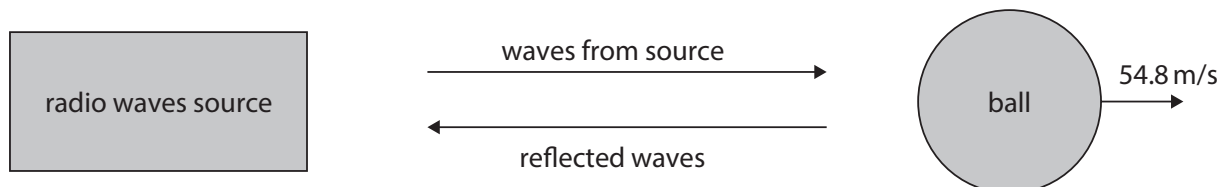
energy in kinetic store = ... J

(b) The speed of the ball is measured using radio waves.

Radio waves of frequency 2.90×10^{10} Hz travel towards the ball from a source.

The radio waves then reflect off the ball.

The reflected radio waves change frequency depending on the speed of the ball.
This change in frequency is due to the Doppler effect.



- (i) The change in frequency can be calculated using this formula.

$$\text{speed of ball} = \frac{\text{change of frequency}}{\text{source frequency}} \times \frac{\text{speed of radio waves}}{2}$$

Show that the change in frequency of the radio waves is approximately $1.1 \times 10^4 \text{ Hz}$.

[speed of radio waves = $3.00 \times 10^8 \text{ m/s}$]

(3)

- (ii) The change in frequency of the radio waves happens because the ball acts as a new source of radio waves.

The ball is moving away from the original source of radio waves.

Explain the change in frequency of the radio waves when the radio waves reflect off the ball.

(3)

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(Total for Question 11 = 10 marks)



SUB-TOPIC 4.2

CONDUCTION, CONVECTION AND RADIATION

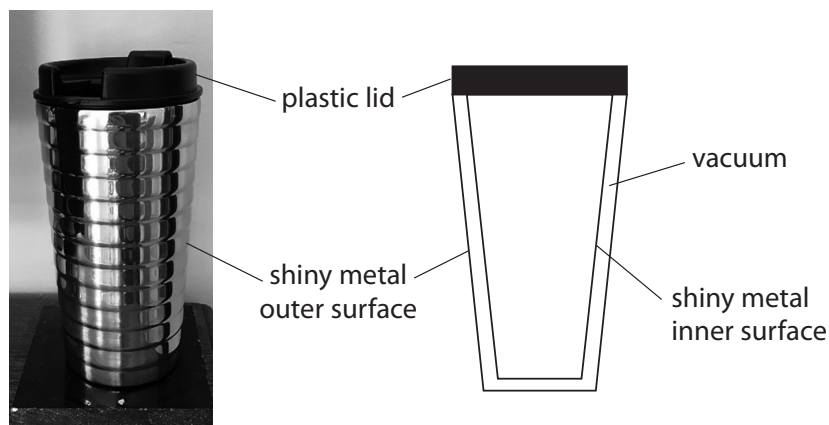
Sub-topic 4.2 · 12 questions · 95 marks · lowest tariff first



6 A teacher makes a hot drink.

He puts the drink in a cup designed to keep the drink hot.

The photograph and cross-section diagram both show the cup.



Explain how the design of the cup keeps the drink hot.

Refer to methods of energy transfer in your answer.

(6)

(Total for Question 6 = 6 marks)



7 The photographs show two different breeds of cat.



© Kucher Serhii/Shutterstock

Cat X

Cat X has no fur and light-coloured skin.

Cat Y has thick, black fur.



© Eric Isselee/Shutterstock

Cat Y

Both cats have the same body temperature and transfer energy to their surroundings when they are outside on a cold day.

(6)

(Total for Question 7 = 6 marks)



10 The photograph shows a large hurdle on an athletics track.



© Sony Ho/Shutterstock

(a) The bar of the hurdle is made of wood and is painted black and white.

The temperature of the hurdle increases when the Sun shines on it.

Explain which part of the bar reaches the highest temperature.

(2)

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(b) The air near the bar receives energy by heating.

Explain how a convection current is formed in the air near the bar.

(4)

(Total for Question 10 = 6 marks)



- 8** In some countries, snow can fall and collect on the ground.

Diagram 1 shows that after the snow has fallen, the sky can be clear, leaving the snow directly exposed to the Sun.

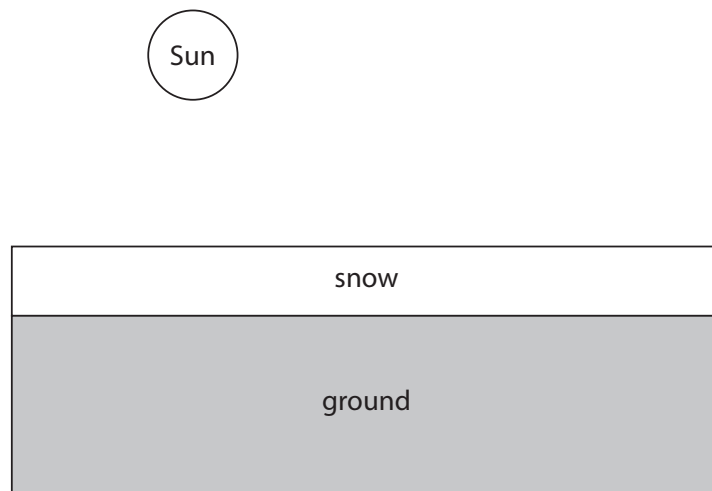


Diagram 1

- (a) Explain why the white snow will take a long time to melt, even though directly exposed to the Sun.

(2)

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(b) Diagram 2 shows a different piece of ground that has a metal drain cover.

If the snow lands on metal, the snow takes a shorter time to melt.

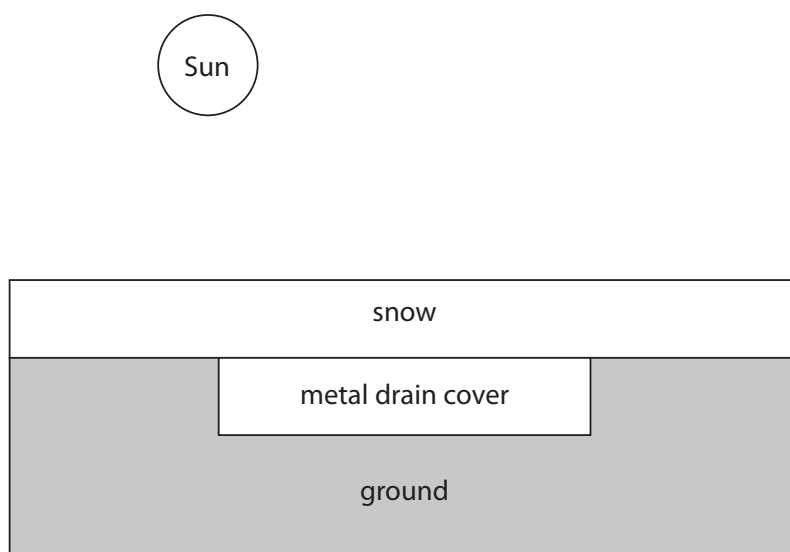


Diagram 2

Explain why the snow melts in a shorter time on the metal drain cover.

(2)

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(c) Explain how a convection current above the snow increases the time taken for the snow to melt.

(2)

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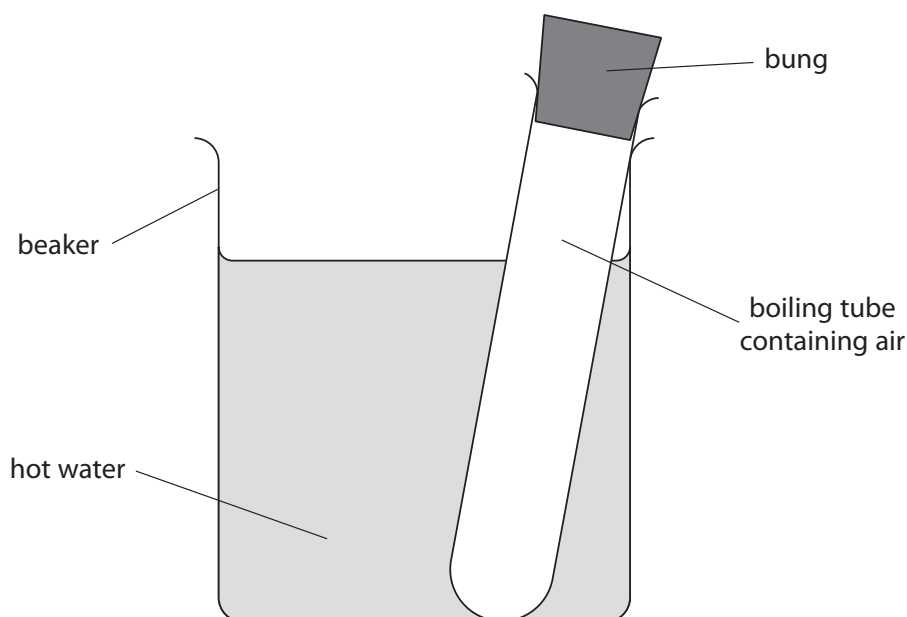
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(Total for Question 8 = 6 marks)

12 Air is trapped in a boiling tube by sealing the boiling tube with a rubber bung.

The boiling tube is placed in a beaker containing hot water.



- (a) Energy is transferred from the thermal store of the water to the thermal store of the air in the boiling tube with an efficiency of 16%.

The air in the boiling tube gains 1800 J of energy during this process. This is defined as the useful energy transfer.

Calculate the amount of energy wasted during this process.

(4)

energy wasted = ... J

(b) Give two ways that the apparatus could be modified to improve the efficiency of the energy transfer.

(2)

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(Total for Question 12 = 6 marks)



4 Photograph 1 shows an outdoor swimming pool.



Photograph 1

(a) The water in the swimming pool is heated by the Sun during the day.

(i) State how energy is transferred from the Sun to the water.

(1)

(ii) State what happens to the average speed of the water molecules as the water is heated.

(1)

(b) The water in the swimming pool cools down at night.

(i) Suggest why the water cools down at night.

(1)

(ii) Photograph 2 shows the swimming pool with a plastic cover over the water.



Photograph 2

Explain why the plastic cover reduces how much the water cools down at night.

(4)

(Total for Question 4 = 7 marks)

- 6 The Parker Solar Probe is a spacecraft that was launched in 2018 on a mission to explore the Sun.

The spacecraft is partly covered in tiles.

These tiles are filled with a solid containing small pockets of trapped air.

The outer surface of the tiles is painted white.

These tiles protect the electric circuits in the spacecraft from extreme temperatures.

- (a) The diagram shows one of these tiles in cross-section.



- (i) Explain why the outer surface of the tile is painted white.

(2)

- (ii) Explain how the small pockets of trapped air help to reduce thermal energy transfer from the outer surface to the inner surface of the tile.

(2)

(b) The electric circuits inside the spacecraft are cooled by 4.5 kg of water.

The initial temperature of the water is 35 °C.

The thermal store of the water increases by 210 kJ.

Calculate the final temperature of the water.

[specific heat capacity of water = 4200 J/kg °C]

(4)

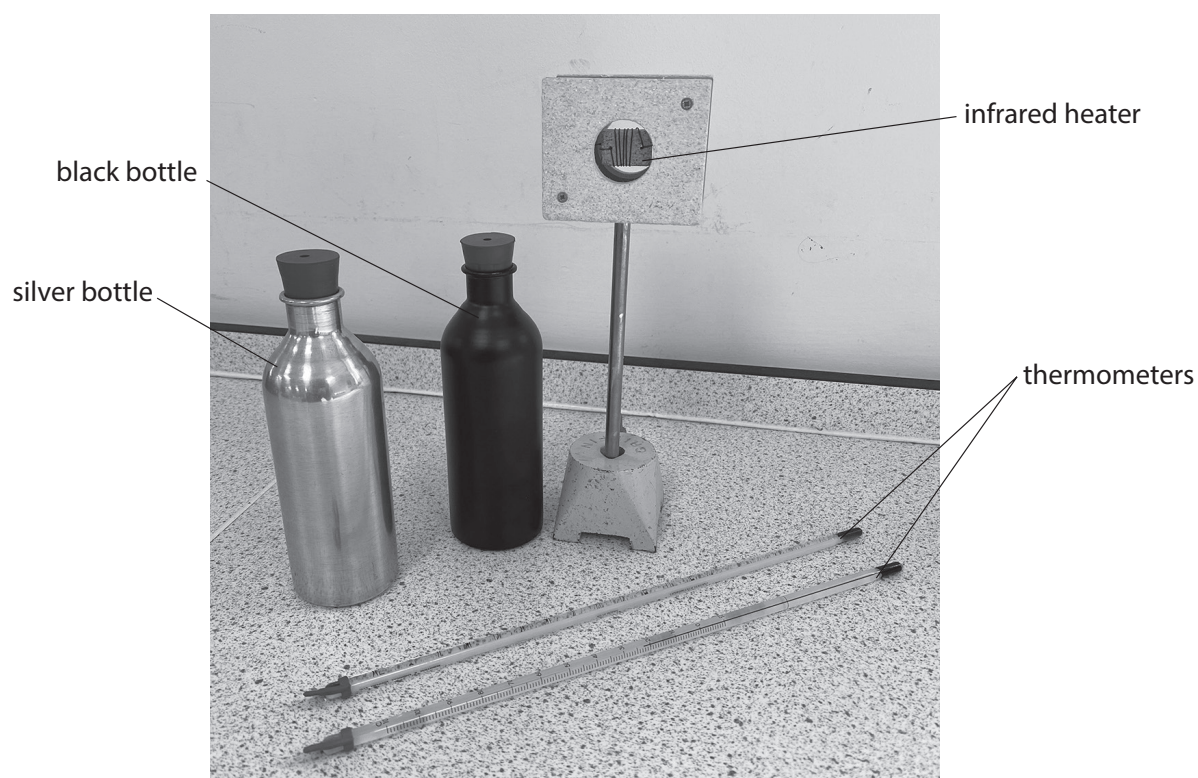
final temperature = ... °C

(Total for Question 6 = 8 marks)



3 A student investigates how much infrared radiation is absorbed by different surfaces.

(a) The photograph shows some of the equipment available to the student.



The student pours some water into each bottle.

Describe a method the student could use to investigate how the colour of the bottle affects the amount of infrared radiation absorbed by the bottle.

You may draw a diagram to help your answer.

(6)

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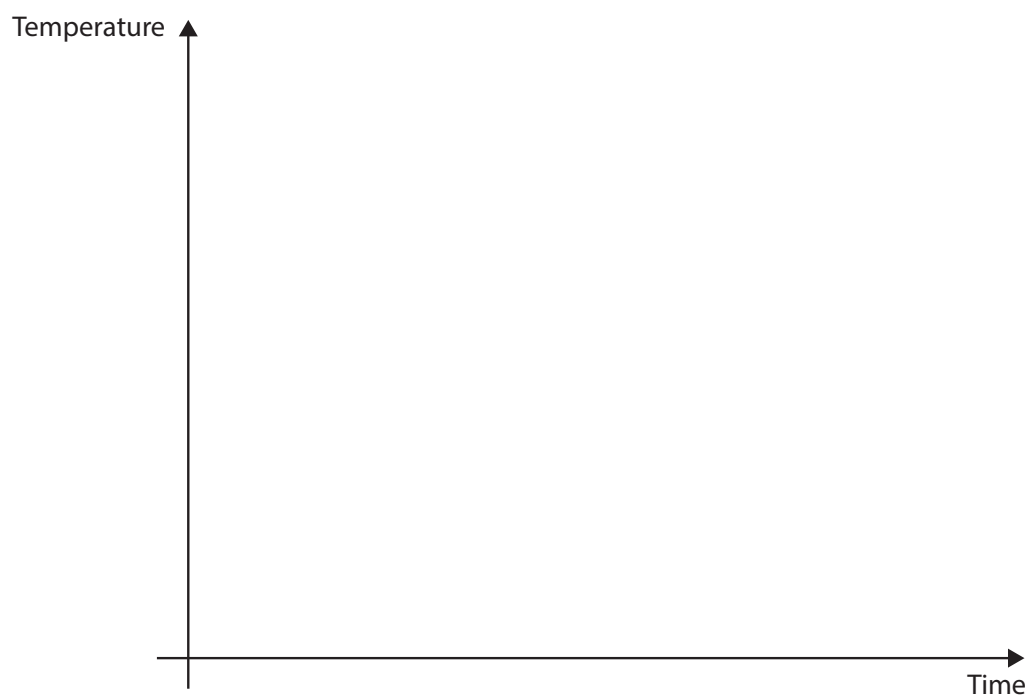
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- (b) The student plots a graph to show how the temperature of the water in each bottle varies with time.

Draw two curves to show the expected variation in temperature of the black bottle and the silver bottle during the investigation.

Label your curves with the colour of each bottle.

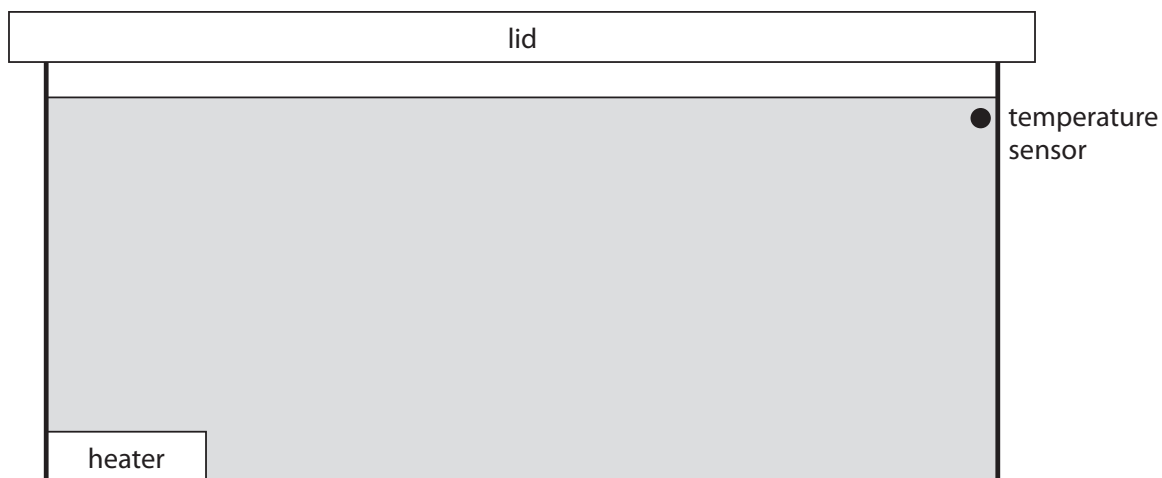
(2)



(Total for Question 3 = 8 marks)

6 The diagram shows a container of water.

The container has a heater in the bottom corner, a temperature sensor and a lid.



(a) Explain how a convection current is formed in the container.

You may add to the diagram or draw your own diagram to support your answer.

(4)

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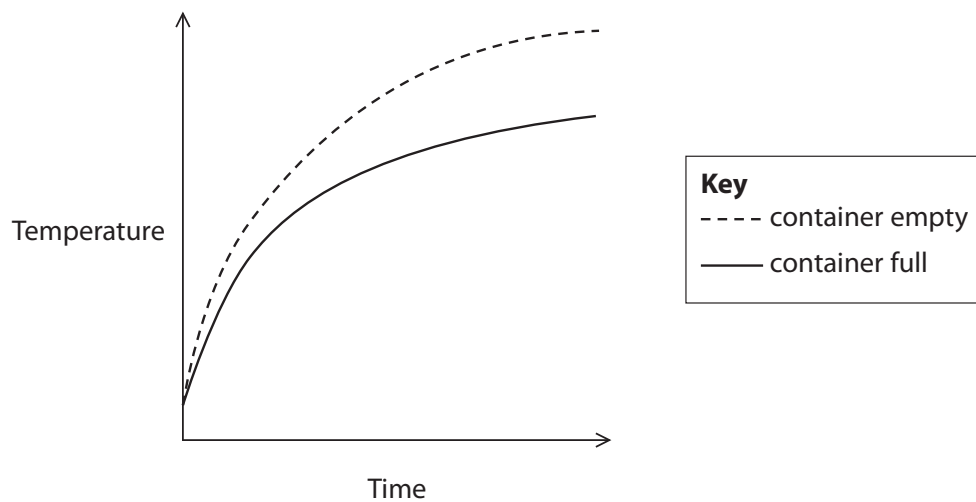
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(b) The graph shows how the temperature sensor reading changes with time.

It shows the change in temperature when the container is full of water and when the container is empty.



(i) Describe the relationship between temperature and time when the container is full of water.

(2)

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(ii) Explain the differences between the two curves on the graph.

(3)

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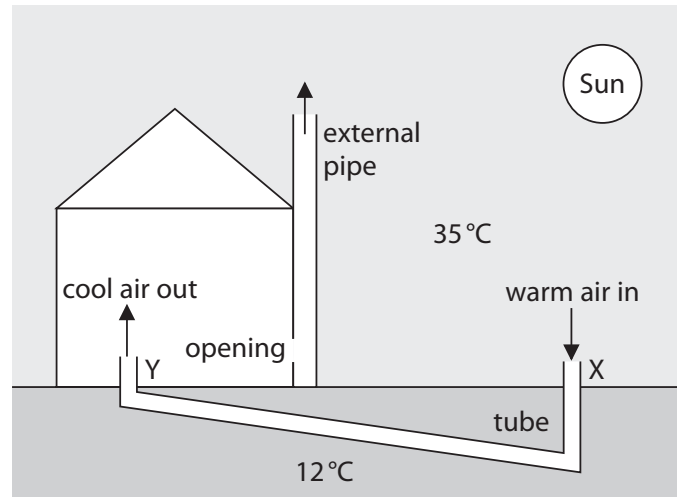
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(Total for Question 6 = 9 marks)

12 The diagram shows a building in a hot climate.

The air temperature is 35°C and the underground temperature is 12°C .

The external pipe is heated by the Sun. This causes cool air to enter the house through a tube in the ground.



(a) How is energy transferred to the external pipe from the Sun?

(1)

- ☒ **A** conduction
- ☒ **B** convection
- ☒ **C** evaporation
- ☒ **D** radiation

(b) Explain why air moves upwards through the external pipe.

(3)

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(c) Warm air enters the tube at point X.

Cool air leaves the tube at point Y.

Explain how the air is cooled as it travels through the tube.

(3)

(d) The external pipe is painted to increase the air flow through the building.

Explain what colour of paint would give the greatest increase in air flow.

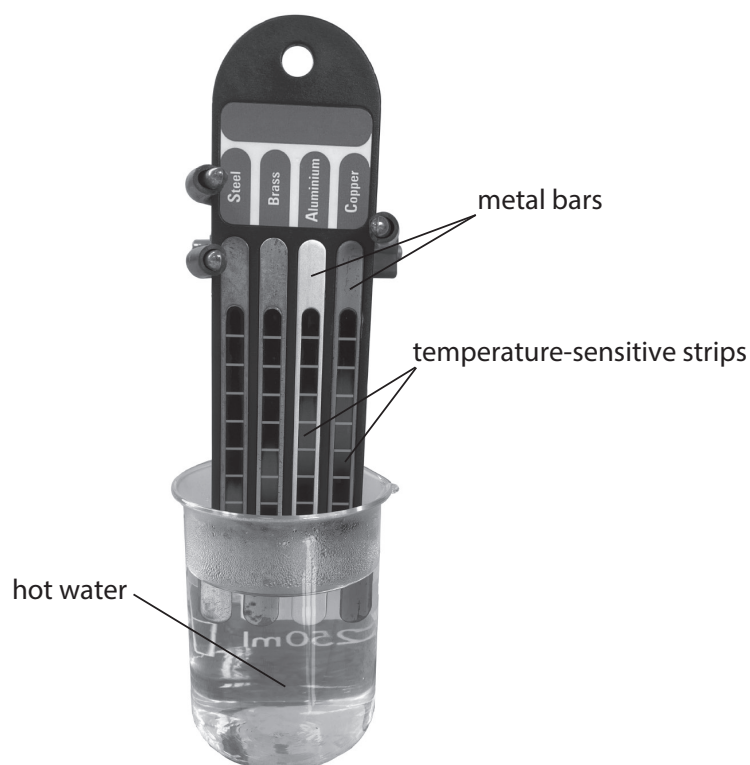
(3)

(Total for Question 12 = 10 marks)



4 A student does an experiment to investigate energy transfer by conduction.

(a) The student plans to use the piece of apparatus shown in the photograph.



The apparatus has four bars made from different metals.

When the apparatus is placed in hot water, energy is transferred from the bottom of the bar to the top of the bar. The temperature-sensitive strip on each bar changes colour as the temperature of the bar changes.

The time taken for the colour change to reach the top of the bar can be used to compare how effective each metal is at transferring energy by conduction.

(i) Give three control variables in the student's investigation.

(3)

- 1
- 2
- 3

(ii) The student has this equipment.

- beaker
- hot water
- stopclock
- clamp and clamp stand

Design a method the student could use to compare the effectiveness of the metals at transferring energy by conduction.

You may draw a diagram to help your answer.

(5)

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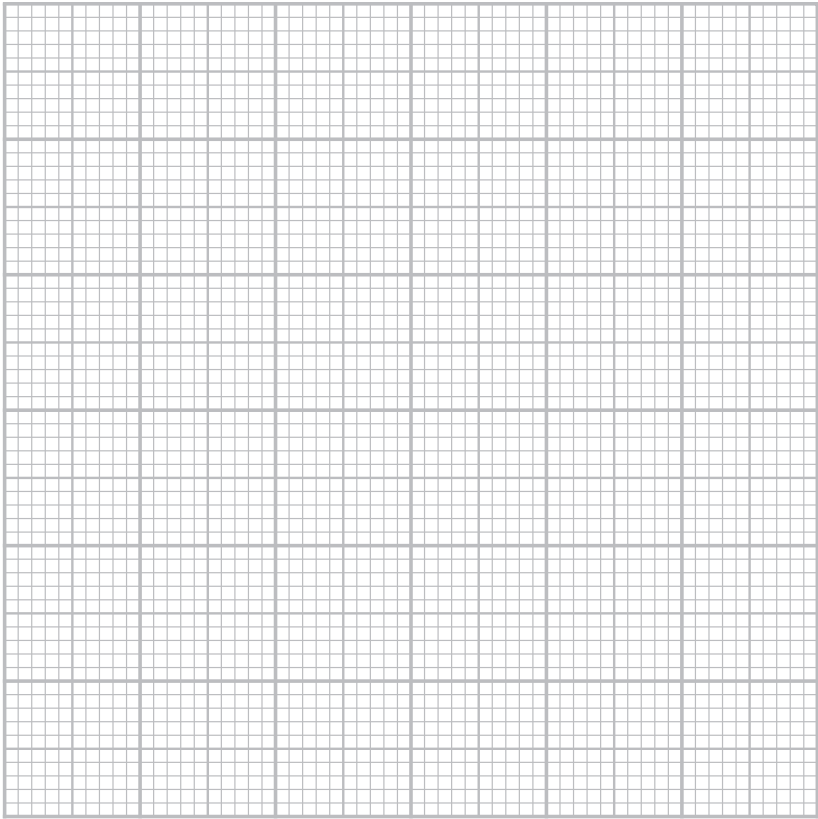
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(b) The table shows the results of the student’s investigation.

Metal	Time taken for colour change in seconds
aluminium	29
brass	64
copper	22
steel	115

(i) Plot a bar chart of the student’s results. (3)



(ii) Deduce which metal is the most effective at transferring energy by conduction.

(2)

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(Total for Question 4 = 13 marks)



7 The photograph shows a cup that is designed to keep a drink hot.

shiny silver-coloured surface



plastic lid

(a) The inside surface of the cup is shiny and silver-coloured.

Explain how the shiny silver-coloured surface helps to keep a drink hot.

(2)

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(b) Explain why a drink in the cup will stay hot for longer when the lid is placed on the cup.

(2)

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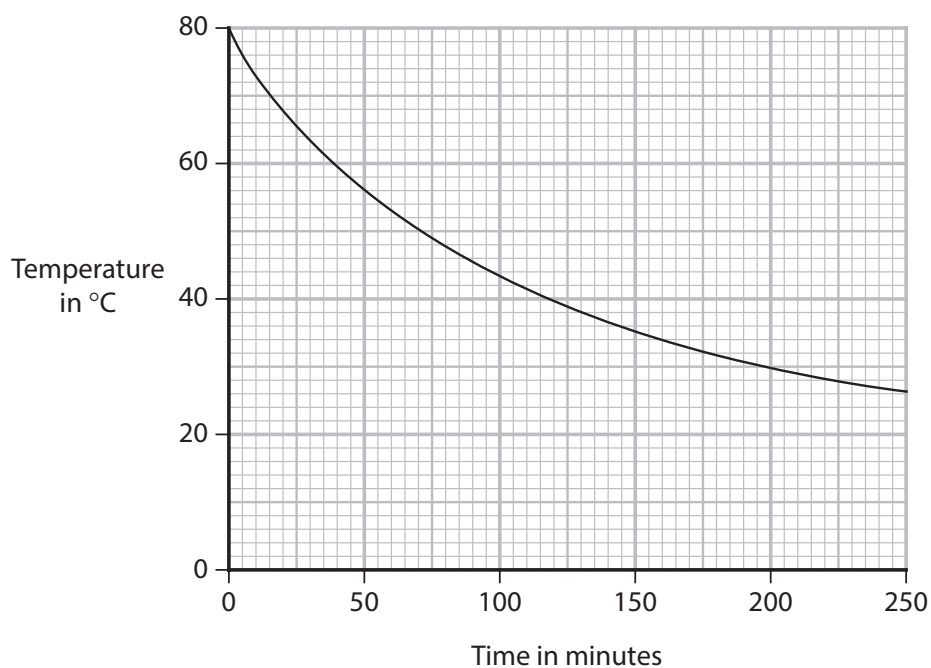
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(c) A student investigates how the temperature of a drink in the cup varies with time.

This is the student's method.

- pour some hot water into the cup and place the lid on the cup
- wait for the water to cool to 80°C and then start a stopwatch
- measure the temperature of the water in the cup every 10 minutes

The graph shows the student's results.



- (i) On the graph, draw a tangent to the curve when the temperature is 40°C .

(1)

- (ii) Calculate the gradient of the tangent to find the rate of temperature change of the water when the temperature is 40°C .

Give your answer in $^{\circ}\text{C}/\text{minute}$.

(3)

rate of temperature change = ... $^{\circ}\text{C}/\text{minute}$

- (iii) The student is working in a laboratory with a room temperature of 20°C .

Draw a line on the graph to show how the temperature of the water in the cup would change if there was no lid on the cup.

(2)

(Total for Question 7 = 10 marks)



SUB-TOPIC 4.3

SPECIFIC HEAT CAPACITY AND HEATING INVESTIGATIONS

Sub-topic 4.3 · 6 questions · 53 marks · lowest tariff first



- 8 Concrete on top of buildings can be used to heat water.

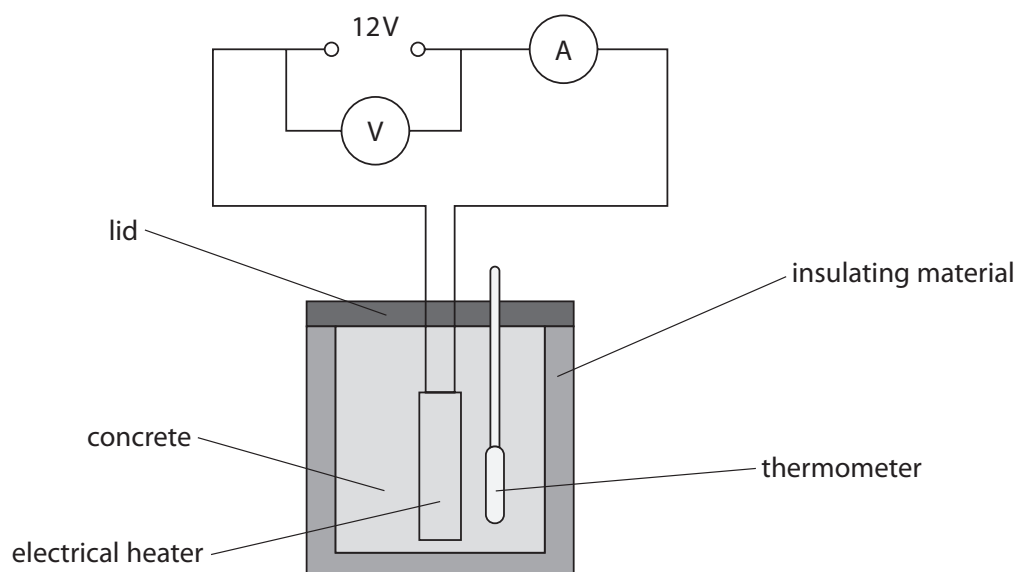
The photograph shows a concrete and water heating system being built into the roof of a house.



(Source: © ejhgndrn/Shutterstock)

- (a) A scientist wants to determine the specific heat capacity of concrete.

The diagram shows some of the equipment they could use.



Describe a suitable method to find the specific heat capacity of concrete.

(5)

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(b) Explain the advantage of the concrete having a high specific heat capacity when it is used to heat water in the heating system.

(2)

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(Total for Question 8 = 7 marks)

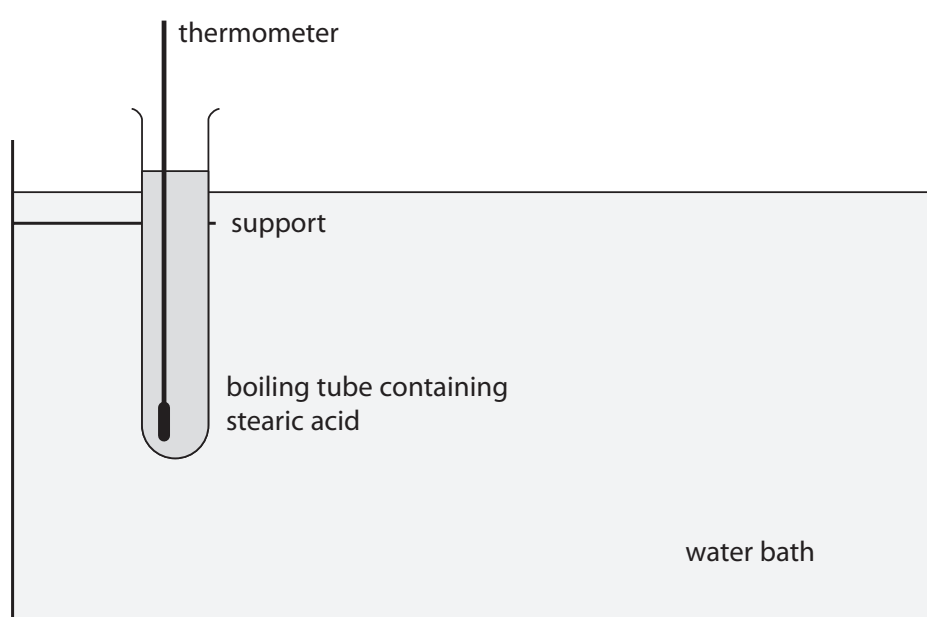


5 This question is about specific heat capacity.

(a) State what is meant by the term **specific heat capacity**.

(3)

(b) The diagram shows a sample of solid stearic acid being heated in a boiling tube using a water bath.



The mass of stearic acid in the boiling tube is 58 g.

When the boiling tube is placed in the water bath, the temperature of the stearic acid increases from 21 °C to 37 °C. The stearic acid does not melt.

As the temperature of the stearic acid increases, an additional 3500 J of energy needs to be transferred electrically to the water bath.

- (i) Using this data, show that the specific heat capacity of the solid stearic acid is approximately 4 J/g °C.

(3)

- (ii) The true value for the specific heat capacity of solid stearic acid is 2.3 J/g °C.

Give a reason for the difference between the value in (i) and the true value.

(1)

(Total for Question 5 = 7 marks)

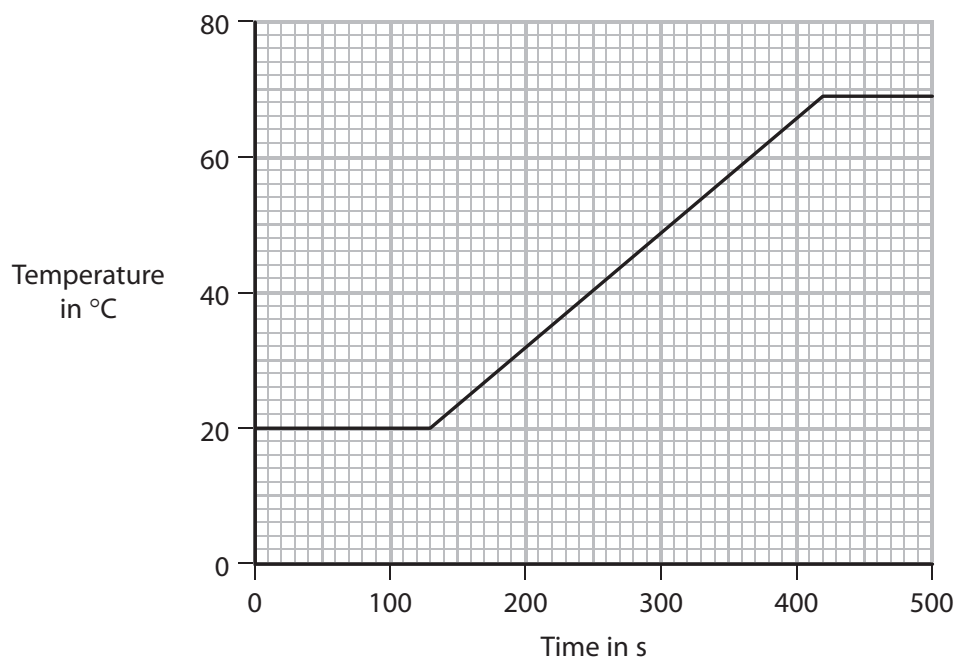


- 5 Stearic acid is a solid at room temperature and melts at a temperature of 69°C .

A student investigates the specific heat capacity of solid stearic acid.

He heats a sample of stearic acid from room temperature using an electrical heater and measures its temperature using a data logger and temperature sensor.

The graph shows his results.



- (a) The student starts heating the stearic acid at 130 seconds.

- (i) Determine the time it takes to heat the stearic acid until it reaches its melting point.

(1)

time = ... s

- (ii) The stearic acid gains 39 kJ of energy during the time it is heated to its melting point.

Calculate the mean (average) power of the heater.

Give a unit with your answer.

[assume no energy lost to surroundings]

(3)

mean power = ... unit



(b) The mass of stearic acid used in the investigation is 0.45 kg.

The stearic acid gains 39 kJ of energy when it is heated to its melting point.

Calculate the specific heat capacity of stearic acid.

You should use data from the graph in your calculation.

(4)

specific heat capacity = ... J/kg °C

(Total for Question 5 = 8 marks)



5 Energy is transferred from the Sun to the Earth.

(a) Nuclear fusion happens in the Sun.

(i) Which energy store of the Sun decreases during nuclear fusion?

(1)

☐ **A** chemical

☐ **B** kinetic

☐ **C** nuclear

☐ **D** thermal

(ii) How is energy transferred through space from the Sun to the Earth?

(1)

☐ **A** by heating

☐ **B** by radiation

☐ **C** electrically

☐ **D** mechanically

(b) Solar panels use energy from the Sun to heat water.



© John_T/Shutterstock

- (i) The total area of the solar panels is 15 m^2 .

Each 1.0 m^2 of the solar panels receives 1000 J of energy per second from the Sun.

Show that the total energy transferred to the solar panels in 2 hours is about 100 MJ .

(3)

- (ii) A mass of 1100 kg of cold water is in the solar panels at an initial temperature of 20°C .

Calculate the final temperature of this water after it has been heated by the Sun for 2 hours.

[specific heat capacity of water = $4200 \text{ J/kg } ^\circ\text{C}$]

(4)

final temperature = ... $^\circ\text{C}$

- (iii) Give a reason why the actual final temperature of the water will be lower than the calculated value.

(1)

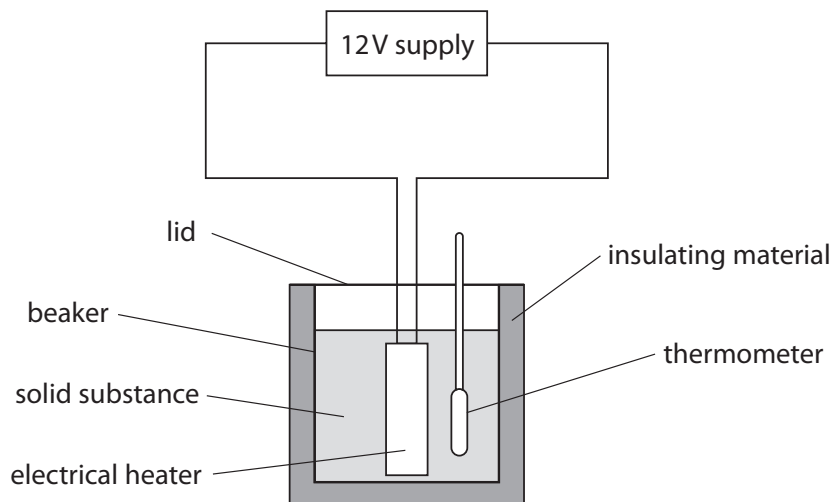
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(Total for Question 5 = 10 marks)



- 5** The diagram shows some of the apparatus a student uses to investigate the effect of heating a solid substance.



- (a) Describe how the student could use their apparatus to help determine the specific heat capacity of the substance.

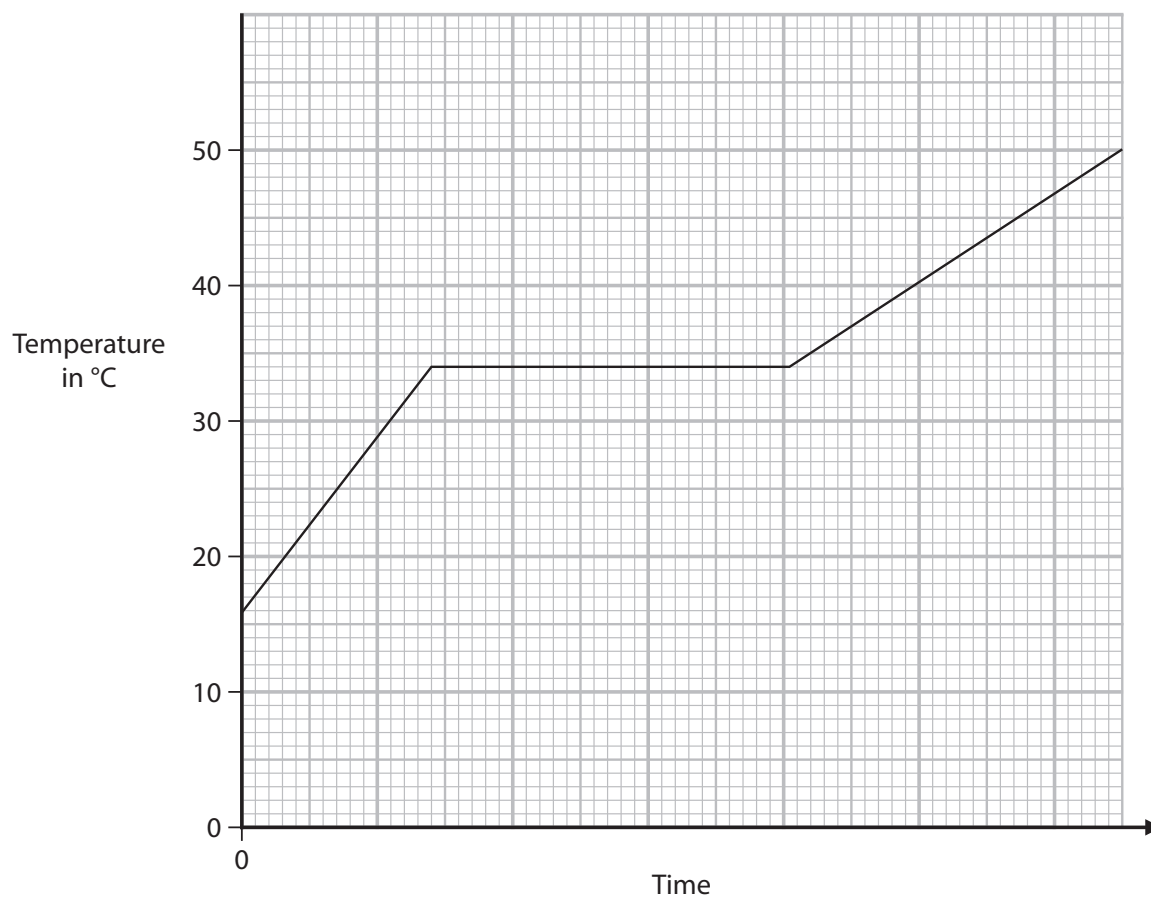
You should give details of any additional apparatus needed in your answer.

(5)

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

(b) The student continues to heat the substance, keeping the power of the heater constant.

The graph shows how the temperature of the substance changes with time.



(i) Use the graph to determine the melting point of this substance.

(1)

melting point = ... °C

(ii) Describe, in terms of particles, what is happening in the substance when the graph line is horizontal.

(2)

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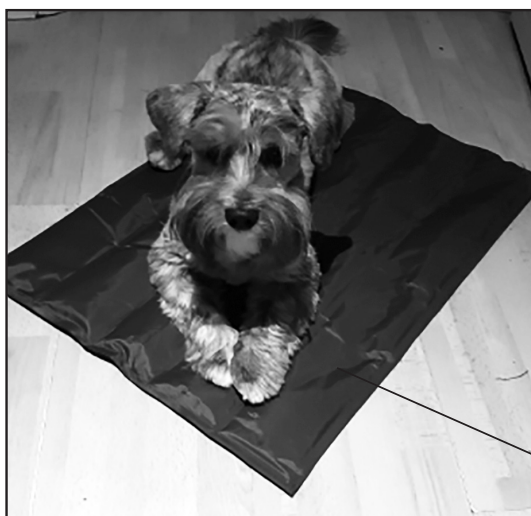
(iii) Suggest why the two non-horizontal lines on the graph have different gradients.

(2)

(Total for Question 5 = 10 marks)



- 6 A dog sits on a water-filled bag to keep cool.



water-filled bag

- (a) The table shows some data about the dog and the water in the bag.

mass of water in kg	8.7
power output of dog by heating in W	75
specific heat capacity of water in J/kg °C	4200
initial temperature of water in °C	16

The dog sits on the bag for 22 minutes.

- (i) Calculate the energy transferred from the dog to the water by heating in 22 minutes.

(3)

energy = ... J

- (ii) State an assumption you have made when calculating the energy transferred.

(1)

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(iii) Calculate the temperature of the water after 22 minutes.

(4)

temperature = ... °C

(b) Discuss why conduction is the main way that thermal energy is transferred from the dog to the water.

(3)

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(Total for Question 6 = 11 marks)



SUB-TOPIC 4.4

ENERGY RESOURCES AND ELECTRICITY GENERATION

Sub-topic 4.4 · 10 questions · 83 marks · lowest tariff first



1 This question is about energy resources.

(a) The table lists some methods of generating electricity using energy resources.

Place ticks (✓) in the table to show if each method uses a renewable energy resource. One has been done for you.

(3)

Method of generating electricity	Uses a renewable energy resource
coal power station	
diesel generator	
geothermal power station	
hydroelectric power station	
natural gas turbine	
nuclear power station	
solar cell	✓
wind turbine	

(b) Solar cells can be used to generate electricity.

(i) How is energy transferred from the Sun to a solar cell?

(1)

- ☐ A by heating
- ☐ B by radiation
- ☐ C electrically
- ☐ D mechanically

(ii) State one disadvantage of using solar cells to generate electricity.

(1)

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(Total for Question 1 = 5 marks)

2 This question is about different methods of generating electricity.

(a) Natural gas can be burned to generate electricity.

Name the energy store that decreases when natural gas is burned.

(1)

(b) Burning natural gas and the movement of water waves can both be used to generate electricity.

Discuss the advantages and disadvantages of these two methods of generating electricity.

(4)

(Total for Question 2 = 5 marks)



- 4 The photograph shows a solar power farm.



© Alessandro Pierpaoli/Shutterstock

- (a) Discuss the advantages and disadvantages of using solar power rather than fossil fuels to generate electricity.

(4)

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(b) Solar panels produce direct current (d.c.).

The National Grid in many countries operates on alternating current (a.c.).

Describe the difference between direct current (d.c.) and alternating current (a.c.).

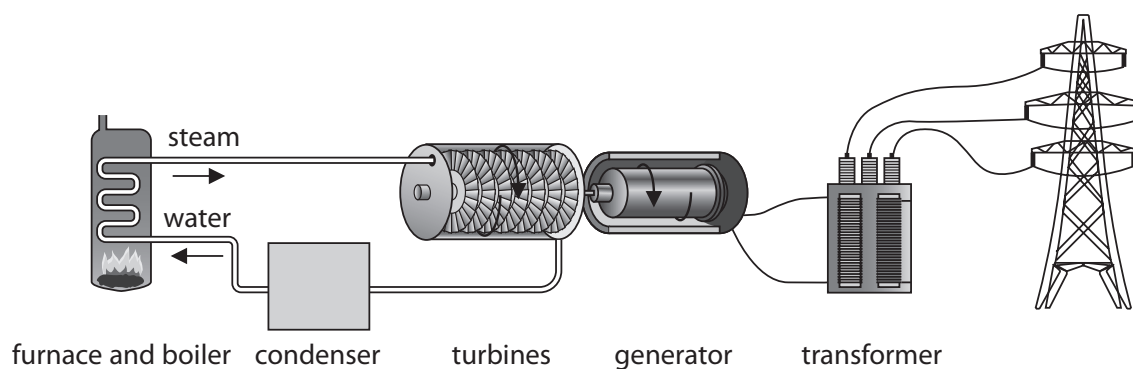
(2)

(Total for Question 4 = 6 marks)



1 (a) The diagram shows a fossil fuel power station.

Five stages of electricity generation and transmission are shown.



(i) The power station burns a fossil fuel in the furnace.

Give an example of a fossil fuel.

(1)

(ii) Which stage of the power station transfers energy from a chemical store to a thermal store?

(1)

- ☐ A condenser
- ☐ B furnace and boiler
- ☐ C generator
- ☐ D turbines

(iii) Which stage of the power station transfers energy electrically from a kinetic energy store?

(1)

- ☐ A condenser
- ☐ B furnace and boiler
- ☐ C generator
- ☐ D turbines

(b) Electricity can also be generated by solar farms.



(Source: © Zoonar GmbH/Alamy)

Energy is transferred from the Sun to the solar farm by radiation.

The solar farm uses photovoltaic cells to transfer this energy electrically.

Discuss the advantages and disadvantages of generating electricity using solar farms.

(4)

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(Total for Question 1 = 7 marks)

- 2 The photograph shows the Three Gorges Dam in China, one of the largest hydroelectric power stations on Earth.



© PRILL/Shutterstock

- (a) State two advantages of generating electricity using hydroelectric power stations.

(2)

1

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2

.....

- (b) Water is held in a reservoir on one side of the dam.

The water flows through turbines to a river on the other side of the dam.

The water level of the river is lower than the water level of the reservoir.

- (i) State which energy store of the water decreases as the water flows from the reservoir to the river.

(1)

.....

- (ii) How is energy transferred from the dam to homes and factories in China?

(1)

- ☐ **A** by heating
- ☐ **B** by radiation
- ☐ **C** electrically
- ☐ **D** mechanically

(c) The Three Gorges Dam has a larger maximum output power than any other hydroelectric power station on Earth.

(i) State what is meant by the term **power**.

(1)

(ii) The mean energy transferred by the dam each day is $9.7 \times 10^{14} \text{ J}$.

Calculate the mean output power of the dam.

(3)

mean output power = ... W

(iii) The maximum output power is 22 500 MW.

Which of these is the same as 22 500 MW?

(1)

- ☐ **A** 22 500 000 J
- ☐ **B** 22 500 000 J/s
- ☐ **C** 22 500 000 000 J
- ☐ **D** 22 500 000 000 J/s

(iv) Suggest why the Three Gorges Dam does not always operate at its maximum output power.

(1)

(Total for Question 2 = 10 marks)

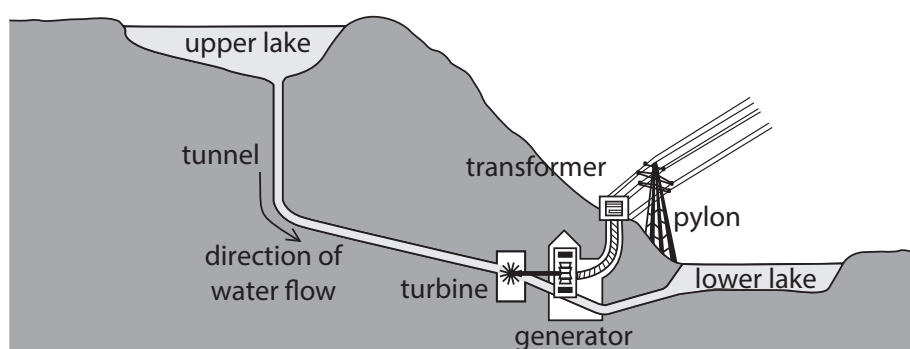


7 A hydroelectric power (HEP) station generates electricity from renewable energy resources.

(a) State what is meant by the term **renewable energy resource**.

(1)

(b) The diagram shows the design of a HEP station.



Water flows from the upper lake to the lower lake through the turbine.

The turbine is connected to a generator, which generates electricity.

Describe the energy transfers involved in generating electricity in the HEP station.

(4)

(c) The HEP station is located near a large wind farm.

- (i) Give one advantage of generating electricity using the HEP station rather than the wind farm.

(1)

- (ii) Give one disadvantage of generating electricity using the HEP station rather than the wind farm.

(1)

- (iii) The HEP station has an electric pump that can pump water from the lower lake back to the upper lake.

The pump can be powered using electricity generated by the wind farm.

Explain how the HEP station and wind farm can be used together to maximise the effectiveness of generating electricity.

(3)

(Total for Question 7 = 10 marks)



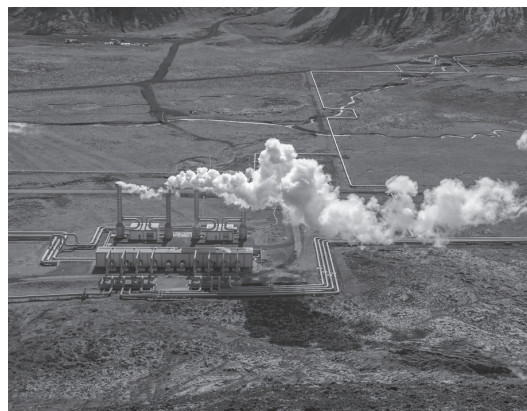
6 This question is about generating electricity from renewable energy resources.

(a) Photograph 1 shows a solar farm in the United Kingdom and photograph 2 shows a geothermal power station in Iceland.



Photograph 1

(Source: © Marcin Jucha / Shutterstock)



Photograph 2

(Source: © Javarman / Shutterstock)

Discuss the advantages and disadvantages of generating electricity using solar power and geothermal resources.

(4)

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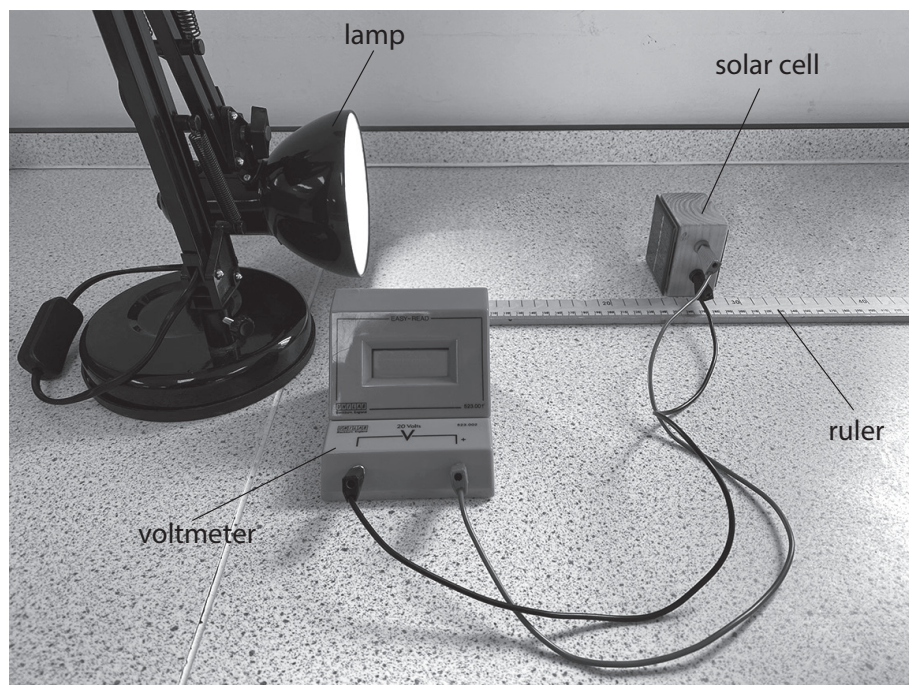
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- (b) A student investigates how the amount of light affects the output voltage of a solar cell.

Photograph 3 shows how the student sets up their equipment.



Photograph 3

- (i) The student varies the distance between the solar cell and the lamp and measures the output voltage of the solar cell at each distance.

The student's results are shown below.

5 cm, 0.45 V	14 cm, 0.06 V
8 cm, 0.18 V	17 cm, 0.04 V
11 cm, 0.10 V	20 cm, 0.03 V

Draw a table showing the student’s results. (3)

(ii) Give a control variable for the student’s investigation. (1)

(iii) The student states that the solar cell could be used as a power source for the lamp. (2)

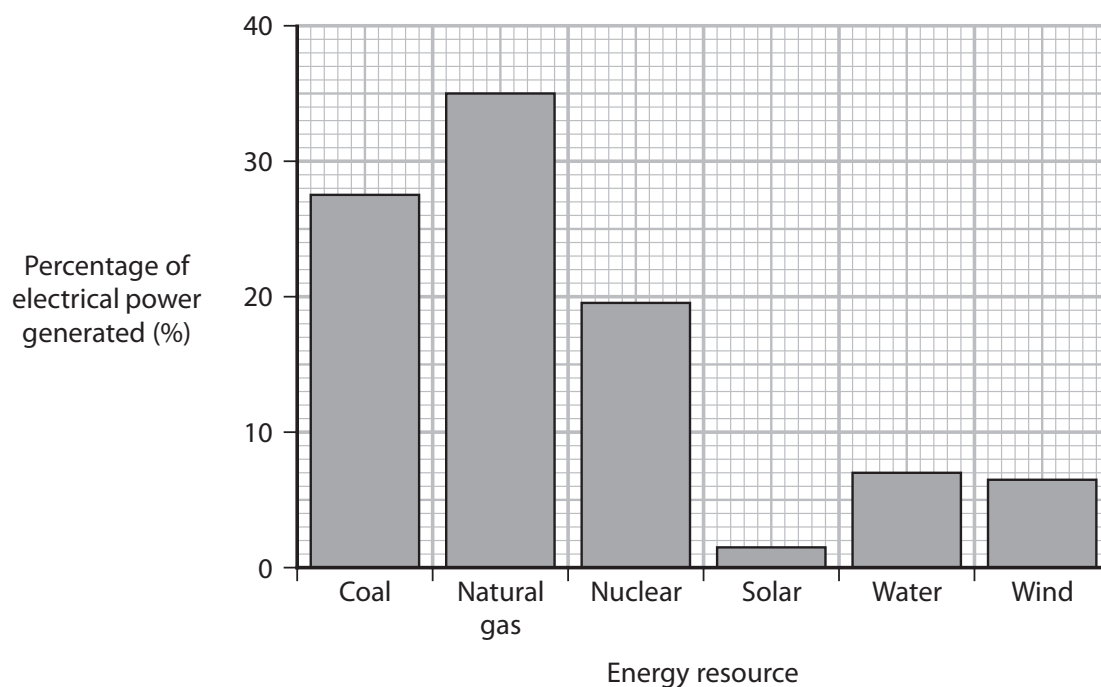
They suggest that this would work if

- the solar cell is connected directly to the lamp
- the light from the lamp is used to produce the output power from the solar cell

Explain, with reference to the principle of conservation of energy, why the student’s suggestion would not work.

(Total for Question 6 = 10 marks)

- 4 The bar chart gives information about how some of the electrical power in the United States of America (USA) was generated in the year 2018.



- (a) Most of the electricity generated in the USA uses non-renewable energy resources.

(i) State what is meant by the term **non-renewable**.

(1)

- (ii) Determine the percentage of electrical power generated using the non-renewable energy resources shown on the bar chart.

(2)

percentage = ...%

- (b) In 2018, the USA generated more than half of its electrical power by burning fossil fuels.

Explain one way that burning fossil fuels can be harmful to the environment.

(2)

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- (c) The mean total electrical power output of the USA in 2018 was 4.76×10^{11} W.

(i) Calculate the mean electrical power output from solar energy resources.

(2)

mean electrical power output = ... W



(ii) The mean total electrical power output of the USA in 2018 was $4.76 \times 10^{11} \text{ W}$.

A typical solar farm generates 250 W of electrical power for every 1.0 m^2 of land area used.

Calculate the amount of land area needed if the USA were to generate all of its electrical power using solar energy resources.

(2)

land area = ... m^2

(iii) The total land area of the USA is $9.83 \times 10^{12} \text{ m}^2$.

Discuss whether the USA could generate all of its electrical power using solar energy resources.

(3)

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(Total for Question 4 = 12 marks)



- 3 The photograph shows a camper van with a solar panel on its roof. The solar panel is made from lots of solar cells connected together.



(Source: © kostasgr/Shutterstock)

The solar panel is connected to a battery. The solar panel receives energy from the Sun to charge the battery.

- (a) Describe how energy is transferred from the Sun's energy store to the battery's energy store.

(3)

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- (b) The petrol engine can also be used to charge the battery of the camper van.

Give an advantage of using the solar panel instead of the petrol engine to charge the battery.

Do not refer to cost in your answer.

(1)

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.....

- (c) The surface of the solar panel is black.

Explain why black is a suitable colour for the solar panel.

(2)

- (d) The solar panel can charge the battery in the camper van with a maximum current of 15 A.

Calculate the minimum time to transfer 360 000 C of charge through the battery.

Use the formula

$$\text{charge transferred} = \text{current} \times \text{time}$$

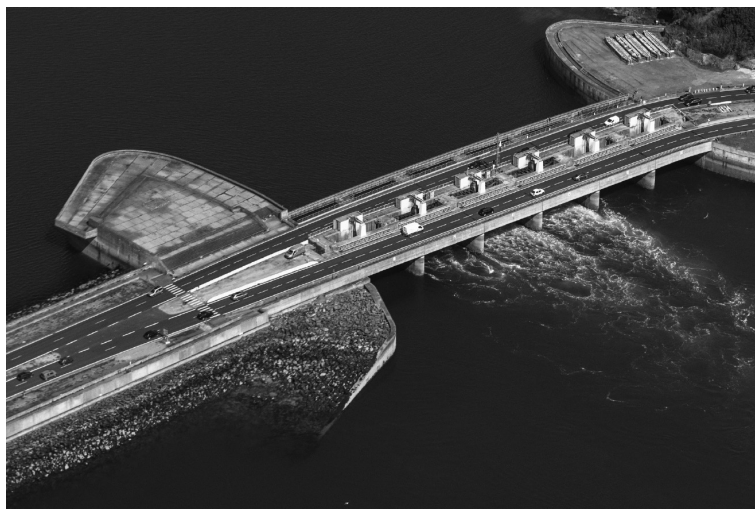
(3)

minimum time = ... s

(Total for Question 3 = 9 marks)

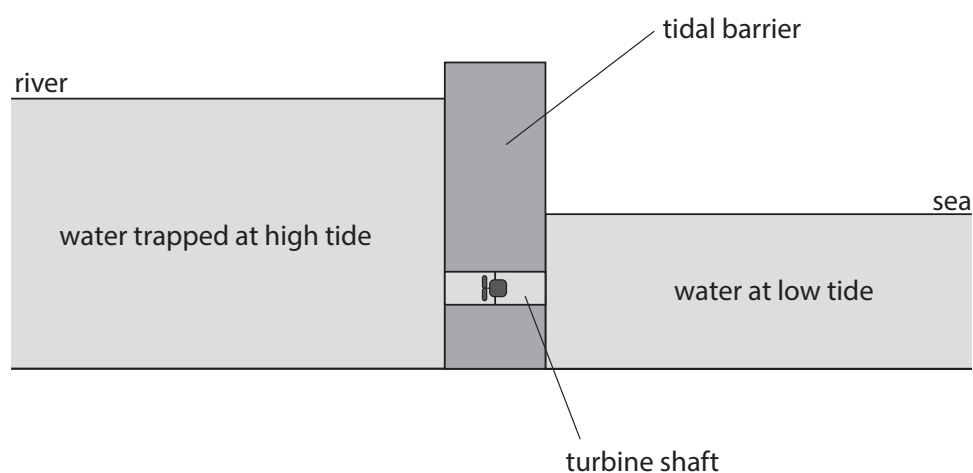


- 3 The photograph shows the tidal power station across the estuary of the river Rance in France.



(Source: © Francois BOIZOT/Shutterstock)

The diagram shows a simplified view of the tidal power station.



At high tide, water is trapped behind the tidal barrier.

At low tide, the trapped water is released through the turbine shaft. This causes a turbine to spin, which generates electricity.

- (a) Give two advantages of generating electricity using tidal power.

(2)

1

2

(b) Give two disadvantages of generating electricity using tidal power.

(2)

1

.....

2

.....

(c) At low tide, water flows through the turbine shaft.

As the height of the trapped water in the river decreases, water falls through a height of 8.0 m to reach the turbine shaft.

- (i) Calculate the energy transferred from the gravitational store of the water when 1.0 kg of water flows through the turbine shaft.

Use the formula

$$\text{change in gravitational potential energy} = \text{mass} \times g \times \text{height}$$

(2)

energy transferred = ... J

- (ii) The tidal power station has a maximum power output of 240 000 kW when water falls through a height of 8.0 m.

Calculate the mass of water flowing through the turbine shaft in 1 second when the power station is operating at maximum power.

Assume the power station is 100% efficient.

(3)

mass of water = ... kg

(Total for Question 3 = 9 marks)



MARK SCHEMES

official mark schemes



Question number	Answer	Notes	Marks
5 (a)	wires have a higher current / voltage;	allow idea that if one breaks the rest will keep working / some can be on but not others / eq	1
(b) (i)	power = current $\times$ voltage;	allow standard symbols and rearrangements e.g. $P = I \times V$ reject C for current, W for power	1
(ii)	substitution; rearrangement; evaluation; e.g. $2800 = \text{current} \times 230$ (current =) $2800 / 230$ (current =) 12 (A)	in either order -1 for POT error allow 12.17...(A)	3
(iii)	(current = $12 / 48$ =) 0.25 (A)	allow ecf from (ii)	1

Total for Question 5 = 6 marks

Question number	Answer	Notes	Marks
6	max. 2 marks for details of varying temperature MP1. suitable method of heating ball; MP2. thermometer used to measure temperature; max. 2 marks for control variables MP3. height ball is dropped from; MP4. bouncing surface; MP5. ball dropped from rest each time; max. 2 mark for high-quality data MP6. suitable method to increase/give good accuracy of bounce height measurement; MP7. at least five different temperatures tested; MP8. repeats and average;	any mark can be given from labelled diagram e.g. water bath, oven, freezer, heating water in beaker allow temperature sensor and data logger ignore "same ball" allow idea of no force being used to drop ball e.g. viewing at eye level, recording with camera and viewing at slow motion can be inferred from method	6

Total for Question 6 = 6 marks



Question number	Answer	Notes	Marks
1 (a)		-1 for each additional line	4
(b) (i)	A - electrical;		1
(ii)	B - light radiation;		1

(Total for Question 1 = 6 marks)

Question number	Answer	Notes	Marks
12 (a)	substitution into $GPE = \text{mass} \times g \times \text{height}$; at least one quantity correctly converted to SI units; correct evaluation; e.g. $GPE = 0.580 \times 10 \times 0.92$ mass = 0.580 (kg) OR height = 0.92 (m) (GPE =) 5.3 (J)	allow substitution with no unit conversions allow $g = 9.8, 9.81$ allow 5.2, 5.34, 5.336, 5.23...	3
(b)	any four from: MP1. mention of energy being transferred <u>mechanically</u> at any stage in the response; MP2. (before it is dropped) dough initially has energy in its gravitational store (and no energy in its kinetic store); MP3. (just before it hits the floor) energy is in the dough's kinetic store (and less energy in its gravitational store); MP4. (as the dough falls / after the dough has hit the floor) the thermal store of the air / floor / surroundings has increased; MP5. (after the dough has hit the floor) the thermal/elastic store of the dough has increased (and the kinetic store of the dough is zero); MP6. energy has been transferred to the surroundings (mechanically and) by radiation;	condone the ball initially having GPE condone energy transferred to KE condone energy transferred to heat energy of the surroundings ignore references to sound energy condone energy transferred to elastic/heat energy of the dough	4

Total for Question 12 = 7 marks



Question number	Answer	Notes	Marks
3 (a)	substitution into given formula; rearrangement; correct evaluation; e.g. $0.27 = \text{energy} / 43\,200$ $\text{energy} = 0.27 \times 43\,200$ $(\text{energy} =) 12\,000 \text{ (J)}$	ignore units allow $E = P \times t$ -1 for not converting units or converting units incorrectly if no other mark scored then evidence of 43 200 seen in working scores 1 mark allow 11 700, 11 660, 11 664 (J) 3.24 (J), 194.4 (J) or answers rounded from these values score 2 marks	3
(b) (i)	idea that current exceeds the fuse rating; fuse (wire) melts; idea that device is isolated;	allow when current is too high, surge of current etc. ignore current increasing allow fuse breaks, fuse blows ignore fuse burns allow idea that circuit is broken	3
(ii)	any two from: MP1. idea that fuse rating is much higher than normal current; MP2. idea that there is still current (even if there is a fault); MP3. idea that (connecting lead/TV) will overheat/cause a fire;	allow fuse value is too high allow fuse will not melt/break/blow allow idea of causing damage to TV / circuit	2

Total for Question 3 = 8 marks



Question number	Answer	Notes	Marks
7 (a)	0 / none / zero (J);		1
(b)	substitution into given formula $E = V \times I \times t$; correct evaluation to at least 3 s.f.; e.g. energy = $7.1 \times 3.9 \times 0.42$ energy = 11.6... (J)	allow use of $P = E/t$ and $P = VI$	2
(c)	energy transferred to motor electrically from battery 12 J; kinetic energy store of motor 10 J; thermal store of the surroundings 2 J;	allow electric, electrical condone heat	3
(d)	useful and total energies correctly selected; substitution into efficiency formula; evaluation; e.g. 10 (J) and 12 (J) seen in working efficiency = $10/12 (\times 100\%)$ efficiency = 83 (%)	allow ecf from (c) allow lack of 100 i.e. 0.83 if % sign removed from answer line allow 83.3... (%)	3

Total for Question 7 = 9 marks

Question number	Answer	Notes	Marks
9 (a) (i)	recall of (unbalanced) force = mass × acceleration; substitution and rearrangement; evaluation to 2 s.f. or more; e.g. $F = m \times a$ $a = 41000 / 830$ $a = 49 \text{ (m/s}^2\text{)}$	allow symbols can be implied from valid substitution of data allow 49.39...	3
(ii)	substitution into $v^2 = u^2 + 2as$; rearrangement; evaluation; e.g. $26^2 = 72^2 + 2 \times (-50) \times s$ (distance =) $5184 - 676 / 100$ (distance =) 45 (m)	allow ecf from (i) expect answers in range 45-46 (m) reject $72 - 26 = 46$ (wrong physics) accept 46 if unqualified	3
(b)	kinetic energy (store) of car decreases; thermal energy (store) of brake(s) increases; energy transferred mechanically;	kinetic energy/ KE of car transforms to {heat/thermal} energy of brakes due to work done by {friction / brakes} NB only award from either the answer column or notes column, not from a mix of the two.	3
(c)	any two from: MP1. idea that insulating materials are poor conductors; MP2. layers trap air; MP3. air itself is a poor conductor/(good) insulator MP4. (energy transfer due to / rate of) conduction reduces; MP5. idea increased thickness reduces (rate of) conduction	condone idea of stopping conduction	2

Total for Question 9 = 11 marks

Question number	Answer	Notes	Marks
8 (a)	take repeats and find the mean;	allow 'average' for 'mean'	1
(b)	any two from: MP1. mass (being lifted); MP2. height (lifted) / distance; MP3. power supply / circuit being used; MP4. temperature (of motor);	ignore 'same motor' condone weight	2
(c)	conversion of cm to m; substitution into $GPE = \text{mass} \times g \times \text{height}$; e.g. $50 \text{ cm} = 0.5 \text{ m}$ $GPE = 1 \times 10 \times 0.5 (= 5 \text{ J})$	allow 0.5 seen anywhere allow use of $g = 9.8(1) \text{ (m/s}^2\text{)}$	2
(d) (i)	efficiency formula seen; substitution; evaluation; e.g. efficiency = useful energy output / total energy input efficiency = $5 / 12.7 (\times 100\%)$ efficiency = 39.4 (%)	ignore s.f. allow 39, 39.37... reject unsupported incorrect answer	3
(ii)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and unit; all plotting correct to nearest half square;	ignore orientation ignore plotting at 10V	3
(iii)	acceptable curve of best fit drawn up to a voltage of 6V; straight horizontal line of best fit drawn from 6V onwards;	i.e. curved line with even distribution of points either side by eye	2
(iv)	correctly read voltage from graph consistent with candidate's curve of best fit;	allow range 5.4V - 6.6V allow ecf from (iii)	1

Total for Question 8 = 14 marks



Question number	Answer	Notes	Marks
6 (a)	idea that reaction time is an issue / eq;	allow student (A) starts/stops stopwatch early/late allow student (B) starts running early/late ignore human error, comments relating to time for sound to travel	1
(b) (i)	selection of $GPE = mgh$; substitution; evaluation to more than 2s.f.; e.g. $GPE = mgh$ $GPE = 67 \times 10 \times 24 \times 0.19$ $GPE = 3055.2 \text{ (J)}$	condone omitting factor of 24 for this mark only allow use of $g = 9.8$, 9.81 ignore POT errors from not converting cm to m allow 3055, 3060, 3100, 2994, 2997.1... (J)	3
(ii)	evaluation of mean; rounded to 3s.f.; e.g. mean time = $(4.28 + 4.95 + 4.65) / 3 = 4.626...$ mean time = 4.63 (s)	independent mark	2
(iii)	substitution into $P = E/t$; evaluation; e.g. power = $3055.2 / 4.63$ power = 660 (W)	allow ecf from (i) and (ii) allow 646 - 671 (W)	2
(c)	any four from: MP1. not enough data points to make a valid conclusion; MP2. idea of testing a greater range of masses; MP3. idea of testing masses in between values; MP4. idea that there is a general (weak) positive correlation;	ignore students are correct / incorrect allow idea that more students/readings are needed allow power increases with mass for the first two data points	4

	MP5. idea that one of the data points could be anomalous; MP6. if first data point considered anomalous then there is a (weak) negative correlation; MP7. idea that final three data points suggest that power could be independent of mass; MP8. person with greatest mass does not have the greatest power;	allow any named data point allow power decreases with increasing mass ignoring the first data point allow final three data points have approximately same power allow statement that 69kg person has the greatest power	
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Total for Question 6 = 12 marks

Question number	Answer	Notes	Marks
9 (a) (i)	B (elastic); A is incorrect because there is no transfer from a chemical store C is incorrect because the gravitational potential store decreases D is incorrect because the spring is stationary in both cases		1
(ii)	any six from: MP1. elastic energy (store) decreases (on way up); MP2. kinetic energy (store) increases (on way up); MP3. gravitational (store) increases (on way up); MP4. idea of process reversing as mass moves downwards; MP5. energy transferred mechanically; MP6. idea of amplitude of oscillations decreasing over time; MP7. (eventually all) energy is transferred to thermal store of spring/surroundings; MP8. (mechanically) by friction between spring and surroundings	 allow reference to 'slowing down' to mean 'max speed decreasing' allow reference to reduction in total energy of mass/spring condone heat for thermal alternate energy transfer scheme: MP1 EPE converted to KE (on way up) MP2 EPE converted to GPE (on way up) MP3 KE converted to GPE (after midway point)	6
(b) (i)	B (it increases the efficiency of the motorcycle);		1

	A is incorrect because it decreases the energy transferred from fuel each second C is incorrect because it does not affect the speed D is incorrect because it does not affect the braking power		
(ii)	magnet(s) move through coil; idea of coil cutting magnetic field lines;	allow RA condone 'magnet slides through coil' (candidate has realised this is relevant) ignore fields interacting accept reference to changing magnetic flux	3
(iii)	inducing a voltage; bigger or more (frequent) bumps; magnet(s) have bigger amplitude of motion / magnet(s) caused to move more times (per metre of road); (so) induced voltage / voltage generated is larger or for a longer time in total;	accept potential difference, p.d. or EMF for voltage condone 'induces a current' allow RA allow idea of shorter time between bumps allow up and down for bump ignore unqualified 'moves more' (needs idea of a quantity e.g. size, speed) allow coil for magnet allow current for voltage	3

Total for Question 9 = 14 marks



Question number	Answer	Notes	Marks
11 (a)	conversion of units from g to kg; substitution; evaluation; evaluation given to 3 s.f.; e.g. $159 \text{ g} = 0.159 \text{ kg}$ $(KE =) \frac{1}{2} \times 159 (\times 10^{-3}) \times 54.82$ $(KE =) 238.74... \text{ (J)}$ $(KE =) 239 \text{ (J)}$	allow 0.159 seen anywhere in working ignore units note: take care not to penalise POT error twice here independent mark	4
(b) (i)	substitution; rearrangement; evaluation to 3 or more s.f.; e.g. $54.8 = \Delta f / 2.90 \times 10^{10} \times 3.00 \times 10^8 / 2$ $\Delta f = 54.8 \times 2.90 \times 10^{10} \times 2 / 3.00 \times 10^8$ $(\Delta f =) 10.59... \times 10^3 \text{ (Hz)}$	allow in either order allow any value that rounds to 1.06×10^4 accept non-standard form e.g. 10.6×10^3 accept answer not in standard form $10594.6... \text{ (Hz)}$ award 1 mark max for a successful attempt at calculating the speed that gives a shift of $1.1 \times 10^4 \text{ (Hz)}$ i.e. $56.8... \text{ (m/s)}$	3
(ii)	frequency (of radio waves) decreases; wavelength increases; speed of (radio) waves stays the same;	condone 'waves stretch'	3

Total for Question 11 = 10 marks

Question number	Answer	Notes	Marks
6	any six from: MP1. cup slows down/stops energy transfer to surroundings; relating to conduction: MP2. vacuum contains no particles; MP3. reducing/stopping conduction (through the sides); MP4. plastic (lid) is a poor conductor / good insulator; relating to convection: MP5. air is trapped by the lid; MP6. reducing/stopping convection (from the surface); relating to radiation: MP7. (inner) shiny surface is poor absorber of infrared / radiation; MP8. (outer) shiny surface is poor emitter of infrared / radiation; MP9. energy transfer by radiation reduced/stopped;	allow idea that <u>energy</u> is trapped ignore 'heat is trapped' allow reducing/stopping evaporation allow idea that inner surface reflects heat	6

Total for Question 6 = 6 marks



Question number	Answer	Notes	Marks
7	any six from: MP1. cat X loses more energy by conduction / convection than cat Y; MP2. cat Y loses more energy by radiation than cat X; MP3. fur traps air; MP4. larger surface area increases conduction (losses); MP5. air is a (good) insulator/ poor conductor; MP6. fur is a (good) insulator / poor conductor; MP7. trapped air cannot move around; MP8. trapped air reduces convection; MP9. black surfaces are better emitters / emit radiation faster;	allow RA throughout ignore black surfaces being better absorbers	6

Total for Question 7 = 6 marks

Question number	Answer	Notes	Marks
10 (a)	black because it is a better/good absorber; of radiation (from the Sun);	ignore references to emission allow IR, infrared for radiation	2
(b)	any four from: MP1. temperature of air increases; MP2. air expands / air particles move further apart; MP3. density of air decreases; MP4. warm/heated air rises; MP5. cool air replaces warmed air; MP6. process repeats;	allow air particles gain KE reject particles expand reject particles become less dense ignore heat rises allow cool air sinks	4

Total for Question 10 = 6 marks

Question number	Answer	Notes	Marks
8 (a)	any reference to absorption or reflection (of infra-red/heat); idea that snow/white objects are poor absorbers/good reflectors (of infra-red/heat);	also scores first mark	2
(b)	any two from: MP1. idea that ground / drain cover is warmer than snow; MP2. idea that drain cover / metal is a good conductor; MP3. energy transfers from drain cover to snow;	allow RA condone heat for energy must be correct direction of energy transfer	2
(c)	any two from: MP1. idea that warmer air rises; MP2. idea that colder air is nearest the snow; MP3. (rate of) energy/heat transfer (from air) to snow decreases;	allow RA allow warm particles rise ignore nearest the ground	2

Total for Question 8 = 6 marks

Question number	Answer	Notes	Marks
12 (a)	substitution into given equation, $\text{efficiency} = \frac{\text{useful output energy}}{\text{total output energy}} \times 100\%$ rearrangement; evaluation of total output energy; evaluation of wasted energy; e.g. $0.16 = 1800 / \text{total output}$ $\text{total output} = 1800 / 0.16$ $\text{total output} = 11\,250 \text{ (J)}$ $(\text{wasted energy} = 11\,250 - 1800 =) 9500 \text{ (J)}$	11250 (J) seen -1 POT here i.e. subtracting 1800 (J) from candidate's total output energy or calculating 84% of total output energy ecf wrong total output energy allow 9450 (J)	4
(b)	any two from: MP1. wrap beaker in insulation; MP2. cover top of beaker; MP3. fully immerse boiling tube in water; MP4. shiny outer layer to the beaker; MP5. use a thinner (walled) boiling tube MP6. use a better conducting boiling tube	allow use a plastic beaker or beaker with better insulating properties allow 'use a lid' allow use a smaller boiling tube i.e. use a metal boiling tube	2

Total for Question 12 = 6 marks



Question number	Answer	Notes	Marks
4 (a) (i)	by radiation / by (infrared) light;	ignore "heat" Allow EM waves/IR, condone visible, UV, sunlight	1
(ii)	(average speed) increases;	condone "light rays" e.g. "faster"	1
(b) (i)	Either idea that water temperature is greater than the outside temperature; Or not receiving radiation / light from the Sun;	allow RA condone 'heat' or 'sunlight' for 'light' or 'radiation'	1
(ii)	any four from: MP1. cover traps air; MP2. (trapped) air is a poor conductor / (good) insulator; MP3. plastic is a poor conductor / (good) insulator; MP4. conduction reduced; MP5. convection reduced / stopped; MP6. less evaporation (from water surface);	ignore reference to radiation ignore 'traps heat' condone "conduction stopped" condone "no evaporation"	4

Total for Question 4 = 7 marks

Question number	Answer	Notes	Marks
6 (a) (i)	reference to reflection or absorption; white is a good reflector/poor absorber;	ignore reference to emission	2
(ii)	any TWO from: air is a (good) insulator / poor conductor; reduction in convection; idea that trapped air cannot circulate;		2
(b)	substitution into given equation (energy = $mc\Delta\theta$); rearrangement; evaluation of temperature change; evaluation of final temperature; e.g. $210\,000 = 4.5 \times 4200 \times \Delta T$ $\Delta T = 210\,000 / (4.5 \times 4200)$ $\Delta T = 11\ (^{\circ}\text{C})$ final temperature = $46\ (^{\circ}\text{C})$	ecf incorrect temp change accept $35(^{\circ}\text{C})$ for 3 marks if supported with working that shows evidence of a temperature change of $11 \times 10^{-3}\ (^{\circ}\text{C})$	4

Total for Question 6 = 8 marks

Question number	Answer	Notes	Marks
3 (a)	any six from: MP1. idea of equal volume of water in each bottle;	allow marks from suitable diagram	6
	MP2. place both bottles an equal distance from the heater; MP3. idea of same heater output for both bottles;	condone have 'heater setting' the same for both bottles	
	MP4. same starting temperature of water in both bottles;	allow 'measure initial temp of water'	
	MP5. measure temperature of water in both bottles after a given time;	allow measure time in for a given temperature change	
	MP6. repeat investigation (more than once);	i.e. the candidate has shown they understand that both bottles have been measured more than once	
	MP7. calculate a mean;	condone average	
	MP8. safety guidance to avoid the hazard of burn/scald/electrocution;	e.g. take care to avoid burns from heater, clean up water spillages etc.	
(b)	two lines drawn showing an increase in temperature over time;	reject whole response if both lines show a decrease ignore starting temperature ignore flat sections	2
	line identified by candidate as black is always above the line identified by candidate as silver;	lines must be labelled for this mark allow "silver" line reaching same temperature as "black" line at a later time	

Total for Question 3 = 8 marks

6 (a)	any four from: MP1. water near heater is heated; MP2. (heated) water expands; MP3. density of (heated) water decreases; MP4. lower density / warm water rises; MP5. cooler / denser water sinks; MP6. process repeats / is continuous;	allow clear annotations on diagram accept 'particles move apart from each other' / 'particles spread out' reject particles expand	4
(b) (i)	temperature increases with time; idea that rate of temperature increase reduces;	allow 'temperature increases at a decreasing rate' / EQ for 2 marks	2
(ii)	temperature rise is quicker when container is empty; with any two explanations from: - particles move around quicker/have more KE in gases; - convection current is faster in gases; - energy transfer (by convection) is quicker; - mass of air in empty container less than mass of water in full container; - specific heat capacity of air is lower than water;	allow empty container reaches higher temperature ignore comments about conduction allow particles in gases are more free to move allow less particles in empty container allow RA	3

Total for Question 6 = 9 marks

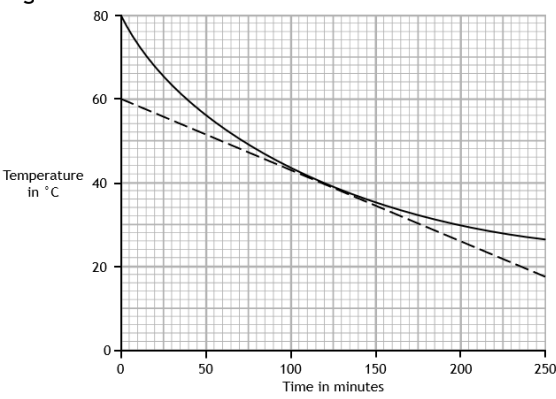
Question number	Answer	Notes	Marks
12 (a)	D (by radiation); A is incorrect because conduction cannot take place through the vacuum of space B is incorrect because convection cannot take place through the vacuum of space C is incorrect because evaporation cannot take place through the vacuum of space		1
(b)	air (inside external pipe) is heated; air expands; air decreases in density (and therefore rises);	allow particles move further apart reject particles become less dense	3
(c)	idea that air entering tube is hotter than the ground; energy is transferred from air (to ground/surroundings); by conduction;	allow RA e.g. ground is cooler than air	3
(d)	black / other dark colour; (because) dark colours are better/good absorbers of radiation; air inside pipe becomes hotter / convection increases;	allow infrared / IR for radiation ignore heat	3

Total for Question 12 = 10 marks

Question number	Answer	Notes	Marks
4 (a) (i)	any three from: MP1. (all bars same) length; MP2. (all bars same) width; MP3. (all bars same) thickness; MP4. (all bars can be) placed in same water; MP5. (all bars will be same) depth in water;	condone 'size' for 'length' accept 'same initial temperature (for all bars)'	3
	(ii) any four from: MP1. support apparatus in (clamp)stand; MP2. place apparatus into hot water and start stopclock; MP3. determine time (from stopclock) for colour change to reach top of strip; MP4. allow apparatus to cool MP5. repeat and calculate mean for each bar; MP6. other relevant extra practical detail;	may be shown in diagram condone (stop)watch or timer for stopclock condone reference to wax falling off end accept 'average' for 'mean' e.g. ensure bars are vertical, repeats have same initial temperature, bars are at same depth for repeats	5
(b) (i)	linear scale that takes up $\geq 50\%$ of the grid for time axis;	ignore orientation of axes	3

		allow use of false origins	
	labelled axes with units;	allow no units on metal axis	
	all bars plotted correctly within $\frac{1}{2}$ small square;	ignore width of bars accept line for bar ignore plotted 'points'	
(ii)	copper (is most effective at transferring energy by conduction);		2
	(because) time taken (for colour change) is shortest ;	condone shorter time (than the others)	

Total for Question 4 = 13 marks

Question number	Answer	Notes	Marks
7 (a)	mention of infrared (radiation); idea that surface is a poor absorber (of infrared);	allow IR for infrared allow idea that surface is a (good) reflector condone surface reflects heat	2
(b)	lid traps air; which reduces/stops convection (currents);	allow steam/gas for air ignore traps heat/energy allow reduces evaporation	2
(c) (i)	suitable tangent drawn at point on curve corresponding to a temperature of 40 °C; e.g. 	if extrapolated, line should intersect temperature axis between 56 and 64 °C	1
(ii)	attempt at gradient calculation; gradient evaluated correctly; minus sign included in answer; e.g. gradient = $(18 - 60) / (250 - 0)$ gradient = $(-)0.17$ (°C/minute) gradient = -0.17 (°C/minute)	allow ecf from (i) allow any clear change in temperature divided by a change in time allow range of 0.14 - 0.21 mark independently	3
(iii)	curve drawn consistently below existing curve; curve starts at same initial temperature and does not decrease below 20 °C;	curve may start at 80 °C, but does not have to for this mark DOP	2

Total for Question 7 = 10 marks

Question number	Answer	Notes	Marks
8 (a)	Any FIVE from: MP1 mass found on balance; MP2 time measured on timer/stopwatch/stopclock; MP3 temperature change = final temp - initial temp; MP4 energy supplied = voltmeter reading × ammeter reading × time; MP5 rearrangement of formula sheet equation; i.e. $c = \text{energy supplied} / (m \times \text{temp change})$ MP6 keep taking temperature after heater switched off for max temp; MP7 plot a graph of temperature against time; MP8 find gradient of temperature-time graph; MP9 use of “equation gradient = power of heater / $m \times c$” or re-arrangement; MP10 (whole experiment) repeated and averaged;	condone scales reject scale allow idea of a known mass e.g. 1 kg allow idea of a specified time e.g. 10 minutes allow idea of a specified temp change e.g. 10 degrees accept idea of measuring temperature change accept energy = power × time accept use of joulemeter	5
(b)	concrete can store/absorb/release a lot of energy (because of high SHC); water temp maintained for longer/ temp rise for water more than temp drop for concrete;	allow idea of large energy store per unit mass allow idea of being able to provide heating to the water for a long time	2

Total for question 8: 7 marks



Question number	Answer	Notes	Marks
5 (a)	energy required; for a unit mass / per gram (of mass) / per kilogram (of mass); to change per unit temperature / change by 1° (C) / change by 1 K;	ignore equations ignore heat for energy allow other statements that imply changing e.g. increasing, raising, heat up, decreasing etc.	3
(b) (i)	substitution into $\Delta Q = mc\Delta T$; rearrangement; correct evaluation to 2 or more s.f.;	answer of 2.9, 1.6, 1.0 gets 1 mark for showing rearrangement allow 3.77...	3
(ii)	any one from: MP1. <u>energy</u> also heating boiling tube; MP2. <u>energy</u> is being transferred/lost to/gained from surroundings; MP3. stearic acid may be impure;	ignore suggestions of human error allow thermometer, support allow alternatives to surroundings e.g. air	1

Total for Question 5 = 7 marks

Question number	Answer	Notes	Marks
5 (a) (i)	290 (s);		1
(ii)	substitution into $P = E/t$; evaluation; a matching unit for power; e.g. $(P =) 39000/290$ $(P =) 130$ watts / W	allow ecf from (a)(i) a correct unit for power may score 1 if no other mark scored allow 134.48... allow J/s answers of 0.13 kW, 0.13 kJ/s gain 3 marks answers of 0.13 W, 0.13 J/s gain 2 marks	3
(b)	correct evaluation of temperature change; substitution into $\Delta Q = m \times c \times \Delta\theta$; rearrangement; evaluation; e.g. temperature change = 49 (°C) $39\,000 = 0.45 \times c \times 49$ $(c =) 39\,000 / (0.45 \times 49)$ $(c =) 1800 \text{ (J/kg}^\circ\text{C)}$	allow 49 seen anywhere in working allow ecf from incorrect temperature change value of 50, 69 or 70 only -1 for POT error allow 1770, 1769, 1768.7... answer of 1.7687... gains 3 marks answer of 1733, 1256, 1238 gains 3 marks answer of 1.256..., 1.733..., 1.238... gains 2 marks	4

Total for Question 5 = 8 marks

Question number	Answer	Notes	Marks
5 (a) (i)	C (nuclear); A is incorrect because chemical reactions do not happen in the Sun B is incorrect because the kinetic store of particles increases during nuclear fusion D is incorrect because the thermal store of the Sun remains constant whilst fusion is taking place		1
(ii)	B (by radiation); A is incorrect because transfers by heating cannot happen in a vacuum C is incorrect because there is no electrical circuit or flow of ions D is incorrect because the transfer does not happen due to forces		1
(b) (i)	evaluation of total power / conversion of hours to seconds; evaluation of energy in J; evaluation of energy in MJ; e.g. power = $(1000 \times 15 =) 15\,000 \text{ (m}^2\text{)}$ OR time = $(2 \times 60 \times 60 =) 7200 \text{ (s)}$ energy = $(15\,000 \times 7200 =) 108\,000\,000 \text{ (J)}$ energy = $(108\,000\,000 \div 1\,000\,000 =) 108 \text{ (MJ)}$	allow $\times 3600$ seen anywhere in working	3
(ii)	substitution into $\Delta Q = m \times c \times \Delta T$; rearrangement; evaluation of ΔT ; evaluation of final temperature; e.g. $100\,000\,000 = 1100 \times 4200 \times \Delta T$ $\Delta T = 100\,000\,000 / (1100 \times 4200)$ $(\Delta T =) 22 \text{ (}^\circ\text{C)}$ $T = (20 + 22 =) 42 \text{ (}^\circ\text{C)}$	-1 for POT error allow ECF from incorrect ΔT allow 23.3..., 21.6... allow 41.6-43.8 ($^\circ\text{C}$)	4
(iii)	any sensible suggestion; e.g. - heating process is not 100% efficient - energy also heats up pipes / not all energy is transferred to water - some energy is transferred to the surroundings - power of Sun may change	allow energy transferred to (solar) panel ignore 'heat is lost'	1

Total for Question 5 = 10 marks

Question number	Answer	Notes	Marks
5 (a)	Any FIVE from: MP1. measure current and voltage to work out power; MP2. use ammeter and voltmeter; MP3. measure temperature increase AND time taken; MP4. find total energy ($E = Pt$ or $E = VIt$); MP5. measure mass of substance; MP6. use a balance; MP7. rearrange to give $c = E / m \Delta\theta$; MP8. plot a temperature-time graph; MP9. use gradient (so $c = P / (m \times \text{gradient})$);	accept 'known power' accept 'power meter' or 'joulemeter' accept idea of 'known voltage' accept measure initial and final temperature for temp increase accept idea of waiting for highest temperature after power switched off accept 'use a stopwatch' for time taken	5
(b) (i)	34 (°C);		1
(ii)	any TWO from: MP1. bonds between particles are weakened or broken; MP2. particles go from regular to irregularly packed/EQ; MP3. particles go from vibrating (about a fixed position) to sliding past each other / EQ;	allow particles get (slightly) further apart /EQ ignore references to KE	2
(iii)	reference to different temperature changes in the same time; different specific heat capacities/EQ;	accept recognition that the states are different condone incorrect SHC comparisons between phases	2

Total for Question 5: 10 marks

Question number	Answer	Notes	Marks
6 (a) (i)	Substitution (including conversion of time to seconds); Re-arrangement of given equation $P = W/t$; Evaluation; e.g. Energy = $75 \times (22 \times 60) = 99\,000$ (J)	Allow W or E for energy or work. Can be implied from their working. Accept 1650 or 5.9 million for 2 marks.	3
(ii)	Any ONE assumption from - dog does not change temperature - dog does not change power output - rate of transfer is constant (despite increase in temp of water) - no heating of outside world/surroundings/material of bag - no heating from the surroundings	Ignore unqualified '100% efficient' or 'no energy lost'	1
(iii)	Use of $Q = m \times c \times \Delta\theta$; Substitution of their energy, mass, c; Evaluation of temp change; Calculation of final temp = temp change + 16; e.g. $99\,000 = 8.7 \times 4200 \times \Delta\theta$ temp rise = $99\,000 / (8.7 \times 4200) = 2.7$ final temp = 19 (°C);	Allow ECF from (a)(i) Allow ECF from evaluation of temp change. Accept 16.04... for all marks (ecf E without min->s conversion) Accept answer to 3 or more sf i.e 18.7	4

(b)	Any THREE from MP1 Dog and water are at different temperatures; MP2 Dog and water in physical contact so likely to be conduction; MP3 No movement of particles from dog to water, so not convection / EQ; MP4 Dog and bag are both solids, so convection impossible; MP5 Not much radiation as dog and water similar temperatures;	Allow "no gap between dog and bag so no convection"	3
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Question number	Answer	Notes	Marks																		
1 (a)	1 mark for each correct tick;;; <table><thead><tr><th>Methods of generating electricity</th><th>Uses a renewable energy resource</th></tr></thead><tbody><tr><td>coal power station</td><td></td></tr><tr><td>diesel generator</td><td></td></tr><tr><td>geothermal power station</td><td>✓</td></tr><tr><td>hydroelectric power station</td><td>✓</td></tr><tr><td>natural gas turbine</td><td></td></tr><tr><td>nuclear power station</td><td></td></tr><tr><td>solar cell</td><td>(✓)</td></tr><tr><td>wind turbine</td><td>✓</td></tr></tbody></table>	Methods of generating electricity	Uses a renewable energy resource	coal power station		diesel generator		geothermal power station	✓	hydroelectric power station	✓	natural gas turbine		nuclear power station		solar cell	(✓)	wind turbine	✓	4 candidate ticks = 2 marks max. 5-6 candidate ticks = 1 mark max. 7 candidate ticks = 0 marks	3
Methods of generating electricity	Uses a renewable energy resource																				
coal power station																					
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natural gas turbine																					
nuclear power station																					
solar cell	(✓)																				
wind turbine	✓																				
(b) (i)	B (by radiation); A is incorrect because transfers by heating cannot take place through space C is incorrect because there are no electrical conductors between the Sun and the panel D is incorrect because it requires particles that are not present in the vacuum of space		1																		
(ii)	any 1 of: MP1. only generates electricity when it is sunny / eq; MP2. idea of visual pollution; MP3. idea that solar panels take up a lot of space;	allow not generating electricity at night ignore 'depends on the weather' Condone 'ugly'	1																		

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
2 (a)	chemical (energy store);		1
(b)	any one advantage of natural gas from: MP1. idea that electricity generated can change to meet demand; MP2. idea that it is reliable; any one disadvantage of natural gas from: MP3. non-renewable / gas will eventually run out; MP4. burning gas produces CO₂ / greenhouse gases; MP5. dependency on other countries to supply gas; any one advantage of wave power from: MP6. idea that it is renewable; MP7. produces no polluting gases; any one disadvantage of wave power from: MP8. idea that waves might not always be present; MP9. (may) cause harm to wildlife; MP10. possible storm damage to the generator;	ignore references to cost allow idea that startup time is (very) short e.g. is always available, does not depend on weather allow causes air pollution, contributes to global warming ignore references to visual pollution allow waves are weather dependent	4

Total for Question 2 = 5 marks



Question number	Answer	Notes	Marks
4 (a)	any FOUR from: advantages: MP1 no carbon (dioxide) emissions; MP2 no contribution to { global warming / greenhouse effect / acid rain }; MP3 is renewable; MP4 low maintenance/no moving parts; disadvantages: MP5 needs a favourable climate; MP6 needs long days / doesn't work at night; MP7 needs a lot of space; MP8 cannot respond to rapid changes in demand;	ignore unnamed 'greenhouse gases'	4
(b)	d.c. travels in one direction only; a.c. changes direction frequently/continuously;		2

Total for Question 4 = 6 marks

Question number	Answer	Notes	Marks
1 (a)	(i) (crude) oil / coal / (natural) gas;	allow petrol / diesel / gasoline / kerosene	1
	(ii) B – (furnace and boiler); A is incorrect because this transfers energy between thermal stores C is incorrect because this transfers energy electrically from a kinetic store D is incorrect because this transfers energy from a thermal to a kinetic store		1
	(iii) C – (generator); A is incorrect because this transfers energy between thermal stores B is incorrect because this transfers energy from a chemical to a thermal store D is incorrect because this transfers energy from a thermal to a kinetic store		1
(b)	any two advantages max. from: MP1. solar is renewable; MP2. no fuel / transportation cost; MP3. no air pollution / greenhouse gases; any two disadvantages max. from: MP4. idea that Sun does not shine all the time; MP5. idea that output depends on geographical location; MP6. need for large open spaces;	allow “sunlight is free”/eq allow named pollutant e.g. CO ₂ etc. ignore comments relating to setup cost ignore “relies on the weather” allow “takes up farm land”/eq	4

Total for Question 1 = 7 marks

Question number	Answer	Notes	Marks
2 (a)	any two from: MP1.water is renewable/eq; MP2.no fuel / transportation cost; MP3.no air pollution / greenhouse gases; MP4.always available (vs wind/solar);	allow "water is free"/eq allow named pollutant e.g. CO ₂ etc. allow "reliable" allow "respond quickly to demand"	2
(b) (i)	gravitational (potential energy);		1
(ii)	C (electrically); A is incorrect because there is no temperature difference B is incorrect because there are no light or sound waves emitted D is incorrect because the transfer does not involve forces		1
(c) (i)	rate of {energy transfer / doing work};	allow alternatives to rate e.g. per second, per unit time etc.	1
(ii)	evaluation of number of seconds in a day; substitution into $P = W \div t$; evaluation; e.g. 1 day = $(24 \times 60 \times 60 =)$ 86 400 seconds $(P =) 9.7 \times 10^{14} \div 86\,400$ $(P =) 1.1 \times 10^{10}$ (W)	seen anywhere in working -1 for POT error allow $1.1226... \times 10^{10}$ (W) allow 6.7×10^{11} J/min or 4.04×10^{13} J/hr if given unit changed. 2 marks max. if time unit conversion attempted but incorrect unit e.g. 6.7×10^{11} (J/min) or 4.04×10^{13} (J/hr)	3 1
(iii)	D (22 500 000 000 J/s); A is incorrect because joules is not the unit for power and mega has not been dealt with correctly B is incorrect because mega has not been dealt with correctly C is incorrect because joules is not the unit for power		
(iv)	any one from: • idea that electricity demand varies; • idea that water level in reservoir varies; • idea that water may not be available as readily at certain times of the year;	ignore idea of efficiency	1

Total for Question 2 = 10 marks



Question number	Answer	Notes	Marks
7 (a)	idea that source will not run out / can be replaced;	ignore 'recycled' or 're-used'	1
		condone 'infinite'	
		accept 'replenished'	
(b)	any four from: MP1. water has (high) {gravitational potential energy/GPE (store)} ;	condone 'turns into', 'becomes' etc for 'transfers' energy starts as gravitational (potential energy)	4
	MP2. water loses GPE / gains {kinetic energy/KE};	transfers from GPE to KE scores MP1 and MP2	
	MP3. transfers mechanically (to water or to turbine or to generator);	allow at any correct stage i.e. for water, turbine or generator allow KE of water to KE of turbine allow KE of turbine to KE of generator	
	MP4. energy is transferred electrically (from power station);	transfers from KE (of water or generator) to electrical (energy)	
	MP5. energy is wasted by heating/radiation e.g. IR, sound;	allow transfer of heat (energy) to surroundings/eq allow transfer of sound (energy)	
(c) (i)	any one from: - idea that energy can be supplied more reliably by HEP; - idea that HEP produces less (environmental) noise; - idea that HEP can respond (quickly) to demand;	ignore cost factors ignore visual pollution e.g. allow does not depend on the weather	1
(ii)	any one from: - large area of land needs to be flooded; - location dependent / mountainous area; - damage to habitats / eq;	ignore cost factors ignore visual pollution	1

(iii)	any THREE from: MP1 idea that wind farm cannot store energy; MP2 idea of wind powering the pump when (energy) demand is low;	do not credit simple reference to wind farm powering pump (repeats question)	3
	MP3 idea that (therefore) upper lake acts as an energy store (for wind farm output); MP4 (so that) energy released from upper lake or to the HEP when demand is high MP5 idea that more electricity/energy is transferred usefully;	allow idea that upper lake acts like a battery (so that) energy can be released from the upper lake when it's not windy condone less energy or less electricity wasted condone less energy or less electricity lost	

Total for Question 7 = 10 marks

Question number	Answer	Notes	Marks
6 (a)	any one advantage for solar: • produces no noise; • available in all locations; • no greenhouse/polluting/harmful gases produced; any one disadvantage for solar: • dependent on amount of sun(light); • requires large area of panels; any one advantage for geothermal: • can be used all day; • requires small amount of space; • produces very little/no noise; any one disadvantage for geothermal: • not available in all locations; • releases some greenhouse/polluting/harmful gases; • possible pollution of ground water;	ignore renewable ignore statements relating to cost allow doesn't work at night, depends on the weather allow takes up lots of space, idea that it takes away land for farming/agriculture etc. ignore renewable allow it is reliable, does not depend on the weather ignore statements relating to cost allow other named gases e.g. ammonia etc.	4

(b)	(i)	two columns/rows with headings of “distance” and “voltage”; units included correctly in both column headings; all data recorded correctly to the same number of decimal places as originally presented; e.g. <table border="1"><thead><tr><th>Distance (cm)</th><th>Voltage (V)</th></tr></thead><tbody><tr><td>5</td><td>0.45</td></tr><tr><td>8</td><td>0.18</td></tr><tr><td>11</td><td>0.10</td></tr><tr><td>14</td><td>0.06</td></tr><tr><td>17</td><td>0.04</td></tr><tr><td>20</td><td>0.03</td></tr></tbody></table>	Distance (cm)	Voltage (V)	5	0.45	8	0.18	11	0.10	14	0.06	17	0.04	20	0.03	ignore additional column for experiment number reject if units included with data in the body of the table	3
Distance (cm)	Voltage (V)																	
5	0.45																	
8	0.18																	
11	0.10																	
14	0.06																	
17	0.04																	
20	0.03																	
	(ii)	any one of: - power/luminosity (of lamp); (amount of) background light; - brightness <u>of lamp</u>; - light intensity <u>of lamp</u>;	condone same lamp ignore amount of light, light intensity, brightness, same solar cell etc.	1														
	(iii)	any two from: MP1. idea that lamp / solar cell is not 100% efficient; MP2. not all light produced by lamp is received by solar cell; MP3. energy losses {in connecting wires / to surroundings / as heat};	allow light spreads out in all directions allow energy wasted/dissipated for energy losses	2														

Total for Question 6 = 10 marks

Question number	Answer	Notes	Marks
4 (a)	(i) idea that it will run out / cannot be replaced;	ignore renewed/re-used	1
	(ii) any two correct readings taken from graph; evaluation of total; e.g. (proportion =) $27.5 + 35 + 19.5$ (proportion =) 82 (%)	allow 81-83 (%)	2
(b)	a named effect e.g. global warming, acid rain; a named pollutant e.g. carbon dioxide, sulphur dioxide, nitrogen (di)oxide;	-1 for incorrectly linked effect and pollutant	2
(c)	(i) correct reading of solar from graph; evaluation; e.g. solar = 1.5% (solar output = $0.015 \times 4.76 \times 10^{11}$ =) $7.1(4) \times 10^9$ (W)	seen anywhere in working	2
	(ii) correct use of ratio; evaluation; e.g. land area = $4.76 \times 10^{11} / 250$ (land area =) 1.90×10^9 (m ²)	allow $1.904... \times 10^9$ (m ²)	2
	(iii) any three from: MP1. land area needed is much less than total land area of USA / there is enough space; MP2. land area needed is (much) less than 1% of total land area; MP3. idea that Sun doesn't shine all the time; MP4. idea that some areas of land may not be suitable for solar power;	no mark for simple yes/no for suitability allow ecf from (ii) also scores MP1 allow idea of competing land uses e.g. housing/agriculture	3

Total for question 4 = 12 marks



Question number	Answer	Notes	Marks
3 (a)	any three from: MP1. idea of reduction of nuclear store of Sun; MP2. (transferred) by radiation (to the solar panel); MP3. energy absorbed by solar panel; MP4. energy transferred (from panel to battery) electrically; MP5. idea of increase of chemical store of battery;	allow by light/ by IR/ by infrared NOT by electricity alternate description MP1 nuclear energy of sun transferred to light energy MP2 light energy from sun transferred to electrical energy of panel MP3 electrical energy of panel transferred to chemical energy of battery NOTE: marks can be scored from either the answer column scheme or the alternate description but not from both	3
(b)	any one from: • solar power is renewable; • solar panel does not produce CO₂; • idea of using less petrol; • idea that it can be used if petrol runs out;	allow it won't run out etc. ignore 'greenhouse gas(es)'	1
(c)	black is a good absorber; of radiation;	allow light allow infra-red / IR condone heat ignore reference to emission ignore reference to conduction or insulation	2
(d)	substitution; rearrangement; evaluation; e.g. $360\,000 = 15 \times \text{time}$ $\text{time} = 360\,000 \div 15$ (time =) 24 000 (s)	-1 POT error	3

Total for Question 3 = 9 marks



Question number	Answer	Notes	Marks
3 (a)	any two from: MP1. idea that it is renewable; MP2. does not produce carbon dioxide / greenhouse gases; MP3. does not produce sulfur dioxide / oxides of nitrogen / acid rain; MP4. idea that it is reliable / tides are dependable; MP5. does not produce radioactive waste;	ignore references to cost allow idea that resource will not run out allow does not contribute to global warming ignore toxic/polluting gases ignore toxic/polluting gases allow doesn't depend on sunlight, wind etc. condone can be used at any time	2
(b)	any two from: MP1. potential impact on wildlife; MP2. idea that it cannot (always) provide electricity when needed (e.g. at high tide); MP3. changes shipping routes; MP4. idea that tides may vary (over time); MP5. idea that not suitable in all locations;	ignore references to cost allow idea that it blocks migration routes, wading bird habitats etc. allow idea that (electrical) output varies allow idea that it doesn't work if not near the sea	2
(c) (i)	substitution; evaluation; e.g. energy transferred = $1 \times 10 \times (8.0)$ (energy transferred =) 80 (J)	allow use of $g = 9.8, 9.81$ (N/kg) condone substitution of mass in grams for this mark only allow 78, 78.4, 78.5, 78.48 (J)	2
(ii)	conversion of kW to W; setting up calculation; evaluation; e.g. $240\,000\text{ kW} = 240\,000\,000\text{ W}$ $240\,000\,000 = \text{mass} \times 10 \times 8(.0) (\div 1)$ (mass of water =) 3 000 000 (kg)	allow ecf from (i) and from incorrect power conversion answers between 3000 and 3100 (kg) scores 2 marks allow use of ratio e.g. $\text{mass} = 240\,000\,000 / 80$ allow $3(.0) \times 10^6$ (kg) allow answers between 3 000 000 and 3 100 000 (kg)	3

Total for Question 3 = 9 marks

