1 All objects emit and absorb infrared radiation.

(a) Use the correct answer from the box to complete each sentence.

dark matt	dark shiny	light matt	light shiny

The best emitters of infrared radiation have

..... surfaces.

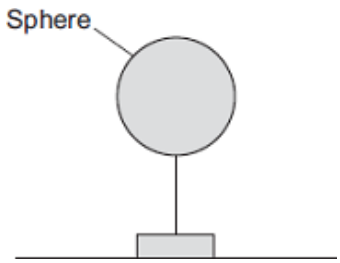
The worst emitters of infrared radiation have

..... surfaces.

(2)

(b) **Diagram 1** shows a sphere which is at a much higher temperature than its surroundings.

Diagram 1



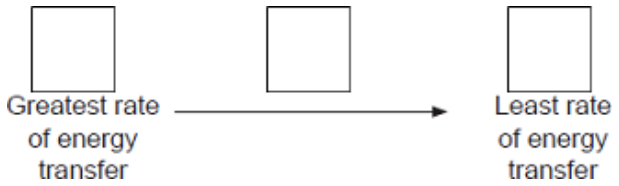
Energy is transferred from the sphere to the surroundings.

The table shows readings for the sphere in three different conditions, **A**, **B** and **C**.

Condition	Temperature of sphere in °C	Temperature of surroundings in °C
A	70	5
B	80	0
C	90	30

In each of the conditions, **A**, **B** and **C**, the sphere transfers energy to the surroundings at a different rate.

Put conditions **A**, **B** and **C** in the correct order.



Give a reason for your answer.

.....

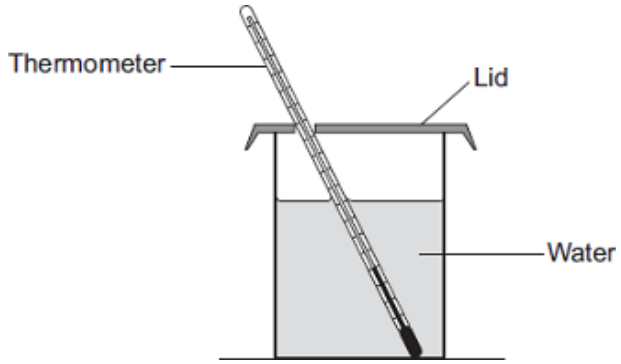
.....

(2)

(c) **Diagram 2** shows a can containing water.

A student investigates how quickly a can of water heats up when it is cooler than room temperature.

Diagram 2



The student has four cans, each made of the same material, with the following outer surfaces.

dark matt **dark shiny** **light matt** **light shiny**

The student times how long it takes the water in each can to reach room temperature.

Each can contains the same mass of water at the same starting temperature.

(i) Which can of water will reach room temperature the quickest?

Give a reason for your answer.

.....

.....

.....

.....

(2)

(ii) Apart from material of the can, mass of water and starting temperature, suggest **three** control variables for the student's investigation.

1 .....

.....

2 .....

.....

3 .....

.....

(3)

(d) The photographs show two different foxes.

Fox A

By Algkalv (Own work) [CC-BY-3.0], via Wikimedia Commons

Fox B

© EcoPic/iStock

Which fox is better adapted to survive cold conditions?

Give reasons for your answer.

.....

.....

.....

.....

.....

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.....

.....

(3)
(Total 12 marks)

2 (a) A company is developing a system which can heat up and melt ice on roads in the winter. This system is called 'energy storage'.

During the summer, the black surface of the road will heat up in the sunshine.

This energy will be stored in a large amount of soil deep under the road surface.
Pipes will run through the soil. In winter, cold water entering the pipes will be warmed and brought to the surface to melt ice.

The system could work well because the road surface is black.

Suggest why.

.....

.....

(1)

(b) (i) What is meant by specific latent heat of fusion?

.....

.....

.....

.....

(2)

(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = 3.4×10^5 J/kg.

.....

.....

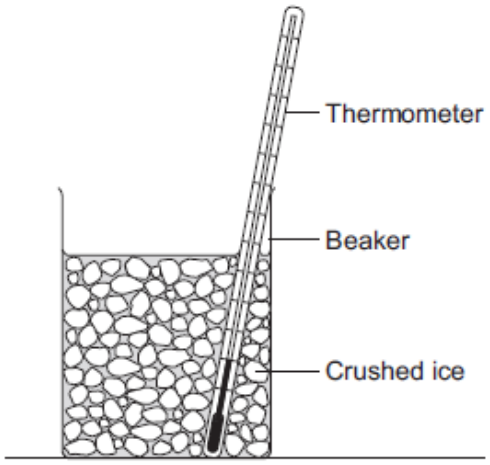
Energy = ... J

(2)

(c) Another way to keep roads clear of ice is to spread salt on them.
When salt is added to ice, the melting point of the ice changes.

A student investigated how the melting point of ice varies with the mass of salt added.

The figure below shows the equipment that she used.



The student added salt to crushed ice and measured the temperature at which the ice melted.

(i) State **one** variable that the student should have controlled.

.....

.....

(1)

(ii) During the investigation the student stirred the crushed ice.

Suggest **two** reasons why.

Tick (✓) **two** boxes.

	Tick (✓)
To raise the melting point of the ice	
To lower the melting point of the ice	
To distribute the salt throughout the ice	
To keep all the ice at the same temperature	
To reduce energy transfer from the surroundings to the ice	

(2)

(iii) The table below shows the data that the student obtained.

Mass of salt added in grams	0	10	20
Melting point of ice in °C	0	-6	-16

Describe the pattern shown in the table.

.....

.....

(1)

(d) Undersoil electrical heating systems are used in greenhouses. This system could also be used under a road.

A cable just below the ground carries an electric current. One greenhouse system has a power output of 0.50 kW.

Calculate the energy transferred in 2 minutes.

.....

.....

.....

Energy transferred = ... J

(3)

(e) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

A local council wants to keep a particular section of a road clear of ice in the winter.

Describe the advantages and disadvantages of keeping the road clear of ice using:

- energy storage
- salt
- undersoil electrical heating.

.....

.....

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Extra space .....

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.....

(6)
(Total 18 marks)

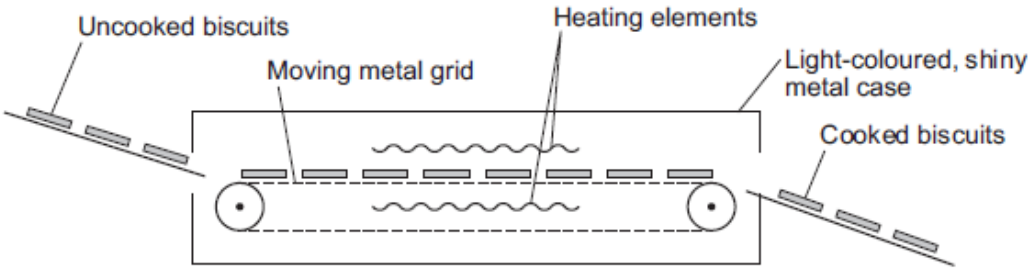
3 **Figure 1** shows one way that biscuit manufacturers cook large quantities of biscuits.

The uncooked biscuits are placed on a moving metal grid.

The biscuits pass between two hot electrical heating elements inside an oven.

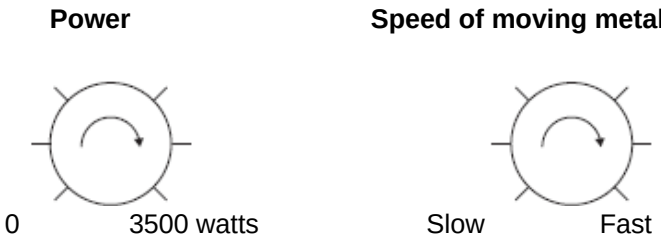
The biscuits turn brown as they cook.

Figure 1



The oven has two control knobs, as shown in **Figure 2**.

Figure 2



(a) Which type of electromagnetic radiation makes the biscuits turn brown?

.....

(1)

(b) Suggest **two** ways of cooking the biscuits in this oven, to make them turn browner.

1 .....

.....

2 .....

.....

(2)

(c) The inside and outside surfaces of the oven are light-coloured and shiny.

Explain why.

.....

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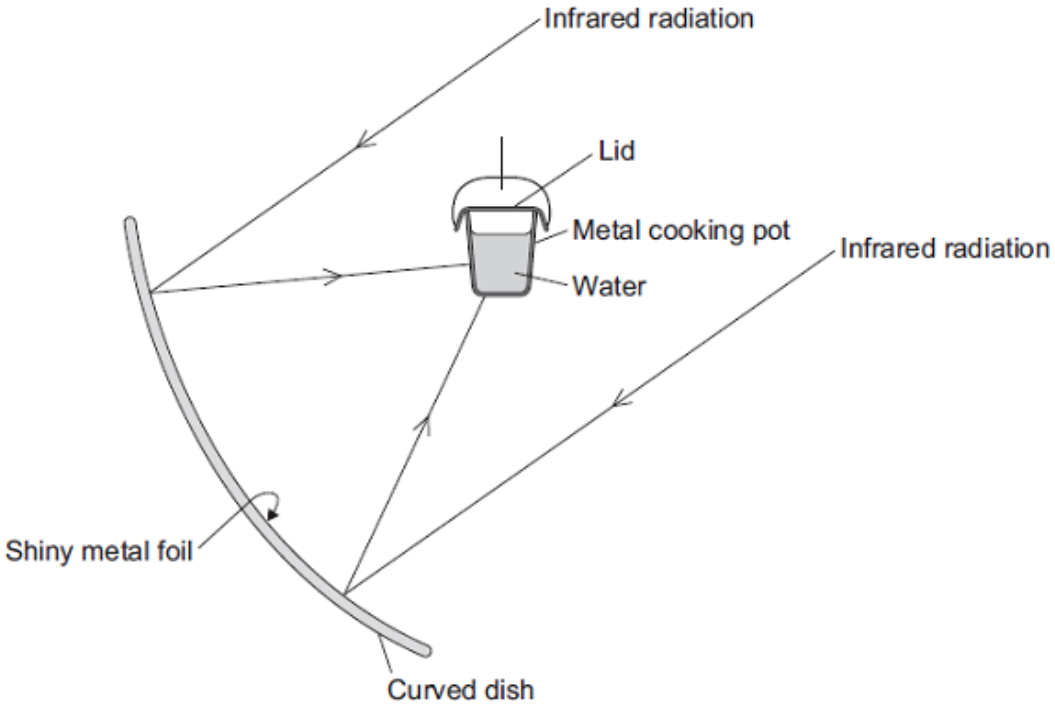
.....

.....

.....

(3)
(Total 6 marks)

4 The diagram shows the design of a solar cooker. The cooker heats water using infrared radiation from the Sun.



(a) Why is the inside of the large curved dish covered with shiny metal foil?

.....

.....

(1)

(b) Which would be the best colour to paint the outside of the metal cooking pot?

Draw a ring around the correct answer.

black **silver** **white**

Give a reason for your answer.

.....

.....

.....

(2)

(c) Why does the cooking pot have a lid?

.....

.....

(1)

(d) Calculate how much energy is needed to increase the temperature of 2 kg of water by 80 °C.

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

.....

.....

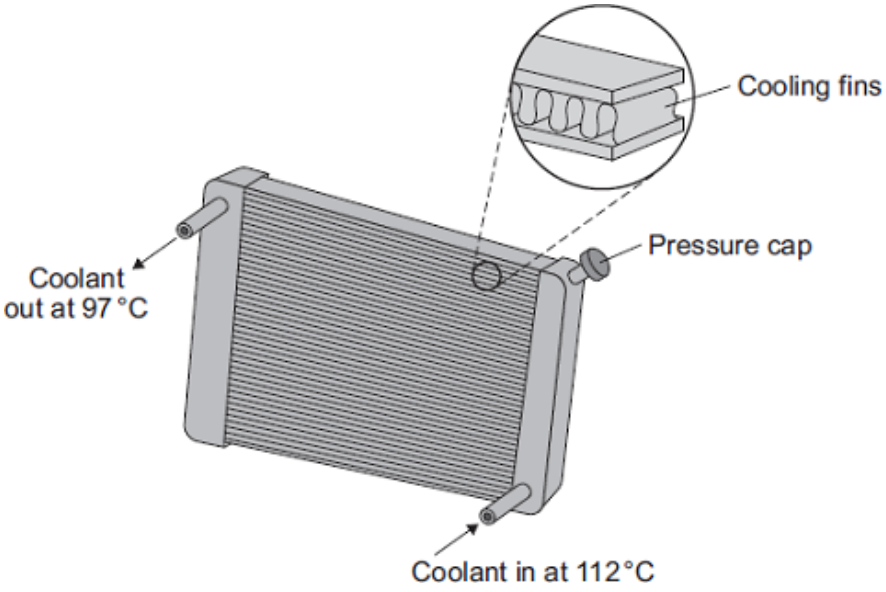
.....

Energy = ... J

(2)

(Total 6 marks)

5 The diagram shows a car radiator. The radiator is part of the engine cooling system.



Liquid coolant, heated by the car engine, enters the radiator. As the coolant passes through the radiator, the radiator transfers energy to the surroundings and the temperature of the coolant falls.

(a) Why is the radiator painted black?

.....

.....

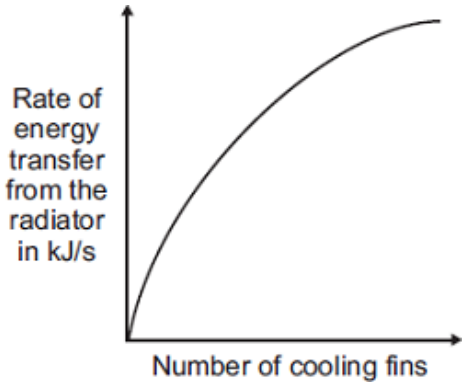
.....

.....

(2)

(b) Different radiators have different numbers of cooling fins along the length of the radiator.

The sketch graph shows how the number of cooling fins affects the rate of energy transfer from the radiator.



The number of cooling fins affects the rate of energy transfer from the radiator.

Explain how.

.....

.....

.....

.....

(2)

(c) When the car engine is working normally, 2 kg of coolant passes through the radiator each second. The temperature of the coolant falls from 112 °C to 97 °C.

Calculate the energy transferred each second from the coolant.

Specific heat capacity of the coolant = 3800 J/kg °C.

.....

.....

.....

.....

Energy transferred each second = ... J

(3)

(d) On cold days, some of the energy transferred from a hot car engine is used to warm the air inside the car. This is a useful energy transfer.

What effect, if any, does this energy transfer have on the overall efficiency of the car engine?

Draw a ring around the correct answer.

decreases the efficiency	**does not change the efficiency**	**increases the efficiency**

Give a reason for your answer.

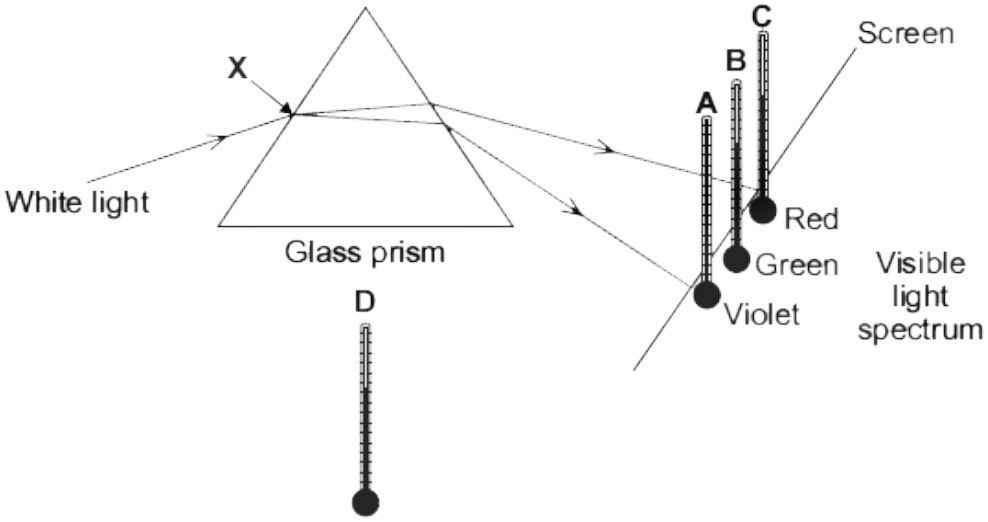
.....

.....

.....

(2)
(Total 9 marks)

6 The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) The student put thermometer **D** outside of the light spectrum.

Suggest why.

.....

.....

(1)

(ii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

.....

.....

.....

.....

(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

.....

.....

.....

.....

(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Show clearly how you work out your answer.

.....

.....

.....

.....

Wavelength = ... m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

.....

.....

.....

.....

(2)
(Total 9 marks)

7 A wood burning stove is used to heat a room.

Photograph supplied by iStockphoto/Thinkstock

The fire in the stove uses wood as a fuel. The fire heats the matt black metal case of the stove.

(a) The air next to the stove is warmed by infrared radiation.

How does the design of the stove help to improve the rate of energy transfer by infrared radiation?

.....

.....

.....

.....

(2)

(b) Burning 1 kg of wood transfers 15 MJ of energy to the stove. The stove then transfers 13.5 MJ of energy to the room.

Calculate the efficiency of the stove.

Show clearly how you work out your answer.

.....

.....

.....

Efficiency = ...

(2)

(c) Some of the energy from the burning wood is wasted as the hot gases leave the chimney and warm the air outside the house.

Name **one** other way energy is wasted by the stove.

.....

(1)

(d) Some people heat their homes using electric heaters. Other people heat their homes using a wood burning stove.

Give **two** environmental advantages of using a wood burning stove to heat a home rather than heaters that use electricity generated from fossil fuels.

1 .....

.....

2 .....

.....

(2)

(e) The metal case of the stove gets hot when the fire is lit.

Here is some information about the stove.

Mass of metal case	100 kg
Starting temperature of metal case	20 °C
Final temperature of metal case	70 °C
Specific heat capacity of metal case	510 J/kg °C

Calculate the energy required to raise the temperature of the metal case to 70 °C.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

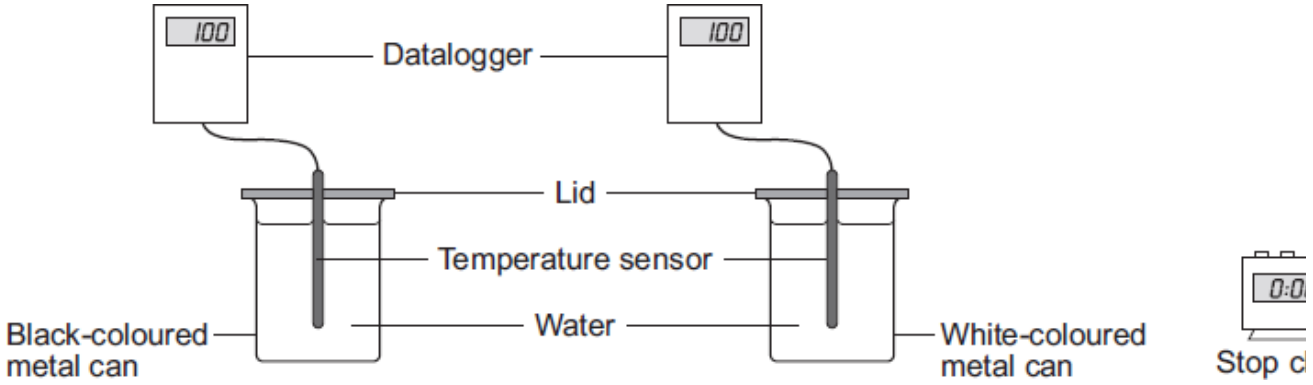
.....

Energy required = ...

(3)

(Total 10 marks)

8 The diagram shows the equipment a student used to investigate how the colour of a surface affects how fast it emits (gives out) heat.



An equal volume of boiling water was poured into each metal can. The student then recorded the temperature of the water in each can every minute for ten minutes.

(a) (i) Which of the following was a control variable in this investigation?

Put a tick (✓) in the box next to your answer.

The volume of boiling water. ☐

The decrease in temperature of the water. ☐

The outside colour of the metal can. ☐

(1)

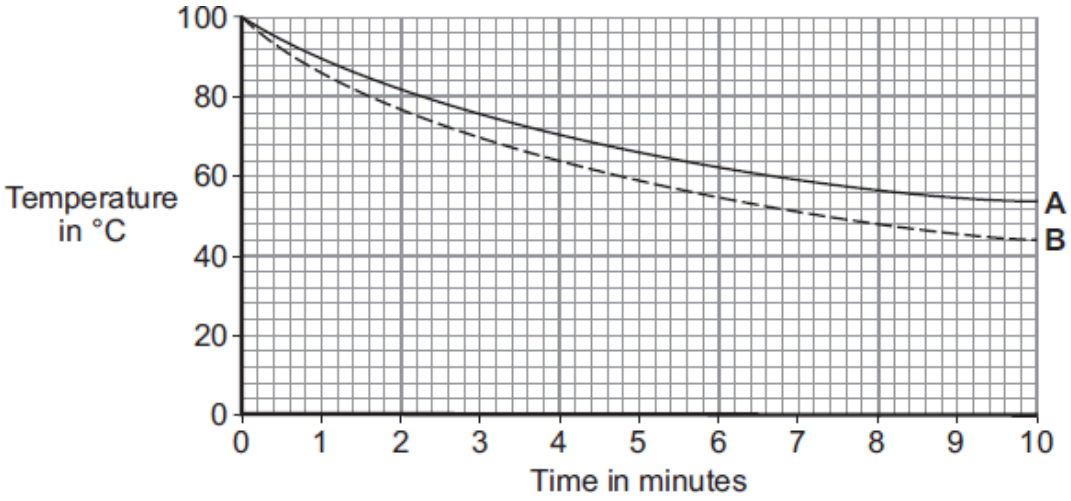
(ii) Give **one** advantage of using a temperature sensor and datalogger rather than a thermometer to measure the temperature of the water.

.....

.....

(1)

(b) The student's results for both cans are plotted on the graph.



Which line, **A** or **B**, shows how the temperature of the water inside the black-coloured metal can changed?

Draw a ring around your answer. **A** **B**

Explain the reason for your answer.

.....

.....

.....

.....

(2)

(c) Some gardeners make soil darker by digging black soot into the soil. Other gardeners use straw to protect plants from the cold.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

On a warm day, the temperature of darker coloured soil will increase

slower than
as fast as
faster than

the temperature of lighter coloured soil.

(1)

(ii) Give a reason for your answer to part (c)(i).

.....

.....

(1)

(iii) The statement in the box is **false**.

Straw keeps plants warm by trapping air. | This is because air is a good conductor.

Change **one** word in the statement to make the statement **true**.

Write down your **new** statement. The answer has been started for you.

This is because air is a .....

(1)

(Total 7 marks)

9 (a) Use the words from the box to complete the following sentences.

conduction	**convection**	**radiation**

(i) The transfer of thermal energy (heat) by the movement of hot liquids

is called ..... .

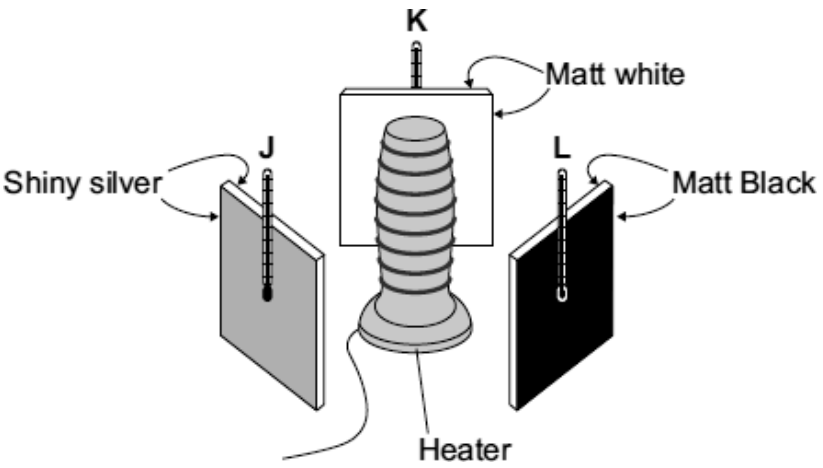
(1)

(ii) The transfer of thermal energy (heat) from one particle to another

is called ..... .

(1)

(b) A student set up the following equipment. The 3 metal plates are the same distance from the heater. The surfaces of each of the 3 metal plates are different colours.



The student switched the heater on for 10 minutes. The thermometers were read before the heater was switched on. The thermometers were read again just after the heaters were switched off.
The readings are shown in the table.

	Temperature before switching on in °C	**Temperature after switching on in °C**
1	19	21
2	19	29
3	19	23

(i) Which set of readings, **1**, **2** or **3**, is most likely to have been taken from the thermometer labelled **L**?

.....

Give a reason for your answer.

.....

.....

(2)

(ii) Which **one** of the following was **not** a control variable in this experiment?

Put a tick (✓) in the box next to your answer.

the distance between the heater and the metal plates ☐

the power of the heater ☐

the temperature before the heater was switched on ☐

the colour of the metal plates ☐

(1)

(iii) Suggest **one** advantage of using a temperature sensor, data logger and computer, rather than a thermometer to carry out this experiment.

.....

.....

(1)

(c) The picture shows a fire fighter putting out a forest fire. The fire fighter's clothing has thick thermal padding inside and a light coloured, fire proof, shiny layer outside.

(i) What is the main way that heat is transferred through the air from the fire to the fire fighter?

.....

.....

(1)

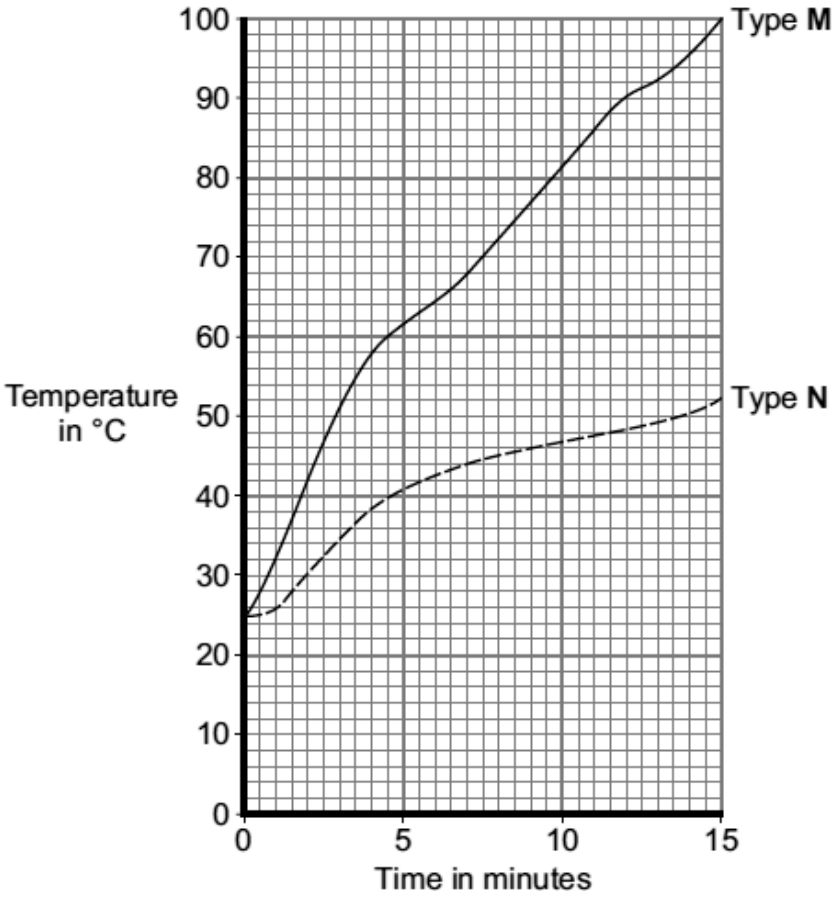
(ii) Why is the outside layer of the clothing shiny?

.....

.....

(1)

(d) The graph shows the result of a laboratory test on two types of thermal padding. Each type of padding was put onto a very hot metal surface and the temperature inside the padding was taken every minute.



Which type of padding, **M** or **N**, would it be best to use inside the fire fighter's clothing?

.....

Give a reason for your answer.

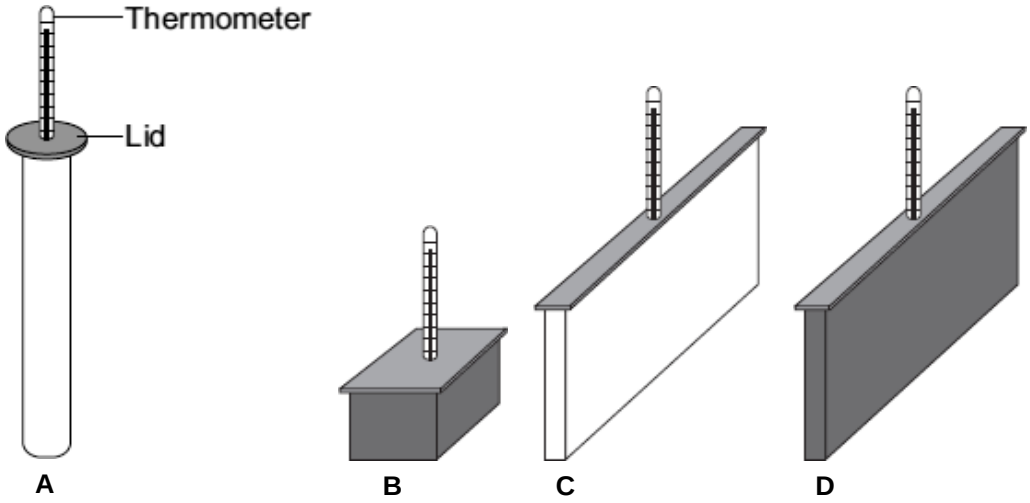
.....

.....

(1)
(Total 9 marks)

10 A student investigated the effect of shape and colour on heat transfer.

The student used metal containers with the same volume but with different shapes and outside colour. The containers were each filled with water at 100 °C.
After 20 minutes the temperature of the water inside each container was measured.



The results from the investigation are given in the table.

Container	Colour	Temperature after 20 minutes in °C	Temperature fall in °C
A	White	86	14
B	Black	86	14
C	White	73	27
D	Black	60	40

(i) The student uses the results in the table to see if shape has affected heat transfer.

Which containers should the student compare to do this?

.....

Give a reason for your answer.

.....

.....

(1)

(ii) Explain why the temperature of the water in both containers **A** and **B** fell by the same amount.

.....

.....

.....

.....

(2)

(iii) A central heating system has several radiators joined together. The hot water goes from the boiler, through each radiator in turn and then back to the boiler for reheating.

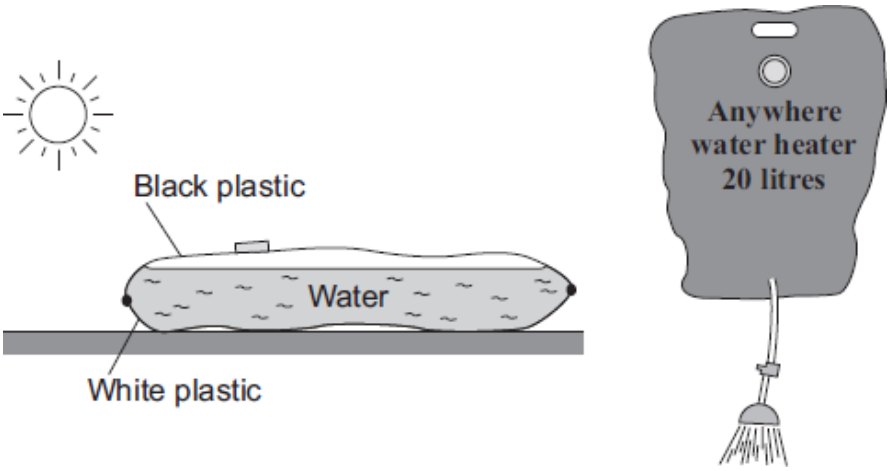
Give **one** reason, other than appearance, why it might **not** be a good idea to paint radiators black.

.....

.....

(1)
(Total 4 marks)

11 The diagram shows a simple type of portable shower. The water container is a strong plastic bag that is black on one side and white on the other. To warm the water, the bag is placed on the ground in direct sunlight, with the black side facing the Sun.



(a) (i) Name the process by which heat is transferred from the Sun to the outside of the bag.

.....

(1)

(ii) Explain why the black side of the bag and not the white side should face the Sun.

.....

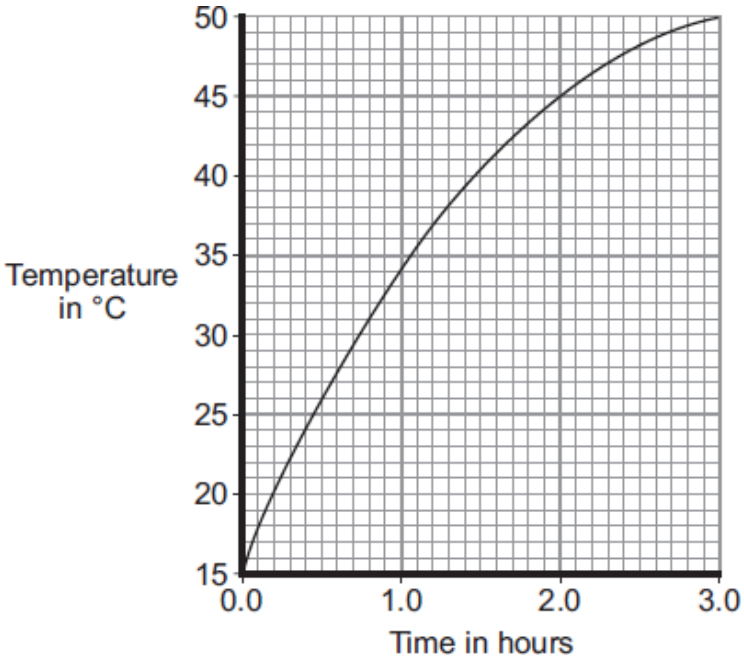
.....

.....

.....

(2)

(b) The graph shows how the temperature of the water inside a full bag increases after the bag is placed outside on a sunny day.



(i) How long does it take for the water to reach 37 °C?

.....

(1)

(ii) Describe how the temperature of the water changes during the three hours.

.....

.....

(1)

(c) A different manufacturer makes the same type of portable shower but uses a bag with a larger surface area. The bag is made from the same coloured plastics and holds the same amount of water.

(i) To compare the efficiency of the two bags at heating water, several variables need to be controlled.

Name **two** variables that need to be controlled.

1 .....

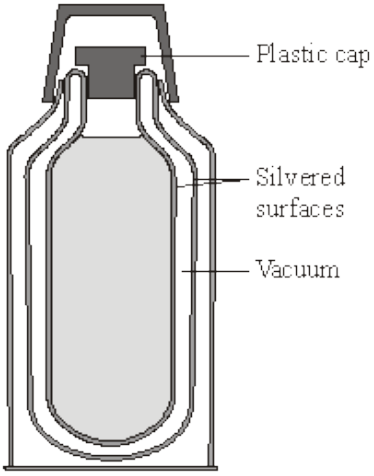
2 .....

(2)

(ii) The second bag has a larger surface area.
Draw a line on the graph to show how the temperature of the water inside the second bag would change over the first hour.
Assume that the two bags are tested in exactly the same way.

(1)
(Total 8 marks)

12 A vacuum flask is designed to reduce the rate of heat transfer.



(a) (i) Complete the table to show which methods of heat transfer are reduced by each of the features labelled in the diagram.

The first row has been done for you.

Feature	Conduction	Convection	Radiation
vacuum	*	*	
silveredsurfaces			
plastic cap			

(2)

(ii) Explain why the vacuum between the glass walls of the flask reduces heat transfer by conduction and convection.

.....

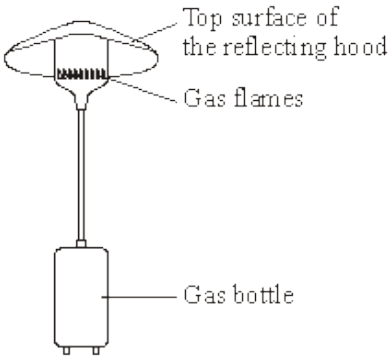
.....

.....

.....

(2)

(b) The diagram shows a gas flame patio heater.



(i) Explain why the top surface of the reflecting hood should be a light, shiny surface rather than a dark, matt surface.

.....

.....

.....

(2)

(ii) Most of the chemical energy in the gas is transformed into heat. A **small** amount of chemical energy is transformed into light.

Draw and label a Sankey diagram for the patio heater.

(2)

(iii) State why the total energy supplied to the patio heater must always equal the total energy transferred by the patio heater.

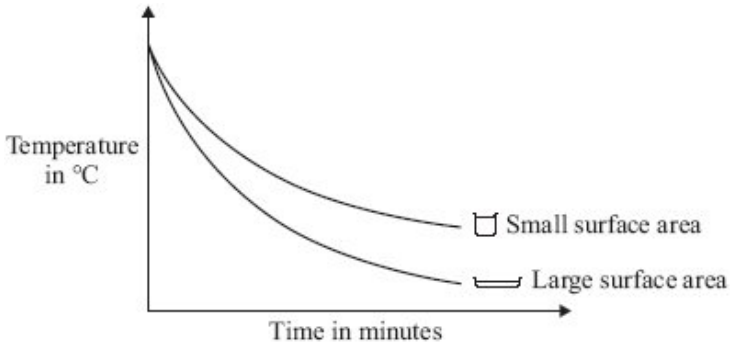
.....

.....

(1)
(Total 9 marks)

13 (a) The graph compares how quickly hot water cooled down in two glass beakers with different surface areas.

The volume of water in each beaker was the same.



Describe how the surface area of the water affected how fast the water cooled down.

.....

.....

(1)

(b) Some foxes live in a hot desert environment.

This type of fox has very large ears.

Explain how the size of the fox's ears help it to keep cool in a hot desert.

.....

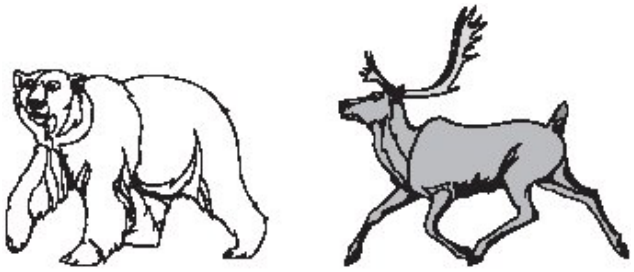
.....

.....

.....

(2)

(c) Polar bears and reindeer are adapted to live in cold environments.



Use the words in the box to complete the following sentences.

conduction	**convection**	**radiation**

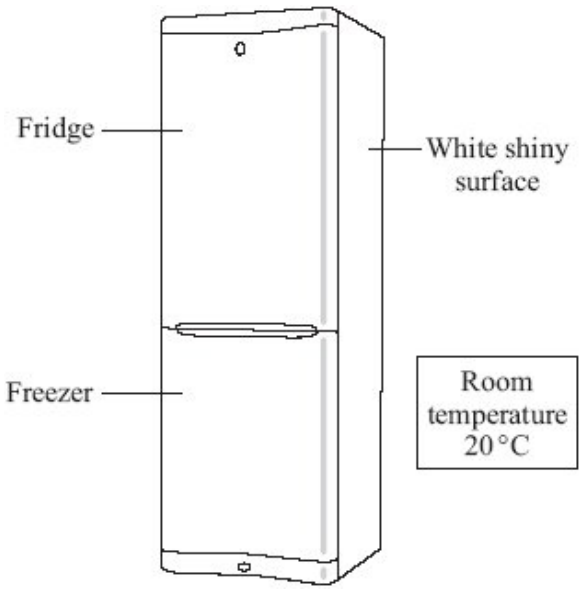
(i) The white colour of a polar bear's fur helps to keep the polar bear warm by reducing the heat lost by ..... .

(1)

(ii) The hairs of a reindeer are hollow. The air trapped inside the hairs reduces the heat lost by ..... .

(1)
(Total 5 marks)

14 The diagram shows a fridge-freezer.



(a) By which method is heat transferred through the walls of the fridge-freezer?

.....

(1)

(b) The inside of the fridge is at 4 °C. The inside of the freezer is at –18 °C.

Into which part of the fridge-freezer will the rate of heat transfer be greater?

Draw a ring around your answer.

the fridge **the freezer**

Give a reason for your answer.

.....

.....

(1)

(c) The outside surface of the fridge-freezer is white and shiny.

Give **two** reasons why this type of surface is suitable for a fridge-freezer.

1 .....

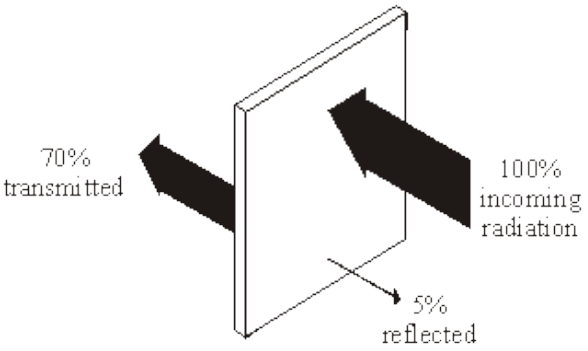
.....

2 .....

.....

(2)
(Total 4 marks)

15 (a) Infra red radiation can be reflected, absorbed and transmitted by glass.



(i) What percentage of infra red is absorbed by the glass?

.....

(1)

(ii) Complete the following sentence by drawing a ring around the correct word or phrase.

Theabsorbed infra red | increases / does not change / decreases | the temperature of the glass.

(1)

(b) **Two** of the following statements are true. **One** of the statements is false.

Tick (✓) the boxes next to the **two** true statements.

All objectsabsorb infra red radiation.	
Blacksurfaces are poor emitters of infra red radiation.	
A hot objectemits more infra red than a cooler object.	

(1)

(c) The following statement is false.

Blacksurfaces are good reflectors of infra red radiation.

Change **one** word in this statement to make it true.

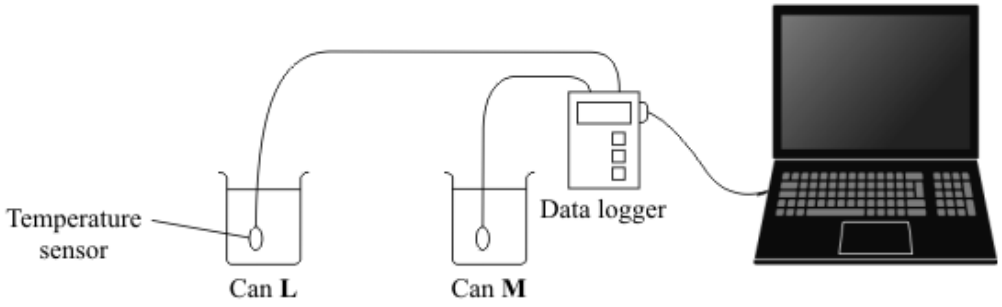
Write down your **new** statement.

.....

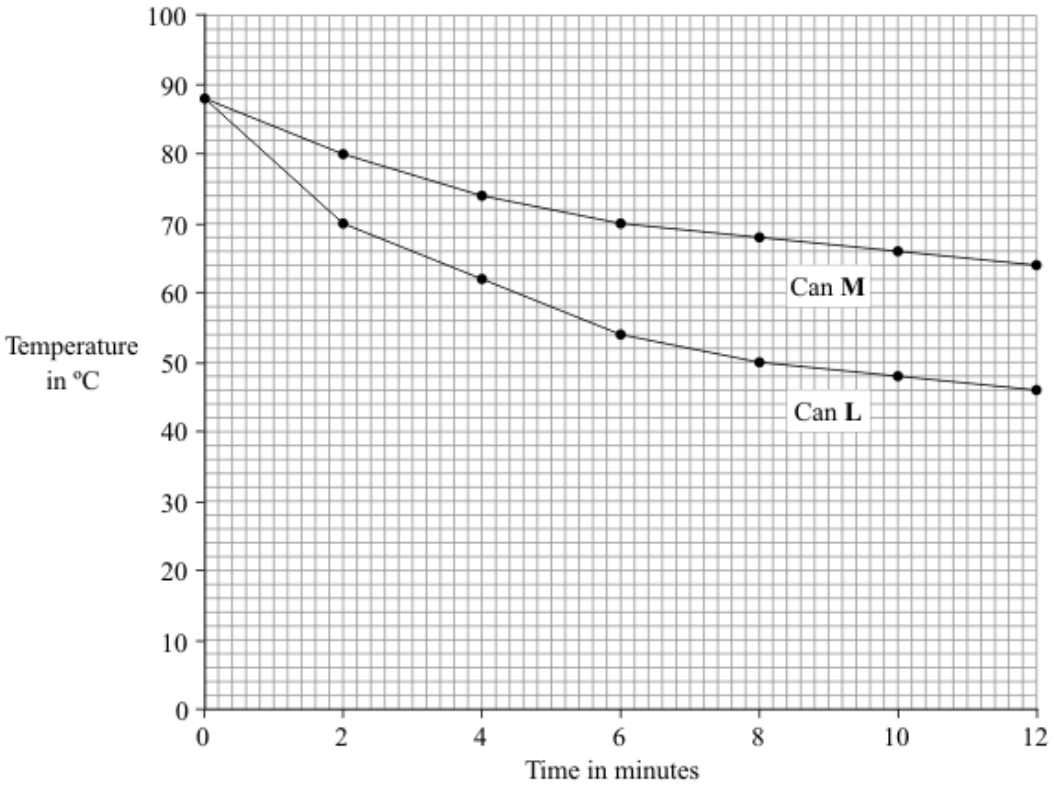
.....

(1)
(Total 4 marks)

16 A student was asked to investigate the heat loss from two metal cans, L and M. The cans were identical except for the outside colour.



The student filled the two cans with equal volumes of hot water. He then placed the temperature sensors in the water and started the data logger. The computer used the data to draw the graph below.



(a) Which **one** of the following is a categoric variable?

Put a tick (✓) in the box next to your answer.

the outside colour of the cans ☐

the starting temperature of the hot water ☐

the time ☐

the volume of hot water ☐

(1)

(b) For can **L**, state the temperature drop of the water:

(i) in the **first** two-minute interval

.....

(1)

(ii) in the **second** two-minute interval.

.....

(1)

(c) In both cans the water cooled faster at the start of the investigation than at the end of the investigation. Why?

.....

.....

(1)

(d) One can was black on the outside and the other can was white on the outside.

What colour was can **L**? .....

Explain the reason for your answer.

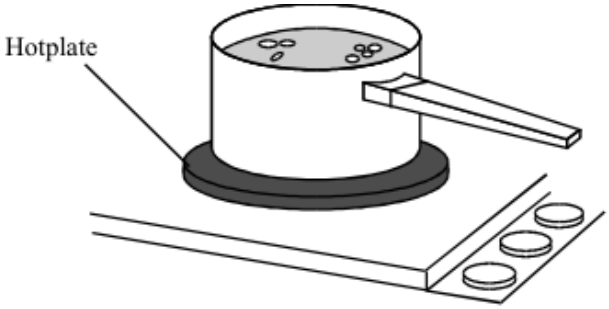
.....

.....

.....

(3)
(Total 7 marks)

17 The drawing shows water being heated in a metal saucepan.



(a) Explain, in terms of the particles in the metal, how heat energy is transferred through the base of the saucepan.

.....

.....

.....

.....

(2)

(b) Energy is transferred through the water by convection currents. Explain what happens to cause a convection current in the water. The answer has been started for you.

As heat energy is transferred through the saucepan, the water particles at the bottom

.....

.....

.....

.....

.....

.....

.....

.....

(3)

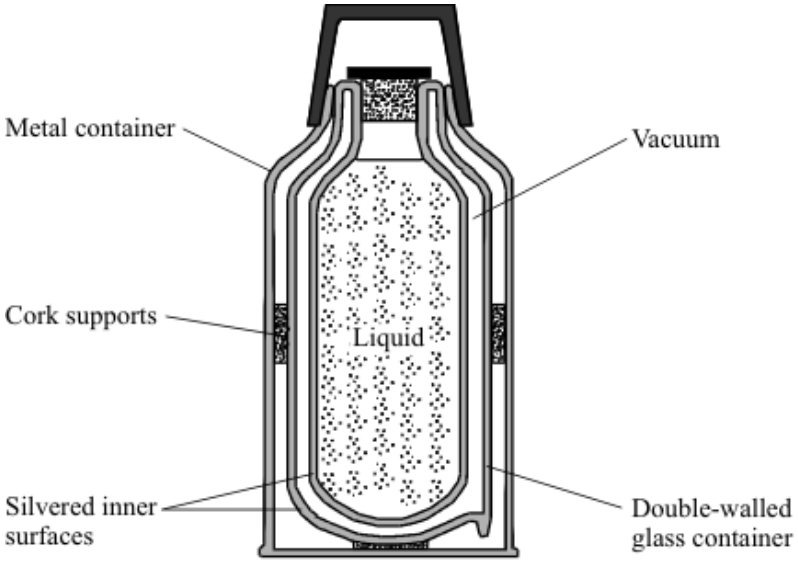
(c) Some energy is transferred from the hotplate to the air by *thermal radiation*. What is meant by *thermal radiation*?

.....

.....

(1)
(Total 6 marks)

18 The vacuum flask shown has five features labelled, each one designed to reduce heat transfer.



(a) (i) Which labelled feature of the vacuum flask reduces heat transfer by both conduction and convection?

.....

(1)

(ii) Explain how this feature reduces heat transfer by **both** conduction and convection.

.....

.....

.....

.....

.....

(2)

(b) (i) Which labelled feature of the vacuum flask reduces beat transfer by radiation?

.....

(1)

(ii) Explain how this feature reduces heat transfer by radiation.

.....

.....

.....

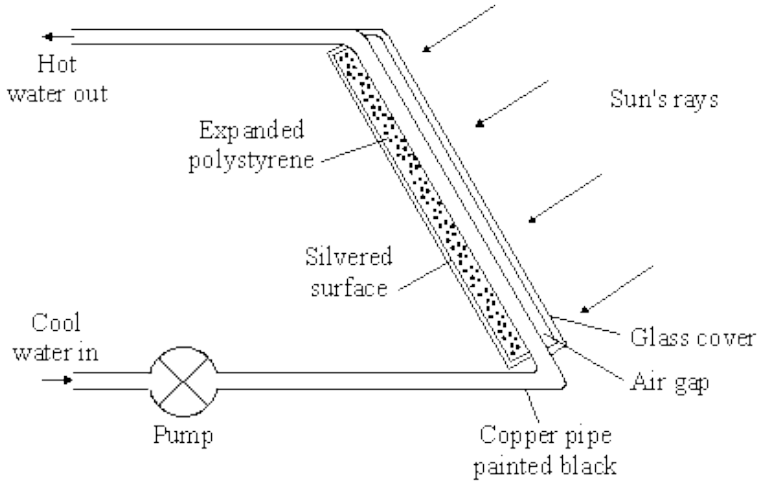
.....

.....

.....

(2)
(Total 6 marks)

19 The diagram shows part of a solar water heater. Water circulating through the solar panel is heated by the Sun.



(i) Complete the following sentence.

Heat energy is transferred from the Sun to the solar panel by

..... .

(1)

(ii) The pipe inside the solar panel is black. Why?

.....

.....

(1)

(iii) There is a layer of expanded polystyrene behind the black pipe. Why?

.....

.....

(1)

(iv) A silvered surface is used at the back of the solar panel. Explain why.

.....

.....

.....

.....

(2)
(Total 5 marks)

20 (a) When an electric kettle is switched on it will take a few minutes to boil the water. Once switched off it will gradually cool down.

(i) When the kettle is switched on the water heats. Explain how all of the water is heated.

.....

.....

(ii) The kettle is now switched off and begins to cool.

(1) Describe how heat energy is transferred **through** the walls of the kettle.

.....

.....

.....

(2) Describe how the heat energy is transferred **from** the walls of the kettle.

.....

.....

.....

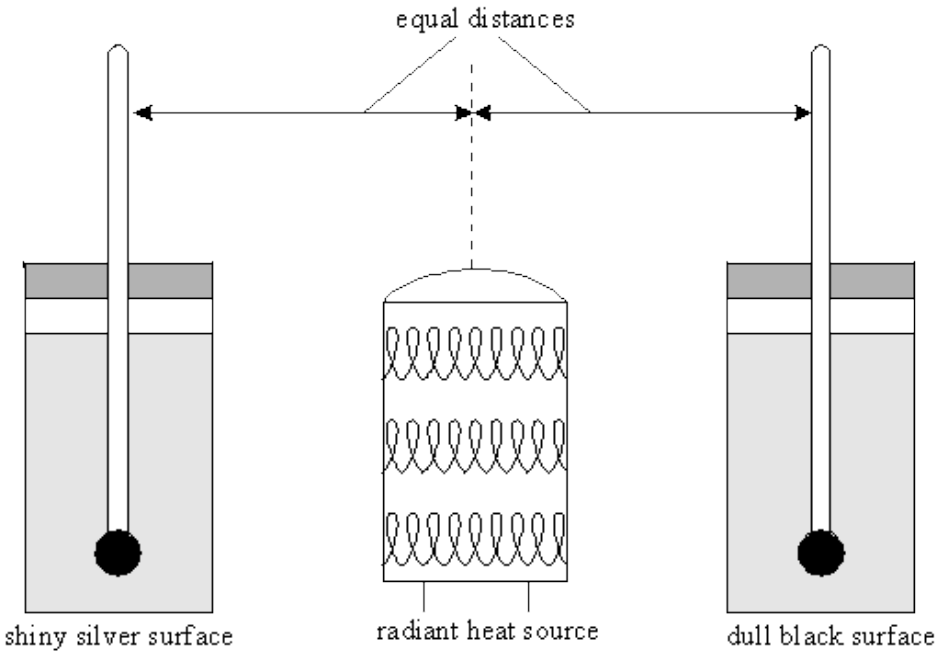
(iii) Describe how heat losses from the surface of a metal kettle may be kept small.

.....

.....

(4)

(b) A shiny metal can and a dull black can are filled with the same amounts of cold water. A radiant heater is placed exactly half way between the cans as shown in the diagram below.



Two thermometers are used to measure the temperature of the water in each can every minute.

(i) Suggest how the temperature of the water in the dull can would be different from the temperature of the water in the shiny can after ten minutes.

.....

.....

(ii) Explain your answer to part (i).

.....

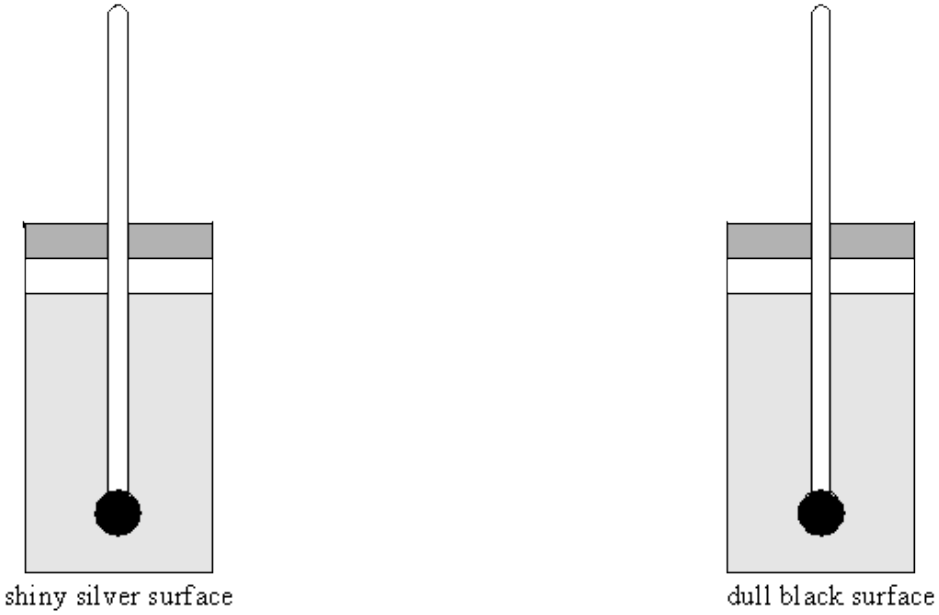
.....

.....

.....

(3)

(c) The radiant heater was removed and both the cans were filled with the same amount of boiling water, as shown in the diagram below.



The temperature was recorded every minute for ten minutes.

(i) Suggest how the temperature of the water in the dull can would be different from the temperature of the water in the shiny can after ten minutes.

.....

.....

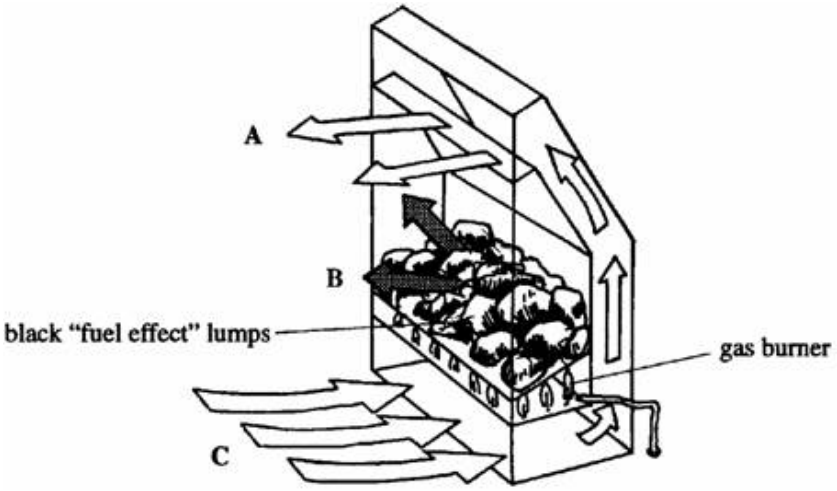
(ii) Explain your answer to part (i).

.....

.....

(3)
(Total 10 marks)

21 The diagram comes from a leaflet about a “coal effect” gas fire.
It shows how air circulates through the fire.



(a) Explain in detail why the air travels from **C** to **A**.

.....

.....

.....

.....

.....

.....

(4)

(b) The black “fuel effect” lumps become very hot.

(i) Name the process by which the lumps transfer thermal energy to the room as shown at **B**.

.....

(1)

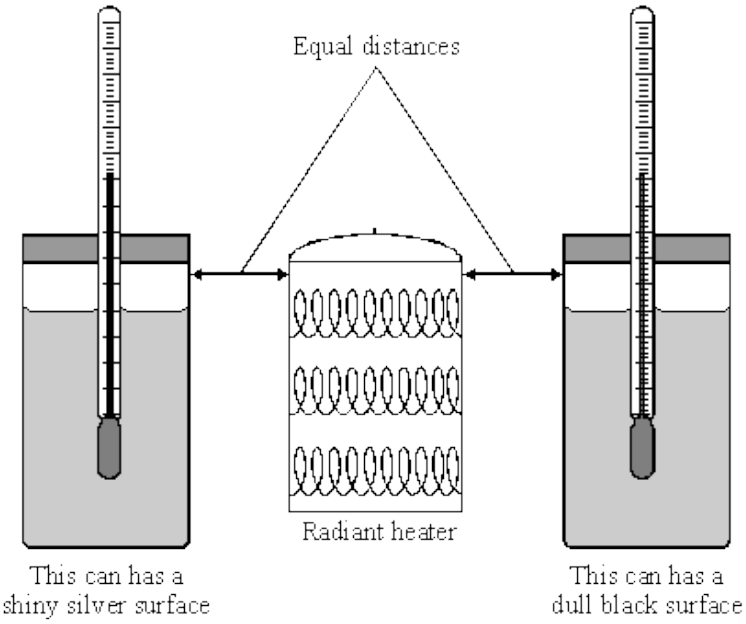
(ii) Suggest **one** feature of the black “fuel effect” lumps which make them efficient at transferring energy.

.....

.....

(1)
(Total 6 marks)

22 A student did two experiments on radiation. The apparatus he used is shown in the diagram.



Experiment 1

- The student put the same volume of cold water into the two cans.
- He then switched on the heater.
- Ten minutes later the water in the can with the dull black surface was much hotter than the water in the other can.

Experiment 2

- The student filled both cans with boiling water.
- This time he left the heater off.
- Ten minutes later the water in the can with the dull black surface was much cooler than the water in the other can.

Use words from the box to complete the sentences.

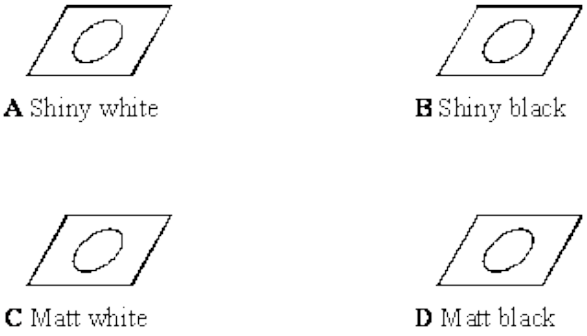
absorber	conductor	emitter	reflector

Experiment 1 shows that the dull black surface is a good ..... of radiation and that the shiny silver surface is a good ..... of radiation.

Experiment 2 shows that the dull black surface is a good ..... of radiation.

(Total 3 marks)

23 The diagram shows four identical pieces of aluminium. Each had been painted with a different type of paint. A drop of water was placed on each and they were then heated by a radiant heater held about one metre above them.



(i) Suggest in which order the pieces of aluminium would become dry.

first .... last

(1)

(ii) Explain why you chose your order.

.....

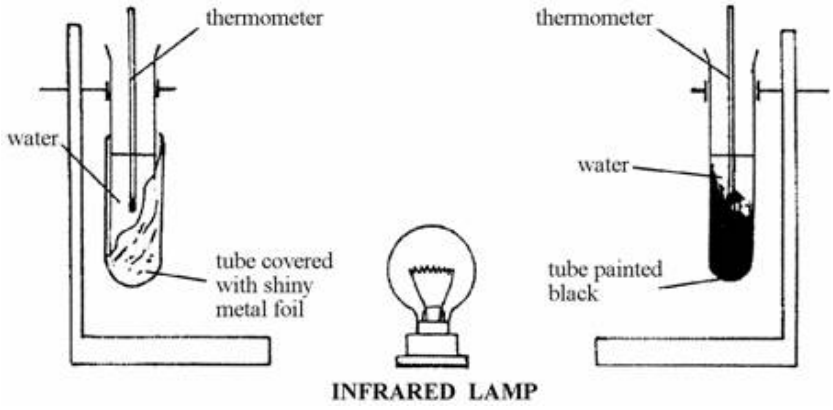
.....

.....

.....

(2)
(Total 3 marks)

24 The diagram shows an experiment to find out what happens to infrared waves when they strike different surfaces.



(a) The water in the black tube gets hotter than the water in the shiny tube.
Choose words from the list to complete the sentences below.

absorbs **conducts** **convects** **radiates** **reflects**

The infrared lamp ..... energy to the tubes of water.

The black surface ..... most of the energy that reaches it.

The shiny surface ..... most of the energy that reaches it.

(3)

(b) Put the sentences A- E below into the correct boxes on the flow diagram so that they tell you how to do the experiment

(You may use just the letters if you want to.)

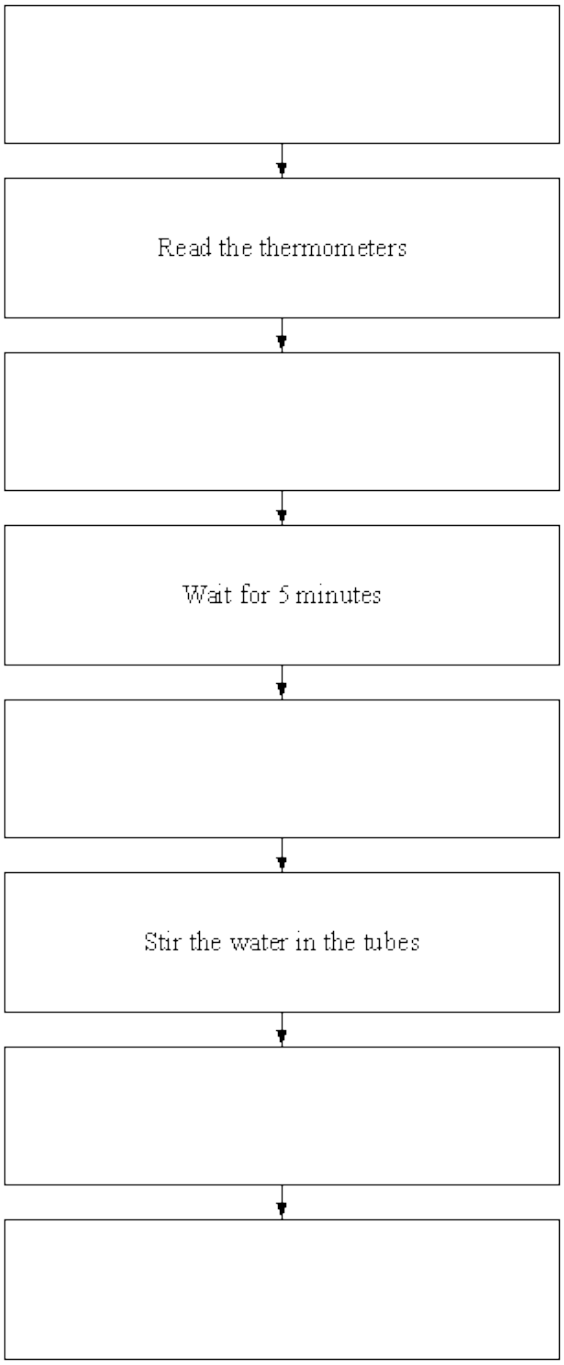
A Switch off the lamp

B Switch on the lamp

C Make sure the lamp is the same distance from both tubes

D Read the thermometers

E Wait for the temperature to stop rising



(5)
(Total 8 marks)

1

(a) dark matt

1

light shiny

1

(b) B A C

1

biggest temperature difference (80 °C)

dependent on first mark

1

(c) (i) (the can that is) dark matt

1

best absorber (of infrared radiation)

1

(ii) any **three** from:

- same area / shape of can
- surrounding temperature is the same for all cans
- same surface underneath cans
- same position in the room

3

(d) fox A

smaller ears

1

thicker fur

1

these minimise energy transfer

dependent on first 2 marks

1

[12]

2

(a) (black) is a good absorber of (infrared) radiation

1

(b) (i) amount of energy required to change (the state of a substance) from solid to liquid (with no change in temperature)

melt is insufficient

1

unit mass / 1kg

1

(ii) 5.1×10^6 (J)

accept 5×10^6

*allow **1** mark for correct substitution ie $E = 15 \times 3.4 \times 10^5$*

2

(c) (i) mass of <u>ice</u>

allow volume / weight / amount / quantity of <u>ice</u>

1

(ii) to distribute the salt throughout the ice

1

to keep all the ice at the same temperature

1

(iii) melting point decreases as the mass of salt is increased

allow concentration for mass

accept negative correlation

*do **not** accept inversely proportional*

1

(d) 60 000 (J)

accept 60 KJ

*allow **2** marks for correct substitution ie E = 500 × 2.0 × 60*

*allow **2** marks for an answer of 1000 **or** 60*

*allow **1** mark for correct substitution ie*

*E = 500 × 2.0 **or** 0.50 × 2.0 × 60*

*allow **1** mark for an answer of 1*

3

(e) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is *an attempt at a description of some advantages or disadvantages.*

Level 2 (3–4 marks)
There is a basic description of *some advantages* ***and / or*** *disadvantages for some of the methods*

Level 3 (5–6 marks)
There is a clear description of the advantages and disadvantages of all the methods.

examples of the points made in the response
extra information

energy storage

advantages:

- no fuel costs
- no environmental effects

disadvantages:

- expensive to set up and maintain
- need to dig deep under road
- dependent on (summer) weather
- digging up earth and disrupting habitats

salt spreading

advantages:

- easily available
- cheap

disadvantages:

- can damage trees / plants / drinking water / cars
- needs to be cleaned away

undersoil heating

advantages:

- not dependent on weather
- can be switched on and off

disadvantages:

- costly
- bad for environment

6

[18]

3 (a) infrared / IR

correct answer only

1

(b) any **two** from:

- increase the power / watts

  allow increase the temperature of the oven or make the oven hotter
- decrease the speed

  allow leave the biscuits in for longer
- put biscuits through again

  increase radiation is insufficient

  ignore changes to the design of the oven

2

(c) (inside) surface is a (good) reflector or poor absorber (of IR)

Ignore bounce for reflect

surface is a (good) reflector of light does not score

surface is a (good) reflector of light and infrared / heat does score

1

(and) <u>outside</u> surface is poor emitter (of IR)

1

(so) increases the energy reaching the biscuits

allow reduces energy loss or makes oven more efficient

*do **not** accept no energy losses*

keeps oven hotter is insufficient

1

[6]

4 (a) to reflect (the infrared)

accept (shiny surfaces) are good reflectors

ignore reference to incorrect type of wave

1

(b) black

1

best absorber (of infrared)

answer should be comparative

black absorbs (infrared) is insufficient

accept good absorber (of infrared)

ignore reference to emitter

ignore attracts heat

ignore reference to conduction

1

(c) to reduce energy loss

accept to stop energy loss
accept heat for energy
accept to stop / reduce convection

or
so temperature of water increases faster

accept to heat water faster
accept cooks food faster

or
reduces loss of water (by evaporation)

1

(d) 672 000

*allow **1** mark for correct substitution, ie 2 × 4200 × 80 provided no subsequent step shown*

2

[6]

5

(a) (matt) black is a good <u>emitter</u> of infrared / radiation

accept heat for infrared / radiation
ignore reference to good absorber
attracts heat negates this marking point

1

to give maximum (rate of) energy transfer (to surroundings)

accept temperature (of coolant) falls fast(er)
*accept black emits more radiation for **1** mark*
*black emits most radiation / black is the best emitter of radiation for **2** marks*

1

(b) the fins increase the surface area

accept heat for energy

1

so increasing the (rate of) energy transfer
or
so more fins greater (rate of) energy transfer

1

(c) 114 000

*allow **1** mark for correct temperature change, ie 15 (°C)*
or
*allow **2** marks for correct substitution, ie 2 × 3 800 × 15*
*answers of 851 200 **or** 737 200 gain **2** marks*
or
*substitution 2 × 3800 × 112 **or** 2 × 3800 × 97 gains **1** mark*
*an answer of 114 kJ gains **3** marks*

3

(d) increases the efficiency

1

less (input) energy is wasted

accept some of the energy that would have been wasted is (usefully) used

or

more (input) energy is usefully used

accept heat for energy

1

[9]

6 (a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

accept as a control / comparison

to measure room temperature is insufficient

1

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

an answer

the longer the <u>wavelength</u> the greater the (rise in) temperature

or

the lower the <u>frequency</u> the greater the (rise in) temperature gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

(c) $v = f \times \lambda$

9.4×10^{-6}

accept 9.375×10^{-6} or 9.38×10^{-6}

or

0.0000094

accept 0.000009375
***or** 0.00000938*
*allow **1** mark for correct substitution*
ie $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

2

(d) at night the surroundings are cooler

accept at night the air is colder
there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

1

[9]

7 (a) any **two** from:

- black is a good emitter of (infrared radiation)

  accept heat for radiation
  ignore reference to absorbing radiation

- large surface (area)

- matt surfaces are better emitters (than shiny surfaces)

  accept matt surfaces are good emitters
  ignore reference to good conductor

2

$$efficiency = \frac{useful\ energy\ out\ (\times 100\%)}{total\ energy\ in}$$

allow 1 mark for correct substitution, ie $\frac{13.5}{15}$

provided no subsequent step shown
*an answer of 90 scores **1** mark*
*an answer of 90 / 0.90 with a unit scores **1** mark*

2

(c) (producing) light

allow (producing) sound

1

(d) any **two** from:

- wood is renewable

  accept wood grows again / quickly
  accept wood can be replanted

- (using wood) conserves fossil fuels

  accept doesn't use fossil fuels

- wood is carbon neutral

  accept a description
  cheaper / saves money is insufficient

2

(e) $E = m \times c \times \theta$

2 550 000

*allow **1** mark for correct substitution*
ie 100 × 510 × 50
provided no subsequent step shown
*answers of 1 020 000, 3 570 000 gain **1** mark*

2

joules /J

accept kJ / MJ
*do **not** accept j*
for full credit the unit and numerical answer must be consistent

1

[10]

8 (a) (i) The volume of boiling water.

1

(ii) any **one** from:

- (more) precise
  *do **not** accept better (reading)*
- accurate
- reliable
  *do **not** accept thermometer is unreliable*
- removes human / reading error
  accept easier to read
  accept take temperature more frequently

1

(b) **B**

marks are for the explanation

temperature falls faster

*this mark point cannot score if **A** chosen*

1

because black is a better / good emitter

ignore reference to better absorber
*accept for both marks an answer in terms of why **A** is the white can*

1

(c) (i) faster than

1

(ii) darker / black surfaces absorb heat faster

accept black is a better / good absorber
dark surfaces attract heat negates this mark

1

(iii) air is a <u>bad / poor</u> conductor
or
air is a good <u>insulator</u>

accept air is an insulator

1

[7]

9 (a) (i) convection

1

(ii) conduction

1

(b) (i) 2

1

black is the best <u>absorber</u> (of thermal energy / heat)

accept black is the best emitter (of thermal energy / heat)
note that a comparative is needed (eg better or best)

1

(ii) the colour of the metal plates

1

(iii) any **one** from:

- more precise / accurate / reliable
  *do **not** accept better reading*
  *do **not** accept thermometer is unreliable*
- can measure continuously
- take many readings in a small time
- removes (human) reading error
  accept easier to read
- can compare / draw graphs automatically
- records data automatically

1

(c) (i) radiation
accept radiates
accept infra red (IR) waves
*do **not** accept heat waves*

1

(ii) to reflect (heat away from the fire fighter)
accept it reflects
accept it is a poor absorber (of thermal radiation / heat)
*do **not** accept deflect / bounce for reflect*

1

(d) **N**
*the mark is for the reason which does not score if **M** is chosen*

transfers / absorbs less heat
or
gives smallest increase in temperature
accept will keep fire fighters cooler
*accept **N** is cooler (after 15 minutes)*
*an answer **N** goes up to 52°C and **M** goes up to 100°C is insufficient*

1

[9]

10 (i) *this mark only scores if a correct pair is chosen **and** a correct reason given*

A and **C**

both required and none other

or

B and **D**

both required and none other

only one (independent) variable

or

different shapes but the same colour

accept only the shape changes

1

(ii) **B** radiates heat faster

*converse answer in terms of **A** gains full marks*

1

or

B is a better emitter (of heat)

but B has a smaller (surface) area

or

B has a smaller (surface) area: volume ratio

*allow **2** marks for both lose the same quantity / amount of heat in the same time*

***or** both have same rate of heat loss*

*allow **1** mark for both lose the same quantity / amount of heat*

1

(iii) any **one** from:

- transfer a lot of heat (too rapidly)
- water temperature drops too rapidly

  accept (significantly) more heat will be lost from the first radiator
- water too cold for the next radiator

  mention of absorption of heat negates mark

1

[4]

11 (a) (i) radiation

ignore thermal / infrared

1

(ii) black is a better / good absorber (of heat / radiation)

ignore reference to black being a good emitter

black absorbs heat is insufficient

*do **not** accept black attracts / absorbs the Sun*

*do **not** accept black attracts heat*

1

(so) temperature rises faster

must be an indication of heating up quicker

or

white is a worse / poor absorber (of heat / radiation) (1)

accept white is a better / good reflector (of heat / radiation)

(so if white faces) temperature would rise slower (1)

ignore any reference to light

1

(b) (i) 1.2 (hours) **or** 1 hour 12 minutes

no tolerance

1

(ii) increases (rapidly at first then increases at a slower rate)

*do **not** accept increases at a steady rate*

1

(c) (i) any **two** from:

- (fill with) same mass / volume / amount of water
- same level of (sun)light / sunshine

  accept same heat / light source

  accept same place
- outside for the same (length of) time
- outside at same time (of day / year)
- initial water temperature
- the side of the bag facing the Sun

  *do **not** accept any factors to do with the construction of plastic bags eg thickness*

2

(ii) curved line drawn above given line

both lines must start from the same point

ignore if continues beyond one hour or levels off after 1 hour

*do **not** accept a straight line*

1

[8]

12 (a) (i) silvered surfaces

more than the correct number of ticks in a row negates the mark

radiation

2

plastic cap

conduction, convection (both required)

	conduction	convection	radiation	
vacuum	✓	✓		
silvered surfaces			✓	(1)
plastic cap	✓	✓		(1)

(ii)

any mention of air or any other substance in a vacuum scores zero

because there are no particles in a vacuum

accept atoms / molecules for particles

accept vacuum is empty space

accept there is nothing in a vacuum

accept there is no air / gas in the vacuum

conduction **and** convection need particles / medium

*need reference to both conduction **and** convection*

accept correct descriptions

2

(b) (i) less heat lost (to air above the heater)

*do **not** accept **no** heat lost*

light shiny surfaces are poor emitters (of radiation)

accept radiators for emitters
references to reflection are neutral

or dull, matt surfaces are good emitters (of radiation)

*do **not** credit answers which infer reflection from the underside of the hood*

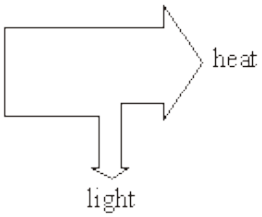
ignore correct reference to absorption

2

(ii) correct diagram drawn with one output arrow narrower than the other

ignore input

arrows correctly labelled with energy form
eg



flow charts score zero

2

(iii) energy cannot be destroyed

accept (principle of) conservation of energy

*do **not** accept because energy cannot be lost without clarification*

1

[9]

13 (a) the bigger the surface area, the faster the water cools down / temperature falls

answers must imply rate

accept heat for temperature provided rate is implied

*do **not** accept cools down more unless qualified*

1

(b) any **two** from:

the ears:

- have large surface / area

  not just has large ears

- radiate heat

  accept loses heat, but does not score if the reason given for heat loss is wrong

- keep blood cooler

2

(c) (i) radiation

1

(ii) conduction

1

[5]

14 (a) conduction

*do **not** accept conductor*

1

(b) the freezer

both parts needed

greater <u>temperature</u> difference (between freezer and room)

*do **not** accept because it is the coldest*

1

(c) any **two** from:

- poor absorber of heat / radiation

  accept does not absorb heat poor emitter of heat / radiation is neutral

- reflects heat / radiation (from room away from fridge-freezer)
- reduces heat transfer <u>into</u> the fridge-freezer
- reduces power consumption of fridge-freezer

  *do **not** accept it is a bad conductor / good insulator*

2

[4]

15 (a) (i) 25 (%)

*do **not** accept ¼*

1

(ii) increases

1

(b) tick (✓) in top and bottom box

both required

1

(c) SHINY surfaces are good reflectors of infra-red radiation

accept white for shiny

or black surfaces are POOR reflectors of infra-red radiation

accept bad for poor
accept insertion of 'not' before 'good' in statement

or black surfaces are good EMITTERS of infra-red radiation

or black surfaces are good ABSORBERS of infra red radiation

1

[4]

-

16 (a) the outside colour of the cans

1

(b) (i) 18 (°C) **or** 88 to 70

ignore negative sign

1

(ii) 8 (°C) **or** 70 to 62

ignore negative sign

1

(c) greater temperature difference between water and surroundings (at start)

must mention temperature difference

ignore just water hotter

accept energy used to heat cans initially

1

(d) black

1

temperature falls the fastest (in L)

accept (can L) loses more heat / cools quicker

accept heat for temperature

1

black is a good / the best / better emitter (of heat / radiation)

accept converse

ignore black is best absorber

1

[7]

17 (a) ions / electrons gain (kinetic) energy

accept atom / particles / molecules for ion
accept ions vibrate faster
accept ions vibrate with a bigger amplitude
accept ions vibrate more
do not accept ions move faster

1

(free) electrons transfer energy by collision with ions
or energy transferred by collisions between vibrating ions

1

(b) move faster or take up more space

*do **not** accept start to move / vibrate*

1

(warmer) water expands **or** becomes less dense (than cooler water)

*do **not** accept answers in terms of particles expanding*

1

warm water rises (through colder water) **or** colder water falls to take its place

1

(c) transfer of energy by waves / infrared (radiation)

accept rays for waves

*do **not** accept transfer of energy by electromagnetic waves*

ignore reference to heat

1

[6]

18 (a) (i) vacuum

do not allow stopper

1

(ii) (absence of particles) means no (transfer of energy between) particles for conduction

*accept particles **or** atoms **or** molecules **or** electrons*

1

no movement of molecules for (transfer of energy by) convection

accept particles/atoms/electrons

if answer to (a)(i) is correct: then in (a)(ii) have stated 'conduction and convection both need a medium/particles/materials' = 2 marks

(If medium is specified, it must be correct, conduction can be solid, liquid or gas, convection must be liquid or gas)

if answer to (a)(i) is incorrect then in (a)(ii) have stated 'conduction and convection both need a medium...'= 1 mark, unless further qualified by stating about absence of particles, in which case get a second mark.

1

(b) (i) silvered surface

accept silver surface

1

(ii) silvered is a bad emitter/radiator

1

surface reflects heat/energy/radiation (at inner and outer surface) **or** is a bad absorber (of energy)

accept bounces off

1

[6]

19 (i) radiation **or** infra red

*do **not** accept rays*

*do **not** accept waves*

accept electromagnetic waves

1

(ii) good absorber (of heat) to absorb heat (**or** infrared)

*do **not** accept 'attract' **or** 'capture' **or** soak*

1

(iii) reduce heat loss (from the panel)

accept (good) (heat) insulator

*accept stop **or** reduce conduction*

*accept stop **or** reduce convection*

accept traps heat

accept keeps water hot

1

(iv) to reflect (back into the panel) heat **or** infrared **or** Sun's energy

*do **not** accept 'bouncing'*

*do **not** accept reflect Sun*

*do **not** accept reflect sunlight **or** sun's rays*

1

radiated **or** given out by the (black) pipe

accept back to pipe
accept reduce heat loss for 1 mark
accept reduce heat loss by radiation for 2 marks
accept stop heat loss by radiation for I mark

1

[5]

20 (a) (i) Carries heat up (as convection current)

1

(ii) (1) By conduction or from molecule to molecule
(2) By radiation or as IR

2

(iii) Use shiny surface (inside or outside) or small area

1

(b) (i) Rise more quickly

1

(ii) Dull surface good absorber
(accept "attract" = "absorb" if context correct,
then penalise spg mark.

Shiny surface poor absorber

2

(c) (i) Fall more quickly

1

(ii) Dull surface good emitter
Shiny surface poor emitter

2

[10]

21 (a) convection
air is heated by the burner / particles gain energy
air expands / particles move about more / particles move faster
air becomes less dense / particles are more spread out
air rises / particles rise - *not* heat rises
air from C moves into the heater / particles from C move into the heater to replace it / them

any four *for 1 mark each*

4

(b) (i) radiation

for one mark

1

(ii) black surface radiates / emits well
(*allow* absorbs and emits well) (*allow* comparison with shiny / white surfaces)

large surface area needed
high temperature (of the lumps)

any one for 1 mark

1

[6]

22 absorber

1

reflector

1

emitter

1

[3]

23 (i) D, C **or** B, in either order, then A

tick or cross on the A

1

(ii) matt absorbs energy (better than shiny)

the converse arguments are acceptable

1

black absorbs energy (better than white)

1

[3]

24 (a) radiates
absorbs / conducts
reflects

for 1 mark each

3

(b) C make sure the lamp is the same distance from both tubes
B switch on the lamp
A switch off the lamp
E wait for the temperature to stop rising
D read the thermometers

for 1 mark each

5

[8]