Mr Baker's Science-Stuff

Thermal Energy

Name: _____

Class: _____

Date: _____

Time: **124 minutes**

Marks: **124 marks**

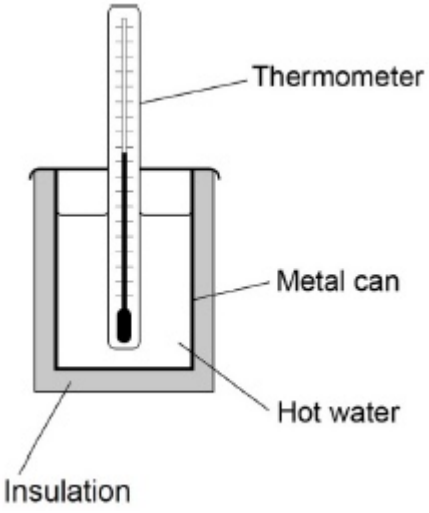
Comments:

Q1.

A student investigated the properties of three insulating materials.

Figure 1 shows the apparatus the student used.

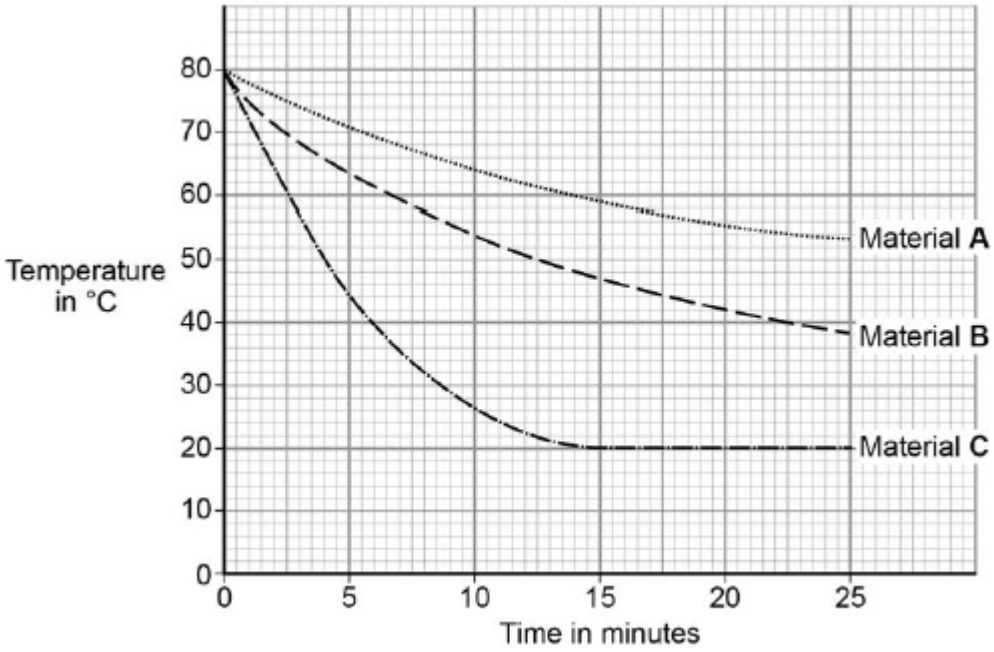
Figure 1



In the investigation, different insulating materials were used to insulate a metal can filled with hot water.

Figure 2 shows how the temperature measured by the thermometer changed over 25 minutes for each of the materials.

Figure 2



(a) What was the temperature of the room where the student carried out the investigation?

Tick **one** box.

20 °C ☐ 38 °C ☐ 53 °C ☐ 80 °C ☐

(1)

(b) Material C has the highest thermal conductivity.

How does the graph in **Figure 2** show this?

_____

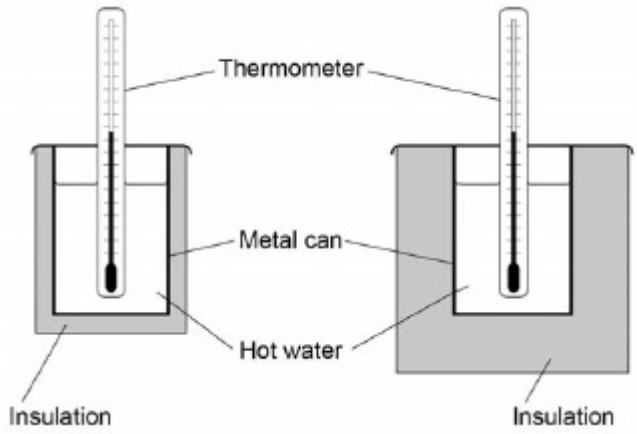
_____

(1)

(c) Another student repeated the investigation using the equipment shown in **Figure 3**.

Figure 1 shows the first set of equipment used.

Figure 1 **Figure 3**



Suggest how using the equipment in **Figure 3** will have affected the student's results.

_____

_____

_____

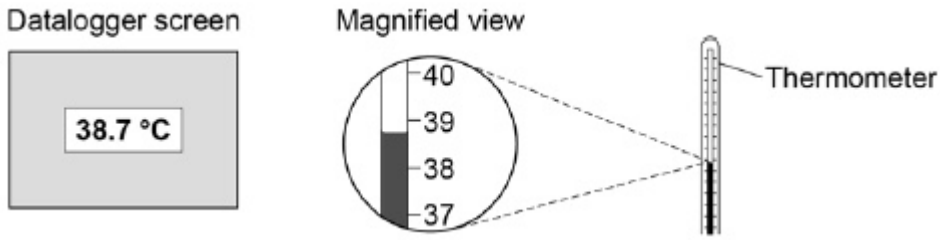
_____

(2)

(d) The students could have used a temperature probe and datalogger instead of a thermometer.

Figure 4 shows the datalogger screen and the thermometer.

Figure 4



Complete the sentences.

Choose the answers from the box.

higher	**lower**	**the same**

Compared to the thermometer, the datalogger and temperature probe have a resolution that is _____ .

Compared to the thermometer, the chance of misreading the datalogger and temperature probe is _____ .

(2)

(e) The table gives information about four types of insulation that could be used in the walls of houses.

Type of insulation	**Thermal conductivity in W/m °C**
Felt wool	0.070
Mineral wool	0.040
Polyurethane foam	0.030
Rock wool	0.045

Which type of insulation would be most effective in reducing the rate of cooling of a building?

Tick **one** box.

Felt wool ☐

Mineral wool ☐

Polyurethane foam ☐

Rock wool ☐

Give a reason for your answer.

_____

_____

_____

_____

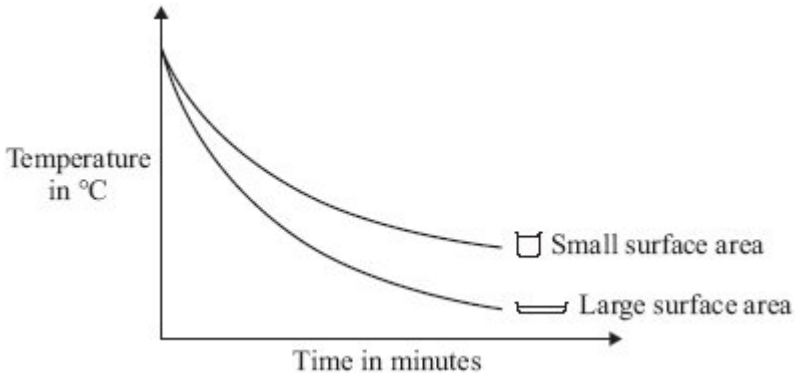
(2)

(Total 8 marks)

Q2.

(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.

_____

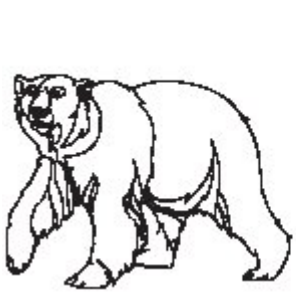
_____

_____

_____

(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)

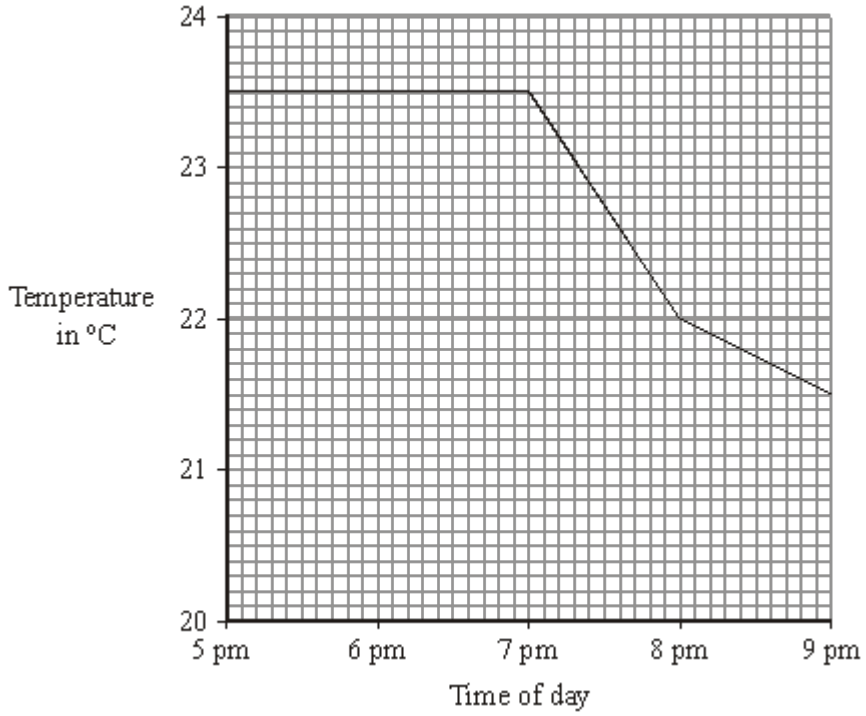
(ii) The hairs of a reindeer are hollow. The air trapped inside the hairs reduces the heat lost by _____ .

(1)

(Total 5 marks)

Q3.

(a) The graph shows the temperature inside a flat between 5 pm and 9 pm. The central heating was on at 5 pm.



(i) What time did the central heating switch off?

_____

(1)

(ii) Closing the curtains reduces heat loss from the flat.

What time do you think the curtains were closed?

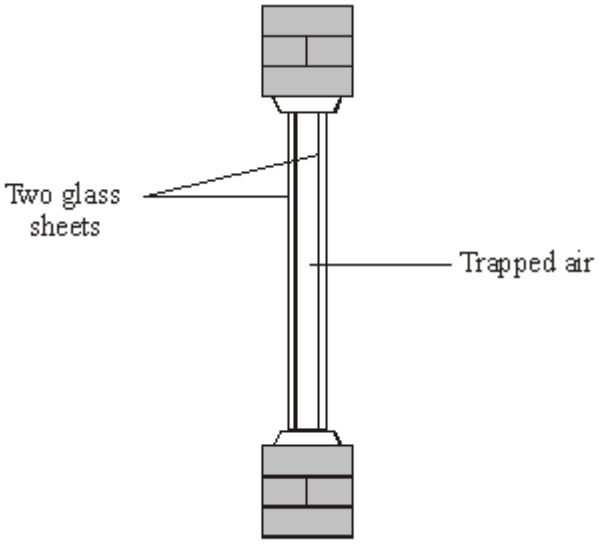
_____

Give a reason for your answer.

_____

(2)

(b) Less heat is lost through double-glazed windows than through single-glazed windows.



A double-glazed window

Complete the following sentences by choosing the correct words from the box. Each word may be used once or not at all.

conduction	conductor	convection	evaporation	insulator	radiation

Air is a good _____ . When trapped between two sheets of glass it reduces heat loss by _____ and _____

(3)

(c) The table gives information about three types of house insulation.

Type of insulation	Cost to install	Money save each year on heating bills	Payback time
Double glazing	£4000	£200	20 years
Loft insulation	£300	£100	3 years
Cavity wallinsulation	£600	£150	

(i) Use the information in the table to calculate the payback time for cavity wall insulation.

_____

(1)

(ii) Explain why people often install loft insulation before installing double glazing or cavity wall insulation.

_____

_____

_____

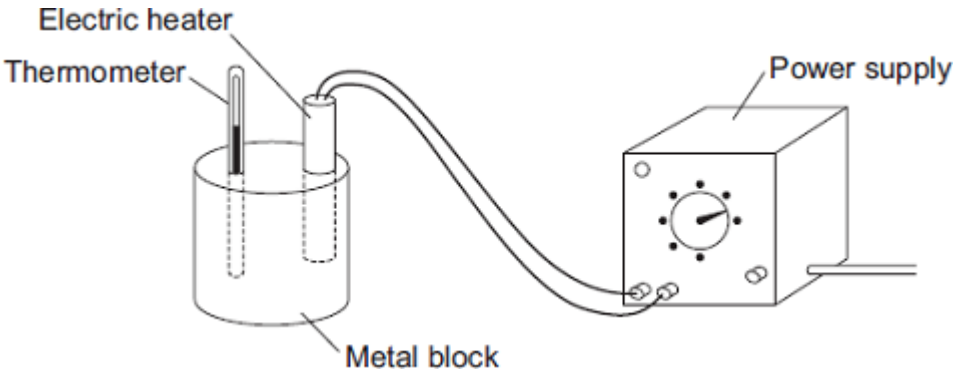
_____

(2)

(Total 9 marks)

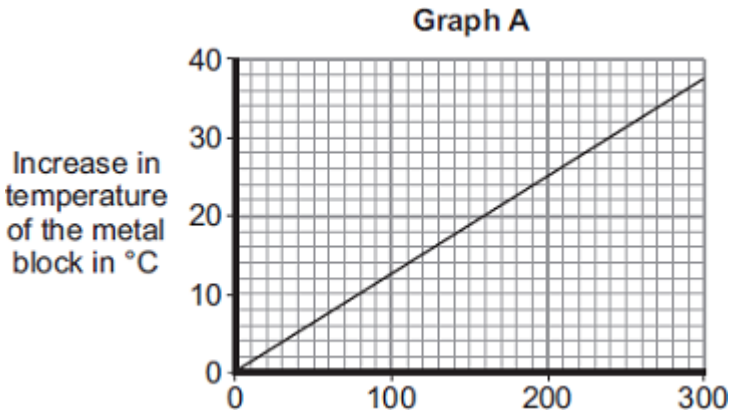
Q4.

(a) A student used the apparatus drawn below to investigate the heating effect of an electric heater.



(i) Before starting the experiment, the student drew **Graph A**.

Graph A shows how the student expected the temperature of the metal block to change after the heater was switched on.



Describe the pattern shown in **Graph A**.

_____

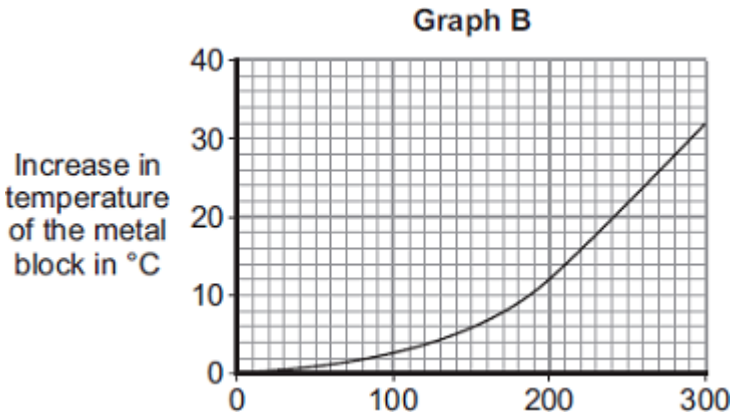
_____

_____

(2)

(ii) The student measured the room temperature. He then switched the heater on and measured the temperature of the metal block every 50 seconds.

The student calculated the increase in temperature of the metal block and plotted **Graph B**.



After 300 seconds, **Graph B** shows the increase in temperature of the metal block is lower than the increase in temperature expected from **Graph A**.

Suggest **one** reason why.

_____

_____

(1)

(iii) The power of the electric heater is 50 watts.

Calculate the energy transferred to the heater from the electricity supply in 300 seconds.

_____

_____

_____

Energy transferred = _____ J

(2)

(b) The student uses the same heater to heat blocks of different metals. Each time the heater is switched on for 300 seconds.

Each block of metal has the same mass but a different specific heat capacity.

Metal	Specific heat capacity in J/kg°C
Aluminium	900
Iron	450
Lead	130

Which **one** of the metals will heat up the most?

Draw a ring around the correct answer.

aluminium **iron** **lead**

Give, in terms of the amount of energy needed to heat the metal blocks, a reason for your answer.

_____

_____

_____

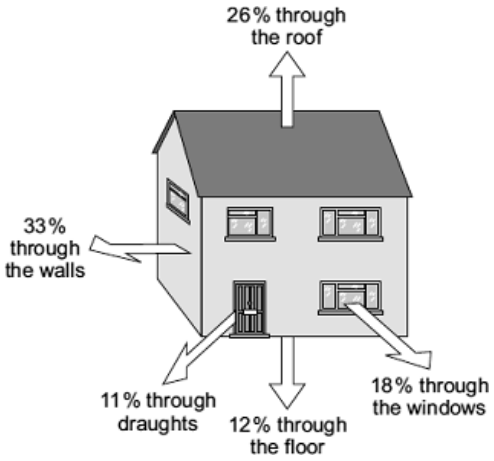
_____

(2)

(Total 7 marks)

Q5.

The diagram shows where heat is lost from a house that is **not** insulated.



(a) (i) Through which part of the house is most heat lost?

_____

(1)

(ii) How can the heat loss through the windows be reduced?

_____

_____

(1)

(b) A homeowner wants to reduce her energy bills and make her home more energy efficient. The table shows five ways this could be done. The table also shows how much money each way would save the homeowner each year.

	Cost	**Money saved each year**
Installing loft insulation	£175	£60
Fitting draught-proofing	£45	£20
Installing cavity wall insulation	£300	£80
Adding a hot water tank jacket	£15	£20
Using energy efficient light bulbs	£60	£30

(i) Which **one** of the five ways of reducing energy bills would reduce the yearly energy bill the most?

_____

(1)

(ii) This year the homeowner has only got £60 to spend to improve the energy efficiency of her home.

Use the information in the table to explain what the homeowner should spend this money on.

_____

_____

_____

_____

(2)

(Total 5 marks)

Q6.

The electric kettle shown below is used to boil water.

©leeser87/iStock

(a) After the water has boiled, the temperature of the water decreases by 22 °C.
The mass of water in the kettle is 0.50 kg.
The specific heat capacity of water is 4200 J/kg °C.

Calculate the energy transferred to the surroundings from the water.

_____

_____

_____

Energy = _____ joules

(2)

(b) Why is the total energy input to the kettle higher than the energy used to heat the water?

Tick (✓) **one** box.

	Tick (✓)
Energy is absorbed from the surroundings.	
Energy is used to heat the kettle.	
The kettle is more than 100% efficient.	

(1)

(Total 3 marks)

Q7.

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 = _____

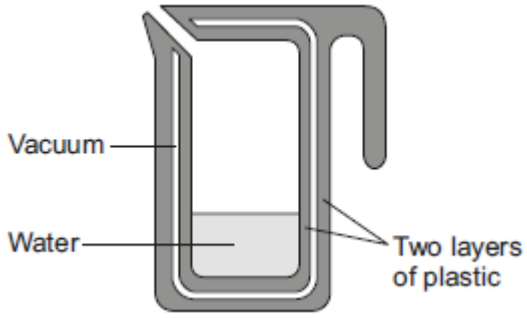
(3)

(Total 10 marks)

Q8.

A new design for a kettle is made from two layers of plastic separated by a vacuum. After the water in the kettle has boiled, the water stays hot for at least 2 hours.

The new kettle is shown below.



(a) The energy transferred from the water in the kettle to the surroundings in 2 hours is 46 200 J.

The mass of water in the kettle is 0.50 kg.

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

The initial temperature of the water is 100 °C.

Calculate the temperature of the water in the kettle after 2 hours.

_____

_____

_____

_____

Temperature after 2 hours = _____ °C

(3)

(b) Calculate the average power output from the water in the kettle to the surroundings in 2 hours.

_____

_____

_____

_____

Average power output = _____ W

(2)

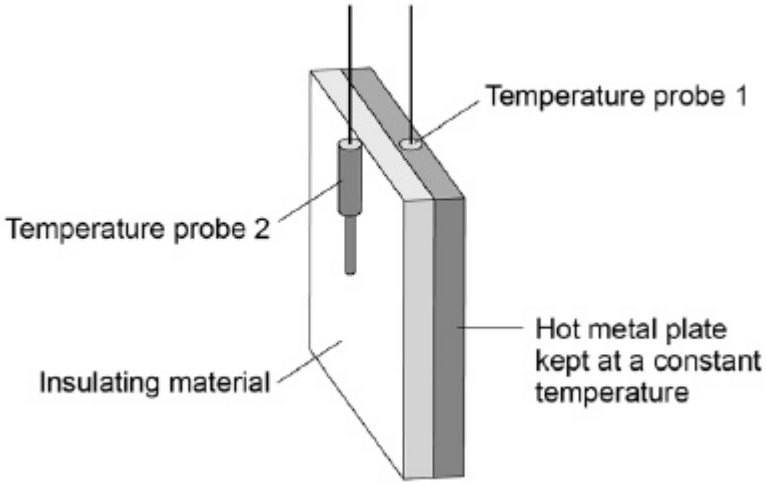
(Total 5 marks)

Q9.

A student investigated the properties of three types of insulation.

Figure 1 shows the apparatus the student used.

Figure 1



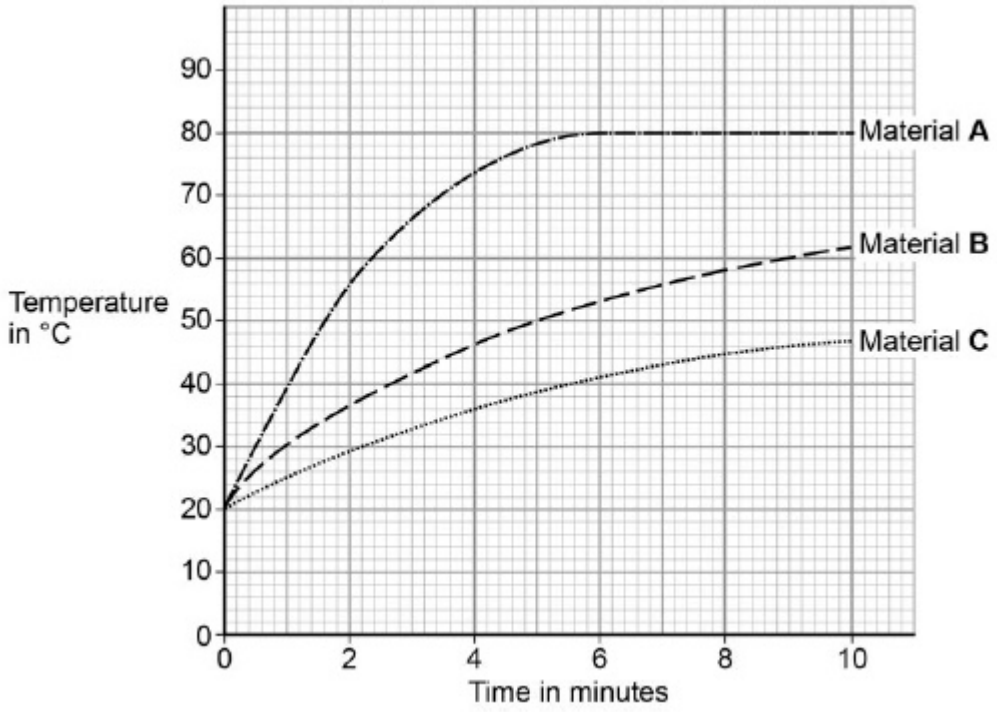
In the investigation different insulating materials were placed in contact with the hot metal plate.

Temperature probes measured the temperature on each side of the material.

The temperature probes were connected to a data logger.

Figure 2 shows how the temperature measured by temperature probe 2 changed over 10 minutes for each of the materials.

Figure 2



(a) What was the temperature of the hot metal plate?

_____ °C

(1)

(b) Which material is the best insulator?

Tick **one** box.

A ☐ **B** ☐ **C** ☐

Give the reason for your answer.

_____

_____

(2)

(c) Another student repeated the investigation but doubled the thickness for all three insulating materials.

Suggest how using thicker insulation would affect the results of the second student's investigation compared with the first student's results.

_____

_____

_____

_____

_____

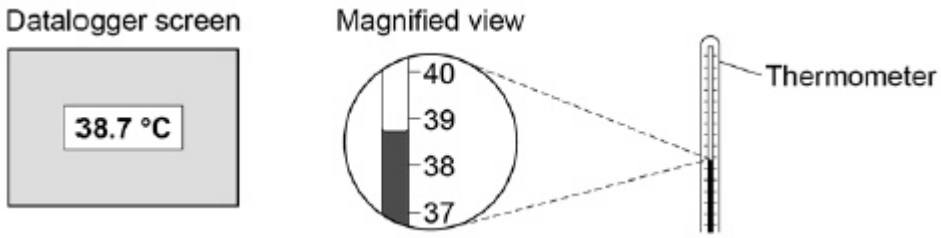
_____

(2)

(d) The students could have used a thermometer instead of temperature probes and a datalogger.

Figure 3 shows the datalogger screen and a thermometer.

Figure 3



Give two advantages of using the datalogger and temperature probes compared to a thermometer.

1. _____

_____

2. _____

_____

(2)

(e) The table gives information about four types of insulation that could be used for insulating the cavity walls of houses.

Type of insulation	**Thermal conductivity in W/m °C**
Felt wool	0.070
Mineral wool	0.040
Polyurethane foam	0.030
Rock wool	0.045

Explain which one of the types of insulation in the table would be the best to use for cavity wall insulation.

_____

_____

_____

_____

_____

_____

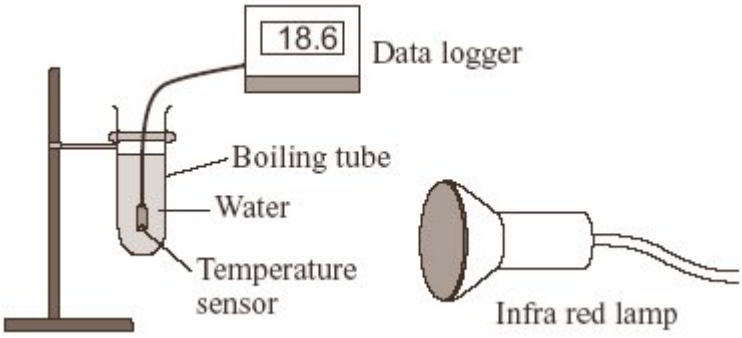
(2)

(Total 9 marks)

Q10.

A student had read about a glacier that had been covered in insulating material. The idea was to slow down the rate at which the glacier melts in the summer.

She investigated this idea using the apparatus shown in the diagram.



(a) These are the steps taken by the student.

- Measure 30 cm^3 of cold water into a boiling tube.
- Place the boiling tube 25 cm from an infra red lamp.
- Record the temperature of the water.
- Switch on the infra red lamp.
- Record the temperature of the water every minute for 5 minutes.
- Repeat with boiling tubes covered in different insulating materials.

(i) Why did she use an infra red lamp?

_____

(1)

(ii) Name **one** control variable in this investigation.

_____

(1)

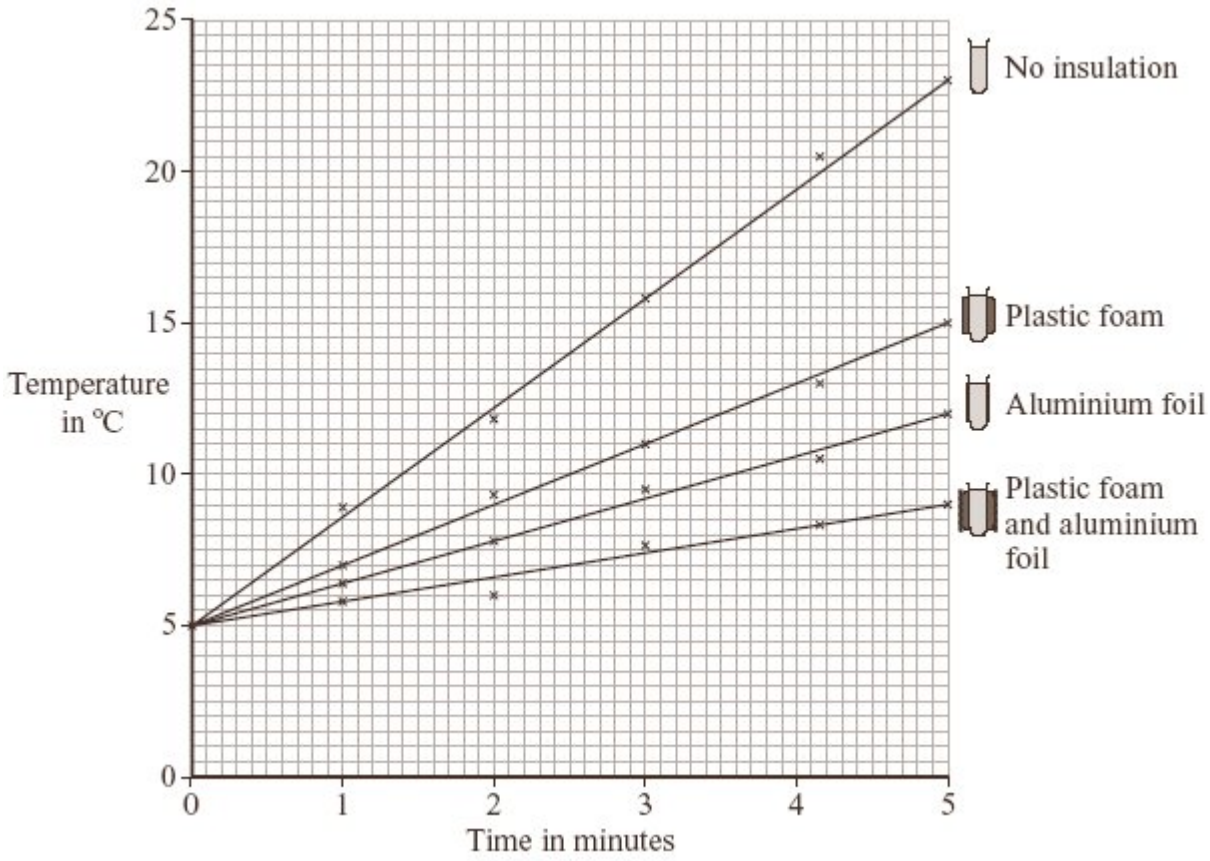
(iii) Give **one** advantage of using a temperature sensor and data logger instead of a glass thermometer to measure temperature.

_____

_____

(1)

(b) The results of the investigation are shown in the graph.



(i) Why did the student use a boiling tube with no insulation?

_____

_____

(1)

(ii) From her results, what should she recommend is used to insulate the glacier?

_____

(1)

(iii) Explain why the insulation recommended by the student will reduce the heat transfer from the Sun to the glacier.

_____

_____

_____

_____

_____

(2)

(c) Explain, in terms of particles, how heat is transferred through the glass wall of a boiling tube.

_____

_____

_____

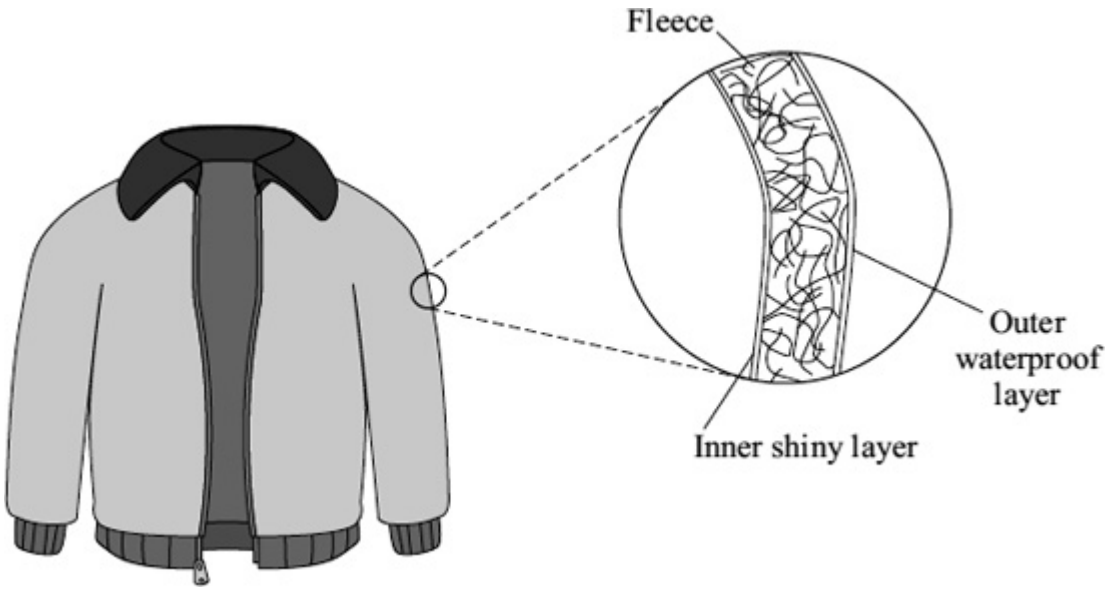
_____

(2)

(Total 9 marks)

Q11.

(a) The diagram shows a ski jacket that has been designed to keep a skier warm. The jacket is made from layers of different materials.



(i) The inner layer is shiny to reduce heat transfer.

Which process of heat transfer will it reduce?

_____

(1)

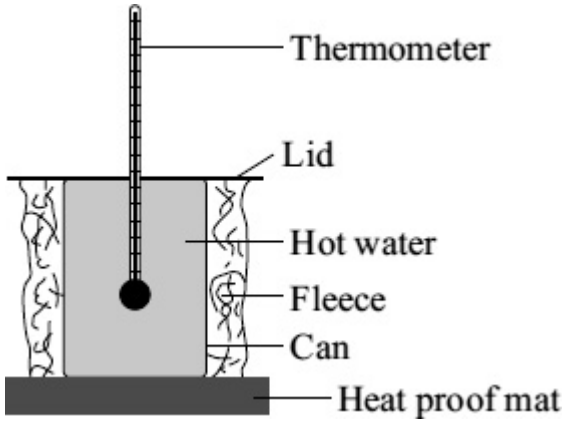
(ii) Why is the layer of fleece good at reducing the transfer of heat from a skier's body?

_____

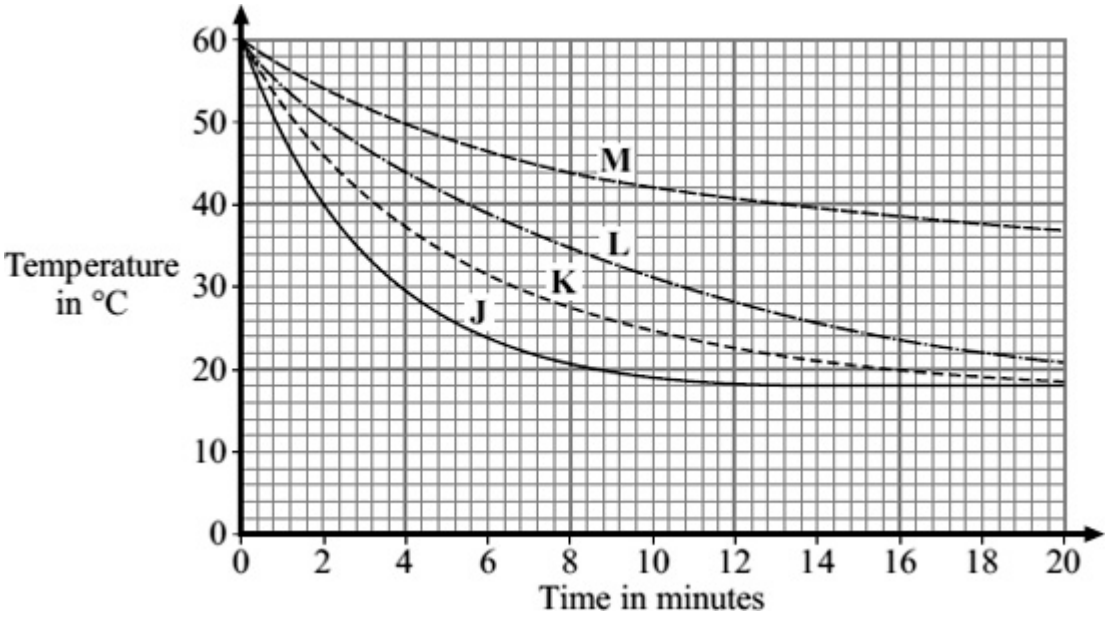
_____

(1)

(b) A student tested four different types of fleece, **J**, **K**, **L** and **M**, to find which would make the warmest jacket. Each type of fleece was wrapped around a can which was then filled with hot water.
The temperature of the water was taken every two minutes for 20 minutes.



The graph shows the student's results.



(i) In each test, the water cooled faster during the first five minutes than during the last five minutes. Why?

_____

_____

(1)

(ii) To be able to compare the results, it was important to use the same volume of water in each test.

Give **one** other quantity that was the same in each test.

_____

_____

(1)

(iii) Look at the graph line for fleece **K**.

Estimate what the temperature of the water in the can wrapped in fleece **K** would be after 40 minutes.

_____

(1)

(iv) Which type of fleece, **J**, **K**, **L** or **M**, should the student recommend to be used in the ski jacket?

_____

Give a reason for your answer.

_____

_____

_____

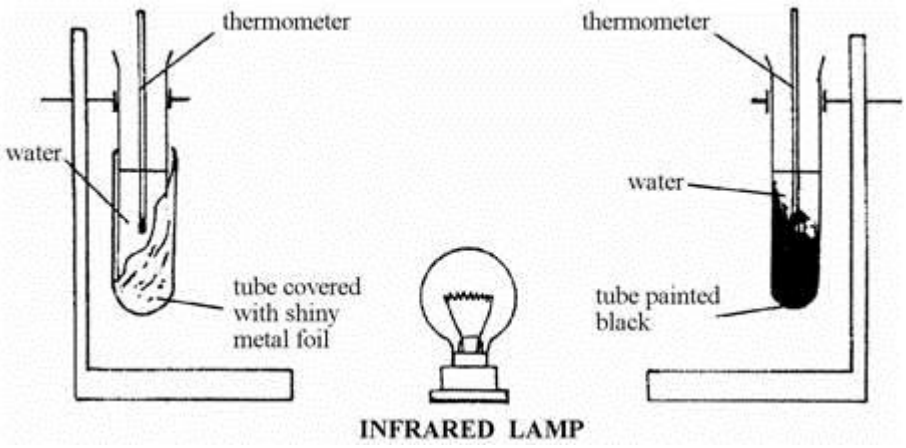
_____

(2)

(Total 7 marks)

Q12.

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.)

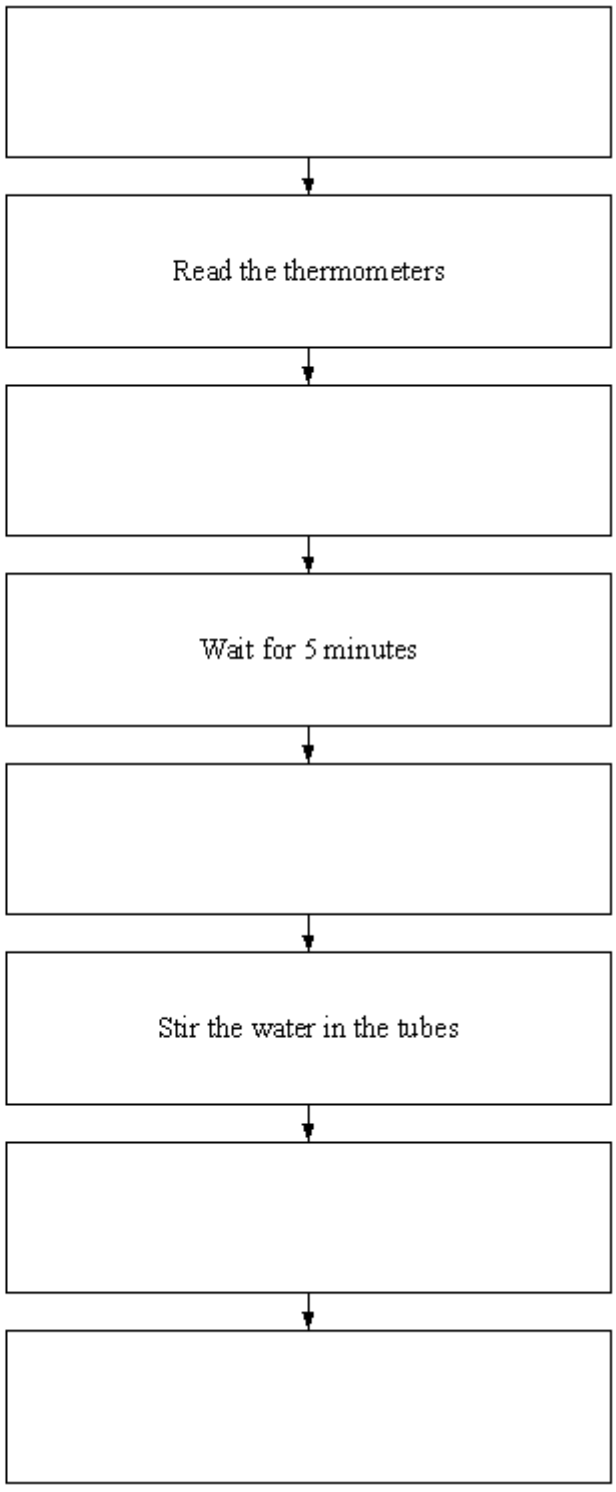
A Switch off the lamp

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



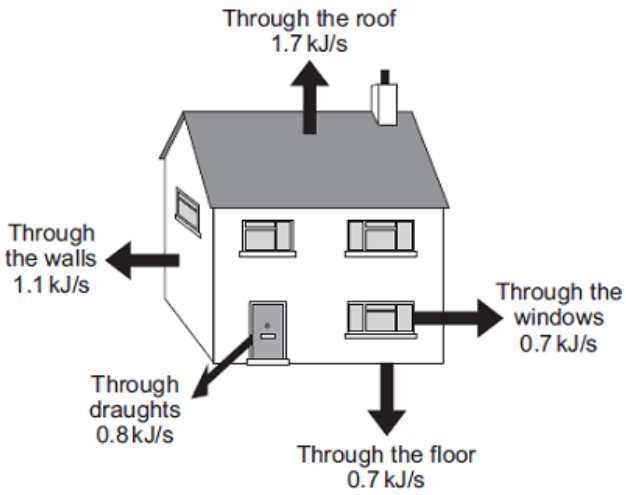
(5)

(Total 8 marks)

Q13.

Diagram 1 shows the energy transferred per second from a badly insulated house on a cold day in winter.

Diagram 1



(a) (i) When the inside of the house is at a constant temperature, the energy transferred from the heating system to the inside of the house equals the energy transferred from the house to the outside.

Calculate, in kilowatts, the power of the heating system used to keep the inside of the house in **Diagram 1** at a constant temperature.

1 kilowatt (kW) = 1 kilojoule per second (kJ/s)

Power of the heating system = _____ kW

(1)

(ii) In the winter, the heating system is switched on for a total of 7 hours each day.

Calculate, in kilowatt-hours, the energy transferred each day from the heating system to the inside of the house.

Energy transferred each day = _____ kWh

(2)

(iii) Energy costs 15 p per kilowatt-hour.

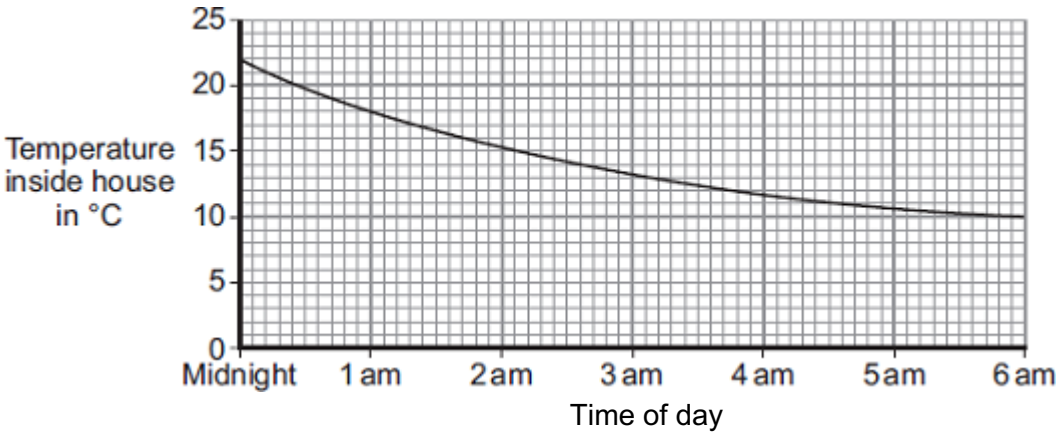
Calculate the cost of heating the house for one day.

Cost = _____

(1)

(iv) The heating system is switched off at midnight.

The graph shows how the temperature inside the house changes after the heating system has been switched off.



Draw a ring around the correct answer in the box to complete the sentence.

Between midnight and 6 am the rate of energy transfer from

the house	decreases. decreases then stays constant. increases.

Give the reason for your answer.

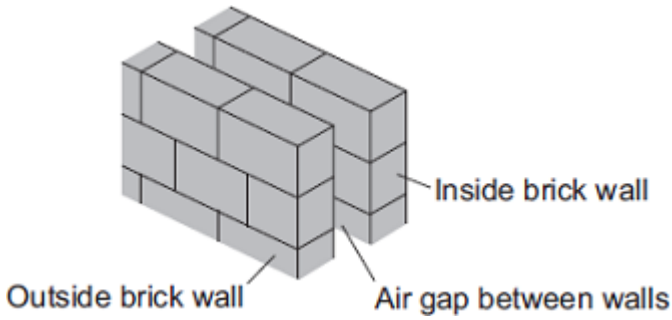
_____

_____

(2)

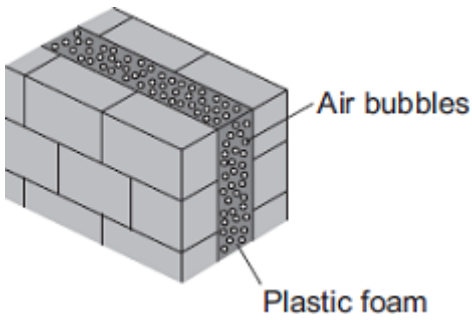
(b) **Diagram 2** shows how the walls of the house are constructed.
Diagram 3 shows how the insulation of the house could be improved by filling the air gap between the two brick walls with plastic foam.

Diagram 2



U-value of the wall = 0.7

Diagram 3



U-value of the wall = 0.3

The plastic foam reduces energy transfer by convection.

Explain why.

_____

_____

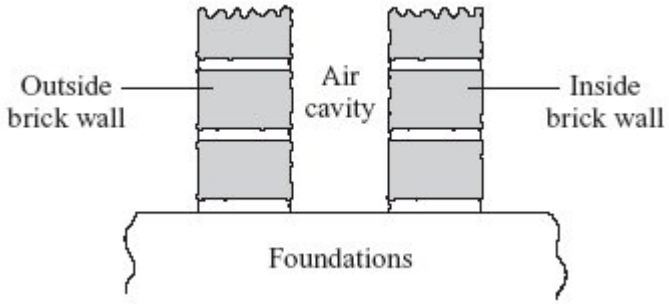
_____

(2)

(Total 8 marks)

Q14.

(a) The diagram shows a section through the walls of a house built in 1930.



Explain how the air cavity between the two walls reduces the heat transfer from the house.

_____

_____

_____

_____

(2)

(b) The table shows the installation costs and yearly savings on energy bills for different methods of insulating a house.

Method of insulation	Installation costin £	Yearly saving on energy bills in £
Double glazing	4000	65
Loft insulation	240	60
Cavity wall insulation	600	80

(i) Give **one** reason why loft insulation is often fitted to an old house before double glazing or cavity wall insulation.

_____

_____

(1)

(ii) The time it takes for the saving on energy bills to equal the cost of installing the insulation is called the pay-back time.

Calculate the pay-back time for loft insulation.

_____

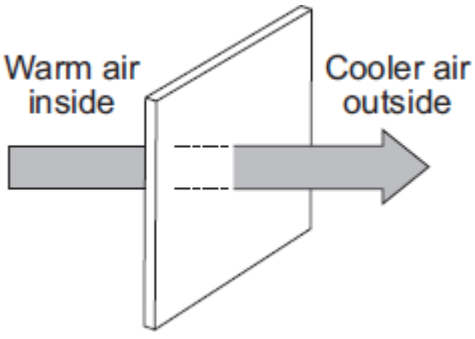
Pay-back time = _____ years

(1)

(Total 4 marks)

Q15.

The diagram shows the direction of heat transfer through a single-glazed window.



(a) (i) Name the process by which heat is transferred **through** the glass.

_____

(1)

(ii) Explain how heat is transferred **through** the glass.

_____

_____

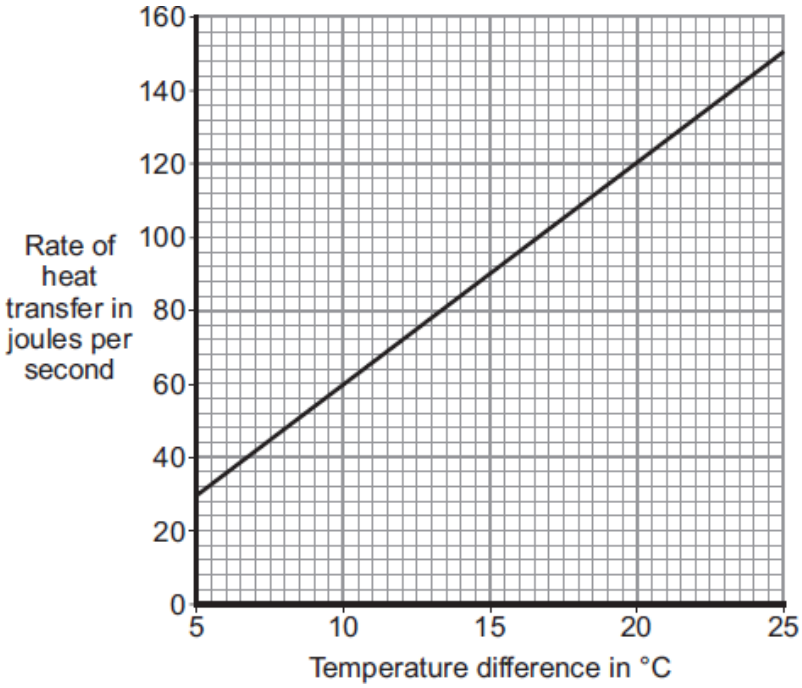
_____

_____

(2)

(b) The rate of heat transfer through a window depends on the difference between the inside and outside temperatures.

The graph shows the rate of heat transfer through a 1 m^2 single-glazed window for a range of temperature differences.



(i) What is the range of temperature differences shown in the graph?

From _____ to _____

(1)

(ii) A student looks at the graph and concludes:

'Doubling the temperature difference doubles the rate of heat transfer.'

Use data from the graph to justify the student's conclusion.

_____

_____

_____

_____

(2)

(iii) A house has single-glazed windows. The total area of the windows in the house is 15 m^2.

On one particular day, the difference between the inside and outside temperatures is 20 °C.

Use the graph to calculate the total rate of heat transfer through all of the windows on this particular day.

Show clearly how you work out your answer.

Rate of heat transfer = _____ J/s

(2)

(c) A homeowner plans to replace the single-glazed windows in his home with double-glazed windows. He knows that double-glazed windows will reduce his annual energy bills.

The table gives information about the double glazing to be installed by the homeowner.

Cost to buy and install	**Estimated yearly savings on energy bills**	**Estimated lifetime of the double-glazed windows**
£5280	£160	30 years

Explain, in terms of energy savings, why replacing the single-glazed windows with these double-glazed windows is not cost effective.

To gain full marks you must complete a calculation.

(2)

(Total 10 marks)

Q16.

(a) The table gives information about some ways of reducing the energy consumption in a house.

Method of reducing energy consumption	Installation cost in £	Annual saving on energy bills in £
Fit a new hot water boiler	1800	200
Fit a solar water heater	2400	100
Fit under floor heating	600	50
Fit thermostatic radiator valves	75	20

Which way of reducing energy consumption is most cost effective over a 10-year period?

To obtain full marks you must support your answer with calculations.

_____

_____

_____

_____

_____

_____

(3)

(b) Explain why using an energy-efficient light bulb instead of an ordinary light bulb reduces the amount of carbon dioxide emitted into the atmosphere.

_____

_____

_____

_____

(2)

(Total 5 marks)

Q17.

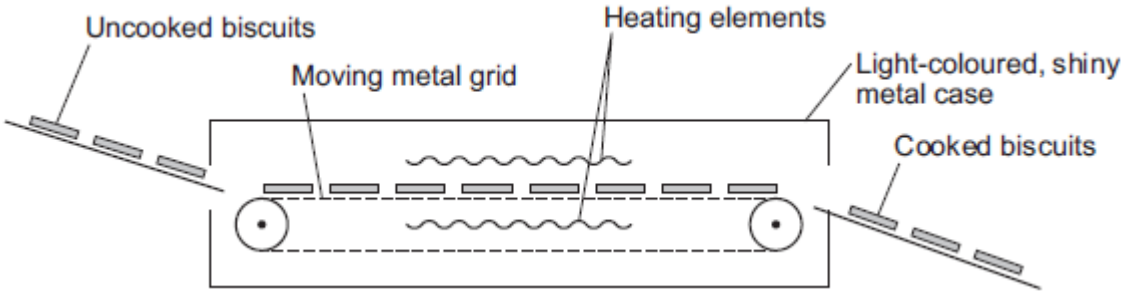
Figure 1 shows one way that biscuit manufacturers cook large quantities of biscuits.

The uncooked biscuits are placed on a moving metal grid.

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

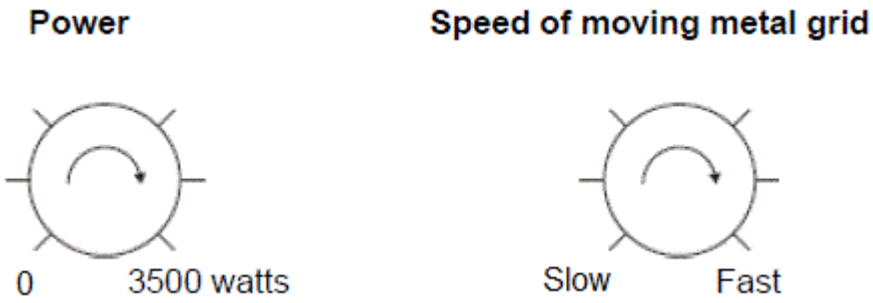
The biscuits turn brown as they cook.

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.

_____

_____

_____

_____

_____

_____

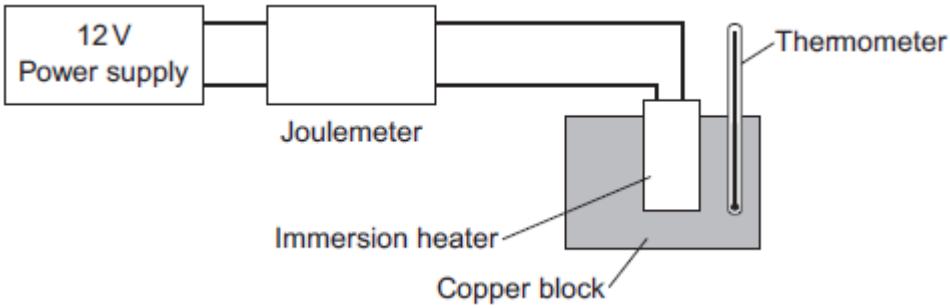
(3)

(Total 6 marks)

Q18.

A student used the apparatus in **Figure 1** to obtain the data needed to calculate the specific heat capacity of copper.

Figure 1



The initial temperature of the copper block was measured.

The power supply was switched on.

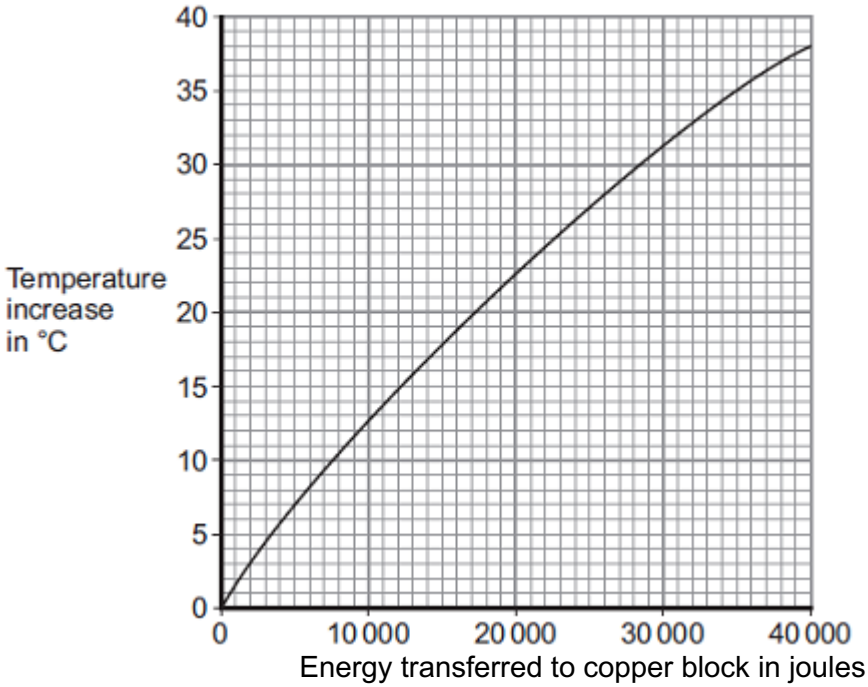
The energy transferred by the heater to the block was measured using the joulemeter.

The temperature of the block was recorded every minute.

The temperature increase was calculated.

Figure 2 shows the student's results.

Figure 2



(a) Energy is transferred through the copper block.

What is the name of the process by which the energy is transferred?

Tick (✓) **one** box.

Conduction ☐

Convection ☐

Radiation ☐

(1)

(b) Use **Figure 2** to determine how much energy was needed to increase the temperature of the copper block by 35 °C.

_____ joules

(1)

(c) The copper block has a mass of 2 kg.

Use your answer to part (b) to calculate the value given by this experiment for the specific heat capacity of copper. Give the unit.

_____

_____

_____

_____

Specific heat capacity = _____

(3)

(d) This experiment does **not** give the correct value for the specific heat of copper.

Suggest **one** reason why.

_____

_____

(1)

(Total 6 marks)

Q1.

(a) 20 (°C)

1

(b) largest temperature decrease

allow larger temperature decrease

1

(c) insulation is thicker

1

so temperature decrease will be lower (for all insulation types)

1

(d) Higher

1

Lower

1

(d) polyurethane foam

1

lowest thermal conductivity

1

[8]

Q2.

(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]

Q3.

(a) (i) 7pm

accept 19.00 / 1900

1

(ii) 8pm

accept 20.00 / 2000

1

temperature drops more slowly

accept heat for temperature accept line is less steep

1

(b) insulator

1

conduction *

1

convection *

** answers can be either way around*

1

(c) (i) 4 (years)

1

(ii) it is the cheapest / cheaper / cheap

*do **not** accept answers in terms of heat rising or DIY*

1

has the shortest / shorter payback time

*do **not** accept short payback time*

1

[9]

Q4.

(a) (i) temperature (increase) and time switched on are directly proportional

accept the idea of equal increases in time giving equal increases in temperature

answers such as:

- *as time increases, temperature increases*
- *positive correlation*
- *linear relationship*
- *temperature and time are proportional*

*score **1** mark*

2

(ii) any **one** from:

"it" refers to the metal block

- energy transfer (from the block) to the surroundings

accept lost for transfer
accept air for surroundings

- (some) energy used to warm the heater / thermometer (itself)
  accept takes time for heater to warm up
- (metal) block is not insulated

1

(iii) 15 000

*allow **1** mark for correct substitution, ie 50 × 300 provided no subsequent step shown*

2

(b) lead

reason only scores if lead is chosen

1

needs least energy to raise temperature by 1°C

accept needs less energy to heat it (by the same amount)
lowest specific heat capacity is insufficient

1

[7]

Q5.

(a) (i) walls

accept sides (of house)

1

(ii) fit double glazing
or
close / fit curtains / fit shutters

accept close windows
accept keep house at a lower temperature
accept fit (foam) draft excluders around the windows / in the jams
accept put plastic (film) across the windows
*do **not** accept fit thicker glass*

1

(b) (i) cavity (wall insulation)

accept the middle one

1

(ii) fit hot water jacket **and** draught-proofing

both required

1

(together) saves most money

only scores if first mark scores
accept saves more than fitting (energy efficient) light bulbs
accept saves £40
accept gives the shortest payback time

*an answer fit energy efficient light bulbs (on its own) gains **1** mark only*

1

[5]

Q6.

(a) 46 200

accept 46 000
*allow **1** mark for correct substitution*
ie 0.5 × 4200 × 22 provided no subsequent step

2

(b) Energy is used to heat the kettle.

1

[3]

Q7.

(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

(b) 90% or 0.9(0)

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

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]

Q8.

(a) 78 (°C)

*allow **2** marks for correct temperature change ie 22 °C*
*allow **1** mark for correct substitution*
ie 46 200 = 0.5 × 4200 x θ
or

$$\frac{46200}{0.5 \times 4200} = \theta$$

3

(b) 6.4 (W)

*allow **2** marks for an answer that rounds to 6.4*
*allow **1** mark for correct substitution*
ie 46 200 = P × 7200
an answer of 23 000 or 23 100 or 385 gains 1 mark

2

[5]

Q9.

(a) 80 (°C)

1

(b) **C**

1

temperature after 10 minutes was lowest
or

final temperature was lowest

*reason only scores if material **C** is chosen*

allow temperature after 10 minutes was lower

1

(c) lower total temperature rise (for all materials)

allow lower final temperature (for all materials)

1

(because) the rate of temperature increase would be lower

allow lower gradient lines

1

(d) higher resolution

1

reduced risk of misreading instrument

1

(e) polyurethane foam

no marks if polyurethane foam not chosen

1

(because it has the) lowest rate of energy transfer

1

[9]

Q10.

(a) (i) as a source of thermal <u>radiation</u>

accept heat for thermal radiation

accept to act as the Sun

*do **not** accept sunlight alone*

1

(ii) any **one** from:

- volume of water

  accept amount for volume
- distance between lamp and boiling tube
- initial / starting temperature of water
- same room temperature

  *do **not** accept time or same insulation material*

1

(iii) any **one** from:

- greater sensitivity / precision

  *do **not** accept more reliable (negates mark)*
- could link to a computer for (automatic) data analysis
- could take more frequent readings

- reduces instrument reading error

  accept more accurate

  *do **not** accept easier to use on its own*

1

(b) (i) acts as a control

accept to be able to make a comparison

accept to see the difference

*do **not** accept 'to make it a fair test' OWTTE on its own*

1

(ii) (plastic) foam and aluminium foil

1

(iii) (aluminium) foil is a poor absorber of thermal radiation

accept heat / infra red for thermal radiation

1

or (aluminium) foil is a (good) reflector of thermal radiation

*do **not** accept 'reflects sunlight' on its own*

(plastic) foam traps air which is a (good) insulator

accept (plastic) foam is a poor conductor / (good) insulator

*do **not** accept 'the material' is a good insulator / poor conductor*

1

(c) particles vibrate with a bigger / stronger amplitude / faster / with more (kinetic) energy

accept particles vibrate more

*do **not** accept start to vibrate only*

1

energy transferred by collisions with other particles

*do **not** accept answers in terms of free/mobile electrons*

1

[9]

Q11.

(a) (i) radiation

1

(ii) traps (small pockets of) air

*do **not** accept it's an insulator*

*do **not** accept reduces conduction and / or convection*

*do **not** allow it doesn't allow heat to escape*

1

(b) (i) bigger temperature difference (between the water and surroundings) at the start (than at the end)

*do **not** accept water is hotter*

1

(ii) starting temperature (of the water)

accept thickness of fleece

*do **not** accept same amount of fleece*

*do **not** accept thermometer / can*

*do **not** accept time is the same*

1

(iii) 18 (°C)

correct answer only

1

(iv) **M**

1

smallest temperature drop (after 20 mins)

*cannot score if **M** is not chosen*

accept it's the best insulator

accept smallest loss in heat

accept keeps heat / warmth in for longer

1

[7]

Q12.

(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]

Q13.

(a) (i) 5(.0)

1

(ii) 35 **or** their (a)(i) × 7 correctly calculated

*allow **1** mark for correct substitution, ie 5 **or** their (a)(i) × 7 provided no subsequent step shown*

2

(iii) 525(p)
or
(£) 5.25
or
their (a)(ii) × 15 correctly calculated

if unit p or £ given they must be consistent with the numerical

answer

1

(iv) decreases

1

temperature difference (between inside and outside) decreases

accept gradient (of line) decreases

*do **not** accept temperature (inside) decreases*

*do **not** accept graph goes down*

1

(b) air (bubbles are) trapped (in the foam)

*do **not** accept air traps heat*
foam has air pockets is insufficient

1

(and so the) air cannot circulate / move / form convection current

air is a good insulator is insufficient
no convection current is insufficient

answers in terms of warm air from the room being trapped are incorrect and score no marks

1

[8]

Q14.

(a) air is (a good) insulator

1

or air is a poor conductor

accept air cavity / 'it' for air

reducing heat transfer by <u>conduction</u>

accept stops for reduces
ignore convection
*do **not** accept radiation*
*do **not** accept answers in terms of heat being trapped*

1

(b) (i) most cost effective

accept it is cheaper or low<u>est</u> cost
accept shortest payback time
accept in terms of reducing heat loss by the largest amount
*do **not** accept it is easier*
ignore most heat is lost through the roof

1

(ii) 4

1

[4]

Q15.

(a) (i) conduction

1

(ii) atoms gain (kinetic) energy

accept particles / molecules for atoms

*do **not** accept electrons for atoms*

or

atoms vibrate with a bigger amplitude

accept vibrate faster / more

*do **not** accept start to vibrate*

or

atoms collide with neighbouring atoms

1

transferring energy to (neighbouring / other) atoms

*do **not** accept heat for energy*

or

making these other atoms vibrate with a bigger amplitude

accept faster / more for bigger amplitude

mention of (free) electrons moving and passing on energy negates this mark

1

(b) (i) 5 (°C) to 25 (°C)

either order

1

(ii) a correct example of doubling temperature difference doubling heat transfer

eg going from 5 to 10 (°C) difference doubles heat transfer from 30 to 60 (J/s)

accept for heat transfer number of joules / it

*allow **1** mark for correctly reading 1 set of data eg at 5 °C the heat transfer is 30*

or

for every 5°C increase in temperature difference heat transfer increases by 30 (J/s)

no credit for stating they are directly proportional

2

(iii) 1800

*allow **1** mark for obtaining heat transfer value = 120*

2

(c) payback time calculated as 33 years

calculations must be correct to score the first mark point

explanations must relate to it not being cost effective

1

this is greater than lifetime of windows

or

total savings (over 30 years) = £4800 (1)

this is less than cost of windows (1)

or

$\frac{5280}{30}$ = 176 (1)

this is more than the yearly savings (1)

1

[10]

Q16.

(a) four calculations correctly shown

200 × 10 – 1800 = £200
100 × 10 – 2400 = –£1400
50 × 10 – 600 = –£100
20 × 10 – 75 = 125

*accept four final answers only **or** obvious rejection of solar water heater and underfloor heating, with other two calculations completed any 1 complete calculation correctly shown **or** showing each saving × 10 of all four calculations = 1 mark answers in terms of savings as a percentage of installation cost **may** score savings mark only*

2

hot water boiler

correct answers only

1

(b) less electricity / energy to be generated / needed from power stations

accept less demand

1

reduction in (fossil) fuels being burnt

accept correctly named fuel

accept answer in terms of:
fewer light bulbs required because they last longer (1 mark)
less energy used / fuels burnt in production / transport etc. (1 mark)

ignore reference to CO_2 or global warming

ignore reference to conservation of energy

1

[5]

Q17.

(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]

Q18.

(a) conduction

1

(b) 35 000

1

(c) 500

*their (b) = 2 x c x 35 correctly calculated scores **2** marks*

*allow **1** mark for correct substitution,*

ie 35000 = 2 x c x 35

or

their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings

or

energy needed to warm heater

accept there is no insulation (on the copper block)

*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

Q2.

(a) Many candidates failed to spot that what was required was a comparison of the *rate* of cooling; thus answers such as 'the large surface area cooled down more' were common. Several candidates were not able to interpret the graph correctly, and stated that the small surface area would cool down more quickly.

(b) Many candidates failed to spot the connection between part (b) and part (a) of the question and therefore did not realise that this question was also about surface area. This mistake led to many answers such as 'the large ears act as sunshades' and 'the fox is able to flap his ears to create a breeze'.

(c) (i)(ii) Both were poorly answered, with many candidates being totally confused between conduction, convection and radiation.

Q3.

The better candidates were able to score all 3 marks in part (a). The weaker candidates failed to relate the question to the data in the graph, and were therefore putting down answers such as "The curtains were closed at 5 o'clock because that is when it gets dark".

In part (b) most candidates were able to score at least 2 out of the 3 marks, however many candidates thought that double glazing reduced heat lost by radiation.

A pleasing number of candidates were able to carry out the calculation in part (c)(i) successfully. In part (c)(ii) candidates again tended to ignore the data in the table. This led to many answers along the lines of either "Hot air rises" or "If you don't insulate the loft first you are wasting your money on double glazing and cavity wall insulation because of all the draughts in the loft".

Q4.

(a) (i) Although most students could describe the pattern as being linear, very few referred to the fact that the graph showed direct proportionality.

(ii) There were very few correct answers to this question. A few suggested it took time for the heater to warm up but other acceptable answers were rarely seen. Many stated that the difference was because the first graph was a "guess" and the second was a "real" result. There was a lot of discussion about the original room temperature and some thought that since the student was reading the temperature every 50s, they had to switch off the heater whilst they were doing this.

(iii) The majority of students could correctly complete the calculation to find the energy transferred.

(b) The majority of students chose aluminium rather than lead, presumably because it had the highest specific heat capacity. Of those who did select lead, very few were able to provide an adequate reason.

Q5.

(a) (i) Most candidates identified the walls as being the part through which most heat is lost.

(ii) Most candidates opted for double glazing as a method for reducing heat loss through the windows.

(b) (i) Most candidates correctly selected cavity wall insulation as the method that would reduce the yearly energy bill the most.

(ii) Only the better candidates realised that by buying a hot water tank jacket and fitting draught-proofing, the householder would save the most money each year. Some candidates, perhaps believing that the householder could only buy one item, opted for the energy-saving light bulbs: this option however would not save as much money. A few candidates decided to buy 4 hot water tank jackets with the £60.

Q6.

(a) Three quarters of students answered correctly scoring 2 marks. Common mistakes included selecting the wrong equation.

(b) Over half the students scored this mark, with incorrect answers being split fairly evenly between the two other choices.

Q7.

(a) Most students stated that matt black surfaces were good absorbers of radiation, but failed to go on to state that they were also good emitters of radiation. Many of the weaker students tried to explain the reason in terms of conduction or convection, even though the term radiation was used in the stem of the question. There is still a common misconception that 'black attracts heat'.

(b) Although most students could select the correct equation to use, many put the numbers in the wrong way round - possibly because they could not cope with the larger number being on the bottom of the fraction. Of those who did the arithmetic correctly, some added a spurious unit or, if they were expressing the efficiency as a percentage, simply left the answer as 90 without adding the percentage sign.

(c) Only a third of students gave a correct response of light or sound as a way in which energy is wasted from the stove. Some students seemed to have interpreted the word 'way' differently, and stated that some energy is lost when the door is opened.

(d) Just over a third of students scored at least one mark in this question, usually for stating that wood is a renewable resource. A common misconception was that the wood burning stove would not give off any gases that contribute to global warming.

(e) Nearly half of the students were able to calculate a correct value for the energy, but few scored all three marks because they either omitted the unit or wrote down an incorrect unit.

Q8.

(a) This question discriminated well, a third of students scored all 3 marks. A third of students scored 2 marks for calculating the temperature change of 22°C. Surprisingly, many students thought the final temperature would be 122°C having added the 22°C to the initial temperature. These students still scored 2 marks for their calculation of temperature change provided working was shown. A surprising number of students failed to correctly subtract 22 from 100, believing the answer to be 88°C.

A number of students selected an incorrect equation. Some students scored 1 mark for the substitution only and then incorrectly rearranged to achieve an incorrect final answer. Students should be reminded that the substitution gains 1 mark, not the subsequent rearrangement.

(b) Only one tenth of students scored 2 marks for the answer of 6.4 (W). Half the students scored 1 mark, with the most commonly seen answer of 23 100, which was achieved by dividing 46 200 by 2 (hours). A number of students attempted the conversion, but only got as far as minutes and ended with an answer of 385, which also scored 1 mark.

Q10.

The candidates were generally aware of the ideas of types of variables, control, accuracy and precision and the way that laboratory equipment can be used to simulate large scale situations. Candidates were able to demonstrate the ability to extract information from investigative results.

However, in part (b)(iii) the skill required to explain the results of the investigation was in little evidence, as was the ability to explain a facet of heat transfer in particulate terms in for part (c).

Q11.

(a) (i) Very few candidates gave the correct answer to this question.

(ii) Very few candidates answered this question correctly, in terms of air being trapped between the fibres of the fleece. Most candidates simply stated that the fleece was an insulator, or that the fleece lining was very thick. There are still many candidates who talk in terms of 'heat particles' being unable to escape.

(b) (i) Almost no correct answers were seen to this question, with the majority of candidates simply repeating the question in their answer.

(ii) The better candidates were able to deduce that the starting temperature of the water had been kept the same. However, most candidates simply referred to the temperature of the water, without stating that it was the starting temperature.

Other candidates correctly stated that the thickness of the fleece should have been kept the same: weaker candidates simply referred to the 'amount' of fleece, which was not sufficiently specific.

(iii) There were very few correct answers to the question. Several candidates thought that the temperature would rise during the next 20 minutes. Some candidates unfortunately failed to read the graph scale correctly and estimated a temperature of 19 °C.

(iv) Many candidates correctly identified jacket **M** as being the one that should be recommended. However, the reasons given for the choice were often very vague.

Q13.

(a) (i) Many students left this part blank. Around half of the students obtained the correct answer of 5 (kW) and they were often able to go on and obtain both

marks in part (ii).

(ii) Many students left this part blank.

(iii) Many students left this part blank. This part caused more difficulty with students commonly multiplying the cost per kWh by the days or by 24. Those failing to calculate part (i) correctly often went on to gain credit with the error carried forward into the other two parts although for part (iii), correct answers for part (ii) were sometimes ignored for another quantity. Perhaps this was due to the students not recognising how the parts were connected.

(iv) Whilst many students scored the first mark for saying that the rate of energy transfer from the house decreases, only a handful gained the second. Most simply stated the temperature dropped over the time period in question. A sizeable minority chose the second option for the first marking point, saying that between 5.30 and 6.00 am the graph did not change.

(b) Most students found this difficult. “Hot air being trapped in the cavity” or “heat being trapped in the air bubbles” were common incorrect responses. Many simply repeated that energy transfer by convection would be reduced, which they were told in the stem of the question.

Q14.

Answers to part (a) were poor with few candidates being able to give an explanation in terms of air being able to reduce heat loss by conduction. Many answers referred to radiation. In part (b) many candidates were able to use the information to give an answer in terms of cost efficiency. However a significant number of candidates simply answered in terms of hot air / heat rising.

Q15.

(a) (i) Only a small minority of students (24%) were able to identify ‘conduction’ as the method of heat transfer.

(ii) This was poorly answered. Students did not appear to be able to even start to describe conduction. Convection or radiation were more often described. There were rare references to particles or atoms and the idea of energy being passed on by collision even rarer. There was a great deal of bad science, often having little to do with heat transfer. Even those students who mentioned vibrations of atoms or particles, suggested that the particles ‘started to vibrate’ as the process started, apparently not realising that they were already vibrating. Few marks were awarded in this question.

(b) (i) Most students gained this mark.

(ii) This was generally well done. Students found it easy to extract data correctly from the graph in order to demonstrate the truth of the statement given in the question. Some students however, tried to answer the question without using any numerical data and consequently simply repeated the question in their own words.

(ii) Many students appeared to ignore the graph and performed a calculation based upon the two quantities given in the question i.e. the area and the temperature. Those students that used the graph were often able to find the rate of heat transfer at 20°C (120 J/s) but did not realise that this was for 1 square metre. These students scored one mark. However, it was pleasing to

see others go on to gain full credit for calculating the total rate of heat transfer for the full window. A significant minority (15%) did not attempt this question.

(c) This question was reasonably well done and students seemed to have a good knowledge of pay-back time and the economics of fitting double glazing. Many students managed a correct calculation and then went on to give an acceptable reason why this particular situation was not cost-effective. The most common method was to calculate the savings over 30 years (£4 800) and to conclude that this was less than the cost of installation (£5 280), giving a 'loss' of £480. There were however, students who did not address the question but simply described how double glazing works and others who had perhaps performed a calculation but given no evidence on their scripts. The latter group should be made aware that for full credit a complete answer is required.

Q16.

In part (a) those candidates who chose the payback route generally gained no credit, unless they picked the boiler as the best option. Many candidates scored two marks for selecting the boiler and a correct calculation. A significant number of candidates scored all three marks for completing all the calculations correctly and making the correct choice.

Few candidates scored 2 marks in part (b). Most candidates failed to link the less energy back to the power station. The common mark scored was for stating the reduction in fuel burnt. Many considered the efficiency of the bulbs; but did not link it back to the need to generate less electricity. Very few thought about the need for fewer bulbs and the energy saving in their manufacture. There were a significant minority of candidates who thought that conventional light bulbs emit carbon dioxide or that energy loss somehow produces carbon dioxide, often as a result of heat loss.

Q17.

(a) Only a fifth of the students could state that hot objects emit infrared radiation.

(b) About half of the students could identify that increasing the power and decreasing the speed would increase the energy incident on the biscuits and therefore make them browner.

(c) Responses did not often include information specifying whether they were referring to the inside or the outside surface of the oven. Several explicitly referred to reflection of light, while others stated what would have occurred if the surfaces had been black. About half of the students appreciated that light shiny surfaces are good reflectors of infrared radiation. Only the most able students stated that a shiny outer surface would reduce emission of infrared, or that the amount of radiation reaching the biscuits would be increased.

Q18.

(a) A very small amount of students did not identify conduction as the process by which energy is transferred through copper.

(b) The majority of students answered correctly, of those who did not score the mark, the most common error was misreading the number on the x-axis (for a temperature increase of 35°C) as 30,500 instead of 35,000.

(c) Around half of students scored two of the three marks available. This was usually for performing the calculation correctly, but failing to give the correct unit.

(d) A very low proportion of students did not attempt this question, with less than a fifth scoring the mark. The most common incorrect answers referred to faulty apparatus, incorrect measurements or values not as stated in the question, e.g. the block was not 2kg.