Particle Model Questions 1
35 Questions

Name: _________________________
Class: _________________________
Date: _________________________

Time:

Marks:

Comments:

______________________________
Figure 1 shows solid ice on a car’s rear window.

The glass window contains an electrical heating element.

(a) Use the particle model in Figure 2 to describe how the heating element causes the arrangement of the ice particles to change as the ice melts.

Figure 2

© Captive cookies/iStock/Thinkstock

You should include a description of how the particles are arranged in the solid ice and in the water.

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A car manufacturer tests different heating elements by measuring how long it takes ice to melt.

During the test some variables must be controlled.

Identify two control variables in the car manufacturer’s test.

Tick two boxes.

- The colour of the car
- The current in the heating element
- The mass of ice
- The size of the car
- The time taken for the ice to melt

Some of the energy supplied by the heater causes the ice to melt without the temperature of the ice increasing.

What is the name given to this energy supplied by the heater?

Tick one box.

- Latent heat of freezing
- Latent heat of fusion
- Latent heat of vaporisation

When the heater is supplied with 120 J of energy each second, the internal energy of the ice increases by 45 J each second.

Use the following equation to calculate the efficiency of the heater.
Output energy transfer
Efficiency = \frac{\text{Output energy transfer}}{\text{Input energy transfer}}

Give your answer to two decimal places.

Efficiency = ____________________

(Total 11 marks)

Q2.
The particle model can be used to explain the properties of gases.

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

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

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

   Explain why a mass of gaseous water at 100 °C contains more energy than an equal mass of liquid water at 100 °C.
(d) Water vapour is a gas. Gases change state when they cool.

The figure below shows condensation on a cold bathroom mirror.

![Image of condensation on a cold bathroom mirror](https://via.placeholder.com/150)

© Dwight Eschliman/Getty Images

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

Density of water = 1000 kg / m$^3$

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

Calculate the energy released when the condensation forms.

\[
\text{Energy released} = \frac{2.5 \times 10^{-5} \text{ m}^3 \times 1000 \text{ kg/m}^3 \times 2.26 \times 10^6 \text{ J/kg}}{1000 \text{ kg/m}^3}
\]

Energy released = _______________________ J

(5)

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

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

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

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

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(5)
Q3. Density can be explained using the particle model.

(a) What is the unit of density (ρ)?

Tick one box.

- joules, J
- joules per kilogram, J / kg
- kilograms, kg
- kilograms per metre cubed, kg / m³

(b) The figure below shows particles of the same substance in three states of matter.

Use the figure above to explain why the solid has the highest density.

(c) Complete the sentences.
The particles in a gas are constantly moving.

The particles move _____________________________________________

When the temperature of the particles in a gas is increased

the particles have more ___________________________________energy .

(d) A gas is put into a closed container.

The container and the gas inside it are heated.

What will happen to the pressure inside the container?

___________________________________________________________________

(Total 6 marks)

Q4.

The figure below shows a simple model of the three states of matter.

(a) What is the correct equation to work out the density of a material?

___________________________________________________________________

(b) A student explains density to his teacher using the particle model in the figure above.

His teacher says there are limitations to the model.

Give two limitations of the particle model in the figure above.

1. _________________________________________________________________

2. _________________________________________________________________

(c) When the gas in a container with a fixed volume is heated, the pressure increases as the temperature increases.
Explain why the pressure increases.

Use the model in the figure above to help you.

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Q5.

Figure 1 shows the plum pudding model of the atom.

This model was used by some scientists after the discovery of electrons in 1897.

Figure 1

Plum-pudding model

[Diagram of Plum-pudding model]

In 1911 the scientists Geiger and Marsden investigated the effect of firing alpha particles at very thin sheets of gold foil.

Their experiment is shown in Figure 2. The arrows show the paths taken by alpha particles in the experiment.

Figure 2

[Diagram of Geiger-Marsden experiment]
(a) Explain why scientists replaced the plum pudding model of the atom with the nuclear model of the atom as a result of the experiment.

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(4)

(b) According to modern measurements:

- the radius of an atom is about $1 \times 10^{-10}$ m
- the radius of an atomic nucleus is about $1 \times 10^{-14}$ m

Show that these values fit with the nuclear model of the atom.

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(2)

(c) In 1931 a scientist discovered that there are hydrogen atoms with mass number 2 as well as hydrogen atoms with mass number 1.

A year later, another scientist discovered neutrons.

Explain why the discovery of neutrons could explain the presence of hydrogen atoms with different mass numbers.

___________________________________________________________________
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___________________________________________________________________

(3)

(d) How would the results of the experiment shown in Figure 2 change if neutrons were used instead of alpha particles to bombard a thin sheet of gold?
Q6.

Solid, liquid and gas are three different states of matter.

(a) Describe the difference between the solid and gas states, in terms of the arrangement and movement of their particles.

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(2) (Total 11 marks)

(b) What is meant by ‘specific latent heat of vaporisation’?

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___________________________________________________________________

(2)

(c) While a kettle boils, 0.018 kg of water changes to steam.

Calculate the amount of energy required for this change.

Specific latent heat of vaporisation of water = $2.3 \times 10^6$ J / kg.
(d) The graph shows how temperature varies with time for a substance as it is heated. The graph is not drawn to scale.

Explain what is happening to the substance in sections AB and BC of the graph.

Section AB

Section BC

(4)

(Total 12 marks)

Q7. (a) The figure below shows a fridge with a freezer compartment.

The temperature of the air inside the freezer compartment is \(-5 \, ^\circ\text{C}\).
Use the correct answer from the box to complete each sentence.
Each answer may be used once, more than once or not at all.

| decreased | unchanged | increased |

When the air near the freezer compartment is cooled, the energy of the air particles is ________________.
The spaces between the air particles are ________________.
The density of the air is ________________.

(b) The table below shows some information about three fridges, A, B and C. The efficiency of each fridge is the same.

<table>
<thead>
<tr>
<th>Fridge</th>
<th>Volume in litres</th>
<th>Energy used in one year in kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>232</td>
<td>292</td>
</tr>
<tr>
<td>B</td>
<td>382</td>
<td>409</td>
</tr>
<tr>
<td>C</td>
<td>622</td>
<td>524</td>
</tr>
</tbody>
</table>

(i) Which fridge, A, B or C, would cost the least to use for 1 year? Give one reason for your answer.

(ii) A householder looks at the data in the table above.

What should she conclude about the pattern linking the volume of the fridge and the energy it uses in one year?
Q8.

A student used the apparatus in Figure 1 to compare the energy needed to heat blocks of different materials.

Each block had the same mass.

Each block had holes for the thermometer and the immersion heater.

Each block had a starting temperature of 20 °C.

![Figure 1]

The student measured the time taken to increase the temperature of each material by 5 °C.

(a) (i) State two variables the student controlled.

1. _____________________________________________________________
2. _____________________________________________________________

Figure 2 shows the student’s results.

![Figure 2]
(ii) Why was a bar chart drawn rather than a line graph?

________________________________________________________________________
________________________________________________________________________

(1)

(iii) Which material was supplied with the most energy?

________________________________________________________________________
Give the reason for your answer.
________________________________________________________________________
________________________________________________________________________

(2)

(iv) The iron block had a mass of 2 kg.

Calculate the energy transferred by the heater to increase the temperature of the iron block by 5 °C.

The specific heat capacity of iron is 450 J / kg °C.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Energy transferred = ______________________________ J

(2)

(b) The student used the same apparatus to heat a 1 kg block of aluminium.

He recorded the temperature of the block as it was heated from room temperature.

The results are shown in Figure 3.
(i) One of the student’s results is anomalous.

Draw a ring around the anomalous result.  

(ii) Draw the line of best fit for the points plotted in Figure 3.

(iii) What was the temperature of the room?

Temperature = _______________ °C

(iv) What was the interval of the time values used by the student?

Interval = _______________ minutes

(Total 11 marks)

Q9.

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

The information in the box is about the properties of solids and gases.

Solids:
- have a fixed shape
- are difficult to compress (to squash).

Gases:
- will spread and fill the entire container
- are easy to compress (to squash).

Use your knowledge of kinetic theory to explain the information given in the box.

You should consider:
- the spacing between the particles
Q10.

- the movement of individual particles
- the forces between the particles.

(Total 6 marks)
A student used the apparatus in Figure 1 to obtain the data needed to calculate the specific heat capacity of copper.

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.

(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
Q11.
The diagram shows three cups A, B and C.

Energy is transferred from hot water in the cups to the surroundings.

(a) Some students investigated how the rate of cooling of water in a cup depends on the surface area of the water in contact with the air.
They used cups A, B and C. They poured the same volume of hot water into each cup and recorded the temperature of the water at regular time intervals.

The results are shown on the graph.

(i) What was the starting temperature of the water for each cup?

Starting temperature = ____________________ °C

(ii) Calculate the temperature fall of the water in cup B in the first 9 minutes.

Temperature fall = ____________________ °C

(iii) Which cup, A, B or C, has the greatest rate of cooling?  

Using the graph, give a reason for your answer.

(iv) The investigation was repeated using the bowl shown in the diagram.
The same starting temperature and volume of water were used.

Draw on the graph in part (b) another line to show the expected result.

(v) After 4 hours, the temperature of the water in each of the cups and the bowl was 20°C.
Suggest why the temperature does not fall below 20°C.

______________________________________________________________

(b) (i) The mass of water in each cup is 200 g.
Calculate the energy, in joules, transferred from the water in a cup when the temperature of the water falls by 8°C.
Specific heat capacity of water = 4200 J / kg°C.

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Energy transferred = ____________________ J

(ii) Explain, in terms of particles, how evaporation causes the cooling of water.

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(4)
(Total 14 marks)

Q12.
(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**.

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________________________________________________________________________

________________________________________________________________________

(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.

__________________________________________________________________________________________________________________________________________

(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

(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.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Specific heat capacity in J/kg°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>900</td>
</tr>
<tr>
<td>Iron</td>
<td>450</td>
</tr>
<tr>
<td>Lead</td>
<td>130</td>
</tr>
</tbody>
</table>

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.

__________________________________________________________________________________________________________________________________________

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(2)

(Total 7 marks)
The picture shows a person taking a hot shower.

(a) When a person uses the shower the mirror gets misty.

Why?
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___________________________________________________________________
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___________________________________________________________________
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(b) The homeowner installs an electrically heated mirror into the shower room.

When a person has a shower, the heated mirror does **not** become misty but stays clear.

Why does the mirror stay clear?
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Q14.
An electric immersion heater is used to heat the water in a domestic hot water tank. When the immersion heater is switched on the water at the bottom of the tank gets hot.
(a) Complete the following sentence.

The main way the energy is transferred through the copper wall of the water tank is by the process of ________________________________.

(1)

(b) The immersion heater has a thermostat to control the water temperature.

When the temperature of the water inside the tank reaches 58°C the thermostat switches the heater off. The thermostat switches the heater back on when the temperature of the water falls to 50°C.

**Graph A** shows how the temperature of the water inside a hot water tank changes with time. The tank is **not** insulated.

(i) The temperature of the water falls at the fastest rate just after the heater switches off.

Explain why.

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____________________________________________________________________________________

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____________________________________________________________________________________
(ii) To heat the water in the tank from 50°C to 58°C the immersion heater transfers 4032 kJ of energy to the water.

Calculate the mass of water in the tank.

Specific heat capacity of water = 4200 J/kg°C

\[
\text{Mass} = \frac{\text{Energy}}{\text{Specific heat capacity} \times \Delta \text{Temperature}} = \frac{4032 \text{ kJ}}{4200 \text{ J/kg°C} \times (58°C - 50°C)} = \frac{4032 \text{ kJ}}{4200 \text{ J/kg°C} \times 8 \text{ °C}} = \frac{4032 \text{ kJ}}{33600 \text{ J/kg}} = 0.12 \text{ kg}
\]

(iii) An insulating jacket is fitted to the hot water tank.

**Graph B** shows how the temperature of the water inside the insulated hot water tank changes with time.

![Graph B](image)

An insulating jacket only costs £12.

By comparing **Graph A** with **Graph B**, explain why fitting an insulating jacket to a hot water tank saves money.

\[
\text{By comparing Graph A with Graph B, we can see that the temperature of the water in the insulated tank (Graph B) decreases more slowly than in the non-insulated tank (Graph A). This means that the heat loss to the environment is reduced, thus saving money on energy costs.}
\]
Q15.

(a) The diagrams, X, Y and Z, show how the particles are arranged in the three states of matter.

![Diagrams X, Y, Z]

(i) Which one of the diagrams, X, Y or Z, shows the arrangement of particles in a liquid?

Write the correct answer in the box.

(ii) Which one of the diagrams, X, Y or Z, shows the arrangement of particles in a gas?

Write the correct answer in the box.

(b) Draw a ring around the correct answer in each box to complete each sentence.

(i) In a gas, the particles are

- moving randomly.
- not moving.

(ii) In a solid, the forces between the particles are

- stronger than
- equal to
- weaker than

the forces between the particles in a liquid.

(c) The picture shows a puddle of water in a road, after a rain shower.
(i) During the day, the puddle of water dries up and disappears. This happens because the water particles move from the puddle into the air.

What process causes water particles to move from the puddle into the air?

Draw a ring around the correct answer.

condensation  evaporation  radiation

(1)

(ii) Describe one change in the weather which would cause the puddle of water to dry up faster.

____________________________________________________________________________________

____________________________________________________________________________________

(1)

(Total 6 marks)

Q16.

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

[ ] decreases.
the house 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

Diagram 3

U-value of the wall = 0.7
U-value of the wall = 0.3

The plastic foam reduces energy transfer by convection.

Explain why.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2)

(Total 8 marks)

Q17.

According to kinetic theory, all matter is made up of small particles. The particles are constantly moving.

Diagram 1 shows how the particles may be arranged in a solid.

Diagram 1
(a) One kilogram of a gas has a much larger volume than one kilogram of a solid.
Use kinetic theory to explain why.

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___________________________________________________________________
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___________________________________________________________________
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___________________________________________________________________
(4)

(b) Diagram 2 shows the particles in a liquid. The liquid is evaporating.

Diagram 2

(i) How can you tell from Diagram 2 that the liquid is evaporating?

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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(1)

(ii) The temperature of the liquid in the container decreases as the liquid evaporates.
Use kinetic theory to explain why.

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Q18.

Heat exchangers are devices used to transfer heat from one place to another.

The diagram shows a pipe being used as a simple heat exchanger by a student in an investigation.

Heat is transferred from the hot water inside the pipe to the cold water outside the pipe.

(a) Complete the following sentence by drawing a ring around the correct word in the box.
Heat is transferred from the hot water inside the pipe by

- conduction.
- convection.
- radiation.

(b) The student wanted to find out if the efficiency of a heat exchanger depends on the material used to make the pipe. The student tested three different materials. For each material, the rate of flow of hot water through the pipe was kept the same.

The student’s results are recorded in the table.

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature of the cold water at the start in °C</th>
<th>Temperature of the cold water after 10 minutes in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>20</td>
<td>36</td>
</tr>
<tr>
<td>Glass</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Plastic</td>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>

(i) The rate of flow of hot water through the pipe was one of the control variables in the investigation.
Give one other control variable in the investigation.

________________________________________________________________________

(1)

(ii) Which one of the three materials made the best heat exchanger?

________________________________________________________________________

Give a reason for your answer.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2)

(c) The student finds a picture of a heat exchanger used in an industrial laundry. The heat exchanger uses hot, dirty water to heat cold, clean water.

This heat exchanger transfers heat faster than the heat exchanger the student used in the investigation.

Explain why.

________________________________________________________________________

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________________________________________________________________________

________________________________________________________________________

(2)

(Total 6 marks)

Q19.

(a) The diagram shows the circuit used to investigate the resistance of a sample of a material. The diagram is not complete; the ammeter and voltmeter are missing.
(i) Draw the symbols for the ammeter and voltmeter on the diagram in the correct places.

(ii) How can the current through the material be changed?

______________________________________________________________

______________________________________________________________

(1)

(b) The material, called conducting putty, is rolled into cylinders of different lengths but with equal thickness.

**Graph 1** shows how the resistance changes with length.

(i) The current through a 25 cm length of conducting putty was 0.15 A.

Use **Graph 1** to find the resistance of a 25 cm length of conducting putty.

Resistance = ________________________________ ohms

(1)
(ii) Use your answer to (b) (i) to calculate the potential difference across a 25 cm length of conducting putty.

Show clearly how you work out your answer.

Potential difference = _________________________ volts

(c) A second set of data was obtained using thicker pieces of conducting putty. Both sets of results are shown in Graph 2.

(i) What is the relationship between the resistance and the thickness of the conducting putty?

(ii) Name one error that may have reduced the accuracy of the results.

Q20.

(a) The diagrams show the arrangement of the particles in a solid and in a gas.
Each circle represents one particle.

(i) Complete the diagram below to show the arrangement of the particles in a liquid.

(ii) Explain, in terms of the particles, why gases are easy to compress.

The diagram below shows the model that a science teacher used to show her students that there is a link between the temperature of a gas and the speed of the gas particles.

The ball-bearings represent the gas particles. Switching the motor on makes the ball-bearings move around in all directions.
(i) How is the motion of the ball-bearings similar to the motion of the gas particles?

_________________________________________________________________

_________________________________________________________________

(1)

(ii) The faster the motor runs, the faster the ball-bearings move. Increasing the speed of the motor is like increasing the temperature of a gas.

Use the model to predict what happens to the speed of the gas particles when the temperature of a gas is increased.

_________________________________________________________________

_________________________________________________________________

(1)

(Total 6 marks)

Q21.

The diagram shows how one type of electric storage heater is constructed. The heater has ceramic bricks inside. The electric elements heat the ceramic bricks during the night. Later, during the daytime, the ceramic bricks transfer the stored energy to the room.
(a) (i) Complete the following sentences using words from the box.

<table>
<thead>
<tr>
<th>conduction</th>
<th>convection</th>
<th>evaporation</th>
</tr>
</thead>
</table>

Energy is transferred through the metal casing by ________________

The warm air rising from the heater transfers energy to the room by ________________

(2)

(ii) The inside of the metal case is insulated.

Which one of the following gives the reason why?

Tick (✔️) one box.

- To transfer energy from the ceramic bricks to the room faster
- To stop energy from the room transferring into the heater
- To keep the ceramic bricks hot for a longer time

(1)

(b) In winter, the electricity supply to a 2.6 kW storage heater is switched on for seven hours each day.

(i) Calculate the energy transferred, in kilowatt-hours, from the electricity supply to the heater in seven hours.

Show clearly how you work out your answer.

______________________________________________________________
Energy transferred = _________________________ kWh

(ii) The electricity supply to the heater is always switched on between midnight and 7 am. Between these hours, electricity costs 5 p per kilowatt-hour.

Calculate how much it costs to have the heater switched on between midnight and 7 am.

Cost = _________________________ p

(c) Between 7 am and 8 am, after the electricity supply is switched off, the temperature of the ceramic bricks falls by 25 °C.

Calculate the energy transferred from the ceramic bricks between 7 am and 8 am.

Total mass of ceramic bricks = 120 kg.
Specific heat capacity of the ceramic bricks = 750 J/kg °C.

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
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Energy transferred = _________________________ J

(Total 8 marks)

Q22.

The diagram shows two thermometers. The bulb of each thermometer is covered with a piece of wet cotton wool. One of the thermometers is placed in the draught from a fan.
The graph shows how the temperature of each thermometer changes with time.

(a) Which of the graph lines, A or B, shows the temperature of the thermometer placed in the draught?

Write the correct answer in the box.

Explain, in terms of evaporation, the reason for your answer.

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___________________________________________________________________
___________________________________________________________________
(b) A wet towel spread out and hung outside on a day without wind dries faster than an identical wet towel left rolled up in a plastic bag.

Explain why.

Q23.

The diagram shows how one type of electric storage heater is constructed. The heater has ceramic bricks inside. The electric elements heat the ceramic bricks during the night. Later, during the daytime, the ceramic bricks transfer the stored energy to the room.

(a) In winter, the electricity supply to a 2.6 kW storage heater is switched on each day between midnight and 7 am. Between these hours, electricity costs 5 p per kilowatt-hour.

Calculate the daily cost of using the storage heater.

Show clearly how you work out your answer.
(b) Homes with electric storage heaters have a separate meter to measure the electricity supplied between midnight and 7 am. Another meter measures the electricity supplied at other times. This electricity supplied at other times costs 15 p per kilowatt-hour.

Electricity companies encourage people to use electricity between midnight and 7 am by selling the electricity at a lower cost.

Suggest why.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(1)

(c) By 7 am, the temperature at the centre of the ceramic bricks is about 800 °C. The temperature of the outside metal casing is about 80 °C.

The ceramic bricks are surrounded by 'super-efficient' insulation.

Explain why.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(d) At 7 am, the electricity supply switches off and the temperature of the ceramic bricks starts to fall. The temperature of the bricks falls by 100 °C over the next four hours. During this time, 9 000 000 J of energy are transferred from the bricks.

Calculate the total mass of ceramic bricks inside the heater.

Specific heat capacity of the ceramic bricks = 750 J/kg °C.

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Mass = _________________________ kg

(2)
Q24.

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 m² 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 m².

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

(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.

<table>
<thead>
<tr>
<th>Cost to buy and install</th>
<th>Estimated yearly savings on energy bills</th>
<th>Estimated lifetime of the double-glazed windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>£5280</td>
<td>£160</td>
<td>30 years</td>
</tr>
</tbody>
</table>

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.

Q25.

(a) The diagram shows two switches on a room heater. The heater has three power settings. The power produced by two of the settings is given in the table.

(i) When both switches are on, the heater works at the high power setting. What is the power of the heater when it is switched to the high power setting?
(ii) The heater is used on the **medium** power setting. It is switched on for three hours.

Use the equation in the box to work out the energy transferred from the mains to the heater in three hours.

\[
\text{energy transferred (kilowatt-hour, kWh)} = \text{power (kilowatt, kW)} \times \text{time (hour, h)}
\]

Show clearly how you work out your answer.

\[
\text{Energy transferred} = \underline{\text{？}} \text{ kWh}
\]

(iii) Electricity costs 12 pence per kilowatt-hour.

Use the equation in the box to calculate how much the heater costs to use on **medium** power for three hours.

\[
\text{total cost} = \text{number of kilowatt-hours} \times \text{cost per kilowatt-hour}
\]

Show clearly how you work out your answer.

\[
\text{Total cost} = \underline{\text{？}} \text{ pence}
\]

(b) The heater is used to warm a room.

The graph shows how the temperature of the room changes from the moment the heater is switched on.

![Graph showing temperature change over time]
The heater was first used on the medium setting.

(i) At what time was the heater setting changed to the high setting?

Give a reason for your answer.

(ii) From 7 pm until 10 pm, the temperature of the room is not changing.

Which one of the following statements gives the reason why the temperature of the room is not changing?

- The room is losing energy slower than the heater supplies energy.
- The room is losing energy as fast as the heater supplies energy.
- The room is losing energy faster than the heater supplies energy.

Q26.

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

(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.

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Money saved each year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installing loft insulation</td>
<td>£175</td>
<td>£60</td>
</tr>
<tr>
<td>Fitting draught-proofing</td>
<td>£45</td>
<td>£20</td>
</tr>
<tr>
<td>Installing cavity wall insulation</td>
<td>£300</td>
<td>£80</td>
</tr>
<tr>
<td>Adding a hot water tank jacket</td>
<td>£15</td>
<td>£20</td>
</tr>
<tr>
<td>Using energy efficient light bulbs</td>
<td>£60</td>
<td>£30</td>
</tr>
</tbody>
</table>

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

(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.

Q27.

Heat exchangers are devices that are used to transfer heat from one place to another.

The diagram shows a simple heat exchanger used by a student in an investigation. Heat is transferred from the hot water inside the pipe to the cold water outside the pipe.
(a)  By which process is heat transferred from the hot water inside the pipe to the cold water outside the pipe?

___________________________________________________________________

(1)

(b)  The student wanted to find out if the efficiency of a heat exchanger depends on the material used to make the pipe. The student tested three different materials. For each material, the rate of flow of hot water through the pipe was kept the same.

The results obtained by the student are recorded in the table and displayed in the bar chart.

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature of the cold water at the start in °C</th>
<th>Temperature of the cold water after 10 minutes in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>20</td>
<td>36</td>
</tr>
<tr>
<td>Glass</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Plastic</td>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>
(i) The rate of flow of hot water through the pipe was one of the control variables in the investigation.

Give one other control variable in the investigation.

(ii) Why did the student draw a bar chart rather than a line graph?

(iii) Which one of the three materials made the best heat exchanger?

Give a reason for your answer.

(c) The student finds a picture of a heat exchanger used in an industrial laundry. The heat exchanger uses hot, dirty water to warm cold, clean water.
Q28. The diagram shows two switches on a room heater. The heater has three power settings. The power produced by two of the settings is given in the table.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Power in kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.5</td>
</tr>
<tr>
<td>Medium</td>
<td>1.5</td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

(i) When both switches are on, the heater works at the high power setting. What is the power of the heater, in kilowatts, when it is switched to the high power setting?

\[
\text{Power} = \underline{\text{_________________________ kilowatts}}
\]

(1)

(ii) The heater is used on the high power setting. It is switched on for 1½ hours. Calculate the energy transferred from the mains to the heater in 1½ hours. Show clearly how you work out your answer and give the unit.

...
Energy transferred = __________________________ (3)

(iii) This type of heater is a very efficient device.

What is meant by a device being very efficient?

(b) The graph shows how the temperature of a room changes during the 1½ hours that the heater is used.

![Graph showing temperature change over time]

After 1 hour, the temperature of the room has become constant, even though the heater is still switched on.

Explain why.

Q29.
(a) In winter, energy is transferred from the warm air inside a house to the air outside.
(i) What effect will the energy transferred from the house have on the air outside?

__________________________________________________________________________

(ii) What would happen to the energy transfer if the temperature inside the house were reduced? Assume the temperature outside the house does not change.

__________________________________________________________________________

(b) To increase energy efficiency, a householder installs a heat exchanger to an outside wall of the house. The heat exchanger uses heat from the air outside to warm the inside of the house. The diagram shows the idea of the heat exchanger.

![Heat Exchanger Diagram]


(i) Why does the heat exchanger cost money to run?

__________________________________________________________________________

(ii) The heat exchanger is cost effective in reducing energy consumption. Explain why.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

(Total 5 marks)

Q30.

(a) The diagram shows how much heat is lost each second from different parts of an uninsulated house.
(i) Each year, the house costs £760 to heat.

How much money is being wasted because of heat lost through the roof?

Show clearly how you work out your answer.

___________________________________________________________________

___________________________________________________________________

(2)

(ii) Insulating the loft would cut the heat lost through the roof by 50%.

The loft insulation has a payback time of $1\frac{1}{2}$ years.

How much did the loft insulation cost to buy?

___________________________________________________________________

Cost of loft insulation = £ _________________________

(1)

(b) What happens to the wasted energy?

___________________________________________________________________

___________________________________________________________________

(1)

(Total 4 marks)

Q31.

(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.
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 ___________________.

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

<table>
<thead>
<tr>
<th>Type of insulation</th>
<th>Cost to install</th>
<th>Money save each year on heating bills</th>
<th>Payback time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double glazing</td>
<td>£4000</td>
<td>£200</td>
<td>20 years</td>
</tr>
<tr>
<td>Loft insulation</td>
<td>£300</td>
<td>£100</td>
<td>3 years</td>
</tr>
<tr>
<td>Cavity wall insulation</td>
<td>£600</td>
<td>£150</td>
<td></td>
</tr>
</tbody>
</table>

(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)

Q32.

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

<table>
<thead>
<tr>
<th>Method of reducing energy consumption</th>
<th>Installation cost in £</th>
<th>Annual saving on energy bills in £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit a new hot water boiler</td>
<td>1800</td>
<td>200</td>
</tr>
<tr>
<td>Fit a solar water heater</td>
<td>2400</td>
<td>100</td>
</tr>
<tr>
<td>Fit underfloor heating</td>
<td>600</td>
<td>50</td>
</tr>
</tbody>
</table>
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)

Q33.

(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.

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

<table>
<thead>
<tr>
<th>Method of insulation</th>
<th>Installation cost £</th>
<th>Yearly saving on energy bills in £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double glazing</td>
<td>4000</td>
<td>65</td>
</tr>
<tr>
<td>Loft insulation</td>
<td>240</td>
<td>60</td>
</tr>
<tr>
<td>Cavity wall insulation</td>
<td>600</td>
<td>80</td>
</tr>
</tbody>
</table>

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

______________________________________________________________
______________________________________________________________

(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

(Total 4 marks)

Q34.

Many people use a sleeping bag when they sleep in a tent. Sleeping bags, designed to keep a person warm, have a fibre filling.

(i) Complete the sentence by choosing the correct words from the box.

conduction  convection  radiation

The fibre is designed to reduce heat transfer by ___________________ and ___________________

(ii) Explain why the fibre is good at reducing heat loss from a person sleeping in the bag.
Q35.

(a) The diagram shows hot water being poured into a mug.

(i) Complete the sentence by choosing the correct words from the box. Each word may be used once or not at all.

| air | mug | table | water |

Heat energy is being transferred from the _______________________ to the ________________________.

(ii) When will this transfer of heat energy stop?

______________________________________________________________

______________________________________________________________

(b) In the box are the names of four types of fuel used to heat homes.

| coal | gas | oil | wood |

Which one of these types of fuel is renewable?
The diagram shows where heat energy is lost from a house.

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

<table>
<thead>
<tr>
<th>conduction</th>
<th>conductor</th>
<th>electric</th>
<th>evaporation</th>
<th>insulator</th>
</tr>
</thead>
</table>

The amount of heat energy lost through the windows by ____________________________ can be reduced by using thick curtains. The curtains trap a layer of air and air is a good ____________________________.

(ii) Write down one other way of reducing heat loss from a house.

__________________________________________________________________________

__________________________________________________________________________

(Total 6 marks)
Mark schemes

Q1.

(a) \textbf{Level 3 (5–6 marks):}  
A clear, logical explanation containing accurate ideas presented in the correct order with links between ideas.

\textbf{Level 2 (3–4 marks):}  
Key ideas presented with some linked together to form a partial explanation.

\textbf{Level 1 (1–2 marks):}  
Fragmented ideas, some may be relevant, insufficient links to form an explanation.

\textbf{0 marks:}  
No relevant content.

Indicative content
- current in the wire causes heating
- increases temperature of the metal wires / ice

\textbf{Solid}  
- arrangement of particles is regular
- particles vibrate about a fixed position

\textbf{Melting}  
- internal energy of the ice increases, increasing the temperature to melting point
- so (as the temperature increases) particles vibrate faster
- eventually particles vibrate fast enough to break free from the (strong) bonds
- therefore the arrangement of particles becomes irregular

\textbf{Liquid}  
- arrangement of particles is irregular
- particles movement (translational) is random

(b) The current in the heating element

The mass of ice

(c) latent heat of fusion

\[ \frac{45}{120} = 0.375 \]

0.38  
\textit{allow 0.38 with no working shown for 2 marks}  
\textit{allow 0.375 with no working shown for 1 mark}

\[ \text{[11]} \]

Q2.
(a) random

*accept in all directions*

description must be of random motion

(b) heating increases the temperature of the gas

temperature is proportional to kinetic energy

if kinetic energy increases speed increases

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

to break the bonds

(d) \[1000 = \frac{m}{2.5 \times 10^{-5}}\]

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

\[m = 0.025 \text{ (kg)}\]

\[E = 0.025 \times 2\,260\,000\]

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

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

0 marks awarded for \(E = m \times L\)

(e) any four from:

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

Q3.

(a) kilograms per metre cubed, kg / m\(^3\)

(b) (solid has) more particles

*allow atoms for particles*

in the same volume or in a given volume

*allow description of a given area*
(c) randomly

\textit{this order only}

kinetic

(d) (pressure) rises

Q4.

(a) density = mass / volume

(b) any two from:

- no forces shown between spheres
- atoms / molecules / ions are not solid spheres
- not all the same size.

(c) at higher temperatures particles have more kinetic energy

(so) the (average) speed of the particles increases

(so there are) more frequent collisions with the wall of the container

which apply a greater force on wall of container (so pressure rises)

Q5.

(a) most alpha particles went straight through, suggesting lots of empty space

a few alpha particles bounced back, suggesting small central nucleus

with all the positive charge

the plum pudding model does not explain the results because it shows the whole atom as a ball of positive charge with no empty space

(b) the figures show that the radius of an atom is 10 000 times bigger than the nucleus

consistent with the nuclear model, which says that the atom has a tiny nucleus at the centre of the atom

(c) all hydrogen atoms have just one proton (in the nucleus)
some hydrogen atoms also have one neutron

protons and neutrons have the same relative mass so mass number of these atoms is 2

(d) neutrons are not attracted or repelled by a positive nucleus

so the neutrons would all pass through the foil

Q6.
(a) solid
particles vibrate about fixed positions

closely packed
accept regular

gas
particles move randomly
accept particles move faster
accept freely for randomly

far apart

(b) amount of energy required to change the state of a substance from liquid to gas (vapour)

unit mass / 1 kg
dependent on first marking point

(c) 41000 or $4.1 \times 10^4$ (J)
accept
41400 or $4.14 \times 10^4$
correct substitution of
$0.018 \times 2.3 \times 10^6$ gains 1 mark

(d) AB
changing state from solid to liquid / melting

at steady temperature
dependent on first AB mark

BC
temperature of liquid rises
until it reaches boiling point

*dependent on first BC mark*

Q7.

(a) decreased

*correct order only*

1 decreased

1 increased

(b) (i) A

(reason only scores if A chosen)

1 uses least / less energy (in 1 year)

*a comparison is required*

*accept uses least power*

*accept uses least kWh*

1

(ii) greater the volume the greater the energy it uses (in 1 year)

1 (iii) a very small number sampled

*accept only tested 3*

*accept insufficient evidence / data*

*allow not all fridges have the same efficiency or a correct description implying different efficiencies*

*only tested each fridge once is insufficient*

*there are lots of different makes is insufficient*

1

Q8.

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

- mass (of block)
  *accept weight for mass*

- starting temperature

- final / increase in temperature
  *temperature is insufficient*

- voltage / p.d.
  *same power supply insufficient*

- power (supplied to each block)

- type / thickness of insulation
  *same insulation insufficient*

2 (ii) one of variables is categoric
or
(type of) material is categoric
accept the data is categoric
accept a description of categoric
do not accept temp rise is categoric

(iii) concrete
reason only scores if concrete chosen

(heater on for) longest / longer time
a long time or quoting a time is insufficient
do not accept it is the highest bar

(iv) 4500 (J)
allow 1 mark for correct substitution ie
2 × 450 × 5 provided no subsequent step shown

(b) (i) point at 10 minutes identified

(ii) line through all points except anomalous
line must go from at least first to last point

(iii) 20 (°C)
if 20°C is given, award the mark.
If an answer other than 20°C is given, look at the graph. If
the graph shows a correct extrapolation of the candidate’s
best-fit line and the intercept value has been correctly stated,
allow 1 mark.

(iv) 2 (minutes)

Q9.
Marks awarded for this answer will be determined by the Quality of Written
Communication (QWC) 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)
Considers either solid or gas and describes at least one aspect of the particles.
or
Considers both solids and gases and describes an aspect of each.

Level 2 (3–4 marks)
Considers both solids and gases and describes aspects of the particles.
or

Considers one state and describes aspects of the particles and explains at least one of the properties.

or

Considers both states and describes an aspect of the particles for both and explains a property for solids or gases.

Level 3 (5–6 marks)
Considers both states of matter and describes the spacing and movement / forces between the particles. Explains a property of both solids and gases.

examples of the points made in the response

extra information

Solids

• (particles) close together
• (so) no room for particles to move closer (so hard to compress)
• vibrate about fixed point
• strong forces of attraction (at a distance)
• the forces become repulsive if the particles get closer
• particles strongly held together / not free to move around (shape is fixed)

any explanation of a property must match with the given aspect(s) of the particles.

Gases

• (particles) far apart
• space between particles (so easy to compress)
• move randomly
• negligible / no forces of attraction
• spread out in all directions (to fill the container)

Q10.
(a) conduction

(b) 35 000

(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

J / kg°C

(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

Q11.

(a)  
(i) 70

accept ± half a square
(69.8 to 70.2)

(ii) 15

accept 14.6 to 15.4 for 2 marks
allow for 1 mark 70 – 55
ecf from (b)(i) ± half a square

(iii) C

biggest drop in temperature during a given time
accept it has the steepest gradient this is a dependent

(iv) starting at 70 °C and below graph for C
must be a curve up to at least 8 minutes

(v) because 20 °C is room temperature
accept same temperature as surroundings

(b) (i) 6720

correct answer with or without working gains 3 marks
6 720 000 gains 2 marks
correct substitution of $E = 0.2 \times 4200 \times 8$ gains 2 marks
correct substitution of $E = 200 \times 4200 \times 8$ gains 1 mark

(ii) the fastest particles have enough energy
accept molecules for particles
to escape from the surface of the water

therefore the mean energy of the remaining particles decreases
accept speed for energy

the lower the mean energy of particles the lower the temperature (of the water)
accept speed for energy
Q12. (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

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

Q13. (a) any two from:
• water evaporates
accept steam / water vapour for water molecules
accept water turns to steam
• water molecules / particles go into the air
• mirror (surface) is cooler than (damp) air
accept the mirror / surface / glass is cold
• water molecules / particles that hit the mirror lose energy
accept water molecules / particles that hit the mirror cool down
• cooler air cannot hold as many water molecules / particles
  (causes) condensation (on the mirror)
  accept steam changes back to water (on the mirror)

  or
  particles move closer together

  (b) mirror (surface) is warm
  mirror is heated is insufficient

  (rate of) condensation reduced
  accept no condensation (happens)

Q14.
(a) conduction

(b) (i) there is a bigger temperature difference between the water and the surrounding air
  accept the water is hottest / hotter

  so the transfer of energy (from hot water) is faster
  accept heat for energy
  ignore temperature falls the fastest

(ii) 120

  allow 1 mark for converting kJ to J correctly, ie 4 032 000

  or

  correctly calculating temperature fall as 8°C

  or

  allow 2 marks for correct substitution, ie 4 032 000 = m × 4200 × 8

  answers of 0.12, 19.2 or 16.6 gain 2 marks

  answers of 0.019 or 0.017 gain 1 mark

(iii) water stays hot for longer

  so heater is on for less time
  accept so less energy needed to heat water

  so cost of the jacket is soon recovered from) lower energy costs / bills
  accept short payback time
Q15.

(a) (i)  Z

(ii)  X

(b) (i) moving randomly

(ii) stronger than

(c) (i) evaporation

(ii) any one from:

- becomes windy
- temperature increases
  accept (becomes) sunny
  “the sun” alone is insufficient
- less humid

Q16.

(a) (i) 5.0

(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

(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

(iv) decreases

  temperature difference (between inside and outside) decreases
  accept gradient (of line) decreases
  do not accept temperature (inside) decreases
  do not accept graph goes down

(b) air (bubbles are) trapped (in the foam)
do not accept air traps heat
foam has air pockets is insufficient

(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

Q17.

(a) there are strong forces (of attraction) between the particles in a solid
accept molecules / atoms for particles throughout
accept bonds for forces

(holding) the particles close together
particles in a solid are less spread out is insufficient

or

(holding) the particles in a fixed pattern / positions
but in a gas the forces between the particles are negligible
accept very small / zero for negligible
accept bonds for forces

so the particles spread out (to fill their container)
accept particles are not close together
accept particles are not in a fixed position is insufficient

(b) (i) particles are (shown) leaving (the liquid / container)
accept molecules / atoms for particles throughout
accept particles are escaping
particles are getting further apart is insufficient

(ii) accept molecules / atoms for particles throughout
accept speed / velocity for energy throughout
particles with most energy leave the (surface of the) liquid
accept fastest particles leave the liquid

so the mean / average energy of the remaining particles goes down

and the lower the average energy (of the particles) the lower the temperature (of the liquid)
Q18.

(a) conduction

(b) (i) any one from:

- starting temperature (of cold water)
  \textit{temperature} \textit{is} \textit{insufficient}

- pipe length
  \textit{accept} \textit{size of pipe}

- pipe diameter

- pipe (wall) thickness

- volume of cold water
  \textit{accept} \textit{amount for volume}

- temperature of hot water (in)

- time

(ii) copper

\textit{greatest temperature change}
\textit{only scores if copper chosen}
\textit{accept} \textit{heat} \textit{for temperature}
\textit{accept} \textit{heated water the fastest}
\textit{accept} \textit{it was hottest (after 10 minutes)}
\textit{accept} \textit{it is the best / a good conductor}

(c) the pipe has a larger (surface) area
\textit{accept} \textit{pipe is longer}

\textit{(so) hot / dirty water (inside pipe) is in contact with cold / clean water (outside pipe) for longer}

Q19.

(a) (i) ammeter symbol correct and drawn in series

\begin{center}
\textbf{A}
\end{center}

\textit{accept}
\textit{do not accept} \textit{lower case a}

voltmeter symbol correct and drawn in parallel with the material

\begin{center}
\textbf{V}
\end{center}

\textit{do not accept}

[6]
(ii) adjust / use the variable resistor
    accept change the resistance

    or
            change the number of cells
    accept battery for cell
    accept change the pd / accept change the voltage
    accept increase / decrease for change

(b)  (i)  37.5 (Ω)
    accept answer between 36 and 39 inclusive

(ii) 5.6(25) or their (b)(i) × 0.15
    allow 1 mark for correct substitution ie 37.5 or their (b)(i) × 0.15 provided no subsequent step shown

(c)  (i) the thicker the putty the lower the resistance
    answer must be comparative
    accept the converse

(ii) any one from:
    • measuring length incorrectly
        accept may be different length
    • measuring current incorrectly
        do not accept different currents
    • measuring voltage incorrectly
        do not accept different voltage
    • ammeter / voltmeter incorrectly calibrated
    • thickness of putty not uniform
        do not accept pieces of putty not the same unless qualified
    • meter has a zero error
        do not accept systematic / random error
        accept any sensible source of error eg putty at different temperatures
        do not accept human error without an explanation
        do not accept amount of putty not same

Q20.
(a)  (i) random distribution of circles in the box with at least 50 % of circles touching
    random distribution of circles occupies more than 50 % of the space
    judged by eye
(ii) (large) gaps between particles
  accept particles do not touch
  accept particles are spread out

  (so) easy to push particles closer (together)
  or
  forces between particles are negligible / none
  an answer in terms of number of particles is insufficient

(b) (i) (both are) random
  accept a correct description of random eg unpredictable or
  move around freely or in all directions
  they take up all the space is insufficient
  they are spread out is insufficient
  they move in straight lines is insufficient

(ii) (speed also) increases

Q21.
  (a) (i) conduction

  convection
  correct order only

(ii) to keep the ceramic bricks hot for a longer time

(b) (i) \[ E = P \times t \]

  18.2
  allow 1 mark for correct substitution ie \(2.6 \times 7\) provided that
  no subsequent step is shown

(ii) 91 (p)
  or their (b)(i) \( \times 5\) correctly calculated
  accept £0.91
  do not accept 0.91 without £ sign

(c) \[ E = m \times c \times \theta \]

  2 250 000
  allow 1 mark for correct substitution ie \(120 \times 750 \times 25\)
  provided that no subsequent step is shown
  answers 2250 kJ or 2.25 MJ gain both marks
Q22.  
(a) B  
no mark for B - marks are for the explanation  
first two mark points can score even if A is chosen  
draught increases (the rate of) evaporation  
accept more evaporation happens  
accept draught removes (evaporated) particles faster  
do not accept answers in terms of particles gaining energy  
from the fan / draught  
evaporation has a cooling effect  
accept (average) kinetic energy of (remaining) particles  
decreases  
so temperature will fall faster / further  
(b) larger surface area  
increasing the (rate of) evaporation  
accept more / faster evaporation  
accept easier for particles to evaporate  
or  
for water to evaporate from  
accept more particles can evaporate  
accept water / particles which have evaporated are trapped  
(in the bag)  
answers in terms of exposure to the Sun are insufficient

Q23.  
(a) \( E = P \times t \)  
91 (p)  
an answer £0.91 gains 3 marks  
an answer 0.91 gains 2 marks  
allow 2 marks for energy transferred = 18.2 (kWh)  
or  
substitution into 2 equations combined, ie \( 2.6 \times 7 \times 5 \)  
allow 1 mark for correct substitution into \( E = P \times t \), ie \( E = 2.6 \times 7 \)  
or  
allow 1 mark for multiplying and correctly calculating an  
incorrect energy transfer value by 5  
(b) answers should be in terms of supply exceeding demand  
accept there is a surplus / excess of electricity (at night)
(c) reduce (rate of) energy transfer (from ceramic bricks)
   accept heat for energy
   do not accept no energy / heat escapes
   do not accept answers in terms of lost / losing heat if this implies heat is wasted energy

so keeping the (ceramic) bricks hot for longer
   accept increase time that energy is transferred to the room
   accept keep room warm for longer

or

to stop the casing getting too hot
   accept so you do not get burnt (on the casing)

(d) \[ E = m \times c \times \theta \]

120

allow 1 mark for correct substitution

ie \[ 9 000 000 = m \times 750 \times 100 \]

[8]

Q24.

(a) (i) conduction

(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

   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

(b) (i) 5 (°C) to 25 (°C)
   either order

(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

(iii) 1800
allow 1 mark for obtaining heat transfer value = 120

(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
this is greater than lifetime of windows
or
total savings (over 30 years) = £4800 (1)
this is less than cost of windows (1)
or
5280
30 = 176 (1)
this is more than the yearly savings (1)

Q25.

(a) (i) 2000
accept 2000 W or 2000 watt(s)
accept answer given in table
do not accept 2000

(ii) 4.5
allow 1 mark for correct substitution
ie 1.5 × 3
allow 1 mark for the answers 1.5 or 6(.0)

(iii) 54
or their (a)(ii) × 12 correctly calculated
allow 1 mark for correct substitution
ie 4.5 × 12
or their (a)(ii) × 12
allow 1 mark if correct answer is given in pounds eg £54

(b) (i) 6 pm
temperature starts to rise faster  
*only scores if 6 pm given*

or

graph (line) is steeper / steepest  
*it refers to graph gradient or temperature*

accept answers in terms of relative temperature rise  
*eg 5 to 6 pm 2 °C rise, 6 to 7 pm 6 °C rise*

accept temperature rises sharply / rapidly / quickly  
*do not accept temperature starts to rise*

(ii) middle box ticked

1

Q26.  
(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

Q27.  
(a) conduction
(b)  (i) any **one** from:

- starting temperature (of cold water)
  *temperature is insufficient*
- pipe length
  *accept size of pipe*
- pipe diameter
- pipe (wall) thickness
- volume of cold water
  *accept amount for volume*
- temperature of hot water (in)
- time

(ii) (type of) material is categoric

  *accept one variable is categoric*
  *accept variable(s) are categoric*
  *accept it is categoric*
  *accept variable(s) are not continuous*
  *descriptions of variables ie names and numbers is insufficient*

(iii) copper

  greatest temperature change
  *only scores if copper chosen*
  *accept heat for temperature*
  *accept heated water the fastest*
  *accept it was hottest (after 10 minutes)*
  *accept it is the best / a good conductor*

(c) larger (surface) area

  *accept the pipe is longer*
  *accept hot (dirty) water (inside pipe) is in contact with the cold water (outside pipe) for a longer time*
  *he pipe is a spiral is insufficient*

**Q28.**

(a)  (i) 2.1

  *correct answer only*

(ii) 3.15

  or

  their (a)(i) × 1.5 correctly calculated
allow 1 mark for correct substitution
ie 2.1 × 1.5
or
their (a)(i) × 1.5

kilowatt-hour
accept kWh
or
a substitution 2100 × 5400 scores 1 mark
2100 × 5400 incorrectly calculated with answer in joules scores 2 marks
an answer of 11 340 000 scores 2 marks
an answer of 11 340 000 J scores 3 marks

(iii) most (input) energy is usefully transformed
accept does not waste a lot of energy
accept most of the output / energy is useful
do not accept it does not waste energy

(b) the room is losing energy / heat

at the same rate as the heater supplies it
this mark only scores if the first is scored
do not accept heater reaches same temperature as room / surroundings
rate of heat gain = rate of heat loss scores both marks

Q29.
(a) (i) makes it warmer / raises the temperature
accept produces convection (current)
accept makes it less dense

(ii) reduced or slows down

(b) (i) electrical energy (to run the pump) must be paid for
accept electricity for electrical energy
accept electricity is needed for the pump
accept it uses electricity
accept because of the pump

(ii) more useful (heat) energy is transferred into the house than the energy used to operate the pump

or reduced cost of heating the house is greater than the cost of running the (electrical) pump
or costs little to run compared to the savings made
accept for 1 mark
reduces energy bills
or reduced fuel costs / heating costs owte
do not accept it’s cheap

Q30.
(a) (i) £190

nb mention idea of cost per J in £ will come to an approx figure full credit given
allow 1 mark for showing that the energy loss through the roof is ¼ of the total energy loss ie 150 / 600

(ii) £142.50

allow ecf 50 % of their (a)(i) × 1.5 ie their (a)(i) × 0.75

(b) transferred to surroundings / atmosphere
or becomes spread out

Q31.
(a) (i) 7pm

accept 19.00 / 1900

(ii) 8pm

accept 20.00 / 2000

temperature drops more slowly
accept heat for temperature accept line is less steep

(b) insulator

conduction *

convection *
* answers can be either way around

(c) (i) 4 (years)

(ii) it is the cheapest / cheaper / cheap

do not accept answers in terms of heat rising or DIY

has the shortest / shorter payback time
do **not** accept short payback time

**Q32.**

(a) four calculations correctly shown

\[
\begin{align*}
200 \times 10 & - 1800 = \£200 \\
100 \times 10 & - 2400 = -\£1400 \\
50 \times 10 & - 600 = -\£100 \\
20 \times 10 & - 75 = 125
\end{align*}
\]

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 \times 10 of all four calculations = 1 mark answers in terms of savings as a percentage of installation cost **may** score savings mark only

hot water boiler

correct answers only

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

accept less demand

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

**Q33.**

(a) air is (a good) insulator

or air is a poor conductor

accept air cavity / ‘it’ for air

reducing heat transfer by conduction

accept stops for reduces

ignore convection

do **not** accept radiation

do **not** accept answers in terms of heat being trapped

(b) (i) most cost effective

accept it is cheaper or lowest 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

(ii) 4

Q34.
(i) conduction, convection
   answer can be in either order

(ii) traps (lots of) air
   do not accept heat is trapped in the fibre
   air is a (good) insulator or poor conductor

Q35.
(a) (i) any one from:
   water to the mug
   water to the air
   mug to the air
   mug to the table
   both required
direction of transfer must be correct

(ii) when temperatures are the same
   accept a specific example eg when the temperature of the water and mug are the same
   accept radiant heat transfer will never stop

(b) wood

(c) (i) conduction
   accept convection if not given as 3rd answer

   insulator

(ii) any one from:
do not accept any rebuilding of house
double glazing
loft insulation
   accept roof for loft

carpets
(cavity) wall insulation
   do not accept closing doors and windows

draft excluders

foil behind radiators
   accept blocking chimney

paint inside walls white