

Particle Model 1

Name: _____

Class: _____

Date: _____

Time: **90 minutes**

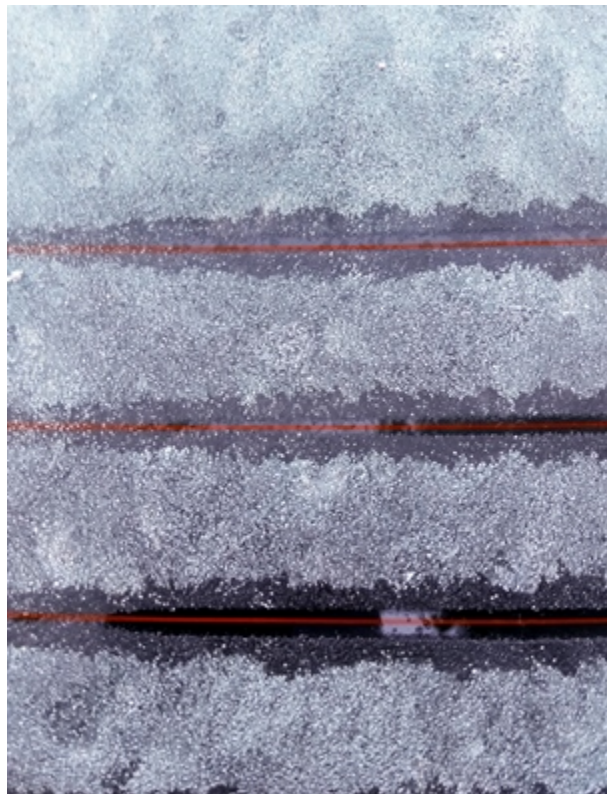
Marks: **88 marks**

Comments:

1.

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

Figure 1

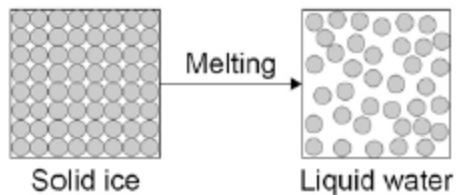


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The glass window contains an electrical heating element.

- (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



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

(6)

- (b) 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

(2)

- (c) 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

(1)

- (d) 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.

$$\text{Efficiency} = \frac{\text{Output energy transfer}}{\text{input energy transfer}}$$

Give your answer to two decimal places.

Efficiency = _____

(2)

(Total 11 marks)

2.

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

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

(1)

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

(3)

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

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

(2)

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

The figure below shows condensation on a cold bathroom mirror.



© Dwight Eschliman/Getty Images

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

Density of water = 1000 kg / m^3

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

Calculate the energy released when the condensation forms.

Energy released = _____ J

(5)

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

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

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

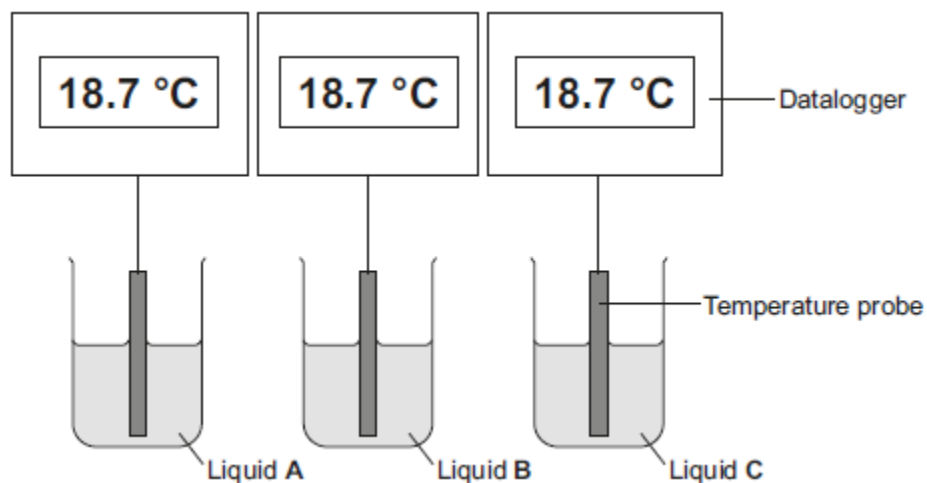
Give some of the arguments in favour of condensing boilers compared to older non-condensing boilers.

(4)
(Total 15 marks)

3.

A student investigated the cooling effect of evaporation. She used the equipment in **Figure 1** to measure how the temperature of three different liquids changed as the liquids evaporated.

Figure 1



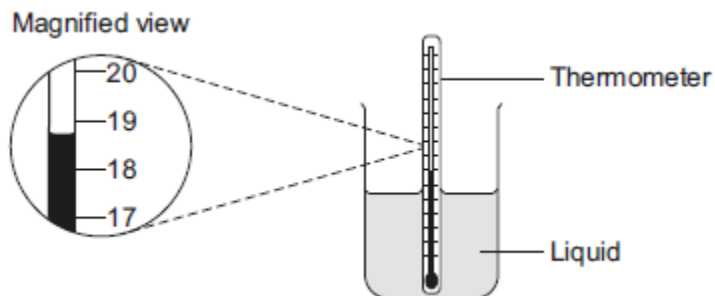
(a) The temperature and volume of each liquid was the same at the start of the investigation.

State **one** further control variable in this investigation.

(1)

(b) Give **two** advantages of using dataloggers and temperature probes compared to using the thermometer shown in **Figure 2**.

Figure 2



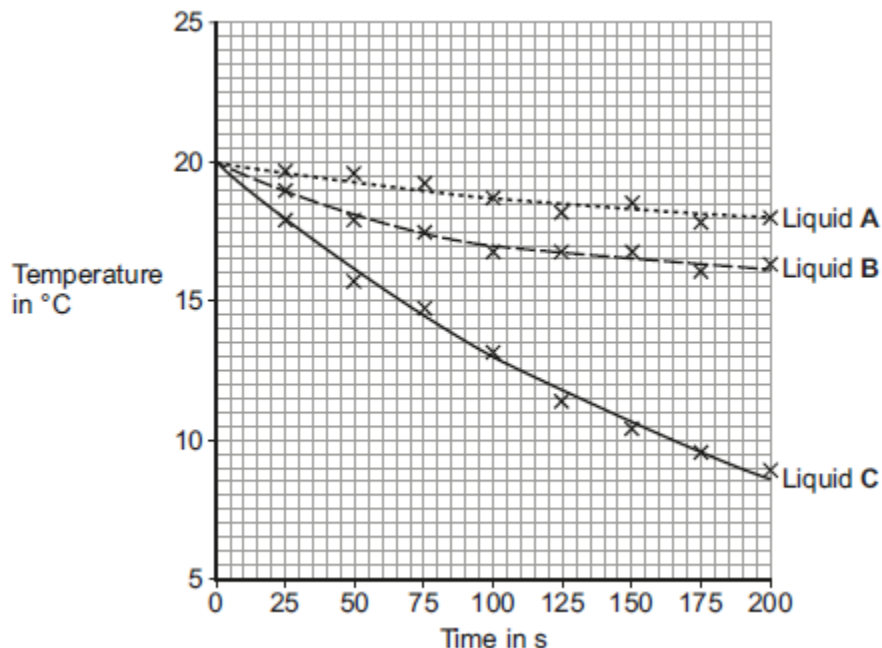
1. _____

2. _____

(2)

(c) The student's results are shown in **Figure 3**.

Figure 3



(i) Calculate the average rate of temperature decrease of liquid **C** between 0 and 100 seconds.

Average rate of temperature decrease = _____ °C / s

(2)

(ii) Give **one** conclusion that can be made about the rate of temperature decrease of **all three** liquids from the results in **Figure 3**.

(1)

(iii) Which liquid had the lowest rate of evaporation? Give a reason for your answer.

Liquid _____

Reason _____

(1)

- (iv) A second student did the same investigation but using a smaller volume of liquid than the first student.

All other variables were kept the same.

What effect would this have on the results of the second student's investigation?

(1)

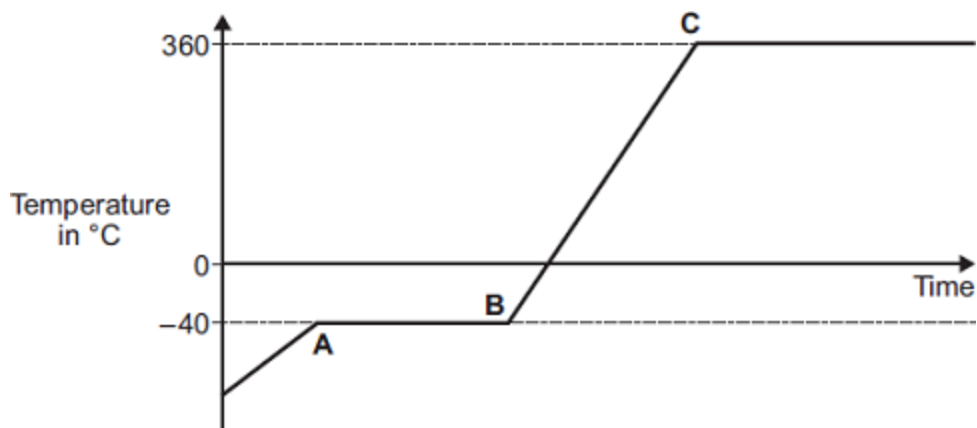
- (d) Explain how the evaporation of a liquid causes the temperature of the remaining liquid to decrease.

(3)

(Total 11 marks)

(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)

5.

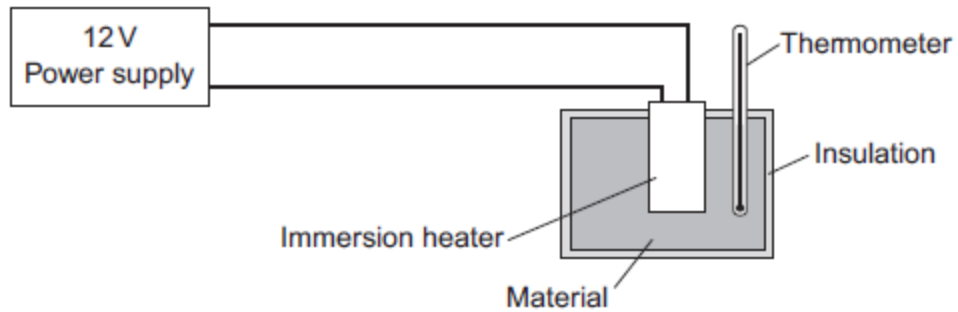
A student used the apparatus in **Figure 1** to compare the energy needed to heat blocks of different materials.

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.

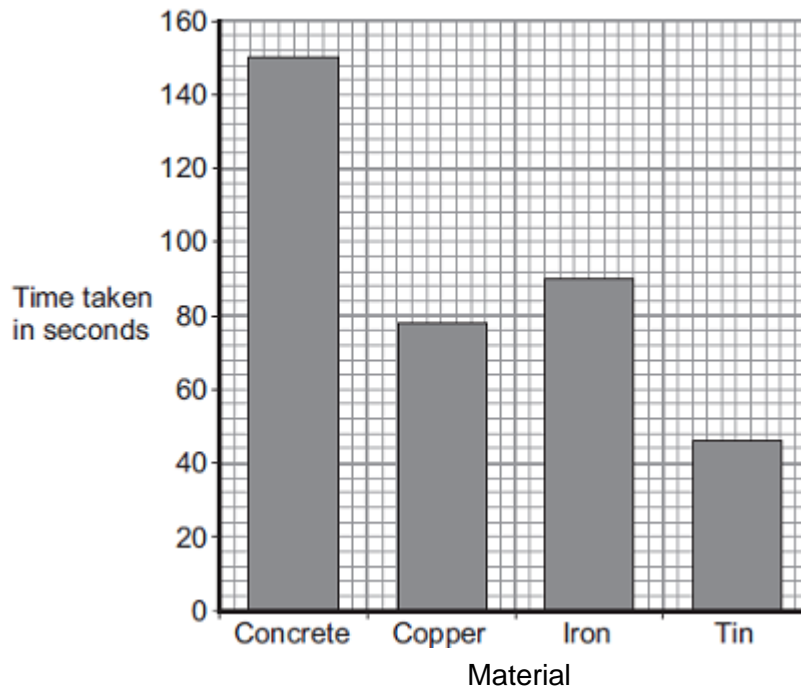
(a) (i) State **two** variables the student controlled.

1. _____
2. _____

(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.

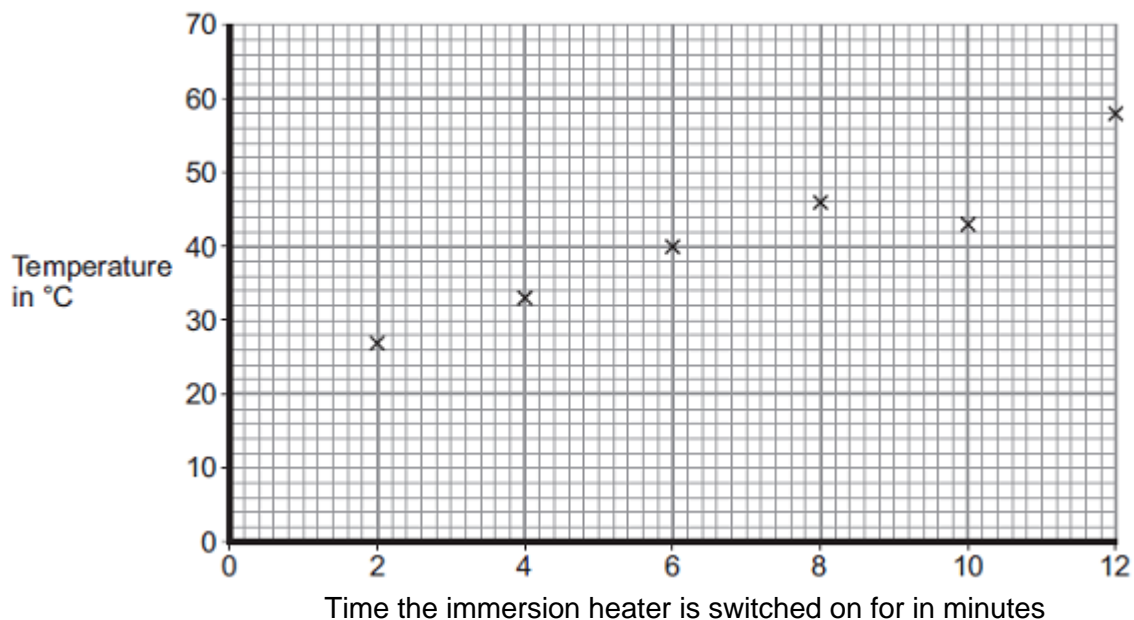
The specific heat capacity of iron is 450 J / kg °C.

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**.

Figure 3



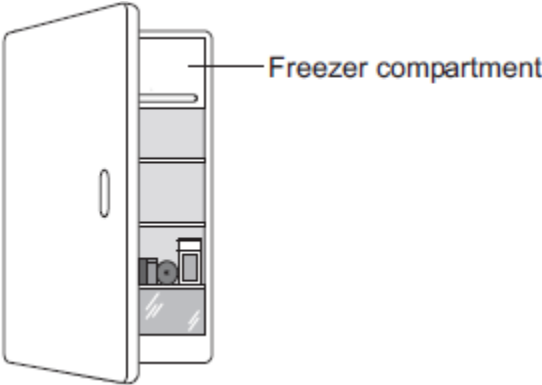
- (i) One of the student's results is anomalous.
 Draw a ring around the anomalous result. (1)
- (ii) Draw the line of best fit for the points plotted in **Figure 3**. (1)
- (iii) What was the temperature of the room?
 Temperature = _____ °C (1)
- (iv) What was the interval of the time values used by the student?
 Interval = _____ minutes (1)

(Total 11 marks)

6.

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

The temperature of the air inside the freezer compartment is $-5\text{ }^{\circ}\text{C}$.



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 _____ .

(3)

(b) The table below shows some information about three fridges, **A**, **B** and **C**.

The efficiency of each fridge is the same.

Fridge	Volume in litres	Energy used in one year in kWh
A	232	292
B	382	409
C	622	524

(i) Which fridge, **A**, **B** or **C**, would cost the least to use for 1 year?

Give **one** reason for your answer.

(2)

(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?

(1)

(iii) The householder could not be certain that her conclusion is correct for all fridges.

Suggest **one** reason why not.

(1)

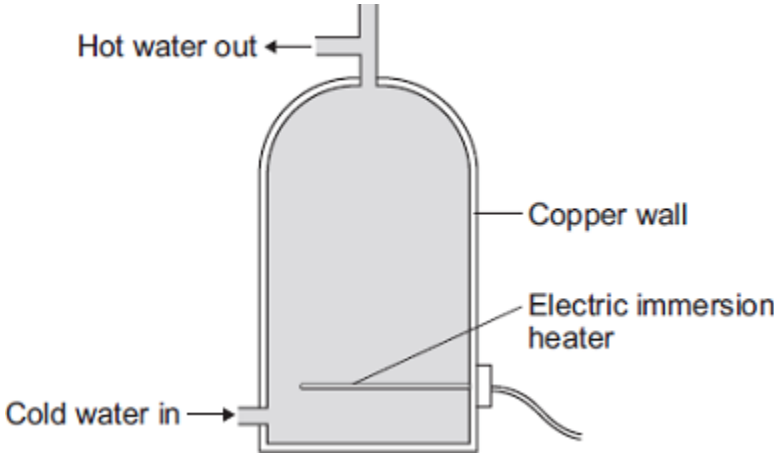
(Total 7 marks)

Extra space _____

(Total 6 marks)

8.

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.



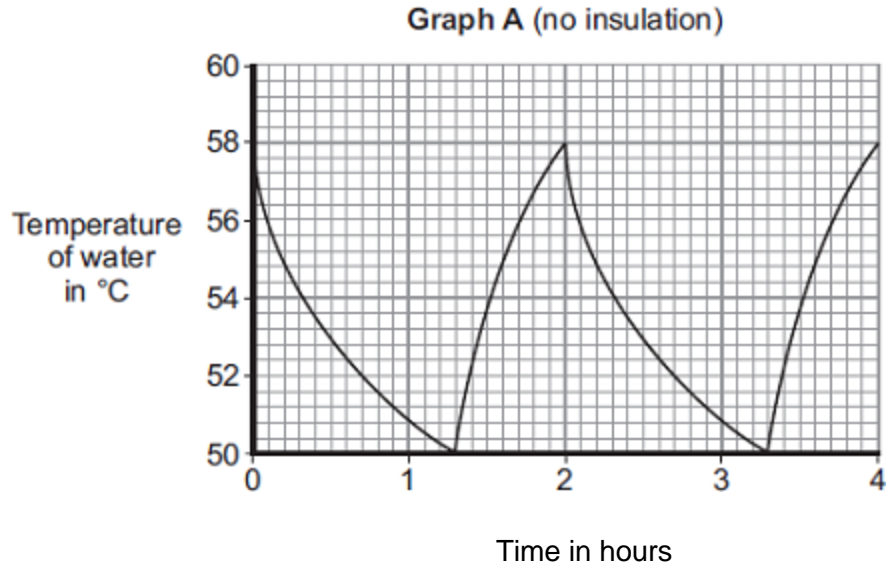
(a) Complete the following sentence.
The main way the energy is transferred through the copper wall of the water tank is by the process of _____.

(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.

(2)

- (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.

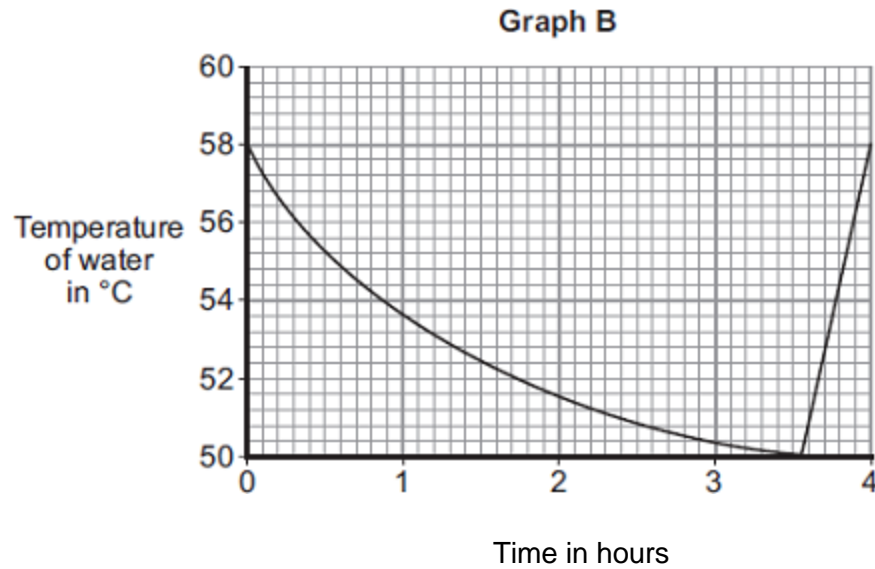
Specific heat capacity of water = $4200 \text{ J/kg}^{\circ}\text{C}$

Mass = _____ kg

(3)

- (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.



An insulating jacket only costs £12.

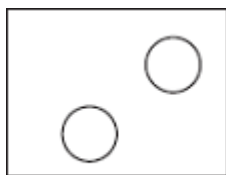
By comparing **Graph A** with **Graph B**, explain why fitting an insulating jacket to a hot water tank saves money.

(3)

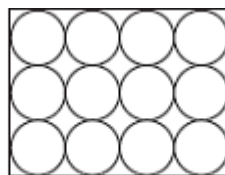
(Total 9 marks)

9.

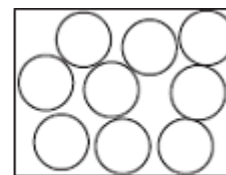
- (a) The diagrams, **X**, **Y** and **Z**, show how the particles are arranged in the three states of matter.



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.

(1)

(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.

(1)

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

(i) In a gas, the particles are

vibrating in fixed positions.

moving randomly.

not moving.

(1)

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

stronger than

equal to

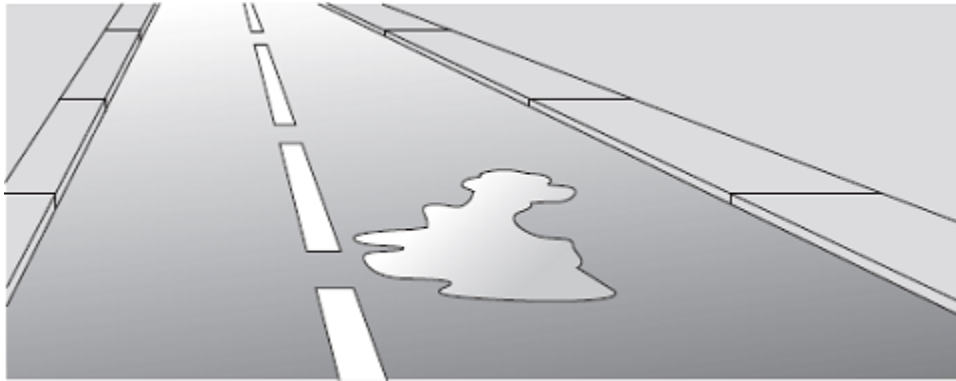
weaker than

the

forces between the particles in a liquid.

(1)

(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)

Mark schemes

1.

(a) **Level 3 (5–6 marks):**

A clear, logical explanation containing accurate ideas presented in the correct order with links between ideas.

Level 2 (3–4 marks):

Key ideas presented with some linked together to form a partial explanation.

Level 1 (1–2 marks):

Fragmented ideas, some may be relevant, insufficient links to form an explanation.

0 marks:

No relevant content.

Indicative content

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

Solid

- arrangement of particles is regular
- particles vibrate about a fixed position

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

Liquid

- arrangement of particles is irregular
- particles movement (translational) is random

6

(b) The current in the heating element

1

The mass of ice

1

(c) latent heat of fusion

1

$45 / 120 = 0.375$

1

0.38

allow 0.38 with no working shown for 2 marks

allow 0.375 with no working shown for 1 mark

1

[11]

2.

(a) random

accept in all directions

1

description must be of random motion

(b) heating increases the temperature of the gas

1

temperature is proportional to kinetic energy

1

if kinetic energy increases speed increases

1

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

1

to break the bonds

1

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

1

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

1

$m = 0.025$ (kg)

1

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

1

$E = 56\,500$ (J)

1

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

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

(e) any **four** from:

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

4

[15]

3.

(a) surface area

or

duration of experiment

accept shape of beaker

size of beaker is insufficient

1

(b) any **two** from:

- takes readings automatically

*ignore easier **or** takes readings for you*

- takes readings more frequently
- reduces / no instrument reading error

ignore human error

- higher resolution

allow better resolution

- don't need to remove probe to take reading
- more accurate

2

(c) (i) 0.07 (°C/s)

allow 1 mark for obtaining a temperature drop of 7 (°C)

allow 1 mark for an answer between 0.068 and 0.069 (°C/s)

2

(ii) rate of temperature change is greater at the start

accept rate of evaporation is greater at the start

or

rate of temperature change decreases

allow rate of evaporation decreases

allow temperature decreases faster at the start

1

(iii) A

reason only scores if A is chosen

lower temperature decrease (over 200 seconds)

accept lower gradient

1

(iv) no effect (as rate of evaporation is unchanged)

allow larger temperature change (per second as mass of liquid is lower)

1

- (d) particles with more energy
accept particles with higher speeds 1
- leave the (surface of the) liquid 1
- (which) reduces the average (kinetic) energy (of the remaining particles)
allow reference to the total energy of the liquid reducing 1

[11]

4.

- (a) **solid**
particles vibrate about fixed positions 1
- closely packed
accept regular 1
- gas**
particles move randomly
accept particles move faster
accept freely for randomly 1
- far apart 1
- (b) amount of energy required to change the state of a substance from liquid to gas (vapour) 1
- unit mass / 1 kg
dependent on first marking point 1
- (c) 41000 **or** 4.1×10^4 (J)
accept
41400 or 4.14×10^4
correct substitution of
 $0.018 \times 2.3 \times 10^6$ gains 1 mark 2
- (d) **AB**
 changing state from solid to liquid / melting 1
- at steady temperature
*dependent on first **AB** mark* 1

BC

temperature of liquid rises

1

until it reaches boiling point

dependent on first BC mark

1

[12]**5.**

(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*

1

(iii) concrete

reason only scores if concrete chosen

1

(heater on for) longest / longer time

a long time or quoting a time is insufficient

*do **not** accept it is the highest bar*

1

(iv) 4500 (J)

allow 1 mark for correct substitution ie

2 × 450 × 5 provided no subsequent step shown

2

(b) (i) point at 10 minutes identified

1

(ii) line through all points except anomalous

line must go from at least first to last point

1

(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.

1

(iv) 2 (minutes)

1

[11]

6.

(a) decreased

correct order only

1

decreased

1

increased

1

(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

[7]

7.

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)

[6]

8.	(a) conduction	1
	(b) (i) there is a bigger temperature difference between the water and the surrounding air <i>accept the water is hottest / hotter</i>	1
	so the transfer of energy (from hot water) is faster <i>accept heat for energy</i> <i>ignore temperature falls the fastest</i>	1
	(ii) 120 <i>allow 1 mark for converting kJ to J correctly, ie 4 032 000</i> or correctly calculating temperature fall as 8°C or allow 2 marks for correct substitution, ie $4\,032\,000 = m \times 4200 \times 8$ answers of 0.12, 19.2 or 16.6 gain 2 marks answers of 0.019 or 0.017 gain 1 mark	3
	(iii) water stays hot for longer so heater is on for less time <i>accept so less energy needed to heat water</i>	1
	so cost of the jacket is soon recovered from) lower energy costs / bills <i>accept short payback time</i>	1
		[9]
9.	(a) (i) Z	1
	(ii) X	1
	(b) (i) moving randomly	1
	(ii) stronger than	1
	(c) (i) evaporation	1

(ii) any **one** from:

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

1

[6]