Section 3: Particle Model

ANSWER KEY

6.1	**Describe the arrangement and movement of particles in a solid.**	**Particles are close together in a regular structure and vibrate around a fixed position.**
6.2	**Describe the arrangement and movement of particles in a liquid.**	**Particles are randomly arranged, close together, but free to move past each other.**
6.3	**Describe the arrangement and movement of particles in a gas.**	**Particles are randomly arranged, spread out and move in random directions with a range of speeds.**
6.4	What is the name for the state change from solid to liquid?	Melting
6.5	What is the name for the state change from liquid to gas?	Evaporating/boiling
6.6	What is the name of the state change from gas to liquid?	Condensing
6.7	What is the name of the state change from liquid to solid?	Freezing
6.8	What is the name of the state change from solid to a gas?	Sublimation
6.9	What happens to mass during a state change?	Remains constant
6.10	What happens to the internal energy store of a system when you heat it?	It increases
6.11	**What two things can happen when you heat a system?**	**Its temperature can increase or its state can change.**
6.12	What is specific heat capacity?	The amount of energy required to increase the temperature of 1kg of a substance by 1^{o}C
6.13	What is specific latent heat?	The amount of energy required to change the state of 1kg of a substance with no change in temperature
6.14	Define specific latent heat of fusion	The amount of energy involved in the change of state from a solid to a liquid
6.15	Define specific latent heat of vaporisation	The amount of energy involved in the change of state from a liquid to a gas
6.16	**How does increasing the temperature of a gas at constant volume affect the pressure of the gas?**	**Pressure will increase**

FOUNDATION QUESTIONS

Q1.

A student investigated the density of different types of rock.

Figure 1 shows a piece of limestone.

Figure 1

(a) The student was **not** able to calculate the volume of the piece of limestone using measurements taken with a ruler.

What is the reason?

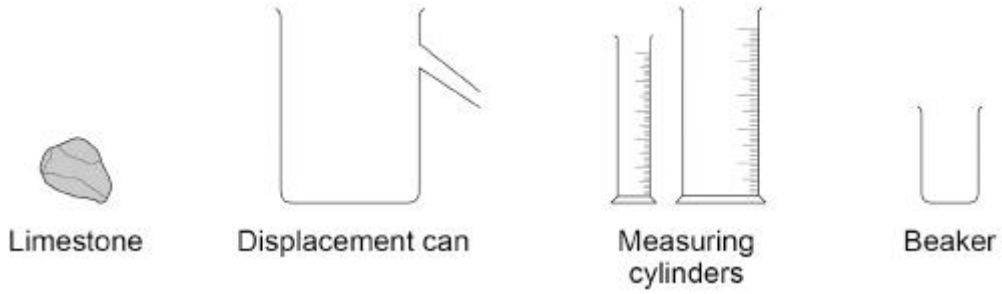
Tick (✓) **one** box.

A ruler is not very accurate.	☐
The piece of limestone has an irregular shape.	☐
There is a large uncertainty when using a ruler.	☐

(1)

(b) **Figure 2** shows some of the equipment given to the student.

Figure 2



Describe a method the student could use to determine the volume of the piece of limestone.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) The mass of the piece of limestone was 155 g.

The volume of the piece of limestone was 62 cm^3.

Calculate the density of the piece of limestone.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

_____

_____

_____

Density = _____ g/cm^3

(2)

(d) Density can be measured in g/cm^3.

What is another unit for density?

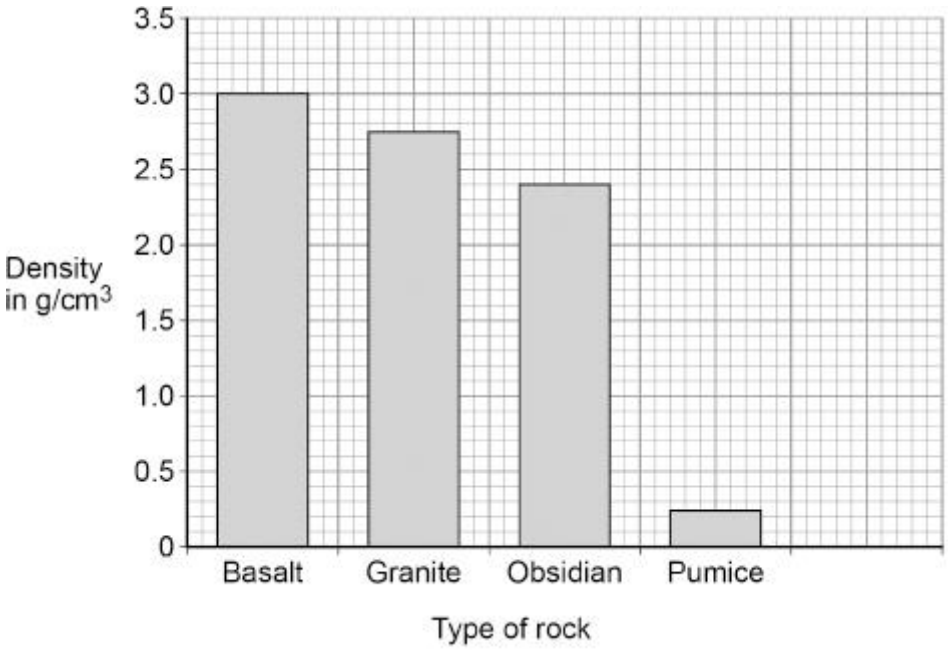
Tick (✓) **one** box.

- cm/g^3 ☐
- kg/m^3 ☐
- kg^3/m ☐
- kg^3/cm ☐

(1)

Figure 3 gives the density of some other types of rock.

Figure 3



The student has a sample of an unknown type of rock.

The density of this rock is 2.4 g/cm^3.

(e) Draw a bar on **Figure 3** to show the density of the unknown type of rock.

(1)

(f) Complete the sentence.

Choose the answer from the box.

basalt	granite	obsidian	pumice

The data in **Figure 3** suggests that the unknown type of

rock is _____.

(1)

(g) The student **cannot** be certain that the unknown type of rock is one of the types of rock in **Figure 3**.

Give a reason why.

_____

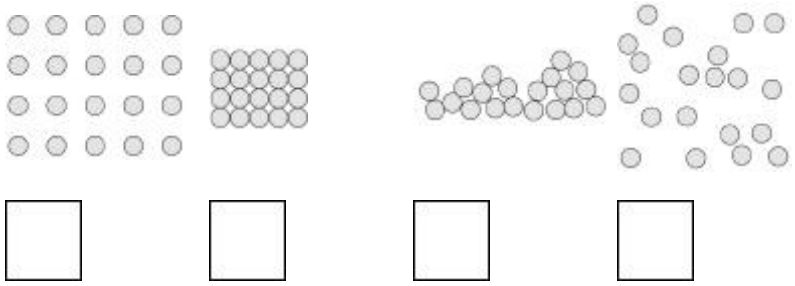
_____

(1)

Pumice is a type of rock that has holes in it. The holes contain air.

(h) Which diagram shows the arrangement of particles in air?

Tick (✓) **one** box.



(1)

(i) Complete the sentence.

Choose the answer from the box.

less than	the same as	more than

The holes containing air cause the density of pumice to

be _____ the density of other types of rock.

(1)

(Total 13 marks)

Q2.

Water exists as ice, water or steam.

(a) Complete the sentences.

Choose the answers from the box.

ice	steam	water

The particles are arranged in a regular pattern in _____ .

The particles are close together but not in a pattern in _____ .

The particles move quickly in all directions in _____ .

(2)

(b) Which will have the most internal energy?

Tick **one** box.

1 kg of ice ☐

1 kg of steam ☐

1 kg of water ☐

(1)

(c) Which will have the lowest density?

Tick **one** box.

Ice ☐

Steam ☐

Water ☐

(1)

The image shows an iceberg floating in the sea.

(d) The iceberg has a mass of 11 200 kg

The volume of the iceberg is 12.0 m^3

Calculate the density of the iceberg.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

_____

_____

Density = _____ kg/m^3

(2)

(e) Explain why the iceberg will melt.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q3.

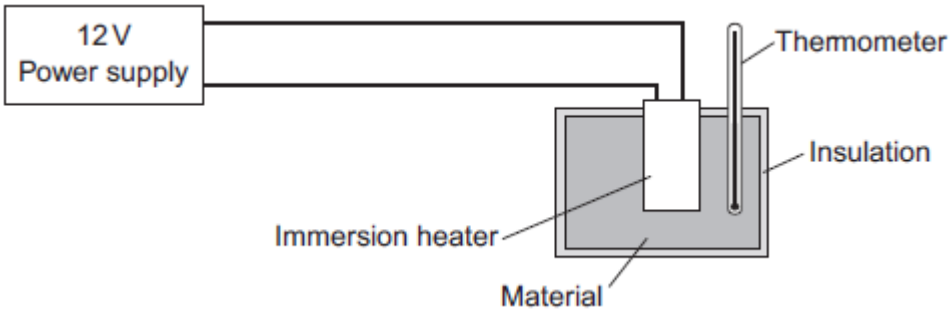
A student used the apparatus in **Figure 1** to compare the energy needed to heat blocks of different materials.

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.

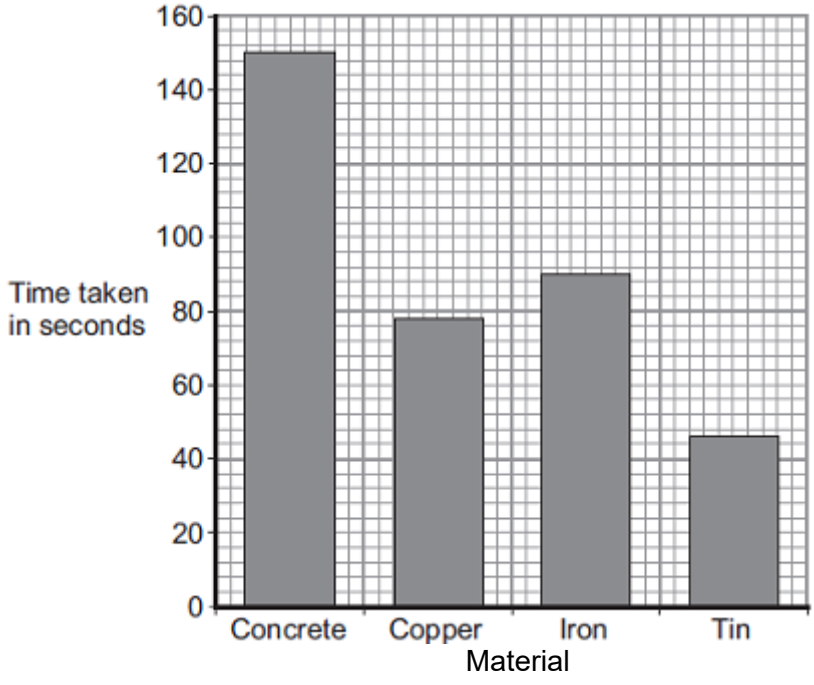
1. _____

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

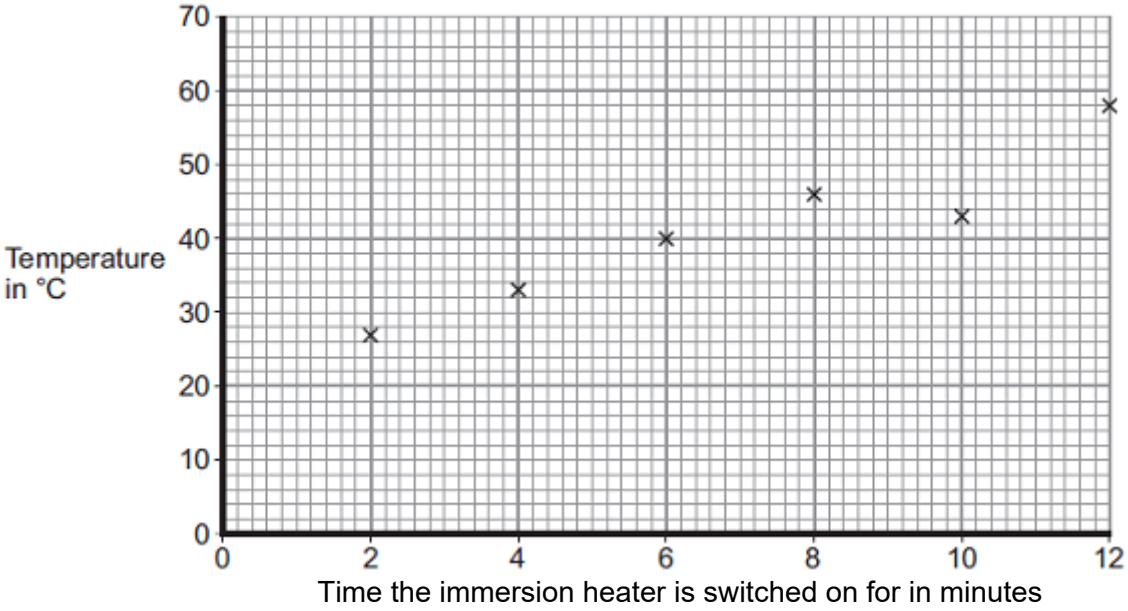
(2)

(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)

HIGHER QUESTIONS

Q1.

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 2.5×10^{-5} m^3 of condensation forms on the mirror.

Density of water = 1000 kg / m^3

Specific latent heat of vaporisation of water = 2.26×10^6 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.

_____

_____

_____

_____

_____

_____

_____

_____

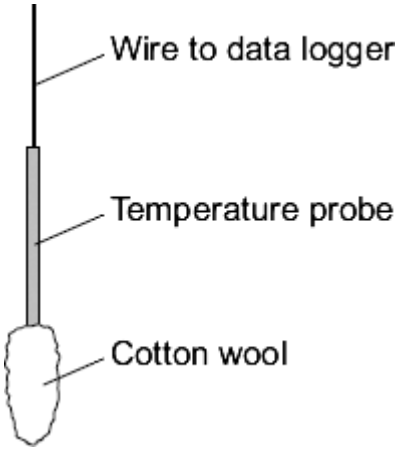
_____

(4)

(Total 15 marks)

Q2.

A student investigated the evaporation of three different liquids using the apparatus shown.

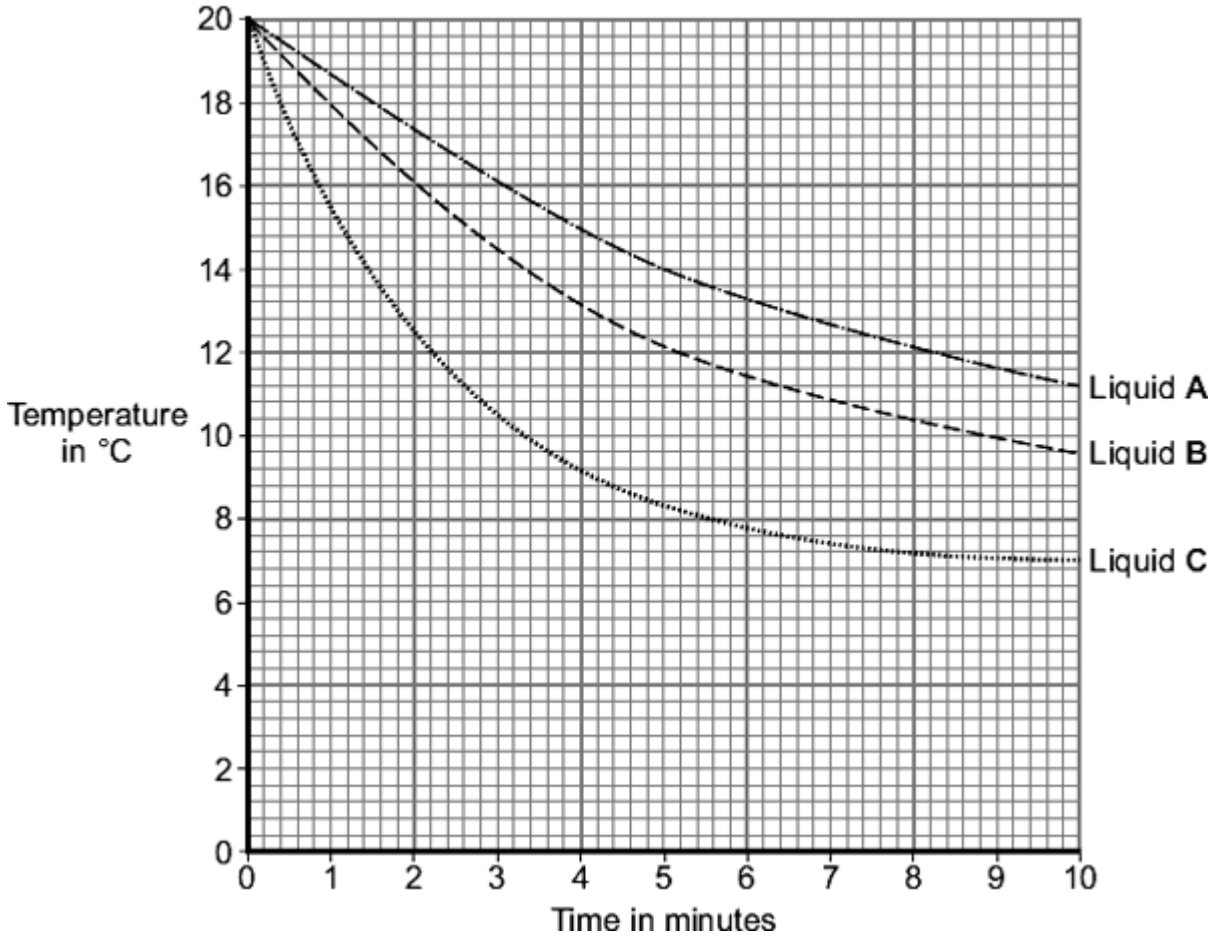


Identical pieces of cotton wool were soaked in one of three liquids, **A**, **B** or **C**, that have different boiling points. The same volume of liquid, at the same starting temperature, was used each time.

The temperature of the cotton wool was measured during a ten minute period.

The results are shown on **Graph 1**.

Graph 1



(a) Which liquid has the lowest boiling point?

Explain your choice.

Liquid _____

Explanation _____

_____

_____

_____

(2)

(b) Room temperature is 20 °C.

The line for liquid **C** reached a lower limit of 7 °C.

Explain why the temperature did **not** fall below 7 °C.

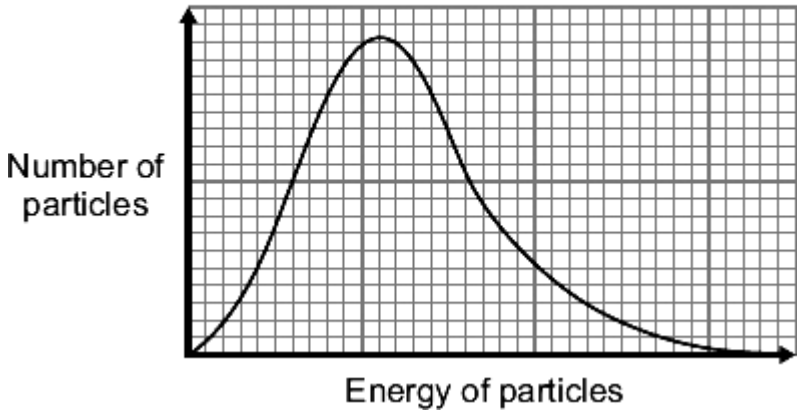
_____

_____

(1)

(c) **Graph 2** shows the distribution of energy among particles in a liquid.

Graph 2



Explain, in terms of the particles in a liquid, why evaporation causes cooling.

You may use information from **Graph 2** to help you with your answer.

(4)

(Total 7 marks)

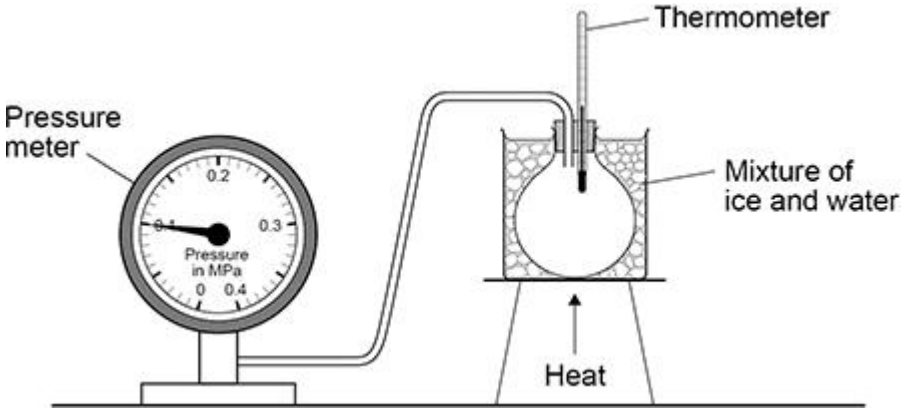
Q3.

A student investigated how the pressure of a gas depends on its temperature.

The volume of the gas did **not** change.

Figure 1 shows the equipment used.

Figure 1



(a) Pressure is sometimes measured in units called atmospheres.

1 atmosphere is 10^5 pascals (Pa).

What is 1 atmosphere in kilopascals (kPa)?

_____

_____

1 atmosphere = _____ kPa

(1)

(b) The student took four pressure readings for each temperature.

The table below shows the pressure readings when the temperature was 50.0 °C

Temperature in °C	**Pressure in MPa**			
	1	**2**	**3**	**4**
50.0	0.115	0.120	0.121	0.116

Calculate the uncertainty in the mean pressure.

_____

_____

_____

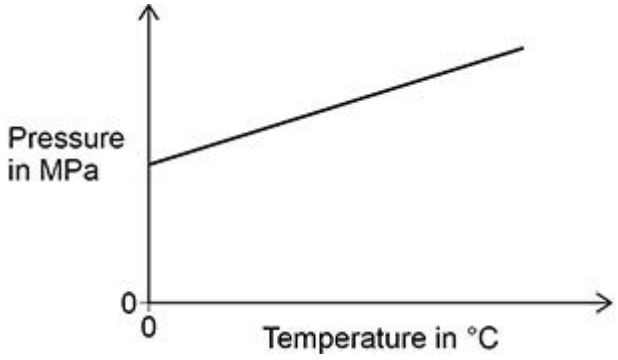
_____

Uncertainty = ± _____ MPa

(2)

(c) **Figure 2** shows a sketch graph of the results.

Figure 2



The student said that as the temperature increases the pressure increases.

Give a better description of the relationship between temperature and pressure.

_____

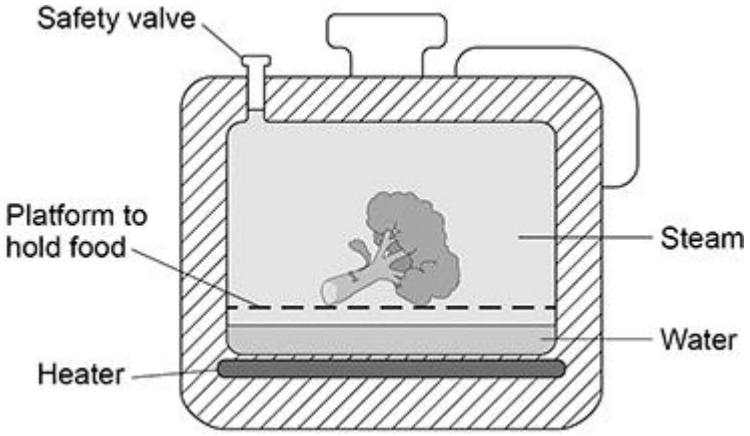
_____

(1)

A pressure cooker is a sealed pot that uses steam to cook food.

Figure 3 shows a pressure cooker.

Figure 3



(d) When the water in the pressure cooker starts to boil:

- the amount of steam in the pressure cooker increases
- the temperature of the steam increases above 100 °C

Explain why these changes make the pressure in the cooker increase.

(5)

(e) If the pressure inside the pressure cooker becomes greater than 200 kPa then some of the steam is released through the safety valve.

The released steam expands as it moves into the atmosphere.

Explain how a change in density of the steam is caused by a change in the arrangement of particles in the steam as it is released.

(3)

(Total 12 marks)

FOUNDATION Mark schemes

Q1.

(a) the piece of limestone has an irregular shape

1

(b) **Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- add water to the displacement can until level with the spout
- place the limestone in the water
- avoid splashing water out of the displacement can
- collect the displaced water in the beaker or measuring cylinder
- measure the volume of the displaced water
- using a measuring cylinder

OR

- use the large measuring cylinder
- part fill the measuring cylinder water
- measure the initial volume on the measuring cylinder
- submerge the limestone in the water
- measure the final volume on the measuring cylinder
- volume of limestone = final volume − initial volume

To access level 2 the answer must refer to submerging the limestone in water and using the measuring cylinder.

(c) density = $\frac{155}{62}$

density = 2.5 (g/cm^3)

2

(d) kg/m^3

1

(e) bar drawn to 2.4 g/cm^3

1

(f) obsidian

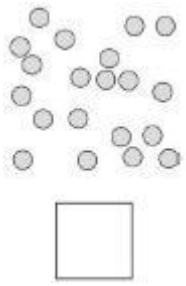
1

(g) other types of rock may have the same density as obsidian

allow not all rock types are plotted on the bar chart

1

(h) 4th box ticked



1

(i) less than

1

[13]

Q2.

(a) ice
water
steam

*allow **1** mark for 1 or 2 correct answers*

2

(b) 1 kg of steam

1

(c) steam

1

(d) ρ = 11 200 / 12.0

1

ρ = 933 (kg/m^3)

*an answer of 933 (kg/m^3) scores **2** marks*

1

(e) the internal energy of the iceberg increases

allow there is a temperature difference between ice and water / air

1

because

therefore

energy is transferred from the sea/water to the ice(berg)

1

[8]

Q3.

(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]

HIGHER Mark schemes

Q1.

(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 × 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 × 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]

Q2.

(a) (liquid C)

no mark awarded for stating liquid C
no marks awarded if liquid A or B chosen

(causes) biggest temperature decrease

allow cools quicker / the quickest

1

(because it) evaporates quickest

allow evaporates quicker

allow most / more evaporated

ignore references to boiling

1

(b) all of the liquid has evaporated

accept no net energy transfer

allow it was dry

1

(c) particles with most energy / highest speed evaporate

allow hottest particles

1

these particles escape from the (surface of the) liquid

accept overcoming the attractive forces (between particles)

1

decreasing mean energy of particles (left in liquid)

allow some reference to the total energy of the liquid reducing

1

which lowers the temperature

ignore cool down

1

[7]

Q3.

(a) 100 (kPa)

allow 10^2 (kPa)

1

(b) range about the mean
= 0.121-0.115 = 0.006
(MPa)

or

mean = 0.118
uncertainty = 0.121-0.118

allow uncertainty = 0.118-0.115

1

uncertainty = ± 0.003 (MPa)

1

(c) the relationship is linear.

allow the pressure is greater than zero when the temperature is zero °C

allow y = mx + c

1

(d) pressure is caused by collisions between the particles and the wall of the cooker

1

the number of steam particles increases

1

as the temperature increases the particles move faster

allow the kinetic energy of the particles increases

1

so each collision (with the wall) exerts more force

1

and there are more collisions per second

1

(e) the particles spread out

the steam / gas spreads out is insufficient

1

so the same mass takes up a greater volume

allow the same volume holds a smaller mass

1

so the density decreases

this mark can only be awarded if at least one other marking point is awarded

1

[12]