

Particle Model 4

Name: _____

Class: _____

Date: _____

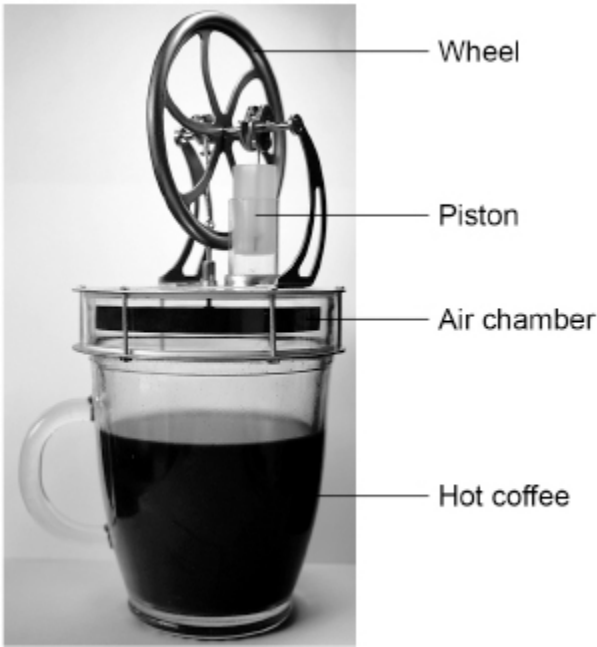
Time: **72 minutes**

Marks: **67 marks**

Comments:

1.

The figure below shows a device that uses a mug of hot coffee to turn a wheel.



(a) The hot coffee increases the temperature of the air in the chamber.

Explain how the pressure in the chamber changes.

(3)

(b) For the device to work, the air in the chamber must increase in temperature quickly.

Explain why the bottom of the air chamber is made of metal rather than plastic.

(2)

(c) The mass of air in the chamber is constant.

What property of air allows a small change in internal energy to cause a large temperature change to the air in the chamber?

(1)

(d) The changes in pressure in the air chamber cause the wheel to turn.

Suggest **one** way to increase the speed at which the wheel turns.

(1)

(e) The temperature of the coffee decreases as the device is used.

The initial temperature of the coffee was 76 °C.

The internal energy of the coffee decreased by 15 kJ.

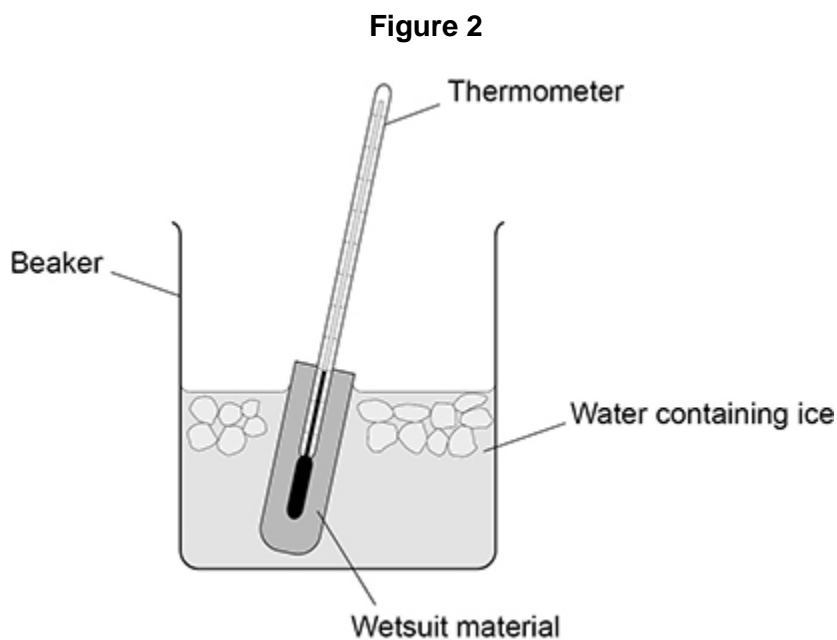
density of coffee = $1.1 \times 10^3 \text{ kg/m}^3$

volume of coffee = $1.9 \times 10^{-4} \text{ m}^3$

specific heat capacity of coffee = 4200 J/kg °C

A student wrapped a thermometer in a piece of wetsuit material and placed the thermometer in water containing ice.

Figure 2 shows the apparatus.



(a) After 30 seconds in the water the temperature of the thermometer had decreased by 7.5 °C

Calculate the average decrease in temperature each second.

Average decrease in temperature each second = _____ °C

(2)

The student recorded the temperature of the thermometer after 30 seconds for four materials. Each piece of material was the same size and thickness.

In each test the starting temperature of the thermometer was 21.0 °C

Table 1 shows the results.

Table 1

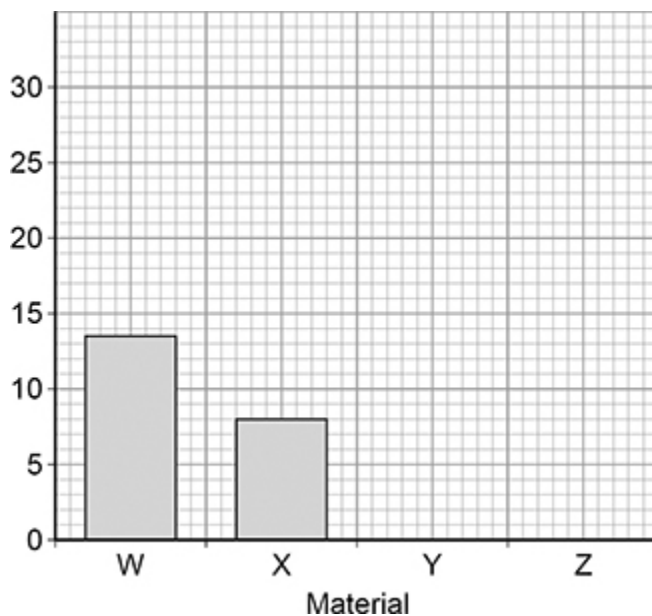
Material	W	X	Y	Z
Temperature in °C	13.5	8.0	16.0	12.0

(b) Complete **Figure 3** using the data in **Table 1**.

You should:

- label the y-axis
- draw the bars for materials Y and Z.

Figure 3



(2)

(c) Which material is the best thermal insulator?

Give a reason for your answer.

Tick (✓) **one** box.

W

X

Y

Z

Reason _____

(2)

- (d) The student tested a new material with a greater thermal conductivity than material Z. The piece of new material was the same size and thickness as the piece of material Z. What was the temperature of the thermometer after 30 seconds?

Tick (✓) **one** box.

Less than 12.0 °C

Exactly 12.0 °C

Greater than 12.0 °C

(1)

- (e) During the investigation 0.0150 kg of the ice melted. The temperature of the water and ice did not change.

specific latent heat of fusion of ice = 334 000 J/kg

Calculate the energy needed to melt the ice.

Use the equation:

energy to melt the ice = mass × specific latent heat

Energy needed to melt the ice = _____ J

(2)

The student wanted to determine the density of a wetsuit material.

The student measured the length of one side of a cube of wetsuit material with:

- a micrometer
- a ruler.

Table 2 shows the results.

Table 2

Equipment	Length in cm		
	Measurement 1	Measurement 2	Measurement 3
Micrometer	0.581	0.557	0.576
Ruler	0.6	0.6	0.6

(f) Complete the sentence.

Choose the answer from the box.

calibration	precision	reproducibility	resolution
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The results show that compared to the ruler the micrometer has a higher

_____.

(1)

Use the Physics Equations Sheet to answer parts (g) and (h).

(g) Write down the equation that links density (ρ), mass (m) and volume (V).

(1)

(h) The student calculated the volume of the cube of wetsuit material to be 0.186 cm^3
The density of the cube was 0.300 g/cm^3
Calculate the mass of the cube.

Give your answer in grams.

Mass = _____ g

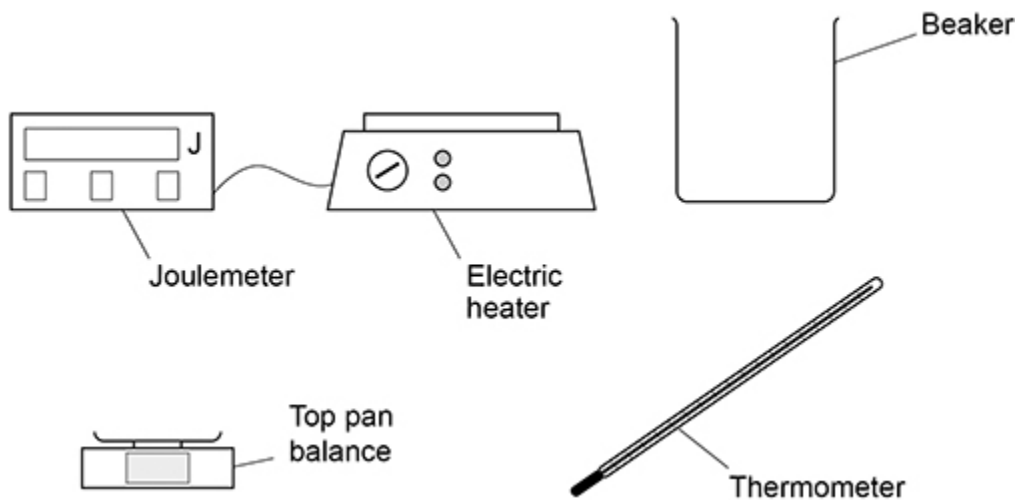
(3)
(Total 14 marks)

3.

A student made measurements to determine the specific heat capacity of vegetable oil.

Figure 1 shows the equipment used.

Figure 1



- (d) The electric heater had a power output of 50 watts.

Calculate the time taken for the electric element to transfer 4750 joules of energy to the vegetable oil.

Time taken = _____ s

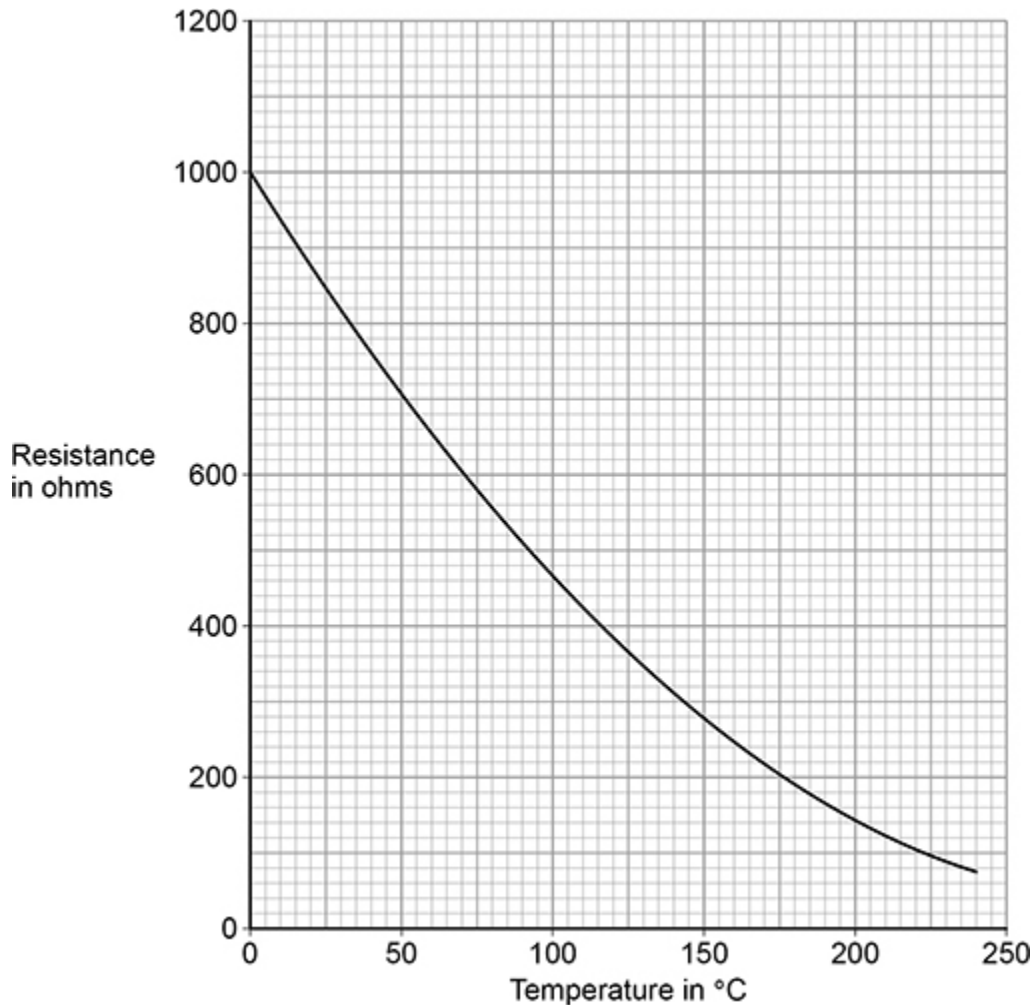
(3)

In a deep fryer, vegetable oil is heated by an electric heating element. Food is then cooked in the hot vegetable oil.

The deep fryer contains an electrical component to monitor the temperature of the vegetable oil.

Figure 2 shows how the resistance of this electrical component changes with temperature.

Figure 2

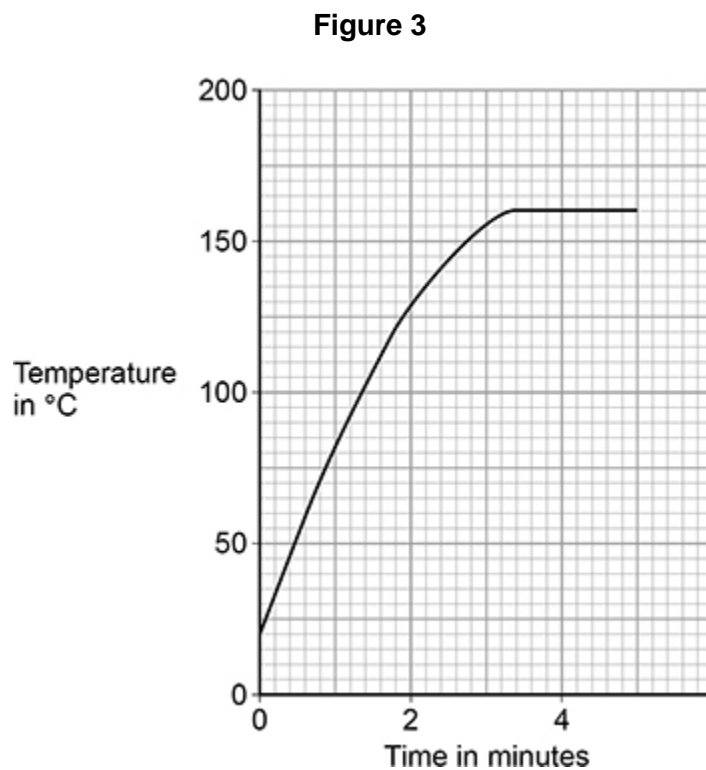


(e) What electrical component is used to monitor the temperature of the vegetable oil?

(1)

- (f) The electric heating element in the deep fryer automatically switches off when the vegetable oil reaches a certain temperature.

Figure 3 shows how the temperature of the vegetable oil changed after the deep fryer was switched on.



Determine the resistance of the electrical component when the electric heating element automatically switched off.

Use **Figure 2** and **Figure 3**.

Resistance = _____ Ω

(2)

(g) Some chips were put in the deep fryer.

In the deep fryer, water in the chips underwent a physical change and became steam.

Why is this a physical change?

Tick (✓) **one** box.

All water can change to steam.

No chemicals are involved when water changes to steam.

The change from water to steam can be detected visually.

The water will recover its original properties if the steam is cooled.

(1)

(Total 15 marks)

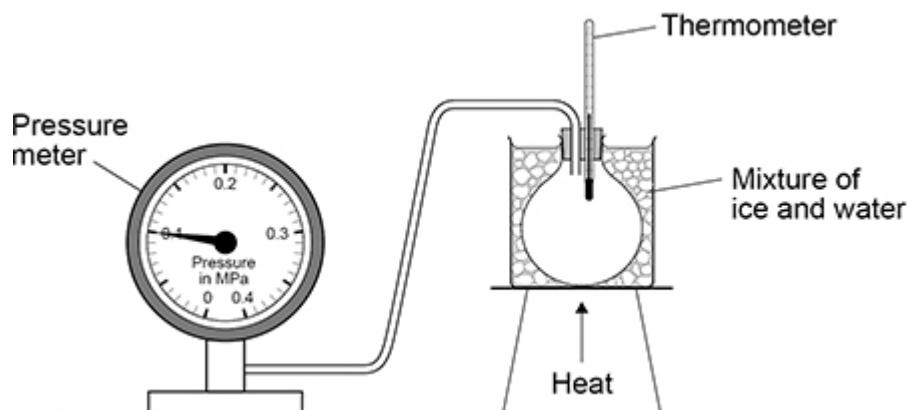
4.

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

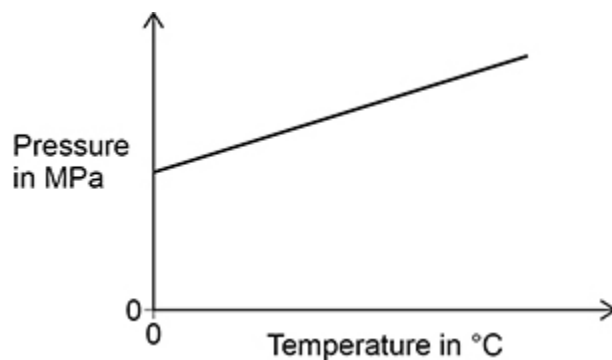
Calculate the uncertainty in the mean pressure.

Uncertainty = \pm _____ 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.

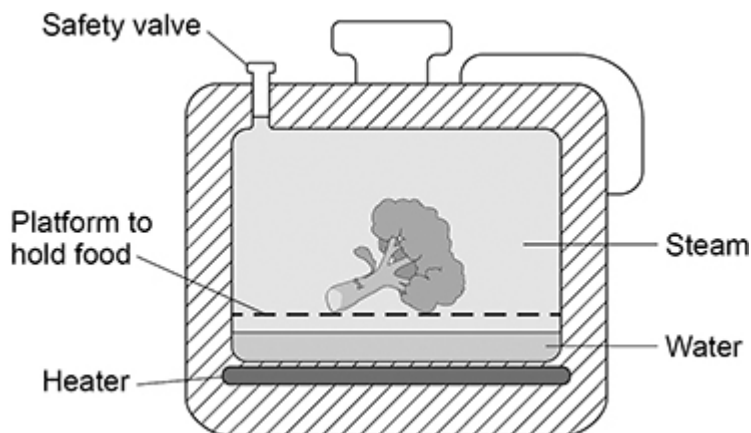
Give a better description of the relationship between temperature and pressure.

(1)

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

Figure 3 shows a pressure cooker.

Figure 3



5.

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.

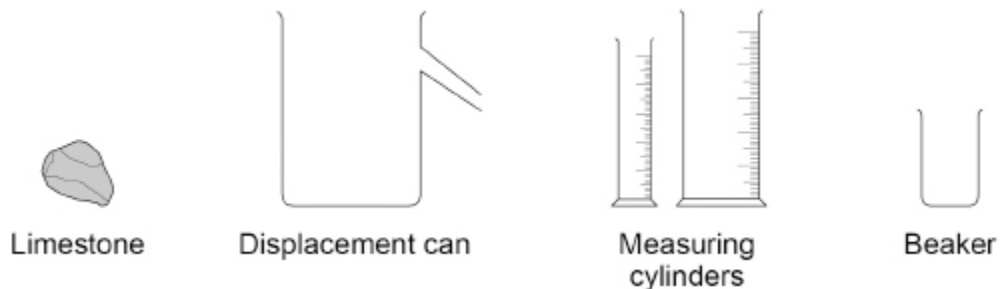
The piece of limestone has an irregular shape.

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 cm³.

Calculate the density of the piece of limestone.

Use the equation:

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

Density = _____ g/cm³

(2)

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

What is another unit for density?

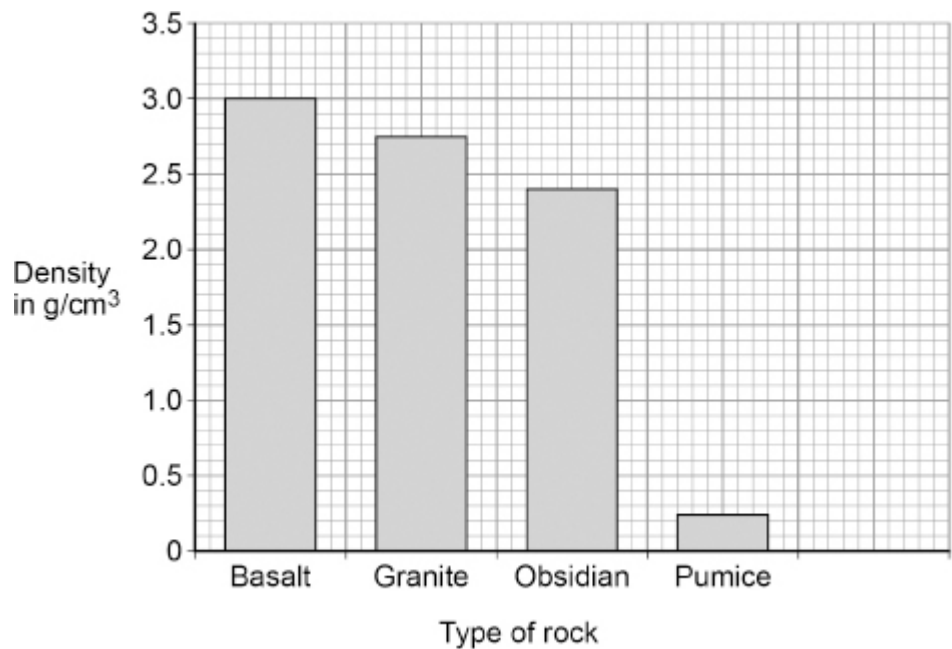
Tick (✓) **one** box.

- 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 $2.4 \text{ g}/\text{cm}^3$.

(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
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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**.


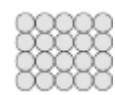


Give a reason why.

(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.

			
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(1)

(i) Complete the sentence.

Choose the answer from the box.

less than	the same as	more than
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The holes containing air cause the density of pumice to be _____ the density of other types of rock.

(1)

(Total 13 marks)

Mark schemes

1.

(a) (air) particles move faster

or

(air) particles have increased kinetic energy

1

(so air) particles collide more frequently with the wall / chamber

or

(so air) particles collide with more force with the wall / chamber

1

(so) the pressure increases

dependent on MP1 or MP2

1

(b) (metals) have a high(er) thermal conductivity

allow metals are good/better (thermal) conductors

1

which allows a greater rate of (thermal) energy transfer

allow (thermal) energy is transferred more quickly

1

(c) (a low) specific heat capacity

1

(d) any **one** from:

- lubrication

allow oil the device/wheel

- use hotter coffee
- decrease the temperature of the surroundings

1

(e) $1.1 \times 10^3 = \frac{\text{mass}}{1.9 \times 10^{-4}}$

1

mass = 0.209 (kg)

allow $m = 1.9 \times 10^{-4} \times 1.1 \times 10^3$

the equation $\text{density} = \frac{\text{mass}}{\text{volume}}$ must have been used to score subsequent marks

1

$$15\,000 = 0.209 \times 4200 \times \Delta\theta$$

allow a correct substitution using their calculated value of mass

1

$$\Delta\theta = \frac{15\,000}{0.209 \times 4200}$$

allow a correct re-arrangement using their value of mass and/or an incorrectly / not converted energy value

1

$$\Delta\theta = 17(.088\dots)$$

allow a correct calculation using their value of mass and / or an incorrectly / not converted energy value

1

final temperature

$$= 76 - 17.088 = 59\text{ }(^{\circ}\text{C})$$

allow 58.9... (^{\circ}\text{C})

allow an answer consistent with their value of mass and / or an incorrectly / not converted energy value

1

[13]

2.

(a) $\Delta\theta = \frac{7.5}{30}$

1

$$\Delta\theta = 0.25\text{ }(^{\circ}\text{C})$$

1

(b) bar Y drawn to 16 **and** bar Z drawn to 12

allow \pm half a small square

1

y-axis labelled 'temperature in $^{\circ}\text{C}$ '

unit must be present

1

(c) Y

1

because it showed the smallest change in temperature

reason only scores if Y is chosen

1

(d) less than $12.0\text{ }^{\circ}\text{C}$

1

(e) $E = 0.0150 \times 334\,000$

1

$$E = 5010\text{ (J)}$$

1

(f) resolution 1

(g) density = $\frac{\text{mass}}{\text{volume}}$

or

$$\rho = \frac{m}{V}$$

1

(h) $0.300 = \frac{m}{0.186}$

1

$$m = 0.300 \times 0.186$$

1

$$m = 0.0558 \text{ (g)}$$

1

[14]

3.

(a) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5-6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully 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

- measure mass of oil using the top pan balance
- measure start temperature of oil using the thermometer
- place beaker of oil on heater
- switch on heater to heat oil
- measure final temperature of oil using the thermometer
- measure energy transferred using joulemeter
- calculate increase in temperature ($\Delta\theta$)
- use the equation $E = mc\Delta\theta$ to determine c

(b) burns / scalds

allow cuts from broken glass

ignore the heater / oil is hot

1

(c) $\text{power} = \frac{\text{energy transferred}}{\text{time}}$

or

$$P = \frac{E}{t}$$

1

(d) $50 = \frac{4750}{t}$

or

$$4750 = 50 \times t$$

1

$$t = \frac{4750}{50}$$

1

$$t = 95 \text{ (s)}$$

1

(e) thermistor

1

(f) 250 (Ω)

allow an answer in the range 240 (Ω) to 260 (Ω)

allow 1 mark for temperature = 160 ($^{\circ}\text{C}$)

2

(g) the water will recover its original properties if the steam is cooled

1

[15]

4.

(a) 100 (kPa)

allow 10^2 (kPa)

1

(b) range = 0.006 (MPa)

allow mean = 0.118

1

uncertainty = ± 0.003 (MPa)

an answer of uncertainty = 0.118 (MPa) scores 0 marks

1

(c) the relationship is linear

allow the relationship obeys $y = mx + c$

allow the gradient (of the graph) is constant

*do **not** accept (directly) proportional*

1

- (d) (as the amount of steam increases) the number of particles increases 1
- and (as the temperature increases) particles move faster
allow (as the temperature increases) the (average) kinetic energy of the particles increases 1
- particles collide with the wall of the cooker
if MP3 is not awarded no subsequent marks may be awarded 1
- these collisions are more frequent 1
- and each collision exerts more force 1
particles refers to particles in the steam throughout
- (e) the particles spread out 1
*do **not** allow particles expand*
- so the steam / gas takes up a greater volume
allow there is less gas in the same volume 1
- and density = $\frac{\text{mass}}{\text{volume}}$ so the density decreases
*do **not** allow density of particles decreases* 1
- [12]**

- 5.** (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/cm³)

2

(d) kg/m³

1

(e) bar drawn to 2.4 g/cm³

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]