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physics

aqa gcse | solutions

particle model of matter

0 2 A scientist cooled the air inside a container.

0 2 . 1 The temperature of the air changed from 20 °C to 0 °C

The volume of the container of air stayed the same.

Explain how the motion of the air molecules caused the pressure in the container to change as the temperature decreased.

[3 marks]

$$E_k = \frac{m \times v^2}{2}$$

$$E_k \propto temp$$

pressure decreased

because molecules have less (kinetic) energy

so fewer collisions (with the wall/container each second)

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0 2 . 2 The air contained water that froze at 0 °C

The change in internal energy of the water as it froze was 0.70 kJ

The specific latent heat of fusion of water is 330 kJ/kg

Calculate the mass of ice produced.

Use the Physics Equations Sheet.

[3 marks]

$E = 700\,J$

$L_f = 330000\,J/kg$

$E = mL_f$ so $m = \frac{E}{L_f}$

$m = \frac{700}{330000} = 0.0021$

Mass of ice = 0.0021 kg

0 2 . 3 The air also contained oxygen, nitrogen and carbon dioxide.

Oxygen boils at –183 °C and freezes at –218 °C
Nitrogen boils at –195 °C and freezes at –210 °C
Carbon dioxide sublimates at –78 °C

The scientist continued to cool the air to a temperature of –190 °C

What is the state of each substance at –190 °C?

[2 marks]

Tick (✓) **one** box for **each** row of the table.

Substance	**Solid**	**Liquid**	**Gas**
Oxygen		✓	
Nitrogen			✓
Carbon dioxide	✓		

Sublimate - The change of the solid state of the matter directly on heating to vapor state (without becoming liquid)

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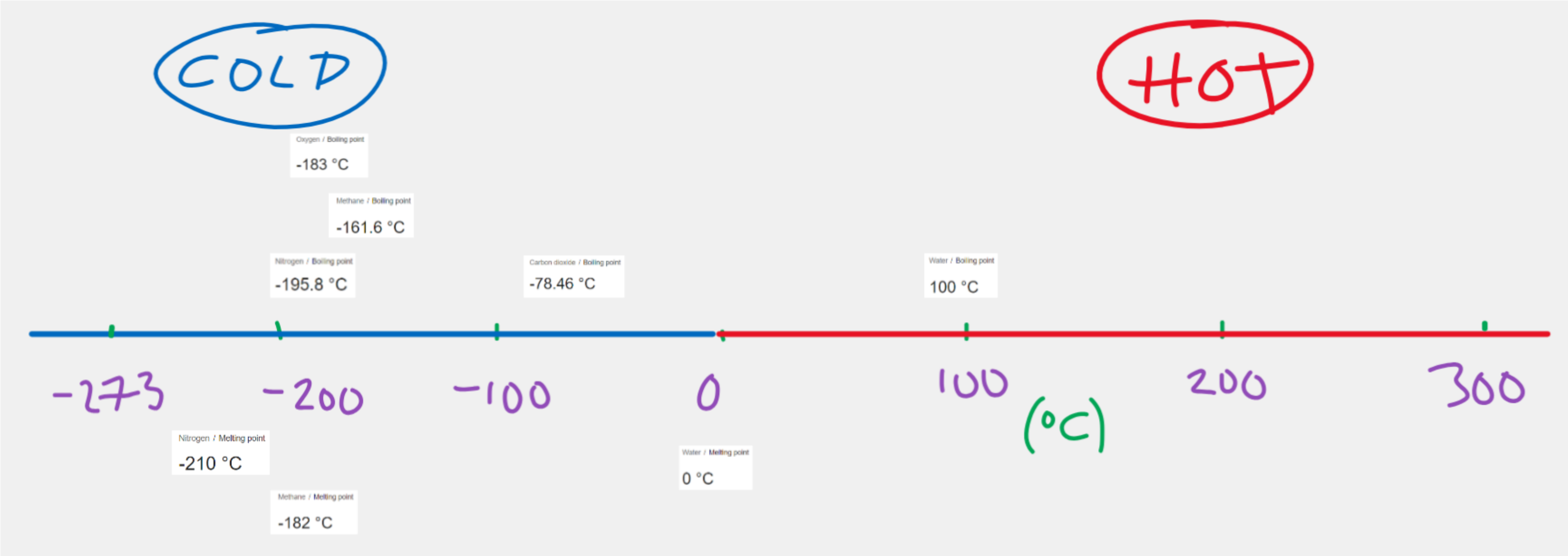

0 2 . 4 The air also contained a small amount of argon.

As the temperature of the air decreased from 20 °C to –190 °C the argon changed from a gas to a liquid to a solid.

Explain the changes in the arrangement and movement of the particles of the argon as the temperature of the air decreased.

[6 marks]

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cooling

- as the argon cools the particles slow down
- particles in a liquid move slower than particles in a gas
- particles in a solid move slower than particles in a liquid
- as the liquid/solid cools the particles get closer together
- as the liquid/solid cools the density increases

gas to liquid

- particles change from being spread apart to touching each other
- particles will (collide with other particles more often and) change direction more often

liquid to solid

- particles change from a random arrangement to a regular pattern
- particles change from moving freely to fixed positions
- particles change from moving freely/randomly to vibrating

explanation

- (internal) energy (of the argon) decreases
- (kinetic) energy (of the particles) decreases with temperature
- (potential) energy (of the particles) changes with change of state (of the argon)
- forces between particles in a gas are negligible/zero
- attractive forces act between atoms when they are close to each other
- attractive forces between particles are stronger in a solid than in a liquid

0 5 Ice cream is made by cooling a mixture of liquid ingredients until they freeze.

0 5 . 1 Which statement describes the motion of the particles in solid ice cream?

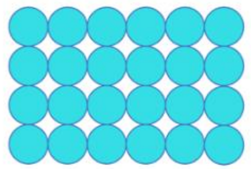
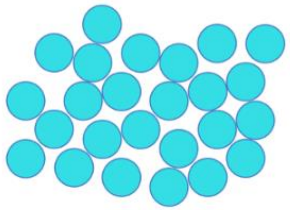
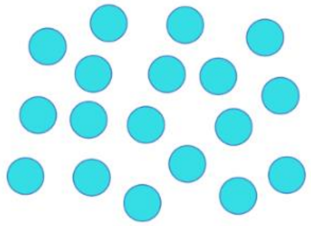
[1 mark]

Tick (✓) **one** box.

They are stationary. ☐

They move freely. ☐

They vibrate about fixed positions. ☐

	Solid	Liquid	Gas
Arrangement of Particles	regular pattern close together	irregular pattern close together	irregular pattern far apart
Movement of Particles	vibrate around their fixed positions	move past each other in random directions	random directions at a range of speeds
Diagram			

0 5 . 2 How do the kinetic energy and the potential energy of the particles change as a liquid is cooled and frozen?

[1 mark]

Tick (✓) **one** box.

Kinetic energy	Potential energy	
Decreases	Decreases	✓
Decreases	Does not change	
Does not change	Decreases	
Does not change	Does not change	

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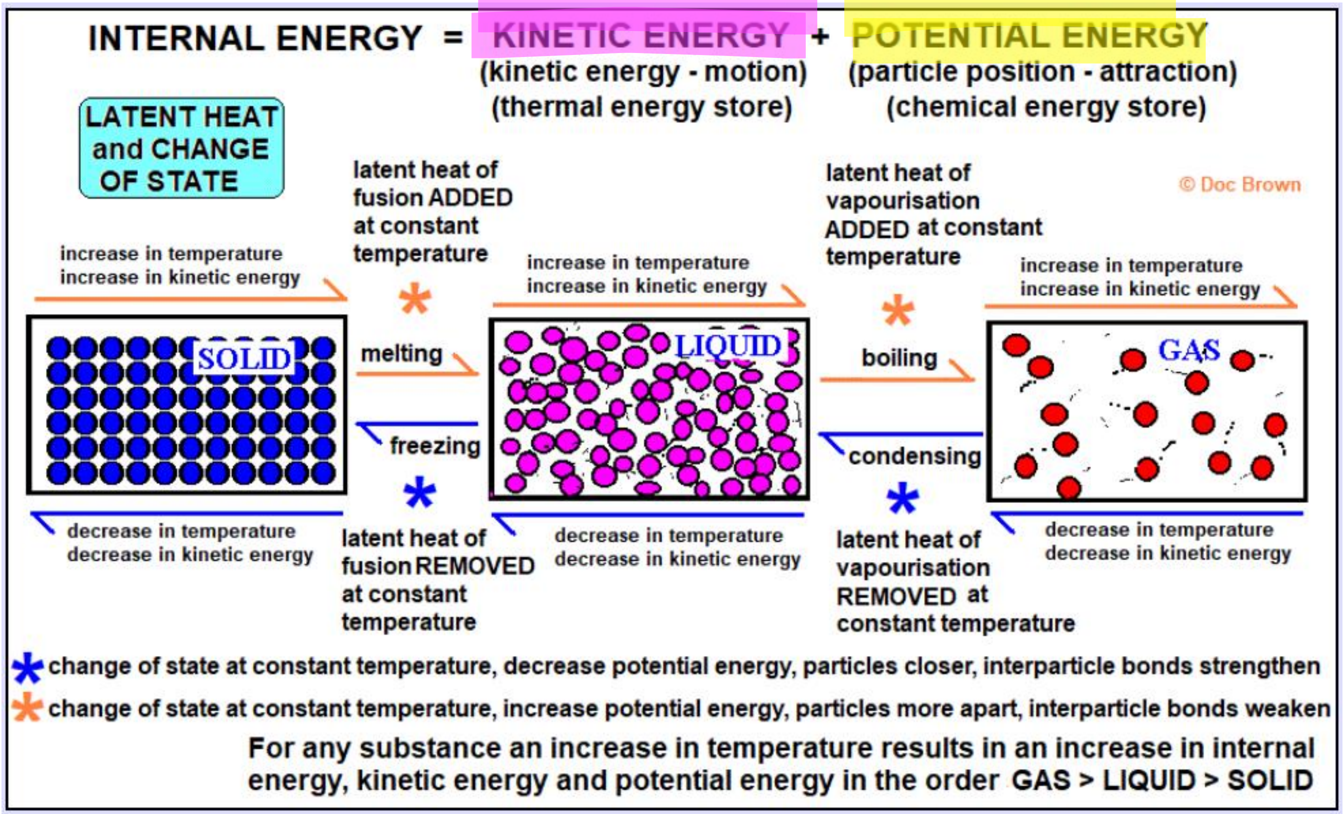


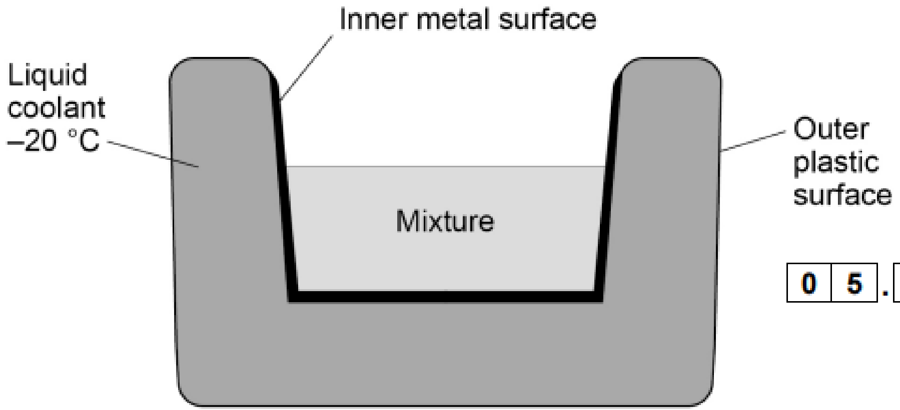
Figure 6 shows a bowl used for making ice cream.

The walls of the bowl contain a liquid coolant.

The bowl is cooled to –20 °C before the mixture is put in the bowl.

The bowl causes the mixture to cool down and freeze.

Figure 6



0 5 . 3 Explain why the different thermal conductivities of metal and plastic are important in the design of the bowl.

[4 marks]

Metal

metal: has a high thermal conductivity which increases the rate of energy transfer from the mixture

Plastic

has a low thermal conductivity which reduces the rate of energy transfer from the surroundings (to the liquid coolant at –20°C)

05.4 The liquid coolant has a freezing point below –20 °C

Explain **one** other property that the liquid coolant should have.

[2 marks]

a high specific heat capacity so it can absorb a large amount of energy with only a small temperature change

0 5 . 5 The initial temperature of the mixture was +20 °C. The mixture froze at –1.5 °C.

A total of 165 kJ of internal energy was transferred from the mixture to cool and freeze it.

specific heat capacity of the mixture = 3500 J/kg °C

specific latent heat of fusion of the mixture = 255 000 J/kg

Calculate the mass of the mixture.

Give your answer to 2 significant figures.

[6 marks]

$\Delta\theta = 21.5$

165000 J

c

m

L_f

Total E

$E + \Delta E = mL + mc\Delta\theta$

$165000 = m(L + c\Delta\theta)$

$165000 = m((255000 + (3500 \times 21.5))$

$m = 0.4996 = 0.50 \text{ kg (2 sf)}$

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1 0 **Figure 15** shows a balloon filled with helium gas.

Figure 15

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1 0 . 1 Which statements describe the movement of the gas particles in the balloon?

[2 marks]

Tick (✓) **two** boxes.

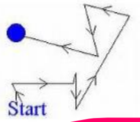
- The particles all move in a predictable way. ☐
- The particles move at the same speed. ☐
- The particles move in circular paths. ☐
- The particles move in random directions. ✓
- The particles move with a range of speeds. ✓
- The particles vibrate about fixed positions. ☐

Random movement

Fluid particles move around randomly, hitting other particles

This means that we cannot predict where one particle of a fluid will be in the future

The fluid, however, which is made of many particles, doesn't move randomly, and we can predict where it will move



This shows the random movement of one particle in a fluid

1 0 . 2 The pressure of the helium in the balloon is 100 000 Pa. P_1

The volume of the balloon is 0.030 m³. V_1

The balloon is compressed at a constant temperature causing the volume to decrease to 0.025 m³. V_2

No helium leaves the balloon.

Calculate the new pressure in the balloon.

[4 marks]

P_2

$P_1 V_1 = P_2 V_2$

$100000 \times 0.030 = P_2 \times 0.025$

$P_2 = 120000$

New pressure = 120000 Pa

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1 0 . 3 The temperature of the helium in the balloon was increased.

The mass and volume of helium in the balloon remained constant.

Explain why the pressure exerted by the helium inside the balloon would increase.

[4 marks]

particles would have a higher (mean) kinetic energy

(so) increased number of collisions with the walls of the balloon per second

greater forces exerted in collisions

(between particles and balloon walls) greater force exerted on same area

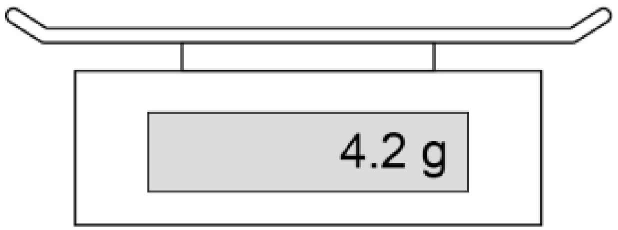
$$P = \frac{F}{A}$$

0 4 A student determined the density of a cube made of bronze.

The student used a balance to measure the mass of the bronze cube.

Figure 5 shows the balance before the cube was added.

Figure 5



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0 4 . 1 What type of error is shown on the balance?

[1 mark]

zero error systematic error

0 4 . 2 How could the student get a correct value for the mass of the cube from the balance?

[1 mark]

reset the balance to zero g

subtract the reading shown on the balance from the reading taken

0 4 . 3 The student measured the length of the bronze cube using Vernier callipers and then using a micrometer.

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Table 1 shows the results.

Table 1

Equipment	**Length in mm**
Vernier callipers	20.1
Micrometer	20.14

Complete the sentence.

[1 mark]

The results in **Table 1** show that the Vernier callipers and the micrometer have

a different ___resolution___ .

The student wanted to determine the density of a bronze coin.

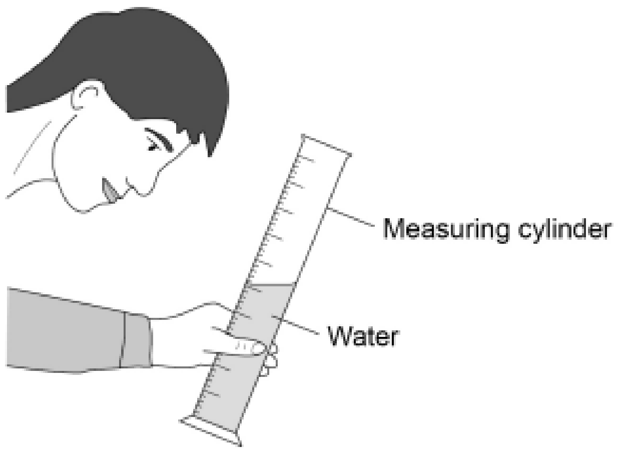
The student had several identical coins.

The volume of each coin was very small.

0 4 . 4 The student added water to a measuring cylinder.

Figure 6 shows the student reading the volume of water in the measuring cylinder.

Figure 6



Give **two** changes the student should make to increase the accuracy of the volume measurement.

[2 marks]

1 place the measuring cylinder on a horizontal surface

2 view with eye in line with the level of the water

0 4 . 5 Describe how the student could use a displacement method to determine an accurate value for the volume of a single coin.

[3 marks]

add several coins to the measuring cylinder

measure the change in the water level in the measuring cylinder

divide by the number of coins added

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0 4 . 6 Old penny coins were made from a disc of bronze.

New penny coins are made from a disc of a different metal.

Figure 7 shows a disc of metal.

Figure 7

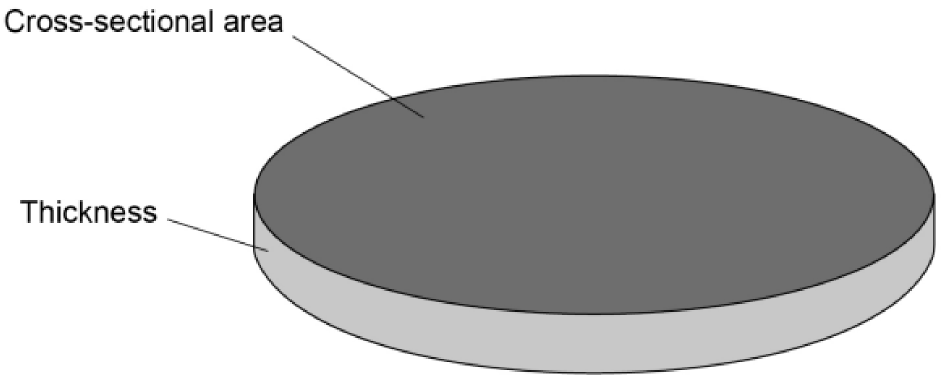

Table 2 shows information about the discs used to make each coin.

Table 2

Disc	Mass in g	Density in g/cm³	Thickness in cm
Old penny	3.6	8.9	0.16
New penny	3.6	**X**	0.17

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

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

$V = 0.404\,cm^3$

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The discs used to make the old and the new coins have the **same** cross-sectional area.

ρ (density)

Calculate value **X** in **Table 2**.

Give your answer to 2 significant figures.

The volume of a disc can be calculated using the equation:

volume of a disc = cross-sectional area × thickness

V

[5 marks]

$V = A.h$

See table

$0.404 = A.0.16$

$A = 2.525 cm^2$

$m = 3.6g$

$h = 0.17cm$

$V = 2.525 \times 0.17 = 0.42925 cm^3$

$\rho = \frac{m}{V} = \frac{3.6}{0.429}$

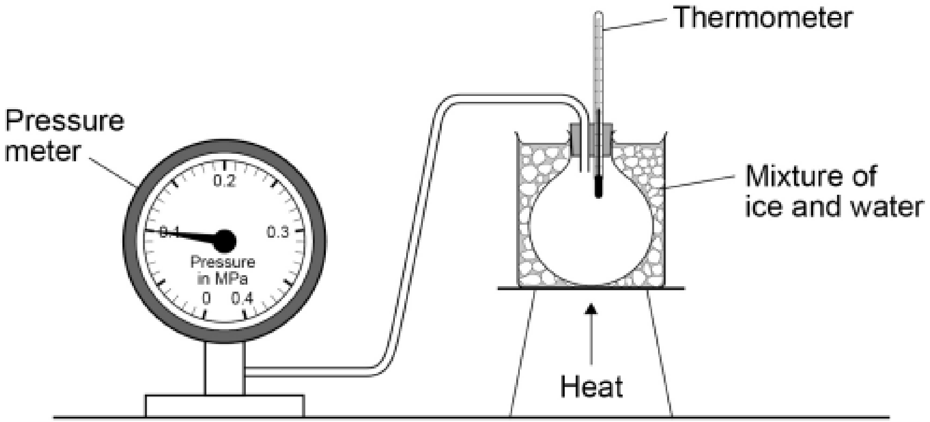
Density (2 significant figures) = 8.4 g/cm³

0 4 A student investigated how the pressure of a gas depends on its temperature.

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

Figure 6 shows the equipment used.

Figure 6



$10^5 Pa = 1 atm$

$10^3 Pa = 1 KPa$

So ÷ by 10^3

$1 atm = 10^2 KPa$

0 4 . 1 Pressure is sometimes measured in units called atmospheres.

1 atmosphere is 10^5 pascals (Pa).

What is 1 atmosphere in kilopascals (kPa)?

[1 mark]

1 atmosphere = 100 kPa

0 4 . 2 The student took four pressure readings for each temperature.

Table 1 shows the pressure readings when the temperature was 50.0 °C

Table 1

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.

[2 marks]

$$\frac{\text{Range}}{2} = \frac{0.121 - 0.115}{2}$$

Uncertainty = ± 0.003 MPa

0 4 . 3 **Figure 7** shows a sketch graph of the results.

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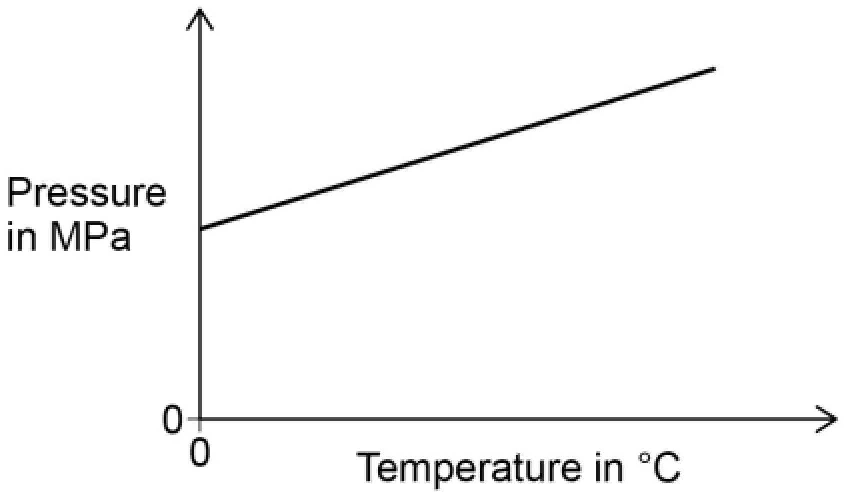
Figure 7



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

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

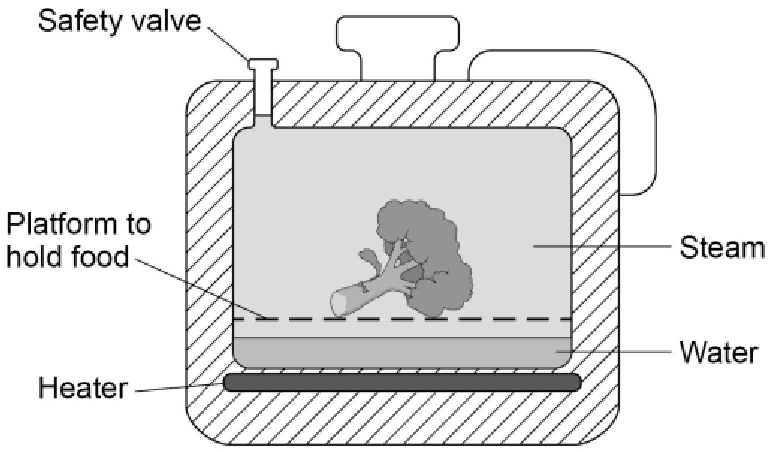
[1 mark]

the relationship is linear

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

Figure 8 shows a pressure cooker.

Figure 8



0 4 . 4 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 marks]

(as the amount of steam increases)
the number of particles increases and

(as the temperature increases)
particles move faster

particles collide with the wall of the cooker

these collisions are more frequent and each collision exerts more force

0 2 **Figure 2** shows a rock found by a student on a beach.

To help identify the type of rock, the student took measurements to determine its density.

Figure 2

0 2 . 1 Describe a method the student could use to determine the density of the rock.

[6 marks]

- measure mass using a balance / scales
- part fill a measuring cylinder with water and measure initial volume
- place rock in water and measure final volume
- volume of rock = final volume − initial volume
- fill a displacement / eureka can with water level with spout
- place rock in water and collect displaced water
- measuring cylinder used to determine volume of displaced water
- volume of rock = volume of displaced water
- use mass and volume to calculate density
- use of:

density = mass/volume

The student determined the density of the rock to be 2.55 ± 0.10 g/cm³.

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0 2 . 2 What are the maximum and minimum values for the density of the rock?

[1 mark]

Maximum density = 2.65 g/cm³

Minimum density = 2.45 g/cm³

0 2 . 4 The student only took one set of measurements to determine the density of the rock.

Explain why taking the measurements more than once may improve the accuracy of the density value.

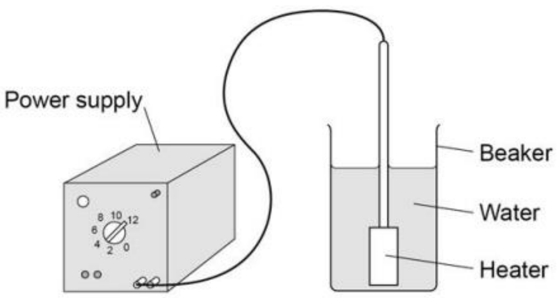
[2 marks]

a mean can be calculated which reduces the effect of random errors

0 8 A student determined the specific latent heat of vaporisation of water.

Figure 9 shows some of the equipment used.

Figure 9



This is the method used:

1. Put 50 cm^3 of water in a beaker.
2. Measure the mass of the beaker and water.
3. Use a heater to boil the water and keep it boiling for 600 seconds.
4. Measure the mass of the beaker and water after 600 seconds.

0 8 . 1 What measuring instrument should be used to measure the volume of water?

[1 mark]

measuring cylinder

0 8 . 2 What is a hazard in the student's investigation?

[1 mark]

Tick (✓) **one** box.

- [ ] burns
- [x] boiling water
- [ ] heatproof gloves
- [ ] safety goggles

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0 8 . 3 The initial mass of the beaker and water was 0.080 kg. — m_1

The final mass of the beaker and water was 0.071 kg. — m_2

The energy transferred by the immersion heater as the water boiled was 25 200 J. — E

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Calculate the specific latent heat of vaporisation of water given by the student's data.

Give the unit.

Use the Physics Equations Sheet.

[5 marks]

$E = (m_1 - m_2) L$

$25200 = 0.009 \times L_v$

$L_v = 2800000 \ \frac{J}{Kg}$

Specific latent heat of vaporisation = 2800000 Unit $\frac{J}{Kg}$

0 8 . 4 Some thermal energy was transferred to the surroundings while the water was being heated.

Explain how this affected the student's value for the specific latent heat of vaporisation of water.

[2 marks]

less energy (than 25 200 J) was transferred to the water

(so) student's value of L was too high

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0 8 . 5 Some of the water evaporated before its temperature reached 100 °C.

Explain how this affected the student's value for the specific latent heat of vaporisation of water.

[2 marks]

the measured change in mass is too high (for the energy supplied) (so) student's value of L is too low