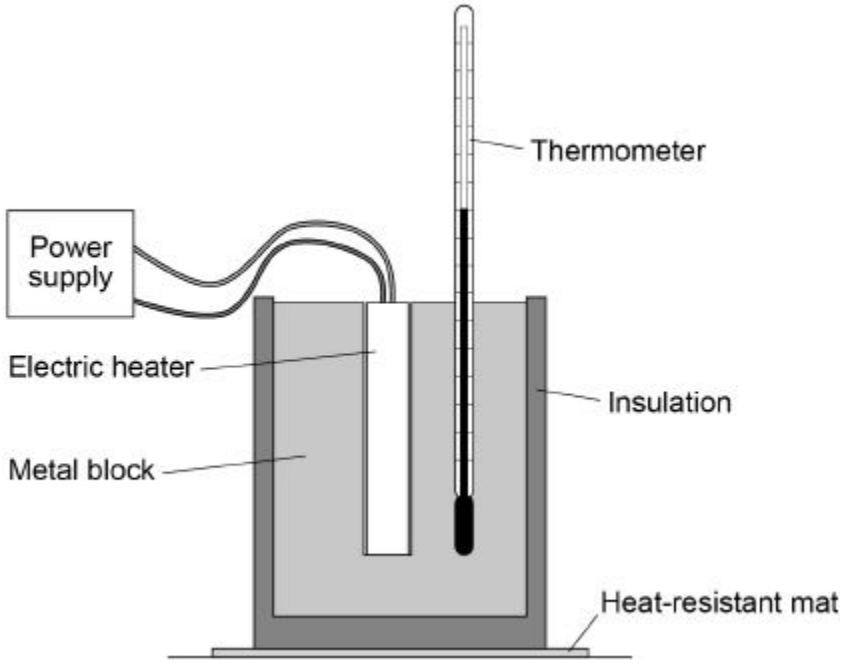
**1** A student investigated how the temperature of a metal block changed with time.

An electric heater was used to increase the temperature of the block.

The heater was placed in a hole drilled in the block as shown in **Figure 1**.

**Figure 1**



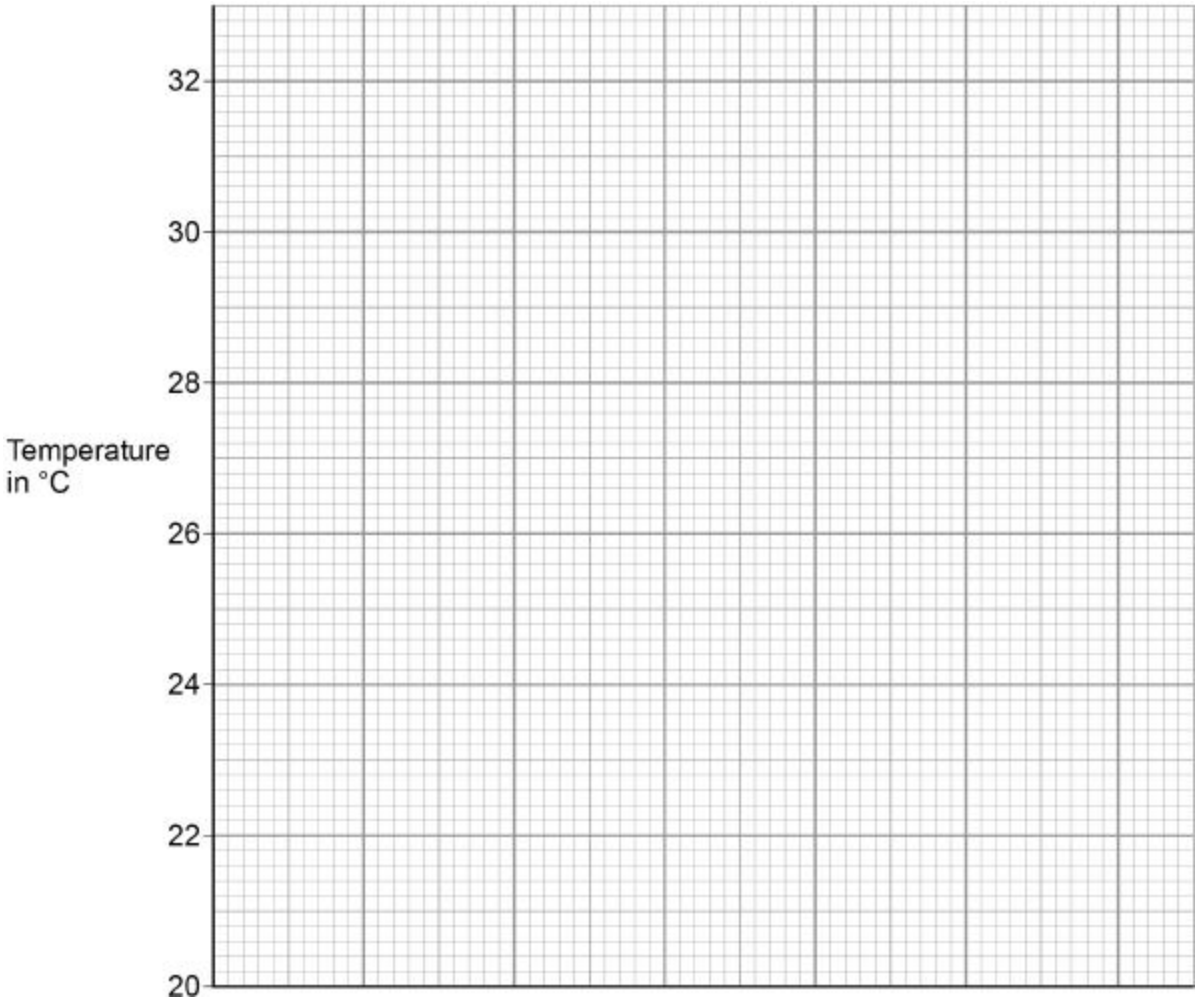

The student measured the temperature of the metal block every 60 seconds.
The table below shows the student's results.

| Time in s | Temperature in °C |
|---|---|
| 0 | 20.0 |
| 60 | 24.5 |
| 120 | 29.0 |
| 180 | 31.0 |
| 240 | 31.5 |

(a) Complete the graph of the data from the table above on the graph below.

- Choose a suitable scale for the x-axis.
- Label the x-axis.
- Plot the student's results.
- Draw a line of best fit.

**Figure 2**




**(4)**

(b) The rate of change of temperature of the block is given by the gradient of the graph.

Determine the gradient of the graph over the first 60 seconds.

_____

_____

_____

_____

Gradient = _____

**(2)**

(c) The metal block had a mass of 1.50 kg

The specific heat capacity of the metal was 900 J/kg °C

Calculate the change in thermal energy of the metal during 240 seconds.

Use the Physics Equations Sheet.

Give your answer in kilojoules.

Change in thermal energy = _____ kJ

**(4)**

(d) Another student repeated the investigation.

Give **two** variables this student would need to control to be able to compare their results with the results in the table above.

1. _____

2. _____

**(2)**

**(Total 12 marks)**

**2** A student wanted to determine the density of the irregular shaped object shown in **Figure 1**

**Figure 1**

(a) Plan an experiment that would allow the student to determine the density of the object.

**(6)**

(b) Another student did a similar experiment.

He determined the density of five common plastic materials.

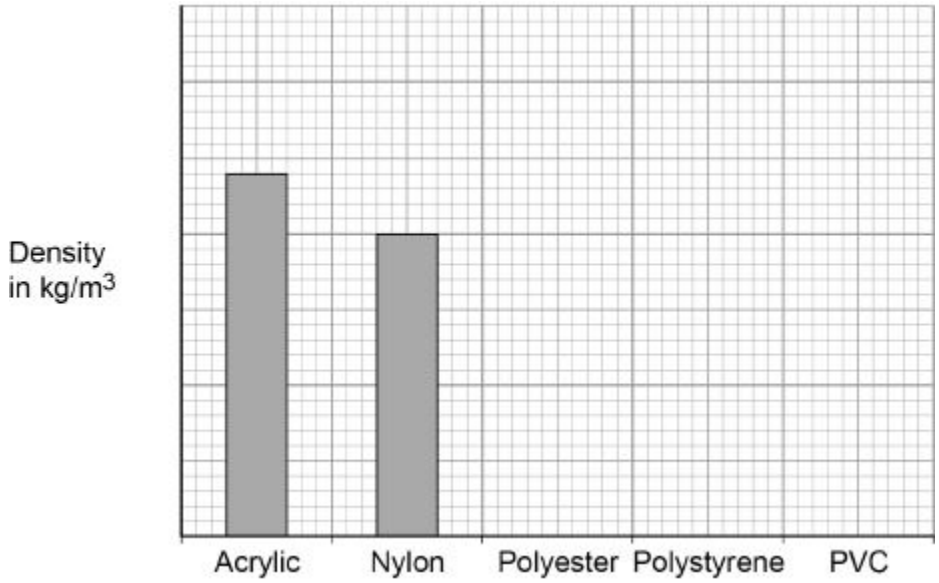
**Table 1** shows the results.

**Table 1**

| **Plastic material** | **Density in kg/m$^3$** |
|---|---|
| Acrylic | 1200 |
| Nylon | 1000 |
| Polyester | 1380 |
| Polystyrene | 1040 |
| PVC | 1100 |

**Figure 2** shows the results plotted in a bar chart.

**Figure 2**




Complete **Figure 2**

You should:

- Write the correct scale on the y-axis.
- Draw the bars for polyester, polystyrene and PVC.

**(4)**

(c) The student is given a piece of a different plastic material.

The student determined the density of the material three times.

**Table 2** shows the results.

**Table 2**

| | **Density in kg/m$^3$** |
|---|---|
| 1 | 960 |
| 2 | 1120 |
| 3 | 1040 |

Determine the uncertainty in the student's results.

_____

_____

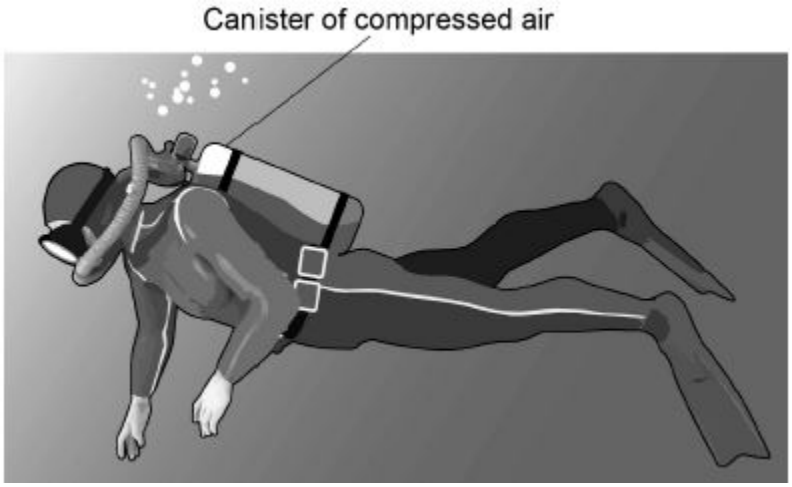
Uncertainty = _____ kg/m$^3$

**(2)**

**(Total 12 marks)**

**3** **Figure 1** shows a diver.

**Figure 1**




(a) Which two sentences describe the movement of the air particles in the canister?

Tick **two** boxes.

They vibrate about a fixed position. ☐

They move in random directions. ☐

The motion of all the particles is predictable. ☐

They move with a range of different speeds. ☐

They move in circular paths. ☐

**(2)**

(b) The temperature of the air inside the canister increases.

What happens to the movement of the air particles?

_____

**(1)**

(c) It could be dangerous if the temperature of the air inside the canister increased by a large amount.

Explain why.

_____

_____

_____

_____

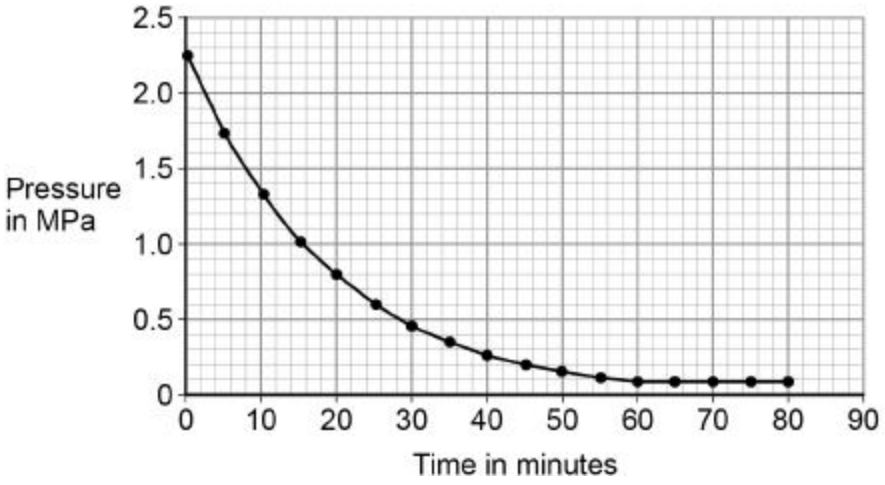
**(2)**

A canister of air was tested to find out how the pressure changed when it was used by a diver.

- Air was allowed to escape from the canister.
- The pressure of the air in the canister was recorded every 5 minutes for 80 minutes.

**Figure 2** shows the results.

**Figure 2**




(d) Estimate the atmospheric pressure.

Use **Figure 2**

Atmospheric pressure = _____ MPa

**(1)**

(e) Divers can safely stay underwater until the pressure of the air in the canister has reduced to 25% of its original value.

Determine the maximum time the diver can safely stay underwater.

Use **Figure 2**

_____

_____

Time = _____ minutes

**(3)**

(f) What happens to the volume of the air when it is released from the canister?

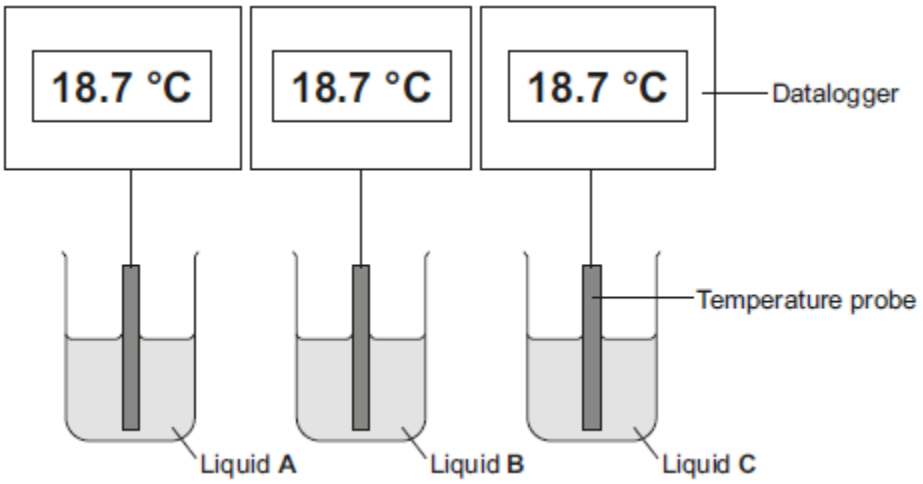
_____

**(1)**

**(Total 10 marks)**

**4** 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.

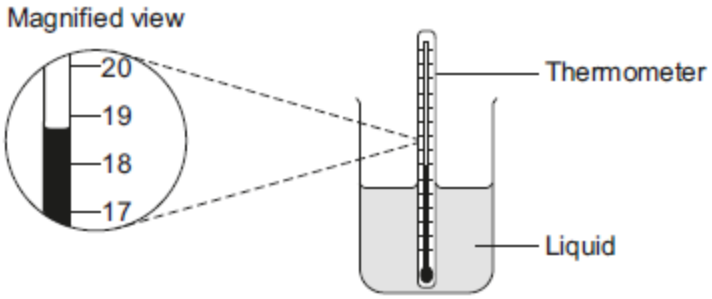
_____

_____

**(1)**

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

**Figure 2**




1. _____

_____

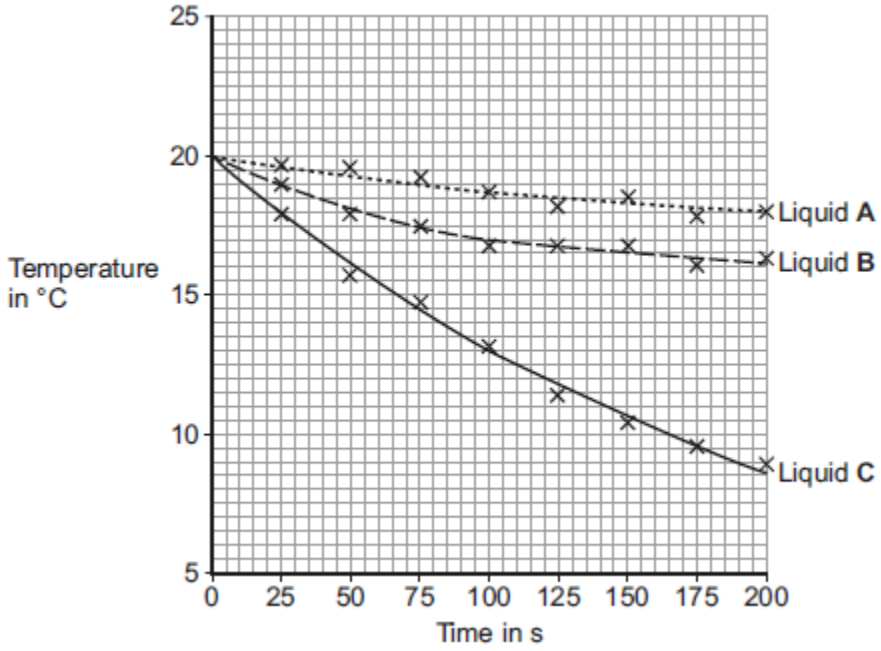
2. _____

_____

**(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.

_____

_____

_____

_____

_____

_____

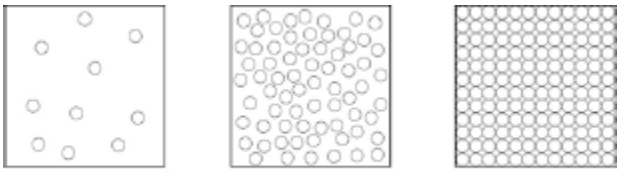
_____

_____

**(3)**

**(Total 11 marks)**

**5** 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?

_____

**(1)**

(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. _____

_____

**(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.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

**(Total 7 marks)**

## Mark schemes

**1**

(a) *x*-axis labelled **and** suitable scale

**1**

points plotted correctly

*allow 5 correctly plotted for **2** marks, 3−4 correctly plotted for **1** mark*
*allow ± ½ square*

**2**

line of best fit

**1**

(b) $\frac{4.5}{60}$

*allow ecf from line of best fit in part **(a)***

**1**

0.075 (°C/s)

**1**

*an answer of 0.075 (°C/s) scores **2** marks*

(c) $\Delta\theta$ = 11.5 (°C)

*a calculation using an incorrect temperature scores max 3 marks*

**1**

$\Delta E$ = 1.50 × 900 × 11.5

**1**

$\Delta E$ = 15 525 (J)

**1**

$\Delta E$ = 15.525 (kJ)

**1**

*an answer of 15.525 (kJ) **or** 15.53 (kJ) **or** 15.5 (kJ) scores **4** marks*

*an answer of 15 525 (kJ) scores **3** marks*

(d) any **two** from:

- mass of block*
- size / dimensions of block*
- material of block*

**allow same block for **1** mark*

- current through heater

*allow power of heater*

- thickness of insulation*
- material of insulation*

**allow same insulation for **1** mark*

- time interval
- starting temperature (of block / heater)

**2**

**[12]**

**2** (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 method 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
- use a top pan balance or scales

- part fill a measuring cylinder with water
- measure initial volume
- place object in water
- measure final volume
- volume of object = final volume − initial volume

- fill a displacement / eureka can with water
- water level with spout
- place object in water
- collect displaced water
- measuring cylinder used to determine volume of displaced water

- use of:

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

(b) all *y*-axis values correct (minimum of 3)

*allow **1** mark for two correct values*

**2**

all bars drawn to the correct height

*allow **1** mark for two correct bars*
*allow ± ½ small square*

**2**

(c) $\frac{(1120 - 960)}{2}$

*ignore + and / or − signs*

**1**

= 80 (kg/m$^3$)

*an answer of 160 scores **1** mark*

**1**

*an answer of 80 scores **2** marks*

**[12]**

**3** (a) they move in random directions

**1**

they move with a range of different speeds

**1**

(b) the (mean) speed of the particles would increase

*allow kinetic energy increases*

**1**

(c) (if the temperature increases) the pressure increases

*allow an explanation in terms of large pressure difference*

**1**

so it could explode

**1**

(d) p = 0.1 (MPa)

**1**

(e) $p = 2.25 \times \left(\frac{25}{100}\right)$

*allow any correct method of determining 25% of 2.25*
*allow use of 2.2−2.3*

**1**

p = 0.56

*allow 0.55−0.575*

**1**

t = 27 (minutes)

*allow 26−28 minutes*
*allow correct value of t using their calculated value of p*

**1**

*an answer of 27 scores **3** marks*

(f) (the volume of the air) increases

**1**

**[10]**

**4**

(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]**

**5** (a) density = mass / volume

**1**

(b) any **two** from:

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

**2**

(c) at higher temperatures particles have more kinetic energy

**1**

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

**1**

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

**1**

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

**1**

**[7]**