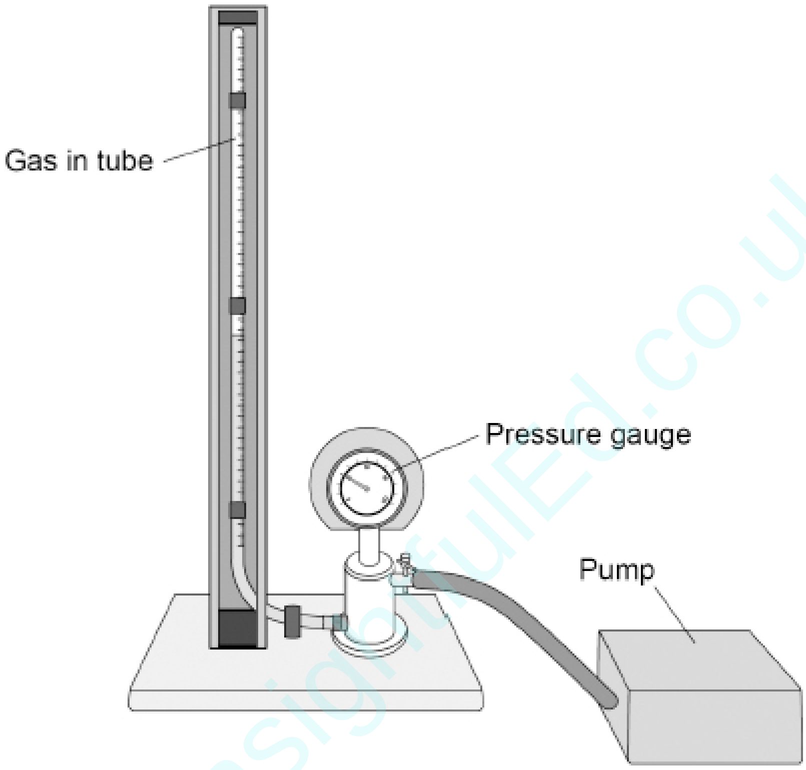
1

A teacher demonstrated the relationship between the pressure and the volume of a fixed mass of gas at a constant temperature.

Figure 1 shows the equipment used.

Figure 1



(a) Complete the sentence.

Choose the answer from the box.

circular paths	**random directions**	**the same direction**

Particles in a gas move in

____.

(1)

(b) Complete the sentence.

Choose the answer from the box.

a constant speed	**a constant velocity**	**a range of speeds**

Particles in a gas move with

____.

(1)

(c) The table below shows some of the results.

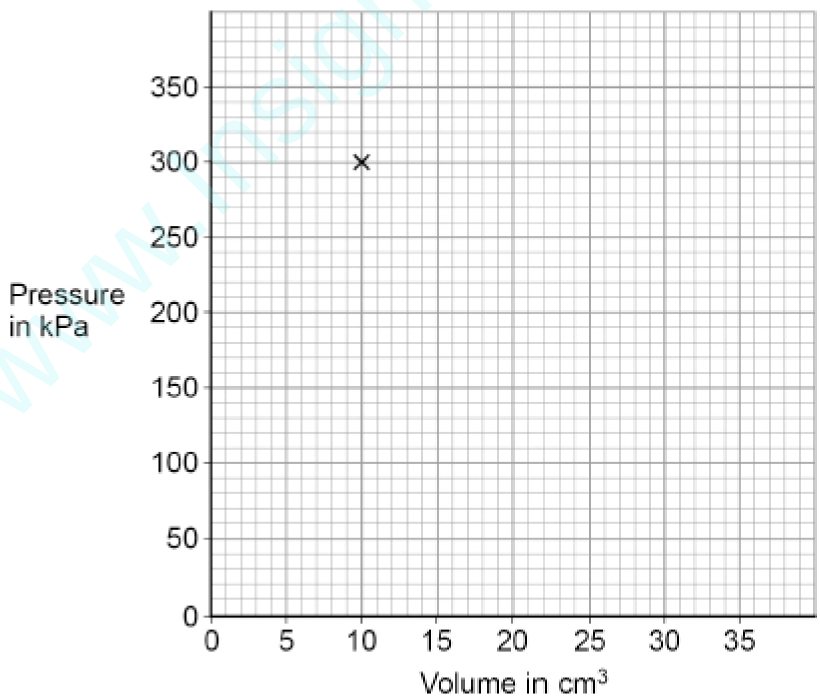
Pressure in kPa	**Volume in cm³**
300	10
200	15
150	20
120	25
100	30

Complete **Figure 2**. The first point has been plotted for you.

You should:

- plot the points from the table above
- draw the line of best fit.

Figure 2



(3)

(d) The relationship between the pressure and the volume of a gas is given by the equation:

pressure × volume = constant

Calculate the constant when the pressure of the gas was 300 kPa.

Use the table above.

____

____

____

____

Constant = __________ kPa cm^3

(2)

(e) When the volume of the gas increases, the pressure in the gas decreases.

The temperature of the gas stays the same.

How does increasing the volume affect each of the following quantities?

Tick (✓) **one** box in **each** row.

Quantity	**Decreases**	**Stays the same**	**Increases**
Mean time between collisions of the particles with the tube			
Mean distance between the particles			
Mean speed of the particles			

(3)

(Total 10 marks)

2

The image below shows air being pumped into a car tyre.

(a) Complete the sentence.

Air particles in the tyre move quickly in ____________________ directions.

(1)

(b) When the tyre is at the correct pressure, pumping more air into the tyre causes the pressure to increase further.

The volume and temperature of the air in the tyre do **not** change.

Explain why the pressure increases as more air is pumped into the tyre.

____

____

____

____

(2)

(c) The air pressure in a car tyre changes if the temperature of the air in the tyre increases.

Explain why.

____

____

(4)

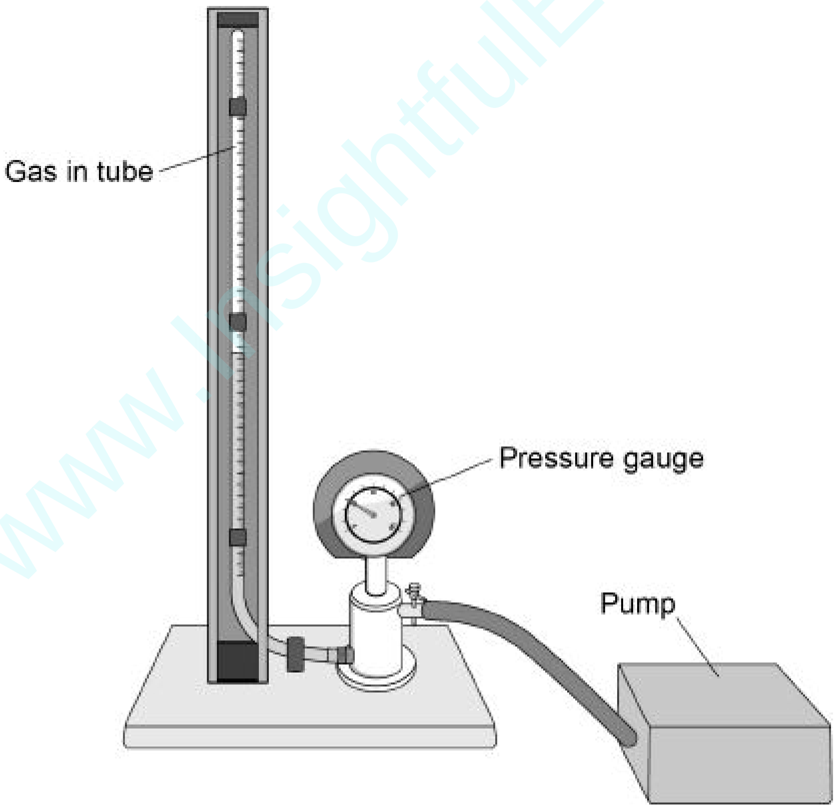
(Total 7 marks)

3

A student investigated how the pressure exerted by a gas varied with the volume of the gas.

Figure 1 shows the equipment the student used.

Figure 1



A pump was used to compress the gas in a tube. As the volume of the gas decreases, the pressure of the gas increases.

(a) The student only recorded one set of results.

Give **two** reasons why taking repeat readings could provide more accurate data.

1. ____

____

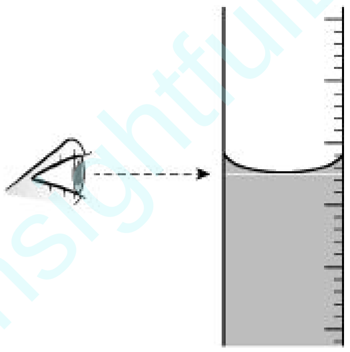
2. ____

____

(2)

(b) **Figure 2** shows the position of the student's eye when taking volume measurements.

Figure 2



Explain what type of error would be caused if the student's eye was **not** in line with the level of the liquid in the tube.

____

____

____

____

(2)

(c) If the gas is compressed too quickly the temperature of the gas increases.

Explain how the temperature increase would affect the pressure exerted by the gas.

(2)

(d) One of the student's results is given below.

pressure = 1.6×10^5 Pa
volume = 9.0 cm^3

Calculate the volume of the gas when the pressure was 1.8×10^5 Pa.

The temperature of the gas was constant.

Volume = ____________________ cm^3

(3)

(e) **Figure 3** shows a person using a bicycle pump to inflate a tyre.

Figure 3

INTERLEAVE

The internal energy of the air increases as the tyre is inflated.

Explain why.

____

____

____

____

(2)

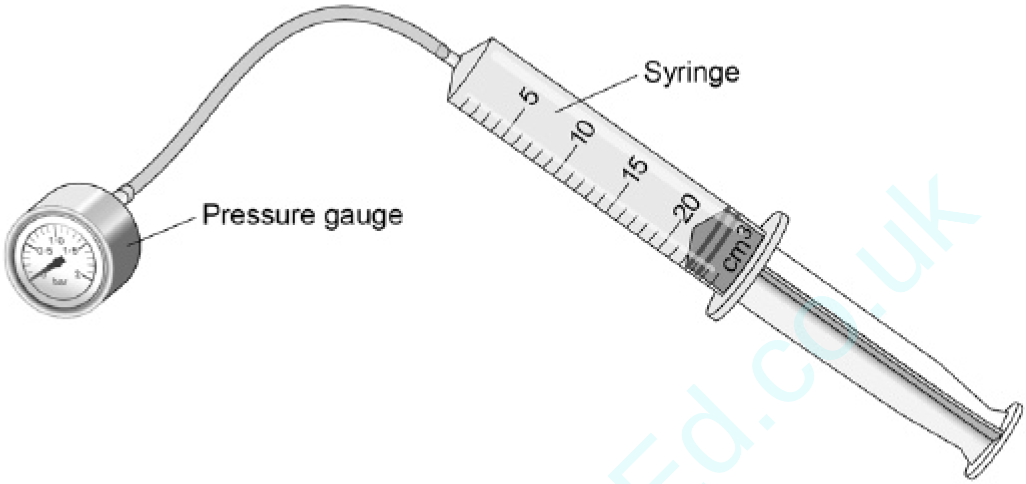
(Total 11 marks)

5

A student investigated how the pressure of a gas varied with the volume of the gas.

The mass and temperature of the gas were constant.

The diagram shows the equipment the student used.



(a) What is the range of the syringe?

Tick **one** box.

0 to 1 cm^3 ☐

0 to 5 cm^3 ☐

0 to 20 cm^3 ☐

0 to 25 cm^3 ☐

(1)

(b) What type of variable was the mass of gas?

Tick **one** box.

Control ☐

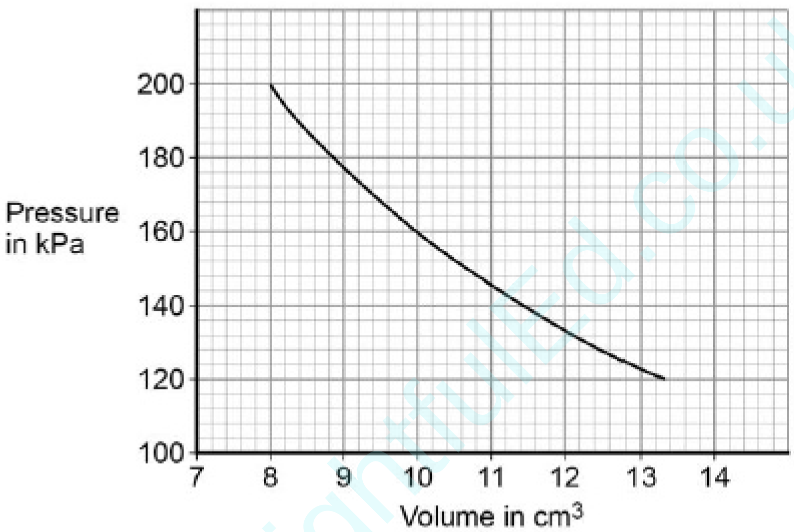
Dependent ☐

Independent ☐

(1)

The student compressed the gas in the syringe and read the pressure from the pressure gauge.

The graph shows the student's results.



(c) The student concluded that when the pressure was multiplied by the corresponding volume the answer was the same.

Use data from the graph to show that the student's conclusion was correct.

___

___

___

___

___

___

(2)

(d) Complete the sentences.

Choose the answers from the box.

Each answer may be used once, more than once or not at all.

decreases	**increases**	**remains the same**

When the gas is compressed, the volume of gas in the syringe

________________ .

So the number of collisions each second between the gas particles inside the

syringe and the inside surface of the syringe ____________________ .

This means the force exerted on the inside surface of the container

walls ____________________ .

(3)

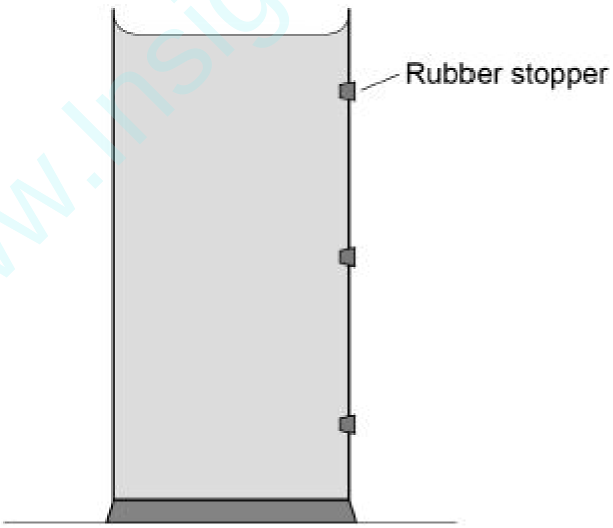
(Total 7 marks)

6

Figure 1 shows a container filled with water.

The three holes in the side of the container are sealed with rubber stoppers.

Figure 1



(a) The water exerts a force of 27 N on the bottom of the container.
The cross-sectional area of the bottom of the container is 0.009 m^2.

Calculate the pressure exerted by the water on the bottom of the container.

Use the equation:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Choose the unit.

kg/m^3	**N/m**	**Pa**

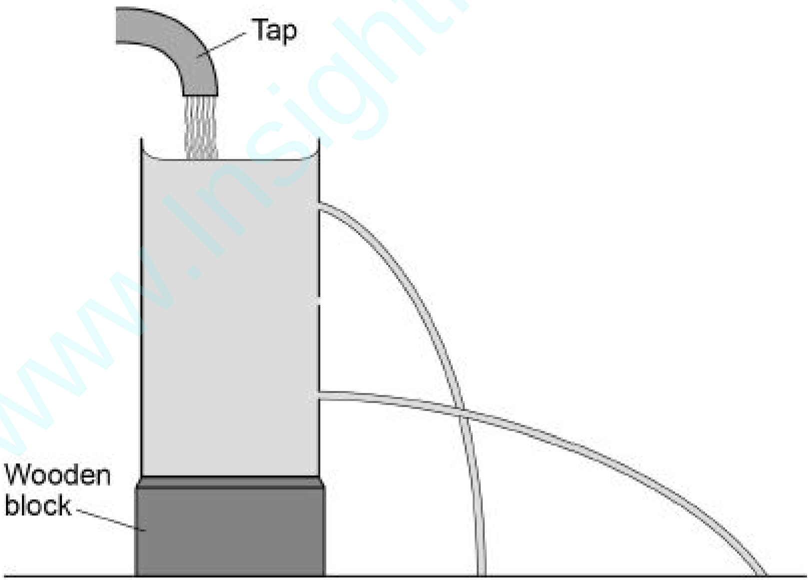
Pressure = ______________________ Unit = __________

(3)

The container is put under running water from a tap and the three rubber stoppers removed.

Figure 2 shows the path taken by the water escaping from the top and bottom holes.

Figure 2



(b) Complete **Figure 2** to show the path taken by the water escaping from the centre hole.

(1)

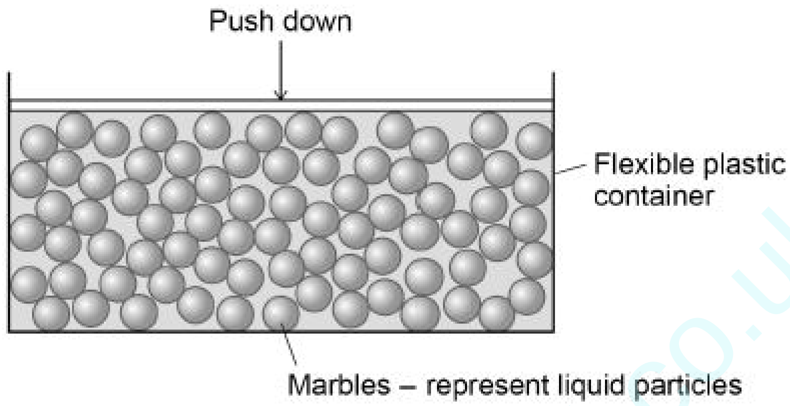
(c) What can be concluded from **Figure 2** about the pressure in a liquid?

(1)

(d) **Figure 3** shows a simple model of a liquid.

When a force pushes down on the marbles, the marbles push the sides and bottom of the container outwards.

Figure 3



What can be concluded from this model about the pressure in a liquid?

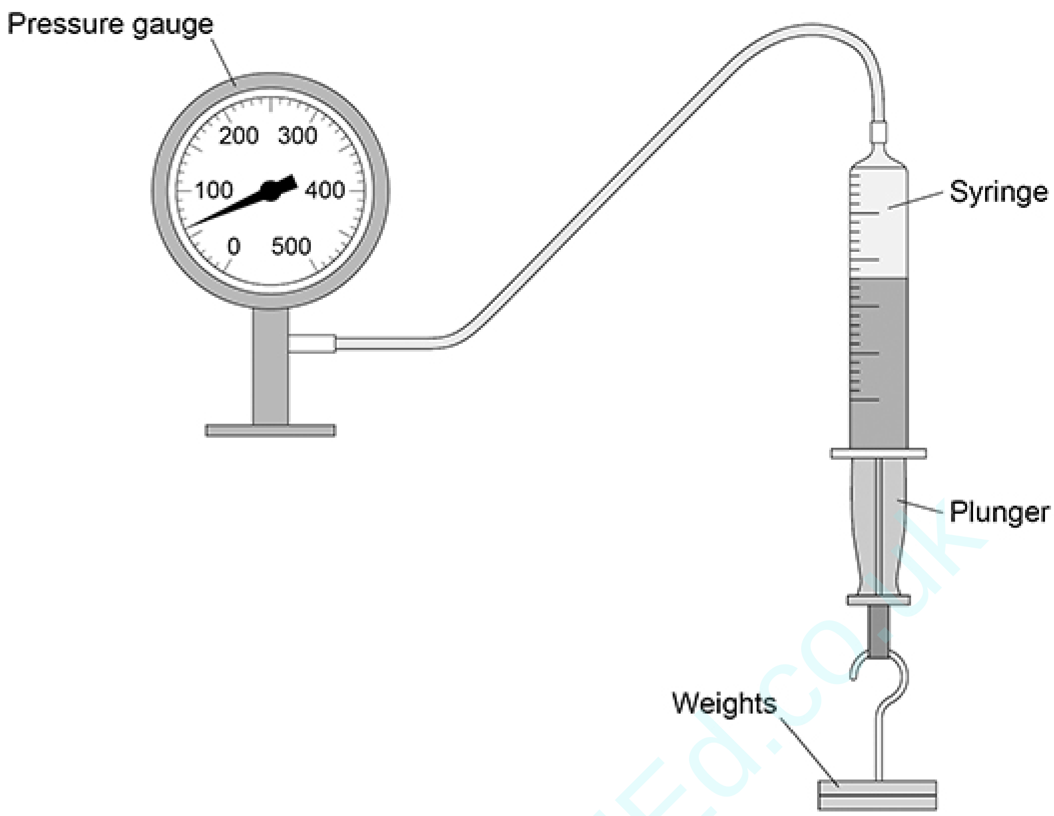
____

____

(1)
(Total 6 marks)

A teacher demonstrated the relationship between the pressure in a gas and the volume of the gas.

The figure below shows the equipment used.



This is the method used.

1. Record the initial volume of gas in the syringe and the pressure reading before any weights are attached.

2. Attach a 2.0 N weight to the syringe.

3. Record the volume of the gas and the reading on the pressure gauge.

4. Repeat steps 2 and 3 until a weight of 12.0 N is attached to the syringe.

(a) What was the range of force used?

From __________ N to __________ N

(1)

(b) Give **one** control variable in the investigation.

____

(1)

(c) When the volume of gas in the syringe was 45 cm^3, the pressure gauge showed a value of 60 kPa.

Calculate the pressure in the gas when the volume of gas in the syringe was 40 cm^3.

____

Pressure = _______________ kPa

(4)

(d) When the volume of gas in the syringe increased, the pressure on the inside walls of the syringe decreased.

Explain why.

(3)

(Total 9 marks)

7

The photograph below shows a balloon filled with helium gas.

(a) Which statements describe the movement of the gas particles in the balloon?

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.	☐

(2)

(b) The pressure of the helium in the balloon is 100 000 Pa.

The volume of the balloon is 0.030 m^3.

The balloon is compressed at a constant temperature causing the volume to decrease to 0.025 m^3.

No helium leaves the balloon.

Calculate the new pressure in the balloon.

____

____

____

____

____

____

____

New pressure = ________________ Pa

(4)

(c) 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)

(Total 10 marks)

8

The Earth is surrounded by an atmosphere.

(a) The radius of the Earth is 6400 km.

Which of the following could be an approximate depth of the Earth's atmosphere?

Tick (✓) **one** box.

100 km ☐

6400 km ☐

100 000 km ☐

640 000 km ☐

(1)

(b) What state of matter is most of the Earth's atmosphere?

Tick (✓) **one** box.

Gas ☐

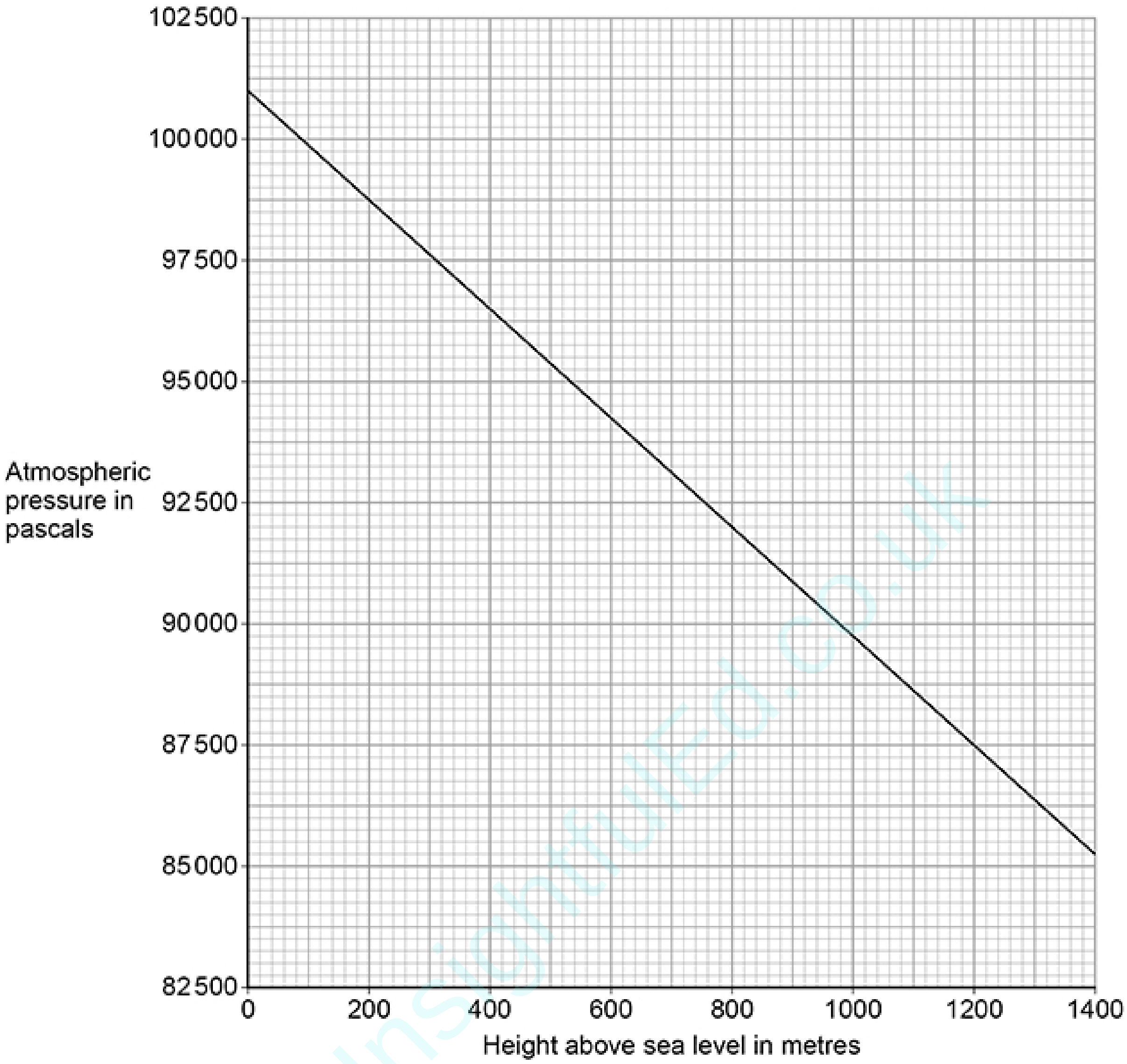
Liquid ☐

Solid ☐

(1)

Figure 1 shows how atmospheric pressure varies with height above sea level.

Figure 1



(c) The highest point above sea level in England is the top of a mountain called Scafell Pike.

The height above sea level of Scafell Pike is 978 m.

Determine the atmospheric pressure at the top of Scafell Pike.

Use **Figure 1**.

____

____

Atmospheric pressure = ________________ Pa

(1)

(d) Determine the difference between the atmospheric pressure at sea level and at the top of Scafell Pike.

Use **Figure 1** and your answer from part (c)

____

____

Difference in atmospheric pressure = ______________ Pa

(1)

(e) A student climbs Scafell Pike.

Why does the atmospheric pressure decrease as the student climbs higher?

Tick (✓) **two** boxes.

The air exerts a greater force on the student. ☐

The density of the air decreases. ☐

The mass of air above the student decreases. ☐

The temperature of the air increases. ☐

The volume of air above the student increases. ☐

(2)

(f) **Figure 2** shows a mountain lake.

Figure 2

The lake has a surface area of 2000 m^2.

Atmospheric pressure exerts a force of 188 000 000 N on the surface of the lake.

Calculate the atmospheric pressure at the surface of the lake.

Use the equation:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

____

____

____

____

Atmospheric pressure = _______________ Pa

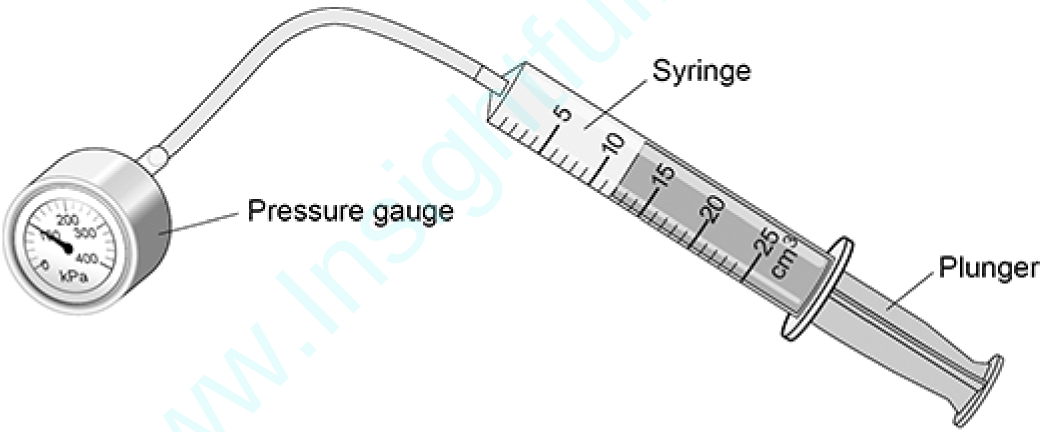
(2)

(Total 8 marks)

9

A teacher demonstrated the relationship between the pressure in a gas and the volume of the gas.

The figure below shows the equipment used.



(a) What is the range of the syringe?

Tick (✓) **one** box.

From 0 to 1 cm^3	☐
From 0 to 5 cm^3	☐
From 0 to 25 cm^3	☐

(1)

(b) The relationship between the pressure and volume of a gas is given by the equation:

pressure × volume = constant

Complete the sentence.

For this equation to apply, both the mass of gas and the
________________ of the gas must stay the same.

(1)

(c) The initial volume of the gas in the syringe was 12 cm^3.

The initial pressure of the gas in the syringe was 101 000 Pa.

Calculate the constant in the equation below.

pressure × volume = constant

____

____

____

Constant = ________________ Pa cm^3

(2)

(d) The teacher pulled the plunger slowly outwards and the gas expanded.

The new volume of the gas was 24 cm^3.

Calculate the new pressure in the gas.

The constant has the same value as in part (c)

____

____

____

____

____

New pressure = ________________ Pa

(3)

(e) Which change occurs when the plunger is pulled slowly outwards?

Tick (✓) **one** box.

The gas particles stop moving.	☐
There are more frequent collisions between the gas particles.	☐
There is more space between the gas particles.	☐

(1)
(Total 8 marks)

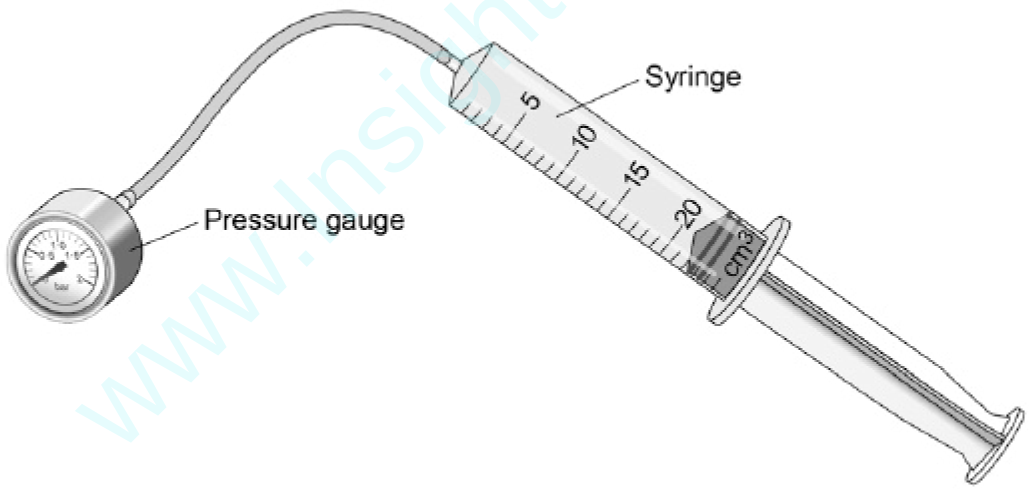
10

A student investigated how the pressure of a gas varied with the volume of the gas.

The mass and temperature of the gas were constant.

Figure 1 shows the equipment the student used.

Figure 1



(a) What is the resolution of the syringe?

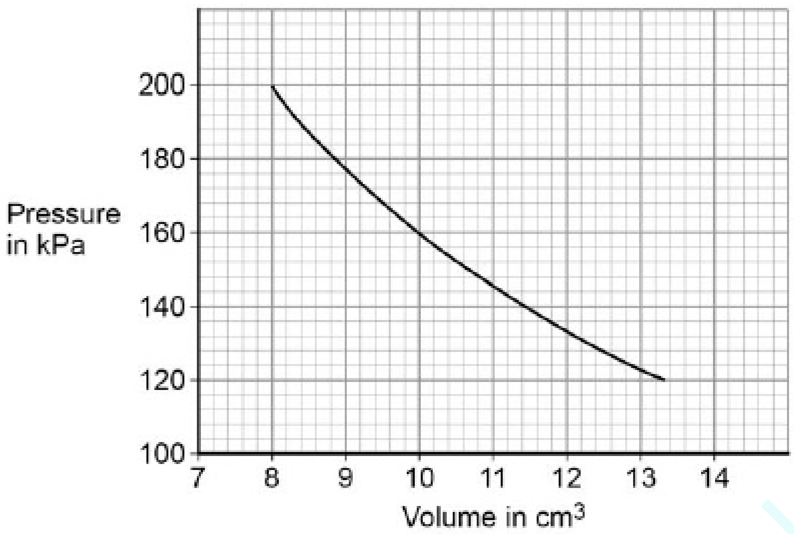
____________________ cm^3

(1)

The student compressed the gas in the syringe and read the pressure from the pressure gauge.

Figure 2 shows the student's results.

Figure 2



(b) What conclusion can the student make from the data in **Figure 2**?

Use data from **Figure 2** in your answer.

Give the reason for your answer.

____

____

____

____

____

____

(3)

(c) Explain why the pressure in the gas increases as the gas is compressed.

____

____

____

____

____

____

____

____

(4)

(Total 8 marks)

Mark Scheme
1

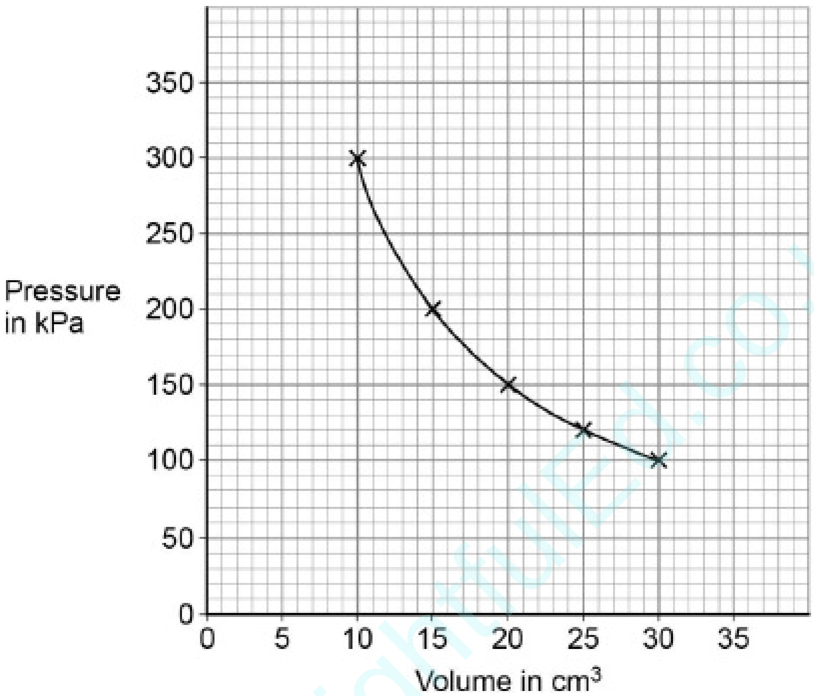
(a) random directions

1

(b) a range of speeds

1

(c)



2 marks for plotting 4 points correctly

1 mark for plotting 2 or 3 points correctly

1 mark for line of best fit

3

(d) 300 × 10 = constant

allow use of any correct pair of values

1

constant = 3000

1

(e)

Quantity	**Decreases**	**Stays the same**	**Increases**
Mean time between collisions of the particles with the tube			✓

Mean distance between the particles			✓
Mean speed of the particles		✓	

additional tick in a row negates the mark for that row

3

[10]

2

(a) random

allow all / any

ignore many different

1

(b) more (air) particles (in the tyre)

1

greater number of collisions with tyre (walls) per second

allow collisions with tyre (walls) are more frequent

allow greater rate of collisions with tyre (walls)

do ***not*** *credit MP2 if linked to an increased air temperature or increased speed / E_k of particles*

ignore greater force per m^2

1

(c) (as temperature increases the) air particles have greater (mean) kinetic energy

allow particles move with greater speeds (on average)

1

(so) more collisions with tyre (walls) per second

allow collisions with tyre (walls) are more frequent

allow greater rate of collisions with tyre (walls)

1

(and) greater force in each collision

allow greater rate of change of momentum in each collision

1

greater (mean) force per square metre causes greater pressure (on wall of tyre) *allow 'on a given area' for 'per square metre'*

1

[7]

3

(a) any **two** from:

- calculate a mean
- reduces the effect of random errors

  reduces human error is insufficient
- identify / remove anomalies

  allow to assess the repeatability of the data

2

(b) random error

allow a parallax error
human error is insufficient

1

(because) eye position would not be the same each time (relative to the liquid)

allow systematic error only if it is clear that the student always viewed liquid level from above meniscus (or below)

1

(c) (a temperature increase would) increase the pressure in the tube (even if the volume was constant)

1

(because a higher temperature would mean) higher (average) kinetic energy of molecules / particles

allow higher (average) speed for higher (average) kinetic energy

1

(d) $1.6 \times 10^5 \times 9.0$ (= 1.44×10^6)

1

$1.44 \times 10^6 = 1.8 \times 10^5 \times V$

*allow for **2** marks*

$$V = \frac{1.6 \times 10^5 \times 9.0}{1.8 \times 10^5}$$

1

or

$$V = \frac{1.44 \times 10^6}{1.8 \times 10^5}$$

V = 8.0 (cm^3)

1

*an answer of 8.0 (cm^3) scores **3** marks*

(e) work is done on the air (in the tyre)

1

so the temperature (of the air) increases

allow the (average) kinetic energy of the particles increases

1

[11]

4

(a) any **two** from:

- calculate a mean
- reduces the effect of random errors

  reduces human error is insufficient
- identify / remove anomalies

  allow to assess the repeatability of the data

2

(b) random error

allow a parallax error
human error is insufficient

1

(because) eye position would not be the same each time (relative to the liquid)

allow systematic error only if it is clear that the student always viewed liquid level from above meniscus (or below)

1

(c) (a temperature increase would) increase the pressure in the tube (even if the volume was constant)

1

(because a higher temperature would mean) higher (average) kinetic energy of molecules / particles

allow higher (average) speed for higher (average) kinetic energy

1

(d) $1.6 \times 10^5 \times 9.0$ (= 1.44×10^6)

1

$1.44 \times 10^6 = 1.8 \times 10^5 \times V$

*allow for **2** marks*

$$V = \frac{1.6 \times 10^5 \times 9.0}{1.8 \times 10^5}$$

1

or

$$V = \frac{1.44 \times 10^6}{1.8 \times 10^5}$$

V = 8.0 (cm^3)

1

*an answer of 8.0 (cm^3) scores **3** marks*

(e) work is done on the air (in the tyre) 1

so the temperature (of the air) increases

allow the (average) kinetic energy of the particles increases 1

[11]

5

(a) 0 to 25 cm^3 1

(b) control 1

(c) 2 sets of data recorded from line of best fit to show that the product is the same in both cases (1600)

*allow for **1** mark one set of calculated data for one point on the line of best fit* 2

(d) decreases 1

increases 1

increases 1

[7]

6

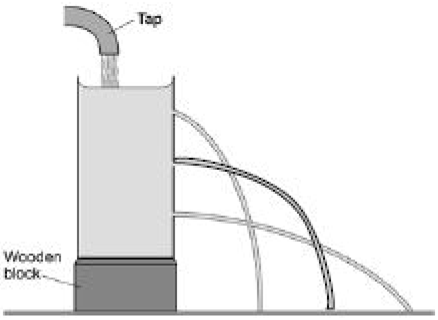
(a) $p = \frac{27}{0.009}$ 1

p = 3000 1

Pa 1

*an answer of 3000 scores **2** marks*

(b)



the water path hits the surface somewhere between the other two paths

1

(c) pressure increases with depth

allow when the pressure is higher, the water travels further

1

(d) pressure acts in all directions
or
pressure causes a force on (all) the surfaces

ignore liquids cannot be compressed

1

[6]

7

(a) The particles move in random directions.

1

The particles move with a range of speeds.

1

(b) 100 000 × 0.030 = 3000

1

p × 0.025 = 3000

allow a correct substitution using an incorrectly calculated value using pV = constant

1

$p = \frac{3000}{0.025}$

allow a correct rearrangement using an incorrect value of the constant

1

p = 120 000 (Pa)

allow a correct calculation using an incorrect value of the constant

allow correct substitution into $p_1V_1 = p_2V_2$ for first 2 marking points

1

(c) particles would have a higher (mean) kinetic energy

allow particles would have a higher (mean) speed
do not accept particles vibrate more

1

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

allow greater frequency of collisions with the walls of the balloon

1

greater forces exerted in collisions (between particles and balloon walls)

allow greater rate of change of momentum (of particles)

1

greater force exerted on same area

allow description using p=F/A

1

[10]

8

(a) 100 km

1

(b) gas

1

(c) 90 000 Pa

allow 89 500 to 90 500

1

(d) 101 000 – 90 000 = 11 000 Pa

*allow ecf from part **(c)***

1

(e) the density of the air decreases

1

the mass of air above the student decreases

1

(f) $P = \frac{188\ 000\ 000}{2000}$

1

94 000 (Pa)

1

[8]

9

(a) 0 to 25 cm^3

1

(b) temperature

1

(c) 101 000 × 12 = constant

1

constant = 1 212 000 (Pa cm^3)

1

(d) p × 24 = 1 212 000

allow ecf from question (c)

1

$$p = \frac{1\,212\,000}{24}$$

1

p = 50 500 (Pa)

1

(e) there is more space between the gas particles

1

[8]

10

(a) 1 (cm^3)

1

(b) pressure is inversely proportional to volume

1

data to prove inversely proportional relationship

eg 8 × 200 = 1600

and 10 × 160 = 1600

if no other marks score allow for ***1*** *mark: as volume decreases pressure increases*

2

(c) (as the gas is compressed) the volume of gas decreases

1

(so there are) more frequent collisions of gas particles with container walls

1

(and) each particle collision with the wall causes a force

1

(so there is a) greater force on walls

1

[8]