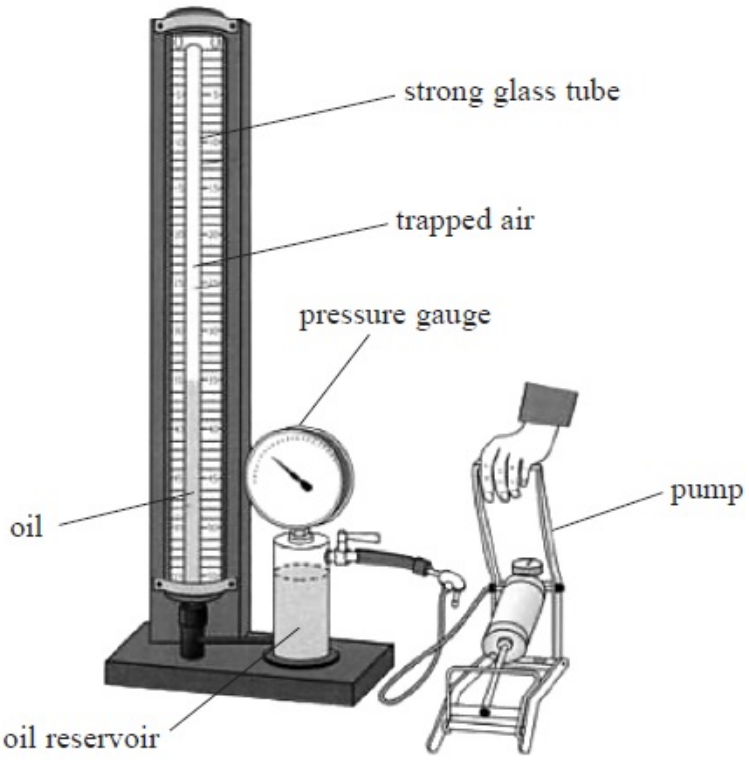
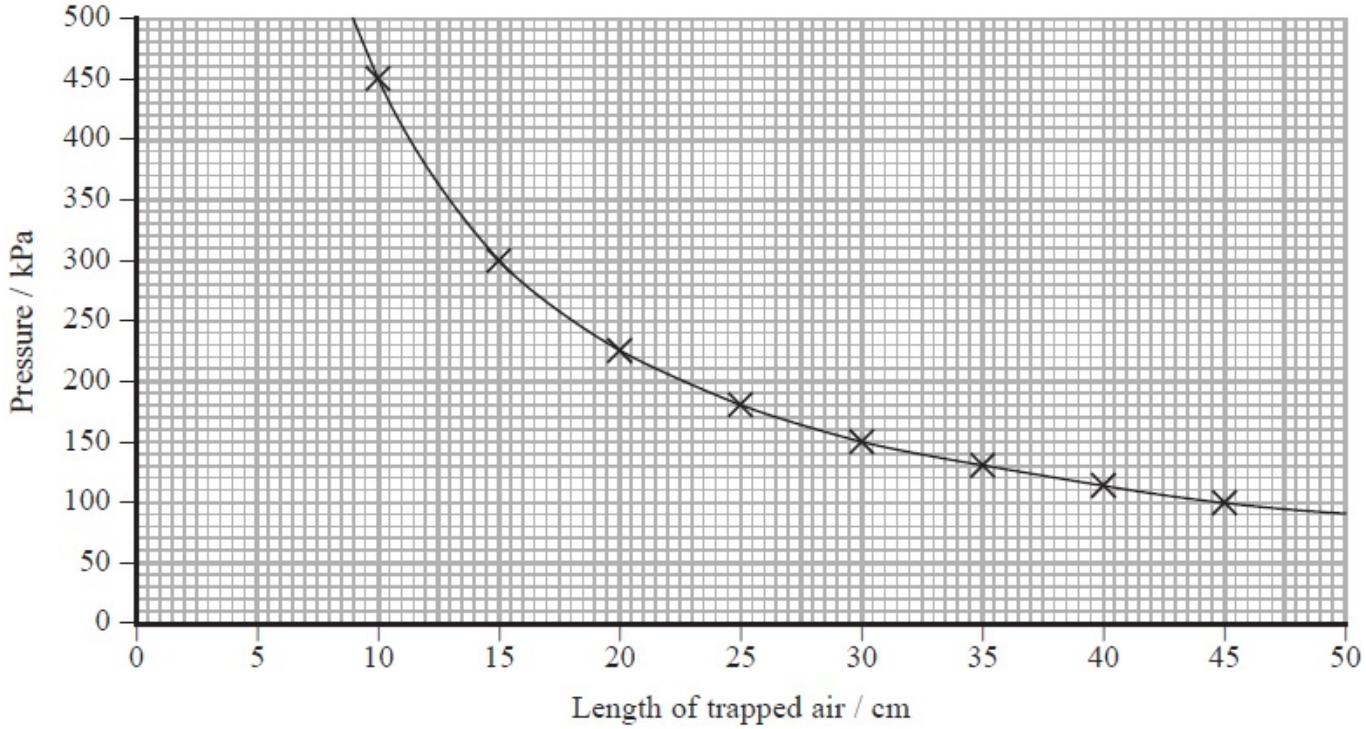
## Questions

1) A student uses the apparatus shown to investigate the relationship between pressure and volume of a gas.




Air is trapped in a glass tube of uniform cross-sectional area. As the pressure of the trapped air is increased, the length of trapped air decreases. The student collects data and plots the following graph.



(a) State the variables that should be controlled in this investigation.

**(2)**

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(b) Theory suggests that, for the air trapped in the tube, the pressure $p$ is inversely proportional to the volume $V$.

Use the graph to show that this relationship is correct. State an assumption that you are making.

**(4)**

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(c) the day that the investigation was carried out, the temperature in the laboratory was 20 °C.

Calculate the number of air molecules trapped in the tube.

cross-sectional area of tube = $7.5 \times 10^{-5}$ m$^2$

**(3)**

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Number of air molecules = .....

(d) State how the graph would change if

(i) the air molecules in the tube were replaced by the same number of molecules of hydrogen gas.

**(1)**

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(ii) the temperature of the laboratory was substantially higher.

**(2)**

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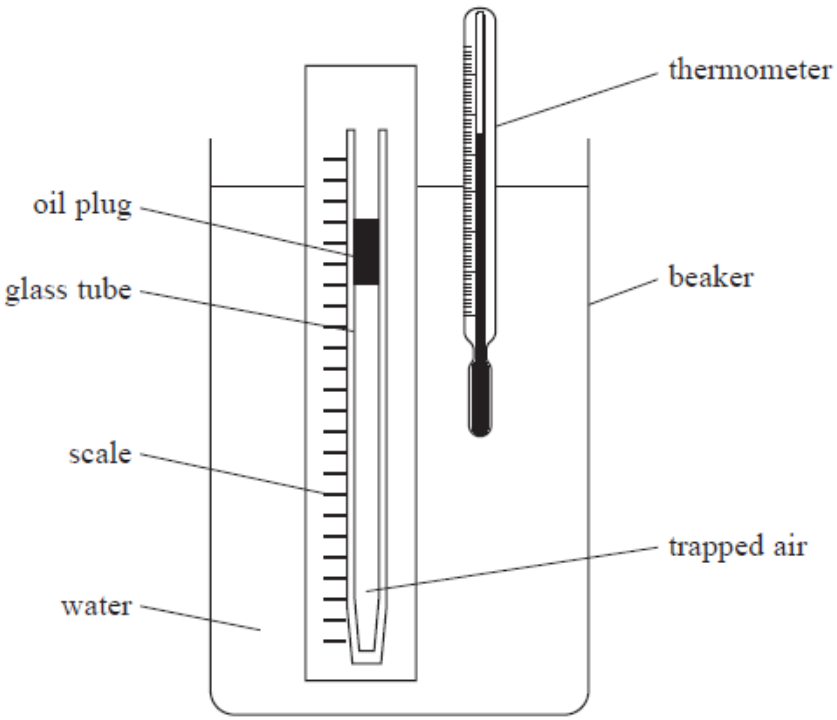
**(Total for Question = 12 marks)**

2)

A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



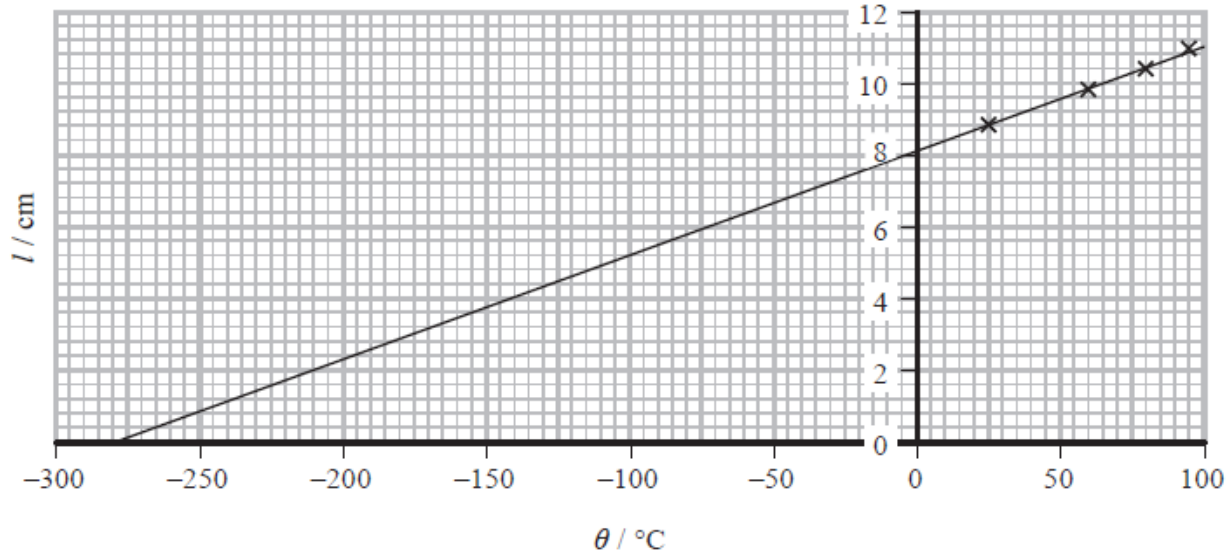
A glass tube was sealed at one end. A plug of oil trapped a length *l* of air in the tube. The water in the beaker was heated to a temperature $\theta$. The corresponding value of *l* was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5 °C. The scale had mm divisions.

The student's results are shown in the table.

| $\theta$ / °C | *l* / cm |
|---|---|
| 24 | 8.8 |
| 60 | 9.8 |
| 78.5 | 10.3 |
| 95.5 | 10.9 |

The student plotted a graph of *l* against $\theta$ as shown.




(i) Explain the significance of the intercept on the *x*-axis.

**(3)**

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(ii) The student wrote a report of the investigation in her lab book. In the conclusion she wrote:

"In this investigation uncertainties were minimised by selecting measuring instruments with a high resolution. The points lie on a perfect straight line, indicating that the investigation is accurate." **(4)**

Discuss the student's conclusion.

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**(Total for question = 7 marks)**

3) A student is investigating how a volume of nitrogen gas is affected by the pressure exerted on it.

*For Examiner's Use*

A sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a small volume of oil. Pressure is applied by a pump. The applied pressure is measured on a gauge, as shown in Fig. 2.1.

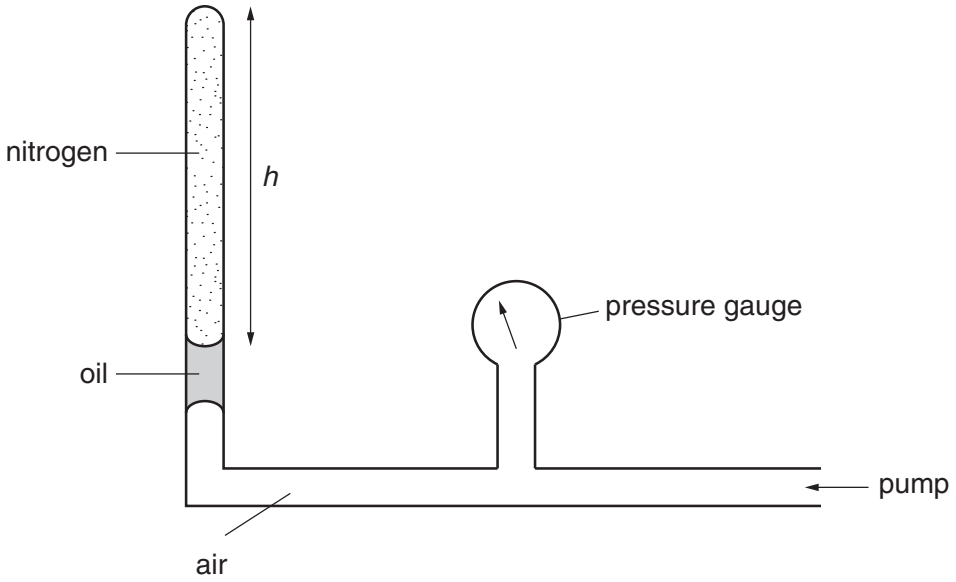



**Fig. 2.1**

The temperature $T$ of the nitrogen is 290 K.

An experiment is carried out to investigate how the height $h$ of nitrogen trapped in the tube varies with the pressure $p$.

**Question 3 continues on the next page.**

It is suggested that $p$ and $h$ are related by the equation

$$pAh = NkT$$

where $A$ is the cross-sectional area of the tube, $k$ is the Boltzmann constant and $N$ is the number of molecules of nitrogen gas.

*For Examiner's Use*

**(a)** A graph is plotted of $p$ on the $y$-axis against $\frac{1}{h}$ on the $x$-axis. Express the gradient in terms of $N$.

gradient = .....[1]

**(b)** Values of $p$ and $h$ are given in Fig. 2.2.

| $p/10^5$ Pa | $h/10^{-3}$ m | |
|---|---|---|
| 1.10 | 400 ± 5 | |
| 1.22 | 360 ± 5 | |
| 1.38 | 320 ± 5 | |
| 1.57 | 280 ± 5 | |
| 1.83 | 240 ± 5 | |
| 2.09 | 210 ± 5 | |

**Fig. 2.2**

Calculate and record values of $\frac{1}{h}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{1}{h}$ .

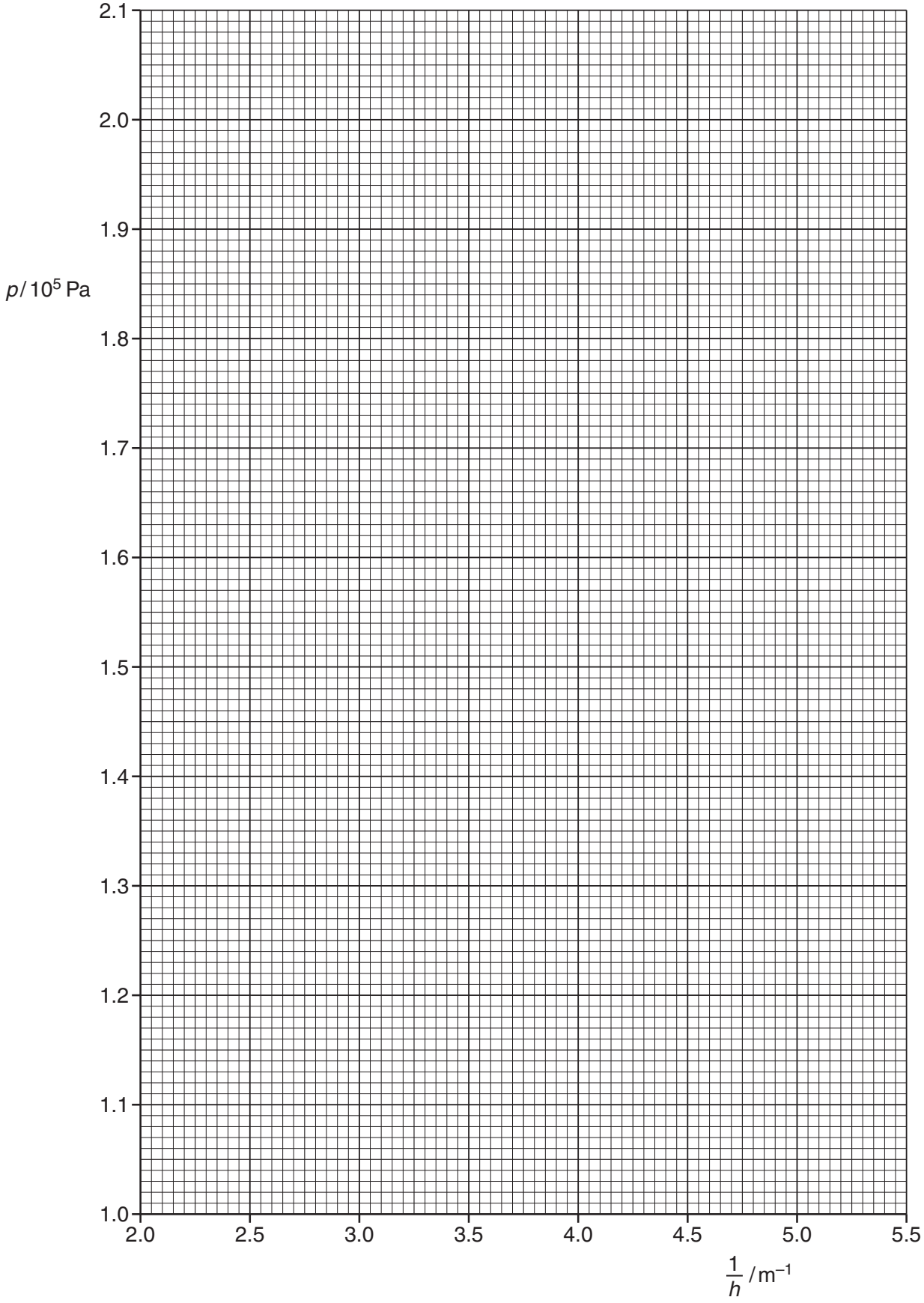
[3]

**(c)** **(i)** Plot a graph of $p/10^5$ Pa against $\frac{1}{h}/\text{m}^{-1}$. Include error bars for $\frac{1}{h}$. [2]

**(ii)** Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

**(iii)** Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = .....[2]




*For Examiner's Use*

**[Turn over**

**(d)** In this experiment, $A = 3.14 \times 10^{-6}\,m^2$ and $k = 1.38 \times 10^{-23}\,JK^{-1}$. Using your answer in **(c)(iii)**, determine the value of $N$. Include the absolute uncertainty in your value.

*For Examiner's Use*

$N$ = .....[2]

**(e)** **(i)** The pressure is reduced so that $p = 1.10 \times 10^5$ Pa and the temperature decreases by 12 ±1 K.

Determine $h$ using the relationship given and your answer in **(d)**.

$h$ = .....[2]

**(ii)** Determine the percentage uncertainty in your value of $h$.

percentage uncertainty = ..... % [1]

4)

A student is investigating how the rate at which water evaporates varies with temperature.

It is suggested that the relationship between the volume of water evaporated per unit time $Y$ and the Celsius temperature $\theta$ of the water is

$$Y = k\theta^s$$

where $k$ and $s$ are constants.

Design a laboratory experiment to test the relationship between $Y$ and $\theta$.
Explain how your results could be used to determine values for $k$ and $s$.

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

5)

Two students are having a discussion about an experiment in which the air inside a bell jar is gradually removed. The sound of a ringing bell inside the jar is heard to decrease in intensity during this process.

One student suggests that the frequency $f$ of a sound wave and the pressure $p$ are related by the equation

$$f = kp^2$$

where $k$ is a constant.

Design a laboratory experiment to test the relationship between $f$ and $p$ and determine a value for $k$. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to:

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- the safety precautions to be taken.

[15]