For Examiner's Use

7 In order to study the sudden compression of a gas, some dry air is enclosed in a cylinder fitted with a piston, as shown in Fig. 7.1.

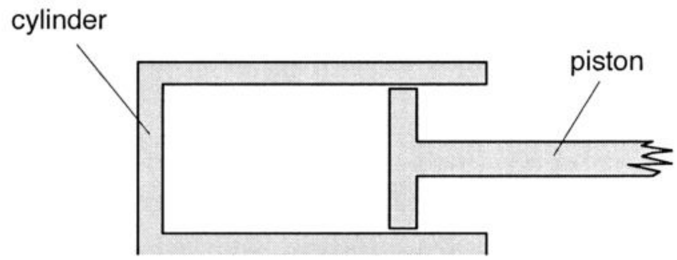

Fig. 7.1

The mass of air in the cylinder is constant. The material of the cylinder and the piston is an insulator so that no thermal energy enters or leaves the air.

The volume and pressure of the air are measured. The piston is then moved suddenly to compress the air and the new volume and pressure are measured.

The variation with volume V of the pressure p of the air is shown in Fig. 7.2.

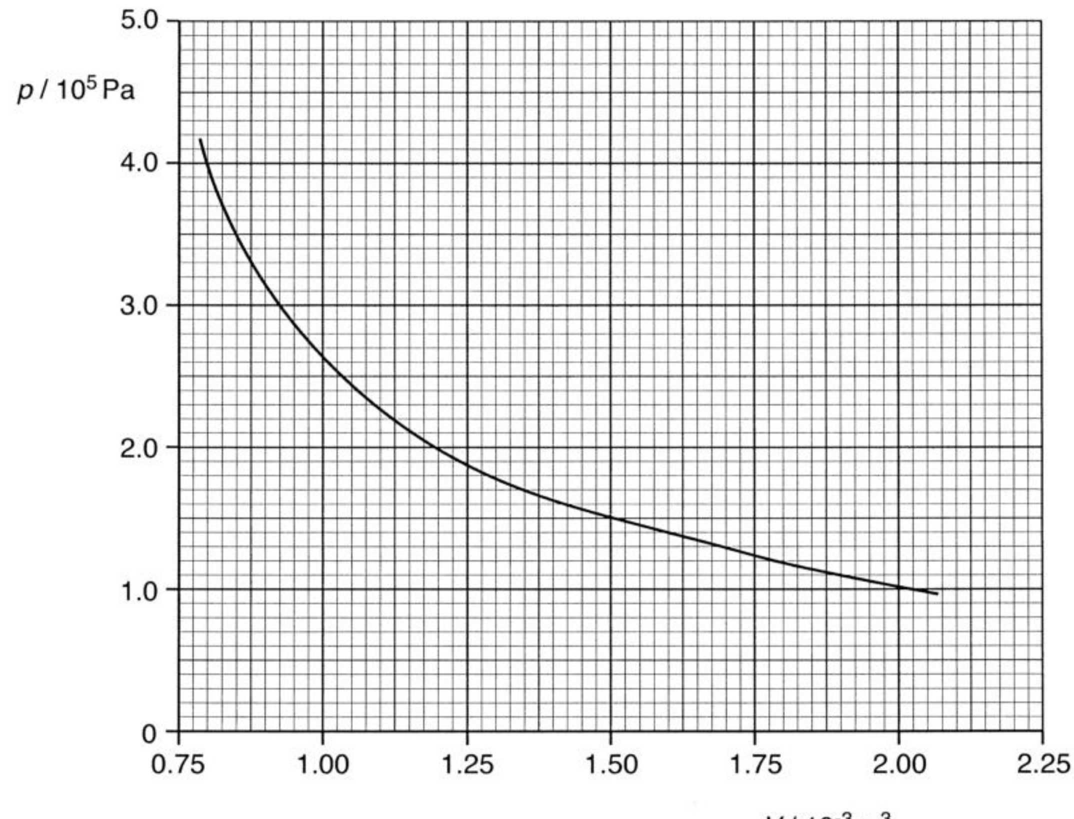

Fig. 7.2

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It may be assumed that the dry air behaves as an ideal gas.

(a) By considering the air at volume $2.0 \times 10^{-3}\,m^3$ and at volume $8.0 \times 10^{-4}\,m^3$, and using the equation of state for an ideal gas, show that the temperature of the air increases when the air is compressed.

....

....

....

....

....[3]

(b) It is thought that the air in the cylinder obeys a relation of the form

$$pV^{\gamma} = c,$$

where γ and c are constants.
Explain how the relation may be tested by plotting a graph of lg p on the y-axis against lg V on the x-axis.

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....

....

....[3]

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(c) Some data from Fig. 7.2 are used to plot the graph of Fig. 7.3.

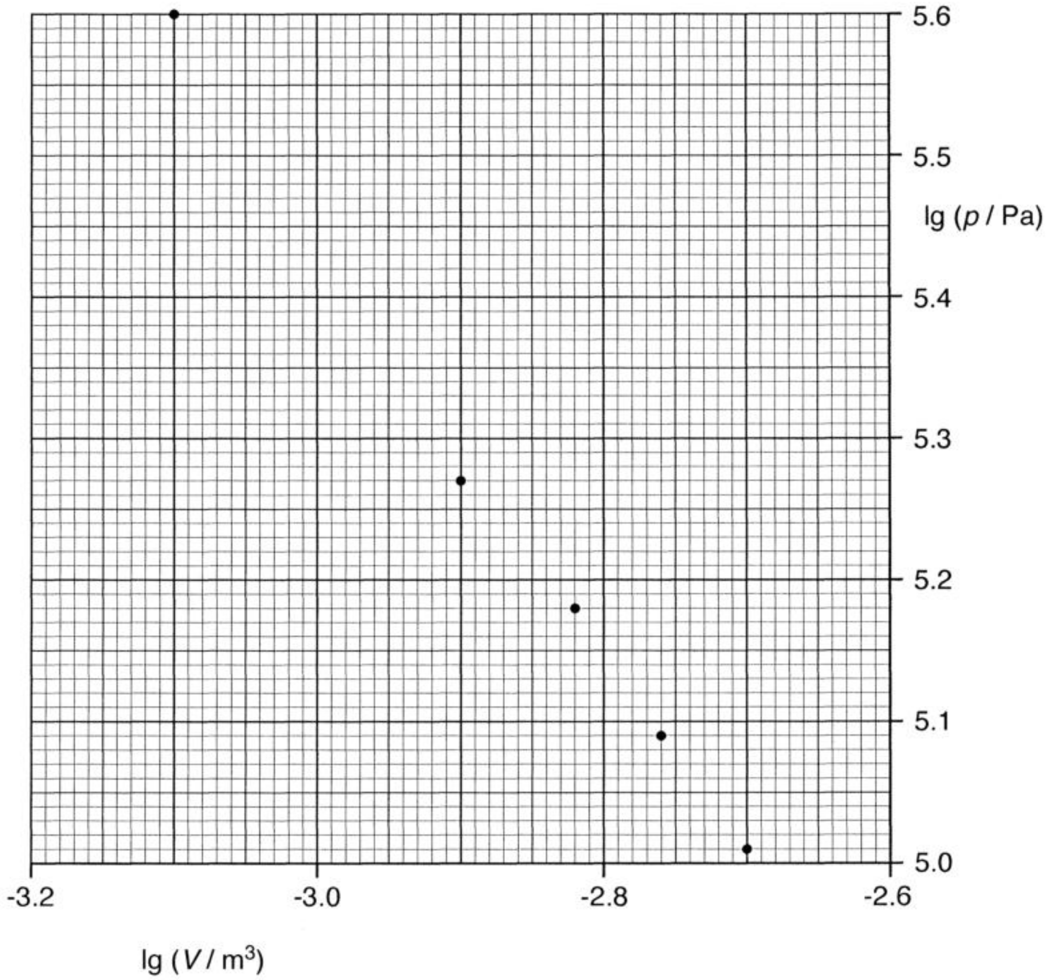

Fig. 7.3

(i) Use Fig. 7.2 to determine lg (p / Pa) for a volume V of $1.00 \times 10^{-3}\,m^3$.

lg (p / Pa) = ... [1]

(ii) On Fig. 7.3,

1. plot the point corresponding to $V = 1.00 \times 10^{-3}\,m^3$, [1]

2. draw the line of best fit for the points. [1]

(iii) Use the line drawn in **(ii)** to determine the magnitudes of the constants γ and c in the expression in **(b)**.

γ = ...

c = ...
[4]

(d) Fig. 7.4 shows the variation with volume V of the thermodynamic temperature T of the air.

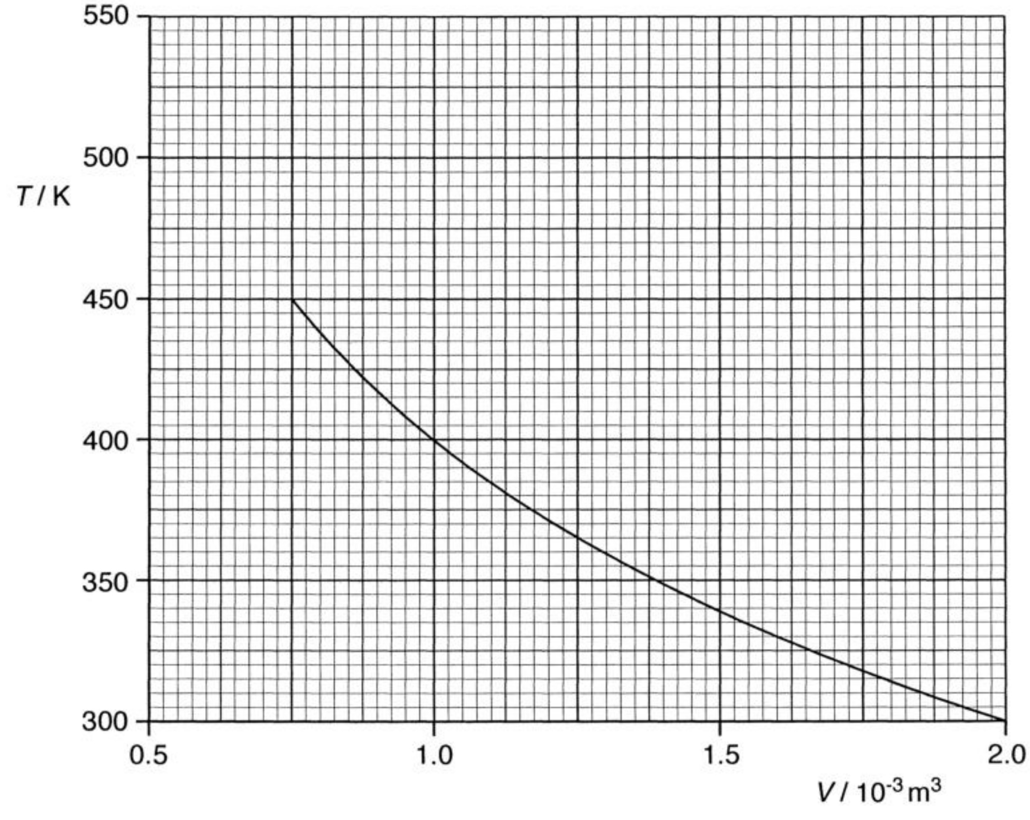

Fig. 7.4

The compression ratio for the air in the cylinder is given by the expression

$$\frac{\text{volume of gas before compression}}{\text{volume of gas after compression}}.$$

By extending the line of Fig. 7.4, estimate the final temperature of the air for an initial volume of $2.00 \times 10^{-3}\,\text{m}^3$ and a compression ratio of 3.85.

temperature = ... K [2]

For Examiner's Use

(e) When a firework explodes, the powder in the firework burns rapidly to produce a small volume of gas at high temperature and pressure.

Use Fig. 7.4 to explain why the temperature of the gas falls rapidly.

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....

....[2]