8 Some argon gas is enclosed in a cylinder fitted with a piston as shown in Fig. 8.1.
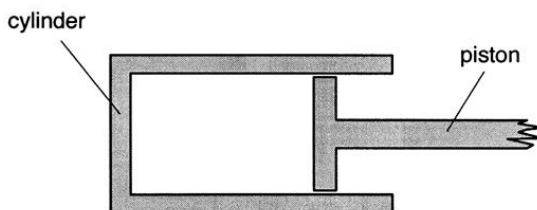

Fig. 8.1

Assume that the mass of argon 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 gas.

The volume and pressure of argon are measured. The piston is then moved to compress the gas and the new volume and pressure are measured. The variation with volume V of the pressure P of the argon gas is shown in Fig. 8.2.
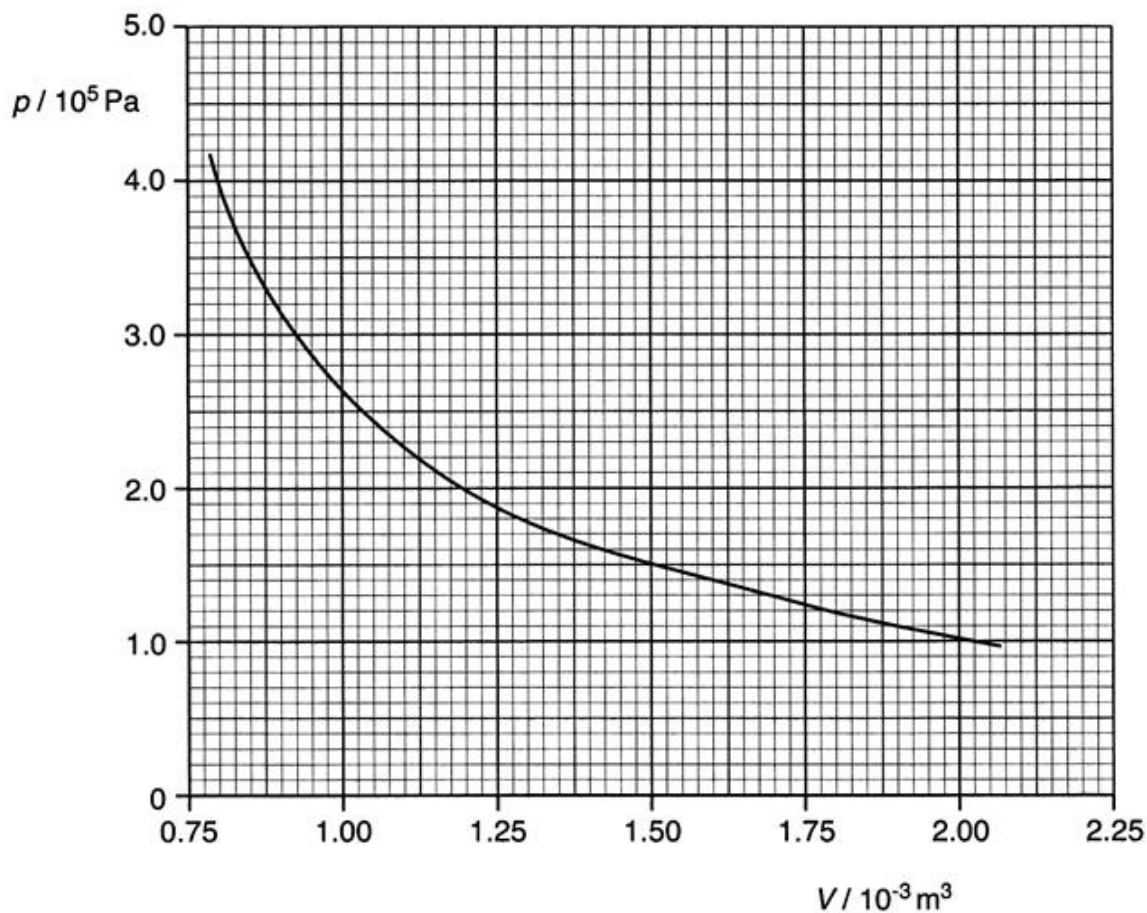

Fig. 8.2

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

(a) Using values from the Fig. 8.2, show that pressure p is not inversely proportional to volume V.

[2]

(b) **(i)** Using the equation of state for an ideal gas, explain what happens to the temperature of the gas when it is compressed.

....

....

....

.... [2]

(ii) By considering the collision between the argon atoms and the moving piston, account for the temperature change of the gas as the piston is pushed in.

....

....

.... [1]

(c) It is thought that the gas in the cylinder obeys a relation of the form

$$pV^x = y$$

where x and y are constants.

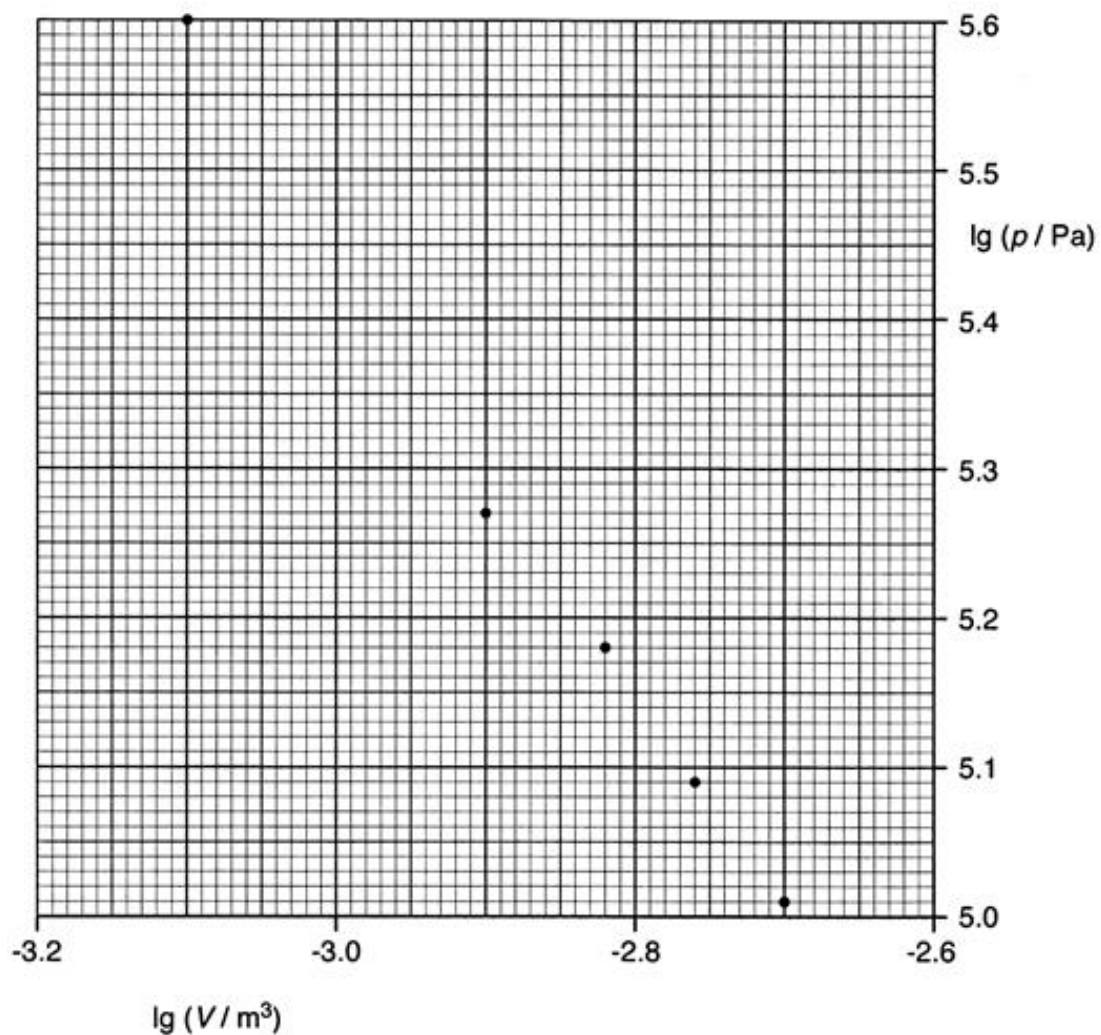Some data from Fig. 8.2 are used to plot the graph of Fig. 8.3.

Fig. 8.3

(i) Use Fig. 8.2 to determine lg (*p* / Pa) for a volume *V* of 1.00 x 10⁻³ m³.

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

(ii) On Fig. 8.3, plot the point corresponding to *V* = 1.00 x 10⁻³ m³ and draw the line of best fit for the points. [2]

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

$x =$ ....

$y =$ .... [4]

(d) The argon atoms in the cylinder have a range of speeds. The distribution of speeds is shown in Fig. 8.4 for a certain temperature.
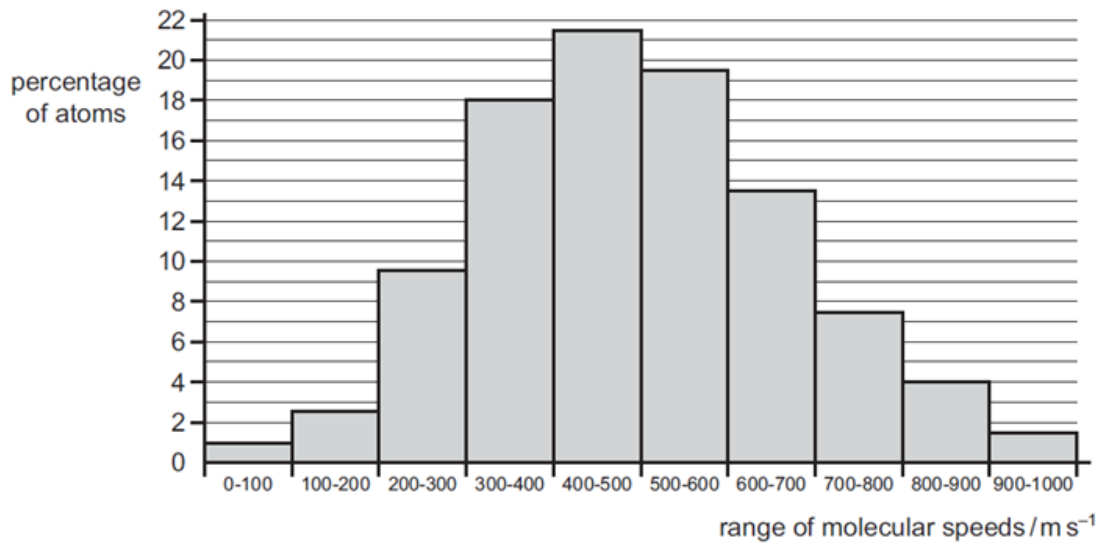

Fig. 8.4

The argon sample contains 3.0 x 10²³ atoms.

(i) Determine the number of atoms in the sample having speeds between 500 m s⁻¹ and 600 m s⁻¹.

number of atoms = ... [1]

(ii) Determine the number of atoms having speeds less than 200 m s⁻¹.

number of atoms = ... [1]

(iii) By referring to the total percentage of all the columns shown in the histogram, determine the total number of atoms with speeds greater than 1000 m s^{-1}.

number of atoms = ... [2]

(iv) Determine, by using a calculation, in which range of speeds shown in Fig 8.4 does the root mean square speed of the atom falls within?

range of speed = ... m s^{-1} [3]

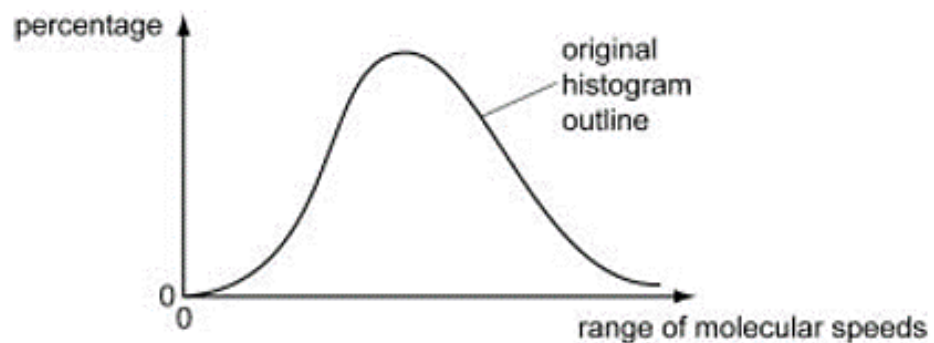**(e)** Fig. 8.5 shows the outline of the histogram in Fig. 8.4.

Fig. 8.5

Illustrate with a sketch in Fig. 8.5 how the outline of the histogram would change if the temperature of the argon is increased.