

11 1.00 g of nitrogen gas is stored in a 2.00 dm³ vessel at 40.0 °C.

What is the pressure in the vessel?

- A** 5940 Pa **B** 11 900 Pa **C** 46 400 Pa **D** 92 900 Pa

8 A pure sample of a gas has a density of 2.62 g dm⁻³ at 101 000 Pa and 25 °C. The gas behaves ideally under these conditions.

Which expression gives the M_r of the gas?

- A** $\frac{101\,000 \times 0.001}{2.62 \times 8.31 \times 25}$
- B** $\frac{101\,000 \times 0.001}{2.62 \times 8.31 \times 298}$
- C** $\frac{2.62 \times 8.31 \times 25}{101\,000 \times 0.001}$
- D** $\frac{2.62 \times 8.31 \times 298}{101\,000 \times 0.001}$

2 Effusion is the process in which a gas escapes through a small hole.

A student investigates the relationship between rate of effusion and relative molar mass of a gas using the apparatus shown in Fig. 2.1.

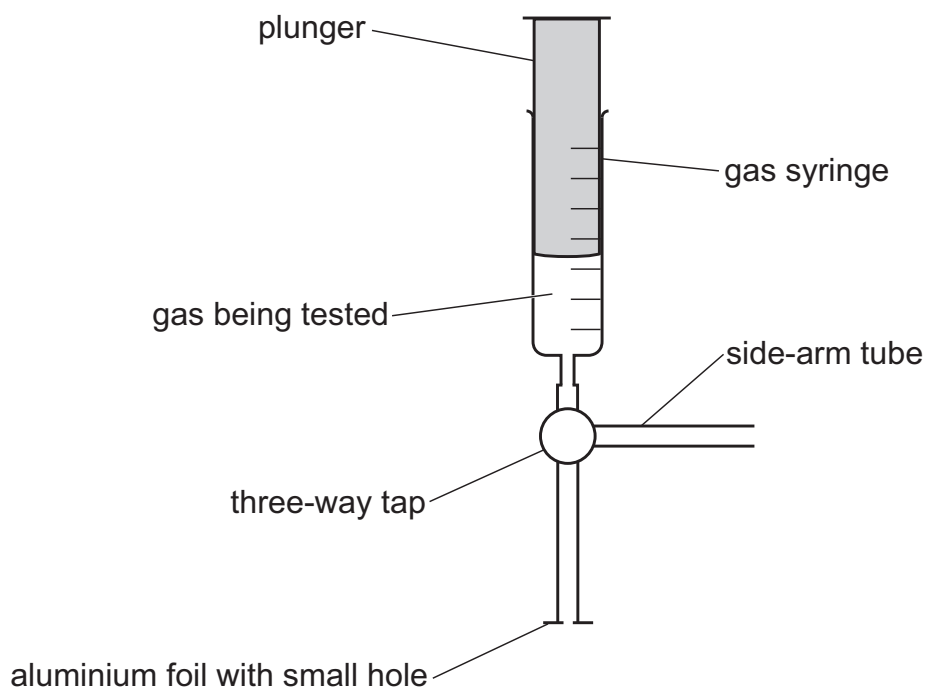


Fig. 2.1

The following method is used:

- step 1 Turn the tap and remove any gas from the syringe through the side-arm tube, by pushing in the plunger.
- step 2 Add 50 cm^3 of the gas being tested to the syringe through the side-arm tube.
- step 3 Remove the gas from the syringe, through the side-arm tube, by pushing in the plunger.
- step 4 Add 70 cm^3 of the gas being tested to the syringe through the side-arm tube.
- step 5 Turn the tap to connect the syringe to the tube with the aluminium foil and small hole.
- step 6 Allow the syringe plunger to fall and start a timer when the volume of gas in the syringe reaches 60 cm^3 .
- step 7 Stop the timer when the volume of gas in the syringe reaches 10 cm^3 . Record the time taken.
- step 8 Repeat steps 1 to 7 with different gases.

- (a) Suggest why the student adds 50 cm^3 of the gas being tested to the syringe in step 2 and then removes this gas in step 3.

.....
..... [1]

- (b) The student's results are shown in Table 2.1.

Table 2.1

gas	hydrogen, H_2	helium, He	neon, Ne	argon, Ar	krypton, Kr
relative molar mass, M	2.0	4.0	20.2	39.9	83.8
$\sqrt{\frac{1}{M}}$					
time taken /s	10.8	15.3	34.5	39.7	70.4
rate of effusion / $\text{cm}^3\text{ s}^{-1}$					

$$\text{rate of effusion} = \frac{\text{volume of gas}}{\text{time taken}}$$

- (i) Complete Table 2.1.

Give the values for $\sqrt{\frac{1}{M}}$ to **three** significant figures.

Give the values for rate of effusion to **two** decimal places. [2]

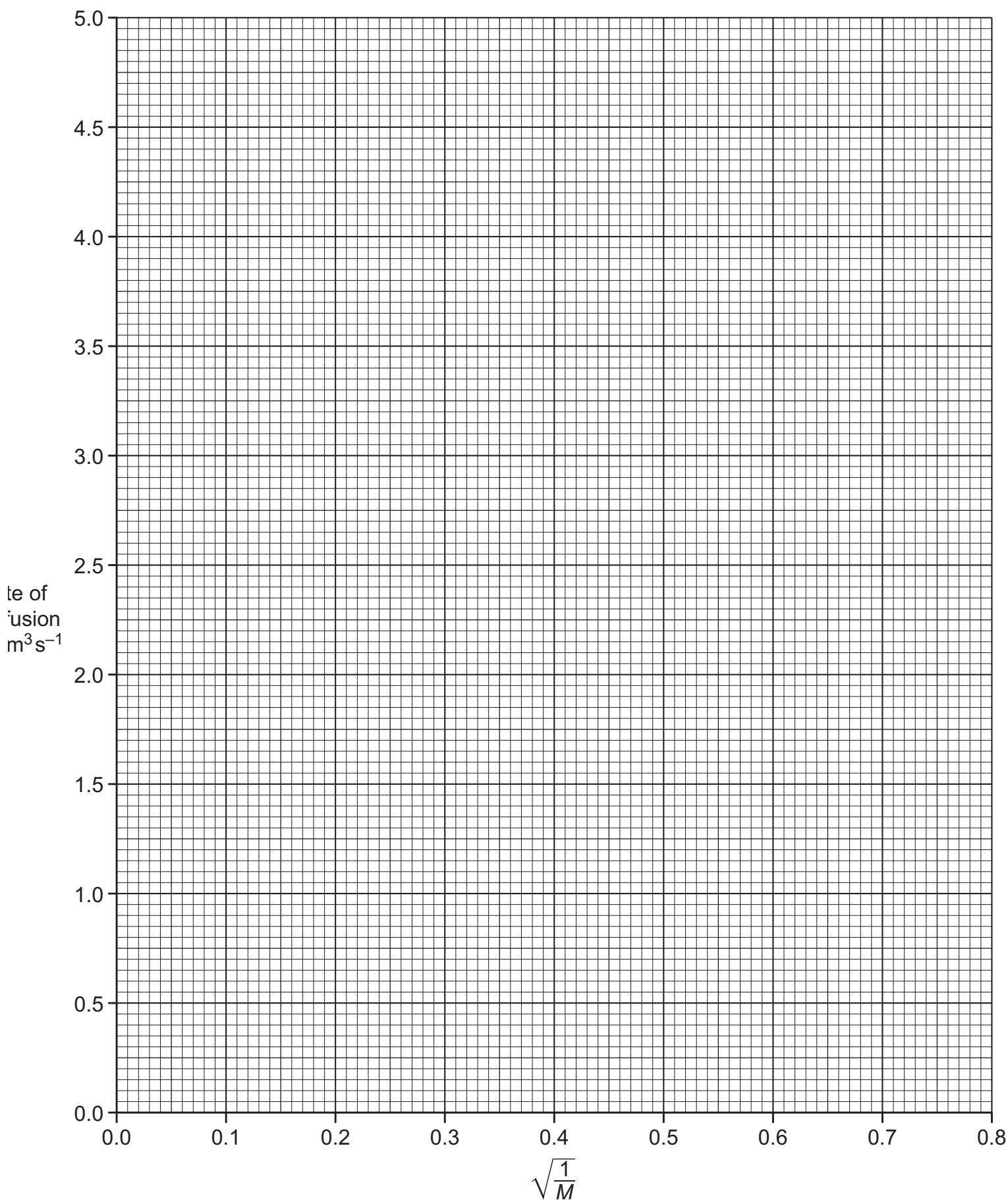
- (ii) Identify the dependent variable in this experiment.

..... [1]

- (iii) Identify a variable, other than temperature, that is controlled when carrying out this experiment.

..... [1]

- (c) Plot a graph on the grid in Fig. 2.2 to show the relationship between rate of effusion and $\sqrt{\frac{1}{M}}$. Use a cross (×) to plot each data point. Draw a suitable line of best fit.

**Fig. 2.2**

- (d) Circle **one** point on the graph in Fig. 2.2 which you consider to be most anomalous.

Suggest **one** reason for this anomaly. Assume there is no error in $\sqrt{\frac{1}{M}}$.

.....
..... [1]

- (e) Graham's law of effusion can be expressed as:

the rate of effusion of a gas is proportional to $\sqrt{\frac{1}{M}}$.

State whether or not the student's results support Graham's law of effusion.

Explain your answer, using the graph in Fig. 2.2.

.....
..... [1]

- (f) Suggest how the position of the plotted points relative to the line of best fit in Fig. 2.2 is related to the reliability of the results.

.....
..... [1]

- (g) The student then repeats this method to determine the value of M of a sample of natural gas.

The time recorded in step 7 is 31.6 s.

- (i) Use the graph in Fig. 2.2 and the student's result to calculate the value of M for this sample.

$M =$ [2]

- (ii) Natural gas is a mixture of mainly methane, CH_4 , with small amounts of other gases.

Suggest what your calculated value of the M of natural gas in (g)(i) tells you about the other gases in the mixture.

.....
..... [1]

(h) The experiment described in (g) is repeated at a higher temperature.

Suggest how the rate of effusion for this sample of natural gas would change, if at all.

Explain your answer.

effect on the rate of effusion

explanation

.....

[1]

[Total: 14]

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 J g ⁻¹ K ⁻¹)

The Periodic Table of Elements

Group																			
1	2													13	14	15	16	17	18