Ideal Gases

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Ideal Gases
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **58 minutes**

Score: **/48**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** State what is meant by an *ideal* gas.

....

.... [1]

(b) A storage cylinder for an ideal gas has a volume of $3.0 \times 10^{-4}\,m^3$. The gas is at a temperature of 23 °C and a pressure of 5.0×10^{7} Pa.

(i) Show that the amount of gas in the cylinder is 6.1 mol.

[2]

(ii) The gas leaks slowly from the cylinder so that, after a time of 35 days, the pressure has reduced by 0.40%. The temperature remains constant.
Calculate the average rate, in atoms per second, at which gas atoms escape from the cylinder.

rate = ... s^{-1} [4]

2 A fixed mass of gas has an initial volume of $5.00 \times 10^{4}\,m^3$ at a pressure of 2.40×10^{5} Pa and a temperature of 288 K. It is heated at constant pressure so that, in its final state, the volume is $14.5 \times 10^{-4}\,m^3$ at a temperature of 835 K, as illustrated in Fig. 3.1.

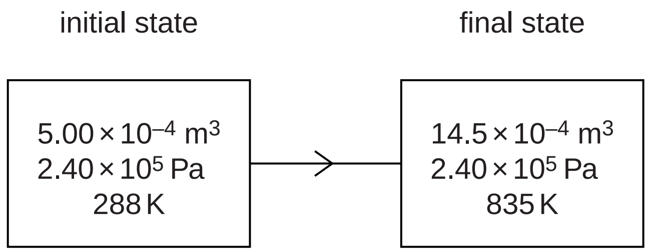

Fig. 3.1

(a) Show that these two states provide evidence that the gas behaves as an ideal gas.

[3]

(b) The total thermal energy supplied to the gas for this change is 569 J.

Determine

(i) the external work done,

work done = ... J [2]

(ii) the change in internal energy of the gas. State whether the change is an increase or a decrease in internal energy.

change in internal energy = ... J

.... [2]

3 **(a)** Explain what is meant by the Avogadro constant.

....

....

.... [2]

(b) Argon-40 ($^{40}_{18}$Ar) may be assumed to be an ideal gas.
A mass of 3.2 g of argon-40 has a volume of 210 cm^3 at a temperature of 37 °C.

Determine, for this mass of argon-40 gas,

(i) the amount, in mol,

amount = ... mol [1]

(ii) the pressure,

pressure = ... Pa [2]

(iii) the root-mean-square (r.m.s.) speed of an argon atom.

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

4 A constant mass of an ideal gas has a volume of $3.49 \times 10^3\,cm^3$ at a temperature of 21.0 °C.

When the gas is heated, 565 J of thermal energy causes it to expand to a volume of $3.87 \times 10^3\,cm^3$ at 53.0 °C. This is illustrated in Fig. 2.1.

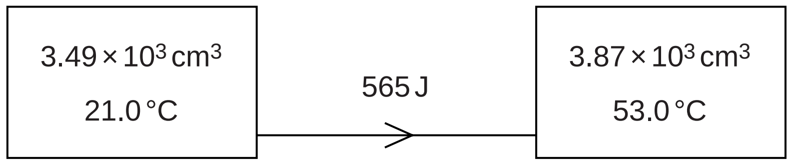

Fig. 2.1

(a) Show that the initial and final pressures of the gas are equal.

[2]

(b) The pressure of the gas is 4.20×10^5 Pa.

For this heating of the gas,

(i) calculate the work done by the gas,

work done = ... J [2]

(ii) use the first law of thermodynamics and your answer in **(i)** to determine the change in internal energy of the gas.

change in internal energy = ... J [2]

(c) Explain why the change in kinetic energy of the molecules of this ideal gas is equal to the change in internal energy.

....

....

....

.... [3]

5 The product of the pressure p and the volume V of an ideal gas is given by the expression

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

where m is the mass of one molecule of the gas.

(a) State the meaning of the symbol

(i) N,

.... [1]

(ii) $\langle c^2\rangle$.

.... [1]

(b) The product pV is also given by the expression

$$pV = NkT.$$

Deduce an expression, in terms of the Boltzmann constant k and the thermodynamic temperature T, for the mean kinetic energy of a molecule of the ideal gas.

[2]

(c) A cylinder contains 1.0 mol of an ideal gas.

(i) The volume of the cylinder is constant.
Calculate the energy required to raise the temperature of the gas by 1.0 kelvin.

energy = ... J [2]

(ii) The volume of the cylinder is now allowed to increase so that the gas remains at constant pressure when it is heated.
Explain whether the energy required to raise the temperature of the gas by 1.0 kelvin is now different from your answer in **(i)**.

....

....

.... [2]

6 **(a)** State what is meant by an *ideal gas*.

....

....

....

.... [3]

(b) Two cylinders A and B are connected by a tube of negligible volume, as shown in Fig. 2.1.

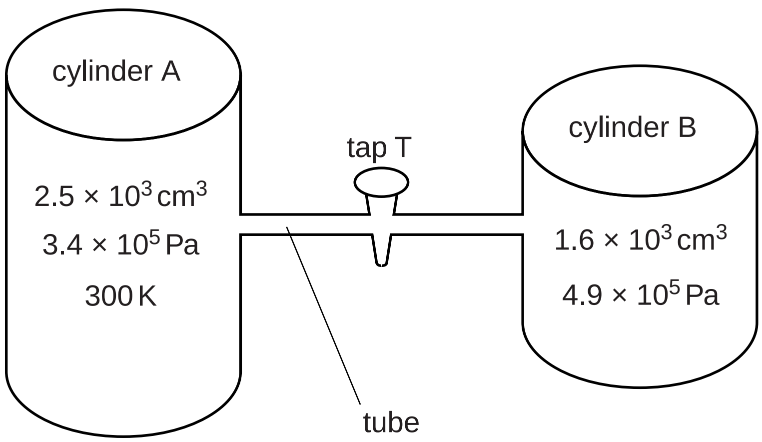

Fig. 2.1

Initially, tap T is closed. The cylinders contain an ideal gas at different pressures.

(i) Cylinder A has a constant volume of $2.5 \times 10^3\,cm^3$ and contains gas at pressure $3.4 \times 10^5\,Pa$ and temperature 300 K.

Show that cylinder A contains 0.34 mol of gas.

[1]

(ii) Cylinder B has a constant volume of $1.6 \times 10^3\,cm^3$ and contains 0.20 mol of gas. When tap T is opened, the pressure of the gas in both cylinders is 3.9×10^5 Pa. No thermal energy enters or leaves the gas.

Determine the final temperature of the gas.

temperature = ... K [2]

(c) By reference to work done and change in internal energy, suggest why the temperature of the gas in cylinder A has changed.

....

....

....

.... [3]