For Examiner's Use

3 (a) (i) The kinetic theory of gases leads to the equation

$$\tfrac{1}{2}m\langle c^2\rangle = \tfrac{3}{2}kT.$$

Explain the significance of the quantity $\tfrac{1}{2}m\langle c^2\rangle$.

....

....

(ii) Use the equation to suggest what is meant by the absolute zero of temperature.

....

....

[3]

(b) Two insulated gas cylinders **A** and **B** are connected by a tube of negligible volume, as shown in Fig. 3.1.

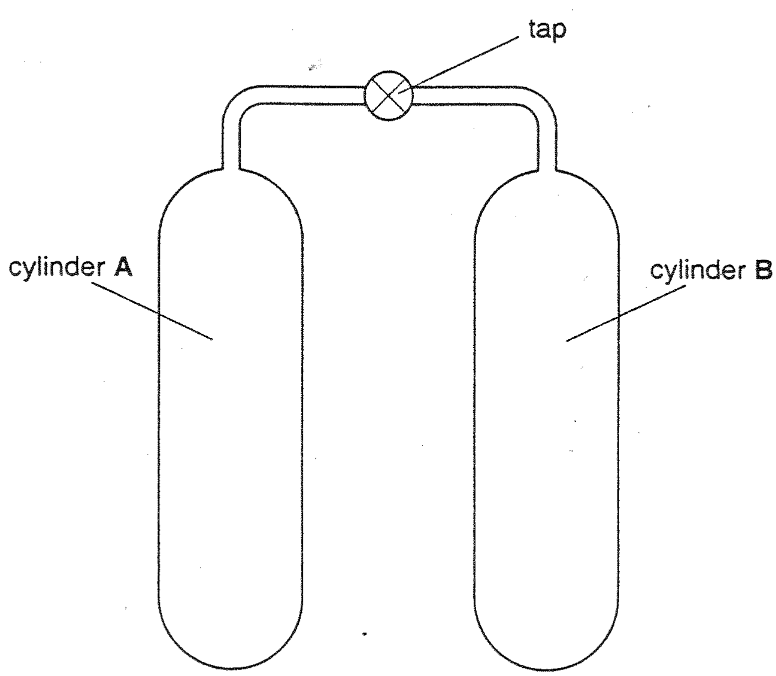

Fig. 3.1

9702/4 J/02 Ideal gases

Each cylinder has an internal volume of $2.0 \times 10^{-2}\,m^3$. Initially, the tap is closed and cylinder **A** contains 1.2 mol of an ideal gas at a temperature of 37 °C. Cylinder **B** contains the same ideal gas at pressure 1.2×10^5 Pa and temperature 37 °C.

(i) Calculate the amount, in mol, of the gas in cylinder **B**.

amount = ... mol

(ii) The tap is opened and some gas flows from cylinder **A** to cylinder **B**. Using the fact that the total amount of gas is constant, determine the final pressure of the gas in the cylinders.

pressure = ... Pa

[6]

J95P3

5 (a) What is meant, in molecular terms, by the *internal energy* of a gas? [2]

(b) State qualitatively and explain in molecular terms, what happens to the internal energy of a fixed mass of an ideal gas when, separately,

(i) the temperature of the gas is raised,

(ii) the volume is decreased at constant temperature,

(iii) the gas as a whole is moving at a certain speed. [6]

(c) The quantity of gas in an engine is 5.2×10^{-3} mol. It has volume $5.0 \times 10^{-5}\,m^3$ and pressure 6.0×10^5 Pa. Assume the gas to be ideal.

(i) Calculate the temperature of the gas. [3]

(ii) The gas is then heated at constant volume, so raising its temperature by 800 K. This is done by supplying 85 J of energy to the gas. Calculate

1. the molar heat capacity of the gas at constant volume,

2. the final pressure of the gas. [5]

(iii) During the power stroke of the engine, the gas expands, doing 62 J of work, but no thermal energy enters or leaves the gas.

1. State the first law of thermodynamics.

2. By applying the law to this process, find the change in the internal energy of the gas during the power stroke. [4]

J96 P3 Q5

(b) (i) What is meant by an *ideal* gas?

(ii) The pressure p of an ideal gas of density ρ is given by the expression

$$p = \tfrac{1}{3}\rho < c^2 > .$$

1. Identify the quantity $< c^2 >$.

2. Deduce an expression for the average translational kinetic energy of a gas molecule in terms of the thermodynamic temperature T. [5]

D94
P3
Q5

5 (a) Some cars are fitted with bags packed into the steering column. In an accident, gas is forced under pressure into the bag and the bag of gas quickly acts as a cushion between the driver and the steering wheel. In one such system, the volume of gas used in the bag is $0.037\,m^3$ when the pressure is 1.8×10^5 Pa and the temperature of the gas is 6 °C. Calculate

(i) the temperature of the gas in kelvins,

(ii) the amount of gas used, in moles,

(iii) the pressure in the bag when the temperature rises to 18 °C assuming the volume to remain constant while the temperature rises. [5]

(b) Explain why the use of the bag described in (a) can reduce injuries. [2]

(c) Consider a cubical box of side l which contains N molecules, each of mass m, all moving horizontally with speed u at right angles to wall A. See Fig. 5.1.

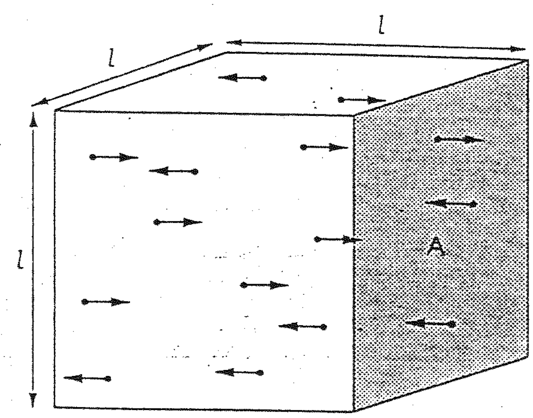

Fig. 5.1

When a molecule hits a wall, it bounces off with no loss of speed and travels in the opposite direction. Deduce

(i) the momentum of a molecule just before a collision with the wall,

(ii) the change in momentum of a molecule when it collides with the wall,

(iii) the time taken by one molecule between collisions with wall A,

(iv) the total number of collisions per unit time made with wall A by all the molecules,

(v) the rate of change of momentum for all the molecules colliding with wall A. [7]

(d) Use your answer to (c) to show that the pressure p on wall A is given by

$$p = \frac{Mu^2}{V},$$

where M is the total mass of all the molecules and V is the internal volume of the box. [2]

(e) The conditions considered in (c) are highly improbable. Explain briefly how the conditions may be altered to provide a better model of an ideal gas. State, without proof, how the equation in (d) might be modified. [4]

J97 P2

For Examiner's Use

4 An ideal gas has volume $0.50\,m^3$ at pressure 1.01×10^5 Pa and temperature 17 °C.

(a) (i) Define *pressure*.

....

(ii) State a unit, other than pascal, for pressure.

.... [2]

(b) Calculate, for this gas, the number of

(i) moles,

number = ...

(ii) molecules.

number = ... [5]

J97 P2

For Examiner's Use

(c) Each molecule may be considered to be a sphere of radius 1.2×10^{-10} m. Calculate

(i) the volume of one molecule of the gas,

volume = ... m^3

(ii) the volume of all the molecules.

volume = ... m^3 [2]

(d) **(i)** State the assumption made in the kinetic theory of gases for the volume of the molecules of an ideal gas.

....

....

(ii) Comment on your answer to **(c)(ii)** with reference to this assumption.

....

.... [3]

J97 P2

For Examiner's Use

5 A student sets up the apparatus illustrated in Fig. 5.1 in order to demonstrate Brownian motion.

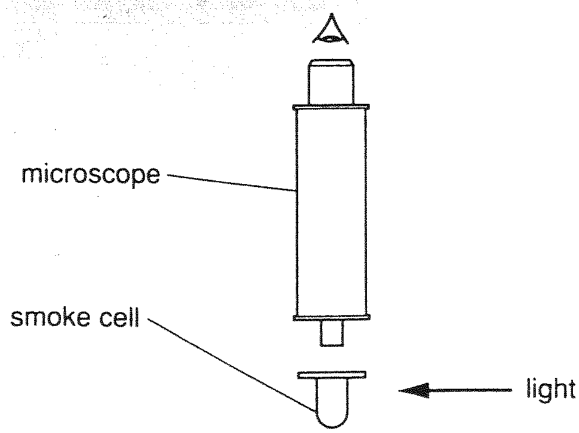

Fig. 5.1

(a) State

(i) the evidence provided by the experiment for the movement of gas molecules,

....

....

(ii) the nature of the movement of gas molecules.

....

.... [3]

(b) State and explain the effect on the observations made if larger smoke particles are used.

....

.... [2]