3 **(a)** One of the assumptions of the kinetic theory of gases is that all collisions involving molecules of the gas are elastic.

(i) State what is meant by an *elastic* collision.

....

.... [1]

(ii) State **two** other assumptions of the kinetic theory of gases.

1. ....

....

2. ....

....
[2]

(b) A molecule of an ideal gas has mass m and is contained in a cubic box of side length L. The molecule is moving with velocity u towards the face of the box that is shaded in Fig. 3.1.

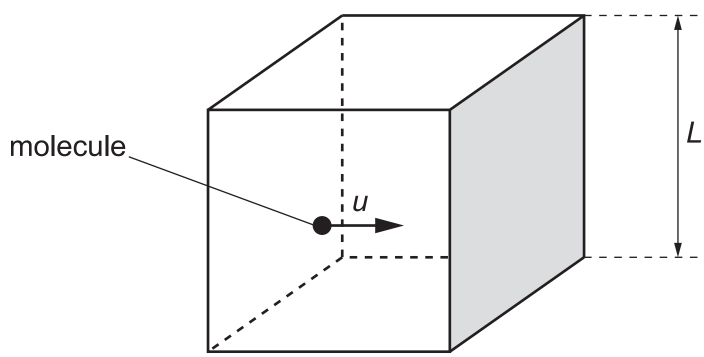

Fig. 3.1

The molecule collides elastically with the shaded face and the face opposite to it alternately.

Deduce expressions, in terms of m, u and L, for:

(i) the magnitude of the change in momentum of the molecule on colliding with a face

change in momentum = ... [1]

(ii) the time between consecutive collisions of the molecule with the shaded face

time = ... [1]

(iii) the average force exerted by the molecule on the shaded face

force = ... [1]

(iv) the pressure on the shaded face if the force in **(iii)** is exerted over the whole area of the face.

pressure = ... [1]

(c) When the model described in **(b)** is extended to three dimensions, and to a gas containing N molecules, each of mass m, travelling with mean-square speed $\langle c^2 \rangle$, it can be shown that

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

where p is the pressure exerted by the gas and V is the volume of the gas.

Use this expression, together with the equation of state of an ideal gas, to show that the average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2}kT$$

where T is the thermodynamic temperature of the gas and k is the Boltzmann constant.

[2]

(d) The mass of a hydrogen molecule is 3.34×10^{-27} kg.

Use the expression for E_K in **(c)** to determine the root-mean-square (r.m.s.) speed of a molecule of hydrogen gas at 25 °C.

r.m.s. speed = ... $\mathrm{m\,s^{-1}}$ [2]

[Total: 11]