

- 3 (a) State what is meant by the *internal energy* of a system.

.....

..... [1]

- (b) A square box of volume V contains N molecules of an ideal gas. Each molecule has mass m .

Using the kinetic theory of ideal gases, it can be shown that, if all the molecules are moving with speed v at right angles to one face of the box, the pressure p exerted on the face of the box follows the expression

$$pV = Nm v^2 \quad (\text{equation 1})$$

This expression leads to the formula

$$p = \frac{1}{3} \rho \langle c^2 \rangle \quad (\text{equation 2})$$

for the pressure p of an ideal gas, where ρ is the density of the gas and $\langle c^2 \rangle$ is the mean-square speed of the molecules.

Explain how each of the following terms in equation 2 is derived from equation 1:

$\frac{1}{3}$:

.....

$\langle c^2 \rangle$:

.....

[2]

- (c) Hence, use equation 2 to show that the internal energy U of an ideal gas is given by

$$U \propto T$$

where T is the thermodynamic temperature of the gas.

[3]

- (d) An ideal gas of volume 0.26 m^3 is at a pressure of $2.0 \times 10^5 \text{ Pa}$ and temperature of 20°C .

- (i) Calculate the number of molecules of the gas.

no. of molecules = [2]

- (ii) Hence, calculate the internal energy of the gas.

internal energy = J [1]

[Turn over

- (e) The volume V of the gas in (d) is now varied, keeping its pressure constant.

On Fig. 3.1, sketch the variation with V of the internal energy U of the gas.

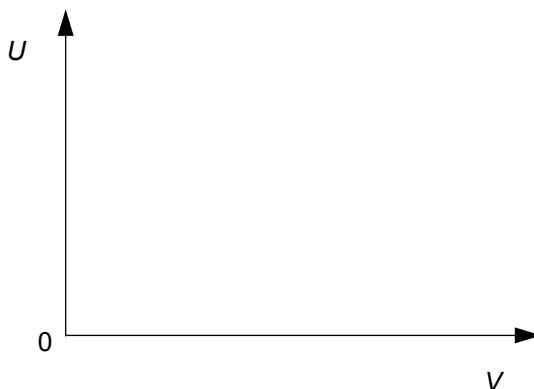


Fig. 3.1

[1]

- (f) The heat capacity of a fixed mass of gas depends on the conditions under which heat is supplied. If the gas is heated at constant pressure, the heat capacity is C_p ; while that heated at a constant volume is C_v .

Suggest, with a reason, if C_p or C_v is higher.

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..... [3]