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

$$pV = Nmv^2 \qquad \text{(equation 1)}$$

This expression leads to the formula

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

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]

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(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 2.0×10^5 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

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(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.

……

……

……

……

…… [3]

[Total: 13]