1. Nov/2020/Paper_41/No.2

(a) The first law of thermodynamics may be expressed as

$$\Delta U = (+q) + (+w)$$

where ΔU is the increase in internal energy of the system.

State the meaning of:

$+q$ ....

....

$+w$. ....

....
[2]

(b) The variation with pressure p of the volume V of a fixed mass of an ideal gas is shown in Fig. 2.1.

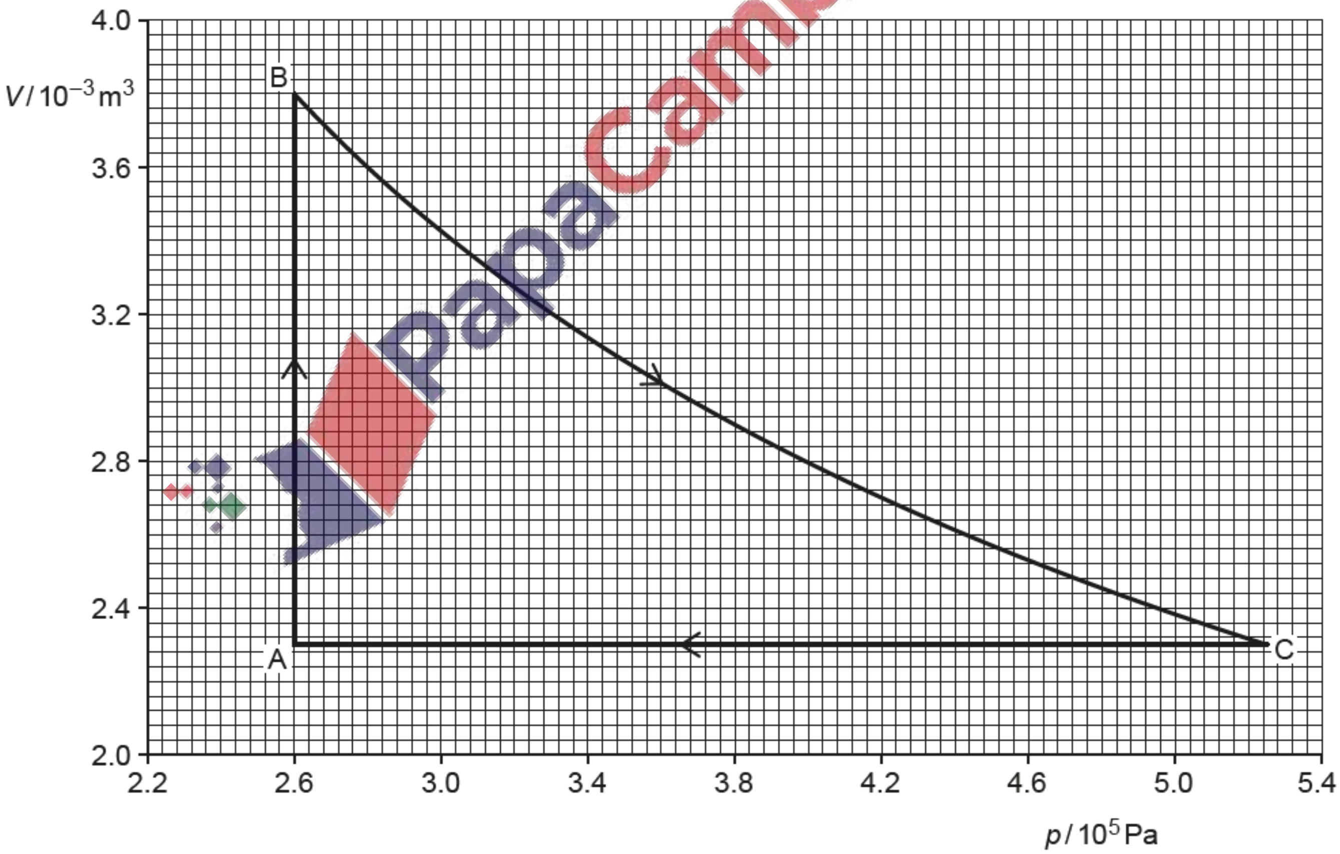

Fig. 2.1

The gas undergoes a cycle of changes A to B to C to A.

During the change A to B, the volume of the gas increases from $2.3 \times 10^{-3}\,m^3$ to $3.8 \times 10^{-3}\,m^3$.

(i) Show that the magnitude of the work done during the change A to B is 390 J.

[1]

(ii) State and explain the total change, if any, in the internal energy of the gas during one complete cycle.

....

....

.... [2]

(c) During the change A to B, 1370 J of thermal energy is transferred to the gas.

During the change B to C, no thermal energy enters or leaves the gas. The work done on the gas during this change is 550 J.

Use these data and the information in **(b)** to complete Table 2.1.

Table 2.1

change	q / J	w / J	ΔU / J
A to B	....	....	....
B to C	....	....	....
C to A	....	....	....

[4]

[Total: 9]

2. Nov/2020/Paper_42/No.2

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

....

....

.... [2]

(b) The atoms of an ideal gas occupy a container of volume $2.30 \times 10^{-3}\,m^3$ at pressure $2.60 \times 10^5\,Pa$ and temperature 180 K, as illustrated in Fig. 2.1.

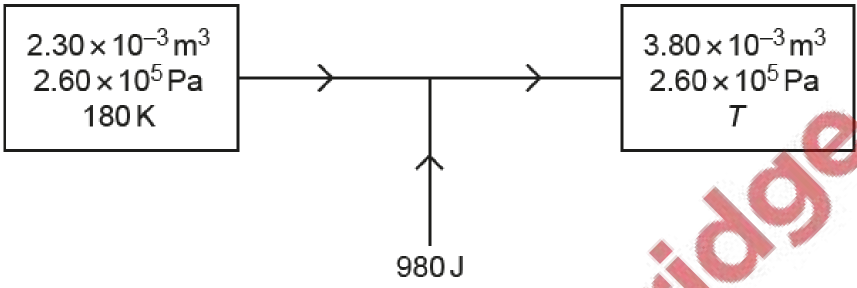

Fig. 2.1

The gas is heated at constant pressure so that its volume becomes $3.80 \times 10^{-3}\,m^3$ at a temperature T.

For the fixed mass of gas, calculate:

(i) the amount of substance, in mol

amount = ... mol [2]

(ii) the temperature T, in K.

T = ... K [2]

(c) During the change in **(b)**, the thermal energy supplied to the gas is 980 J.

(i) Determine the work done on the gas during this change. Explain your working.

work done = ... J [3]

(ii) Determine the change ΔU in internal energy of the gas.

ΔU = ... J [1]

[Total: 10]

3. June/2020/Paper_41/No.2

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

....

....

....

.... [2]

(b) By reference to intermolecular forces, explain why the change in internal energy of an ideal gas is equal to the change in total kinetic energy of its molecules.

....

....

.... [2]

(c) State and explain the change, if any, in the internal energy of a solid metal ball as it falls under gravity in a vacuum.

....

....

....

.... [3]

[Total: 7]

4. June/2020/Paper_42/No.2

(a) 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 is given by 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:

ρ: ....

....

$\frac{1}{3}$: ....

....

$\langle c^2\rangle$: ....

....
[4]

(b) An ideal gas has volume, pressure and temperature as shown in Fig. 2.1.

volume $6.0 \times 10^{-3}\,m^3$
pressure $3.0 \times 10^5\,Pa$
temperature 17 °C

Fig. 2.1

The mass of the gas is 20.7 g.

Calculate the mass of one molecule of the gas.

mass = ... g [4]

[Total: 8]

5. March/2020/Paper_42/No.2

A large container of volume 85 m^3 is filled with 110 kg of an ideal gas. The pressure of the gas is 1.0×10^5 Pa at temperature *T*.

The mass of 1.0 mol of the gas is 32 g.

(a) Show that the temperature *T* of the gas is approximately 300 K.

[3]

(b) The temperature of the gas is increased to 350 K at constant volume. The specific heat capacity of the gas for this change is 0.66 $J\,kg^{-1}\,K^{-1}$.

Calculate the energy supplied to the gas by heating.

energy = ... J [2]

(c) Explain how movement of the gas molecules causes pressure in the container.

....

....

....

....

....

....

.... [3]

(d) The temperature of a gas depends on the root-mean-square (r.m.s.) speed of its molecules.

Calculate the ratio:

$$\frac{\text{r.m.s. speed of gas molecules at 350 K}}{\text{r.m.s. speed of gas molecules at 300 K}}.$$

ratio = ... [2]

[Total: 10]