7 A metal cylinder that contains a fixed amount of a monatomic ideal gas is shown in Fig. 7.1. The cylinder is fitted with a piston that moves freely.

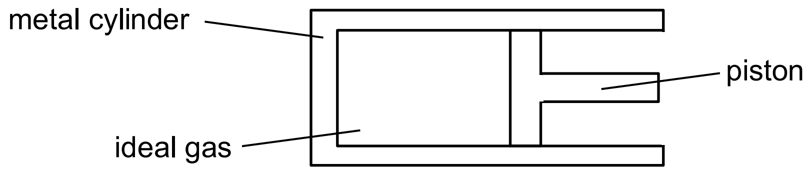

Fig. 7.1

Initially, the gas in the cylinder has a volume of $10.0\ \text{cm}^3$ and a temperature of $27.0\ °\text{C}$. Its initial pressure is the same as the atmospheric pressure of 1.00×10^5 Pa.

(a) **(i)** Explain what is meant by *an ideal gas*.

....

....

.... [1]

(ii) Calculate the number of moles n of gas in the cylinder.

n = ... mol [2]

(b) The gas in the cylinder undergoes a cycle of changes A→B→C→A, where

process A→B: the gas is expanded at a constant temperature until its pressure decreases to 0.10×10^5 Pa.

process B→C: the gas is heated at a constant volume until it reaches atmospheric pressure again.

process C→A: the gas is compressed at a constant pressure until it returns to its initial state.

Fig. 7.2 shows the *p*-*V* curves for two of the three processes.

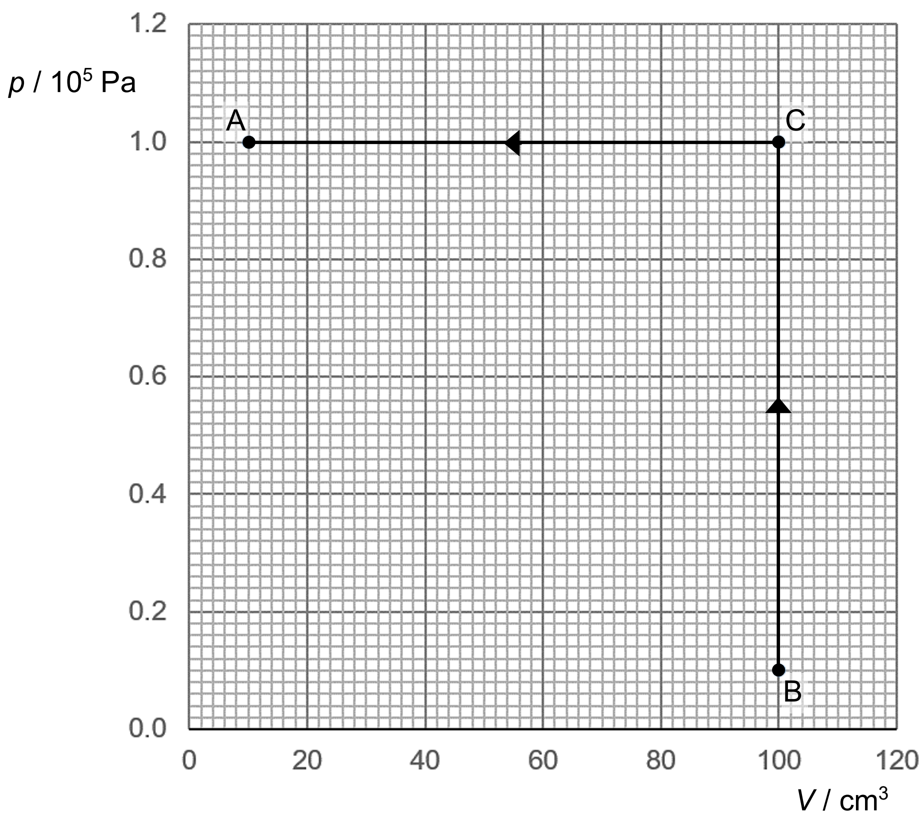

Fig. 7.2

(i) State *the first law of thermodynamics*, indicating the directions of all energy changes.

....

....

....

.... [1]

....

(ii) With reference to the process A→B,

1. state how this process can be achieved in practice,

....

.... [1]

2. complete Fig. 7.2 by drawing the p–V curve as accurately as possible. [2]

(iii) With reference to the process B→C, show that the heat supplied to the gas is 13.5 J.

[2]

(iv) With reference to the process C→A,

1. by considering the change in internal energy during one complete cycle, state and explain the change in internal energy of the gas during this process,

....

....

....

....

....

....

.... [3]

2. compare the rate at which heat is removed from the gas and the rate at which work is done on the gas.

....

....

.... [2]

(c) The product of the pressure p and the volume V of an ideal gas, as derived from the kinetic theory of gases, is given by the equation

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

(i) State the meaning of each of the symbols N, m and $\langle c^2 \rangle$.

N: ....

m: ....

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

(ii) State the assumption of the kinetic theory of gases that allows the potential energies associated with the gas particles to be neglected.

....

.... [1]

(iii) Using the given equation in **(c)**, derive an expression for the relationship between the average translational kinetic energy of a gas particle and the thermodynamic temperature T.

[1]

(iv) Calculate the root-mean-square speed of the gas particles at point B in Fig. 7.2. The mass of one mole of the gas is 14 g.

root-mean-square-speed = ... $m\ s^{-1}$ [2]