2 An ideal gas has a volume of $3.1 \times 10^{-3}\,\text{m}^3$ at a pressure of $8.5 \times 10^5\,\text{Pa}$ and a temperature of 290 K, as shown in Fig. 2.1.

volume $3.1 \times 10^{-3}\,\text{m}^3$		volume $6.3 \times 10^{-3}\,\text{m}^3$
pressure $8.5 \times 10^5\,\text{Pa}$	$\longrightarrow$	pressure $2.7 \times 10^5\,\text{Pa}$
temperature 290 K		temperature T_F

Fig. 2.1

The gas suddenly expands to a volume of $6.3 \times 10^{-3}\,\text{m}^3$. During the expansion, no thermal energy is transferred. The final pressure of the gas is $2.7 \times 10^5\,\text{Pa}$ at temperature T_F, as shown in Fig. 2.1.

(a) Show that the number of gas molecules is 6.6×10^{23}.

[3]

(b) **(i)** Show that the final temperature T_F of the gas is 190 K.

[1]

(ii) 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 and k is the Boltzmann constant.

Calculate the increase in internal energy ΔU of the gas.

ΔU = ... J [3]

(c) Use the first law of thermodynamics to explain why the external work w done on the gas during the expansion is equal to the increase in internal energy in **(b)(ii)**.

....

....

.... [2]

[Total: 9]