

2 (a) State what is meant by an ideal gas.

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(b) A fixed amount of helium gas is sealed in a container. The helium gas has a pressure of $1.10 \times 10^5 \text{ Pa}$, and a volume of 540 cm^3 at a temperature of 27°C .

The volume of the container is rapidly decreased to 30.0 cm^3 . The pressure of the helium gas increases to $6.70 \times 10^6 \text{ Pa}$ and its temperature increases to 742°C , as illustrated in Fig. 2.1.

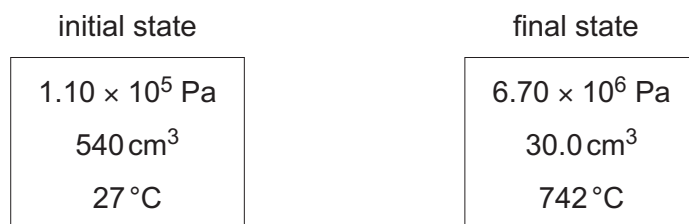


Fig. 2.1

No thermal energy enters or leaves the helium gas during this process.

(i) Show that the helium gas behaves as an ideal gas.

[2]

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

$$\Delta U = q + W.$$

Use the first law of thermodynamics to explain why the temperature of the helium gas increases.

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- (iii) The average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2} kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

Calculate the change in the total kinetic energy of the molecules of the helium gas.

change in kinetic energy = J [3]

- (c) The mass of nitrogen gas in another container is 24.0 g at a temperature of 27 °C. The gas is cooled to its boiling point of –196 °C. Assume all the gas condenses to a liquid.

For this change the specific heat capacity of nitrogen gas is 1.04 kJ kg^{–1} K^{–1}.

The specific latent heat of vaporisation of nitrogen is 199 kJ kg^{–1}.

Determine the thermal energy, in kJ, removed from the nitrogen gas.

energy = kJ [3]