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

....

....

.... [2]

(b) A fixed amount of helium gas is sealed in a container. The helium gas has a pressure of 1.10×10^5 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 6.70×10^6 Pa and its temperature increases to 742 °C, as illustrated in Fig. 2.1.

initial state	final state
1.10×10^5 Pa	6.70×10^6 Pa
$540\,cm^3$	$30.0\,cm^3$
27 °C	742 °C

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.

....

....

....

....

.... [2]

(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]

[Total: 12]