8 **(a)** **(i)** The pressure p of an ideal gas is related to the density ρ of the gas by

$$p = \frac{1}{3}\rho\langle c^2\rangle$$

State what is meant by the symbol $\langle c^2\rangle$.

....

.... [1]

(ii) Use the expression in **(a)(i)** to show that the mean kinetic energy E_k of an ideal gas molecule is given by

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

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

[3]

(b) State the first law of thermodynamics.

....

....

………………………………………………………………………………………………… [2]

(c) Use the first law to explain whether the internal energy increases, decreases or remains constant when

(i) the gas in a balloon expands suddenly when the balloon bursts,

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [3]

(ii) ice melts at constant temperature and constant atmospheric pressure into water that is denser than the ice.

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…………………………………………………………………………………………….. [3]

(d) 1.0 mol of an ideal gas is heated at constant volume.

(i) Use the first law and the mean kinetic energy E_k of an ideal gas molecule in **(a)(ii)** to show that the thermal energy required to raise the temperature of the gas by 1.0 K is $\frac{3}{2}R$ (where R is the molar gas constant).

[3]

(ii) Nitrogen may be assumed to be an ideal gas.
The molar mass of nitrogen gas is 28 g mol^{-1}.

Calculate the specific heat capacity at constant volume for nitrogen.

specific heat capacity = …………………………………… J kg^{-1} K^{-1} [2]

(e) A fixed mass of an ideal gas undergoes the cycle of changes ABCA, as shown in Fig. 8.1.

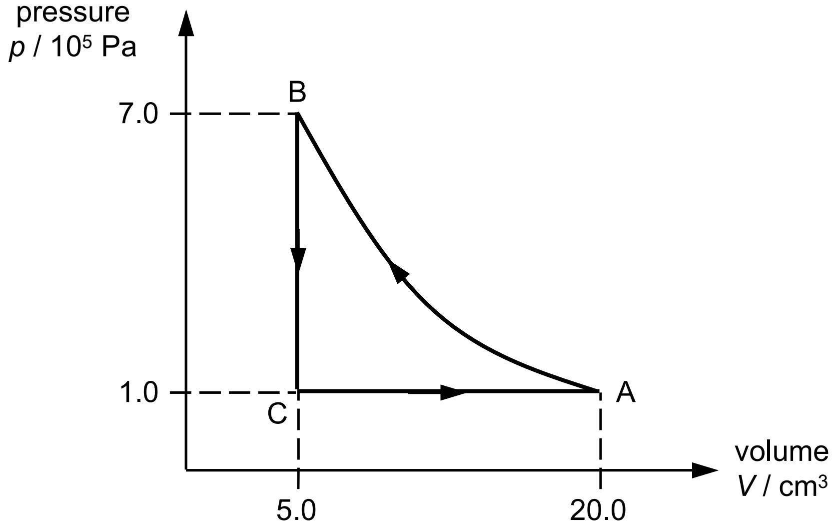

Fig. 8.1

Some energy changes during one cycle of ABCA are shown in Fig. 8.2.

change	heating supplied to gas / J	work done on gas / J	increase in internal energy / J
A $\longrightarrow$ B	0	4.2	
B $\longrightarrow$ C	– 8.5		
C $\longrightarrow$ A			

Fig. 8.2

Complete Fig. 8.2. [3]

[Total: 20]