4 **(a)** State what is meant by *internal energy of an ideal gas.*

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………………………………………………………………………………………… [1]

(b) The variation of pressure with volume for an ideal gas is as shown in Fig. 4.1 below.
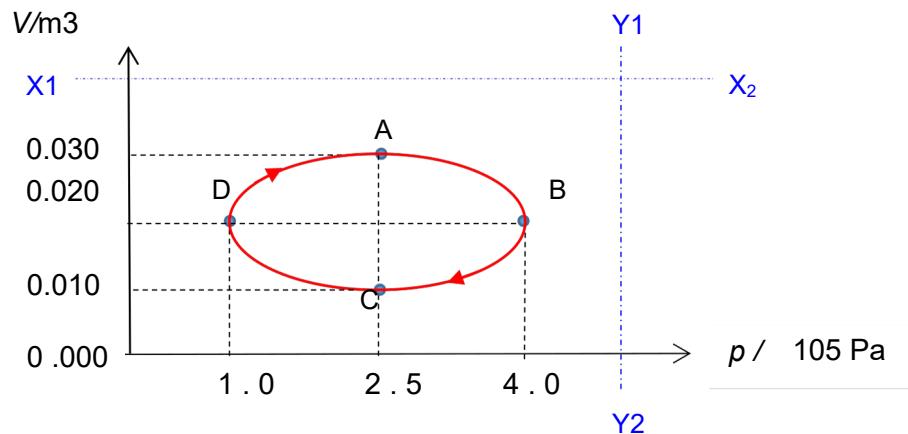

Fig. 4.1

(i) The temperatures T_A, T_B, T_C and T_D at states A, B, C and D respectively are as follows

$$T_D \quad T_C \quad T_A \quad T_B.$$

Show that the relationship between the temperatures is as stated above.

[2]

(ii) Sketch the four isotherms that pass through states A, B, C and D.
Each isotherm must extend to touch lines X1X2 and Y1Y2. [1]

(iii) Explain why there is no change in internal energy of the gas after one
complete cycle from A → B → C → D → A.

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(iv) The *first law of thermodynamics* may be expressed in the form

$$+\Delta U \ = \ (+q) \ + \ (+w).$$

Hence, complete the table in Fig. 4.2 with '+' and '−'.

Process	+ΔU	+q	+w
A → B		−	
B → C			+
C → D		+	
D → A			−
After one complete cycle	0		

Fig. 4.2

[3]

[**Turn over**

(v) Determine the net heat gain afteronecompletecycle.

Hint: Area of an ellipse, $A = \Box ab$

where a and b are the largeandsmallradiirespectively.

net heat gain = ……………………………... J [2]

(c) Arelationship between the average translational kinetic energy and thermal energy is given by the expression

$$\frac{1}{2}m \ c2 \ = \ \frac{3}{2}kT.$$

Explain if the above expression is applicable to the ideal gas in **(b)**.

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