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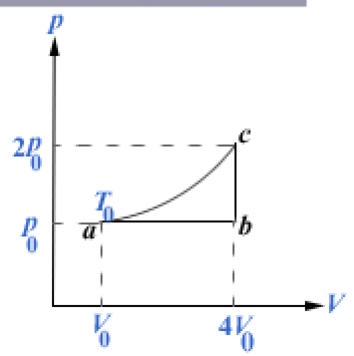
Problem 26.36 (RHK)

One mole of an ideal monatomic gas is caused to go through the cycle as shown in the figure. (a) *We have to find the work done on the gas in expanding the gas from a to c along the path abc.* (b) *We have to find the change in internal energy and entropy in going from b to c.* (c) *We have to find the change in internal energy and entropy in going through one complete cycle. We have to express all answers in terms of the pressure* p_0 *and volume* V_0 *at point a in the diagram.*



Solution:

(a)

The working substance undergoing the cyclic process shown in the figure is one mole of a monatomic ideal gas. At the state *a* the temperature of the gas can be found from the ideal gas equation of state as we know pressure and volume of the gas there are p_0 and V_0, respectively. We have

$$T_0 = \frac{p_0 V_0}{R}.$$

The work done on the gas during its isobaric expansion from a to b will be

$$W = -p_0\left(4V_0 - V_0\right) = -3p_0V_0.$$

And, as the change from *c* to *b* takes place at constant volume, no work is done on the gas during this part of the cycle. Therefore, the work done on the gas during the expansion from *a* to *c* along the path *abc* will be

$$W = -3p_0V_0 = -3RT_0.$$

(b)

Change in the internal energy of the gas from b to c will be

$$E_c - E_b = \frac{3}{2}R\left(T_c - T_b\right) = \frac{3}{2}\left(8p_0V_0 - 4p_0V_0\right) = 6p_0V_0$$
$$= 6RT_0.$$

We calculate the change in entropy between *c* and *b*. As the process b to c takes place at constant volume, heat absorbed

$$dQ = C_V dT = \frac{3}{2} R dT.$$

And,

$$S_c - S_b = \int_{T_b}^{T_c} \frac{C_V dT}{T} = \frac{3}{2} R \ln\left(\frac{T_c}{T_b}\right).$$

As

$$T_c = \frac{8 p_0 V_0}{R}, \text{ and } T_b = \frac{4 p_0 V_0}{R},$$

we find

$$S_c - S_b = \frac{3}{2} R \ln(2).$$

(c)

As the process is cyclic, the change in internal energy and entropy in going through one complete cycle will be zero.