214.

Problem 23.43 (RHK)

Gas occupies a volume of 4.33 L *at a pressure of* 1.17 atm *and a temperature of* 310 K. *It is compressed adiabatically to a volume of* 1.06 L. *We have to determine* (a) *the final pressure and* (b) *the final temperature, assuming the gas to be an ideal gas with* $\gamma = 1.40$. (c) *We have to calculate the work done on the gas.*

Solution:

Data of the problem are

$V_i = 4.33 \text{ L} = 4.33 \times 10^{-3} \text{ m}^3,$

$P_i = 1.17 \times 1.01 \times 10^5 \text{ Pa} = 1.18 \times 10^5 \text{ Pa},$

$T_i = 310 \text{ K},$

$V_f = 1.06 \times 10^{-3} \text{ m}^3,$

and

$\gamma = 1.40.$

(a)

As the gas has been compressed adiabatically, we have

$$P_f V_f^{\gamma} = P_i V_i^{\gamma}.$$

Therefore,

$$P_f = 1.18 \times 10^5 \left(\frac{4.33}{1.06} \right)^{1.4} \text{ Pa} = 8.475 \times 10^5 \text{ Pa=8.39 atm.}$$

(b)

Using the ideal gas equation, we calculate the molar amount of gas.

$$\mu = \frac{P_i V_i}{RT_i} = \frac{1.18 \times 10^5 \times 4.33 \times 10^{-3}}{8.3145 \times 310} \text{ mol} = 0.1985 \text{ mol.}$$

Temperature of the compressed gas can be obtained from the ideal gas equation

$$T_f = \frac{P_f V_f}{\mu R} = \frac{8.475 \times 10^5 \times 1.06 \times 10^{-3}}{0.1985 \times 8.3145} \text{ K} = 544 \text{ K.}$$

(c)

Work done on a gas is given by

$$W = -\int P dV.$$

For an adiabatic process

$$P = \frac{P_i V_i^\gamma}{V^\gamma}.$$

Therefore,

$$W_{adiabatic} = -\int \frac{P_i V_i^{\gamma}}{V^{\gamma}} dV = \frac{1}{(\gamma - 1)}\left(P_f V_f - P_i V_i\right)$$

$$= \frac{1}{(1.4-1)}\left(8.475\times10^{5}\times1.06\times10^{-3} - 1.182\times10^{5}\times4.33\times10^{-3}\right) \text{ J}$$

$$= 966 \text{ J.}$$