「Thermodynamics」 第一章末問題の略解

1, When a body of gas was expanded from V_i to V_f at the pressure of p, the work L is

$$L = \int_{V_i}^{V_f} p\, dV\,. \tag{1}$$

Now $p =$ constant, thus

$$\begin{aligned} L &= p(V_f - V_i) \\ &= 2.34[\mathrm{atm}] \cdot (4.01 - 3.12)[\mathrm{l}] \\ &= 2.34 \times 1.01 \times 10^5[\mathrm{Pa}] \cdot (4.01 - 3.12) \times 10^{-3}[\mathrm{m}^3] \\ &= 2.1 \times 10^2[\mathrm{J}]\,. \end{aligned}$$

In the following questions, we treat ideal gas.
2, The equation of state is witten

$$\begin{aligned} pV &= nRT \\ &= \frac{m}{M} RT\,, \end{aligned} \tag{2}$$

where m is mass, M is molecular weight, R is gas constant, T is temperature. Thus, the pressure p of hydrogen is yields

$$\begin{aligned} p &= \frac{1}{V}\frac{m}{M}RT \\ &= \frac{1}{1[\mathrm{m}^3]} \cdot \frac{30[\mathrm{g}]}{2.0[\mathrm{g/mol}]} \cdot 8.3[\mathrm{J/(K \cdot mol)}] \cdot (273 + 18)[\mathrm{K}] \\ &= 4 \times 10^4[\mathrm{Pa}]\,. \end{aligned}$$

3, From (2), we obtain

$$\frac{m}{V} = \frac{Mp}{RT}\,.$$

We consider the nitrogen at the pressure of 1.013×10^5[Pa]. Then, the density ρ and spesific volume $1/\rho$ are,

$$\begin{aligned}\rho &= \frac{28.00[\mathrm{g/mol}] \cdot 1.013 \times 10^5[\mathrm{Pa}]}{8.314[\mathrm{J/(K \cdot mol)}] \cdot 273[K]} \\ &= 1.25 \times 10^3[\mathrm{g/m^3}] \\ &= 1.25[\mathrm{kg/m^3}]\,, \\ 1/\rho &= 0.800[\mathrm{m^3/kg}]\,.\end{aligned}$$

4, From (1) (2), the work L is given by

$$\begin{aligned}L &= \int_{V_i}^{V_f} p\,dV \\ &= \int_{V_i}^{V_f} \frac{mRT}{MV}\,dV\,.\end{aligned}$$

Now, the process is isothermal,

$$\begin{aligned}L &= \frac{m}{M}RT\int_{V_i}^{V_f} \frac{1}{V}\,dV \\ &= \frac{m}{M}RT\ln\frac{V_f}{V_i}\,.\end{aligned}$$

We consider the oxygen is ideal gas, therefore

$$\frac{V_f}{V_i} = \frac{p_i}{p_f}\,.$$

So, we get

$$\begin{aligned}L &= \frac{m}{M}RT\ln\frac{V_f}{V_i} \\ &= \frac{m}{M}RT\ln\frac{p_i}{p_f} \\ &= \frac{10[\mathrm{g}]}{32[\mathrm{g/mol}]} \cdot 8.31[\mathrm{J/(K \cdot mol)}] \cdot (273+20)[\mathrm{K}] \cdot \ln\left(\frac{1[\mathrm{atm}]}{0.3[\mathrm{atm}]}\right) \\ &= 9 \times 10^2[\mathrm{J}]\,.\end{aligned}$$