11-03-40

Ideal gas quasi-static expands isothermally: $p, V \rightarrow 4V$

How much heat is needed

$$pV = nRT, \quad dE_{int} = dQ - dW$$

$$E_{int} = E_{int}(T), \quad \Delta T = 0 \rightarrow \Delta E_{int} = 0$$

$$dQ = dW = p\,dV = \frac{nRT}{V} \rightarrow \Delta Q = \int_V^{4V} \frac{nRT}{V'}\,dV'$$

$$\Delta Q = nRT\left[\ln V' \Big|_V^{4V}\right] = nRT\left[\ln(4V) - \ln(V)\right]$$

$$= \underline{nRT \ln(4) > 0}$$

11-03-72

Ideal diatomic gas at $T_i = 80K$ compressed adiabatically $V \rightarrow \frac{V}{3}$

Find T_f

$$pV = nRT, \quad dE_{int} = dQ - dW, \quad dW = p\,dV$$

Adiabatic (övermiз) $\rightarrow dQ = 0, \; dW \neq 0 \rightarrow dE_{int}(T) \neq 0 \rightarrow \Delta T \neq 0$

In section 3.6 the authors of the book derive (3.14):

$$T V^{\gamma-1} = \text{Const.} \rightarrow T_i V^{\gamma-1} = T_f \left(\frac{V}{3}\right)^{\gamma-1}$$

$$\rightarrow T_f = T_i \left[\frac{3V}{V}\right]^{\gamma-1} = T_i\, 3^{\gamma-1}$$

$$\gamma - 1 = \frac{C_p}{C_v} - 1 = \frac{C_v + R - C_v}{C_v} = \frac{R}{C_v}$$

Diatomic (tvíatóma) kjörgas

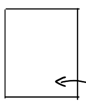
$$C_v = \frac{d}{2}R = \frac{5}{2}R, \quad \text{as} \quad d = \underbrace{3}_{\text{translation 3D}} + \underbrace{1}_{\text{rotation}} + \underbrace{1}_{\text{Vibrations}}$$

$$\rightarrow \gamma - 1 = \frac{2R}{5R} = \frac{2}{5}$$

$$\rightarrow \underline{T_f = T_i (3)^{2/5} \approx 124\ K}$$

11-04-66

Carnot refrigerator



$\rightarrow T_H = 25°C, \rightarrow Q_H$

Freezes $1{,}5g\ H_2O/s$, $T_c = 0°C$

How much work/s or power is needed?

Latent heat for ice: $334\ kJ/kg = 334\ J/g$

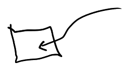
$$\rightarrow Q_c = L_f \cdot m_{ice}, \quad Q_c = K_R W, \quad K_R = \frac{T_c}{T_H - T_c}$$

$$\rightarrow W = Q_c \frac{1}{K_R} = L_f \cdot m_{ice} \frac{1}{K_R}$$

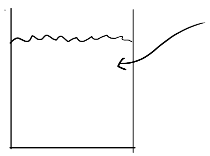
$$P = W/s = L_f \cdot \left(\frac{m_{ice}}{s}\right) \frac{1}{K_R} = 46\ J/s$$

Notice that much higher Q_H is pumped into the environment

11-04-76



$20g$ ice, $T_c = 0°C$



$300g\ H_2O$, $T_H = 60°C$

Estimate the total change in entropy as the mixture comes to equilibrium at T_e

We look at this in steps, the entropy change due to:

1. Melting of the ice
2. Heat transfer from the cold water (coming from the ice) to the hot water
3. mixing of the two bodies of water

The melting is at a fixed temperature

$$\rightarrow \Delta S_{melting} = \frac{Q^{ice}}{T} = \frac{m^{ice} \cdot L_f^{H_2O}}{T_c} = \frac{20g \cdot 335\ J/g}{273\ K}$$

...but, this lowers the temperature of the hot water to

$$T_H \rightarrow T_H'$$

5

Isobaric heat transfer, see Ex. 4.9 in the book

$$\Delta S_c = C \cdot m_c \ln\left\{\frac{T_e}{T_c}\right\} > 0$$

$$\Delta S_H = C\, m_H \ln\left\{\frac{T_e}{T_H'}\right\} < 0$$

$$\Delta S_{T_H \to T_H'} = C\, m_H \cdot \ln\left\{\frac{T_H'}{T_H}\right\} < 0$$

The book does not cover mixing entropy, but wikipedia gives

$$\Delta S_{mix} = -nR\left\{\frac{V_H}{V_H+V_c}\ln\left(\frac{V_H}{V_H+V_c}\right) + \frac{V_c}{V_H-V_c}\ln\left(\frac{V_c}{V_H+V_c}\right)\right\}$$

But, what about T_H'

$$C m_H T_H' = C m_H T_H - L_f m_c$$

$$\to T_H' = T_H - \frac{L_f m_c}{C m_H} = (273+60) - \frac{335 \cdot 20}{4{,}19 \cdot 300} = \underline{328\,K}$$

55°C

6

I stop here, I am not sure the authors of the book had all these details in mind, but we have to have in mind, that we do not know how the ice melts in the water. The details are not accessible, and this is just an estimate of the total entropy changes. It is positive, and we could calculate it using the initial information given.