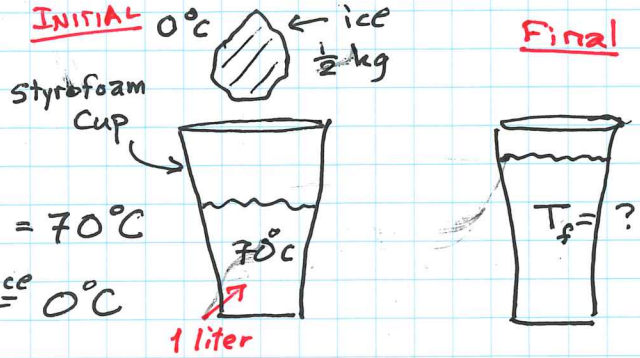
Example of Change in Entropy

Chapter 20

Water – Constants for H_2O

1.) $L_{fusion}^{w,ice} = 334 \times 10^3 \ J/kg$

2.) $c_w = 4190 \ J/kg \cdot K$



Exercise

1 kg of water $T_i = 70°C$

½ kg of ice $T_i^{ice} = 0°C$

$$\overset{(-)}{Q_w} + \overset{+}{Q_{ice}} + \overset{+}{Q_{fus}} = 0$$

$$m_w c_w (T_f - T_i^w) + m_{ice} L_{fus}^{w} + m_{ice} c_w (T_f - 0°C) = 0$$

$$(m_w c_w + m_{ice} c_w) T_f = m_w c_w T_i^w - m_{ice} L_{fus}^{ice}$$

$$T_f = \frac{m_w c_w T_i^w - m_{ice} L_{fus}^{ice}}{m_w c_w + m_{ice} c_w}$$

$$T_f = \frac{1.0(4190)70° - 0.5(334{,}000)}{1.0(4190) + 0.5(4190)} = \frac{126{,}300}{6285} = 20.1°C$$

$$\boxed{T_f = 20.1°C}$$

Change in Entropy

① $\Delta S_{melting} = \frac{Q}{T} = \frac{mL}{273 \ K} = \frac{+\frac{1}{2} kg \ (334{,}000 \ J/kg)}{273 \ K} = +611.7 \frac{J}{K}$

② $\Delta S_{ice \to 20.1°C} = \int_{T_i}^{T_f} \frac{dQ}{T} = m c_w \int_{273}^{293.1} \frac{dT}{T} = 0.5 kg \left(4190 \frac{J}{kg \cdot K}\right) \ln\left(\frac{293.1}{273}\right) = +148.8 \frac{J}{K}$

③ $\Delta S_{water} = \int_{T_i}^{T_f} \frac{dQ}{T} = m_w c_w \int_{343}^{293.1 K} \frac{dT}{T} = 1.0 kg \left(4190 \frac{J}{kg \cdot K}\right) \ln\left(\frac{293.1}{343}\right) = -658.7 \frac{J}{K}$

$273 + 70 \to 343$

$$\Delta S_{TOTAL} = \left(\overset{①}{+611.7} + \overset{②}{148.8} - \overset{③}{658.7}\right) \frac{J}{K} = +101.8 \frac{J}{K}$$

$$\boxed{\Delta S_{TOT} = +101.8 \ J/K}$$

$\Delta S \geq 0$ in a closed system.