Entropy

$dS = \frac{dq_{rev}}{T}$

state function

Reversible Process

Carnot Cycle

$\Delta S = S_f - S_i$

$= \int \left(\frac{dq_{rev}}{T} \right)$

$S = k_B \ln W$

particles

W ← # "ways" a system can exist

– # states accessible to system

$$S = -k_B \sum_{\text{states}, i}^{W} \left[P_i \ln(P_i) \right]$$

$W = 3$

$$-k_B \left[(P_1 \ln P_1) + (P_2 \ln P_2) + (P_3 \ln P_3) \right]$$

2 states: P_1 & P_2 $\quad P_2 + P_1 = 1$

Example: Irreversible Process

Constant $P = 1\,atm$ $\quad \Delta S = ?$

H_2O (liquid, $-10^\circ C$) $\longrightarrow$ H_2O (ice (solid), $-10^\circ C$)

$\uparrow$ $dq = C_p^{liquid}(T)\, dT$

$\downarrow$ Heat solid Ice to $0^\circ C$: $dq = C_p^{solid}(T)\, dT$

H_2O (liquid, $0^\circ C$) $\longleftarrow$ H_2O (solid, $0^\circ C$)

$q_{rev} = \Delta H(\text{solid} \to \text{liquid})$

Construct a Reversible Path / Process

$$\Delta S_1 = \int \left(\frac{dq_{rev}}{T}\right) = \int C_p^{solid}(T)\frac{dT}{T} = \int_{T=-10^\circ C}^{T=0^\circ C} C_p^{solid}(T)\, d(\ln T)$$

$$\Delta S_2 = \int \frac{dq_{rev}}{T} = \frac{1}{T}\int dq_{rev} = \frac{q_{rev}}{T} = \frac{\Delta H}{T}$$

$$\Delta S_3 = \int \frac{dq_{rev}}{T} = \int_{T=0^\circ C}^{T=-10^\circ C} C_p^{liquid}(T)\frac{dT}{T} = \int_{T=0^\circ C}^{T=-10\,C} C_p^{liq}(T)\, d(\ln T)$$