Ideal Gas

Ideal gas law

$$PV = kNT$$

Equipartition law

$$U = \frac{f}{2} kNT$$

with $f = 3$ for a mono-atomic gas and $f = 5$ for a di-atomic gas. Adiabatic expansion

$$pV^{\gamma} = const, \qquad \gamma = (f+2)/2$$

Entropy of an ideal mono-atomic gas

$$S = kN \left\{ \log \left(\frac{V}{N} \left(\frac{4\pi mU}{3Nh^2} \right)^{3/2} \right) + \frac{5}{2} \right\}$$

Entropy and Heat

First law

$$\Delta U = Q + W$$

Thermodynamic Identity

$$dU = TdS - PdV$$

If $W = -PdV$ have $Q = TdS$. Also

$$\frac{1}{T} = \left. \frac{\partial S}{\partial U} \right|_{V,N}, \qquad P = T \left. \frac{\partial S}{\partial V} \right|_{U,N}$$

Specific heat $C = Q/\Delta T$. Have

$$C_V = \left. \frac{\partial U}{\partial T} \right|_{V,N}$$

Enthalpy

$$H = U + PV \qquad \Delta H = Q + W_{other} \ (P = const)$$

Statistical Definition of Entropy

Entropy

$$S = k\log(\Omega)$$

Binomial coefficient

$$\left(\begin{array}{c} N \\ k \end{array}\right) = \frac{N!}{k!(N-k)!}$$

Stirling formula

$$\log(N!) \simeq N\log(N) - N + \ldots$$

Numerical Constants

$$\begin{aligned}
k &= 1.381\times10^{-23}\,J/K = 8.617\times10^{-5}\,eV/K \\
N_A &= 6.022\times10^{23} \\
R &= 8.351\,J/mol/K \\
h &= 6.626\times10^{-34}\,J\cdot s \\
1\,atm &= 1.1013\times10^{5}\,N/m^2 \\
1\,cal &= 4.186\,J \\
1\,eV &= 1.602\times10^{-19}\,J \\
1\,u &= 1.661\times10^{-27}\,kg
\end{aligned}$$