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

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

Entropy of an ideal mono-atomic gas

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

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 ($N \gg 1$)

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

Numerical Constants

$$\begin{aligned}
k &= 1.381 \times 10^{-23}\, J/K = 8.617 \times 10^{-5}\, eV/K \\
N_A &= 6.022 \times 10^{23} \\
R &= 8.315\, J/mol/K \\
h &= 6.626 \times 10^{-34}\, J \cdot s \\
1\, atm &= 1.013 \times 10^{5}\, N/m^2 \\
1\, cal &= 4.186\, J \\
1\, eV &= 1.602 \times 10^{-19}\, J \\
1\, u &= 1.661 \times 10^{-27}\, kg
\end{aligned}$$

Atomic Masses

Hydrogen	1.01u	Helium	4.00u	Carbon	12.0u
Nitrogen	14.0u	Oxygen	16.0u	Iron	55.8u