Formula Sheet

$$PV = NkT \qquad PV = nRT \qquad kN_A = R$$

$$\bar{K}_{trans} = \frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$$

$$U_{trans} = N\bar{K}_{trans} = \frac{3}{2}NkT = \frac{3}{2}PV$$

$$U_{thermal} = N \cdot f \cdot \frac{1}{2}kT$$

$$\Delta U = W + Q$$

$$W = -P\Delta V \quad \text{for constant pressure}$$

$$W = -\int P\,dV \quad \text{for variable pressure}$$

For isothermal compression, $PV = \text{const}$

For adabiatic compression, $VT^{f/2} = \text{const}$ and $V^{(f+2)/f}P = \text{const}$

$$C = Q/\Delta T$$

For the ideal gas, $C_V = fNk/2$ and $C_P = (f+2)Nk/2$

$$H = U + PV$$

Multiplicity of the two-state paramagnet:

$$\Omega(N, q) = \binom{N}{q} = \frac{N!}{q!(N-q)!}$$

Multiplicity of the Einstein solid:

$$\Omega(N, q) = \binom{N+q-1}{q} = \frac{(N+q-1)!}{q!(N-1)!}$$

$$N! \approx N^N e^{-N}\sqrt{2\pi N}$$

$$N! \approx N^N e^{-N}$$

$$\ln N! \approx N \ln N - N$$

For x small, we have:

$$f(x) = f(0) + \frac{df}{dx}|_{x=0}\ x\ +\ \frac{1}{2}\ \frac{d^2 f}{dx^2}|_{x=0}\ x^2$$

$$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \dots$$

$$(1+x)^\alpha = 1 + \alpha x + \frac{1}{2}\alpha(\alpha-1)x^2 + \dots$$

$$S = k \ln \Omega$$

Multiplicity of a monatomic ideal gas:

$$\Omega_N = \frac{V^N}{N!}\ \left(\frac{2\pi m U}{h^2}\right)^{3N/2} \frac{1}{\left(\frac{3N}{2}\right)!} = f(N)\ V^N\ U^{\frac{3N}{2}}$$

The entropy of a monatomic ideal gas is

$$S(N,V,U) = kN\left[\ln\left(\frac{V}{N}\right) + \frac{3}{2}\ln\left(\frac{U}{N}\right) + \frac{3}{2}\ln\left(\frac{4\pi m}{3h^2}\right) + \frac{5}{2}\right]$$

$$T \equiv \left(\left(\frac{\partial S(U,N,V)}{\partial U}\right)_{N,V}\right)^{-1}$$

$$dS = \frac{Q}{T} \qquad \text{quasistatic, reversible only}$$

$$\Delta S = \int_{T_i}^{T_f} \frac{C_V}{T}\ dT$$