Important formulars for StatMech II

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1 Thermostatics

1.1 Equation of State

The **Internal Energy** $U(V, S, N)$ is given in its differential form by:

$$dU = -pdV + TdS + \mu dN. \tag{1}$$

Which yields:

$$-p = \left(\frac{dU}{dV}\right)_{S,N} \quad , \quad T = \left(\frac{dU}{dS}\right)_{V,N} \quad , \quad \mu = \left(\frac{dU}{dN}\right)_{V,S} \tag{2}$$

From this we get the differential form of the entropy S:

$$dS = \frac{1}{T}dU + \frac{p}{T}dV - \frac{\mu}{T}dN. \tag{3}$$

The Legendre-Transforms for U lead to the other functions of the state:

$$\textbf{Helmholtz free energy: } d(U - TS) = -pdV - SdT + \mu dN \tag{4}$$

$$\textbf{Enthalpy: } d(U + pV) = +Vdp + TdS + \mu dN \tag{5}$$

$$\textbf{Gibbs free energy: } d(U - TS + pV) = Vdp - SdT + \mu dN \tag{6}$$

And finally we have the Gibbs-Duhem relation:

$$Nd\mu = Vdp - SdT \tag{7}$$