

10.11: K- Useful Formulas

Isothermal compressibility:

$$\kappa_T = -\frac{1}{V} \left(\frac{\partial V}{\partial p} \right)_{T,N} = \frac{1}{\rho} \left(\frac{\partial \rho}{\partial p} \right)_T = \frac{1}{\rho^2} \left(\frac{\partial^2 p}{\partial \mu^2} \right)_T$$

Master thermodynamic equation:

$$dF = -SdT - pdV - MdH + \sum_i \mu_i dN_i$$

Gibbs-Helmholtz equation:

$$E(T, V, N) = \frac{\partial(F/T)}{\partial(1/T)}_{V,N} = -\frac{\partial \ln Z}{\partial \beta}_{V,N}$$

Free energy from partition function:

$$F(T, V, N) = -k_B T \ln Z(T, V, N)$$

Classical pure point-particle partition function:

$$Z(T, V, N) = \frac{1}{h^{3N} N!} \int d^{3N} p \int d^{3N} r e^{-H(r,p)/k_B T}$$

$$Z(T, V, N) = \frac{1}{\lambda^{3N}(T)} \int d^{3N} r e^{-U(r)/k_B T} \quad \text{where} \quad \lambda(T) = \frac{h}{\sqrt{2\pi m k_B T}}$$

Quantal ideal gases (+ for fermions, - for bosons):

$$\Xi(\beta, \mu) = \prod_{r=1}^M [1 \pm e^{-\beta(\epsilon_r - \mu)}]^{\pm 1}$$

$$\langle n_r \rangle = \frac{1}{e^{\beta(\epsilon_r - \mu)} \pm 1}$$

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