Thermodynamic functions [tln5]

First partial derivatives of thermodynamic potentials with respect to natural independent variables

Entropy:

$$S = -\left(\frac{\partial A}{\partial T}\right)_{X,N} = -\left(\frac{\partial G}{\partial T}\right)_{Y,N} = -\left(\frac{\partial \Omega}{\partial T}\right)_{X,\mu}$$

Temperature:

$$T = \left(\frac{\partial U}{\partial S}\right)_{X,N} = \left(\frac{\partial E}{\partial S}\right)_{Y,N}$$

Volume/magnetization ($X \equiv V, M$):

$$X = -\left(\frac{\partial E}{\partial Y}\right)_{S,N} = -\left(\frac{\partial G}{\partial Y}\right)_{T,N}$$

Pressure/magnetic field ($Y \equiv -p, H$):

$$Y = \left(\frac{\partial U}{\partial X}\right)_{S,N} = \left(\frac{\partial A}{\partial X}\right)_{T,N} = \left(\frac{\partial \Omega}{\partial X}\right)_{T,\mu}$$

Number of particles:

$$N = -\left(\frac{\partial \Omega}{\partial \mu}\right)_{T,X}$$

Chemical potential:

$$\mu = \left(\frac{\partial U}{\partial N}\right)_{S,X} = \left(\frac{\partial E}{\partial N}\right)_{S,Y} = \left(\frac{\partial A}{\partial N}\right)_{T,X} = \left(\frac{\partial G}{\partial N}\right)_{T,Y}$$