Table 20.1 Statistical thermodynamic relations

In terms of the canonical partition function Q

internal energy
$$U - U(0) = -\left(\frac{\partial \ln Q}{\partial \beta}\right)_V$$
$\beta = 1/kT$

entropy
$$S = \frac{U - U(0)}{T} + k \ln Q$$

Helmholz
$$A - A(0) = -kT \ln Q$$
$A = U - TS$

pressure
$$p = kT\left(\frac{\partial \ln Q}{\partial V}\right)_T$$

enthalpy
$$H - H(0) = -\left(\frac{\partial \ln Q}{\partial \beta}\right)_V + kTV\left(\frac{\partial \ln Q}{\partial V}\right)_T$$
$H = U + PV$

Gibbs F.E
$$G - G(0) = -kT \ln Q + kTV\left(\frac{\partial \ln Q}{\partial V}\right)_T$$
$G = H - TS$
$= A + PV$

For indistinguishable, independent particles $Q = q^N/N!$

$$U - U(0) = -N\left(\frac{\partial \ln q}{\partial \beta}\right)_V$$

$$S = \frac{U - U(0)}{T} + nR(\ln q - \ln N + 1)$$

$$G - G(0) = -nRT \ln\left(\frac{q_m}{N_A}\right)$$

$\left.\begin{matrix} U \\ G \\ H \\ A \end{matrix}\right\} \lim_{T \to 0} = U(0)$

where q_m is the molar partition function.
For distinguishable, independent particles $Q = q^N$

$$U - U(0) = -N\left(\frac{\partial \ln q}{\partial \beta}\right)_V$$

$$S = \frac{U - U(0)}{T} + nR \ln q$$

$$G - G(0) = -nRT \ln q$$