# E: Interpreting the Fundamental Equations

The fundamental equation for the variation of a state function $\mathfrak{F}$ expresses the contributions due to changes in its natural independent variables $(x, y, z)$

$$d\mathfrak{I} = \left(\frac{\partial \mathfrak{F}}{\partial x}\right)_{y,z} dx + \left(\frac{\partial \mathfrak{F}}{\partial y}\right)_{x,z} dy + \left(\frac{\partial \mathfrak{F}}{\partial z}\right)_{x,y} dz$$

The following table summarizes the partial derivatives for the most commonly used state functions.

| $\mathfrak{F}$ | fundamental equation | natural independent variables | first derivatives |
|---|---|---|---|
| E | $dE = TdS - PdV + \Sigma_i \tilde{\mu}_i dn_i$ | $S, V, \{n_\mathrm{i}\}$ | $(\partial E/\partial S)_{V,\{n_i\}} = T$<br>$(\partial E/\partial V)_{S,\{n_i\}} = -P$<br>$(\partial E/\partial ni)_{S,V,\{n_{j\neq i}\}} = \tilde{\mu}_i$ |
| H | $dH = TdS + VdP + \Sigma_i \tilde{\mu}_i dn_i$ | $S, P, \{n_\mathrm{i}\}$ | $(\partial H/\partial S)_{P,\{n_i\}} = T$<br>$(\partial H/\partial P)_{S,\{n_i\}} = V$<br>$(\partial H/\partial n_i)_{S,P,\{n_{j\neq i}\}} = \tilde{\mu}_i$ |
| F | $dF = -SdT - PdV + \Sigma_i \tilde{\mu}_i dn_i$ | $T, V, \{n_i\}$ | $(\partial F/\partial T)_{V,\{n_i\}} = -S$<br>$(\partial F/\partial V)_{T,\{n_i\}} = -P$<br>$(\partial F/\partial n_i)_{T,V,\{n_{j\neq i}\}} = \tilde{\mu}_i$ |
| G | $dG = -SdT + VdP + \Sigma_i \tilde{\mu}_i dn_i$ | $T, P, \{n_i\}$ | $(\partial G/\partial T)_{P,\{n_i\}} = -S$<br>$(\partial G/\partial P)_{T,\{n_i\}} = V$<br>$(\partial G/\partial n_i)_{T,P,\{n_{j\neq i}\}} = \tilde{\mu}_i$ |