

Equations of state [tln78]

The empirical specification of a thermodynamic system is traditionally expressed in the form of two kinds of equations of state.

- **Thermodynamic equation of state:**

Functional relation between thermodynamic variables.

For example: $pV = nRT$ (classical ideal gas).

- **Caloric equation of state:**

Temperature dependence of internal energy or heat capacity.

For example: $U = C_V T$ with $C_V = \text{const}$ (classical ideal gas).

The complete thermodynamic information about a system is encoded in this dual specification. In more complex systems the thermodynamic equation of state consists of multiple relations.

The most concise way of encoding the complete specification of a thermodynamic system is in the form of a *thermodynamic potential*. All thermodynamic quantities of interest about a given system can directly be derived from a thermodynamic potential.

Strategies commonly pursued:

- **Equilibrium thermodynamics:**

Construct a thermodynamic potential from the empirical information contained in the thermodynamic and caloric equations of state. Then derive any thermodynamic quantity of interest from the thermodynamic potential.

- **Equilibrium statistical mechanics:**

Derive a thermodynamic potential (or partition function) from the microscopic specification of the system in the form of a many-body Hamiltonian. Then derive any thermodynamic quantity of interest from the thermodynamic potential.