

In thermodynamics, the **Gibbs free energy** is a thermodynamic potential that can be used to calculate the maximum of reversible work that may be performed by a thermodynamic system at a constant temperature and pressure. The Gibbs free energy ($\Delta G = \Delta H - T\Delta S$, measured in joules in SI) is the *maximum* amount of non-expansion work that can be extracted from a thermodynamically closed system (can exchange heat and work with its surroundings, but not matter). This maximum can be attained only in a completely reversible process. When a system transforms reversibly from an initial state to a final state, the decrease in Gibbs free energy equals the work done by the system to its surroundings, minus the work of the pressure forces.^[1]

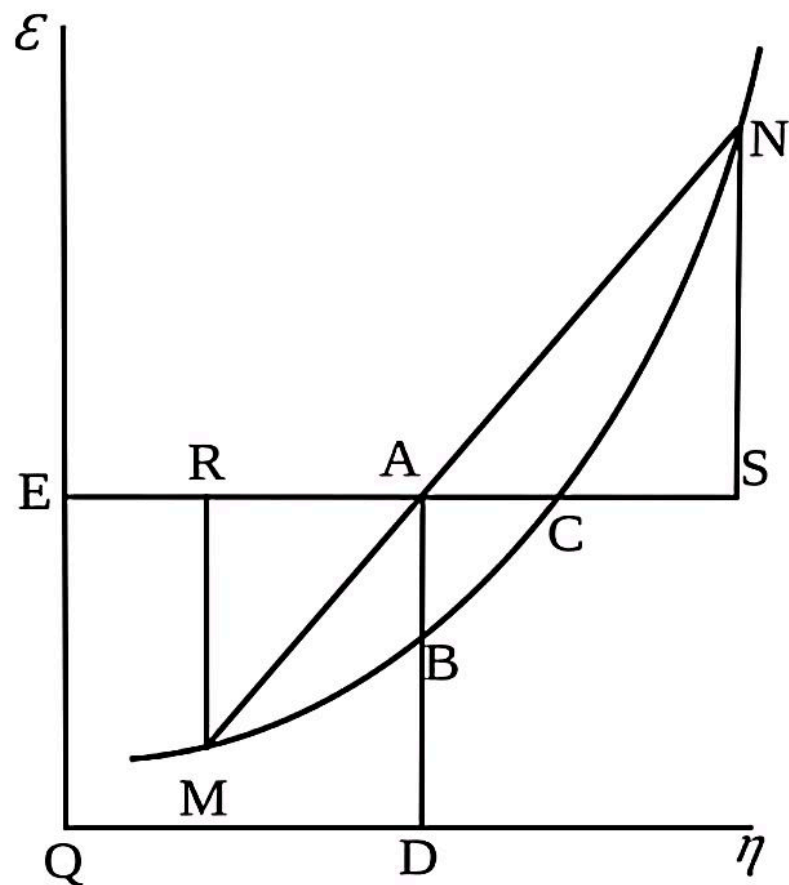
The Gibbs energy (symbol G) is also the thermodynamic potential that is minimized when a system reaches chemical equilibrium at constant pressure and temperature. Its derivative with respect to the reaction coordinate of the system vanishes at the equilibrium point. As such, a reduction in G is necessary for a reaction to be spontaneous at constant pressure and temperature.

The Gibbs free energy, originally called *available energy*, was developed in the 1870s by the American scientist Josiah Willard Gibbs. In 1873,

the greatest amount of mechanical work which can be obtained from a given quantity of a certain substance in a given initial state, without increasing its total volume or allowing heat to pass to or from external bodies, except such as at the close of the processes are left in their initial condition.

The initial state of the body, according to Gibbs, is supposed to be such that "the body can be made to pass from it to states of dissipated energy by reversible processes". In his 1876 magnum opus *On the Equilibrium of Heterogeneous Substances*, a graphical analysis of multi-phase chemical systems, he engaged his thoughts on chemical free energy in full.

If the reactants and products are all in their thermodynamic standard states, then the defining equation is written as $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$.



Willard Gibbs' 1873 available energy (free energy) graph, which shows a plane perpendicular to the axis of v (**volume**) and passing through point A, which represents the initial state of the body. MN is the section of the surface of **dissipated energy**. $Q\varepsilon$ and $Q\eta$ are sections of the planes $\eta = 0$ and $\varepsilon = 0$, and therefore parallel to the axes of ε (**internal energy**) and η (**entropy**), respectively. AD and AE are the energy and entropy of the body in its initial state, AB and AC its *available energy* (Gibbs free energy) and its *capacity for entropy* (the amount by which the entropy of the body can be increased without changing the energy of the body or increasing its volume) respectively.