

Part 1

Equilibrium

The reaction Gibbs energy $\Delta_r G$ is the slope of the graph of Gibbs energy versus the extent of the reaction α : $\Delta_r G = (\partial G / \partial \alpha)_{p,T}$.

The criterion for a spontaneous change is $\Delta_r G < 0$.

The expression for $\Delta_r G$ at an arbitrary stage in the reaction is: $\Delta_r G = \Delta_r G^\ominus + RT \ln Q$.

The expression for $\Delta_r G$ at equilibrium: $\Delta_r G = \Delta_r G^\ominus + RT \ln K = 0$ i.e., $\Delta_r G^\ominus = -RT \ln K$.

The standard reaction Gibbs energy $\Delta_r G^\ominus$ may be calculated from the standard Gibbs energies of formation $\Delta_f G^\ominus$ as: $\Delta_r G^\ominus = \sum_{\text{products}} \nu \Delta_f G^\ominus - \sum_{\text{reactants}} \nu \Delta_f G^\ominus$

The equilibrium quotient in terms of concentrations, partial pressures, and activities $Q_{c,p,a}$ is given by:

$$\frac{\prod_j [\text{product } j]^{v_j}}{\prod_i [\text{reactant } i]^{v_i}} \text{ or } \frac{\prod_j p(\text{product } j)^{v_j}}{\prod_i p(\text{reactant } i)^{v_i}} \text{ or } \frac{\prod_j a(\text{product } j)^{v_j}}{\prod_i a(\text{reactant } i)^{v_i}}$$

The equilibrium constant K_c , K_p or K_a is the value of the equilibrium quotient when the concentrations, partial pressures or activities have their specific equilibrium values.

At equilibrium the rates of the forward and backward reactions are the same. Hence, at equilibrium there is no net change in the amounts of reactants and products present.