Law of Mass Action

Chemical Equilibrium

When a specified chemical system (held at some fixed temperature) after a sufficient amount of time attains a condition of dynamic equilibrium, i.e. it has evolved to the status of a state: **then in particular the amounts and concentrations of reactants and products are no longer changing with time** even though forward and reverse reactions are occurring at the microscopic level at equal rates.

It is interesting to ask if there is a more subtle relationship involving equilibrium reactant and product concentrations, a relationship which is independent of any non-equilibrium initial concentrations of any experiment carried out at the specified temperature. In other words, can we start with an arbitrary mixture of reactants and products at a specified temperature, let the system evolve until equilibrium is reached, and then discover some property which is independent of the arbitrary initial concentrations.

Such a relationship was discovered by Norwegians Cato Guldberg and Peter Waage around 1865:

For an given reaction system, say **aA + bB <- ->cC + dD** at a specified temperature,

where the lower case letters are stoichiometric coefficients and the capital letters are chemical formulas,

Guldberg and Waage found that when dynamic equilibrium is reached, the ratio $[C]^c[D]^d/[A]^a[B]^b = K$, a constant. K is called the equilibrium constant and K is constant in the sense that this quantity is independent of starting concentrations of reactants and products.

Here [X] means “molarity of species X”.

For historical reasons, Guldberg and Waage called this data pattern the “Law of Mass Action”. We will call it the Law of Equilibrium Concentrations.

Here is an English translation Guldberg and Waage’s original paper.