Chapter 17: Chemical Equilibrium

Start with a physical example…

I. Characteristics of a System at Equilibrium

A. Co-existence of reactants and products

B. No change in the concentrations of any species over time

C. Dynamic Balance: The forward reaction (conversion of reactants to products) and the reverse reaction (conversion of products to reactants) keep happening, but at equal rates

II. Law of Mass Action

A. Consider concentration of gases and solutes only

B. For the process $a\,A + b\,B \rightleftharpoons c\,C + d\,D$
the equilibrium concentrations obey the "mass action expression":

$$K_c \equiv K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

where ***K* is the equilibrium constant** and [X] is the molarity of X (mol X/L container or solution)

C. *K* is (nevertheless) a unitless number

D. *K* indicates the relative stability of reactants and products:

a. If $K < 1$, reactants are more stable than products
b. If $K > 1$, products are more stable than reactants

An example from atmospheric chemistry…

III. Reaction Quotient (*Q*)

B. Also compute using the mass action expression:

$$Q_c \equiv Q = \frac{[C]_t^c [D]_t^d}{[A]_t^a [B]_t^b}$$

C. Difference between *Q* and *K*: *Q* is based on the concentrations at any point in time (*t*)—does not have to characterize a system at equilibrium

D. *Q* tells us how the reaction system must change to achieve equilibrium:

a. If $Q < K$, reaction moves right (to products) to achieve equilibrium
b. If $Q > K$, reaction moves left (to reactants) to achieve equilibrium
c. If $Q = K$, <u>congratulations</u>! The reaction is already at equilibrium