Chapter 7: Equilibrium – fast facts

7.1 Equilibrium

Many reactions are reversible. These reactions will reach a state of equilibria when the rates of the forward reaction and reverse reaction are equal. The position of equilibrium can be controlled by changing the conditions.

- Equilibrium state is when rate of forward reaction = rate of backward reaction in a closed system.
- The equilibrium mixture contains a fixed concentration of reactants and products.
- For a reaction $aA + bB \rightarrow cC + dD$

  $$Kc = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$
- K_c, the equilibrium constant, is a constant for a given reaction at a specified temperature.
- The higher the value of K_c the further to the right the equilibrium mixture lies.
- Q, the reaction quotient, is a measure of the relative amounts of reactants and products in a reaction mixture at a particular time. It is calculated by substituting non-equilibrium values for reactant and product concentration into the equilibrium expression:

  if $Q = K_c$, then the reaction is at equilibrium

  if $Q < K_c$, reaction is not at equilibrium; reaction proceeds to right in favour of products

  if $Q > K_c$, reaction is not at equilibrium; reaction proceeds to left in favour of reactants.
- Manipulations of the same reaction at the same temperature are expressed by corresponding changes to the value of K_c:

  inversing the reaction $\Rightarrow K_c^{-1}$

  doubling the reaction coefficients $\Rightarrow K_c^2$

  halving the reaction coefficients $\Rightarrow \sqrt{K_c}$

  adding together two reactions $\Rightarrow K_{c1} \times K_{c2}$
- When a change is applied to an equilibrium mixture, the composition will change to minimize the effect of the change. The new equilibrium mixture will have different concentrations of reactant and product, but the value of K_c will be unchanged at the same temperature.
- Catalysts do not change the yield or the equilibrium mixture because they have an equal effect on the forward and backward reactions.
- Optimum conditions for an industrial process are based on equilibrium, kinetic, and economic considerations.
- When K_c is very small, $[R]_{equilibrium} \approx [R]_{initial}$
- The equilibrium law is used in calculations of reacting concentrations and equilibrium mixtures.
- Equilibrium occurs at a maximum value of entropy and a minimum value of Gibbs free energy.
- Gibbs free energy, ΔG, and the equilibrium constant, K_c, can both be used to measure the position of an equilibrium reaction. They are related by the expression $\Delta G = -RT \ln K$

17.1 The equilibrium law

The position of equilibrium can be quantified by the equilibrium law. The equilibrium constant for a particular reaction only depends on the temperature.

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Get it straight

- The *only* thing that changes the value of K_c for a reaction is the temperature.