

Equilibrium and kinetics Notesheet

$K_P > K_c$: at Equilibrium, $[P] > [R]$. Lies to the right, or Favors products.

$K_P = K_c$: at Equilibrium, $[P] = [R]$. Lies to the left, or Favors reactants.

$K_P < K_c$: at Equilibrium, $[R] > [P]$. Lies to the left or Favors reactants.

$$K_c = \frac{[R]^d}{[P]^a} \cdot \frac{[A]^b}{[B]^c} \quad [K_c = K_{eq}]$$

$$K_P = \frac{[P]^a \cdot [B]^c}{[R]^d \cdot [A]^b}$$

$$K_P = K_c (RT)^{\Delta n} \quad (\Delta n = \text{moles of gas, P} - \text{moles of gas, R})$$

$$K_P = K_c \quad \text{if } \Delta n = 0$$

	Stress	Change in K or Q	Results
Equimolar Res ⁿ	Add more reac.	decrease Q	Reaction to the right
	Remove reac.	increase Q	Reaction to the left
	Add more prod.	increase Q	Reaction to the left
	Remove prod.	decrease Q	Reaction to the right
Substantive Res ⁿ	Increase Temp.	decrease K	Reaction to the left
	Decrease Temp.	increase K	Reaction to the right
	Increase Temp.	increase K	Reaction to the right
	Decrease Temp.	decrease K	Reaction to the left
	Inc. partial p.	shift K	Reaction to fewer gas mole.
	Dec. partial p.	shift K	Reaction to more gas mole.
	Inc. volume	shift K	Reaction to more gas mole.
	Dec. volume	shift K	Reaction to fewer gas mole.
	Adding Catalyst	No change to K or Q	Reach equilibrium sooner

Relating Q , K and ΔG

$$\Delta G < 0 \quad Q < K$$

$$\Delta G > 0 \quad Q > K$$

$$\Delta G = 0 \quad Q = K$$

Characteristics
 Spontaneous, towards products (right)
 Spontaneous, towards reactants (left)
 Reaction at Equilibrium

Homogeneous vs Heterogeneous Equilibria

Homogeneous: same phases. Usually gas or aqueous sol.
 Heterogeneous: different phases.

K_c consists of only gaseous or aqueous phases of products and reactants.

K vs Q

Q is Reaction Quotient = current conc. of reactants and products.

If $Q > K$ then: proceeds towards the reactants

$Q = K$ then: equilibrium achieved.

$Q < K$ then: proceeds towards products.

Thermodynamics and Equilibrium

At Eq $\Delta G = 0$, $Q = K$

$$\therefore \Delta G = \Delta G^\circ + RT \ln Q$$

$$0 = \Delta G^\circ + RT \ln K$$

$$-RT \ln K = \Delta G^\circ$$

OR

$$K = e^{\left[\frac{-\Delta G^\circ}{RT}\right]}$$

Notesheet

Van't Hoff Equation

$$K = e^{\left[\frac{-\Delta G^\circ}{RT}\right]}$$

$$\ln K = \frac{-\Delta G^\circ}{RT} = \ln K = \frac{-\Delta H^\circ + T\Delta S^\circ}{RT}$$

$$\ln K = \frac{-\Delta H^\circ}{R} \left[\frac{1}{T}\right] + \frac{\Delta S^\circ}{R} \quad \text{slope} = \frac{-\Delta H^\circ}{R}$$

$$\ln \left[\frac{K_2}{K_1}\right] = \frac{-\Delta H^\circ}{R} \left[\frac{1}{T_1} - \frac{1}{T_2}\right] \quad \text{Notesheet}$$

Conjugate acid / base pair

Strong acids have weaker affinity for protons, and have weak conjugate bases.

Weak acids have stronger affinity for protons and have strong conjugate base.

pH and acidity

$$-\log [H^+] = pH$$

$$\downarrow pH = \uparrow \text{Acidity}$$

$$-\log [OH^-] = pOH$$

$$\uparrow pH = \uparrow \text{Basicity}$$

$$pH + pOH = 14$$

$$K_w = [H^+][OH^-]$$

\hookrightarrow ion product constant.

$$\text{At } 25^\circ C (298K), K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$$

$$K_a K_b = K_w$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$TK_b = \text{Base strength } \uparrow$$

$$pK_b = \text{Base strength } \uparrow$$

Identifying acids and bases

A strong acid completely dissociates in water. Weak acids only partially dissociates.

A strong base ionizes completely in water, a weak base only partially ionize.

Bronsted Lowry Definition: Acids \rightarrow donate protons, Bases \rightarrow accept protons

Compounds who act as an acid / base depending on what else is present: amphoteric compounds. Eg. water

$$K_a [\text{acid ionization constant}] = \frac{[A^-][H^+]}{[HA]}$$

$$pK_a = -\log(K_a)$$

$$K_a \uparrow \quad \text{Acid Strength } \uparrow$$

$$K_a \uparrow \quad pH \downarrow$$

$$pK_a \downarrow \quad \text{Acid Strength } \uparrow$$

$$pK_a \downarrow \quad pH \downarrow$$

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