

CHEM 20B Week 8

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Acid-Base Equilibria

Arrhenius Definition of Acids and Bases

- Acids: when dissolved in water increases the concentration of H_3O^+
- Bases: when dissolved in water increases the concentration of OH^-

Brønsted-Lowry Definition of Acids and Bases

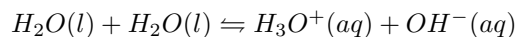
- Acids: Proton donor
- Bases: Proton acceptor

Lewis Definition of Acids and Bases

- Electron pair acceptor
- Electron pair donor

Properties of Acids and Bases in Aqueous Solutions: The Brønsted-Lowry Scheme

Autoionization of Water



K_w , the acid-base constant of water is determined by

$$K_w[\text{H}_3\text{O}^+][\text{OH}^-]$$

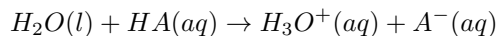
This constant varies by temperature.

Temperature Dependence of K_w

Temperature ($^{\circ}\text{C}$)	K_w	pH of Water
0	0.114×10^{-14}	7.47
10	0.292×10^{-14}	7.27
20	0.681×10^{-14}	7.08
25	1.01×10^{-14}	7.00
30	1.47×10^{-14}	6.92
40	2.92×10^{-14}	6.77
50	5.47×10^{-14}	6.63
60	9.61×10^{-14}	6.51

Strong Acids

Strong Acids ionize completely in aqueous solution.

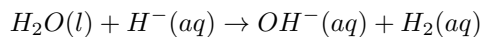
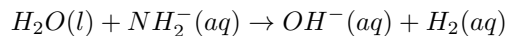


Common Strong Acids

- HBr (aq)
- HCl (aq)
- HI (aq)
- HNO₃ (aq)
- HClO₄ (aq)
- HClO₃ (aq)
- H₂SO₄ (aq)

Strong Bases

Strong Bases react completely to give OH^- when put in water.



Common Strong Bases

- Group 1 hydroxides
- Alkaline earth metal hydroxides
- Group 1 and Group 2 oxides

The pH Function

$$pH = -\log_{10}[H_3O^+]$$

At 25°C,

- $pH < 7$ = Acidic solution
- $pH = 7$ = Neutral solution
- $pH > 7$ = Basic solution

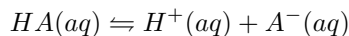
Similar to how $[H_3O^+][OH^-] = K_w$, $pH + pOH = pK_w$.

As a consequence,

- $[H^+] = 10^{-pH}$
- $[OH^-] = 10^{-pOH}$

Acid and Base Strength

Acid strength is based on the extent to which they are ionized in solution.



The Acid Ionization Constant, K_a is a quantitative measure of the strength of the acid.

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

If:

- $K_a \gg 1 \rightarrow$ HA is a strong acid.
- $K_a \ll 1 \rightarrow$ HA is a weak acid.

Convenient characterization of strength of acid is pK_a .

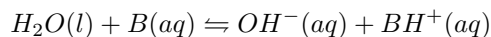
$$pK_a = -\log_{10}(K_a)$$

For Example:

$$K_a = 10^7 \rightarrow pK_a = -7 \text{ (strong acid)}$$

$$K_a = 10^{-5} \rightarrow pK_a = 5 \text{ (weak acid)}$$

Similarly to acids, base strength is represented by K_b , which is inversely related to the strength of its conjugate acid.



$$K \equiv K_b = \frac{[OH^-][BH^+]}{[B]}$$

Similarly, a convenient characterization of strength of base is pK_b .

$$pK_b = -\log_{10}(K_b)$$

If:

- $K_b \gg 1 \rightarrow$ strong base, many OH^- produced, little $[B]$ left.
- $K_b \ll 1 \rightarrow$ weak base, most $[B]$ remains.

Importantly,

$$K_b K_a = K_w$$

$$pK_b + pK_a = pK_w$$