Lecture Notes O: Acid-Base Chemistry II

1) Bronsted-Lowry definition of an acid and a base:
   Acid: proton donor
   Base: proton acceptor

Examples of Bronsted acids and bases:

\[ \text{HAc} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Ac}^- \quad (\text{HAc} = \text{CH}_3\text{COOH}, \quad \text{Ac}^- = \text{CH}_3\text{COO}^-) \]

\[ \text{H}_2\text{S} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HS}^- \]

\[ \text{HS}^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{S}^2^- \]

\[ \text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- + \text{NH}_4^+ \]

\[ \text{Ac}^- + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- + \text{HAc} \]

\[ \text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^- \]
2) Weak acids and bases

Hydrofluoric acid \( \text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{F}^- \) \( K_a = 6.6 \times 10^{-4} \) \( pK_a = 3.18 \)

Formic acid \( \text{HCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HCOO}^- \) \( K_a = 1.77 \times 10^{-4} \) \( pK_a = 3.75 \)

Acetic acid \( \text{HAc} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Ac}^- \) \( K_a = 1.76 \times 10^{-5} \) \( pK_a = 4.75 \)

Nitrous acid \( \text{HNO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NO}_2^- \) \( K_a = 4.6 \times 10^{-4} \) \( pK_a = 3.34 \)

Acetyl Salicylic acid \( \text{C}_9\text{H}_8\text{O}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_9\text{H}_7\text{O}_4^- \) \( K_a = 3 \times 10^{-4} \) \( pK_a = 3.52 \)

Hydrocyanic acid \( \text{HCN} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{CN}^- \) \( K_a = 6.17 \times 10^{-10} \) \( pK_a = 9.21 \)

Ammonia \( \text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^- \) \( K_b = 1.79 \times 10^{-5} \) \( pK_b = 4.74 \)

\( \text{C}_2\text{H}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{C}_2\text{H}_3\text{NH}_3^+ + \text{OH}^- \) \( K_b = 5.6 \times 10^{-4} \) \( pK_b = 3.25 \)

Problem
What is the pH of a 1M solution of acetic acid?
3) Hydrolysis

What is the pH of a 1M solution of Sodium Acetate?
Concept

Consider an exceptionally weak acid, HA, with a $K_a = 1 \times 10^{-20}$. You make a 0.1M solution of the salt NaA. What is the pH?

a) 1  b) 2  c) 12  d) 13

4) Various acid-base reactions

Acid dissociation

$$
HAc + H_2O \leftrightarrow H_3O^+ + Ac^- \\
K_a = 1.76 \times 10^{-5} \quad (pK_a = 4.75)
$$

Hydrolysis

$$
Ac^- + H_2O \leftrightarrow OH^- + HAc \\
K_b = Kw/K_a = 5.68 \times 10^{-10}.
$$

Reverse of the above:

$$
Ac^- + H_3O^+ \leftrightarrow HAc + H_2O \\
1/K_a = 5.68 \times 10^4
$$

$$
HAc + OH^- \leftrightarrow Ac^- + H_2O \\
1/K_b = 1.76 \times 10^9
$$