Chapter 14 Part 3

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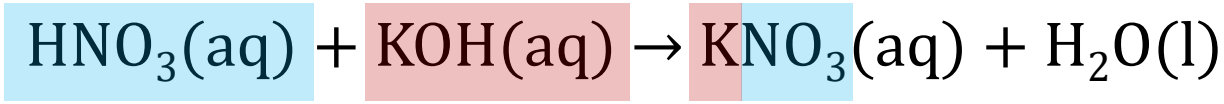
Conjugate acid/base strength

- The conjugate acids of weak bases are stronger
- The conjugate bases of weak acids are stronger
- The conjugate acids of strong bases are so weak that they are neutral
- The conjugate bases of strong acids are so weak that they are neutral

Acid-Base Reactions



Acid

Base

Salt (First part comes from the base, second part comes from the acid)

Water

Strong acid and strong base salts

The products of a strong acid and strong base reaction will form a neutral solution since the conjugate acid and base produced are of negligible strength

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Neutral conjugate acid + Neutral conjugate base = Neutral salt

Strong acids and weak bases

- Strong acids and weak bases yield a weakly acidic solution because of the conjugate acid that results from the weak base

$$HCl(aq) + NH_3(aq) \rightarrow NH_4Cl(aq)$$

Stronger conjugate acid + Neutral conjugate base = Acidic salt

Weak acids and strong bases

- Weak acids and strong bases yield a weakly basic solution because of the conjugate acid that results from the weak base

$$HC_2H_3O_2(aq) + NaOH(aq) \rightarrow H_2O(l) + NaC_2H_3O_2(aq)$$

Neutral conjugate acid + Stronger conjugate base = Basic salt

Weak acids and weak bases

- A weak acid and weak base can yield an acidic, basic, or neutral solution.
- There are three cases
  1. Stronger weak acids and weaker bases
  2. Weaker acids and stronger weak bases
  3. Weaker acids and equally weak bases

Stronger weak acids and weaker bases

1. When the conjugate acid is stronger than the conjugate base, the resulting salt is slightly acidic

$$HSO_4^-(aq) + NH_3(aq) \rightarrow NH_4SO_4^-(aq)$$

- Since the K_a of HSO_4^- is 1.1×10^{-2} and the K_b of NH_3 is 1.8×10^{-5}, their resulting salt, $NH_4SO_4^-(aq)$, is slightly acidic.

Stronger conjugate acid + Weaker conjugate base = Acidic salt

Weaker acids and stronger weak bases

2. When the conjugate acid is weaker than the conjugate base, the resulting salt is slightly basic

$$HC_2H_3O_2(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3C_2H_3O_2(aq)$$

- Since the K_a of $HC_2H_3O_2^-$ is 1.8×10^{-5} and the K_b of $CH_3NH_2(aq)$ is 4.4×10^{-4}, their resulting salt, $C_6H_5NH_3C_2H_3O_2(aq)$, is slightly basic.

Weaker conjugate acid + Stronger conjugate base = Basic salt

Weaker acids and equally weak bases

3. When the weak acid and weak base are of the same strength their respective conjugate acid and base have the same strength and are neutral

$$HC_2H_3O_2(aq) + NH_3(aq) \rightarrow NH_4C_2H_3O_2(aq)$$

- Since the K_a of $HC_2H_3O_2$ is 1.8×10^{-5} and the K_b of NH_3 is 1.8×10^{-5}, their resulting salt, $NH_4C_2H_3O_2(aq)$, is neutral.

Stronger conjugate acid + Equally strong conjugate base = Neutral salt

Predicting the acidity of salts

- As a general rule the stronger thing determines the salt acidity

1. Stronger acid + Weaker base → Acidic salt
2. Weaker acid + Stronger base → Basic salt
3. Strong acid + Equally strong base → Neutral salt

Qualitatively Predicting Hydrolysis Reactions

Predict whether each of the following solutions is acidic, basic, or pH neutral

A. $NaOCl\ (HOCl, K_a = 2.9 \times 10^{-8})$
B. KCl
C. $NH_4NO_3\ (NH_3, K_b = 1.8 \times 10^{-5})$
D. $NH_4F\ (NH_3, K_b = 1.8 \times 10^{-5}; HF, K_a = 3.5 \times 10^{-4})$
E. $NaHCO_3\ (H_2CO_3, K_a = 4.7 \times 10^{-11})$

Acidity of salts

Identify the acidic salt solution.

A. $CaBr_2$
B. $KNO_2(aq)$
C. $K_2SO_4(aq)$
D. $LiC_2H_3O_2(aq)$
E. $NH_4Cl(aq)$

Basicity of salts

Identify the basic salt solution.

A. $NaNO_3(aq)$
B. $KCl(aq)$
C. $NH_4Cl\,(aq)$
D. $LiC_2H_3O_2(aq)$
E. $CaBr_2$

Ionization Constants for Hydrolysis Reactions

If solutions of sodium nitrite, $NaNO_2$, and sodium benzoate, $NaC_7H_5O_2$, have the same molarity, which solution will have the higher pH? $HNO_2, K_a = 7.2 \times 10^{-4}$; $HC_7H_5O_2, K_a = 6.3 \times 10^{-5}$

A. $NaNO_2$
B. $NaC_7H_5O_2$
C. Their pH values are the same

Calculating the pH of Salt solutions

A solution of NaF has a concentration of 0.10 M (HF, $K_a = 6.6 \times 10^{-4}$). (A) Is NaF acidic or basic. (B) Write the reaction of the acidic or basic component of part A reacting with water. (C) What is the pH of the solution?

Calculating the pH of Salt solutions

A solution of $C_6H_5NH_3ClO_3$ has a concentration of 0.30 M ($C_6H_5NH_2, K_b = 4.3 \times 10^{-10}$). (A) Is $C_6H_5NH_3ClO_3$ acidic or basic. (B) Write the reaction of the acidic or basic component of part A reacting with water. (C) What is the pH of the solution?

Calculations using salt solutions

The pH of an aqueous solution of NH_4Cl is 5.38. For $NH_3, K_b = 1.8 \times 10^{-5}$. (A) Is NH_4Cl acidic or basic. (B) Write the reaction of the acidic or basic component of part A reacting with water. (C)What was the initial $[NH_4{}^+]$ in this solution?