# Chapter 14 (continued)

## Equilibria in Solutions of Weak Acids and Bases

## Weak Acids

* Only a small percentage of weak acid molecules ionize in water to give $H_3O^+$ ions.
* $K_A$ = Acid Dissociation Constant and specifies the equilibrium established by the acid in water.

***Example:*** For the weak acid HA. Write the equilibrium of the weak acid HA in water (i.e. the equilibrium specified by $K_A$).

HA Eq:

The value of $K_A$ gives information on _____.

**Q** Which is the stronger acid: acetic acid ($K_A=1.8x10^{-5}$), hydrofluoric acid ($K_A=3.5x10^{-4}$), or hydrochloric acid ($K_A = 2x10^6$)? Write the eq. specified by $K_A$ for these three acids.

**Q** Which is the stronger acid: boric acid with $pK_a = 9.24$ or carbonic acid with $pK_a = 6.37$?

# Weak Bases

* Only a small percentage of weak base ionizes in water to give $OH^-$ ions.
* $K_B$ = Base Dissociation Constant and specifies the equilibrium established by the base in water.

***Example:*** For the weak base B. Write the equilibrium of the weak base B in water (i.e. the equilibrium specified by $K_B$).

B Eq:

The value of $K_B$ gives information on _____.

**Q** Which is the stronger base: ammonia ($NH_3$, $K_B=1.8 \times 10^{-5}$), methylamine ($CH_3NH_2$, $K_B=3.7 \times 10^{-4}$), or dimethylamine ($(CH_3)_2NH$, $K_B=5.4 \times 10^{-4}$)? Write the equilibrium specified by $K_B$ for these bases.

# pH of Weak Acids and Bases

## Sample Questions

1. Calculate the pH, pOH and percent ionization of 2.5 M HF. For HF, $K_A = 3.5 \times 10^{-4}$.

2. Calculate the pH, pOH, and percent ionization of 0.75 M ammonia. For ammonia, $K_B = 1.8 \times 10^{-5}$.

3. A solution of the weak acid formic acid (HCOOH) has a pH of 2.14 when the concentration of formic acid is 0.30 M. What is the numerical value of the acid ionization constant for formic acid? What is the percent ionization of the formic acid?

4. Morphine ($C_{17}H_{19}NO_3$), a narcotic used in painkillers, is a weak organic base. If the pH of a 7.0 x $10^{-4}$ M solution of morphine is 9.5, what are the values of $K_b$, $pK_b$ and percent ionization? ($K_b$ = 1 x $10^{-6}$; $pK_b$ = 5.8, % = 5 %)

## Polyprotic Acids

1. Calculate the pH and the concentrations of all species present ($HSO_3^-$, $SO_3^{2-}$, $H_3O^+$, and $OH^-$) in a 0.25 M $H_2SO_3$ solution. $K_{a1}$ = 1.5x$10^{-2}$; $K_{a2}$ = 6.3 x $10^{-8}$.

2. Calculate the pH and concentration of all species present ($H_2CO_3$, $HCO_3^-$, $CO_3^{2-}$, $H_3O^+$, and $OH^-$) in a 0.020 M carbonic acid. $K_{a1}$ = 4.3 x $10^{-7}$; $K_{a2}$ = 5.6 x $10^{-11}$. (pH=4.03; $[H_2CO_3]$=0.020 M; $[H_3O^+]=HCO_3^-]$= 9.3 x $10^{-5}$ M; $[CO_3^{2-}]$= 5.6x$10^{-11}$; $[OH^-]$=1.1x$10^{-10}$M )

# Acid – Base Properties of Salts

*Hydrolysis – when a salt (ionic compound) is dissolved in water, a neutral, acidic, or basic solution is obtained dependent on the identity of the cation and anion.*

Keep in mind……strong acids have _____ conjugate bases that have _____ to react with water (or hydrolyze); while weak acids have _____ conjugate bases that have _____ to react with water (or hydrolyze).

How is a salt formed?

Example:

**CASE #1: Basic Salts ($pH_{soln} > 7$)**

Salts derived from…..

Ex. $KNO_2$, NaF, $KC_2H_3O_2$

Use equations to show how $KNO_2$ forms a basic solution when dissolved in water.

**CASE #2: Neutral Salts ($pH_{soln} = 7$)**

Salts derived from…..

Ex. NaCl, KBr, $Ca(NO_3)_2$, $KClO_4$

Use equations to show how KBr forms a neutral solution when dissolved in water.

**CASE #3: Acidic Salts ($pH_{soln} < 7$)**

Salts derived from…..

Ex. $NH_4Cl$, $CH_3NH_3Br$

Use equations to show how $NH_4Cl$ forms an acidic solution when dissolved in water.

**CASE #4:** **Acidic Salts (pH soln < 7)**
Salts derived from…..

Ex. $AlCl_3$, $FeBr_2$, $ZnCl_2$, $FeI_3$, $CrBr_3$, $Pb(NO_3)_2$

Use equations to show how $AlCl_3$ forms an acidic solution when dissolved in water.

*We could also look at salts that contain cation from weak base (i.e. strong conj acid) and anion from weak acid (i.e. strong conj base) but that is beyond the scope of this course. The pH of a solution of this type of salt would depend on the relative values of $K_A$ and $K_B$ for the conjugates.*

### Sample Questions

1. Classify each of the following salt solutions as acidic, basic or neutral:

$KClO_4$ $NaNO_2$ $NH_4Br$ $Zn(NO_3)_2$ $NH_4F$

$K_2CO_3$ $KC_2H_3O_2$ $Fe(ClO_4)_2$ $NaClO_3$ NaF

2. Which of the following ions will hydrolyze and what type of solution (acidic or basic) will result?

$PO_4^{3-}$ $N_2H_5^+$ $I^-$ $Cr^{+3}$ $S^{2-}$ $ClO_3^-$ $N_3^-$ $(CH_3)_3NH^+$

# Relationship Between $K_A$ and $K_B$

*For a conjugate acid-base pair, the two equilibrium constants ($K_A$ and $K_B$) are related through $K_W$.*

Using the conjugate acid-base pair HF ($K_A$=3.5x10$^{-4}$)/$F^-$, derive the relationship between $K_A$ for HF and $K_B$ for $F^-$.

HF Eq:
$F^-$ Eq: _____
Net Eq:

### Calculation of pH of Salt: Sample Questions

1. Calculate the pH of 0.45 M NaF. ($K_A$for HF = 3.5x10$^{-4}$)

2. Calculate the pH of 0.75 M $NH_4ClO_4$ ($K_B$ for $NH_3$ = 1.8x10$^{-5}$).

3. Calculate the pH for each of the following solutions:
   a. 0.10 M $AlCl_3$; $K_a(Al(H_2O)_6^{3+})$ = 1.4 x 10$^{-5}$ (2.93)
   b. 0.20 M $NaNO_2$; $K_a$ ($HNO_2$) = 4.5 x 10$^{-4}$ (8.32)