

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 Ionization 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 ($K_A=1.8 \times 10^{-5}$), hydrofluoric acid ($K_A=6.8 \times 10^{-4}$), or hydrochloric acid ($K_A = 2 \times 10^6$)? Write the eq. specified by K_A for these three acids.
- Q** Which is the stronger acid: boric acid with $\text{p}K_a = 9.14$ or carbonic acid with $\text{p}K_a = 6.35$?

Weak Bases

- * Only a small percentage of weak base molecules ionize in water to give OH^- ions.
- * K_B = Base Ionization 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 , $K_B=4.4 \times 10^{-4}$), or dimethylamine ($(\text{CH}_3)_2\text{NH}$, $K_B=9.6 \times 10^{-4}$)? 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, $K_A = 6.8 \times 10^{-4}$.

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

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

Polyprotic Acids

- 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. $K_{a1} = 1.2 \times 10^{-2}$; $K_{a2} = 6.6 \times 10^{-8}$.
- 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. $K_{a1} = 4.3 \times 10^{-7}$; $K_{a2} = 5.6 \times 10^{-11}$. (pH=4.03; $[H_2CO_3]=0.020$ M; $[H_3O^+]=HCO_3^-]=9.3 \times 10^{-6}$ M; $[CO_3^{2-}]=5.6 \times 10^{-11}$; $[OH^-]=1.1 \times 10^{-10}$ 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 ($\text{pH}_{\text{soln}} > 7$)

Salts derived from.....

Ex. KNO_2 , NaF , $\text{KC}_2\text{H}_3\text{O}_2$

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

CASE #2: Neutral Salts ($\text{pH}_{\text{soln}} = 7$)

Salts derived from.....

Ex. NaCl , KBr , $\text{Ca}(\text{NO}_3)_2$, KClO_4

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

CASE #3: Acidic Salts ($\text{pH}_{\text{soln}} < 7$)

Salts derived from.....

Ex. NH_4Cl , $\text{CH}_3\text{NH}_3\text{Br}$

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 , $\text{Pb}(\text{NO}_3)_2$

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 $\text{Zn}(\text{NO}_3)_2$ NH_4F
 K_2CO_3 $\text{KC}_2\text{H}_3\text{O}_2$ $\text{Fe}(\text{ClO}_4)_2$ 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^- $(\text{CH}_3)_3\text{NH}^+$

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 ($K_A=6.8 \times 10^{-4}$)/ 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

- Calculate the pH of 0.45 M NaF. (K_A for HF = 6.8×10^{-4})
- Calculate the pH of 0.75 M NH_4ClO_4 (K_B for $\text{NH}_3 = 1.8 \times 10^{-5}$).
- Calculate the pH for each of the following solutions:
 - 0.10 M AlCl_3 ; $K_a(\text{Al}(\text{H}_2\text{O})_6^{3+}) = 1.4 \times 10^{-5}$ (2.93)
 - 0.20 M NaNO_2 ; $K_a(\text{HNO}_2) = 4.6 \times 10^{-4}$ (8.32)