Chapter 19

Acids and Bases

Properties of acids

- Taste Sour (kids, don't try this at home).
- Conduct electricity.
- Some are strong, some are weak electrolytes.
- React with metals to form hydrogen gas.
- Change indicators (litmus red).
- React with hydroxides to form water and a salt.

Properties of bases

- React with acids to form water and a salt.
- Taste bitter.
- Feel slippery (Don't try this either).
- Can be strong or weak electrolytes.
- Change indicators (litmus blue).

Types of Acids and Bases

Several Definitions

Arrhenius Definition

- Acids produce hydrogen ions in aqueous solution.
- Bases produce hydroxide ions when dissolved in water.
- Limits to aqueous solutions.
- Only one kind of base.
- NH_3 ammonia could not be an Arrhenius base.

Polyprotic Acids

- Some compounds have more than 1 ionizable hydrogen.
- HNO_3 nitric acid - monoprotic
- H_2SO_4 sulfuric acid - diprotic - 2 H^+
- H_3PO_4 phosphoric acid - triprotic - 3 H^+

Bronsted-Lowry Definitions

- An acid is a proton (H^+) donor and a base is a proton acceptor.
- Acids and bases always come in pairs.
- HCl is an acid.
- When it dissolves in water it gives its proton to water.
- $HCl(g) + H_2O(l) \rightleftharpoons H_3O^+ + Cl^-$
- Water is a base -makes hydronium ion.

Come in Pairs

- General equation
- $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$
- Acid + Base $\rightleftharpoons$ Conjugate acid + Conjugate base
- This is an equilibrium.
- $B(aq) + H_2O(l) \rightleftharpoons BH^+(aq) + OH^-(aq)$
- Base + Acid $\rightleftharpoons$ Conjugate acid + Conjugate base
- $NH_3(aq)+H_2O(l) \rightleftharpoons NH_4^+(aq)+OH^-(aq)$

Water

- Water ionizes- falls apart into ions.
- $H_2O \rightarrow H^+ + OH^-$
- Called the self ionization of water.
- Only a small amount.
- $[H^+] = [OH^-] = 1 \times 10^{-7}M$
- A neutral solution.
- In water $Kw = [H^+] \times [OH^-] = 1 \times 10^{-14}$
- Kw is called the ion product constant.

Ion Product Constant

- $H_2O \rightleftharpoons H^+ + OH^-$
- Kw is constant in every aqueous. solution $[H^+] \times [OH^-] = 1 \times 10^{-14}M^2$
- If $[H^+] > 10^{-7}$ then $[OH^-] < 10^{-7}$
- If $[H^+] < 10^{-7}$ then $[OH^-] > 10^{-7}$
- If we know one, we can determine the other.
- If $[H^+] > 10^{-7}$ acidic $[OH^-] < 10^{-7}$
- If $[H^+] < 10^{-7}$ basic $[OH^-] > 10^{-7}$

Logarithms

- Powers of ten.
- A shorthand for big, or small numbers.
- $pH = -\log[H^+]$
- in neutral $pH = -\log(1 \times 10^{-7}) = 7$
- in acidic solution $[H^+] > 10^{-7}$
- $pH < -\log(10^{-7})$
- $pH < 7$
- in base $pH > 7$

pH and pOH

- $pOH = -\log[OH^-]$
- $[H^+] \times [OH^-] = 1 \times 10^{-14}M^2$
- $pH+pOH = 14$

[H^+]

10^0 10^{-1} 10^{-3} 10^{-5} 10^{-7} 10^{-9} 10^{-11} 10^{-13} 10^{-14}

pH

0 1 3 5 7 9 11 13 14

Acidic **Neutral** **Basic**

14 13 11 9 7 5 3 1 0

pOH

10^{-14} 10^{-13} 10^{-11} 10^{-9} **Basic** 10^{-7} 10^{-5} 10^{-3} 10^{-1} 10^0

[OH^-]

How Strong

Strength

- Strong acids and bases are strong electrolytes
- They fall apart completely.
- Weak acids don’t completely ionize.
- Concentrated- much dissolved.
- Strong forms many ions when dissolved.
- $Mg(OH)_2$ is a strong base- it falls completely apart when dissolved.
- Not much dissolves.

Measuring strength

- Ionization is reversible.
- $HA \rightleftharpoons H^+ + A^-$
- makes an equilibrium.
- Equilibrium constant for an acid(acid dissociation constant.)
- $K_a = \frac{[H^+][A^-]}{[HA]}$
- Stronger acid- more products.
- larger K_a (pg 450)

What about bases?

- Strong bases dissociate completely.
- $B + H_2O \rightleftharpoons BH^+ + OH^-$
- Base dissociation constant.
- $K_b = \frac{[BH^+][OH^-]}{[B]}$
- We can ignore the water because it’s concentration doesn’t change.
- Stronger base more dissociated.
- Larger K_b.

Practice

- Write the expression for HNO_2
- Write the K_b for NH_3

Neutralization reactions

Neutralization Reactions

- Acid + Base $\rightarrow$ Salt + water
- Salt = an ionic compound
- Water = HOH
- HNO_3 + KOH $\rightarrow$
- HCl + $Mg(OH)_2$ $\rightarrow$
- H_2SO_4 + NaOH $\rightarrow$
- Really just double replacement.

Reactions Happen in Moles

- How many moles of HNO_3 are need to neutralize 0.86 moles of KOH?
- How many moles of HCl are needed to neutralize 3.5 moles of $Mg(OH)_2$?

Usually happen in solutions

- If it takes 87 mL of an HCl solution to neutralize 0.67 moles of $Mg(OH)_2$ what is the concentration of the HCl solution?
- If it takes 58 mL of an H_2SO_4 solution to neutralize 0.34 moles of NaOH what is the concentration of the H_2SO_4 solution?

Titration

Determining an unknown

Titration

- When you add the same number of moles of acid and base, the solution is neutral.
- By measuring the amount of a base added you can determine the concentration of the acid.
- *If you know the concentration of the base.*
- This is a titration.

Titration equations

- $M_a \times V_a \times \#$ of $H^+ = M_b \times V_b \times \#$ of OH^-
- really moles of H^+= moles of OH^-

More Practice

- If it takes 45 mL of a 1.0 M NaOH solution to neutralize 57 mL of HCl, what is the concentration of the HCl ?
- If it takes 67 mL of 0.500 M H_2SO_4 to neutralize 15mL of $Al(OH)_3$ what was the concentration of the $Al(OH)_3$?
- How much of a 0.275 M HCl will be needed to neutralize 25mL of .154 M NaOH?

Solubility

- Dissolving stuff is an equilibrium
- $CaCl_2(s) \rightleftharpoons Ca^{+2}(aq) + 2\,Cl^-(aq)$
- You can write and equilibrium constant for dissolving
- $K_{eq} = \frac{[Ca^{+2}]\,[Cl^-]^2}{[CaCl_2]}$
- The concentration of a solid does not change, so we can combine it with K_{eq}
- $K_{sp} = [Ca^{+2}]\,[Cl^-]^2$

Solubility

- K_{sp} is called the solubility product constant
- The more soluble a solid is the greater K_{sp}
- Used for slightly soluble salts.
- Can tell if a precipitate will form.
- Do the math
- If the answer is bigger than the Ksp it will form
- If not, it will all stay dissolved