Strong Acids		Weak Acids (examples)	
$HClO_4$	perchloric acid	CH_3COOH	acetic acid
HI	hydroiodic acid	HCOOH	formic acid
HBr	hydrobromic acid	HF	hydrofluoric acid
HCl	hydrochloric acid	HCN	hydrocyanic acid
HNO_3	nitric acid	HNO_2	nitrous acid
H_2SO_4	sulfuric acid	HSO_4^-	hydrogen sulfate ion
Strong Bases		**Weak Bases** (examples)	
** All group I hydroxides and most group II hydroxides – $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$		NH_3	ammonia
		CH_3NH_2	methylamine
		C_5H_5N	pyridine

Based on their formulas, acids can be defined as: Lesson 6.8 Review + Hwk

- **Monoprotic**: produce 1 H+ ion in solution (example: HCl (aq), HNO_3 (aq))
- or **diprotic**: produces 2 H+ ions in solution (example: H_2SO_4 (aq))
- or **polyprotic**: produces several H+ ions in solution (example: H_3PO_4 (aq))
- and/or **amphoteric**: acts as either an acid or a base (example: H_2O (l))

Polyprotic acids ionize stepwise; that is, one H^+ at a time.

Review:

1. Write an equation for the dissociation (ionization) of the following acids in water: (follow example:)

a) $HClO_4 \longrightarrow H^+ + ClO_4^-$

b) HSO_4^-

$HSO_4^-{}_{(aq)} \longrightarrow H^+{}_{(aq)} + SO_4^{2-}{}_{(aq)}$

c) H_2S (complete ionization)

$H_2S_{(aq)} \longrightarrow H^+{}_{(aq)} + HS^-{}_{(aq)}$

$HS^-{}_{(aq)} \longrightarrow H^+{}_{(aq)} + S^{2-}{}_{(aq)}$

d) $HC_2H_3O_2$

$HC_2H_3O_2{}_{(aq)} \longrightarrow H^+{}_{(aq)} + C_2H_3O_2^-{}_{(aq)}$

2. Write an equation for the dissociation of the following bases in water: (follow example:)

a) $Mg(OH)_2 \leftrightarrow Mg^{+2} + 2OH^-$

c) KOH

$KOH_{(aq)} \longrightarrow K^+{}_{(aq)} + OH^-{}_{(aq)}$

b) NaOH

$NaOH_{(aq)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$

d) $Ba(OH)_2$

$Ba(OH)_{2\,(aq)} \rightarrow Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

There are two main theories in chemistry that attempt to define acid and base behavior. They attempt to explain their behavior in terms of ions that are either released or donated, or their ability to release or donate ions. Here is a summary:

	Arrhenius Theory	Bronsted-Lowry Theory
Acid	Releases a H^+ ion in water *Example: HCl* $HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$	Donates a H^+ ion in water to a Bronsted base, forming hydronium ion, H_3O^+ *Example: HCl* $HCl\ (aq) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$
Base	Releases a OH- ion in water *Example: NaOH* $NaOH\ (aq) \rightarrow Na^+\ (aq) + OH^-\ (aq)$	Accepts a H^+ ion in water from a Bronsted acid, forming hydroxide ion, OH- *Example: NH_3* $NH_3\ (aq) + H_2O\ (l) \leftrightarrow NH_4+\ (aq) + OH^-\ (aq)$

You should notice some interesting things about the two theories:

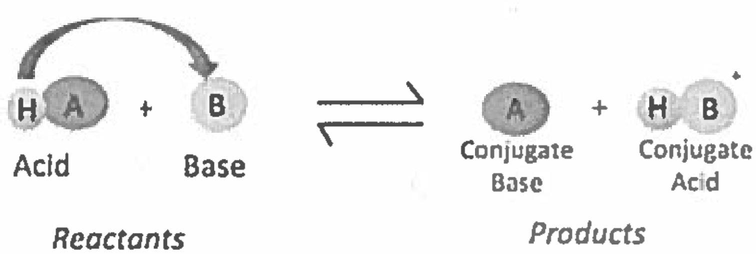
- An Arrhenius acid (or base) can also be classified as a Bronsted-Lowry acid (or base), <u>BUT not all Bronsted acids (or bases) are Arrhenius acids (or bases)</u>. The classic example is NH_3. NH_3 *does* cause hydroxide to form in solution, but it doesn't contain OH^- in its formula.

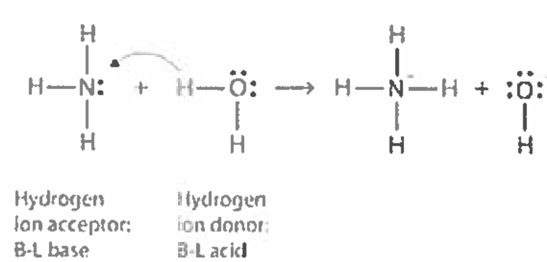
- Water is **amphoteric**: it is acting as a Bronsted base (accepting H^+) in the first example and acting as a Bronsted acid (donating H^+) in the second. Generally any species that has more than one H^+ AND can accept at least one more H^+ can be amphoteric.

Water can be amphoteric with itself in a process called the **auto-ionization** of water.

$$H_2O(l) + H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$$

When Bronsted acids and bases react, they form **conjugate acids and bases**:





Bronsted-Lowry Acid-Base Reaction

Review:

1. Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair.

a) $HNO_3 + OH^- \rightarrow NO_3^-{}_{(aq)} + H_2O_{(l)}$
acid base c.base c.acid

b) $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$
base acid c.acid c.base

c) $OH^- + HPO_4^{-2} \rightarrow H_2O_{(aq)} + PO_4^{3-}{}_{(aq)}$
base acid c.acid c.base

Lesson 6.9: pH and pOH Calculations of Strong Acids and Bases

Recall that water is amphoteric, meaning that it will behave like an acid or base, and will to a slight extent dissociate.

$$H_2O(l) + H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$$

The concentration of hydronium and hydroxide ions present from the dissociation of pure water at a given temperature always multiply to give you a constant. This constant is given the symbol K_w and is often called the **ion product constant**. K_w does not have a given unit.

$$K_w = [H_3O^+][OH^-] = \mathbf{1.0 \times 10^{-14}}$$

This relationship till holds true even if additional hydronium or hydroxide ion is present from the ionization or dissociation of an acid or base.

If $[H_3O^+] > [OH^-]$, the solution is acidic. If $[OH^-] > [H_3O^+]$, the solution is basic. If they are equal (that is, both are 1.0×10^{-7} M – the solution is neutral.

Review:

1. Find [H+] for solutions having the following [OH-] value in molarity:

a) $[OH^-] = 1 \times 10^{-13}$

b) $[OH^-] = 2.7 \times 10^{-4}$

c) $[OH^-] = 1 \times 10^{-3}$

d) $[OH^-] = 6.3 \times 10^{-10}$

2. Calculate $[OH^-]$ of a solution when its $[H^+]$ has the following values in molarity:

a) $[H^+] = 1 \times 10^{-3}$

b) $[H^+] = 3.6 \times 10^{-5}$

c) $[H^+] = 1 \times 10^{-2}$

d) $[H^+] = 7.8 \times 10^{-8}$

Lesson 6.6

1. 65.0 mL of a 1.30 M K_3PO_4 solution is evaporated. How many grams of solid should be recovered after all the water boils away?

2. Fill in the blank: To make orange juice from frozen concentrate, one usually mixes the can of concentrate with three cans of water. This dilutes the concentrate to _______ (what fraction?) its original concentration.

3. Describe each step of the preparation of a standard solution of 750. mL of 0.250 *M* $CuSO_4$, and include the necessary calculations in detail.

4. Sketch a volumetric flask and explain precisely how you would use a 500.0 mL volumetric flask to make some 1.500 M $NaNO_3$ solution. (You have available some 2.000 M $NaNO_3$ solution and whatever other lab equipment you need) How much 2.000 M solution is needed?

5. You need to make up some 5.0 M KCl solution but all you have is 125 mL of 3.0 M KCl. Explain what to do to make up the 5.0 M solution. How much 5.0 M KCl will you get? Show calculations: (hint - calculate how much water to evaporate)

lesson 6-8 hwk

Lesson 6.8

1. Write an equation for the ionization of the following acids in water.

a) HNO_2 $HNO_{2(aq)} \rightarrow NO_2^-{}_{(aq)} + H^+$

b) HCO_3^- $HCO_3^-{}_{(aq)} \rightarrow H^+{}_{(aq)} + CO_3^{2-}{}_{(aq)}$

c) $H_2PO_4^-$ (complete ionization)

$H_2PO_4^- \rightarrow H^+ + HPO_4^{-2}$

$HPO_4^{-2} \rightarrow H^+ + PO_4^{3-}$

* You could equally write: ex. a) $HNO_{2(aq)} + H_2O_{(l)} \rightarrow NO_2^-{}_{(aq)} + H_3O^+{}_{(aq)}$

b) $HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+{}_{(aq)} + CO_3^{2-}{}_{(aq)}$ c) $H_2PO_4^- + H_2O \rightarrow H_3O^+ + HPO_4^{-2}$ etc.

2. Write an equation for the dissociation of each of the following bases in water.

a) RbOH $RbOH \rightarrow Rb^+ + OH^-$

c) $Sr(OH)_2$ $Sr(OH)_2 \rightarrow Sr^{2+} + 2OH^-$

b) CsOH $CsOH \rightarrow Cs^+ + OH^-$

3. Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair.

a) $CH_3CH_2NH_2 + H_3O^+ \leftrightarrow CH_3CH_2NH_3^+ + H_2O$
base acid conj. acid conj. base

b) $NH_3 + HSO_4^- \leftrightarrow NH_4^+(aq) + SO_4^{2-}(aq)$
base acid c. acid c. base

c) $HC_2H_3O_2 + H_2O \leftrightarrow C_2H_3O_2^-(aq) + H_3O^+(aq)$
acid base conj. base conj. acid

d) $OH^- + HNO_3 \leftrightarrow H_2O(l) + NO_3^-(aq)$
base acid conj. acid conj. base

Lesson 6.9

1) Complete the following table by calculating the desired quantities. All concentrations are in *M*.

	$[H^+]$	$[OH^-]$	pH	pOH	acid, basic, neutral
a	3.2×10^{-3}				
b		1.8×10^{-14}			
c			10.23		
d				6.78	
e	0.0050				
f		0.000011			
g			10.97		
h				7.01	

2. What would be the pH and pOH of each of the following solutions?

a) 0.0010 M HCl ____

g) 1.0 M $Ca(OH)_2$ ____

b) 0.0010 M HNO_3 ____

h) 0.075 M KOH ____

c) 0.010 M $HClO_4$ ____

i) 0.000034 M $Ba(OH)_2$ ____