AR Chemistry Notes: Acids and Bases **Name**________________________________ **M T 1 2 5**

1. Acids

When dissolved in water, excess ______________ are in the water

Identified in the formula with ______ **in front**. Ex:______________________________________

Example:____________________________ ______________________________________

2. Bases

When dissolved in water, excess ______________ are in the water

Identified in the formula with ______ **in back**. Ex:______________________________________

Example:____________________________ ______________________________________

3. Definitions

a. Arrhenius acid____

bases____

b. Bronsted-Lowry acid____

base____

4. Properties of Acids and Bases (Lab on Wednesday / Thursday)

5. Neutralization

Eq:____

________________ = ____________________

________________ = ____________________

________________ = ____________________

6. The K_{eq} equation for water (Kw)

Ionization of water: ____

Kw = 1.0×10^{-14} = ____________________

Math Review: $(10^{a})(10^{b}) = 10$ $10^{a} / 10^{b} = 10$

7. Kw and pH

pH															
$[H^{+1}]$	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10
$[OH^{-1}]$	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
EXAMPLES															

Examples: $[H^{+1}] = 1 \times 10^{-4}$ $[OH^{-1}] = ??$

$[OH^{-1}] = 4 \times 10^{-5}$ $[H^{+1}] = ?$

8. pH and pOH

pH = ____

$[H^{+1}] = 1 \times 10^{-4}$ pH = ____________

$[H^{+1}] = 5 \times 10^{-7}$ pH = ____________

$[H^{+1}] = 3 \times 10^{-8}$ pH = ____________

$[OH^{-1}] = 1 \times 10^{-4}$ pH = ____________

AR Chemistry Notes: Acids and Bases **Name**________________________________ **M T 1 2 5**

1. Acids

When dissolved in water, excess H^{+1}, H_3O^{+1} are in the water

Identified in the formula with H **in front**. Ex HCl, H_2SO_4, HNO_3, HI, H_2O

Example $HCl \xrightarrow{H_2O} H^{+1} + Cl^{-1}$ $HCl + H_2O \rightarrow H_3O^{+1} + Cl^{-1}$

2. Bases

When dissolved in water, excess OH^{-1} are in the water

Identified in the formula with OH **in back**. Ex NaOH, $Ba(OH)_2$, KOH, $Ca(OH)_2$, HOH

Example $NaOH \xrightarrow{H_2O} Na^{+1} + OH^{-1}$ $NH_3 + H_2O \rightarrow NH_4^{+1} + OH^{-1}$

3. Definitions

a. Arrhenius acid releases H^{+1} in water

bases releases OH^{-1} in water

b. Bronsted-Lowry acid Proton donor: ${}_1^0P^{+1} = H^{+1}$

base Proton acceptor

4. Properties of Acids and Bases (Lab on Wednesday / Thursday)

5. Neutralization

Eq $H^{+1} + OH^{-1} \rightarrow H_2O$

Moles H^{+1} = Moles OH^{-1}

$m\,v\,(H^{+1}) = m\,v\,(OH^{-1})$

$N\,v\,(H^{+1}) = N\,v\,(OH^{-1})$

6. The K_{eq} equation for water (Kw)

Ionization of water: $H_2O_{(l)} \leftrightarrow H^{+1}_{(aq)} + OH^{-1}_{(aq)}$

$Kw = 1.0 \times 10^{-14} = [H^{+1}]\,[OH^{-1}]$

Math Review: $(10^a)(10^b) = 10^{a+b}$ $10^a / 10^b = 10^{a-b}$

7. Kw and pH

	ACIDS							Neutral	Bases						
pH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
$[H^{+1}]$	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	**10^{-7}**	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{0}
$[OH^{-1}]$	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}	10^{-9}	10^{-8}	**10^{-7}**	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{-0}
	Increasing acid ←								→ Increasing base						
			100,000	10,000	1000	100	10		10	100	1000	10,000	100,000		
EXAMPLES		Stomach Acid (1.7)	Lemon Juice (2.3)	Cola (3.8), Vinegar	Tomatoes (4.2)	Black Coffee 5.0	Rain, Milk (6.4)	Distilled Water	Baking Soda (8.4)	Borax	Milk of Magnesia	Household Ammonia 11.5	Washing Soda (12.0)	Household Bleach	

Examples: $[H^{+1}] = 1 \times 10^{-4}$ $[OH^{-1}] = ??$

$1.0 \times 10^{-14} = [1 \times 10^{-4}][OH^{-1}]$

$$\frac{1.0 \times 10^{-14}}{[1 \times 10^{-4}]} = [OH^{-1}] = 1.0 \times 10^{-14 - -4} = 1.0 \times 10^{-10}$$

$[OH^{-1}] = 4 \times 10^{-5}$ $[H^{+1}] = ?$

$1.0 \times 10^{-14} = [H^{+1}][4 \times 10^{-5}]$

$$\frac{1.0 \times 10^{-14}}{[4 \times 10^{-5}]} = [H^{+1}] = \text{calculator} = 2.5 \times 10^{-10}$$

8. pH and pOH

$pH = -\log[H^{+1}]$ $pOH = -\log[OH^{-1}]$ $pH + pOH = 14$ ALWAYS

$[H^{+1}] = 1 \times 10^{-4}$ pH = 4

$[H^{+1}] = 5 \times 10^{-7}$ pH = 6.3

$[H^{+1}] = 3 \times 10^{-8}$ pH = 7.52

$[OH^{-1}] = 1 \times 10^{-4}$ pH = ?? pOH = 4 pH + pOH = 14, pH = 10

AR Chemistry: Acids / Bases Notes

1. Properties of Acids and Bases

Properties of Acids:

1. Taste Sour
2. Change the Colors of Indicators
   Litmus = Pink, Phenolphthalein = Clear
3. React with Metals to form H_2 gas
   $Zn^0 + 2\,H^{+1} \rightarrow Zn^{+2} + H_2^0$
4. Neutralize Bases

Properties of Bases:

1. Taste Bitter, are slippery
2. Change the Colors of Indicators
   Litmus = Blue, Phenolphthalein = Pink
3. Form precipitate $Mg(OH)_2$ with Mg^{+2} ions
   $Mg^{+2} + 2\,OH^{-1} \rightarrow Mg(OH)_{2\,(s)}$
4. Neutralize Acids

2. Neutralization

$H^{+1} + OH^{-1} \rightarrow H_2O$ Example: $\mathbf{H}Cl_{(aq)} + K\mathbf{OH}_{(aq)} \rightarrow H_2O + KCl_{(aq)}$
Acid Base Water Salt

3. Definitions of Acids and Bases

Arrhenius (1887):

Acids Release H^{+1} ions in water   Ex: HCl, HNO_3, H_2SO_4
HCl --H_2O--> $H^{+1} + Cl^{-1}$

Bases Release OH^{-1} ions in water   Ex: $NaOH$, KOH, $Ca(OH)_2$
$NaOH$ --H_2O--> $Na^{+1} + OH^{-1}$

Bronsted-Lowry (1923)

Acids are Proton Donors   Ex: $HCl + H_2O \rightarrow H_3O^{+1} + Cl^{-1}$ (hydrochloric acid)

Bases are Proton Acceptors   Ex: $NH_3 + H_2O \rightarrow NH_4^{+1} + OH^{-1}$ (ammonia water)

4. Definitions specific to Acids / Bases

H_3O^{+1} = hydronium ion (the acid ion)
Amphoteric: A material that can act as an acid (proton donor) or base (proton acceptor) See **Water** in the examples above
Salt: The ionic compound formed from Acid / Base neutralization

5. <u>Kw / pH</u>

--Water undergoes a natural equilibrium ionization:

$$H_2O_{(l)} \;\text{<------->}\; H^{+1}_{(aq)} + OH^{-1}_{(aq)}$$

The equilibrium equation and value is:

$$K_w = 1.0 \times 10^{-14} = [\,H^{+1}\,]\,[\,OH^{-1}\,]$$

Acids: $[\,H^{+1}\,] > 10^{-7}$ M
Bases: $[\,OH^{-1}\,] > 10^{-7}$ M
Neutral: $[\,H^{+1}\,] = 10^{-7} = [\,OH^{-1}\,]$

--pH Scale--tells how concentrated a solution is in [H^{+1}]:

(Each change in pH number represents a 10 times greater/lesser concentration)

	ACIDS							Neutral	BASES					
pH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
$[H^{+1}]$	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
$[OH^{-1}]$	10^{-14}	10^{-13}	10^{-1}	10^{-112}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}
Examples		Stomach Acid (1.7)	Lemon Juice (2.3)	Cola (3.8), Vinegar	Tomatoes (4.2)	Black Coffee 5.0	Rain, Milk (6.4)	Distilled Water	Baking Soda (8.4)	Borax	Milk of Magnesia	Household Ammonia 11.5	Washing Soda (12.0)	Household Bleach

Example 1: What is the $[H^{+1}]$ if the $[OH^{-1}] = 1.0 \times 10^{-9}$?

Kw = 1.0 x 10^{-14} = [H^{+1}] [OH^{-1}]

$1.0 \times 10^{-14} = [H^{+1}] [1.0 \times 10^{-9}]$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-9}} = 1.0 \times 10^{-5} \text{ M}$$

Example 2: What is the $[OH^{-1}]$ if the $[H^{+1}] = 4.2 \times 10^{-5}$?

Kw = 1.0 x 10^{-14} = [H^{+1}] [OH^{-1}]

$1.0 \times 10^{-14} = [4.2 \times 10^{-5}] [OH^{-1}]$

$$\frac{1.0 \times 10^{-14}}{4.2 \times 10^{-5}} = 2.4 \times 10^{-10} \text{ M}$$

6. pH Determination

pH is a logarithmic function. For each 10 fold increase or decrease in hydrogen ions, the pH changes by one. Therefore, the following equation can be used to determine the pH of a solution.

$$\mathbf{pH = - \log [H^{+1}]}$$

Example 1: What is the pH of a solution that has a hydrogen concentration of 1.0×10^{-5} M?

$pH = - \log [H^{+1}] = - \log [1.0 \times 10^{-5}] = -(-5) = \mathbf{5}$

Example 2: What is the pH of a solution that has a hydrogen concentration of 3.6×10^{-3} M?

$pH = - \log [H^{+1}] = - \log [3.6 \times 10^{-3}] = -(-2.44) = \mathbf{2.44}$

<u>Problems</u>

1. Given the following $[H^{+1}]$ concentrations, determine the $[OH^{-1}]$ concentration.
   a. 1.34×10^{-4} M H^{+1} ($[OH^{-1}]$ = Kw / $[H^{+1}]$ = $1.0 \times 10^{-14} / 1.34 \times 10^{-4} = 7.46 \times 10^{-11}$ M OH^{-1})
   b. 6.78×10^{-12} M H^{+1} ($[OH^{-1}]$ = Kw / $[H^{+1}]$ = $1.0 \times 10^{-14} / 6.78 \times 10^{-12} = 1.47 \times 10^{-3}$ M OH^{-1})
   c. 3.56×10^{-6} M H^{+1} ($[OH^{-1}]$ = Kw / $[H^{+1}]$ = $1.0 \times 10^{-14} / 3.56 \times 10^{-6} = 2.81 \times 10^{-9}$ M OH^{-1})

2. Given the following $[H^{+1}]$ concentrations, determine the pH of the solution.
   a. 2.75×10^{-3} M H^{+1} (pH = -log $[H^{+1}]$ = -log [2.75×10^{-3} M] = 2.56)
   b. 7.89×10^{-10} M H^{+1} (pH = -log $[H^{+1}]$ = -log [7.89×10^{-10} M] = 9.10)
   c. 1.78×10^{-5} M H^{+1} (pH = -log $[H^{+1}]$ = -log [1.78×10^{-5} M] = 4.75)

3. Given the following $[OH^{-1}]$ concentrations, determine the $[H^{+1}]$ and the pH.
   a. 4.56×10^{-3} M OH^{-1} ($[H^{+1}] = 2.19 \times 10^{-12}$ M, pH = 11.7)
   b. 9.65×10^{-7} M OH^{-1} ($[H^{+1}] = 1.04 \times 10^{-8}$ M, pH = 7.98)
   c. 3.81×10^{-11} M OH^{-1} ($[H^{+1}] = 2.62 \times 10^{-4}$ M, pH = 3.58)

4. Calculate the OH^{-1} concentration for the following solutions.
   a. 0.40 M $Ca(OH)_2$ (0.80 M OH^{-1})
   b. 67.8 grams NaOH in 1.50 Liters of solution (1.70 mol / 1.50 L = 1.13 M x 1 OH^{-1} = 1.13 M OH^{-1})
   c. 1.24 grams $Ba(OH)_2$ dissolved in 3.40 L solution. (0.00724 mol / 3.40 L = 0.00213 M x 2 OH^{-1} = 0.00426 M OH^{-1})

5. Calculate the H^{+1} concentration for the following solutions.
   a. 0.00682 M H_2SO_4 (0.00682 M x 2 H^{+1} = 0.0136 M H^{+1})
   b. 23.9 grams HCl dissolved in a 2.35 Liter solution. (0.656 mol / 2.35 L = 0.279 M x 1 H^{+1} = 0.279 M H^{+1})
   c. 5.82 grams H_2SO_4 dissolved in a 1.29 Liter solution. (0.0593 mol / 1.29 L = 0.0460 M x 2 H^{+1} = 0.0920 M H^{+1})

6. Calculate the pH for each of the solutions in problem 5.
   a. pH = 1.8