

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 (K_w)

Ionization of water: _____

$K_w = 1.0 \times 10^{-14} =$ _____

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

7. Kw and pH

pH															
[H ⁺]	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 ⁻]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
E X A M P L E S															

Examples: [H⁺] = 1 x 10⁻⁴ [OH⁻] = ??

[OH⁻] = 4 x 10⁻⁵ [H⁺] = ?

8. pH and pOH

pH = _____

[H⁺] = 1 x 10⁻⁴ pH = _____

[H⁺] = 5 x 10⁻⁷ pH = _____

[H⁺] = 3 x 10⁻⁸ pH = _____

[OH⁻] = 1 x 10⁻⁴ pH = _____

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 $\text{HCl} - \text{H}_2\text{O} \rightarrow \text{H}^{+1} + \text{Cl}^{-1}$ $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^{+1} + \text{Cl}^{-1}$

2. Bases

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

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

Example $\text{NaOH} - \text{H}_2\text{O} \rightarrow \text{Na}^{+1} + \text{OH}^{-1}$ $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^{+1} + \text{OH}^{-1}$

3. Definitions

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

bases releases OH^{-1} in water

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

base Proton acceptor

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

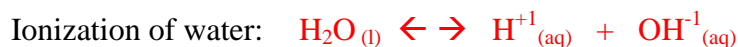
5. Neutralization



$$\text{Moles } \text{H}^{+1} = \text{Moles } \text{OH}^{-1}$$

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

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

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

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

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

7. Kw and pH

	ACIDS							Neutral	Bases						
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
[H ⁺]	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 ⁻]	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	1,000	100	10		10	100	1,000	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 x 10⁻⁴ [OH⁻] = ??

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

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

[OH⁻] = 4 x 10⁻⁵ [H⁺] = ?

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

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

8. pH and pOH

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

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

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

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

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

AR Chemistry: Acids / Bases Notes

1. Properties of Acids and Bases

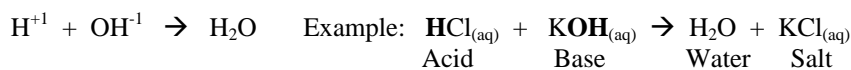
Properties of Acids:

1. Taste Sour
2. Change the Colors of Indicators
Litmus = Pink, Phenolphthalein = Clear
3. React with Metals to form H₂ 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



3. Definitions of Acids and Bases

Arrhenius (1887): Acids Release H⁺¹ ions in water Ex: HCl, HNO₃, H₂SO₄
 $HCl \rightarrow H_2O \rightarrow H^{+1} + Cl^{-1}$

Bases Release OH⁻¹ ions in water Ex: NaOH, KOH, Ca(OH)₂
 $NaOH \rightarrow H_2O \rightarrow Na^{+1} + OH^{-1}$

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

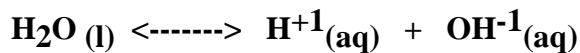
H₃O⁺¹ = hydronium ion (the acid ion)

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. Kw / pH

--Water undergoes a natural equilibrium ionization:



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)

pH	ACIDS							Neutral	BASES						
	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 ⁻¹²	10 ⁻¹¹	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 $[H^+]$ if the $[OH^-] = 1.0 \times 10^{-9}$?

$$\begin{aligned}K_w &= 1.0 \times 10^{-14} = [H^+][OH^-] \\1.0 \times 10^{-14} &= [H^+][1.0 \times 10^{-9}] \\ \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-9}} &= 1.0 \times 10^{-5} \text{ M}\end{aligned}$$

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

$$\begin{aligned}K_w &= 1.0 \times 10^{-14} = [H^+][OH^-] \\1.0 \times 10^{-14} &= [4.2 \times 10^{-5}][OH^-] \\ \frac{1.0 \times 10^{-14}}{4.2 \times 10^{-5}} &= 2.4 \times 10^{-10} \text{ M}\end{aligned}$$

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.

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

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

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

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

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

Problems

- Given the following $[H^+]$ concentrations, determine the $[OH^-]$ concentration.
 - 1.34×10^{-4} M H^+ ($[OH^-] = K_w / [H^+] = 1.0 \times 10^{-14} / 1.34 \times 10^{-4} = 7.46 \times 10^{-11}$ M OH^-)
 - 6.78×10^{-12} M H^+ ($[OH^-] = K_w / [H^+] = 1.0 \times 10^{-14} / 6.78 \times 10^{-12} = 1.47 \times 10^{-3}$ M OH^-)
 - 3.56×10^{-6} M H^+ ($[OH^-] = K_w / [H^+] = 1.0 \times 10^{-14} / 3.56 \times 10^{-6} = 2.81 \times 10^{-9}$ M OH^-)
- Given the following $[H^+]$ concentrations, determine the pH of the solution.
 - 2.75×10^{-3} M H^+ ($\text{pH} = -\log [H^+] = -\log [2.75 \times 10^{-3}] = 2.56$)
 - 7.89×10^{-10} M H^+ ($\text{pH} = -\log [H^+] = -\log [7.89 \times 10^{-10}] = 9.10$)
 - 1.78×10^{-5} M H^+ ($\text{pH} = -\log [H^+] = -\log [1.78 \times 10^{-5}] = 4.75$)
- Given the following $[OH^-]$ concentrations, determine the $[H^+]$ and the pH.
 - 4.56×10^{-3} M OH^- ($[H^+] = 2.19 \times 10^{-12}$ M, $\text{pH} = 11.7$)
 - 9.65×10^{-7} M OH^- ($[H^+] = 1.04 \times 10^{-8}$ M, $\text{pH} = 7.98$)
 - 3.81×10^{-11} M OH^- ($[H^+] = 2.62 \times 10^{-4}$ M, $\text{pH} = 3.58$)
- Calculate the OH^- concentration for the following solutions.
 - 0.40 M $Ca(OH)_2$ (0.80 M OH^-)
 - 67.8 grams NaOH in 1.50 Liters of solution ($1.70 \text{ mol} / 1.50 \text{ L} = 1.13 \text{ M} \times 1 \text{ } OH^- = 1.13 \text{ M } OH^-$)
 - 1.24 grams $Ba(OH)_2$ dissolved in 3.40 L solution. ($0.00724 \text{ mol} / 3.40 \text{ L} = 0.00213 \text{ M} \times 2 \text{ } OH^- = 0.00426 \text{ M } OH^-$)
- Calculate the H^+ concentration for the following solutions.
 - 0.00682 M H_2SO_4 ($0.00682 \text{ M} \times 2 \text{ } H^+ = 0.0136 \text{ M } H^+$)
 - 23.9 grams HCl dissolved in a 2.35 Liter solution. ($0.656 \text{ mol} / 2.35 \text{ L} = 0.279 \text{ M} \times 1 \text{ } H^+ = 0.279 \text{ M } H^+$)
 - 5.82 grams H_2SO_4 dissolved in a 1.29 Liter solution. ($0.0593 \text{ mol} / 1.29 \text{ L} = 0.0460 \text{ M} \times 2 \text{ } H^+ = 0.0920 \text{ M } H^+$)
- Calculate the pH for each of the solutions in problem 5.
 - $\text{pH} = 1.8$