INTRODUCTION TO ACIDS AND BASES
ALIGNED STANDARDS

• S.C. 912.P.8.11 Relate acidity and basicity to hydronium and hydroxide concentration and pH.

• S.C.912.N.1.2 Describe and explain what characterizes science and its methods.
OBJECTIVES

• SWBAT distinguish between an Acid and a Base
• SWBAT describe the relationship between pH & the strength of an acid
ESSENTIAL QUESTIONS

• What is meant by the pH of a substance?
Acids

- Sour taste
- High concentration of H\(^+\) ions
- Conduct electricity
  - good conductor → strong acid
  - weak conductor → weak acid
- React with bases to form water and a salt
- pH of 1-6, the lower the pH the stronger the acid

Example → lemon juice
Bases

Also called “alkaline”

- bitter taste, soapy feel
- High Concentration of OH⁻ ions
- conduct electricity
  - good conductor → strong base
  - weak conductor → weak base
- react with acids to form water and a salt
- pH of 8-14, the higher the pH the stronger the base

Example → baking soda
What are some tests you could do to figure out whether a compound is an acid, a base, or neither?
ACID/BASE TESTS

• Touch / Taste
• Conductivity test (to see if it is weak or strong)
• pH paper or pH probe
**pH of Common Substances**

<table>
<thead>
<tr>
<th>ACIDIC</th>
<th>NEUTRAL</th>
<th>ALKALINE OR BASIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Battery Acid, Stomach Acid (Hydrochloric)</td>
<td>Lemon Juice, Vinegar</td>
<td>Household Ammonia and Cleaners</td>
</tr>
<tr>
<td>Coke and Pepsi, Grapefruit and Orange Juice, Apples, Dr. Pepper, Soda</td>
<td>Tomato Juice, Beer, Acid Rain, 7-UP Soda, Black Coffee, Pepto Bismol, Healthy Skin, Hair and Nails</td>
<td>Milk of Magnesia, Mild Detergent, Hair Straighteners (11.5 to 14.0)</td>
</tr>
<tr>
<td>“Pure” Water, Blood</td>
<td>Shampoos (7.0 to 10.0)</td>
<td>Baking Soda, Seawater, Eggs, Perm Solutions (8.5 to 9.5)</td>
</tr>
<tr>
<td>Urine, Saliva, Milk</td>
<td>Toothpaste, Hand Soap</td>
<td>Bleach, Oven Cleaner, Liquid Drain Cleaner, Caustic Soda</td>
</tr>
</tbody>
</table>

**pH SCALE**

- pH below 7 is acidic
  - The closer to 1, the more acidic.
- pH above 7 is basic
  - The closer you get to 14, the more basic.
- Ranges from 1-14
- pH 7 is neutral
ACID-BASE VIDEO
INDEPENDENT PRACTICE

Complete the worksheet and we will grade it in class. If you get done early start on your homework.
ACIDS & BASES CALCULATIONS
ALIGNED STANDARDS

• S.C. 912.P.8.11 Relate acidity and basicity to hydronium and hydroxide concentration and pH.

• S.C.912.N.1.2 Describe and explain what characterizes science and its methods.
OBJECTIVES

• SWBAT compare and contrast the similarities and differences of the 3 main acid-base theories.

• SWBAT illustrate the dissociation of water and its explain importance.

• SWBAT recognize common strong/weak acids and bases

• SWBAT articulate the relationship between pH and H⁺ concentration

• SWBAT perform calculation involving pH, pOH, OH⁻, and H⁺
ESSENTIAL QUESTIONS

• What is meant by the pH of a substance?
AGENDA

Acid Base Theory
- Arrhenius Acids and Bases
- Bronsted-Lowry Acids and Bases
- Lewis Acids and Bases

Dissociation of Water

Memorizing Common Acids and Bases

pH Calculations and Hydrogen Ion Concentrations
- Relationship between pH and H⁺ concentration
- Calculating pH
- Calculating hydronium ion concentration from pH
- Calculating pOH
- Calculating hydroxide ion concentration from pOH
- The relationship between pH and pOH
ARRHENIUS ACIDS AND BASES

ACIDS
• HAVE A HIGHER H+ CONCENTRATION
• LOW pH
• ACIDIC

BASES
• HAVE A HIGHER OH- CONCENTRATION
• HIGH pH
• BASIC
What is a proton?
A proton is commonly used to discuss the donation and acceptance of the H+ ion.
LEWIS ACIDS & LEWIS BASES

Electron-pair Donor

any substance, such as the \( \text{H}^+ \) ion, that can accept a pair of nonbonding electrons.

Electron-pair Acceptor

any substance, such as the \( \text{OH}^- \) ion, that can donate a pair of nonbonding electrons. A Lewis base is therefore an electron-pair donor.
### Acid-Base Theories

<table>
<thead>
<tr>
<th>Acid-Base Theories</th>
<th>Acid</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrhenius</td>
<td>Increases the amount of H+ ions in solution Example: HCl (hydrochloric acid)</td>
<td>Increases the amount of OH- ions in solution Example: NaOH (sodium hydroxide)</td>
</tr>
<tr>
<td>Bronsted-Lowry</td>
<td>Proton (H+) donor</td>
<td>Proton (H+) acceptor</td>
</tr>
<tr>
<td>Lewis</td>
<td>Electron-pair acceptor</td>
<td>Electron-pair donor</td>
</tr>
</tbody>
</table>
DISSOCIATION OF WATER

Water has the ability to split into an $\text{H}^+$ ion and an $\text{OH}^-$ ion.

- Water can act as an acid when it donates a $\text{H}^+$ ion.
- Water can act as a base by accepting an $\text{OH}^-$ ion.
Common Aqueous Strong Acids & Strong Bases

Strong Acids
- HI – Hydroiodic acid
- HClO₄ – perchloric acid
- HBr – hydrobromic acid
- HCl – hydrochloric acid
- H₂SO₄ – Sulfuric Acid
- HClO₃ – chloric acid

Strong Bases
- Ca(OH)₂ – Calcium hydroxide
- Sr(OH) – Strontium hydroxide
- BaOH – Barium hydroxide
- NaOH – Sodium hydroxide
- KOH – Potassium hydroxide
- RbOH – Rubidium hydroxide
- CsOH – Cesium hydroxide
COMMON AQUEOUS
WEAK ACIDS & STRONG BASES

Weak Acids

- HSO₄⁻ - Hydrogen sulfate ion
- H₃PO₄ – Phosphoric acid
- HF – Hydrofluoric acid
- CH₃COOH – Acetic acid
- H₂CO₃ – Carbonic acid
- H₂S – Hydrosulfuric acid
- HCN - Cyanide
- HCO₃⁻ - hydrogen carbonate ion

Weak Bases

- NH₃ – Ammonia
- C₆H₅NH₂ - Aniline
RELATIONSHIP BETWEEN pH AND HYDROGEN ION CONCENTRATION:

- As the hydrogen ion concentration increases, the pH decreases.
If Solution A has a pH of 3 and Solution B has a pH of 2, the first solution is not twice as acidic as the second—the hydrogen ion concentration has only increased by a factor of ___________.

\[
\text{Factor} = 10
\]
Example: Solution A has a pH of 2 and Solution B has a pH of 6. How much more acidic is solution A than solution B?

\[10 \times 10 \times 10 \times 10 = 10^4\]

10,000 times more ACIDIC

THIS MEANS THAT WHEN WE MOVE FROM ONE pH LEVEL TO THE NEXT WE MULTIPLY BY 10.
## IMPORTANT FORMULAS

<table>
<thead>
<tr>
<th>Formula</th>
<th>Derived Relationship</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{pH} = -\log \left[ \text{H}_3\text{O}^+ \right]$</td>
<td>Use the hydronium concentration to determine the pH</td>
<td>Calculate pH based on $\text{H}^+$ Concentration</td>
</tr>
<tr>
<td>$[\text{pOH}] = -\log (\text{OH}^-)$</td>
<td>Use the pOH to determine hydroxide concentration</td>
<td>Calculate pOH based on OH$^-\ldots$ Concentration</td>
</tr>
<tr>
<td>$[\text{OH}^-] = 10^{-\text{pOH}}$</td>
<td>Use the pOH to determine the hydroxide concentration</td>
<td>Calculate OH$^-\ldots$ based on pOH Concentration</td>
</tr>
<tr>
<td>$[\text{H}^+] = 10^{-\text{pH}}$</td>
<td>Use the pH to determine the hydronium concentration</td>
<td>Calculate $\text{H}^+$ based on pH</td>
</tr>
<tr>
<td>$\text{pH} = 14 - \text{pOH}$</td>
<td>pH and pOH</td>
<td>Calculate pH based on pOH</td>
</tr>
</tbody>
</table>
CALCULATING PH

• Calculate the pH of a solution with a hydronium concentration of $2.3 \times 10^{-3}$ M
  $\text{pH} = -\log [2.3 \times 10^{-3}] = 2.64$

• Calculate the pH of a solution with a hydronium concentration of $8.3 \times 10^{-4}$ M
  $\text{pH} = -\log [8.3 \times 10^{-4}] = 3.08$

• Calculate the pH of a solution with a hydronium concentration of $5.39 \times 10^{-10}$ M
  $\text{pH} = -\log [5.39 \times 10^{-10}] = 9.27$
CALCULATING THE H⁺ CONCENTRATION IN A SOLUTION OF A KNOWN pH

• Calculate the hydrogen ion concentration of a solution with a pH of 4.5

  \[ [H^+] = 10^{-4.5} = 3.16 \times 10^{-5} \text{ M} \]

• Calculate the hydrogen ion concentration of a solution with a pH of 6.8

  \[ [H^+] = 10^{-6.8} = 1.58 \times 10^{-7} \text{ M} \]

• Calculate the hydrogen ion concentration of a solution with a pH of 12.2

  \[ [H^+] = 10^{-12.2} = 6.31 \times 10^{-13} \text{ M} \]
Calculating the pOH

• Calculate the pOH concentration of a solution with a OH⁻ concentration of $5.23 \times 10^{-6}$ M

\[
[pOH] = -\log (5.23 \times 10^{-6}) = 5.28
\]

• Calculate the pOH concentration of a solution with a OH⁻ concentration of $8.02 \times 10^{-3}$ M

\[
[pOH] = -\log (8.02 \times 10^{-3}) = 2.10
\]

• Calculate the pOH concentration of a solution with a OH⁻ concentration of $7.36 \times 10^{-8}$ M

\[
[pOH] = -\log (7.36 \times 10^{-8}) = 7.13
\]
CALCULATING THE OH- CONCENTRATION IN A SOLUTION OF A KNOWN pOH

• Calculate the hydroxide ion concentration of a solution with a pOH of 5

\[
[\text{OH}^-] = 10^{-5} = 1.00 \times 10^{-5} \text{ M}
\]

• Calculate the hydrogen ion concentration of a solution with a pH of 12

\[
[\text{OH}^-] = 10^{-12} = 1.00 \times 10^{-12} \text{ M}
\]

• Calculate the hydrogen ion concentration of a solution with a pH of 3

\[
[\text{OH}^-] = 10^{-3} = 1000 \text{ M}
\]
RELATIONSHIP BETWEEN pH AND pOH

• A solution has a pOH of 11.76. What is the pH of this solution?

\[
pH = 14 - 11.76 = 2.24
\]

• A solution has a pOH of 9.23. What is the pH of this solution?

\[
pH = 14 - 9.23 = 4.77
\]

• A solution has a pH of 11.76. What is the pH of this solution?

\[
7.23 = 14 - \text{pOH} = 6.77
\]

\[
\text{pOH} = 14 - 7.23
\]
Determining $\text{pH}, \text{pOH, } [\text{OH}^-], [\text{H}_3\text{O}^+]$.

Remember $[\text{H}^+] = [\text{H}_3\text{O}^+]$

Learning this chart helps make the memorization easier.

$[\text{H}_3\text{O}^+]$

10^{-\text{pH}} \quad -\log [\text{H}_3\text{O}^+] \quad 14.0 - \text{pH}

$[\text{OH}^-]$

-\log[\text{OH}^-] \quad 10^{-\text{pOH}} \quad 14.0 - \text{pOH}$
INDEPENDENT PRACTICE

Complete the worksheet and we will grade it in class. If you get done early start on your homework.
CONJUGATE ACIDS AND CONJUGATE BASE PAIRS
ALIGNED STANDARDS

- S.C. 912.P.8.11 Relate acidity and basicity to hydronium and hydroxide concentration and pH.

- S.C.912.N.1.2 Describe and explain what characterizes science and its methods.
OBJECTIVES

• SWBAT identify the conjugate acids and conjugate bases of well known acids and bases.
ESSENTIAL QUESTIONS

• What is meant by the pH of a substance?
SO FAR WHAT DO WE KNOW?

Day 1
• What is an acid and a base?
• What is pH? What is the range of the pH scale?

Day 2
• What ions common in acids? Bases?
• How is pH affected by the concentration the H$^+$ ions
• Naming Acids and Bases
BRøNSTED-LOWRY ACIDS AND BASES

Brønsted-Lowry Theory

- acids donate a proton (H\(^+\)).
- bases accept a proton (H\(^+\)).
NH₃, A BRØNSTED-LOWRY BASE

In the reaction of ammonia and water,

• NH₃ is the base that accept H⁺.

• H₂O is the acid that donates H⁺.
CONJUGATE ACID-BASE PAIRS

- In any acid-base reaction, there are **TWO** conjugate acid-base pairs.

- Each pair is related by the loss and gain of H⁺
CONJUGATE ACIDS AND BASES

In this acid-base reaction,

• An acid, HF, donates $H^+$ to form its conjugate base, $F^-$.  

• A base, $H_2O$, accepts $H^+$ to form its conjugate acid, $H_3O^+$.  

• There are two conjugate acid-base pairs.
In the reaction of HF and H₂O,

- one conjugate acid-base pair is HF/F⁻.

- the other conjugate acid-base pair is H₂O/H₃O⁺.

- each pair is related by a loss and gain of H⁺.
CONJUGATE ACID-BASE PAIRS

In the reaction of NH$_3$ and H$_2$O,
- one conjugate acid-base pair is NH$_3$/NH$_4^+$
- the other conjugate acid-base is H$_2$O/H$_3$O$^+$. 
LEARNING CHECK

A. Write the conjugate base of the following.
   1. HBr
   2. H₂S
   3. H₂CO₃

B. Write the conjugate acid of the following.
   1. NO₂⁻
   2. NH₃
   3. OH⁻
A. Remove H\(^+\) to write the conjugate base.

1. HBr \(\rightarrow\) Br\(^-\)
2. H\(_2\)S \(\rightarrow\) HS\(^-\)
3. H\(_2\)CO\(_3\) \(\rightarrow\) HCO\(_3\)^-\

B. Add H\(^+\) to write the conjugate acid.

1. NO\(_2\)^- \(\rightarrow\) HNO\(_2\)
2. NH\(_3\) \(\rightarrow\) NH\(_4\)^+
3. OH\(^-\) \(\rightarrow\) H\(_2\)O
LEARNING CHECK

Identify the sets that contain acid-base conjugate pairs.

1. $\text{HNO}_2$, $\text{NO}_2^-$
2. $\text{H}_2\text{CO}_3$, $\text{CO}_3^{2-}$
3. $\text{HCl}$, $\text{ClO}_4^-$
4. $\text{HS}^-$, $\text{H}_2\text{S}$
5. $\text{NH}_3$, $\text{NH}_4^+$
SOLUTION

Identify the sets that contain acid-base conjugate pairs.

1. $\text{HNO}_2$, $\text{NO}_2^-$
4. $\text{HS}^-$, $\text{H}_2\text{S}$
5. $\text{NH}_3$, $\text{NH}_4^+$
A. The conjugate base of $\text{HCO}_3^-$ is
1. $\text{CO}_3^{2-}$ 2. $\text{HCO}_3^-$ 3. $\text{H}_2\text{CO}_3$

B. The conjugate acid of $\text{HCO}_3^-$ is
1. $\text{CO}_3^{2-}$ 2. $\text{HCO}_3^-$ 3. $\text{H}_2\text{CO}_3$

C. The conjugate base of $\text{H}_2\text{O}$ is
1. $\text{OH}^-$ 2. $\text{H}_2\text{O}$ 3. $\text{H}_3\text{O}^+$

D. The conjugate acid of $\text{H}_2\text{O}$ is
1. $\text{OH}^-$ 2. $\text{H}_2\text{O}$ 3. $\text{H}_3\text{O}^+$
A. The conjugate base of $\text{HCO}_3^-$ is
   1. $\text{CO}_3^{2-}$
B. The conjugate acid of $\text{HCO}_3^-$ is
   3. $\text{H}_2\text{CO}_3$
C. The conjugate base of $\text{H}_2\text{O}$ is
   1. $\text{OH}^-$
D. The conjugate acid of $\text{H}_2\text{O}$ is
   3. $\text{H}_3\text{O}^+$
INDEPENDENT PRACTICE

Complete the worksheet and we will grade it in class. If you get done early start on your homework.
NAMING ACIDS AND BASES
• S.C. 912.P.8.11 Relate acidity and basicity to hydronium and hydroxide concentration and pH.

• S.C.912.N.1.2 Describe and explain what characterizes science and its methods.
• SWBAT identify the conjugate acids and conjugate bases of well known acids and bases.
ESSENTIAL QUESTIONS

• What is meant by the pH of a substance?
Would you use an acid to wash out your eye?

Hydrochloric acid causes major damage to even your skin...

...While boric acid is a main ingredient in eye-drop solutions

What's the difference?
Which is a **strong** acid?

**Weak** acids/bases only create a small percentage of ions.

**Strong** acids/bases create many ions.

Which is a strong acid?
The more ions released in solution, the stronger the acid or base.
So, why do you think strong acids and bases are good conductors of electricity?

Strong acids and bases are strong electrolytes, because they release many ions.
Which two compounds are electrolytes?

1. $\text{C}_6\text{H}_{12}\text{O}_6$ and $\text{CH}_3\text{CH}_2\text{OH}$
2. $\text{C}_6\text{H}_{12}\text{O}_6$ and $\text{HCl}$
3. NaOH and HCl
4. NaOH and $\text{CH}_3\text{CH}_2\text{OH}$
Arrhenius Acids

A substance whose water solution contains $\text{H}^+$ as the only positive ion.

$$\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$$

Does that mean that all compounds that contain $\text{H}$ are acids?

Nope! $\text{CH}_4$ does not release $\text{H}^+$ in water.
Check for understanding:

According to Arrhenius theory of acids, citric acid in oranges and acetic acid in vinegar are classified as **acids** because their aqueous solutions contain

a. hydrogen atoms  
**b. hydrogen ions**  
c. hydroxide atoms  
d. hydroxide ions
**Binary** acids are made of Hydrogen + another element.

*Hydro* + name of element + *ic* and *acid*

Ex. HCl: hydro**chloric** acid.

**Ternary** acids are more randomly-named:

Perchloric Acid -

Nitric Acid -

Sulfuric Acid -

**How do we name** HBr?

**hydrobromic acid**
CHECK FOR UNDERSTANDING

• Write the formula for the following acids
  ▫ Hydroiodic Acid
  ▫ Hydrochloric Acid
  ▫ Hydrobromic Acid

• Which of the following is NOT an acid?
  a. NH3
  b. H2SO4
  c. HClO4
  d. HNO3
**Arrhenius Bases**

A substance whose water solution contains $\text{OH}^{-}$ as the only negative ion.

NaOH $\rightarrow$ Na$^{+}$ + OH$^{-}$

Are all compounds containing OH’s bases?  

Nope! CH$_3$OH is not a base.
Check for Understanding:

When an Arrhenius base is dissolved in $\text{H}_2\text{O}$, the only negative ion present in the solution is

a. $\text{OH}^-$
b. $\text{H}_3\text{O}^-$
c. $\text{H}^-$
d. $\text{O}^{2-}$
Naming bases

Name of element + hydroxide.
Ex. NaOH: sodium hydroxide

How do we name KOH?

Potassium hydroxide
Fill in the missing boxes

<table>
<thead>
<tr>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaOH</td>
<td>Potassium Hydroxide</td>
</tr>
<tr>
<td></td>
<td>Cesium Hydroxide</td>
</tr>
<tr>
<td>RbOH</td>
<td></td>
</tr>
<tr>
<td>LiOH</td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td>Conjugate Base</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Perchloric acid</td>
<td>Perchlorate ion</td>
</tr>
<tr>
<td>Hydroiodic acid</td>
<td>Iodide ion</td>
</tr>
<tr>
<td>Hydrobromic acid</td>
<td>Bromide ion</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>Chloride ion</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>Hydrogen sulfate ion</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>Nitrate ion</td>
</tr>
<tr>
<td>Hydronium ion(^a)</td>
<td>Water(^a)</td>
</tr>
<tr>
<td>Hydrogen sulfate ion</td>
<td>Sulfate ion</td>
</tr>
<tr>
<td>Nitrous acid</td>
<td>Nitrite ion</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>Acetate ion</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>Hydrogen carbonate ion</td>
</tr>
<tr>
<td>Ammonium ion</td>
<td>Ammonia</td>
</tr>
<tr>
<td>Hydrogen carbonate ion</td>
<td>Carbonate ion</td>
</tr>
<tr>
<td>Water</td>
<td>Hydroxide ion</td>
</tr>
<tr>
<td>Methanol</td>
<td>Methoxide ion</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Amide ion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acid</th>
<th>Conjugate Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>HClO(_4)</td>
<td>ClO(_4)(^-)</td>
</tr>
<tr>
<td>HI</td>
<td>I(^-)</td>
</tr>
<tr>
<td>HBr</td>
<td>Br(^-)</td>
</tr>
<tr>
<td>HCl</td>
<td>Cl(^-)</td>
</tr>
<tr>
<td>H(_2)SO(_4)</td>
<td>HSO(_4)(^-)</td>
</tr>
<tr>
<td>HNO(_3)</td>
<td>NO(_3)(^-)</td>
</tr>
<tr>
<td>H(_3)O(^+)</td>
<td>H(_2)O(_2)(^-)</td>
</tr>
<tr>
<td>HNO(_2)</td>
<td>NO(_2)(^-)</td>
</tr>
<tr>
<td>HC(_2)H(_3)O(_2)</td>
<td>C(_2)H(_3)O(_2)(^-)</td>
</tr>
<tr>
<td>H(_2)CO(_3)</td>
<td>HCO(_3)(^-)</td>
</tr>
<tr>
<td>NH(_4)(^+)</td>
<td>NH(_3)(^-)</td>
</tr>
<tr>
<td>HCO(_3)(^-)</td>
<td>CO(_3)(^2-)</td>
</tr>
<tr>
<td>H(_2)O</td>
<td>OH(^-)</td>
</tr>
<tr>
<td>CH(_3)OH</td>
<td>CH(_3)O(_2)(^-)</td>
</tr>
</tbody>
</table>

\(^a\)The hydronium ion–water combination refers to the ease with which a proton is passed from one water molecule to another; that is, H\(_3\)O\(^+\) + H\(_2\)O \rightleftharpoons H\(_2\)O + H\(_3\)O\(^+\)
ACTIVITY: DRAWING ACIDS AND BASES

Each pair will be given two substances. For each, use your notes and the chart below to follow each step:
1. Is your substance an acid or a base?
2. What kind of ions will its water solution contain?
3. Draw what will happen to your acid or base when you put it in water.

EXAMPLES:
INDEPENDENT PRACTICE

Complete the worksheet and we will grade it in class. If you get done early start on your homework.