CHAPTER 19 NOTES: ACIDS, BASES AND NEUTRALIZATION

ACIDS: substances that give H+ (a proton) to water

\[ \text{pH} < 7 \]
\[ [\text{H}^+] > [\text{OH}^-] \]

[ ] means “the molarity of..”

Review: Formula Writing for Acids

**binary acids:** hydro___________ ic acid  (DOESN’T have O!)

ex:  
- HCl: ___ hydrochloric acid _______
- HBr: ___ hydrobromic acid _______
- \( \text{H}_2\text{S} \): ___ hydrosulfuric acid _______
- \( \text{H}_3\text{N} \): ___ hydronitric acid _______

**ternary acids:**  “ate-ic-ite-ous”

ate = ic

ex:  
- sulfuric acid (sulfate) ___ \( \text{H}_2\text{SO}_4 \)________________________
- nitric acid (nitrate) ___ \( \text{HNO}_3 \)________________________
- \( \text{HC}_2\text{H}_3\text{O}_2 \) ___ acetic acid________________________

ite = ous

ex:  
- sulfurous acid (sulfite) ___ \( \text{H}_2\text{SO}_3 \)________________________
- nitrous acid (nitrite) ___ \( \text{HNO}_2 \)________________________
- \( \text{H}_3\text{PO}_3 \) ___ phosphorous acid________________________

**Strong Acids:**
- HCl – hydrochloric acid
- HBr – hydrobromic acid
- HI – hydroiodic acid
- HNO₃ – nitric acid
- \( \text{H}_2\text{SO}_4 \) – sulfuric acid
- HClO₃ – chloric acid
- HClO₄ – perchloric acid

**Weak Acids:**
- Ex: vinegar – acetic acid  \( \text{HC}_2\text{H}_3\text{O}_2 \)
Dissociation of Strong Acids

HCl $\rightarrow$ H$^+$ + OH$^-$

H$_2$SO$_4$ $\rightarrow$ 2 H$^+$ + SO$_4^{2-}$

Dissociation of Weak Acids

HCOOH $\leftrightarrow$ H$^+$ + C$_2$H$_3$O$_2^-$
BASES substances that dissociate to form OH- ions, or remove H⁺ from water to make OH⁻ ions

pH > 7

[OH⁻] > [H⁺]

STRONG BASES:
Group I Hydroxides, Sr(OH)₂, Ba(OH)₂

NaOH
Ba(OH)₂

WEAK BASES:

NH₃

**Dissociation of Strong Bases**

NaOH → Na⁺ + OH⁻

Ba(OH)₂ → Ba²⁺ + 2 OH⁻

**Dissociation of Weak Bases** Weak bases take hydrogen ions (H⁺) from water, leaving OH⁻ which makes the solution basic. This is an equilibrium.

NH₃ + H₂O ↔ NH₄⁺ + OH⁻
Dissociation of Water:

\[ \text{H}_2\text{O} \leftrightarrow \text{H}^+ + \text{OH}^- \]

Water itself ionizes into H+ and OH-, but only to a very small extent. All water based solutions have H+ and OH-. If there is more H+ the solution is acidic. If there is more OH- it is basic.

**pH**

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

\[ \text{pH} + \text{pOH} = 14 \quad \quad [\text{H}^+] \times [\text{OH}^-] = 1.0 \times 10^{-14} \text{ M} \]

**Acids:** pH < 7  
**Bases:** pH > 7  
**Neutral:** pH = 7

<table>
<thead>
<tr>
<th>Solution</th>
<th>Acid or Base?</th>
<th>[H+]</th>
<th>[OH-]</th>
<th>pH</th>
<th>pH</th>
<th>pOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.010M HCl</td>
<td>Acid</td>
<td>0.010M</td>
<td>10^{-12}M</td>
<td>2</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>0.00010M HNO₃</td>
<td>Acid</td>
<td>0.00010M (10^{-4}M)</td>
<td>10^{-10}M</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>1 x 10^{-6}M HI</td>
<td>Acid</td>
<td>10^{-6} M</td>
<td>10^{-8}M</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>0.0010M NaOH</td>
<td>Base</td>
<td>10^{-11}M</td>
<td>0.0010M</td>
<td>11</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Windex</td>
<td>Base</td>
<td>10^{-12}M</td>
<td>0.010M</td>
<td>12</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Lemon Juice</td>
<td>Acid</td>
<td>0.0010M (10^{-3}M)</td>
<td>10^{-11}M</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Sprite</td>
<td>Acid</td>
<td>0.00010M (10^{-4}M)</td>
<td>10^{-10}M</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>Base</td>
<td>10^{-12}M</td>
<td>0.010M</td>
<td>12</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>Acid</td>
<td>10^{-6} M</td>
<td>10^{-8}M</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>
PROPERTIES OF ACIDS & BASES: MINI LAB

Safety: Acids and Bases are caustic. If you spill an acid in lab, neutralize with baking soda before cleaning up with water. If you spill a base in lab, neutralize with a weak vinegar solution before cleaning up with water. If you spill acid OR base on your skin, flush with plenty of water (DO NOT neutralize).

1. Conductivity
   1. Clean and dry a well plate thoroughly.
   2. Add 5 drops of each solution into the well plate.
   3. Use your conductivity tester to test whether or not each solution conducts electricity. Be sure to clean off the tester with distilled water after each solution!
   4. Record observations in the chart below:

<table>
<thead>
<tr>
<th>Solution</th>
<th>Conducts? Yes or No? To what extent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>No</td>
</tr>
<tr>
<td>Distilled water</td>
<td>No</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>Yes, brightly</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>Yes, brightly</td>
</tr>
<tr>
<td>Gatorade</td>
<td>Yes, brightly</td>
</tr>
</tbody>
</table>

a) Use your textbook to define the term electrolyte: ___compound that conducts an electric current when it is in an aqueous solution (includes all ionic compounds)

________________________________________________________________________

b) What do solutions need to conduct electricity? ____ions dissociated in solution

________________________________________________________________________

c) What ions are in a solution of hydrochloric acid? ___H⁺₁, Cl⁻₁_____________________

d) What ions are in a solution of sodium hydroxide? ___Na⁺₁, OH⁻₁_____________________

e) Why do you think Gatorade conducts electricity if it is not an acid or a base? ____

   **Gatorade contains electrolytes which conduct electricity**

________________________________________________________________________
2. Reactivity with Metals

1. Measure out 10mL of hydrochloric acid using a graduated cylinder.
2. Pour the hydrochloric acid into a small beaker.
3. Add a piece of zinc to hydrochloric acid and observe.
4. Record observations in the below.
5. Remove zinc with forceps and rinse with water.
6. Clean out graduated cylinder and beaker.
7. Repeat steps 1-4 using sodium hydroxide instead of hydrochloric acid.
8. Remove zinc with forceps and rinse with water. Return zinc to zinc beaker.
9. Clean out graduated cylinder and beaker.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric acid and solid zinc</td>
<td>BUBBLING, ZINC TURNING BLACK</td>
</tr>
<tr>
<td>Sodium hydroxide and solid zinc</td>
<td>NO REACTION</td>
</tr>
</tbody>
</table>

a) Write the formula for hydrochloric acid: ______ $\text{HCl}$ ______________________________

b) Write the formula for sodium hydroxide: _____ $\text{NaOH}$ ______________________________

c) Write a balanced reaction for the reaction you observed:

$$\text{Zn} + 2 \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$$

d) What type of reaction is this? _____ single displacement __________________

e) Given 3.5g of zinc, what volume of hydrogen gas would form at STP?

$$\begin{align*}
\frac{3.5\text{g Zn}}{65.4\text{g}} &= \frac{1\text{ mol Zn}}{1\text{ mol Zn}} \\
1\text{ mol H}_2 &= \frac{22.4\text{L}}{1\text{ mol H}_2} \\
1.2\text{L} &= \frac{22.4\text{L}}{18\text{g}}
\end{align*}$$

f) What mass of zinc must react in order to form 12.0L of hydrogen gas at 23°C and 675mmHg?

$$\begin{align*}
\text{PV} &= \text{nRT} \\
675\text{mmHg}(12.0\text{L}) &= n(62.4)(296°C) \\
0.4382\text{ mol H}_2 &= n
\end{align*}$$

$$\frac{0.4382\text{mol H}_2}{1\text{ mol Zn}} \times \frac{1\text{ mol Zn}}{65.4g} = 28.7g$$
3. **Exploring with Indicators**

1. Add 5 drops of each solution into a clean well plate. Be sure you identify for yourself which well contains which solution.
2. Test each well using pH paper. Match the color of the pH paper to the scale and record readings in the data table below.
3. Test each well using the red litmus paper. Record observations in the data table below.
4. Test each well using the blue litmus paper. Record observations in the data table below.
5. Add one drop of phenolphthalein into each well. Record observations in the data table below.
6. Clean and dry well plate thoroughly.
7. Add 5 drops of each solution into a clean well plate. Be sure you identify for yourself which well contains which solution.
8. Add one drop of universal indicator into each well. Record observations in the data table below.
9. Clean and dry the well plate thoroughly.

<table>
<thead>
<tr>
<th>Solution</th>
<th>pH paper</th>
<th>Red litmus</th>
<th>Blue litmus</th>
<th>Phenolphthalein</th>
<th>Universal indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
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<tr>
<td>C</td>
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<tr>
<td>D</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Other properties of Acids and Bases:**

Common household acids include citrus, vinegar, and yogurt. Based on your experience with these items, acids taste ______ sour ________.

Common household bases include bleach, soap, and baking soda. Based on your experience with these items, bases taste ______ bitter __________. Bases feel ____slippery__________ to the touch.

Both acids and bases are ____ caustic _____. If you spill acid in lab, you should neutralize it with ____ baking soda _______ before cleaning up. If you spill a base in lab, you should neutralize it with ____ weak vinegar ______ before cleaning up.
a) Use the pH (from your data) of the unknown solutions to complete the pH chart below:

<table>
<thead>
<tr>
<th>Solution</th>
<th>Acid or Base?</th>
<th>[H+]</th>
<th>[OH⁻]</th>
<th>pH</th>
<th>pOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) What volume of 0.01M HCl is needed to completely react with 2.0g magnesium ribbon?

RXN: ______ 2 HCl + Mg → MgCl₂ + H₂ _____________

\[
\begin{align*}
2.0 \text{g Mg} & \quad 1 \text{ mol Mg} \quad 2 \text{ mol HCl} \quad 1 \text{L HCl} \quad = \quad 16.5 \text{L HCl} \\
24.3 \text{g Mg} & \quad 1 \text{ mol Mg} \quad 0.01 \text{ mol HCl} \\
\end{align*}
\]

c) A student spills 5mL of sulfuric acid on the lab table. To neutralize the acid, he pours sodium hydroxide on it and forms sodium sulfate and water. If the initial concentration of the sulfuric acid solution is 0.010M, find the mass of sodium sulfate formed.

RXN: ______ \(\text{H}_2\text{SO}_4 + 2 \text{ NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ HOH} \) _____________

\[
\begin{align*}
0.005 \text{L} & \quad .01 \text{ mol } \text{H}_2\text{SO}_4 \quad 2 \text{ mol HOH} \quad 18 \text{g HOH} \quad = \quad 0.0018 \text{g HOH} \\
1 \text{ L } \text{H}_2\text{SO}_4 & \quad 1 \text{ mol } \text{H}_2\text{SO}_4 \quad 1 \text{ mol HOH} \\
\end{align*}
\]
Based on the information you discovered in this lab, complete the following properties chart:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>ACIDS</th>
<th>BASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Reacts with Metals</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>pH</td>
<td>&lt; 7</td>
<td>&gt; 7</td>
</tr>
<tr>
<td>Red Litmus</td>
<td>Stays red</td>
<td>Turns blue</td>
</tr>
<tr>
<td>Blue Litmus</td>
<td>Turns red</td>
<td>Stays blue</td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td>clear</td>
<td>pink</td>
</tr>
<tr>
<td>Universal Indicator</td>
<td>Red, Orange, Yellow</td>
<td>Blue, Violet, Purple</td>
</tr>
<tr>
<td>Taste</td>
<td>Sour</td>
<td>Bitter</td>
</tr>
<tr>
<td>Texture</td>
<td></td>
<td>Slippery</td>
</tr>
<tr>
<td>Spills</td>
<td>Neutralize with a base (baking soda)</td>
<td>Neutralize with vinegar solution</td>
</tr>
</tbody>
</table>
NEUTRALIZATION REACTIONS

Acid    +   Base →   Salt (Ionic Compound)   +   Water

Example: Sodium hydroxide + hydrochloric acid →

\[
\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} \quad (\text{HOH})
\]

Potassium hydroxide + nitric acid →

\[
\text{KOH} + \text{HNO}_3 \rightarrow \text{KNO}_3 + \text{H}_2\text{O}
\]

Lithium hydroxide + sulfuric acid →

\[
2\text{LiOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Li}_2\text{SO}_4 + 2\text{H}_2\text{O}
\]

Barium hydroxide + phosphoric acid →

\[
3 \text{Ba(OH)}_2 + 2 \text{H}_3\text{PO}_4 \rightarrow \text{Ba}_3(\text{PO}_4)_2 + 6 \text{H}_2\text{O}
\]

Acetic acid + sodium hydroxide →

\[
\text{HC}_2\text{H}_3\text{O}_2 + \text{NaOH} \rightarrow \text{NaC}_2\text{H}_3\text{O}_2 + \text{H}_2\text{O}
\]
TITRATION  A method of finding the molarity of an unknown solution by reacting it with a solution of known molarity

# H’s in solution = # OH’s in solution

\((\# \text{ H in Acid}) \times (M_{\text{acid}}) \times (V_{\text{acid}}) = (\# \text{ OH in Base}) \times (M_{\text{base}}) \times (V_{\text{base}})\)

Titration Problems:

a. What volume of 0.15M sodium hydroxide solution is needed to react with 12.2mL of 0.350M hydrochloric acid?

\[
1 \times 12.2\text{mL} \times 0.350\text{M} = 1 \times 0.15\text{M} \times V
\]

\[V = 28.5\text{mL}\]

b. What volume of 0.250M nitric acid is needed to react with 20.5mL of 0.10M lithium hydroxide?

\[
1 \times V \times 0.250\text{M} = 1 \times 0.10\text{M} \times 20.5\text{mL}
\]

\[V = 8.2\text{mL}\]

c. Find the molarity of an unmarked hydrochloric acid solution of 14.51mL of the solution reacts completely with 12.24mL of 0.030M sodium hydroxide solution.

\[
1 \times 14.51\text{mL} \times M = 1 \times 0.030\text{M} \times 12.24\text{mL}
\]

\[V = 0.025\text{M}\]

d. Find the molarity of a nitric acid solution if 10.4mL of the solution is needed to react with 25.0mL of 0.45M barium hydroxide.

\[
1 \times 10.4\text{mL} \times M = 25\text{mL} \times 0.45\text{M} \times 2 \quad (2 \text{ because Ba(OH)}_2 \text{ has two hydroxides})
\]

\[V = 2.16 \text{M}\]