4.8 - Acid/Base Chemistry

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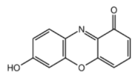
Properties of Acids and Bases

Physical:
Acids taste tart or sour: lemons, vinegar
Acids turn blue litmus* paper red.

Bases taste bitter and feel slippery: ever eaten soap?
Bases turn red litmus* paper blue.

* - Litmus is a pH sensitive compound historically extracted from lichens. First used in the 1300's, the chromophore (color sensitive compound) in litmus is 7-hydroxyphenoxozone.



Don't identify chemicals by taste or feel!

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Properties of Acids and Bases

Acids and bases are electrolytes - what's that again?

Acids can react with metals to produce hydrogen gas and a metal salt.

Acids react with carbonates to produce carbon dioxide, water, and a salt (ionic compound).

Strong acids or bases ionize completely in water and are good electrolytes; weak ones do/are not.
Weak acid Ex: acetic acid (vinegar) dissolves well, but only about 1% of molecules ionize.

$$CH_3COOH + H_2O \rightarrow H_3O^+ + CH_3COO^- \ (about\ 1\%)$$

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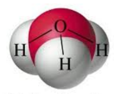
Hydronium and Hydroxide Ions

Water hydrolyzes (breaks up) into hydroxide and hydrogen ions.
The hydrogen ions merge with water forming hydronium ions (H_3O^+).



Hydronium ion
H_3O^+

In a neutral solution (pH = 7), these ions are equal.
In acids, (pH < 7) hydronium outnumbers hydroxide.
In bases (pH > 7) hydroxide outnumbers hydronium.

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Arrhenius model of acids/bases

Svante Arrhenius in 1883 proposed a model that defined acids as substances that contain hydrogen atoms which ionize in water.

Bases contain hydroxide ions.

H^+ H^+ H^+ OH^- OH^- OH^-

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1. You do!

Move the following chemicals into the acid or base corrals!

HCl H_2SO_4

Acids

KOH $Zn(OH)_2$ NaOH

Bases

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Brønsted-Lowry Model

Focuses on H^+ transfer: an acid is a H^+ donor; a base is a H^+ acceptor.

Example 1: HCl and water:

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

Here, water is a base because it accepts the H^+ ion.

Example 2: ADD!!! ammonia in water.

$$NH_3 + H_2O \longrightarrow NH_4^+ + OH^-$$

Here, water is an acid because it loses an H^+ ion.

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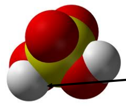
Mono and Polyprotic acids

Monoprotic acids have one ionizable hydrogen ion.

Polyprotic – "many protons", such as:

Diprotic = two. Ex: sulfuric acid.

Triprotic = three. Ex: phosphoric acid.



Sulfuric Acid has two ionizable hydrogen atoms.

The counterpart in bases is called mono, di, and tribasic.

Ex: $Al(OH)_3$ is tribasic. ADD THIS!!

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Parent Chemicals

If given a salt's chemical formula, determine which acid and base could combine to make it.

A. Split the chemical into its cation and anion.
B. Add hydroxide ions to the cation, and hydrogen ions to the anion until the charge is neutral.
C. Name the base or acid.

2. Name and formula parent chemicals of $ZnSO_4$.

zinc hydroxide: $Zn(OH)_2$, and sulfuric acid: H_2SO_4.

3. Name and formula parent chemicals of Hg_2SO_3.

mercury (I) hydroxide: $Hg_2(OH)_2$, and sulfurous acid: H_2SO_3.

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Acid/Base Reactions

In a neutralization reaction, an acid and a base will react and produce an ionic compound and water.

The ionic compound (called a 'salt') is made of a cation from the base and an anion from the acid.

In the process, the pH of the reaction mixture will approach 7.0 (neutral).

4. Neutralization Example

Balance the neutralization reaction of magnesium hydroxide and hydrochloric acid.

$$Mg(OH)_2 + 2\ HCl \rightarrow MgCl_2 + 2\ H_2O$$

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Titration

Titration: Method of determining concentration.

React a known volume of an unknown concentration with an amount of a known solution (called a titrant).

Ex: to determine the concentration of an unknown acid, use a measured amount of a base of known concentration.

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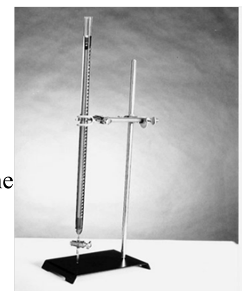
Procedure

1. Put a measured volume of unknown concentration of acid or base in a beaker.

2. Fill A buret with a titrant of known concentration.

3. Add measured volumes of titrant (called aliquots) until the reaction reaches the equivalence point (end point).



A Buret

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Equivalence Point (End Point)

Def: The point in a neutralization when moles of H^+ and OH^- equal each other.

How is this point determined?

1. pH meter (if available): stop reaction at desired pH.
2. Indicators change color at a specific pH:
   - Phenolpthalien: clear to pink above pH = 8.2,
   - Bromothymol Blue: yellow to blue above pH = 6.8.

Not useful if necessary pH level is different than indicator's changing pH, or if solution is colored.

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Performing Calculations for Acid–Base Reactions

List species present in the combined solution before the reaction, and decide what reaction will occur.

Write the balanced net ionic equation.

Calculate moles of reactants (realize that you are interested in moles of H^+ or OH^-).

Determine the limiting reactant, where appropriate.

Calculate moles of the required reactant or product.

Convert to grams or volume (of solution), as required.

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Neutralization Example

5. How many moles of sodium hydroxide are required to react with 1.25 L of 0.350 M sulfuric acid to reach the endpoint?

6. If it takes 850.0 mL of sodium hydroxide solution to achieve neutralization, what is the concentration of the sodium hydroxide?

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5. Moles NaOH

Balanced reaction:

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

This shows us that each acid molecule has two hydrogen ions.

Moles of hydrogen ions:

$$mol = M \bullet L = 0.350 M\ H_2SO_4 \bullet 1.25 L = 0.4375\, mol\ H_2SO_4$$

$$0.4375\, mol\ H_2SO_4 \bullet \frac{2\, mol\ H^+}{1\, mol\ H_2SO_4} = 0.875\, mol\ H^+$$

Since 1 mol H^+ reacts with 1 mol OH^-, and NaOH is monobasic:

$$0.875\, mol\ H^+ \bullet \frac{1\, mol\ OH^-}{1\, mol\ H^+} = 0.875\, mol\ OH^- \Rightarrow \boxed{0.875\, mol\ NaOH}$$

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6. Concentration of NaOH

6. If it takes 850.0 mL of sodium hydroxide solution to achieve neutralization, what is the concentration of the sodium hydroxide?

$$M\ NaOH = \frac{0.875\, mol\ NaOH}{0.8500\, L} = \boxed{1.03\, M\ NaOH}$$

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Homework

Read 4.9 - 4.10 in your textbook.

4.8 Problems in your Booklet
Due: Next Class.

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