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| **Objectives:** |
| * Use the three acid-base theories to identify acids and bases under different conditions.
* Write the names of binary acids.
* Write the names of ternary acids.
* Write the anhydrous form of ternary acids.
* Predict whether an oxide is an acid anhydride or a basic anhydride.
* Use the formula of an acid to determine if it is strong or weak.
* Use factor-label for titration calculations.
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**Acids and Bases**

 **There are three "theories" used to define acids and bases.** Each of these theories focuses on a slightly different property. As you go down the list, the definition broadens to include a wider range of substances.

**1. Arrhenius Theory:**

* **Acid - produces hydrogen ions, H + in water solution.**
	+ In an equation, the positive part of a Arrhenius acid will be hydrogen.
* **Base - produces hydroxide ions, OH - in water solution.**
	+ In an equation, the negative part of a Arrhenius base will be hydroxide.
* Acids and bases are thought of as electrolytes. When each dissolves, it ionizes to release the appropriate ion.
* While this is not completey accurate, it is a good description of those chemicals we call acids and bases.
* **Practice Problems:**

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| Each of the following unbalanced equations represents a reaction between a Arrhenius acid and base. Identify those in each reaction: 1. H2CO3 + NH4OH (NH4)2CO3 + H2O

1. KOH + H3PO4 K3PO4 + H2O

1. HF + NaOH NaF + H2O

1. Ba(OH)2 + HNO2 Ba(NO2)2 + H2O

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Arrhenius Practice Problems:

1. (acid) H2CO3 + (base) NH4OH
2. (base) KOH + (acid) H3PO4
3. (acid) HF + (base) NaOH
4. (base) Ba(OH)2 + (acid) HNO2

**2. Bronsted - Lowry Theory:**

* **Acid - proton donor.**
	+ In an equation, a Bronsted - Lowry acid must have hydrogen in its formula.
* **Base - proton acceptor.**
	+ A Bronsted - Lowry base is hard to generalize for all equations. It may be a negative ion. You may have to look at the products. Find one that contains hydrogen. If the negative part of this product was in a reactant that did not contain hydrogen, that reactant is most likely the base.
* This theory focuses on the action of protons in reactions. Since protons are in the nucleus of an atom, the hydrogen ion is the only source of protons in a normal chemical reaction.
* The definition of acids and bases is broadened because no specific ions must be formed, but hydrogen is needed in the reaction to produce the proton.
* Three important terms are used in association with this theory:
	+ **Conjugate base** - the particle that remains after an acid gives up a proton.
	+ **Conjugate acid** - the particle formed when a base accepts a proton.

HCl + H2O Cl - + H3O+
Acid + Base Conjugate Base + Conjugate Acid

* + **Hydronium ion** - formed by a hydrogen ion and a water molecule - **H3O+**

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|  | **Since a hydrogen ion is nothing more than a proton (a bare positive charge), when formed, this proton is immediately attracted to a polar water molecule forming a hydronium ion. For this reason, hydrogen ions never actually exist in water solution.**  |

* **Practice Problems:**

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| Each of the following unbalanced equations represents a reaction between a Bronsted - Lowry acid and base. Identify those in each reaction: 1. CaCO3 + HCl CaCl2 + H2CO3

1. H2S + NO3 - S + NO

1. IO3- + H2S I2 + SO3-2

1. H2SeO3 + Br - Se + Br2

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**3. Lewis Theory:**

* **Acid - electron-pair acceptor.**
	+ In an equation, a Lewis acid gets more negative from the left side to the right.
* **Base - electron-pair donor.**
	+ In an equation, a Lewis base gets more positive from the left side to the right.
* This theory is the broadest of all.
* According to this theory, any reaction involving the exchange of a pair of electrons will have an acid and base.
* Important terms associated with this theory are:
	+ **Complex ion** - a central positive ion surrounded by bonded ligands.
		- The central ion has empty orbitals and can act as an electron pair acceptor, (Lewis Acid).
	+ **Ligands** - a negative ion or polar molecule bonded to the central ion in a complex.
		- Ligands have unshared electron pairs to donate, (Lewis Base).
* **Practice Problems:**

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| Each of the following unbalanced equations represents a reaction between a Lewis acid and base. Identify those in each reaction: 1. Cl - + Br2 Cl2 + Br -

1. Mn + Co+2 Mn+2 + Co

1. Cl2 + Sn+2 Cl - + Sn+4

1. Fe+2 + ClO3 - Fe+3 + Cl -

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1. Why are hydrogen ions NEVER found in an aqueous solution?
2. HCN(aq) + SO4-2(aq) HSO4-(aq) + CN -(aq)

* 1. What is the Bronsted - Lowry acid in this equation?
	2. What is the Bronsted - Lowry base in this equation?
	3. What is the conjugate acid in this equation?
	4. What is the conjugate base in this equation?
1. 2NH3 + Ag+ Ag(NH3)2+

* 1. What is the Lewis acid in this equation?
	2. What is the Lewis base in this equation?
1. O-2 + SO3 SO4-2
In this equation, the O-2 is the Lewis base and the SO3 is the Lewis acid.

* 1. Draw the **electron dot diagram** for the acid.
	2. Draw the electron dot diagram for the base.
	3. Draw the electron dot diagram for the product, SO4-2

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| **Binary acids: made up of only two elements -** hydrogen and one other element. |

* **Naming binary acids:**
	+ Begin with the prefix hydro.
	+ Determine the "stem" - part of the name of the element that combines with hydrogen.
	+ **Add the suffix ic.**

**Examples:**

* + HCl - **hydro chlor ic** - hydrochloric acid
	+ HBr - **hydro brom ic** - hydrobromic acid

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| **Ternary acids: made up of three elements -** hydrogen, oxygen, and another element.  |

* **Naming ternary acids:**
	+ Determine the "stem" - part of the name of the third element.
	+ **The most common acid is given the suffix ic.**
	+ **Add the prefix per for the acid with one more oxygen.**
	+ **The suffix ous is given to the acid with one less oxygen.**
	+ **Add the prefix hypo for the acid with two less oxygen atoms.**

**Examples:**

* + HClO4 - **per chlor ic** - perchloric acid - one more oxygen atom.
	+ HClO3 - **chlor ic** - chloric acid - the most common form of the acid.
	+ HClO2 - **chlor ous** - chlorous acid - one less oxygen atom.
	+ HClO - **hypo chlor ous** - hypochlorous acid - two less oxygen atoms.

**Other important terms:**

* **Amphoteric** - a substance that acts as either acid or base, depending on what it reacts with.
	+ Water is the most common amphoteric substance. In the presence of a proton donor, it acts like a base. In the presence of a proton acceptor, it acts like an acid.
* **Anhydrous** - without water.
	+ Anhydrides are substances that have had water removed.
	+ Example: Taking the water out of Ba(OH)2 leaves BaO.
	+ Practice Problems: write the anhydrous form of the following
		1. H2SO3
		2. H2C2O4
		3. H3PO4
		4. H4C2O2
* **Acid anhydride** - an oxide that produces an acid when dissolved in water.
	+ Oxides of nonmetals are acid anhydrides.
	+ Example: SO2 + H2O H2SO3 (an acid)

* + Practice Problems: write the formula of the compound formed when these are dissolved in water.
		1. P2O3
		2. NO2

 **Basic anhydride** - an oxide that produces a base in when dissolved in water.

* Oxides of metals are basic anhydrides.
* Example: Na2O + H2O 2NaOH (a base)

* Practice Problems: write the formula of the compound formed when these are dissolved in water.
	1. MgO
	2. Al2O3

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| **Strong acids and bases ionize completely in water solution.** * **This rule-of-thumb can be used in our class:**
	+ **HCl, HBr, and HI are the only strong binary acids.**
	+ **In strong ternary acids, the number of oxygen atoms exceeds the number of hydrogen atoms by two or more. Examples are H2SO4 and HNO3**
	+ **Hydroxides of groups 1 and 2, except Be, are strong bases.**
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| **Weak acids and bases ionize only slightly in water solution.** * **This rule-of-thumb can be used in our class:**
	+ **Any binary acid not listed above is weak.**
	+ **A ternary acid is weak if the ratio of oxygen to hydrogen is less than two to one. An example is H3PO4**
	+ **Any hydroxide not listed above is a weak base.**
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