Chemistry 141 Laboratory Section 5
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Chemical Reactions Lab Lecture
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I. Proper Notebook Records
   a. The notebook needs to be a complete record of your experimental procedure and all measurements that you make. It needs to be sufficiently detailed that you or someone else could pick up your lab notebook a year from now, and do the experiment exactly as you originally did.
   b. All data, procedural information and observations should be written directly into your notebook, not written on another piece of paper and copied in later.
   c. If you make an incorrect entry, strike it out with a single line (so that it remains legible) and write a brief note explaining the reason for the change.
   d. Every student needs to keep their own notebook record.

II. Today's Experiment
   a. Overview: You'll be mixing a wide variety of chemicals in small test tubes and observing the changes that occur. In some cases these changes will be the formation of a precipitate. In others there may be a color change, or evolution of gas as evidenced by the formation of bubbles. In some cases the evidence of a reaction occurring will be a change in temperature or a change in smells. Some processes will occur immediately and some gradually. In some cases no reaction will occur at all. In some cases you may have two reactions occurring – one in solution and one in the vapor phase above the solution.

      This means that you will need to take special care in your observations. You will need these careful observations in order to do your bottle experiment next week, in which you'll have an unknown that you'll have to identify by its reactive properties.

      Therefore in addition to noting whether a precipitate has formed, you should note when it forms (quickly or slowly), changes in odor (look for the odor of ammonia or vinegar), and the colors of the substances you're working with. You should make these observations before you mix your reagents, immediately after mixing, and five minutes later.

      <u>All observations need to be recorded directly into your laboratory notebooks.</u>

      After you do these reactions and make these observations you need to write down balanced net ionic equations for each reaction. In those cases where your observations indicate that more than one reaction has occurred, you should write equations for each reaction.

b. Net Ionic Equations:

The concept here is fairly simple. In many ionic reactions, there are species that react, and species that are unchanged. For example in the reaction between lead nitrate and sodium iodide, a complete equation would be

$$Pb^{+2}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \rightarrow PbI_2(s) + 2NO_3^-(aq) + 2K^+(aq)$$

Note that in this complete equation the nitrate ion and the potassium ions remain unchanged. In a net ionic equation those species that remain unchanged are eliminated, in this case resulting in the equation:

$$Pb^{+2}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$$

Another example is the neutralization of perchloric acid by sodium hydroxide. The full equation is

$$H_3O^+(aq) + ClO_4^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow 2H_2O(l) + Na^+(aq) + ClO_4^-(aq)$$

In this case the net ionic equation is:

$$H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$$

In many cases you'll know immediately from your observations that a reaction has occurred but not which of the species has reacted. In those cases, referring to the solubility charts on page ChemRxns5 will help a great deal. If one pair of species forms a precipitate and the remaining species do not, then the ones that form the precipitate are the ones that have reacted.

Note that in order to be correct you need to indicate the phase of each species. Species dissolved in water are designated (aq) for aqueous, gases are designated (g), liquids by (l), solids by (s). Sometimes when a precipitate is formed in a reaction a downward arrow is used instead of the (s), and sometimes when a gas is evolved an upward arrow will replace the (g).

All of your equations must be balanced. This means that you must maintain the same number of each type of atom in the reactant side of the equation and in the product side of the equation. Note that this requirement is satisfied in both of our examples.

c. Polyatomic ions:

In addition to atomic ions, such as Na^+ and Cl^-, some species contain groups of atoms which, when the molecule dissolves in water, remain bonded to each other. An example that you may be familiar with is the solvation of nitric acid,

$$HNO_3(l) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$$

Note that in this process the NO_3^- does not break up into its constituent atoms, but remains as a single species. These species are called polyatomic ions and are very common. A list of many important polyatomic ions can be found in your manual on page ChemRxns 6. It is important that you be aware if one of these polyatomic ions is involved in one of your reactions or you will not be able to write the net ionic equation correctly.

d. Types of reactions:

It is useful to know the most common classes of chemical reactions that you'll see in this experiment. While you will not be required to identify which of these classes of reaction you are observing, being aware of these classes will help you in identifying the reactions that are occurring in this experiment.

The types of reaction are double replacement, single replacement, neutralization, and addition reactions.

The reaction we just looked at between lead nitrate and potassium iodide is an example of a double replacement. It is easier to see this if we write the reaction as follows:

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

Note that in each of the molecules we start with one ion is replaced by another. It is important to realize that unless a precipitate is formed, no reaction has occurred.

An example of a single replacement reaction is the reaction between nitric acid and Zn:

$$2HNO_3(aq) + Zn(s) \rightarrow Zn(NO_3)_2(aq) + H_2(g)$$

Notice that in this type of reaction only one ion, the nitrate ion, NO3-, is transferred from the H to the Zn. Notice also that the oxidation state of the H goes from +1 to 0, while the oxidation state of the Zn goes from 0 to +2. This change in oxidation states is something that all single replacements have in common – therefore all single replacement reactions are also oxidation-reduction reactions.

Neutralization reactions: A neutralization reaction is a reaction between an acid and a base which produces water as one of it's products. The most common neutralization reaction is the one we mentioned before:

$$H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$$

Neutralization reactions typically take place between an acid and a hydroxide containing base. Neutralization reactions are special cases of acid-base reactions. The most common types of acid base reactions involve the transfer of a proton from an acid to a base. An example of this is the reaction between hydrochloric acid and methylamine,

$$HCl(aq) + CH_3NH_2(aq) \rightarrow Cl^-(aq) + CH_3NH_3{}^+(aq)$$

Combination reactions: A combination reaction is one in which two compounds combine to make a single new compound. For example, the reaction with sulfur with oxygen to form sulfur dioxide,

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

is an important reaction in the chemistry of air pollution. The opposite of a combination reaction is a decomposition reaction. An important reaction in this class is the decomposition of carbonic acid into water and carbon dioxide, which often follows immediately on reactions of acids with metal carbonates:

$$H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$$

III. Safety and Waste Disposal

a. Wear your safety glasses throughout this experiment.
b. Smell the solutions by wafting the odors toward your nose
c. Label one of your beakers as a waste beaker and then deposit the contents in the waste container at the end of the session. Do not put any chemicals down the sink. Rinse out your test tubes and dispose of them in the glass waste bins.