Project IV: Hot and Cold

For project III, we will follow the lab on page 121 of the *Cooperative Chemistry Laboratory Manual, 5th edition*. This lab is a calorimetry experiment, an experimental technique used to measure the heat transferred in chemical or physical processes. In this lab, we will carry out a calorimetry experiment where we will investigate the heat changes involved in various types of reactions. This experiment will also give us experience in writing chemical equations for several different types of reactions.

Requirements Goal 1: Construction of Calorimeter

- Construction and calibration of calorimeters
    - Each group will need to construct two coffee cup calorimeters. A good calorimeter will not allow heat transfer between the surroundings and the system. Thus, you will want to experiment with the experimental design of your calorimeter so that heat transfer between the surroundings and the system is minimized.
    - After construction of your calorimeters, you will need to determine the heat capacity of each one. The ideal calorimeter would not absorb any of the heat involved in the reaction and thus have a heat capacity of zero. Since we cannot construct a perfect calorimeter with coffee cups, we must determine the amount of heat our calorimeter absorbs and thus adjust for it in subsequent calculations.
    - Follow the procedure in the lab manual for finding the heat capacity of a calorimeter.
    - You should do at least three trials in order to determine the heat capacity of each of your calorimeters. You should set up a spreadsheet in Excel for all calculations.

Requirements Goal 2: Determining Heats of Reactions

- Once you have determined the heat capacity of your calorimeters, you are ready to measure heats of reactions.
- There are four different types of reactions you will investigate: acid/base reactions, salts in water, oxidation/reduction reactions, and precipitation reactions.
- You will have to investigate the chemicals available in the lab in order to determine what reactions you will be able to investigate.
- Since each group has two calibrated calorimeters, you will want to divide the work among your group members.
- You should do at least three trials of each reaction you investigate.
- Since you will be collecting a lot of data, your group will want to set up a spreadsheet so that you can enter your data and set up the spreadsheet to calculate the heat of reaction.
- In order to work safely, there are some guidelines you must adhere to:
    - For any reaction, use only 1M and 3M acids and bases.
    - The oxidation of metals by acids results in the production of hydrogen gas. Thus, when investigating these oxidation-reduction reactions, you will want to use small quantities of the metals (no more than 0.1 g per trial) and make sure you work under the fume hood.
    - **Due to the production of hydrogen gas through the oxidation of metals by acids, there can be no open flames in lab these two weeks**.

Requirements for Goal 3: Literature Search

- Goal 3 requires you to use various reference sources for finding scientific data. This is an individual assignment. Each member of your group must conduct their own literature search.
    i. Provide the answers to the following questions in your lab report. You must find this data in a CRC Handbook or a Merck Index. Provide a reference for each response.
        - What is the $\Delta H°_f$ for water (l)?
        - What is the $\Delta H°_{sol}$ (enthalpy of solution) for ammonium nitrate?
        - What is the $\Delta H°_{sol}$ (enthalpy of solution) for potassium hydroxide?

    ii. Provide the answers to the following questions in your lab report. You must find this data in a material safety data sheet (MSDS). You must provide a reference for the MSDS used. Find the following MSDS for nitric acid
        - http://hazard.com/msds/mf/baker/baker/files/n3662.htm
        - What are the health, flammability, reactivity and contact rating for nitric acid?
        - What are the OSHA PEL-TWA and PEL-STEL values for nitric acid?
        - What type of eye protection must be worn when working with nitric acid? What type of safety equipment must be present in the lab in which nitric acid is used?

Requirements for writing your lab report:

- You must include a complete balanced equation and a net ionic equation (where appropriate) for each reaction investigated in your lab report.
- The lab report is an individual project. Although you collected data in a group, the lab report is an individual project. Thus, each member of the group must generate their own tables and graphs and write their own lab report.
- All results must be reported in tabular format. (Use your textbook as a reference to see the proper format for a scientific table.)
- Your lab report will consist of a results and discussion section with data tables and graphs, if appropriate.
- All lab reports must be typed including all tables.

Grading Project IV:

- Prelab Assignments
- Weekly Summaries
- Lab Report
    - Results and discussion- Your lab instructor will be looking for the following when grading your results and discussion section:
        * Is data reported in tables?
        * Is data reported in the proper scientific format (correct units, significant figures?)
        * Chemical equations included for each reaction investigated.
        * Literature search results
    - Experimental
- Peer Evaluation

Safety Precautions:

- Wear your safety goggles at all times. You will be using several different acid, base and salt solutions. If you get any solution on you, wash immediately with lots of water and inform your lab instructor.
- When working with acids and bases, wear protective gloves.
- **NO OPEN FLAMES DURING WEEKS 2 AND 3**
- **Work under the hood when carrying out any oxidation-reduction reaction.**
- Dispose of all waste in the labeled containers in the common equipment area. Use a wash bottle to rinse glassware into the container.
- You will use several different reagents throughout this experiment. Many of the reagents are located in the common reagent area in the front of the lab. When you need a reagent, take a container to the stock solution and pour the amount that you need into your container.
- Never pour anything back into the stock solution.
- Never lay reagent bottle stoppers or caps on the lab bench. The entire reagent may become contaminated. In addition, the residue on the bench may be hazardous and linger for days or weeks. This could injure someone well after the fact. Hold the stopper in your other hand while you get the material out of the bottle. Replace stoppers immediately and completely.
- Balances are especially sensitive, expensive devices. **Never weigh chemicals directly on the pan**. Use a container such as a beaker or flask. Remove the container from the balance, add the chemical and then replace the container. If you spill anything onto the balance, please notify the instructor immediately.

Background Reading and Practice Problems:
Cooperative Chemistry Laboratory Manual

- Project 12: Hot and Cold

General Chemistry, 4th Edition by McQuarrie

- Calorimetry: Read Section 14-8, (501-503);
- Precipitation Reactions: Read Section 10-9, (328-332); Complete Practice Problems 10-13, 10-14, 10-15, and End of Chapter Problems 10-52
- Acids and Bases: Read Section 10-10 (332-335); Complete End of Chapter Problems 10-56
- Oxidation-Reduction Reactions: Read Section 10-11, (335-338); Complete Practice Problems 10-18, 10-19