Energy of Chemical Reactions

Target audience: 9-12

Background and Notes:

Calorimetry is the study of heat transfer. In chemical reactions, energy exchanges can be measured as temperature changes. These energy changes can be calculated knowing the mass of the liquid or solid, the temperature change and the specific heat of a substance using the equation
$Q = m\ Cp\ \Delta T$.

Two chemical reactions will be studied, an exothermic and an endothermic.

Knowledge and skills:

- Students should understand the process of energy transfer during chemical reactions.
- Students should know and understand the following terms: polar, nonpolar, hydrophilic, hydrophobic, exothermic, endothermic, calorimetry
- Students should be able to use an electronic balance and weigh solid chemicals.
- Students should be able to use a graduated cylinder to properly measure liquids.
- Students should be able to calculate the heat absorbed or released in a chemical reaction using the equation, $Q = m\ Cp\ \Delta T$.

Fundamental understanding:

- Energy changes occur in nature during chemical and physical changes.

Essential Questions:

- How is energy converted in chemical reactions?
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National standard:
National content standard B, students should develop an understanding of the structure of atoms and the structure and properties of matter. Students should understand the motions and forces with Interactions of energy and matter.

State standard(s):
3.03 and 3.04 Objectives for North Carolina Chemistry Standard Course of Study Objective: Analyze calorimetric measurement in simple systems.

Purpose: to observe energy changes in chemical reactions and calculate Q, the heat released to or absorbed from the surroundings.

Safety Precautions:

- Do not eat or drink any of the chemicals or any other food at the lab table. Metals can be poisonous to consume.

- Wash your hands well after working with any chemicals. Copper II Chloride may stain your clothes.
- The products of the reaction with Copper II Chloride and Aluminum need to be placed in a waste beaker not down the sink.
- The products of baking soda and citric acid may be disposed of down the sink with plenty of running water.

Materials:

Equipment:

1. Thermometers
2. 100 ml beakers
3. 250 ml beakers
4. glass rods
5. LabPros or CBL's with Temperature probes can be used in place of thermometers

Reagents:

1. Copper II chloride (exp.1)
2. Al (exp.1)
3. ~ 255.0 ml tap water (exp.1)
4. ~30.0 ml 1.5 M citric acid (exp.2)
5. ~ 10.0 g baking soda (exp.2)

Procedure:

Experiment 1

1. Add approximately 25 ml of tap water to the 100 ml beaker. Record exact amount of water, then add the crystals of copper (II) chloride (~5.0 g) to the water. Stir well.
2. Record temperature.
3. Tear the foil into small pieces and add to the solution of Copper II Chloride, stirring constantly. Do not stir with the thermometer. Record temperature every 5 seconds until the increasing temperature starts to decrease. You will use the maximum temperature to calculate Q, the amount of heat released or absorbed in the reaction.

Experiment 2

1. Add approximately 30 ml of citric acid to the 250 ml beaker. Record exact volume of citric acid.
2. Record temperature of citric acid solution before adding baking soda.
3. Add the baking soda to the citric acid. Stir well with glass rod. Do not stir with the thermometer. Record temperature every 5 seconds until the temperature starts to reverse. You will use the minimum temperature to calculate Q, the amount of heat released or absorbed in the reaction.
4. After experiment, wash down the sink with plenty of running water.

Results:

- **Observations:**
- Exp. 1 & 2: Prior to combining any chemicals, describe them in a data table
- **Data table:** You must design the format of the table
- Exp. 1 & 2: Record temperatures before combining any chemicals. Record the exact volumes of liquids used. This is critical data.

Calculations and Data Analysis:
Exp. 1 & 2: Calculate the energy gained or lost in both experiments using the formula: Q = m Cp □T

Conclusion:

1. Restate Purpose and/or hypothesis
2. Which combination of chemicals resulted in an exothermic reactions?
3. Which combination of chemicals resulted in an endothermic reactions?
4. State the final quantities of energy evolved or absorbed with the proper sign, no raw data should appear here.
5. How would you change (includes human error) or improve this experiment?
6. What other investigation could you try?

References and Resources:
High School or College Chemistry Textbook containing information on Calorimetry.
Vernier Software and Technology: info@vernier.com

Teacher Notes:
Lab Set Up
1. 30 ml 1.5 M citric acid** for each team of 2 students
2. ~10 g baking soda for each team of 2 students
3. 5 g copper (II) chloride (1 vial/2students)
4. 2 inch squares of Al foil (1 square/ 2 students)
5. 100 ml beaker (1for 2 students)
6. 200-250 ml Beakers (1 for 2 students)
7. glass stir rods (1 for 2 students)
8. 50 or 100 ml grad. Cylinders (1 for 2 students)
9. styrofoam cups Forget these too confusing
10. 1 large beaker at each stations to dispose of $CuCl_2$ reaction (to be filtered later), the other reaction can go down the sink

**1.5M Citric Acid 288.2 g citric acid or 315.2 g citric acid. H_20 in 1.0 Liter
** pre-weighed small vials with the copper II chloride and the baking soda prior to the experiment, save class time, but if time allows students can weigh their own chemicals.