Introduction

You will carefully measure the amount of heat released by mixing several chemicals. To be sure that your results are accurate, you will measure the heat of reaction in two ways. First you will break the reaction into two steps and measure the heat change of each step. Then, you will measure the heat change of the overall reaction when it takes place in one step. When you are finished, you should find that the sum of the two steps equals the overall reaction that takes place in one step. Thus, the sum of the changes in enthalpy for the two steps should also equal the change in enthalpy for the overall reaction that takes place in one step.

Objectives

- ☐ Demonstrate proficiency in the use of a coffee-cup calorimeter and related equipment
- ☐ Relate temperature changes to enthalpy changes
- ☐ Determine heats of reaction
- ☐ Demonstrate that heats of reaction can be additive (Hess's Law)

Procedure—Rxn 1

1. Pour about 50 mL of tap water into a graduated cylinder. Measure and record the volume of the water to the nearest 0.1 mL. Pour the water into your calorimeter. Use the LabQuest with the temperature probe to record the water's temperature after 1 minute.
2. Zero the balance with a piece of weighing paper on it. Quickly measure approximately 1 g of NaOH solid pellets onto the weighing paper and record its exact mass. *You must measure the NaOH quickly because it is hygroscopic which means that it absorbs water from air and will increase its mass as it does so. DO NOT TOUCH THE NaOH…IT WILL BURN YOU!*
3. When you get back to your lab station, immediately place the NaOH pellets into the calorimeter that contains the tap water. Stir the mixture gently with the temperature probe. Record the highest temperature reached by the reaction.
4. Write the reaction that just occurred with phases of the substances. *Hint: Do not include water as a reactant; this is simply a phase change reaction..*

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5. Pour the contents of the calorimeter down the drain and flush with running water. Rinse the calorimeter and the temperature probe several times with water to clean them.

Procedure—Rxn 2

6. Pour about 25 mL of 1.0 M HCl(aq) into a graduated cylinder. Measure and record the volume of the 1.0 M HCl(aq) to the nearest 0.1mL. Pour the HCl(aq) into your calorimeter. Use the LabQuest with the temperature probe to record the HCl(aq)'s temperature after 1 minute. Rinse the graduated cylinder several times with tap water.
7. Pour about 25 mL of 1.0 M NaOH(aq) into a graduated cylinder. Measure and record the volume of the 1.0 M NaOH(aq) to the nearest 0.1 mL. Pour the NaOH(aq) into your calorimeter. Stir the mixture gently with the temperature probe. Record the highest temperature reached by the reaction.
8. Write the reaction that just occurred with phases of the substances. *Hint: This is a double-replacement reaction*

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9. Pour the contents of the calorimeter down the drain and flush with running water. Rinse the calorimeter and the temperature probe several times with water to clean them.

Procedure—Rxn 3

10. Pour about 50 mL of 0.5 M HCl(aq) into a graduated cylinder. Measure and record the volume of the 0.5 M HCl(aq) to the nearest 0.1 mL. Pour the 0.5 M HCl(aq) into your calorimeter. Use the LabQuest with the temperature probe to record the 0.5 M HCl(aq)'s temperature after 1 minute. Rinse the graduated cylinder several times with tap water.
11. Zero the balance with a piece of weighing paper on it. Quickly measure approximately 1 g of NaOH solid pellets onto the weighing paper and record its exact mass. When you get back to your lab station, immediately place the NaOH pellets into the calorimeter that contains the 0.5 M HCl(aq). Stir the mixture gently with the temperature probe. Record the highest temperature reached by the reaction.
12. Write the reaction that just occurred with phases of the substances. *Hint: This is a double-replacement reaction.*

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13. Pour the contents of the calorimeter down the drain and flush with running water. Rinse the calorimeter and the temperature probe several times with water to clean them.

LAB REPORT—(106)—entirety in 3rd person!!

- ☐ All lab partners' names, with your name delineated (1 pt.)
- ☐ Title (1)
- ☐ Abstract (5)
- ☐ Introduction (5)
- ☐ Materials & Methods (9)
- ☐ Results (11)
- ☐ Discussion (66)…see below
- ☐ Conclusion (5)
- ☐ Works Cited (3)

Discussion Items

1. Write a balanced equation for each of the three reactions. (10 pts.)
2. Use Hess's Law to show that you can add two of the reactions together in order to obtain the other reaction. (10 pts.) *Remember that you can cancel like terms (those of the same formula and phase are like terms) on opposite sides of the equation.*
3. Calculate the change in temperature ($\Delta T = T_f - T_i$) for each of the three reactions. (6 pts.)
4. Assuming that the density of each solution is 1g/mL, calculate the mass of solution present in each of the three reactions. (6 pts.) *Remember that the addition of 1 g of NaOH in rxns 1 and 3 are part of the total mass of the solutions.*
5. Using ΔH = (mass)(ΔT)(SHC), calculate the heat released (ΔH) in kJ by each reaction. (12 pts.) *Hint: SHC of each solution is equal to the SHC of water, 4.18 J/g°C.*
6. Calculate the number of moles of NaOH in each solution. (9 pts.) *Hint: For reaction 2, recall that 1.0 M means that there is 1 mol of NaOH for every 1 L of NaOH solution.*
7. Calculate the ΔH in kJ/mol of NaOH for each of the three reactions. (9 pts.)
8. Using your answer to #2, explain and prove how the enthalpies of each reaction are mathematically related. (4 pts.)

<u>Supplies</u>

- ☐ Calorimeters
- ☐ LabQuests w/temperature probes
- ☐ 100-mL graduated cylinders
- ☐ 48g NaOH pellets
- ☐ HCl soln, 1M, 500mL…20.84mL of 12M in 500mL flask, 2x
- ☐ HCl soln, 0.5M, 1000mL…41.67mL of 12M in 1000mL flask, 2x
- ☐ NaOH soln, 1M, 500mL…10g in 500mL flask, 2x