Heats of reaction and Hess's Law

Purpose: 1) to measure the $\Delta H°$ of a reaction using a "coffee cup" calorimeter. 2) To compare the $\Delta H°$ of three related equations, thus demonstrating Hess's law.

Background: calculate the # of moles in a) 4.00 g NaOH, b) 100 mL of 1.0 M NaOH (recall, mol = mol/L x L)

Procedure:

1. Obtain the following equipment: two (300 mL) Styrofoam cups, a 100 mL graduated cylinder, a thermometer (ensure that your thermometer is reading in the same range as other thermometers). Thoroughly rinse the graduated cylinder, thermometer, and Styrofoam cups with tap water. To dry the graduated cylinder turn it upside down and allow it to drip dry (about 20 seconds). Dry the cups with paper towel. Place cups together (one inside the other). These will always stay together (two cups will provide more insulation than one).
2. Measure 200 mL of room temperature distilled water into the cup. Stir the water gently with the thermometer. Once the temperature reading for the water stabilizes, record it in top left cell of the chart below (to 1 decimal place). N**ote: never rest the thermometer against the side of the cup – always hold it or clamp it to a retort stand.**
3. **Read this entire step before proceding.** Using a scrap piece of paper as a "weigh-boat" quickly measure out 4.00 g (±0.03 g) of NaOH. This must be done quickly (within about 20 seconds) and with care, since NaOH absorbs water from the air. Also, tightly close the lid of the NaOH container when you are done. Note: NaOH is a strong base. Avoid contact. Flush your skin with water if you accidentally touch it. If you spill any NaOH, pick it up with a paper towel & flush it down the sink. As soon as you have measured the NaOH, quickly add it to the water. Stir slowly to dissolve the NaOH. Record the highest temperature reached (to one decimal place).
4. Dump the solution down the sink. Rinse and dry both the thermometer and the Styrofoam cup.

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5. Measure 200 mL of 0.50 M HCl. Place it in the cup. Stir. Record the temperature (under reaction 2).
6. Quickly weigh 4.00 g of NaOH. Add it to the HCl. Stir gently. Record the highest temperature reached.
7. Dump the solution down the sink. Rinse and dry the Styrofoam cup, thermometer, and graduated cylinder.

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8. Place 100 mL of 1.0 M HCl in the cup. Stir. Record the temperature. Rinse and dry the graduated cylinder.
9. Measure 100 mL of 1.0 M NaOH; add it to the HCl. Stir. Record the highest temperature reached.
10. Dump the solution down the sink. Rinse and return all equipment.

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11. Give your instructor your ΔT values for all 3 equations.
12. In the chart below, indicate how many moles of NaOH and HCl are present in each reaction.
13. Your instructor will write values for ΔT (class avg.) on the board. Record these and use them for all calculations.
14. Calculate ΔH for each reaction (assume $\Delta H = q$). Notice that all reactions are written as having one mole of products and reactants. Show your calculations. Record your final answer in the last row of the chart.

	Reaction 1	Reaction 2	Reaction 3
	$NaOH(s) \rightarrow NaOH(aq)$	$NaOH(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O$	$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O$
Temp (initial) °C			
Temp (final) °C			
ΔT			
ΔT (class avg)			
moles of NaOH			
moles of HCl			
$\Delta H°$ (from class avg)			

Questions:

1. Write out the three reactions from today's lab as thermochemical equations (use the correct sign for ΔH).
2. What causes the temperature change in reaction 1?
3. What causes the temperature change in reaction 2?
4. What causes the temperature change in reaction 3?
5. **Read 5.6 (pg. 164 – 165).** Define Hess's law.
6. Draw the enthalpy diagram for today's lab (use fig. 5.6 on page 165 as an example)
7. Arrange the thermochemical equations from the lab, to demonstrate Hess's law (see examples on pg. 166-7). Indicate the difference between the theoretical (calculated from Hess's law) and actual (from lab) ΔH values.
8. Suggest possible sources of error in the experiment and explain how these would affect your results (i.e. explain why you do not get exactly the same value for reaction 2 vs. reaction 1 + 3).