Lower Merion High School Chemistry

Hess' Law

Lab #26

Hess' Law states that when one reaction can be written as the sum of two or more others, then the heat of the reaction is the sum of the heats of the other reactions. In this lab you will have chance to verify Hess's Law using the reactions below:

$NaOH_{(s)} \rightarrow NaOH_{(aq)}$

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H2O_{(l)}$

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The heat for each reaction will be measured in a calorimeter (Styrofoam cup). You will then be able to calculate heat by measuring the temperature change and using the formula $q = m\ c\ \Delta T$. For this lab, it will not make a significant difference to assume that the specific heat (c) of the solution is equal to the specific heat of water (1 cal/g^{o}C).

Materials:

TI-83 calculator with CHEMBIO		CBL System	temperature probe
Styrofoam cup	balance	water	NaOH pellets
1M HCl	1 M NaOH	0.5M HCl	

Procedure:

CAUTION: NaOH is corrosive in both solid and aqueous form. HCl is corrosive. If you get anything on your skin, rinse the area with plenty of water and inform your instructor. If solution or pellets are spilled, inform your instructor immediately.

Part A:

Find the mass of a Styrofoam cup. Add approximately 100 mL of water and reweigh the cup and water.

Set up the calculator, CBL and temperature probe. Run the program CHEMBIO. Set up the temperature probe using the STORED calibration, if asked. From the DATA COLLECTION menu, choose TIME GRAPH, with data points taken every 2 seconds for 99 data samples. Set the YMIN = 0, YMAX = 60 and the Y SCALE = 10.

Place a piece of paper on the balance and rezero it. Carefully weigh out 2 g of NaOH pellets on the paper.

Take the NaOH back to your desk. Put the temperature probe into the water and press ENTER to begin data collection. After 10 seconds, dump in the NaOH and stir the solution with the temperature probe until the pellets completely dissolve.

When the data collection is finished the calculator will display a graph of temperature v time. Use the cursor buttons to move from point to point on the graph. Find the temperature of the water just before mixing and the highest temperature reached.

Rinse the temperature probe, dump the solution and rinse out and dry the cup.

Part B:

Set up the CBL system using the same settings as before.

Carefully add 50 mL of 1 M NaOH solution to the cup and weigh it. Obtain 50 mL of 1M HCl solution. Press ENTER to begin data collection. After 10 seconds, add the HCl to the cup and stir with the temperature probe.

When the data collection is finished the calculator will display a graph of temperature v. time. Use the cursor buttons to move from point to point on the graph. Find the temperature of the water just before mixing and the highest temperature reached.

Reweigh the cup with the solution in it. Rinse the temperature probe, dump the solution and rinse out and dry the cup.

Part C:
Set up the CBL system using the same settings as before. Carefully pour 100 mL of 0.5 M HCl solution into the cup and weigh it. Using the same procedure you did before, obtain 2 g of NaOH pellets.

Put the temperature probe into the solution and press ENTER to begin data collection. After 10 seconds, dump in the NaOH and stir the solution with the temperature probe until the pellets completely dissolve.

When the data collection is finished the calculator will display a graph of temperature v time. Use the cursor buttons to move from point to point on the graph. Find the temperature of the water just before mixing and the highest temperature reached.

Rinse the temperature probe, dump the solution and rinse out and dry the cup. Put away all equipment.

Calculations:

For each reaction, determine the mass of the solution and the change in temperature.

Determine the heat of each reaction, then divide each heat by the moles of NaOH used in that reaction.

Theoretically, the sum of the first two reaction heats should be the heat of the third reaction. If it is not, determine the percent error, using the heat of the third reaction as the expected value.