AP Mini Lab
Application of Hess's Law

Background

In this lab activity you will measure and compare the quantity of heat involved in three chemical reactions. A polystyrene cup will serve as your calorimeter in this experiment (any small heat losses to the surroundings will be neglected). We will also assume that the aqueous solutions used in this lab have the same density and specific heat as water.

The reactions to compare are:

(1)	$NaOH(s) \rightarrow Na^{+}(aq) + OH^{-}(aq)$	$\Delta H = ?$
(2)	$H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O(l)$	$\Delta H = ?$
(3)	$NaOH(s) + H^{+}(aq) \rightarrow H_2O(l) + Na^{+}(aq)$	$\Delta H = ?$

When Hess's Law is used to add equations one and two, the resulting equation is identical to equation three above.

In this lab, you will carry out all three reactions, then, after calculating the heat of reaction for each, you will add equations one and two and compare this value to the value obtained for reaction three. Any difference between them will be expresses as your percent error.

Purpose

To use Hess's Law to calculate the heat of reaction (ΔH)

Procedure

Reaction One

1. Clean and dry your thermometer, scoop, large graduated cylinder, watch glass, and cup.
2. Using your large graduated cylinder, place 100.0 mL of dH_2O into your cup.
3. ***Record*** the mass of your clean, dry watch glass.
4. Bring your scoop ***and*** watch glass to your instructor to obtain some sodium hydroxide pellets. Determine and ***record*** the mass of the watch glass and pellets immediately.
5. While one partner is determining the mass of the watch glass and pellets, the other should determine the temperature of the dH_2O in the cup (to the nearest .2 degree Celsius).
6. Place the pellets in the cup and dissolve them. Stir carefully and constantly. Record the *highest* temperature reached.
7. Clean and dry the equipment you used.

Reaction Two

8. Obtain 50.0 mL of 1.00 M HCl and place it into your clean cup.
9. Clean and dry your graduated cylinder and obtain 50.0 mL of 1.00 M NaOH. Don't add it to the hydrochloric acid solution yet.

10. Measure the temperature of each solution to the nearest .2 degree Celsius (be sure to rinse and dry the thermometer before changing from one solution to another).
11. Add the NaOH solution to the HCl solution in the cup. Mix quickly and ***record*** the ***highest*** temperature reached.
12. Clean and dry the equipment you used.

Reaction Three

13. Repeat the steps used for reaction one ***except*** use 100. mL of **.50** M HCl (instead of 100. mL of dH_2O. Also, the watch glass does not need to be weighed again if it is the same one used before.
14. Clean and dry the equipment you used. Don't throw away the styrofoam cup. Wash your hands, return the goggles, and wipe down your area.

Data

Reaction 1	**Reaction 2**	**Reaction 3**
Mass of watch glass g	Exact volume of 1.00 M HCl mL	Mass of watch glass g
Mass of watch glass + NaOH g	Exact volume of 1.00 M NaOH mL	Mass of watch glass + NaOH g
Mass of NaOH g	Initial T of HCl in calorimeter ˚C	Mass of NaOH g
Initial T of water in calorimeter ˚C	Initial T of NaOH ˚C	Exact volume of 0.50 M HCl mL
Final T of solution ˚C	Final T of solution ˚C	Initial T of 0.50 M HCl in calorimeter ˚C
		Final T of solution ˚C

Calculations

Assume that the aqueous solutions in this lab have the same specific heat and density as water.

Reaction One: $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$

1. mass of NaOH used (yes, show your work for this one)

2. change in temperature (ditto)

3. heat energy (in kJ) produced by reaction

4. moles of NaOH used

5. $\Delta H_{rxn\ 1}$ (in kJ/mol)

Reaction Two: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

1. average starting temperature

2. change in temperature

3. heat energy (in kJ) produced by reaction

4. moles of NaOH used

5. $\Delta H_{rxn\ 2}$ (in kJ/mol)

Reaction Three: $NaOH(s) + H^+(aq) \rightarrow H_2O(l) + Na^+(aq)$

1. mass of NaOH used

2. change in temperature

3. heat energy (in kJ) produced by reaction

4. moles of NaOH used

5. $\Delta H_{rxn\ 3}$ (in kJ/mol)

Questions

1. Write the net-ionic, thermochemical equations for reactions one, two and three.

2. Using Hess's Law, add equations one and two to obtain the experimental ΔH. How does the resulting equation (what you get when you add equations one and two) compare to the equation for reaction three?

3. Calculate the percent error. Use the ΔH obtained for reaction three as the theoretical value and the value obtained by using Hess's Law in number two as the experimental value.