LAD C.4 (pg 1 of 3) Enthalpy Change of a Rx − Hess' Law

Name_____Per____

Introduction:

- heat (q) measured temperature changes used in combination with $q = m \times c \times \Delta T$ will be used to calculate the amount of heat transferred during a reaction. (m = mass, c = specific heat capacity, ΔT = temp change)

Heat measured under constant pressure conditions (as is the case in this experiment − reactions that occur in solution in an open container are under the constant pressure of the open atmosphere) is called enthalpy, ΔH.

The sign of ΔH is important

- ΔH will be negative (exothermic) when heat is lost by a system (or reaction)
- ΔH will be positive (endothermic) when heat is gained by a system (or reaction)

PreLAD:

***Data Table − On a separate piece of paper, not* on this LAD sheet.**

Read the all of this LAD sheet and then set up a data/results table. Put your data entries in rows and make two columns for two trials (in the event, a second trial is needed). Leave a third column for calculations. These data & calculation items will be put into your google spreadsheet data table. Use the same spreadsheet, just make a new sheet with the tab at the bottom.

Write balanced equations for the following reactions.

1. Rx 1: Write both the balanced *overall* equation and balanced *net ionic* equation that represents the reaction of aqueous sodium hydroxide with aqueous hydrochloric acid.

2. Rx 2: Write both the balanced *overall* equation and balanced *net ionic* equation that represents the reaction of solid sodium hydroxide with aqueous hydrochloric acid.

3. Rx 3: Write both the balanced *overall* equation and balanced *net ionic* equation that represents the aqueous dissolution of solid sodium hydroxide.

4. Two of the equations above will combine to produce the other of the three equations above. Write out the equations to demonstrate that Hess' Law "works."

5. What are the *typical* units for c, specific heat capacity?

6. What are the *typical* units for ΔH_{rx} ?

Procedure Overview:

We will experimentally determine the ΔH_{rx} of three chemical reactions. Since two of the three reactions will add to the third reaction, so too will the ΔH_{rx} of the same two reactions will also add to the ΔH_{rx} of the third reaction, and calculate a percent error. Further you can calculate the theoretical value for ΔH_{rx} for all three reactions and calculate a percent error.

Materials on tray for two groups − *Please leave the tray and your lab bench clean and neat.*

- 2× foam cups
- 2× thermometer
- vial of solid NaOH (*Be sure and keep covered at all times when not actively removing material.*)
- flask of 1.0 M NaOH
- flask of 1.0 M HCl
- 2× stirring bar and stirrer

Procedure - *Protective eyewear is not optional.*

Waste solutions from reactions 1 and 2 can go down the sink. Solution ONLY from reaction 3 should go into the collection beaker on the center lab bench.

A. For each reaction involving volume, you will be using 50 ml (in reaction 1 use 50 ml of each of the solutions). For the mass of NaOH, you will be using 2.0 g. Be sure and always replace the cover on the bottle of NaOH as quickly as possible.

B. For each reaction trial you will need to determine the mass of each of the three solutions involved. You can make the (nearly correct) assumption that the density of the 1.0 M solutions are 1.0 g/ml.

C. For each reaction trial you must measure the starting and final temperature.

Processing the data:

Make the assumption (*nearly correct*) that the specific heat capacity of all solutions in the lab will be 4.18 J/gºC

1. Calculate the energy absorbed by the solution during each reaction (Solve for $q_{solution}$)
2. Convert the energy absorbed by the solution to the energy released by the reaction.
3. Calculate the moles of reactants involved in the reactions (moles of acid should be the same as moles of base).
4. Calculate experimental ΔH *per mole reaction* for each reaction. Think hard about what this "per mole reaction" means.
5. Calculate the experimental ΔH for the two reactions that combine to produce the third reaction.
6. Calculate the percent error between the ΔH of one of the reaction that is the combination of the ΔH of the other two reactions.
7. Use thermodynamic tables to compute the theoretical ΔH for each of the reactions. Compare to your experimental values by calculating a percent error.

Post LAD Questions − Answer all of the following questions by stating what **data** would be affected, and follow the effect of any data changes through the **calculations** ending with commenting on the resulting effect, if any on $q_{sol'n}$ **and** $\Delta H_{dissolve}$**.**
(*Be very careful/clear explaining bigger/smaller when negative numbers are involved − use either "magnitude" or absolute values.*)

1. For reaction 1, if 6 M solutions had been used,
   a. would the value of q be larger, smaller, or the same? Justify your answer.

   b. Would the value of ΔH be larger, smaller, or the same? Justify your answer.

2. For reaction 3, if twice the mass of NaOH had been used,
   a. would the value of q be larger, smaller, or the same? Justify your answer.

   b. Would the value of ΔH be larger, smaller, or the same? Justify your answer.

3. For reaction 2, why is important that exactly 2 g of NaOH be used with the 50 ml of 1 M HCl, yet in reaction 3 it would have been fine if you uses 3 g of NaOH with the 50 ml of water?

4. For reaction 1, your lab mate proposes that there is nothing so special about using 50 ml of each solution, but insists it is VERY important that you use the SAME volume of both the HCl and the NaOH solutions. Do you agree? Explain why or why not.

5. For reaction 3 would you expect $\Delta H^{o}_{dissolution}$ of NaOH to be larger, smaller, or remain the same if by not covering the calorimeter, we lost some heat into to the air during the reaction? Justify your answer.

6. Think back to a demonstration at the beginning of the year, in which you learned about the terms hygroscopic and deliquescent. Your partner is very particular and got upset with you when you weighed out the NaOH at the very beginning, and then let it sit around for many minutes before using it in reaction 3. Would this have caused the ΔH to be larger, smaller, or the same? Explain. Did your partner actually have good cause to be upset?