Name: ______________________________________

Lab 11. Enthalpy of Reaction

Introduction

Enthalpy, a state function, is particularly useful to chemists because it is related to the heat evolved or absorbed by a chemical reaction occurring at constant pressure. In particular, the standard molar enthalpy change of a reaction equals the heat absorbed when one mole of product is created at standard temperature and pressure (STP).

In this lab, you will quantify the heat added to or taken from the solvent by the reacting reagents of two different reactions:

The single replacement redox reaction between iron and copper(II) chloride

$$2\ Fe + 3\ CuCl_2 \rightarrow 2\ FeCl_3 + 3\ Cu$$

The acid-base and decomposition reaction between hydrochloric acid and sodium bicarbonate

$$HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$$

Materials

- spatula
- HCl solution
- sodium bicarbonate powder
- polystyrene foam cup "calorimeter"
- graduated cylinder
- thermometer
- $CuCl_2$ solution
- iron powder
- lid for foam cup
- PPE

Procedure

Redox reaction

1. Measure the mass of the empty calorimeter and lid. Enter in the data table.
2. Weigh out the assigned mass of iron powder. Enter the actual mass in the data table.
3. Place the assigned volume of copper(II) chloride solution into the calorimeter.
4. Measure the mass of the calorimeter (with lid) containing the solution.
5. Insert the thermometer through the hole in the lid of the calorimeter so that you can measure the temperature of the solution. Be careful not to punch the thermometer through the bottom of the calorimeter: the bottom of the foam cup is not very durable.
6. Remove the lid and add the iron powder to the calorimeter. Immediately replace the lid (with the thermometer).
7. Gently swirl the calorimeter to allow all the iron powder to react.

8. Continue gently swirling the calorimeter. Record the temperature every 30 seconds or so until the temperature stops increasing. Record the maximum temperature in the data table.
9. Pour the solution and solid in the labeled Copper Waste container. Chase with a little water from a wash bottle. Dispose of the foam cup in the solid waste.

Acid-base reaction

1. Measure the mass of the empty calorimeter and lid. Enter in the data table.
2. Weigh out the assigned mass of sodium bicarbonate powder. Enter the actual mass in the data table.
3. Place the assigned volume of hydrochloric acid solution into the calorimeter.
4. Measure the mass of the calorimeter (with lid) containing the solution.
5. Insert the thermometer through the hole in the lid of the calorimeter so that you can measure the temperature of the solution. Be careful not to punch the thermometer through the bottom of the calorimeter: the bottom of the foam cup is not very durable.
6. Remove the lid and add the sodium bicarbonate powder to the calorimeter *in small amounts*. Allow the foaming to subside and gently swirl the cup before adding more powder. Replace the calorimeter lid (with the thermometer).
7. Gently swirl the calorimeter to allow all the iron powder to react.
8. Continue gently swirling the calorimeter occasionally. Record the temperature every 30 seconds or so until the temperature stops decreasing. Record the minimum temperature in the data table.
9. Pour the solution and solid into the labeled Acid Waste container. Chase with a little water from a wash bottle. Dispose of the foam cup in the solid waste.

Calculations

Enter all the values you calculate into the appropriate Calculations table. Report the proper unit with your numbers.

1. Calculate the mass of the solution added to the calorimeter.
2. Calculate the moles of solute ($CuCl_2$ or HCl) added to the calorimeter.
3. Calculate the molar masses of the two powders.
4. Calculate the number of moles of the powders added to the calorimeter.
5. Calculate the theoretical yield in moles of the products NaCl and Cu.
6. Calculate the temperature changes of the solutions. The temperature change is the extreme (maximum or minimum) temperature minus its initial temperature. Enter these values in the

Calculations Table. Make sure you have the correct signs for the two ΔT's! (If the temperature goes down, ΔT is negative.)

7. (1 point) Calculate the heat q added to the reactants. Enter into the Calculations Table. Make sure you have the correct signs for the two q's! If ΔT is positive, heat came *from* the reactants and q is *negative*. If ΔT is negative, heat was added *to* the reactants and q is *positive*. Enter the formula you used here.

   $q =$

8. Calculate the heat input to the reaction per mole of product created. This is the molar enthalpy change ΔH of the reaction. Divide the heat input by moles of product, $\Delta H = q/n$.

Questions

1. (2 points) Consider the measurements in the Data tables. For each measurement, identify the possible influences that might render the measurement incorrect.

   Masses determined using the balance:

   Volume of liquid:

   Temperatures:

2. (4 points) Consider the calculations in the Calculations tables. For each calculation, identify the assumptions inherent in the calculation.

   Mass of solution:

   Moles of solute:

   Moles of powder:

   Theoretical yield:

Heat transfer q:

Enthalpy change ΔH:

Report

Turn in this lab sheet with the data and calculations tables completed and questions answered.

Scoring

Points will be allocated as specified above in these instructions for your data table, calculations table, the questions, and for identifying the formula heat added to the reactants. In addition, 7 points are allocated for your skill, effort, housekeeping, safety, and focus in lab. Keep your work station neat, use careful technique, work safely, and clean up after yourself.

Tables

Redox Reaction Data Table
(3.5 points)

Mass of calorimeter and lid	
Volume of $CuCl_2$ solution	
Mass of calorimeter, lid, and solution	
Concentration of $CuCl_2$ solute	
Mass of Fe powder	
Initial temperature	
Maximum temperature	

Redox Reaction Calculations Table
(4.5 points)

Mass of $CuCl_2$ solution	
Moles of $CuCl_2$ solute	
Molar mass of Fe	
Moles of Fe	
Limiting reactant	
Moles Cu / mole limiting reactant	
Theoretical yield of Cu n (moles)	
Temperature change ΔT	
Heat input to reactants q	
Molar enthalpy change $\Delta H = q/n$	

Acid-Base Reaction Data Table

(3.5 points)

Mass of calorimeter and lid	
Volume of HCl solution	
Mass of calorimeter, lid, and solution	
Concentration of HCl solute	
Mass of $NaHCO_3$ powder	
Initial temperature	
Minimum temperature	

Acid-Base Reaction Calculations Table

(4.5 points)

Mass of HCl solution	
Moles of HCl solute	
Molar mass of $NaHCO_3$	
Moles of $NaHCO_3$	
Limiting reactant	
Moles NaCl / mole limiting reactant	
Theoretical yield of NaCl n (moles)	
Temperature change ΔT	
Heat input to reactants q	
Molar enthalpy change $\Delta H = q/n$	