The Enthalpy Change of a Chemical Reaction

Purpose: Determine the change in enthalpy (ΔH^o) for the reaction of magnesium metal with hydrochloric acid

$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow Mg^{2+}{}_{(aq)} + 2Cl^{1-}{}_{(aq)} + 460 \text{ kJ/mol}$$

Introduction: To determine the enthalpy change for a reaction the heat released or absorbed by the reaction must be measured. When an exothermic reaction occurs in a container, the heat which is released warms up the container and its contents. The contents include the reaction products and the solvent if it is present. The container used for this measurement is called a calorimeter. The amount of heat energy released into this calorimeter by the reaction (q_p) is related to its change in temperature by the equation:

Equation (1) $q_p = q_{calorimeter} + q_{solution}$

$q_{calorimeter} = c_{calorimeter\ x}\ m_{calorimeter\ x}\ \Delta T$

$q_{solution} = c_{solution\ x}\ m_{solution\ x}\ \Delta T$

where: $c_{calorimeter\ x}\ m_{calorimeter}$ = heat capacity of calorimeter ($J/^0C$)

ΔT is the temperature change (^0C) = $T_{final} - T_{initial}$

The experiment is carried out by mixing the reactants ($Mg_{(s)}$ and $HCl_{(aq)}$) in the styrofoam calorimeter and measuring the change in the calorimeter temperature. The specific heat and mass of the resulting solution are known. The **heat capacity (= $c_{calorimeter}$ x $m_{calorimeter}$)** of the styrofoam calorimeter has been calibrated and has been determined to be **92.9 J/^{0}C**. For every degree increase in temperature of a solution in the calorimeter, 92.9 joules are absorbed by the calorimeter.

Using the measured heat capacity of the calorimeter, the temperature change, and the values for the specific heat and mass of the final solution, the total heat released can be calculated using Equation 1 (see above).

The heat which would be released for one mole of magnesium is calculated and represents the ΔH^0 for the reaction.

Change in Enthalpy for the Reaction of Magnesium and Hydrochloric Acid

Procedure:

1. Use a balance to weigh 0.50 g of magnesium turnings (Mg) onto a piece of weighing paper. Use a spatula to do this so that you do not touch the magnesium. Oily residue from your hands will inhibit the reaction with acid. Place all of the magnesium into the calibrated calorimeter.

2. Using a graduated cylinder, measure out 100.0 mL of 1.0 M HCl and measure its temperature. Assuming that the HCl solution, the calorimeter and the magnesium metal are all at the same temperature, this is also the initial temperature of the calorimeter. Pour the HCl solution into the calorimeter. While stirring gently with your thermometer, measure and record the temperature immediately after mixing and then every 15 seconds thereafter until the temperature reaches a maximum temperature even if it occurs at mid-interval.
3. Repeat the experiment for Trial 2.

Analysis:

1. For each trial, calculate the total heat released during the reaction of 0.50 g of magnesium using Equation (1).
   In this equation the value of ΔT is the difference between the initial and maximum temperatures.
   The mass of the solution is calculated from the volume of HCl solution (100.0 mL) times its density (1.015g/mL plus the mass of the magnesium (0.50g).
   The specific heat capacity ('solution') of the resulting $MgCl_2$ solution is 3.97 J/g°C.

2. Use the calibrated values for the heat capacity of your calorimeter (92.9J°C)

3. Calculate the average heat released by the reaction and the ΔH^0 for the reaction in kilojoules per mole of magnesium.

Your Lab Report Should Include the Following:

Observation Charts:

1. Qualitative Data Table
2. Quantitative Data Table:
3. Time vs. Temperature readings for reaction solution for each Trial

Calculations: (Must show **ALL** steps and use units throughout, obey all significant digit rules, include concluding statements)

1. Total Heat Released by Reaction (q_p): each Trial and Average
2. Heat Released per Mole of Mg (ΔH^o)- Average
3. Calculate the % error of the molar enthalpy using the theoretical value for the reaction, given at the beginning of the lab.

Conclusion:- brief summary of the results of your lab.