LAD 5.2 (pg 1 of 2) Enthalpy Change of a Reaction Using Hess' Law

Introduction:

Thermochemistry and thermodynamics is the branch of chemistry that studies energy and its transformations. The First Law of Thermodynamics states that the energy of the universe is a finite quantity and that energy can be neither created no destroyed, only transformed. An object can contain energy in two forms

- kinetic energy - energy of motion (directly proportional to temperature)
- potential energy - energy stored because of position (electrostatic attractions and repulsions, bond energy)

Energy can be transferred in two different forms

- work (w) -defined as force over distance. In chemistry, the work performed is usually the work done by or done on gases in the form of volume changes, gases expanding or compressing. $w = P\Delta V$. But in many cases as with this experiment, the reaction occurs in solution, and there are no pressure or Δ in gas volume considerations and thus no measurable work is done.
- heat (q) - measured temperature changes used in combination with $q = c * m * \Delta T$ will be used to calculate the amount of heat transferred during a reaction. (c = specific heat capacity, m = mass, ΔT = temp change)
- $\Delta E = q + w$

When heat is 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, H. Heat itself is very difficult to measure, but we can measure change in enthalpy, ΔH which is usually recorded in kJ/mole.

The sign of ΔH is important

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

PreLAD:

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

Read the Procedure Overview, Procedure and Processing the Data and 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.

Write balanced net ionic equations for the following reactions

1. One mole of magnesium oxide is formed by burning a strip of magnesium in oxygen.
2. A strip of magnesium reacts with hydrochloric acid
3. Magnesium oxide powder is reacted with hydrochloric acid
4. Write the formation reaction for liquid water, and look up the ΔH^o_f value.

Answer the following questions, showing work as appropriate

1. What are the typical units for c, specific heat capacity?
2. What are the typical units for ΔH_{Rx} ?

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Procedure Overview:

The enthalpy of the first reaction written above is very difficult to measure directly with any accuracy. Thus three different reactions can be manipulated using Hess' Law to determine the enthalpy for the combustion on magnesium. Two of enthalpy values for the reactions needed in the Hess' Law manipulation will be measured during the experiment, the third value for the formation of water will be acquired from the formation tables.

Materials on tray for two groups

- 2x foam cups
- 2x thermometer
- 2x Mg strip
- 2x vial of magnesium oxide powder
- 2x 100 ml graduated cylinder
- 3M hydrochloric acid solution
- 2x stirring bar and stirrer
- 500 ml 3 M HCl

Procedure - ***Protective eyeware is not optional.***

Reaction 1 - All waste solutions can go down the sink. Hang on to the stirring bar.

A. Measure 100 ml of 3 M HCl into a foam cup. Place the stirring bar in an measure an initial temperature.

B. Measure the mass of magnesium strip. Fold it loosely into a shape that will completely submerge and fit on the bottom of the cup. Turn the stirrer on slow speed.

C. Drop in the magnesium and record the highest temperature.

D. Dispose of the solution down the sink, and rinse the calorimeter with plenty of tap water.

Reaction 2 - All waste solutions can go down the sink. Hang on to the stirring bar.

A. Measure a fresh 100 ml of 3 M HCl into a foam cup. Place the stirring bar in an measure an initial temperature.

B. Measure the mass of the vial with MgO powder (without cover). Turn the stirrer on slow speed.

C. Pour the MgO into the acid and record the highest temperature. Measure the mass of the empty vial.

D. Dispose of the solution down the sink, and rinse the calorimeter with plenty of tap water.

Processing the data:

Consider the density of 3 M HCl to be 1.05 g/ml

Consider the specific heat capacity (c) of 3 M HCl to be 4.05 J/g°C

1. Calculate the mass of 100.0 ml of HCl.
2. Calculate q for reaction 2 & 3
3. Calculate the number of moles of Mg (MM 24.31 g/mole) and MgO (MM 40.31g/mole) used.
4. Calculate ΔH for reaction 2 & 3
5. With ΔH values for reaction s 2 & 3 in combination with the ΔH^o_f value for the formation of water, you can use Hess' law to calculate the ΔH_f for MgO. Show clearly how the reactions add and their enthalpy values add to result in the desired reaction and ΔH value.

Questions to Ponder

1. How would q for reaction 2 have been different if 6 M HCl had been used?
2. How would ΔH for reaction 2 have been different if 6 M HCl had been used?
3. You saw a demonstration of the combustion of Mg in class. What problems would be encountered trying to directly determine the ΔH for this reaction by doing the reaction itself (instead of employing Hess' Law.)?
4. What major assumption(s) is(are) made in this experiment?
5. We did not cover the calorimeter. How would the calculation of the ΔH^o_f of MgO be affected if a large amount of heat were lost in reactions 2 & 3