LAD C.1 (pg 1 of 3) Enthalpy of Dissolving and Solvation

Name_____Per___

Using ΔH_f values to Calc $\Delta H_{dissolve}$ and Compare to Experimental Values

Introduction

Enthalpy of formation (heat of formation, ΔH_f^o) is the enthalpy change associated with the reaction for the formation of a substance from its constituent elements. A set of values has been tabulated for a large number of compounds at a defined set of conditions called the standard state. The standard state conditions are 1 atm pressure and 25ºC.

> Thus ΔH^o_f (standard enthalpy of formation) is the change in enthalpy for the reaction that forms one mole of a particular compound from its elements, with all substances in their standard states.

We can use values to calculate *theoretical* heats of particular reactions. (ΔH values are located in your text pg 1041 or you can find a set of tables on chap 5 document page.)

Experimentally we can calculate heat energy transferred by measuring temperature changes. Remember the heat equation below:

$$q = c \times m \times \Delta T$$

heat lost or gained = specific heat capacity × mass × change in temperature ($T_{final} - T_{initial}$)

For a chemical reaction (or dissolving or phase change)

$$q_{salt} = \left(\triangle H_{dissolve}\right)\frac{mass_{salt}}{MolarMass_{salt}}$$

If you put these two equations together:

$$q = -q$$

$$\left(c_w\right)\left(m_w\right)\left(\triangle T_w\right) = -\left(\triangle H_{dissolve}\right)\frac{mass}{MolarMass}$$

In this LAD, an ionic compound will be dissolved into solution. There is an energy change associated with this process. We will determine the molar value for this process and then compare that experimental value with the calculated theoretical value.

PreLAD

A. Make a data/results table. Please use excel.

B. Write the chemical formula and calculate the molar mass for ammonium nitrate.

C. Write out the equation that represents the dissolving process of ammonium nitrate.

D. Write the chemical formula and calculate the molar mass for calcium chloride.

E. Write out the equation that represents the dissolving process of calcium chloride.

F. Calculate the theoretical $\Delta H_{dissolve}$ for the two equations above using the ΔH_f^o values in your thermodynamic tables distributed in class. Put those theoretical values in your data/results table.

Procedure for determining the $\Delta H_{dissolve}$

A. Set up your stirring plate apparatus.
B. Measure a mass (around 100 ml or so, you need to know exactly) of tap water into your foam cup calorimeter.
C. Using the plastic weighing boats, measure out a mass of ammonium nitrate (around 5+ g or so).
D. Record the starting temperature of the water.
E. Dump all of the ammonium nitrate into the water, turn on the stirrer, then watch the temperature until thermal equilibrium is reached. Record the temperature at thermal equilibrium.
F. The solution can be flushed down the drain.
G. Repeat the procedure for the second chemical.

Process the Data − Same calculation set for both trials. Use the space below as a work sapce if you wish, however all of your calculations should be clearly represented on your data table − best if done in excel as embedded formulas.

1. Calculate the temperature change, ΔT

2. Calculate the energy lost/gained by the solution . Using the $q_{sol'n} = c_{sol'n} \times m_{sol'n} \times (T_{final\ mix} - T_{start\ water})$
   - Since the concentration of the solution is fairly low, we will assume that the specific heat capacity of the solution is the same as pure water.
   - The mass should be that of the solution − the sum of the water and the dissolving salt.
   - What is the significance of sign of the q for the water? Is the water losing or gaining heat?

3. We must assume that the energy lost/gained by the solution, is the same magnitude (though lost vs gained or gained vs lost) by the dissolving compound. i.e. $q = -q$
   - What sign should be attached to the q for the dissolving process?

4. Calculate the moles of the salt that was dissolved.

5. The energy calculated in number 3 is for a very particular mass of ammonium nitrate (or calcium chloride), convert this energy value in number 3 to a per mole value.

6. Compare your experimental $\Delta H_{dissolve}$ (in #4) to the theoretical $\Delta H_{dissolve}$ that you calculated in the preLAD and calculate your 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 effect, if any on q_{water} and $\Delta H_{dissolve}$.

1. Imagine the same procedure using twice the mass of salt to be dissolved.
   a. How would q_{water} change? Explain and justify.

   b. How would $\Delta H_{dissolve}$ change? Explain and justify.

2. Imagine the same procedure using the same amount of salt, but instead using twice the volume of water.
   a. How would q_{water} change? Explain and justify.

   b. How would $\Delta H_{dissolve}$ change? Explain and justify.

3. Imagine the same procedure using the same amount of salt, and the same amount of water, but the initial temperature of the water was 10ºC warmer. (Consider the assumption that we make about the specific heat capacity of water $\frac{4.18 Joule}{1g \cdot 1°C}$.)
   a. How would q_{water} change? Explain and justify.

   b. How would $\Delta H_{dissolve}$ change? Explain and justify.

4. Suppose that during your procedure for calcium chloride that a significant amount of heat were lost out the top of the calorimeter, what effect would this have on your measured data and calculated molar enthalpy of dissolving, $\Delta H_{dissolve}$. Explain and justify.