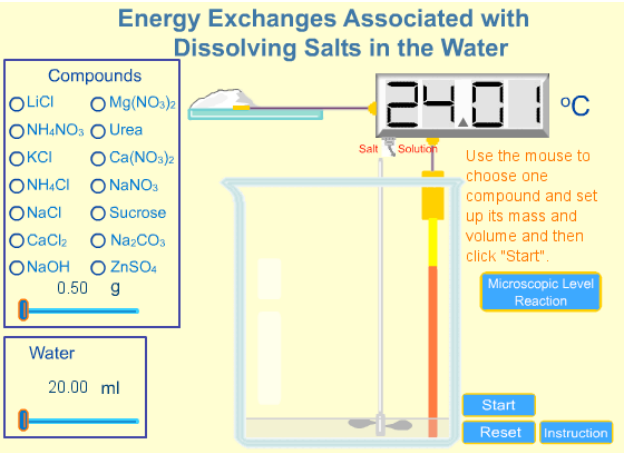
# Heats of Solution

Name_____ Lab Section_____

Problem Statement: How is heat energy related to the dissolving process?

I. Data Collection:

A. Go to http://introchem.chem.okstate.edu/DCICLA/heat_soln.html and open the Heat of Solution Simulation. Your screen should look like the figure.




The apparatus represents a beaker that can be filled with different amounts of water. Different amounts of various soluble solids can be added to the beaker. The amounts are controlled by slide bars. A temperature gauge monitors the temperature of the contents of the beaker. A microscopic representation of the dissolving process can be accessed by a microscopic level button.

B. Use the button to pick LiCl. Leave the water volume at 20mL and the amount of LiCl at 0.50g. Record the beginning condition of the solution in the table below.

| Compound | Mass of solution | Mass of compound | Initial temperature | Final temperature | Change in temperature |
|---|---|---|---|---|---|
| LiCl | 20mL | 0.50g | | | |
| $NH_4NO_3$ | 20mL | 0.50g | | | |
| KCl | 20mL | 0.50g | | | |
| $NH_4Cl$ | 20mL | 0.50g | | | |
| NaCl | 20mL | 0.50g | | | |
| $CaCl_2$ | 20mL | 0.50g | | | |
| NaOH | 20mL | 0.50g | | | |
| $Mg(NO_3)_2$ | 20mL | 0.50g | | | |
| Urea | 20mL | 0.50g | | | |
| $Ca(NO_3)_2$ | 20mL | 0.50g | | | |
| $NaNO_3$ | 20mL | 0.50g | | | |
| Sucrose | 20mL | 0.50g | | | |
| $Na_2CO_3$ | 20mL | 0.50g | | | |
| $ZnSO_4$ | 20mL | 0.50g | | | |

C. Click on the Start button. What do you observe happening? Record the final conditions of the solution in the table above.

D. Repeat the experiment for each of the compounds in the list. Record your data in the table above.

II. Data Analysis and Interpretation

A. Which compounds release heat when they dissolve? (This is termed an exothermic process.) Which compounds gain heat when they dissolve? (This is called an endothermic process.)

B. How are the compounds that didn't gain or release heat when they dissolved different from those that did?

C. An animation that models the dissolving process for ionic salts can be viewed by clicking on the Microscopic Level Reaction button. Describe in your own words this process. Write a chemical equation representing the process of LiCl dissolving (LiCl(s)→?). Write a chemical equation representing the process of $CaCl_2$ dissolving. Write a chemical equation representing the process of $Mg(NO_3)_2$ dissolving. How many dissolved particles result from one particle of each compound?

D. Consider the following statements made by students about this experiment. Are these statements true or false? Provide evidence for your conclusions.

The number of dissolved particles (ions or moles of ions) is related to the temperature change.

Certain cations are associated with either exothermic or endothermic processes.

Certain anions are associated with either exothermic or endothermic processes.

The amount of heat gained or released by a compound is different for different compounds.

III. Data Collection:

A. Set the volume of the water at 100 mL and the mass of LiCl at 0.50g. Click on the start button. Record the data in the table below. Repeat this experiment four more times with masses between 1.00 and 5.00 grams. Record the data in the table below.

| Mass of Compound | Mass of Solution | Initial Temp | Final Temp | Change in Temp |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

IV. Data Analysis and Interpretation:

A. Test to see if the temperature change is related to the mass of compound by plotting them on a graph and determining the equation of the line. Record you results below. Include the graph in your report. (If you have a straight line you can use the equation for a straight line ($y = mx + b$). If the line is a curved line you can test to see if the plot is a power function ($y = x^2$) or a logarithmic function ($y = \log x$). This can be made easier if you are using a graphing or data analysis program like Excel™. Your instructor can show you how to do this.)

B. Express the equation you determined in the previous section in units of ºC/g. Do you expect this value to be the same for the other compounds? What would you expect the temperature change would be if you had dissolved 8.50g of LiCl in 100mL of water?

C. Determine the change in temperature if you dissolved 8.50g of NaOH in 100mL of water.

D. Using the data you collected in the above experiment, make a statement that summarizes the relationship between the heat energy when LiCl dissolves and the temperature change of the solution.

V. Data Collection:

Set the volume of the water at 20mL and the mass of LiCl at 0.50g. Click on the start button. Record the data in the table below. Repeat this experiment four more times with volumes of water between 30mL and 200mL. Record the data in the table below.

| Mass of Compound | Mass of Solution | Initial Temp | Final Temp | Change in Temp |
|---|---|---|---|---|
| 0.50g | | | | |
| 0.50g | | | | |
| 0.50g | | | | |
| 0.50g | | | | |
| 0.50g | | | | |

VI. Data Analysis and Interpretation:

A. Considering that the amount of LiCl is the same in each trial, what can you say about the amount of heat energy released when the LiCl dissolves in water. How do you account for any differences in the temperature changes?

B. Compare the amount of heat energy gained by the water solution in each of the five trials. What accounts for this comparison?

C. How is heat gained by the water solution related to the temperature change?

VII. Conclusions:

A. You can assume that the heat (given the symbol "q" and expressed in units of Joules) that is lost or gained by the compounds studied in this activity is equal to the heat gained or lost by the solution (mostly water). If this is correct, you can measure the heat of the solution process for a compound by measuring the heat gained by the solution/water. Considering the results of the previous section of this activity, what factors control how much heat is gained or lost by the solution/water ($q \propto ?$ and ?).

B. Water, as is true of all substances, has a characteristic ability to gain or lose heat. A measure of this ability is expressed as the specific heat content ($C_s$). ($C_s$ can be used as a proportionality constant to change the $\propto$ sign from the previous section to an = sign. This constant has a value for water of 4.184 J/g-ºC. Write the equation for the heat (q = ?) LiCl is dissolved in 20mL of water. Calculate how much heat LiCl releases per gram.