

HOT PACKS, COLD PACKS, AND HEATS OF SOLUTION (#1.4)

CCLI Experiments
Computers in Chemistry Laboratory Instruction

Learning Objectives

The objectives of this experiment are to ...

- use the MicroLab interface to measure the heats of solution (ΔH_{soln} , in kJ/mol) of several salts.
- calculate the heats of formation (ΔH_f , in kJ/mol) of single aqueous ions.
- predict the heats of solution of additional salts.
- design a hot pack and a cold pack for specified temperature changes.

Background

All chemical reactions and many physical processes are accompanied by the absorption or release of heat. Your body temperature of 37 °C is maintained by heat released from chemical reactions occurring inside of cells. Sometimes it is medically desirable to temporarily increase or decrease the temperature of a certain body part, such as in the treatment of sprains or bruises. These temperature changes can be achieved with commercially available hot packs or cold packs in which the dissolving of a salt in water either generates or absorbs heat. In this experiment you will measure the heat changes which occur when various salts are dissolved in water and use that information to design both a hot pack and a cold pack capable of producing specified temperature changes.

Measuring heats of solution

The heat of solution, ΔH_{soln} , is the heat that is generated or absorbed when a salt is dissolved in water and is expressed in kJ/mol solute. ΔH_{soln} is negative for an exothermic solution process and positive if it is endothermic. Thermochemical equations for the solution process are given. The experimental measurement of ΔH_{soln} is done in a calorimeter. The student calorimeter consists of two nested styrofoam cups containing 100 grams of water, a magnetic stirring bar, and a temperature probe inserted through a styrofoam lid. Since the calorimeter is assumed to be an adiabatic system (which means that it is a constant temperature system), the heat absorbed in the solution process (q_{soln}) must be equal but opposite in sign to the heat lost by the rest of the calorimeter (q_{cal}). The heat change for the calorimeter (q_{cal}) equals the measured temperature change ($\Delta T = T_f - T_i$) times the heat capacity (C_p) of the calorimeter.

ΔH_f of single aqueous ions and predicting ΔH_{soln}

Hess's Law is used to evaluate ΔH_f for single aqueous ions. ΔH_f values for the aqueous ions can be determined if ΔH_{soln} and ΔH_f for the solid are known. For this exercise, ΔH_f values for the appropriate solids are given in Table 1, and the ΔH_{soln} values will be obtained experimentally.

Temperature probe calibration and experiment program

The temperature probe is calibrated at a minimum of three different temperatures using mixtures of ice/water and tap and hot water.

Experiment Performed

Heat of solution for $\text{MgSO}_4(\text{s})$: The heat of solution of 5 grams of anhydrous magnesium sulfate in 100 mL of water is determined with instructions on how to collect the data.

Heat of solution for $\text{K}_2\text{SO}_4(\text{s})$, $\text{KNO}_3(\text{s})$, and $\text{NH}_4\text{NO}_3(\text{s})$: The heat of solution of 5 grams of each of these anhydrous salts in 100 mL of water is determined.

Calculations performed.

Cold Pack: Based on their results, Students will design a cold pack using $\text{NH}_4\text{NO}_3(\text{s})$. It should have a total mass of 400 g (salt plus water) and be able to achieve a temperature of 10°C . Assume a specific heat for the solution of $4.18\text{ J/g }^\circ\text{C}$ (same as water) and that the water in the cold pack is initially 23°C . They must show their calculations.

Hot Pack: Using the same guidelines given for the cold pack, design a hot pack (using $\text{MgSO}_4(\text{s})$) that will reach a temperature of 60°C . They must show their calculations.

Instructor Resources Provided

- Sample Report Sheets providing the format to organize the data collection with sample data.
- Questions to consider, answer and turn-in with suggested answers.
- Tips and Traps section to assist the instructor with potential problems and solutions.
- Sample *MicroLAB* screen shots and graphs.
- Laboratory preparation per student station.

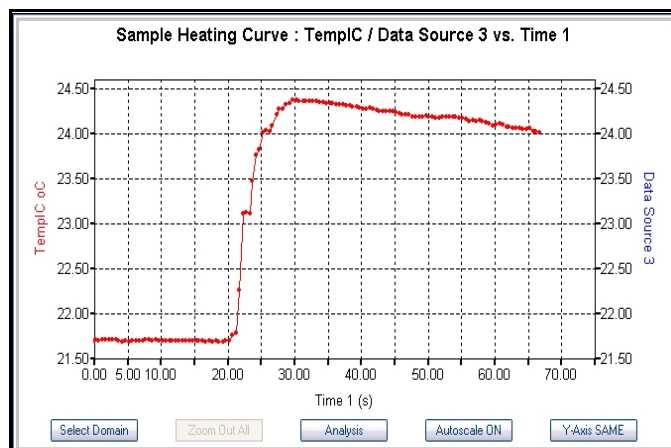


Figure 1. Sample MicroLAB heating curve.

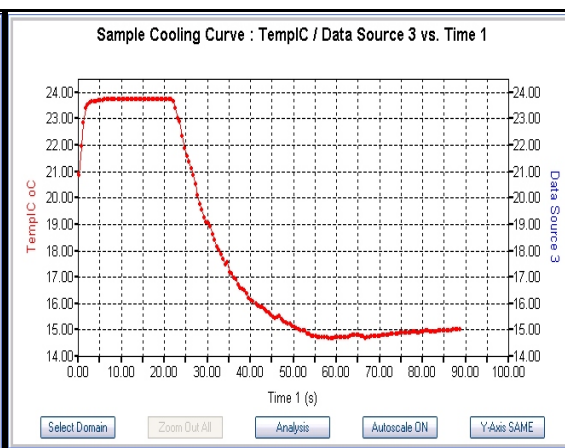


Figure 2. Sample MicroLAB cooling curve.

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