Hand Warmer Investigation Lab

Have your fingers ever been so cold they felt numb? Wouldn't it be great if you could generate heat to warm your hands up anytime you want to? That's exactly what a "hand warmer" does. Hand warmers are small packets that people put inside gloves or mittens on cold days to keep their fingers warm. They are very popular with people who work outside in winter or engage in winter sports. One type of hand warmer contains water in one section of the packet and a soluble substance in another section. When the packet is squeezed the water and the soluble substance are mixed, the solid dissolves and the packet becomes warm. In this experiment, you will learn how a hand warmer works and use chemistry to design an effective, safe, environmentally benign (no harm is done to the environment through their use), and inexpensive hand warmer.

In this lab, you are challenged to use chemistry to design an effective, safe, environmentally benign, and inexpensive hand warmer. You will carry out an experiment to determine which substances, in what amounts, to use in order to make a hand warmer that meets these criteria.

Breaking bonds and particulate attractions absorb energy from the surroundings, while forming new bonds and particulate attractions release energy to the surroundings. When an ionic solid dissolves in water, ionic bonds between cations and anions in the ionic solid and hydrogen bonds between water molecules are broken, and new attractions between water molecules and anions and water molecules and cations are formed. The amount of energy required to break these bonds and form new ones depends on the chemical properties of the particular anions and cations. Therefore, when some ionic solids dissolve, more energy is required to break the cation–anion bonds than is released in forming the new water–ion attractions, and the overall process absorbs energy in the form of heat. When other ionic compounds dissolve, the converse is true, and the bond making releases more energy than the bond breaking absorbs, and therefore the process overall releases heat. When heat is absorbed, the enthalpy change, *q*, is endothermic, and the enthalpy change is positive. When heat is released, the change is exothermic, and the value of *q* is negative. Recall that heat (q) can be calculated by:

$$Q = mC\Delta T$$

In this experiment, you will collect data that will allow you to calculate the change of enthalpy of dissolution (also called the "heat of solution," with symbol ΔH_{soln}, and units of kJ/mol solute) occurring in aqueous solution. The data necessary to calculate the heat of solution can be obtained using a device called a calorimeter. A calorimeter is a container used to determine the enthalpy change that occurs during a process. Calorimetry is an important technique in chemistry, and chemists often work with devices called bomb calorimeters. For home or classroom experiments, however, a coffee cup calorimeter is sufficient to make rough measurements.

Process:

1. Measure 50ml of H_2O and place in Coffee Cup Calorimeter
2. Record the temperature
3. Mass 5-10 grams of a chemical in a weigh boat and record the mass
4. Place the chemical in the Coffee Cup Calorimeter
5. Wait until all of the chemical dissolves and record final temperature
6. Dispose of all chemicals down the drain with plenty of water.
7. Repeat with all chemicals
8. Calculate the heat change in the water using $Q = mC\Delta T$
9. Calculate the heat change per gram of the chemical.
10. Calculate the heat change per mole of the chemical.

Materials Available:

Materials	Quantity
Thermometers	1
Balance	1
Graduated Cylinder, 100 mL	2
Coffee Cup Calorimeters	1
Distilled H_2O	1
Sodium Acetate, $NaC_2H_3O_2$	5 – 10 g
Magnesium Sulfate, $MgSO_4$	5 – 10 g
Calcium Chloride, $CaCl_2$	5 – 10 g
Lithium Chloride, LiCl	5 – 10 g
Ammonium Nitrate, NH_4NO_3	5 – 10 g
Sodium Chloride, NaCl	5 – 10 g

Chemical Name	Mass of Chemical (g)	Mass of Water (g)	Initial Temp of Water (°C)	Final Temp of Water (°C)	Change in Temp of Water (ΔT)	Energy Absorbed by water (J) ($Q=mC\Delta T$)	Energy per gram of chemical (divide energy (J) by mass (g) of chemical)
Sodium Acetate, $NaC_2H_3O_2$							
Magnesium Sulfate, $MgSO_4$							
Calcium Chloride, $CaCl_2$							
Lithium Chloride, LiCl							
Ammonium Nitrate, NH_4NO_3							
Sodium Chloride, NaCl							