

AP Chemistry Lab 04

Investigation 12 *The Hand Warmer Design Challenge:* *Where Does the Heat Come From?*

Context for This Investigation - 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, and inexpensive hand warmer.

Central Challenge - Design an effective, safe, environmentally benign, and inexpensive hand warmer. The ideal hand warmer increases in temperature by 20°C (but no more) as quickly as possible, has a volume of about 50 mL, costs as little as possible to make, and uses chemicals that are as safe and environmentally friendly as possible. 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.

Explanation to Strengthen Student Understanding

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. The entropy change of solution formation is always positive, regardless of whether it is endothermic or exothermic, because solutions are much more disordered than are the pure solute and solvent from which they are made. This positive entropy change is thermodynamically favorable.

Prelab Guiding Questions/Simulations

Answer these questions on separate paper and discuss with instructor before continuing with the lab.

An animation showing the dissolution of an ionic compound on the particulate level can be found on the website Chemistry Experiment Simulations and Conceptual Computer Animations:

<http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/solutionSalt.html>

1. Describe the changes you observe in the animation, including changes in the bonds and particulate attractions and changes in the amount of disorder in the system.
2. When sodium chloride is dissolved in water, the temperature of the resulting solution is lower than the temperature of the water before the salt dissolves. How can this result be explained based on the bond breaking and bond making that is occurring?
3. Why do some salts, such as sodium chloride, dissolve spontaneously even though the process is endothermic overall?
4. When some ionic salts are dissolved in water, the temperature of the resulting solution is higher than the temperature of the water before the salt dissolves. What do you think determines whether the resulting solution is cooler or warmer than the starting water?

Hand Warmer Design Challenge Lab Report

Thomas Griffiths



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