

Designing a Hand Warmer

AP® Chemistry Big Idea 5, Investigation 12

An Advanced Inquiry Lab

Introduction

Put your chemistry skills to commercial use! From instant cold packs to flameless ration heaters and hand warmers, the energy changes accompanying physical and chemical transformations have many consumer applications. The backbone of these applications is calorimetry—measuring heat transfer. Investigate the energy changes accompanying the formation of solutions for common laboratory salts, and then apply the results to design a hand warmer that is reliable, safe and inexpensive.

Concepts

- Enthalpy change
- Heat of solution
- Exothermic versus endothermic
- Calorimetry
- Specific heat
- System and surroundings

Background

Hand warmers are familiar cold weather gear used to quickly provide warmth to frigid fingers. Many commercial hand warmers consist of a plastic package containing a solid and an inner pouch filled with water. When the pack is activated, the solid dissolves in water and produces a large temperature change.

The energy or *enthalpy change* associated with the process of a solute dissolving in a solvent is called the *heat of solution* (ΔH_{soln}). At constant pressure, this enthalpy change, ΔH_{soln} , is equal in magnitude to the heat loss or gain, q , to the surroundings. In the case of an ionic solid dissolving in water, the overall energy change is the net result of three processes—the energy required to break the attractive forces between ions in the crystal lattice ($\Delta H_1 = +C$ kJ/mole), the energy required to disrupt intermolecular forces between water molecules ($\Delta H_2 = +D$ kJ/mole), and the energy released when the dissociated (free) ions form ion-dipole attractive forces with the water molecules ($\Delta H_3 = -F$ kJ/mole). The overall process can be represented by the following equations:



If the amount of energy *released* in the formation of hydrated ions (ΔH_3) is greater than the amount of energy *required* to separate the solute and solvent particles ($\Delta H_1 + \Delta H_2$), then the sum (ΔH_{soln}) of the energy changes will be negative and the solution process exothermic (releases heat). If the amount of energy released in the formation of hydrated ions is less than the amount of energy required to separate the solute and solvent particles, then the sum of the energy changes will be positive and the solution process endothermic (absorbs heat).

Heats of solution and other enthalpy changes are generally measured in an insulated vessel called a *calorimeter* that reduces or prevents heat loss to the atmosphere outside the reaction vessel. The process of a solute dissolving in water may either release heat into the resulting aqueous solution or absorb heat from the solution, but the amount of heat exchanged between the calorimeter and the outside surroundings should be minimal. When using a calorimeter, the reagents being studied are mixed directly in the calorimeter and the temperature is recorded both before and after the reaction has occurred. The amount of heat transfer (q) may be calculated using the heat energy equation:

$$q = m \times s \times \Delta T \quad \text{Equation 1}$$

where m is the **total mass of the solution** (solute plus solvent), s is the specific heat of the solution, and ΔT is the observed temperature change. The specific heat of the solution is generally assumed to be the same as that of water, namely, 4.18 J/g·°C.

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Chem Fax Instructor Guide

Dr. Dennis Englin



Chem Fax Instructor Guide:

Chemistry (Teacher Guide) Dr. Dennis Englin, 2018-02-26 This book was created to help teachers as they instruct students through the Master's Class Chemistry course by Master Books The teacher is one who guides students through the subject matter helps each student stay on schedule and be organized and is their source of accountability along the way With that in mind this guide provides additional help through the laboratory exercises as well as lessons quizzes and examinations that are provided along with the answers The lessons in this study emphasize working through procedures and problem solving by learning patterns The vocabulary is kept at the essential level Practice exercises are given with their answers so that the patterns can be used in problem solving These lessons and laboratory exercises are the result of over 30 years of teaching home school high school students and then working with them as they proceed through college Guided labs are provided to enhance instruction of weekly lessons There are many principles and truths given to us in Scripture by the God that created the universe and all of the laws by which it functions It is important to see the hand of God and His principles and wisdom as it plays out in chemistry This course integrates what God has told us in the context of this study Features Each suggested weekly schedule has five easy to manage lessons that combine reading and worksheets Worksheets quizzes and tests are perforated and three hole punched materials are easy to tear out hand out grade and store Adjust the schedule and materials needed to best work within your educational program Space is given for assignments dates There is flexibility in scheduling Adapt the days to your school schedule Workflow Students will read the pages in their book and then complete each section of the teacher guide They should be encouraged to complete as many of the activities and projects as possible as well Tests are given at regular intervals with space to record each grade About the Author DR DENNIS ENGLIN earned his bachelor's from Westmont College his master of science from California State University and his EdD from the University of Southern California He enjoys teaching animal biology vertebrate biology wildlife biology organismic biology and astronomy at The Master's University His professional memberships include the Creation Research Society the American Fisheries Association Southern California Academy of Sciences Yellowstone Association and Au Sable Institute of Environmental Studies

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ENC Focus, 2003 *Instructor's Guide for Introductory Chemistry in the Laboratory* James F. Hall, 1996

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