CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

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Project Number

J1816

Project Title

An Original Calorimetric Experiment to Measure the Thermodynamic Properties of a Hot Pack Solution

Abstract

Objectives/Goals

The objectives of this study are (1) to measure the specific heat and heat of solution of a mixture of magnesium sulfate (MgSO4) and water, and (2) to use these thermodynamic properties to determine the amount of solute and solvent required for a first-aid hot pack.

Methods/Materials

The following materials are used in my project: electric calorimeter, glass thermometer, test wires with alligator clips, digital multimeter, 6-volt battery, graduated cylinder, digital scale and tare weight, stopwatch, test substances (MgSO4, water), and a sealable plastic bag.

I fill the calorimeter with a volume of water and dissolve 20 g of MgSO4 in the water to form the test solution. Before the start of each test, I measure the battery voltage and DC current with the digital multimeter. I then connect the battery to the multimeter and the heating wire of the calorimeter. I start the timer and record the time, fluid temperature,and electric current every minute. To obtain a uniform temperature distribution in the solution, I continually stir it with the mixer. When the temperature reaches 10 deg C, I disconnect the battery from the calorimeter. For sampling purposes, I perform Test Series 1, 2, and 3 with three water volumes (100, 125 and 150 mL) and conduct the experiments three times for each volume. In addition, I perform Test Series A with water only to determine the specific heat of the calorimeter.

Results

From Test Series A, I determined the specific heat of the calorimeter to be 5.68 J/g-deg C. From Test Series 1, 2, and 3, I obtained the specific heat of the MgSO4 and water solution as 4.19 J/g-deg C and its heat of solution as -303 J/g (the negative value shows that the reaction is exothermic). Using these thermodynamic properties, I determine the amount of MgSO4 and water needed to warm up the mass of an average male hand from 22 deg C to normal body temperature of 37 deg C. The results show that I need 94 g of MgSO4 and 574 mL of water.

Conclusions/Discussion

I performed a calorimetric experiment to measure the specific heat and heat of solution of MgSO4 in water. I then used these thermodynamic properties to determine the mass of MgSO4 and volume of water needed to warm up a human hand by 15 deg C and prevent frostbite.

My hypothesis has been proven: my calorimetric experiment enables me to design a first-aid hot pack by handily mixing in a Ziplog bag 94 g of MgSO4 with water from a 20-oz bottle.

Summary Statement

An original calorimetric experiment to measure the thermodynamic properties of a solution and design a first-aid hot pack

Help Received

Father explained concepts of thermodynamics and calorimetry; Mother helped with poster board and binder.