CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
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Project Number
S0516

Project Title
Examining Freezing Point Depression as a Function of Solute Ionization from a Thermodynamic Perspective

Abstract

Objectives/Goals
The objective was to determine whether solutes which ionize (like NaCl) would lower the freezing point of water more than solutes which do not ionize (like sucrose).

Methods/Materials
Freezing points were determined for 44 aqueous solutions of four non-ionizing solutes and eight ionizing solutes. The solutes were tested over a range of concentrations, from 0.1 m to 5.0 m. A Pyrex test tube containing each solution was lowered into a dry ice bath. Temperature readings were obtained every thirty seconds during the freezing process and graphed to produce cooling curves. Freezing points were extrapolated from the curves.

Results
At all concentrations, the ionizing solutes lowered the freezing point of water more than the non-ionizing solutes. In addition, three-ion solutes lowered the freezing point more than two-ion solutes; and four-ion solutes lowered the freezing point even more. The results, however, were not linear, suggesting that factors other than the degree of solute ionization might play a role in lowering the freezing point.

Conclusions/Discussion
It may be possible to express the effect of a given solute on the freezing point of water through the following equation: Delta T(f) equals 1.8CA(s), where Delta T(f) is the freezing point depression, C is the solute concentration, 1.8 is the value derived from this experiment for the freezing point depression of water by 1.0 mol/kg of non-ionizing solute, and A(s) is a constant unique to each solute which takes into account such factors as the number of solute ions; the enthalpy of solution; the size of the solute molecule; hydrogen bonding; and solute/solute and solute/water interactions.

Summary Statement
A hypothesis derived from thermodynamics regarding the effect of solute ionization on the freezing point of water was confirmed by testing aqueous solutions of various molecular and ionic solutes over a wide range of concentrations.

Help Received
Dad drove me to the library to do research, paid for my lab equipment and chemicals, and handled the dry ice for me during the experiments. My project supervisor and the scientists at askascientist.com (a great resource) helped me learn about thermodynamics, solutions, and phase changes.