

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

■ ■ Central Challenge

You are challenged to use chemistry to 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

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. 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.

■ ■ Investigation

You will design and execute an experimental procedure to determine which of three ionic compounds is most suitable for use in a hand warmer. You will be assigned to one of the following groups:

Group 1	Group 2	Group 3	Group 4	Group 5
NH ₄ NO ₃	NaCl	NH ₄ NO ₃	NaCl	NH ₄ NO ₃
Na ₂ CO ₃	LiCl	LiCl	Na ₂ CO ₃	LiCl
CaCl ₂	Na ₂ C ₂ H ₃ O ₂	Na ₂ C ₂ H ₃ O ₂	CaCl ₂	Na ₂ C ₂ H ₃ O ₂

H Warmer Design Challenge Answers

J Dewey



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