

Dissolving Energy

Household substances are every bit as much “chemicals” as those used in the laboratory. Thus, conclusions based upon experiments utilizing these substances will be equally valid. You are to investigate temperature changes that occur when various household substances dissolve in water.

Materials

- cup measure
- tablespoon measure
- thermometer (if available, its scale must include room temperature and allow measuring temperature differences of 2°)
- 2–3 small plastic bags (or cups and a stirrer if a thermometer is available)
- baking soda
- powdered “ultra” laundry detergent (e.g., Tide, Cheer, All®, etc.)
- water
- one or more of the following solids: Epsom salt, table salt, borax (a laundry product), calcium chloride (a de-icer)

Safety

Because some household solids are especially hazardous, confine your exploration to those listed above.

Exploration

- Step 1 In separate small plastic bags or cups, combine various amounts of baking soda with a small fixed amount (such as 1/4 cup) of tepid water (noting its initial temperature with the thermometer if available), kneading or stirring the contents to mix, noting the temperature again and rinsing out each bag or cup after each trial. Record your observations in a tabular format. Does a temperature change accompany the dissolving process and is it affected by the amount of solid used? Why is it important to use a fixed amount of water?
- Step 2 Repeat Step 1 using powdered “ultra” laundry detergent in place of baking soda. Are the observations with the second solid the same as for the first? What can be concluded from the changes that accompany the dissolving process with respect to the identity of a solid?
- Step 3 Repeat Step 1 using one or more of the additional solids listed in the Materials section. Do your data from this step alter your conclusions about the changes that accompany the dissolving process with respect to the amount of solid and/or the identity of solid?
- Step 4 The thermometer could be used to collect more quantitative data for the dissolving process. Discuss external factors, such as the initial temperature of the water, that might introduce error.

Challenge

Does a temperature change occur when common household substances dissolve in water?

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Concepts

solutions, enthalpy of dissolving

Expected Responses to Exploration

These responses are valid for mixtures of equal amounts of water and solid. Significantly different combinations may give significantly different results.

- Step 1 (a) When baking soda dissolves in water, the temperature of the solution decreases approximately 5°F (3°C) when equal volumes of water (1/4 cup) and solid (4 tablespoons) are mixed.
- (b) It would be impossible to determine the effect of different quantities of solid if the amount of water varied with each trial. If the amount of water varied, the same amount of heat released or absorbed would result in a different temperature: less water would result in a greater temperature change; more water would result in a smaller change.
- Step 2 (a) When “ultra” laundry detergent dissolves in water, the temperature of the solution increases approximately 7°F (4°C) when equal volumes of water and solid are mixed. However, increasing the quantity of the detergent does increase the magnitude of the temperature change as in Step 1.
- (b) Some substances dissolve with an accompanying increase in temperature; others with a decrease. However, the magnitude of the temperature change increases with an increase in amount of solid.
- Step 3 (a) Typical results would be:
epsom salt causes a decrease in temperature (Δ 2°F; about 1°C)
table salt causes a decrease in temperature (Δ 4°F; about 2°C)
borax causes an increase in temperature (Δ 22°F; about 12°C)
calcium chloride causes an increase in temperature (Δ 52°F; about 29°C)
These temperature changes are for mixtures with equal amounts of water and solid.
- (b) These data do not alter the previous conclusions.
- Step 4 The increase or decrease in the temperature of the solution might be more or less noticeable based on the original temperature of the water, and this could cause error, especially if the temperature was different for each trial of one solid. The time that it takes for the solid to dissolve competes with continual loss of generated heat.

Expected Student Answer to Challenge

The temperature may either increase or decrease when common household substances dissolve in water.

Reference

- “Energy Changes with Everyday Materials”; *Fun with Chemistry: A Guidebook of K–12 Activities*; Sarquis, M., Sarquis, J., Eds.; Institute for Chemical Education: Madison, WI, 1993; Vol. 2, pp. 223–228.

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