TEACHER INFORMATION

A Good Cold Pack

1. Vials can be used instead of the 50 mL beakers. Test tubes, size 20 × 150 or 25 × 150 mm, can also be used. It is, however, more difficult to transfer the solids into test tubes, and the solids tend to stick to the sides of test tubes.

2. Baking soda is sodium bicarbonate, $NaHCO_3$. Non-sodium salt substitutes commonly have KCl as their main ingredient. Both are available in grocery stores.

3. Ammonium nitrate, NH_4NO_3, is commonly used in commercial cold packs. Because of its hazards, however, we have elected not to include it in this procedure. Ammonium chloride, NH_4Cl, also gives a large temperature drop and is safer to use.

4. Your students may be surprised when the temperature goes up as sodium carbonate dissolves. Be ready to make the most of this opportunity.

5. You may wish to use the terms *endothermic* for processes that absorb heat and *exothermic* for processes that release heat.

6. Table salt, NaCl, is a possible substitute whose dissolving is an endothermic process. Calcium chloride, $CaCl_2$, is a possible substitute whose dissolving is an exothermic process.

7. You might want to have a contest to see which student group can obtain the coldest temperature using their Part-II procedure.

8. You may wish to have your students calculate heat energy absorbed or released per gram of solid used. The heat energy may be calculated using the equation

$$H = \Delta t \cdot m \cdot C_p$$

where H = heat energy absorbed or released (in J), Δt = change in temperature (in °C), m = mass of water (in g), and C_p = specific heat capacity (4.18 J/g°C for water). Dividing the resulting energy value by grams of solid dissolved gives the heat energy absorbed or released per gram of solid used (in J/g).

10. **HAZARD ALERTS:**

Ammonium chloride, (NH_4Cl): Slightly toxic by ingestion. **Hazard Code:** C—Somewhat Hazardous.

Calcium chloride, anhydrous ($CaCl_2$): Slightly toxic. **Hazard Code:** D—Relatively Non-Hazardous.

Calcium chloride, dihydrate ($CaCl_2 \cdot 2H_2O$): Slightly toxic. **Hazard Code:** D—Relatively Non-Hazardous.

Citric acid, monohydrate ($H_3C_6H_5O_7 \cdot H_2O$): Severe eye irritant. **Hazard Code:** D—Relatively Non-Hazardous.

Potassium chloride (KCl): Slightly toxic by ingestion. **Hazard Code:** D—Relatively Non-Hazardous.

Sodium bicarbonate ($NaHCO_3$): **Hazard Code:** D—Relatively Non-Hazardous.

Sodium carbonate, anhydrous (Na_2CO_3): May be skin irritant. **Hazard Code:** D—Relatively Non-Hazardous.

Sodium carbonate, monohydrate ($Na_2CO_3 \cdot H_2O$): May be skin irritant. **Hazard Code:** D—Relatively Non-Hazardous.

Sodium chloride, (NaCl): Slightly toxic. **Hazard Code:** D—Relatively Non-Hazardous.

The hazard information reference is: Flinn Scientific, Inc., *Chemical & Biological Catalog/Reference Manual, 2000*, www.flinnsci.com. See *Appendix E* of this book, *Middle School Science with Vernier*, for more information.

SAMPLE RESULTS

Substance	Maximum temperature (°C)	Minimum temperature (°C)	Temperature change (°C)
Ammonium chloride (NH_4Cl)	24.6	10.5	14.1 (↓)
Citric acid ($H_3C_6H_5O_7$)	24.5	18.6	5.9 (↓)
Potassium chloride (KCl)	24.5	14.5	10.0 (↓)
Sodium bicarbonate ($NaHCO_3$)	24.6	22.5	2.1 (↓)
Sodium carbonate (Na_2CO_3)	33.9	24.6	9.3 (↑)

ANSWERS TO QUESTIONS

For Sample Answers to the questions in this lab, please contact Vernier Software and Technology at swnanswers@vernier.com