

# Saturated, Unsaturated, and Supersaturated Solutions



## Introduction

Watch a supersaturated solution of sodium acetate trihydrate crystallize instantly upon activation in this exothermic reaction.

## Concepts

- Supersaturation
- Crystallization
- Exothermic reactions

## Materials

The Heat Solution™ Instant Hand Warmer  
Boiling water bath

Tongs

## Safety Precautions

*This activity requires the use of hazardous components and/or has the potential for hazardous reactions. The sodium acetate contained in the pouch is a body tissue irritant. Should the pouch develop a leak, wash any sodium acetate off the skin thoroughly with water. The temperature of the pouch will reach about 54 °C (130 °F) and has the potential to cause burns. Avoid contact of all chemicals with eyes and skin. Follow all laboratory safety guidelines. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Remember to wash hands thoroughly with soap and water before leaving the laboratory.*

## Procedure

1. Observe the Heat Solution pouch, liquid contents, and metal disc before activating the solution.
2. Grasp the metal disc with the thumb and forefingers of both hands.
3. Rapidly bend the metal disc back and forth. Activation may take only one bend of the metal disc.
4. Hold the pouch up to a light to observe crystallization. Within seconds, all of the sodium acetate trihydrate appears to be solidified, and the solution in the pouch gets very hot. The pouch will remain hot for over 30 minutes.
5. To reactivate the solution, place the pouch in a beaker of water and boil for 10–15 minutes. When all of the crystals have re-dissolved, remove the pouch from the boiling water bath using tongs.
6. Allow the pouch to cool to room temperature before using it again.

## Tips

- With proper use, the Heat Solution™ Instant Hand Warmer can be reused 30–40 times and will remain hot for over 30 minutes at a time.
- To extend the duration of heat produced: (1) Warm the pouch before activating it by running it under warm water or keeping it in a warm pocket. The warmer the pad is before it is activated, the longer the heat lasts. (2) Use the pouch as a “hot water bottle” after removal from the boiling water bath during the cool-down phase. During the cool down, the pad is extremely hot (up to 100 °C or 212 °F). (3) Keep the pad from exposure to the cold after being activated. The heat produced will last longer.
- Lengthen the lifetime of the pouch by storing the pad in the liquid state rather than in its solid state until needed for use.
- Do not microwave the pouch for recharging. Use of microwave ovens for recharge may be dangerous and may explode the pad.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The pouch may be regenerated and used over again about 30–40 times. When the pouch is completely expended, dispose of it in the trash according to Flinn Suggested Disposal Method #26a.

### Discussion

The Heat Solution™ contains a supersaturated, supercooled sodium acetate solution and a stainless steel disc in a sealed vinyl pouch. The metal disc, when bent, will cause a single molecule of sodium acetate trihydrate to crystallize and act as a seed crystal. The seed crystal is the start of a chain reaction, which causes the entire solution, all of the sodium acetate trihydrate molecules, to crystallize. Remember, crystallize means that a liquid is becoming a solid, or “freezing.”

The solution is supersaturated and supercooled—this means that it contains more dissolved sodium acetate than a saturated solution and has been cooled to below its freezing point without crystallization occurring. This is because in a sealed container, the solution can be cooled to as low as  $-10^{\circ}\text{C}$  ( $14^{\circ}\text{F}$ ) without freezing. When the crystallization is activated, the solution climbs to its freezing point, which is  $54^{\circ}\text{C}$  ( $130^{\circ}\text{F}$ ). At this temperature, the sodium acetate solution changes from a liquid to a solid. The pouch will not exceed  $54^{\circ}\text{C}$  when triggered, and will remain at approximately  $46^{\circ}\text{C}$  ( $115^{\circ}\text{F}$ ) for 30–40 minutes.

When the solidified sodium acetate trihydrate crystals are then heated (boiled) to a temperature greater than  $54^{\circ}\text{C}$  ( $130^{\circ}\text{F}$ ), the crystals will melt. The sodium acetate will to some extent actually dissolve in its own water of hydration.

The liquifying (melting) and solidifying (freezing) of the sodium acetate trihydrate is a reversible reaction represented by the following equation



The forward reaction represents the crystallization process. Notice that heat is a product that is given off by the reaction. The reaction is exothermic ( $\Delta H = -19.7 \text{ kJ/mol}$ ), which was easily observed by feeling the very warm, newly-activated pouch.

The reverse reaction represents the melting process. Notice that this time heat is a reactant that is put into the reaction. The reaction is endothermic ( $\Delta H = +19.7 \text{ kJ/mol}$ ), which was evident by the need to boil (or add heat to) the pouch.

### Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

***Unifying Concepts and Processes: Grades K–12***

Evidence, models, and explanation

***Content Standards: Grades 5–8***

Content Standard B: Physical Science, properties and changes of properties in matter

***Content Standards: Grades 9–12***

Content Standard B: Physical Science, chemical reactions

### References

Marek, Lee “Questions Frequently Asked About the Heat Solution”; Naperville North High School, Naperville, IL.

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry*; University of Wisconsin, Madison; Vol. 1, pp 27–30.

### Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of this activity, presented by Kathleen Dombrink, is available in *Saturated, Unsaturated, and Supersaturated Solutions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Saturated, Unsaturated and Supersaturated Solutions* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1933	The Heat Solution™—Instant Hand Warmer
AP8937	Discover Heat Packs Experiment Book

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.