# Designing and Testing a Device to Thaw a Watering Station

*A Carolina Essentials™ Design Challenge*

## Overview

Understanding the flow of thermal energy can be a difficult task for students, but it can be tackled through a design challenge. In this activity, students use the scenario of a habitat that must occasionally thaw its watering stations. After determining the heat released during the solvation of calcium chloride, students design, test, and improve a device to thaw and prevent freezing of watering stations. Designs are scored on how long the water remains liquid and the cost per device.

**Physical Science**
**Grades: 6–8**

## Phenomenon

**Teacher demonstration**

Pour 500 mL of water in a 1,000 mL beaker and take the temperature of the water. Activate an instant ice pack, submerge it in the beaker of water, and take the temperature of the water 5 minutes later. Ask students how the temperature change can be explained.

## Essential Question

How can chemical processes be used for heat transfer?

## Objective

Design, test, and improve a device that can prevent the freezing of water in a watering station.

## Next Generation Science Standards* (NGSS)

**MS-PS1-6.** Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
|---|---|---|
| **Constructing Explanations and Designing Solutions**<br>• Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. | **PS1.B: Structure and Properties of Matter**<br>• Some chemical reactions release energy, others store energy.<br>**ETS1.B: Developing Possible Solutions**<br>• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. | **Energy and Matter**<br>• The transfer of energy can be tracked as energy flows through a designed or natural system. |

## Safety Procedures and Precautions

Wear gloves and safety goggles.

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### TIME REQUIREMENTS

| PREP | ACTIVITY |
|---|---|
| 45 min | 3–4.5 hr |

**Teacher Prep**: 45 min
**Student Activity:** 4 to 6 45 min sessions

### SAFETY REQUIREMENTS

### MATERIALS

**Phenomenon**

Plastic beaker, 1,000 mL
Instant cold pack
Digital thermometer
Tap water, 500 mL
Student Guided Research
Access to online and print resources

**Product Design**

Graduated cylinder, 100 mL
Plastic beaker, 250 mL
Electronic balance
Digital thermometer
Calcium chloride, 100–150 g
Deli container, 4 1/2 in
Foil tart pan, 4 7/8 in
Resealable plastic bags, various sizes
2 × 3 in
3 × 4 in
4 × 6 in
6 × 9 in
Weigh boats
Plastic spoons
Insulating materials (cotton balls, newsprint, pillow stuffing, foam cups, packing peanuts, and other materials students may suggest)
Tap water
Ice chest with crushed ice or freezer access for testing designs

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## Teacher Preparation and Disposal

Gather supplies for the phenomenon and engineering challenge. Copy or upload student the activity guide.

Calcium chloride needs to be disposed of according to state and local regulations. Consult your chemical hygiene plan and SDS. Dispose of the cold pack according to package instructions.

## Student Procedure

### Phenomenon

1. Pour 500 mL of water in a 1,000 mL beaker and take the temperature of the water.
2. Activate an instant cold pack.
3. Submerge the pack in the beaker of water.
4. Take the temperature of the water 5 minutes later.

### Guided Research: Dissociation of Calcium Chloride

1. In a weigh boat, measure 12.0 g of calcium chloride ($CaCl_2$).
2. In the graduated cylinder, measure 100 mL of water and pour it into the beaker.
3. Take the temperature of the water and record it in the data table.
4. Add the $CaCl_2$ to the beaker and stir gently with the spoon while taking the temperature.
5. Record the highest temperature reached.
6. Repeat the same procedure with 6.0 g of $CaCl_2$ and 100 mL of water.

### Engineering Design Project

1. Review the project specifications.
2. Complete the design and testing phases using the Carolina™ Engineering and Design Process Worksheet.
3. Share your final design and data with the class.

## Teacher Preparation and Tips

***Phenomenon***

*Put data in a model table so all students can see the results. You may want to record and broadcast the demonstration.*

***Guided Research***

*To save time, you may want to preweigh the calcium chloride for each group.*

*Emphasize to students to record the highest temperature reached.*

*Stop and discuss the meaning of these results and the implications for design.*

***Engineering Design***

*You may wish to print the design project worksheet for each group.*

*Provide the cost for each material you supply. If students bring other materials, they will need to know the cost.*

*Student information:* ***cost of $CaCl_2$ = $0.02/g***

*Inform students of how you want them to present their final design. They can choose a formal written report, slide presentation, video presentation, or other medium.*

**HELPFUL LINKS**

Engineering and Design Process Worksheet

Carolina STEM Challenge® Kits

Engineering and Design Vocabulary

How to Plan an Engineering Design Challenge

STEM Activities for Interdisciplinary Teams

Heat Transfer Between Components of a System

Carolina STEM Challenge®: Keep It Hot: Sample Teacher's Manual

**REFERENCE KITS**

Carolina STEM Challenge®: Keep It Hot Kit

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## Data and Observations

*Answers for temperatures will vary depending on the initial temperature of the water. Generally, 6.0 g of $CaCl_2$ should produce half of the change in temperature when compared to the 12.0 g. An increase of about 20 to 21° C for the 12 g of $CaCl_2$ is typical.*

## Data Table

**Exothermic Reaction**

| $CaCl_2$ (g) | Initial Temperature (°C) | Final Temperature (°C) | Change in Temperature (°C) |
|---|---|---|---|
| 12.0 | | | |
| 6.0 | | | |

## Analysis and Discussion

*Present your final design with supporting evidence to the class. Use the engineering worksheet and project specifications for the basis of the presentation.*

## TEACHER NOTES