Activity 6.5
From gas to liquid to solid

What causes frost to form on the outside of a cold container?

This activity is an extension of *Activity 6.4a* in which ice is used to make a container cold. As in *Activity 6.4a*, this activity will work only with sufficient water vapor in the air. Here, a metal can is used and salt is added to the ice to make the container even colder. Students have already learned that water vapor in air can condense to become liquid water. In this activity, they will see that the liquid water can change state again and *freeze* to become ice.

Materials needed for each group

Ice
Salt
Clean empty metal can
Metal spoon
Paper towel

Notes about the materials

- **Be sure you and the students wear properly fitting goggles.**
- Use soup or vegetable cans.
- It is much easier for students to stir the ice–salt mixture if they use crushed ice instead of ice cubes.
- Students will need enough crushed ice to fill their metal can.

Preparing materials

- Remove the labels from the empty cans and carefully wash the cans.
- Use pliers to carefully press down any sharp or jagged edges around the top of each can. Cover the rim of each can with duct tape.

Activity sheet

Copy *Activity sheet 6.5—From gas to liquid to solid*, pp. 370–371.

Assessment

An assessment rubric for evaluating student progress during this activity is on pp. 372–373. For this formative assessment, check a box beside each aspect of the activity to indicate the level of student progress. Evaluate overall progress for the activity by circling either "Good", "Satisfactory", or "Needs Improvement".

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Question to investigate

What causes frost to form on the outside of a cold container?

1. Discuss how cooling can cause changes in state.

Tell students that they discovered that cooling water vapor can change it from a gas to a liquid. Ask students how they could change liquid water to a solid. Students should suggest making the liquid colder until it turns to ice. Tell students that they will do an activity to see whether they can cool water vapor enough to get it to change to a liquid and then to a solid.

2. Add ice and salt to a can to make it very cold.

Distribute *Activity sheet 6.5—From gas to liquid to solid* and have students follow the procedure.

Procedure

1. Dry the outside of a can with a paper towel.
2. Place 3 heaping teaspoons of salt in the bottom of the can. Fill the can about halfway with crushed ice.
3. Add another 3 heaping teaspoons of salt.

4. Add more ice until the can is almost filled and add another 3 teaspoons of salt.
5. Hold the can securely and mix the ice–salt mixture with a sturdy metal spoon for about 1 minute. Remove the spoon, and observe the outside of the can. Do not touch it yet.
6. Wait 3–5 minutes. While you wait, answer the questions on the activity sheet.
7. Look at and touch the outside of the can. Then record your observations.

After completing Step 5, you may choose to have students place a thermometer inside the can because the temperature of the salt and ice mixture will be below the normal freezing point of water, which is 0 °C. The reason for this subfreezing temperature is explained in the *Science background information for teachers*, on page 332.

***Expected results*: The outside of the can will become covered with a thin layer of frost. Students will notice this frost on the coldest part of the can at or below the level of the ice. Above the ice, the can is cold but not cold enough to change the moisture on the outside of the can to frost.**

3. Discuss student observations.

Ask students questions such as the following:

- What do you notice on the outside of the can?
- Why do you think there was frost on one part of the can and water on another part?
- Explain how water vapor in the air surrounding the can became frost.

Students should remember from *Activity 6.3* that cooling water vapor causes it to condense to liquid water. In this activity, students see that cooling water enough causes it to *freeze* to form frost.

Explain that this activity can be used as a *model* of what happens to water vapor in the atmosphere. Tell students that models help us to understand objects or processes that cannot easily be seen. In this model, the can represents the cold temperature in the upper atmosphere and the water vapor in your classroom represents the water vapor in the atmosphere. Ask students to use this activity as a model and explain what the liquid and frost on the outside of the can might represent.

Students may suggest that the liquid could be tiny drops of water in clouds or rain and the frost could be tiny ice crystals in clouds or snow.