## Part 1: Background Information and Context

| Activity |
| --- |
| Seltzer Freeze |
| A bottle of seltzer water is chilled in a salt-ice mixture; when opened, the contents of the bottle immediately freeze. |

## Suggested NGSS Dimensions to Address (click on the titles to learn more from the K-12 Framework)

### Science and Engineering Practices

- Asking Questions/Defining Problems
  - Students can observe the teacher performing this activity as a demo, record observations, and ask questions.
- Planning and Carrying Out Investigations
  - Students could then develop an experiment to test their ideas or the teacher could develop the experiment, and students could conduct it. These could include other examples of freezing point depression for students to explore.
- Modeling
  - Students could draw an initial model of the seltzer bottle freezing and then revise it after further explorations. To be most effective, students should explore other examples of freezing point depression to make their models as robust as possible.
- Constructing Explanations/Designing Solutions
  - After students explore the different variables that affect their art bot, the teacher could propose a series of art challenges for the students to design the appropriate art bot to create the specific design.

### Disciplinary Core Ideas

- PS1.A Structure of matter
  - 6-8: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2), (MS-PS1-3) Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

### Crosscutting Concepts

- **Cause and Effect**
  - Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- **Systems and System Models**
  - Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering
- **Energy and Matter**
  - Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
- **Scale, Proportion, and Quantity**
  - In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

**Part 2: Lesson Facilitation for Phenomenon**

**Teacher Background**

Instantly freezing something might sound impossible. Even after placing something directly into a freezer it still takes time to actually freeze. For this experiment, the instantaneous freezing is possible because the carbon dioxide, or $CO_2$, in the club soda actually lowers the freezing point of the water. Whenever something is added and dissolved in a liquid it is called a solute, and the liquid it is dissolving into is called the solvent. When solutes are added to a liquid, the freezing point of that liquid (solvent) changes based on the characteristics of the additive. Water freezes at zero degrees Celsius when pure; however, when a solute is dissolved in it, water can be cooled to temperatures below zero. This is referred to as a "freezing point depression." Although it is a gas, carbon dioxide can dissolve in water and, as a result, become a solute and reduce the freezing point of water. The $CO_2$ is only trapped within the bottle for as long as cap is on, so when the cap is removed the carbon dioxide is able to escape from the water and is no longer a solute. In this experiment, we cool the seltzer water to about -15 degrees Celsius, which is well below the freezing point of water (zero degrees Celsius). Once the $CO_2$ is no longer a solute, the seltzer water is at a temperature below its freezing point, and as a result it instantly freezes.

In this experiment the soda is super cooled in an ice bath. In order for the ice bath to work it actually has to become much colder than ice while still being an ice bath, and not a large block of ice. To do this rock salt or ice cream salt, which is sodium chloride, is added to regular ice in order to bring down the temperature. Sodium chloride is also a solute and mixing it with water lowers the freezing point of the water. The freezing point of water and the melting point of ice are the same temperature. When sodium chloride is added to ice (solid water), the melting point of ice is lowered and, as a result, the salt and ice mixture is much colder ( -10 to -15 degrees Celsius) than ice water (zero degrees Celsius). Using salt and ice, we can cool the club soda to a temperature that is much lower than it would be with pure water.

**Materials**

1. 8 oz. Bottled Water
2. Large ice chest
3. Club Soda
4. Pack of Seltzer/ Sparkling Water (5-6 dozen bottles) in plastic bottles, e.g. half-liter Perrier in plastic bottles.
5. 1 Cooler
6. 1 Bag of ice (2-3 x 5 lb bags)
7. Rock Salt (5 – 6 boxes)
8. Roll of Paper Towels
9. Pairs of Thick Gloves
10. Thermometer
11. Safety Goggles

**Procedures**

(Note: Start 1 hour prior to experiment)

1. Peel labels off club soda
2. Keep soda refrigerated or stored in ice for as long as possible before the start of the experiment
3. Place ice into the ice chests

4. Add sufficient rock salt into the chest with ice so that you have a 5:1 to 8:1 ratio of volume of ice to volume of salt. Mix ice and salt well.
5. Submerge unopened club soda bottles into the salt/ice combo for least 45 minutes before start of the experiment. As ice melts, drain water from the ice chest and add more ice/ salt mix in the same ratio as above. Add only minimum additional salt to ensure that the ice chest temperature is approximately -10°C to -8°C.
6. Cool the bottle to a temperature of -10°C to -8°C. DO NOT cool past -10°C or the soda will freeze
7. Remove the bottle from the ice using the thick gloves (note: club soda should still be in liquid form)
8. Wipe off condensation on outside of bottle
9. Open the bottle or have the participant open the bottle.
10. Carbon dioxide gas will rapidly escape the bottle. The soda should begin to freeze immediately and be completely frozen within 30 seconds

*Safety Concerns*

Note: Do not use glass bottles. When water freezes, its volume increases. Using glass bottles could mean that the bottles will shatter sending glass fragments out toward anyone near the freezing bottle. Caution the students about the low temperatures, as even ice can cause a burn!

**3-Dimensional Questions**

1. What did you notice during the demonstration?
2. What did you wonder during the demonstration?
3. How is this liquid different from regular water? How do you think that changes its behavior?
4. What are some of the experimental variables that affect this experiment? How could you design an experiment that could test the importance of these variables to the instant freezing of the seltzer water?
5. What is a freezing point? What is the freezing point of pure water?

Questions students may generate:

- What would happen if other liquids were used instead of soda? If other materials were dissolved?
- What is the purpose of the rock salt? What would happen without it?
- What is the importance of the CO2 being a gas and the water being a liquid?

*These questions could drive you into further investigations to ultimately figure out the phenomenon.

**5E Model Alignment/Suggestions**

<u>Engage</u>:

Consider using this activity as a demonstration and having students ask questions about what they see through a prompt such as "Make 5 observations and 3 questions about the following demonstration". Consider having the students make predictions (cause and effect chart) about what would happen if you repeated the demonstration under different conditions (i.e. a different liquid, different temperature, etc)

<u>Explore</u>:

1. After students have made preliminary predictions and explanations, they could explore the concept further by experimenting with other examples of freezing point depression such as different substances like salt, sugar, sand, etc in water as well as similar conditions with melting point. Students could either **develop the investigation** or simply **conduct** it using provided procedures.
2. After conducting an investigation, students could ***revise*** their original predictions/explanations about the seltzer freezing.

Explain:

After the teacher has helped the students make meaning of their activity through direct teaching, video, or text, the students can then explain their learning back to the teacher.

The students can **construct an explanation** or write a **Claim-Evidence-Reasoning** on freezing point depression. This would also be an appropriate time for students to show their thinking through modeling.

Elaborate:

1. Students could **apply their knowledge to a new situation** such as iced over roads. Students could explain and model a way for people to melt the ice quickly. Alternatively, you could ask them to propose a way to cool drinks down quickly or other scenarios which require the knowledge of freezing point depression.