Extreme Phases or Cryogens and You- Dorothy Ahlf

Purpose

1) To show the students some of the more extreme examples of solids and liquids, and how they can be useful in research.

2) For the students to start to think about safety in handling substances and to think about where cryogens could be useful.

Overview

Students will already have prior knowledge of phase changes and some substances, so the lesson will focus on the more "extreme" ones used in research at Northwestern University or other areas. We will discuss these substances in general, with real examples in front of the students (liquid nitrogen, dry ice) so we will talk them through why they are used and think about some of the advantages and disadvantages for using them. At the end for fun and a special treat, we will make liquid nitrogen ice cream!

Student Outcomes

Students should be able to remember several concepts covered before like phase changes, sublimation. They will be able to define and give examples of phase changes beyond the water example used previously in class. Students should be able to describe some of the physical characteristics associated with cryogens as well as define what makes a liquid a cryogen. Students should be able to reason through some of the hazards when handling substances like cryogens and design a way to mitigate some of the hazards for use.
For the advanced students, teaching the conversion of temperatures between Fahrenheit, Celsius, and Kelvin, so to understand how cold these liquids are.
Standards Impacted:
12.C.3a Explain interactions of energy with matter including changes of state and conservation of mass and energy.
12.C.3b Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).
13.A.3a Identify and reduce potential hazards in science activities (e.g., ventilation, handling chemicals)
13.B.3a Identify and explain ways that scientific knowledge and economics drive technological development.
13.B.3c Describe how occupations use scientific and technological knowledge and skills.

Time

This lesson is intended for one 45 minute class period.

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Level

This lesson is intended for 8th grade students. Classes were held combined in the large theater room so about 40-50 students were present. This could be changed in the future.

Materials and Tools

Powerpoint presentation (see **attached**) with videos and pictures of usage at Northwestern University

Projector

Pre-made Dot-style ice cream (requires cream, sugar, flavor, liquid nitrogen)

Worksheet for the students to fill out (**attached**)

Previous discussions on phase change following the textbook and lesson plans.

Another teacher is very helpful with this lesson to either change the powerpoint slides and to carry around the dry ice.

Dry ice

Liquid nitrogen and dewar

Proper safety gear for handling (please set a good example for your students!)

Preparation

Lots of the students are interested in freezing body parts, so it's good to prepare for that. The ice cream made during class will be too cold to eat right away, so the dot-style ones with small paper cups (~3oz) are an easy way to dish up premade ice cream so the students can enjoy. Lots of the students don't know that's how that ice cream is made so it's a nice trivia bit for them, most of them have seen that style before.

Prerequisites

The 8th grade curriculum at the school this lesson was designed for starts with a lot of matter questions, and has had several lessons investigating the characteristic properties of matter before this. These are recommended so the students are familiar with phase change as well as the properties of matter types and how they differ.

Background

Just the other day we've been thinking about phase changes. What are the three main phases of matter? (Solid, liquid, gas). When we look at this phase diagram, what is shown by #1? (#2, #3, etc). Can someone tell me what the transition between #2 and 3 is called? Work around to sublimation.

Who here has actually observed dry ice? Does anyone know how cold it is? (Ask Nick to help walk the dry ice around so all the students can see it sublimating. While it's really neat to look at, why do we use it? What could it be good for?

What would you think scientists/engineers would use if they needed to make things even colder? Cryogens are something that actually BOILS at -160C. Discussion of safety, how they're useful (see powerpoint). How would you actually work with something like that? How do you keep it around?

You always have to remember with phase changes that while it's easy to remember water's changes because it's all around us, boiling doesn't always mean hot. Freezing doesn't always mean cold! Sometimes, the states of matter that are the most unfamiliar are the ones that are the most useful.

Teaching Notes

1) Review Phase changes and what they know about them for about 5 minutes. See if they can draw a phase diagram on the board/tell me about the one I have up (label parts that are solid, liquid, and gas).
2) Ask them about the part of the diagram that contains the transition between vapor to solid.
3) Show dry ice for those who haven't seen it. Discuss what this is used for or could be used for. This part was helpful to have another teacher with proper safety gloves and goggles take around to show the students up close.
4) Ask them about ways they could make things even colder.
5) Introduce Cryogens-safety ideas, containing, transporting, etc (see worksheet). Show the students the dewar, make the connection to the thermos that many of them carry.
6) Pictures/Videos of where Cryogens are used at Northwestern in the KRG – ~5 minutes
7) Ice Cream! – A small amount will be made on site to show them how it is done, but pre-made Dot-style ice cream will be handed out so the students can eat it during class.
8) If time: brainstorm more places cryogens could be used or see what they've retained (Math between Fahrenheit, Celsius, Kelvin?)

Assessment

I've made a short worksheet for the students to take notes/write thoughts on, but most of the assessment will be done by in-class question and answer sessions while the demonstrations are going on.

Example Questions:

1) Name one place where you think dry ice could be useful? Examples: Sandblasting away graffiti, shipping things that require more deep cold than ice, making ice cream

2) If using the example of freezing-and-breaking items, I used a flower—a rose I bought for cheap. Asking the students: What do you think will happen to the rose when it is dipped in liquid nitrogen? Will it wilt? Turn brown? Result: the rose opens up further because the nitrogen boils, pushing the petals apart. However, it does not wilt and look dead as it freezes too quickly. Afterwards though, the flower is so hard it will shatter when tapped on a table (a big hit with the students. Many asked if you could do that to your own hand and other questions for the movies.

3) Using cryogens to store things: In my lab, we store cell lines in liquid nitrogen for re-growth. It was introduced to the students in this way: Has anyone ever seen a science fiction movie where the hero/bad guy is frozen and then unfrozen later? In my lab we do that, but not with whole people. After seeing what happened to the flower, who has any ideas as to why you couldn't just unfreeze a person? When we re-grow cancer cells, we only get back ~60% of the cells. Would someone want to be revived with only 60% of their brain!?

4) On making ice cream: Has anyone ever made ice cream before? How long did it take? Mix the liquid nitrogen into the ice cream mixed provided. Show the students the before and after, but don't let them eat it! Ask them why—answer—way too cold! We have to let the ice cream warm up before we can eat it safely.

5) Specialty ice cream (this kind I made for the students in this example, and was a big hit): What would happen if instead of adding the liquid nitrogen to the ice cream mix, we took a small dropper and added the mix to a big bowl of liquid nitrogen (if you have enough, you can do this at that point). Would the drops all join together? They're frozen as individual drops! So you would have big piles of small drops of ice cream…many of us has seen that before, but to protect us from copyright issues we'll just mention that it's a famous company. They make their ice cream that way, and how do they keep it cold to ship to you? Dry ice! That keeps the ice cream as little drops so it doesn't become one big ball before you eat it.

Additional Information