POLAR TREC
Learning Resources

Details

Completion Time: About 1 period

Permission: Download, Share, and Remix

South Pole Ice Cream!

Overview

Before leaving for the South Pole in late 2009, I received many suggestions for things to try down under. Liz Ratliff's math classes suggested we try making ice cream! So, before I left, I had my students follow her recipe to make ice cream in our classroom in balmy California. After arriving at the pole, I was able to gather the required ingredients (with some substitutions…) to try it down there, and see what happens.

Objectives

Making ice cream requires removing energy from the cream mixture (freezing is an exothermic process). In this recipe, the energy required to melt the ice (in the ice-salt mixture - melting is an endothermic process) comes from the cream mixture, reducing the temperature of the cream mixture until it freezes.

Snow is frozen water, obviously, but is actually mostly air. Air is an excellent insulator, meaning heat does not transfer very effectively through it through conduction. Liquid water transfers heat effectively through convection.

Adding impurities to water changes its properties. For this lesson, water containing added salt has a lower freezing/melting point than fresh water.

Lesson Preparation

Content can vary depending on class level. The following concepts could be taught: exothermic/endothermic processes, ionic compounds (sodium chloride), heat transfer: conduction, convection, radiation.

You may wish to have students watch the first part of the lesson on the PolarTREC website: http://www.polartrec.com/expeditions/icecube-in-ice-antarctic-telescope/journals/2009-11-30. Make sure to stop/pause it

Materials

- 1 cup of half-&-half (milk works well enough but half-&-half gives a better texture)
- 2 tbsp sugar
- ½ tsp vanilla or other flavoring
- Ice
- Salt (road salt, or salt pellets for water softeners, is fine since it will not be eaten)
- 1 quart-sized zip-lock food storage bag (heavy duty is recommended)
- 1 gallon-sized zip-lock food storage bag (heavy duty is recommended)
- Paper cups, spoons, and lots of paper towels

after the classroom portion of the activity, before the South Pole part.

Procedure

For each group:

- Mix the three "cream mixture" ingredients in the smaller zip-lock bag, remove as much of the air as possible, and seal tightly.
- Mix the ice and salt (about ½ cup salt and two good handfuls of ice) in the larger zip-lock bag. It should be about half full.
- Place the smaller bag (still sealed!) into the larger bag, then seal the larger bag.
- At this point, different groups may wish to try various "agitation" techniques. The intro video has some demonstrations, or they can come up with their own. Timers can help determine which is most "effective" though results will vary.
- NOTE: the bags will get really cold! Students shouldn't hold onto the bags for extended periods of time, or could use sweatshirts/gloves/etc to handle them.
- After about 5-8 minutes, groups should have ice cream the consistency of soft-serve. Remove the cream mixture bags from the ice/salt, rinse (to remove the salt), and carefully open and serve in paper cups.
- Ask students to hypothesize what will happen if you try to do this outside at the South Pole. Students should try to back up their hypotheses with a reasonable explanation. Most students will suggest that it will take much less time. You may want to ask what kinds of difficulties someone might have trying to do this at the South Pole?
- After discussing hypotheses, show the remainder of the video: http://www.polartrec.com/expeditions/icecube-in-ice-antarctic-telescope/journals/2009-11-30 to see what actually happened (hint: it actually took significantly longer!). Ask for student ideas on why it would take longer, and see if they have suggestions on how to make it work better in a follow-up experiment.
- Following this, you may wish to show the South Pole Ice Cream part 2 video: http://www.polartrec.com/expeditions/icecube-in-ice-antarctic-telescope/journals/2009-12-08-0 to see a follow-up experiment.

Background on what was going on: Because the snow is so cold, there was no chance for it to melt. It remained solid, with a lot of air trapped in between the crystals. Air acts as an insulator, so the heat transfers much more slowly out of the cream mixture. In the classroom, the ice melts, which takes energy in the first place, and then creates a liquid which can conduct heat much more quickly from the cream mixture.

This also explains why you can die of hypothermia much faster in cold ocean (above freezing) than in very cold air (well below freezing); also why cold-weather gear is puffy to trap lots of air.

In the follow-up experiment, I used rubbing alcohol to turn the snow into a liquid. Rubbing alcohol freezes at a much lower temperature, so stays liquid even at the south pole. This super-cold liquid (well below freezing) very quickly froze the cream mixture, and was actually

quite painful to handle with my bare hands.

Extension
Students can suggest follow-up experiments to speed up the freezing process. Perhaps try it with ice and alcohol instead of ice and salt?

There are other fun ways to make ice cream, including with liquid nitrogen. Find directions on line for this - it is very impressive and makes great ice cream.

Resources
n/a

Assessment
This lesson has no formal assessment to go along with it; student understanding can be assessed through discussion, exit tickets, questions on a homework assignment or exam questions.

Credits
Recipe from Liz Ratliff, Videos filmed and edited by Casey O'Hara, 2009.

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National Science Education Standards (NSES):

Content Standards, Grades K-4

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry

Content Standard B: Physical Science
a. Properties of objects and materials
b. Light, heat, electricity, and magnetism

Content Standards, Grades 5-8

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
a. Properties and changes of properties in matter
b. Transfer of energy

Content Standards, Grades 9-12

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
a. Structure and properties of matter
b. Chemical reactions
c. Interactions of energy and matter

Content Standard E: Science and Technology
a. Abilities of technological design
b. Understandings about science and technology