TEACHER INSTRUCTIONS

Cold and Hot Processing of Materials

Objective: To demonstrate how increasing or decreasing temperature can affect the processing of materials.

Background Information: Atoms are in constant vibration at temperatures above 0 K (-273.15°C/-459.67°F). As the temperature is increased, the vibration of these atoms is increased, which encourages them to move from one place to another inside a material. Thus, by controlling the temperature, the extent to which various reactions take place can be controlled. This allows the processing of materials from one form to the other to also be controlled. Generally, as temperature is increased, a material goes from solid to liquid to gaseous state. Decreasing temperature usually has the opposite effect.

Ice cream is processed at temperatures lower than normal room temperature, which gives it a semi-solid texture. Sugar syrup is processed at temperatures higher than room temperature so that the sugar dissolves quickly in water to form a uniform liquid.

Description: In this demonstration, students will learn about the influence of lowering temperatures by processing ice cream using liquid nitrogen. They will then learn about the influence of increasing temperatures by processing sugar syrup.

Keywords:
Temperature: quantity which indicates how hot or cold a material is
Solid: fundamental state of matter that is characterized by structural rigidity
Liquid: fundamental state of matter that is characterized as having a definite volume, but no shape
Liquid Nitrogen: nitrogen that is in a liquid state at a very low temperature

Materials List:
- Liquid nitrogen
- Styrofoam bowl (or some other well-insulating container)
- Insulating gloves
- Wire whisk
- Half-and-half cream
- Stainless steel bowl

- Transparent glass cup/bowl that can be heated (e.g. a small Pyrex container or a beaker)
- Spoon
- Sugar
- Hot plate
- Vanilla/Chocolate ice cream syrup
- Safety glasses/goggles
- 1 teaspoon measuring spoon
- 1 cup measuring cup
- Wooden spatula

Safety Precautions: Liquid nitrogen is a hazardous substance. If misused, it may cause frostbite, eye damage, torn flesh, or asphyxiation. **ALWAYS FOLLOW THESE SAFETY RULES:**

- Keep liquid nitrogen away from students.
- Wear safety goggles at all times.
- Use tweezers to handle superconductors, magnets, or other small, cold objects. Plastic tweezers are desired but should be tested for embrittlement (see last caution) before use in the classroom.
- Wear insulating gloves when handling liquid nitrogen containers or large, cold objects.
- Use liquid nitrogen only in well ventilated places.
- Do not allow liquid nitrogen to touch any part of your body.
- Items in contact with liquid nitrogen become **EXTREMELY COLD**. Do not touch any item that has been immersed in liquid nitrogen until it has warmed to room temperature.
- Do not store liquid nitrogen in any container with a tight-fitting lid. A tightly sealed container will build up pressure as the liquid boils and may **EXPLODE** after a short time.
- Many substances become brittle and may shatter when cold, sending pieces of the material flying. Avoid common glass and large, solid plastics.

Instructions:

(a) For making ice cream

1. Mix 1 quart of half-and-half cream and ½ cup of sugar in the stainless steel bowl using the wire whisk. Continue mixing until the sugar has dissolved.
2. Add 2 teaspoons of vanilla or chocolate syrup to the cream and sugar mixture and whisk until well blended.
3. Put on insulating gloves and safety glasses. Using the Styrofoam bowl, pour a small amount of liquid nitrogen directly into the stainless steel bowl containing the ice cream

ingredients. Stir the mixture with a wooden spatula while slowly adding more liquid nitrogen until the ice cream starts to thicken.

4. Allow the remaining liquid nitrogen to boil off from the bowl. The ice cream will be left behind!
5. Serve or taste ice-cream only when all the liquid nitrogen vapors have gone away.

(b) For making sugar syrup

1. Add 2 cups of normal tap water to the clear/transparent glass cup.
2. Add 1 teaspoon of sugar to the glass of water and whisk using the spoon.
3. Continue adding teaspoons of sugar to the water until the sugar will no longer dissolve. Be sure to keep track of the number of teaspoons added to the water.
4. Empty the glass and again add 2 cups of water to it.
5. Put the glass on a hot plate and heat the water to 90 ºC. ***Note:*** the boiling point of water is 99.98°C, so the water should be almost to the boiling point.
6. Once this temperature has been attained, wear insulating gloves and safety glasses and repeat steps 2-3.

Demo Delivery Hints: At room temperature, the liquid nitrogen is already boiling and thus depletes very quickly. While making ice cream, be sure to whisk swiftly to minimize the use of the liquid nitrogen. While making the sugar syrup, the glass cup and hot plate can get very hot. Make sure to wear insulating gloves or use tongs to avoid accidentally burning your hands.

Troubleshooting: If the ice cream does not thicken after adding liquid nitrogen, then continue to add more liquid nitrogen. During the sugar syrup demonstration, if the sugar takes too much time to dissolve, do not hesitate to raise the temperature of the hot plate.

Cleanup/Replacement parts: Dispose of the liquid nitrogen by either letting it boil away completely, or for a bit more excitement, pour it carefully onto the floor where the liquid will form small spheres that will scatter and dissipate quickly. The half-and-half cream will also need to be replaced every time the ice cream is made.

TEACHER DISCUSSION QUESTIONS

Cold and Hot Processing of Materials

Discussion Questions to Ask Before the Demo

1. What is material processing?

   Discussion: Material processing is converting from one form of matter/material into another more useful or desired form.

Discussion Questions to Ask During the Demo

1. Why does the liquid half-and-half cream become semi-solid when the liquid nitrogen is added?

   Discussion: As liquid nitrogen is poured on the half-and-half cream, it cools it and thus reduces the vibrations of the atoms. This causes the half-and-half cream to change its state from liquid to semi-solid.

2. Ask students what they think will happen when sugar is poured in hot water as compared to cold water?

   Discussion: Sugar in hot water dissolves much faster as water molecules have lots of energy/vibrations due to the heat and want to move quickly. This creates more space between the water molecules, which allows more sugar particles to fill in this space.

Discussion Questions to Ask After the Demo

1. What other material processing requires increasing or decreasing temperature?

   Discussion: There are a variety of applications that students may mention. For example, frozen meals require heating to continue cooking the food and convert it to a semi-solid state appropriate for eating.

STUDENT QUESTION HANDOUT

Cold and Hot Processing of Materials

1. What happens to the half-and -half cream when the liquid nitrogen is added?

2. Why do you think this happens?

3. How many teaspoons of sugar were added to the room temperature water?

4. How many teaspoons of sugar were added to the hot water?

5. Was there a difference? Why or why not?

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