Week 5 – Phase Changes – USC Science Outreach

Summary:

Liquid Nitrogen is one of several elements that boil at room temperature (it in fact boils at 320F below 0F). As it turns from liquid to gas, it expands about 700x its liquid volume. Apart from the many applications of rapidly being able to drop the temperature of something to -320F, the rapid expansion serves many useful applications. We will demonstrate some of the ways liquid nitrogen's properties can be used to learn more about the phases of matter, and the effect of temperature on molecular properties.

Goal:

1)To help kids understand the phases of matter
2) Understand that temperature is a measure of how fast molecules move
3) The three states of matter differ in their molecular arrangement and nothing more.

Materials:

Materials:	Amount per Trial:
Liquid Nitrogen	1.5 Liters
Rubber Tubing	9 inches
Flower (with large petals and 6" stem)	1
Long Cylindrical Bucket	1
Balloons	1
Sandwich Bag	1
Orange	1
Tongs	1
Work Gloves (waterproof and temperature proof)	1
Hammer	1
Safety Goggles	2-3 For SCouts

White board Drawings:

- Draw solid, liquid, and gas phases
- Use dots to show how closely the molecules are spaced together

Procedure:

Part 1:

1. Pour the Liquid Nitrogen into the Cylindrical Bucket
2. Add a little water to the zip lock bag (about the size of a shot)

3. Place bag into liquid nitrogen
4. Wait until boiling stops and liquid nitrogen calms down
5. Remove bag and see the frozen water

Part 2:

1. Place the Flower in the liquid nitrogen and wait for the boiling to calm down
    1. Use the tongs and hold the flower down
2. Remove and crumple the flower in your hand and watch it turn to dust

Part 3

1. Inflate the Balloon to a diameter that fits in the cylinder bucket
2. Place the balloon in the liquid nitrogen and watch it shrink
3. Take it out and place it on the table
4. Shake the Balloon and listen for the slight movement of the liquefied air
5.As it heats up, the balloon re-inflates

Part 4:

1. Place the Orange in the liquid nitrogen
2. Wait 5-10 minutes for the boiling to settle
3. Carefully take it out with the tongs and place it on the table
4. Hit the orange with a hammer and keep shattering it into hundreds of small pieces
5. After 2-3 minutes, it should be safe to touch and still frozen, but test it yourself before giving it to the kids!

<u>Concepts Being Covered:</u>

Phases of Matter:

- Solid (Do not fill their container)
    - Molecules rigidly held in place
    - Molecules do not move
    - Does not change shape with temperature
    - Most become brittle as temperature decreases

- Liquid(Spreadsouttofillupcontainer)
    - Molecules held in place, but have flexible bonds
    - Does not really change shape with temperature (some do: Mercury)

- Gas(Overflowsfromcontainer)
    - Molecules are unattached to one another
    - Molecules move freely through space
    - Fill entire container they are in
    - Expand with temperature

(**Temperature is a measurement of the kinetic energy of molecules**. High temperatures correlate to very quick moving molecules (gases), whereas low temperatures relate to slow or even stagnant molecules (solids). Imagine the difference between running on a really cold day and on a really hot day. You will notice how your limbs tend to be stiffer on the cold day, similarly to molecules at low temperatures. They have very little kinetic energy and end up forming ordered crystalline-like structures. This is essentially what you see during this experiment as you use the liquid nitrogen to change the phase of various objects.)

Brittle Behavior

- As you see in this experiment, when solids are placed in liquid nitrogen, they tend to become brittle. Most solids are not perfect crystalline structures. The bonds between molecules are flexible and move with an applied pressure. But as we drop the temperature continuously, the molecules become more rigid, and begin to adapt crystalline structures, and become extremely brittle. The temperature at which this happens is called glass temperature (no need to introduce this to the kids). This is notable during the phase when we freeze the rubber tubing.

Liquid nitrogen is so cold that it causes water to freeze. When you place the bag with water in the liquid nitrogen, you will see that it turns to ice. This point can be used to discuss how molecules rearrange themselves into more crystalline structures as their temperature drops. This can also be seen with the flower and orange. These to things are made up mostly of water. So when you freeze it, the water rearranges to become ice, and forms a solid. Solids, unlike liquids, tend to break rather than flow, that is why we can shatter the orange and flower.

Rubber has properties of a solid, but moves like a liquid in some respects. It is very malleable and reacts easily to pressure, where as solids do not. So when you freeze the rubber tubing, you bring it closer to what we call the glass temperature (do not bring up glass temperature to the kids). Glass temperature is essentially the temperature at which a material begins to exhibit crystalline structure, making it very brittle.

A balloon will shrink when it is placed in liquid nitrogen. One thing to take note that as a substance changes shape from gas to liquid to solid, its volume shrinks, and expands when changing in the other direction. **The balloon shrinks because we are making the gas cold enough that it becomes a liquid**. If you shake the balloon, you will hear something inside rolling around, which is liquefied air! As you let the balloon heat up, the liquid air turns back into a gas and expands to the max volume it needs!