Liquid Nitrogen

https://www.youtube.com/embed/BlFUjRfDgI8

The Liquid Nitrogen demonstration is one of our most popular demonstrations to be requested. This demonstration requires a lot of practice before being performed, and volunteers must first go through the proper Cryogen Safety training before they are allowed to perform this demonstration.

Materials

- Liquid Nitrogen
- Thermos container for presenting, with lid
- Tongs
- Balloon
- Racquetball (Hollow)
- Flowers OR Bananas
- Nail
- Hammer
- Green Board
- Ladle
- Small Blast Shield
- Cryo gloves and safety glasses/goggles

Safety Precautions

Please read the Cryogentic Demonstration saftey section on the Demonstration Safety page before performing this demonstartion. This demonstration requires the use of cryo gloves, as noted in the demonstrations below. When doing this demonstration, safety glasses or goggles are required at all times. Wear the cryo gloves whenever you are pouring liquid Nitrogen, carrying a liquid Nitrogen container or handling any object that has been submerged or exposed to liquid Nitrogen.

Demonstration

Preparation

Fill the presentation thermos, and put the polystyrene lid on it, making sure it isn't tight. Set up the demonstration area, laying out the different items you need around the thermos on a table. Set a small blast shield in front of the presentation thermos. Blow up the balloon, making sure that it is just slightly too big to fit into the presentation thermos

Balloon

1. Show the balloon to the audience, and ask them for ideas on what will happen if it were put into the liquid Nitrogen.
2. Show that the balloon does not fit into the thermos. Using the ladle, pour liquid nitrogen on top of the balloon while it is on top of the thermos, and it will start to collapse. After pouring one or two scoops onto the balloon, it should fit.
3. After getting the balloon into the thermos, use a pair of tongs to pull it out. Immediately drop it onto the table, and pick it up using your hands (It will be warm enough to handle). As it expands, carefully turn it over in your hands, and blow onto any spots that look frozen to help thaw it out. It should re-expand to the original size!

Banana & Flowers

Banana

1. Show the banana to the audience, and push a nail into the side of it to show that it is a normal banana. Drop the banana into the liquid Nitrogen.
2. As the banana cools and freezes, explain to the audience what is happening to it.
3. After 1-2 minutes, the banana will be sufficiently frozen. While wearing the cryo gloves, pull the banana out of the thermos using the tongs. Drop it on the table.
4. Try to stab the banana with the nail repeatedly, while holding it on the green board. After a few attempts, use the hammer to shatter the banana

Flower

1. Show one of the flowers to the audience, and tap it gently against the blast shield to show that it is a regular flower.
2. While wearing a cryo glove, stick the head of the flower into the liquid Nitrogen for 8-10 seconds. Pull it out, then tap it against the blast shield on the presenter's side. It will shatter!

3. Repeat the above steps, making sure to take time to explain each part of the demonstration.

Leidenfrost Effect

Note: This demonstration works best either right before or after the Banana & Flower demonstration. Do not perform this demonstration if you have not practiced it. Please use all necessary safety precautions before performing this demonstration.

1. Show the audience your bare hand, and ask them why you wore a glove to handle the banana/Why you didn't wear a glove to handle the balloon.
2. Explain how cold liquid Nitrogen is, and how it is dangerous to handle directly. Ask if you should stick your hand in.
3. Hold your hand directly over the open thermos. Quickly submerge your hand in the container and pull it back out. repeat this process a few times, allowing time between dips to show that your hand is, in fact, intact.
4. Hold one hand directly over the thermos, and have the other holding the ladle. Scoop up a small amount of liquid Nitrogen with the ladle. Have the hand over the thermos open, tilted downward toward the thermos, and pour the liquid Nitrogen onto your hand. It will roll off your hand, and not hurt you!

Racquetball

1. Show the Racquetball to the audience, and bounce it a few times to show that it is elastic. Lock the tongs on it, and put it in the liquid Nitrogen. You might need to use the ladle as well to keep it submerged.
2. While the racquetball is cooling, explain what is happening to the audience
3. After 1-2 minutes, put on the cryo gloves and take the racquetball out. Drop it on the table to show that it has little elasticity, making note of what sound it makes.
4. If you have a back wall that is concrete or similar, throw the ball against the wall to shatter it. If the floor is concrete or there is a metal plate, throw it against it to shatter the ball.

- **Do not throw it against a wood wall or wood floor;** it will bounce off! If there are no sufficiently hard surfaces, then hold the ball on the green board, and hit it hard with the hammer to shatter it.

5. Show one of the shattered pieces to the audience, and have a fellow presenter heat up one of the other pieces to show that it regains elasticity once it is warm again.

Why This Works

Liquid Nitrogen is extremely cold, and sits at about -321 degrees Fahrenheit, or about -196 degrees Celsius. It is very dangerous that it is this cold, which is why we state time and again throughout this write-up to use all necessary safety precautions. The expansion rate of liquid Nitrogen is about 700:1, or for every 1 liter of liquid Nitrogen we have, we will get 700 liters of Nitrogen gas when it warms to room temperature. Please make sure the lid on the container is never tight for this reason, because it can explode if that expanding gas builds up pressure. This is also why this demonstration needs to be performed in a ventilated area.

Balloon

This helps to build the connection between moving molecules and temperature, which was started in the Molecule Dance. When the balloon is at room temperature, the air inside is moving quickly, and takes up a lot of space. As the balloon is cooled by the liquid Nitrogen, the air inside moves much more slowly, as it loses heat to the LN2. This makes the air inside condense, and allows the balloon to "deflate" and fit into the thermos. After pulling it out, the air inside will warm back up and expand the balloon back to its original size.

Banana & Flowers

This shows the effects of heat loss on living organisms, such as ourselves. We know that we have water inside of our bodies, and plants are similar in that they have a lot of water. When the flower or Banana are put inside of the liquid Nitrogen, the water in their cells starts to freeze. Water is unique in that, when it goes from a liquid to solid, it expands. Most of the rest of matter contracts when it goes from a liquid to solid state! When the ice forms in those cells, it causes them to expand as well, and this can break some of the cells as it happens. The frozen water and broken cells become apparent when we pull the plant out of the liquid Nitrogen and shatter it! At the end of the performance, you can show students that the banana and flower petals rapidly wilt and brown when they thaw, due to these broken cells.

Leidenfrost Effect

We need to remember two things to understand this effect. First, that the liquid Nitrogen is extremely cold. Second, that we are extremely hot compared to it. There is an over 400 degree difference (Fahrenheit) between our bodies and the liquid Nitrogen. So, when it first comes in contact with our hand, some of this liquid will instantly turn to gas. The rest of the liquid lands on this gas layer, and rolls across it, never touching us! This effect only works, however, if we do not keep prolonged exposure to the cold liquid. Prolonged exposure allows the gas layer to escape, and

that would result in frostbite or worse. Also, this does NOT work for solid-on-solid contact. The solid objects we use are solids at room temperature as well, so they would not create this gas layer, and would quickly freeze to your exposed hand. That is why you need to wear gloves when handling a cold solid.

Racquetball

This demonstration shows how the elasticity of a material is temperature dependent. Many of us heard as kids that you need to "warm up" a rubber band before you use it, and there is some fact to that. A materials elasticity, or how much it can stretch or bounce, is dependent on the temperature of the material. The racquetball we know is elastic at room temperature, but after we put it in the thermos it will start to cool rapidly. Remind students that the racquetball cannot freeze, since it does not have a lot of water in it. What can happen, however, is that the ball will get less and less elastic, to the point where it will not bounce or stretch at all. It is also worth noting that racquetballs are hollow, with air in the center to help with the bounce. We know that air will contract and condense when cooled, so the inside of the ball will have a small vacuum, or empty space, inside of it. This empty space is what causes it to make a loud popping sound when it shatters!

Note: The reason why the ball will not shatter when thrown against a wood surface is because, surprisingly, the wood is too elastic!

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