4. Liquid nitrogen fountain

A spectacular experiment showing liquid nitrogen spraying from tubes

Overview

Lengths of rubber tubing are immersed in liquid nitrogen, causing it to boil and create a fountain of cryogenic material and water vapour.

What's happening?

Liquid nitrogen is extremely cold. Its temperature is -196 °C inside the Dewar. When a rubber tube is inserted into the Dewar, it is at (or near) room temperature. This is significantly warmer than the boiling point of nitrogen and causes the liquid nitrogen in contact with it to boil. The vapour produced on contact with the warm tubing propels the liquid up the tube until it is released into the air. When exiting the tube, the liquid nitrogen is still at a very low temperature and condenses water in the surrounding air, causing jets of cloud to go off in all directions in a dramatic fountain effect.

Why is this important?

Understanding cryogenic substances is an important part of industrial chemistry, as well as having exciting applications in current and future technology. At temperatures such as this, some materials can have zero resistance. Liquid nitrogen (-196 °C) and liquid helium (-269 °C) are used to cool down superconducting materials, allowing the creation of incredibly strong magnetic fields. These are used in medical imaging such as MRI (Magnetic Resonance Imaging) scanners, maglev trains and in the Large Hadron Collider at CERN.

More stories to tell

Why does the liquid spray out of the tube?

If you have ever watched a drop of water on the surface of a very hot pan, you will see that it doesn't boil instantaneously, but bunches into a droplet that hovers and dances around the surface of the pan for longer than expected. This is called the Leidenfrost effect and occurs when a liquid comes into contact with an object that is hotter than the boiling point of that liquid. The bottom of the liquid vapourises immediately but provides a cushion of gas that the drop can skid around on. This is very similar to what is happening inside the rubber tubing in this demonstration.

Why does the rubber tube go hard when it is cold?

Different substances can behave in a number of ways when in contact with the low temperature liquid nitrogen. On

a molecular level, rubber is made up of billions of long chains of molecules called polymers, which are all entwined together. At room temperature these polymers are able to stretch significantly, allowing the rubber to bend, twist, stretch and return to its original shape. When the rubber is cooled with liquid nitrogen, the polymers enter what is called a 'glassy state' where they are unable to stretch or unwind, making the rubber brittle.

What would happen if you accidentally put your hand in liquid nitrogen?

As soon as the hand entered the liquid nitrogen it would cause the liquid nitrogen to boil violently, transitioning to nitrogen gas. It will carry on boiling until the hand cools down. Due to the extreme temperature difference the nitrogen would boil at such a rate that, for a while, the hand would be surrounded by an insulating layer of gas. This is another example of the Leidenfrost effect and would actually make it possible to submerge the hand into liquid nitrogen for a brief period of time without freezing it, although it would be very dangerous, and we do not recommend trying this out.

The Activity

1. Place a collection of tubes into the dewar of liquid nitrogen. If you have submerged them deeply enough you should immediately get a spray out of the top of the tubes.

For a double-ended fountain, try the following. Take a tube, insert one end into the dewar and place one (gloved) hand over the top. Remove the tube from the dewar and hold the tube in the middle with your other hand. Remove your hand from the end of the tube but be sure to point it away from your face and the audience!

Troubleshooting

1. Use rubber tubes not plastic ones. Plastic tubes will soon become very brittle and susceptible to shattering.

2. As the rubber tubes cool they will also become brittle and the rate of liquid nitrogen flow will decrease, so be careful not to hold the tubes in the dewar for too long.

Health and Safety

Every delivery centre must undertake their own risk assessments for the specific audiences, locations and conditions they are presenting in. Sample assessments are available on The Secret World of Gases website. Below is a guide to the key risks and hazards:

1. Please see risks associated with handling liquid nitrogen in 'Additional Resources'.

2. Tubes can break when cold. Ensure that the presenter wears eye protection and the audience is two metres away.

3. Always ensure the fountaining ends of the tubes not in the liquid nitrogen are pointing up and away from the presenter and the audience.

4. The tubes will still be extremely cold when they have been removed from the liquid nitrogen. Ensure they are not handled with bare hands and they are out of reach of any volunteers or members of the audience.