Cryogenics: Temperature, energy, and Fun with liquid nitrogen!!

Focus: Physical Engineering **Grades:** suggested for all grade levels

Background:

How fun would it be to put a freeze on science, well now you can! We demonstrate how science examines the energy produced by changing temperatures and how it can be made to do work for us. The really fun part of this demo isn't, however, in the deep scientific insights into the nature of energy in matter and temperature, but in how we illustrate it to the class. Boiling, roiling, bubbling and fuming, freezing and steaming all at once- liquid nitrogen is the centerpiece of this fun- and WOW-filled demo! Shrinking balloons, popping canisters and bending metals- the vast temperature difference between liquid nitrogen and our own 70-degree world can fuel all sorts of amazing phenomenon, causing strange things to happen to items as ordinary as a balloon or a piece of metal.

This demo is sure to cause quite a stir in the classroom, and also hopefully to stir up the scientist's imagination in each student, as they start to wonder, "how does that really work?" and as they marvel at the only thing they've ever seen that boils at room temperature. Students get the opportunity to participate in many activities, including pretending to become melting atoms, shrinking balloons by dunking them in liquid nitrogen and eating slushies made with liquid nitrogen. There participation ensures their best chance to absorb these important basis science concepts and have fun at the same time!

Understanding what liquid nitrogen does and how it works is the key element to this demonstration. With our expert wizards on hand they are ready to unthaw any myths students may have about the use and cautions relative to working with a chemical such as liquid nitrogen.

Having fun while learning certainly takes the chill of the routine way of teaching science.

Objectives:

Students will be able to:

•Observe energy and how it works

•Explain in their own words that heat and temperature are a form of energy in matter

•Restate how temperature, volume and pressure of gasses are related due to change in temperature

•Demonstrate how temperatures and pressure can operation of a motor

•Describe the phases of matter

•Be able to explain how they know that temperature and energy are related

Learning outcomes:
Learning outcomes from this lesson parallel the 4th grade Ohio proficiency test.

Writing
d. Communicate clarity of thought;

SCIENCE
1. Use a simple key to classify objects, organisms, and/or phenomena.

2. Identify the potential hazards and/or precautions involved in scientific investigations.

3. Make inferences from observations of phenomena and/or events.

4. Identify the positive and/or negative impact of technology on human activity.

5. Evaluate conclusions based on scientific data.

6. Recognize the advantages and/or disadvantages to the user in the operation of simple technological devices.
7. Predict the influences of the motion of some objects on other objects.

8. Propose and/or evaluate an investigation of simple physical and/or chemical changes.

9. Provide examples of transformation and/or conservation of matter and energy in simple physical systems.

10. Identify simple patterns in physical phenomena.

12. Identify characteristics and/or patterns in rocks and soil.

13. Demonstrate an understanding of the cycling of resources on earth, such as carbon, nitrogen, and/or water.

Activities

Note: Each demo is modified to fit grade level standards. Please let us know what activities best suits your class.

Introduction

-Energy = the capacity to do Work

Work = ***Force*** times ***Distance***
Power = Rate at which ***Work*** is done

-Forms of Energy:

Potential & Kinetic
Electric
Chemical
Mechanical (Including Rotational, etc.)
Heat

Activity 1

-Energy and Phases of Matter, or "The Atom Dance" (student participation: students = atoms in matter, rising in temperature and undergoing phase changes)

At absolute zero temperature, atoms (which make up matter) have no energy, and are motionless in ***solid*** form. At a higher temperature, the atoms move more- this motion is ***heat energy***. Atoms will move within their solid confines until, when enough energy is added, the atoms move so much that they break free from the confines of the solid and become a ***liquid***. This process is what we know as ***melting***. The atoms retain loose association with each other, and so are contained in the volume of the liquid. Add enough more ***energy***, and the atoms move so much that they break out of all association with each other and fly around, bouncing off of the walls of their container- this phase is called a ***gas***. Going from a liquid to a gas is called ***boiling***. The combined force of the atoms hitting the walls of the container (or, of air atoms hitting our own skin) is called ***pressure***.

Activity 2

-Boiling Liquid Nitrogen at Room Temperature Demo

Nitrogen boils at room temperature because it's boiling point is 77 Kelvin (-321º Fahrenheit or -196º Celsius). The energy in the room then flows into the nitrogen, giving it enough energy to boil and become a gas. Different liquids boil at very different temperatures, because different atoms or molecules bond or associate with each other more strongly than others. The stronger the association, the higher the boiling point!

Temperature, Pressure, Volume and Phases of Matter: thermal expansion and phase changes

Activity 3

-Balloon in Liquid Nitrogen Demo (student participation)

The balloon shrinks when it is put into the cold liquid nitrogen; because the air in the balloon loses it's heat energy to the cold liquid nitrogen (heat energy always flows from hot to cold) and liquefies. The balloon re-expands in the room air because it takes energy from the room to boil the liquefied air inside (mostly nitrogen) and make it a gas again.

Activity 4

-Pop-top Canister Demo

Liquid nitrogen, allowed to boil inside this canister, will expand with enough force to pop the top off the canister so hard that it hits the ceiling!! This shows that gasses take up *much* more space (volume) than liquids or solids, and that much energy (the energy to propel the pop-top) goes into a material as it transforms from a liquid to a gas. The energy from the room is transferred into the gas, making it hit the walls of the container harder than before. The force of the gas hitting the walls of its container is called ***pressure***.

Activity 5

-Bi-metallic Strip and Ball and Ring Demos (student participation)

Illustrate that even solids change how much space (***volume***) they take up with changes in temperature, and that different solids will expand more or less for a given temperature change.

Activity 6

-Fruit Juice Slushies ala Liquid Nitrogen!! (Student participation)

We demonstrate the tastiest phase change of all by freezing fruit juice in a mixer by simply pouring in excess liquid nitrogen. ☺ This makes excellent Slushies for all to enjoy!! (We bring the necessary cups, spoons and napkins, as well as the juice)

Additional activities: (Demo performed by request only.)

Ice Bomb Demo

Did you know that you can make a bomb with just plain old water? Water, when it fills a closed container, can explode that container when it freezes! You've seen it happen with soda cans left in the freezer too long- we do it with a steel pipe!! This dramatically demonstrates water's peculiar property of actually expanding when it freezes (most materials contract when freezing).

Temperature, Energy flow and Engines: covers conversion of heat into mechanical and electrical energy (various demos)

Pressure, Force, and Aerodynamics

(various demos)