

Ease: 3

Mess: 3

## Description

In this experiment, we explore the unique properties of dry ice, the name given to frozen carbon dioxide. CO<sub>2</sub> has the curious nature of skipping the liquid stage and “melting” from ice straight into a gas (sublimation), leaving the ice completely dry as it warms. Students will be mesmerized by the amazing process of sublimation, and will be left with a greater appreciation of the 3 stages of matter: solid, liquid, and gas.

## Ingredients

- Dry ice (not included)
- Tongs
- Quarters (optional variety of coins, not included)
- Honey
- Several cups of hot water and cold water
- Liquid dish soap
- Mixing bowl
- Paper towel
- Plastic spoon and cup
- Hard metal tool, such as hammer (not included)

## Instructions

ALWAYS USE TONGS AND/OR GLOVES WHEN HANDLING DRY ICE.

ALWAYS PUT A TABLE CLOTH ON THE SURFACE YOU ARE WORKING ON.

It must be impressed upon the students that they are not to approach the teacher’s desk too closely.

Wedge a quarter into the dry ice and watch it quiver. (Optional: compare results when using various sized coins.)

Drip honey onto the dry ice. It will freeze into honey candy, which can then be enjoyed by the students.

## Experiment 3

- A. Fill  $\frac{1}{3}$  of the bowl with hot water.
- B. Using a hammer or other tool, break off a chunk of dry ice and place in the hot water.
- C. In a separate cup, mix  $\frac{1}{2}$  ounce of dish soap with  $\frac{3}{4}$  cup of water.
- D. Fold paper towel several times along its width, keeping the length unfolded.
- E. Wet the paper towel with the soapy water until completely saturated. Spread the paper towel and run it
- F. tightly across the lip of the bowl, forming a bubble.
- G. Watch a bubble form, and wait for it to explode!
- H. Fill  $\frac{1}{2}$  bowl with hot water and mix in  $\frac{1}{2}$  cup of soapy water.
- I. Drop in a chunk of dry ice. Fun warm gas bubbles are created!

## Explanation of Results

Dry ice is frozen carbon dioxide. Because of the very loose bonds holding its molecules together, CO<sub>2</sub> does not melt into a liquid like frozen water and most other solids. Instead, sublimation occurs: the solid ice turns into a gas. This produces very exciting results when watching the dry ice “melt”. Soap helps trap the CO<sub>2</sub> into bubbles.

Metal is a great conductor of heat. When a metal coin is stuck into the dry ice, the warm side melts part of the ice into gas, which expands and pushes the coin towards the other side. Now the other side is melted by the warm coin and pushes it back. This pushing to and fro creates a vibrating effect until the coin cools off.

## 6. Dry Ice

Matter refers to anything that takes up space and has mass (weight).

Air is 78% nitrogen, 21% oxygen, 1% argon, and 0.04% carbon dioxide, as well as small amounts of water vapor.

Water freezes at 32°F.

There are a few exceptions, the most common being frozen water. Water is denser as a liquid than as a solid. This is due to its unique polar properties which pull the water molecules close to each other. This is what allows ice to float on top of water.

## What It's About

**Matter vs. energy** – *Matter* is the scientific term for all substances. Clothing, baseballs, water, air, and even *your body* are all made up of matter! The other main component of the universe is *energy*. Energy is what allows matter to move, heat up, give off light or change shape. You could say that matter is the universe, while energy is what makes it tick! Matter exists in *three states*, or types, which you are probably familiar with.



**State #1: Gas** – *Gases* are fluids, like liquids. In a fluid, particles are free to move around. They take on the shape of the container that holds them. However, gases are much less dense (lighter) than liquids; the forces between the particles are not strong enough to hold them close together. Oxygen, carbon dioxide, hydrogen, helium and nitrogen are all gases when they are at room temperature. Air is actually a mix of many different gases.



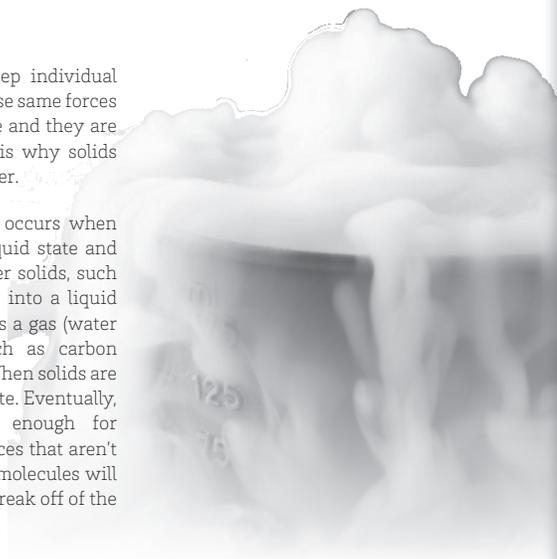
**State #2: Liquid** – *Liquids* are similar to gases, but they are denser (heavier). Common examples of liquids include water and oil. Other common liquids, such as fruit juices and milk, are actually mostly water. Molecules in liquid are more strongly attracted to each other than they are in gas. For this reason, they remain closer together and are therefore *denser*.



**State #3: Solid** – Solids are made up of molecules that do not move around freely and are tightly connected to each other. Common examples are frozen water, metal, and wood. The solid state is generally the densest of the

three states; molecular forces keep individual molecules very close together. These same forces keep individual molecules in place and they are not free to move around, which is why solids hold their shape without a container.

**Sublimation** – *Sublimation* occurs when a solid (i.e., ice) skips over the liquid state and becomes a gas. This is unlike other solids, such as frozen water, which first melt into a liquid and then as it gets hotter becomes a gas (water vapor). Only rare materials such as carbon dioxide experience sublimation. When solids are heated, individual molecules vibrate. Eventually, the vibration becomes strong enough for molecules to break off. In substances that aren't held together strongly, individual molecules will freely float away as soon as they break off of the solid, forming a gas.



### How The Experiment Works -



Carbon dioxide is a chemical that is made out of oxygen (an element that we need to breathe in to survive) and carbon (which is what diamonds are made out of!). Carbon dioxide molecules are held together very loosely; so loosely, in fact, that they can only remain together at extremely low temperatures,  $-109^{\circ}$  Fahrenheit. (That's 109 degrees below zero!) When their temperature rises above  $-109^{\circ}$  Fahrenheit, the particles break off, and it becomes a gas. Dry ice is the term for frozen carbon dioxide, which is held at temperatures lower than  $-109$  degrees. Today, we will witness the sublimation of dry ice into carbon dioxide gas, and interesting things will happen!

The oxygen gas that we breathe is made up of only oxygen atoms (O), formed into diatomic (2-atom) molecules ( $O_2$ ). A substance which is composed of only one type of atom is called an element. Other examples of diatomic elements are hydrogen ( $H_2$ ), nitrogen ( $N_2$ ), and chlorine ( $Cl_2$ ). When a molecule has different atoms, it is called a compound. Water ( $H_2O$ ) is a compound, made of hydrogen (H) and oxygen (O) atoms.

By contrast, the freezing point of water is  $32^{\circ}F$ .

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Experiment 6

## 6. Dry Ice

A<sup>a</sup>

## Science Words

e matterd energyf states of mattera gash liquidi solidj fluidg denseb oxygenb carbon dioxideb hydrogenb heliumb nitrogenc sublimation

A. lightest state

B. a gas

C. going from solid to gas

D. makes things act or move

E. substances

F. gas, liquid, solid

G. heavy

H. like water

I. like ice

J. doesn't hold shape

## Lesson Review Questions

1. Name 3 solids, 3 liquids and 3 gases. Do you know one substance that could be all 3?

3 solids: ice, metal, wood. 3 liquids: water, hydrogen peroxide, alcohol.

3 gases: helium, oxygen, carbon dioxide. Water can be all 3: ice, water, and vapor. (Sample)

2. What is **sublimation**? What can cause sublimation?

Sublimation is a solid that "melts" directly into a gas. This happens to dry ice when it rises above its freezing point (-109°).

3. What state is skipped when the **dry ice** is warmed up? What does it become?

Dry ice becomes a gas and skips the liquid state.

4. Why do you think it's called "dry ice"?

Typical ice will get wet as it melts into a liquid, but dry ice remains dry!

Whatever melts becomes a gas and floats away.