Ghost coin

Overview: This spooky idea takes almost no time, requires a dime and a bottle, and has the potential for creating quite a stir in your next magic show. The idea is basically this: when you place a coin on a bottle, it starts dancing around. But there's more to this trick than meets the scientist's eye.

What to Learn: Heat energy is carried through different substances and affects the properties of different types of matter

Materials

- Coin
- Freezer
- Plastic bottle (not glass)

Lab Time

1. Remove the cap of an empty plastic water or soda bottle and replace it with a dime.
2. Stick the whole thing upright in the freezer overnight. Make sure your group's bottle is labeled! First thing in the morning, take it out and set it on the table. What happens?
3. Record all observations in the worksheet.

Ghost Coin Observations

Draw a picture of the water molecules inside of the water bottle when this experiment begins.

Now draw a picture of what they look like in the morning. What happened?

Reading

Matter has a tendency to hang out in fairly stable states under normal temperatures. There are three common states of matter; solid, liquid, and gas. There is another state of matter called plasma, but it is not common on Earth. Plasma is a highly energized gas. It is used in fluorescent lights. I'm going to assume you know a bit about solids, liquids and gases so I won't go into much detail about them here (see Unit 3 and 8 for more information).

What I do want to talk about is what happens as temperatures change in a substance. Let's take one of the neatest substances on the Earth, water. Water is quite special since it can be in its solid, liquid and gas state at relatively "normal" temperatures. It's quite special for a variety of other reasons, too, but we'll leave it at that for now.

Pretend we have an ice cube on a frying pan (poor ice cube). Right now the water is in a solid state. It's holding its shape. The molecules in the water are held together by strong, stiff bonds. These bonds hold the water molecules in a tight, very specific pattern called a matrix.

This matrix holds the water molecules in a crystalline pattern and the solid water holds its shape. Now, let's turn on the heat. The heat is transferred from the stove to the frying pan to the ice cube. (We'll talk about heat transfer a bit later.)

As the ice cube absorbs the heat, the molecules begin to vibrate faster (the temperature is increasing). When the molecules vibrate at a certain speed (gain enough thermal energy) they stretch those strong, stiff bonds enough that the bonds become more like rubber bands or springs. When the bonds loosen up, the water loosens up and becomes liquid. There are still bonds between the molecules, but they are a bit loose, allowing the molecules to move and flow around each other.

The act of changing from a solid to a liquid is called melting. The temperature at which a substance changes from a solid to a liquid is called its melting point. For water, that point is 32° F or 0° C. Now we will watch carefully as our ice cube continues to melt (little is more exciting than watching an ice cube melt – golf, maybe). A bit after we see our ice cube go from solid to completely liquid, we notice bubbling. What's going on now? If we were able to see the molecules of water at this point we'd be quite amazed at the fantastic scene before us.

At 212° F or 100° C water goes from a liquid state to a gaseous state. This means that the loosey goosey bonds that connected the molecules before have been stretched as far as they go, can't hold on any longer and "POW!" they snap. Those water molecules no longer have any bonds and are free to roam aimlessly around the room. Gas molecules move at very quick speeds as they bounce, jiggle, crash and zip around any container they are in. The act of changing from a liquid to a gas is called evaporation or boiling, and the temperature at which a substance changes from a liquid to a gas is called its boiling point.

I don't know about you, but I think it's getting a bit hot in here. Let's turn the heat down a bit and see what happens. If our gaseous water molecules get close to something cool, they will combine and turn from gaseous to liquid state. This is what happens to your bathroom mirror during a shower or bath. The gaseous water molecules that are having fun bouncing and jiggling around the bathroom get close to the mirror. The mirror is colder than the air. As the gas molecules get close, they slow down due to loss of temperature. If they slow enough, they form loosey goosey bonds with other gas molecules and change from gas to liquid state.

The act of changing from gas to liquid is called condensation. The temperature at which molecules change from a gas to a liquid is called the condensation point. Clouds are made of hundreds of billions of tiny little droplets of liquid water that have condensed onto particles of some sort of dust. Now let's turn the heat down a bit more and see what happens. As the temperature drops and the molecules continue to slow, the bonds between the molecules can pull them together tighter and tighter. Eventually the molecules will fall into a matrix, a pattern, and stick

together quite tightly. This would be the solid state. The act of changing from a liquid to a solid is called freezing, and the temperature at which it changes is called (say it with me now) freezing point.

Think about this for a second – is the freezing point and melting point of an object at the same temperature? Does something go from solid to liquid or from liquid to solid at the same temperature? If you said yes, you're right! The freezing point of water and the melting point of water are both 32° F or 0° C. The temperature is the same. It just depends on whether it is getting hotter or colder as to whether the water is freezing or melting. The boiling and condensation point is also the same point. Now I'm going to mess things up a little bit. Substances can change state at temperatures other than their different freezing or boiling points. Many liquids change from liquid to gas and from gas to liquid relatively easily at room temperatures. And, believe it or not, solids can change to liquids and even gases and vice versa at temperatures other than the usual melting, freezing, or boiling points. So what's the point of the points?

At a substance's boiling, freezing, etc, points, all of the substance must change to the next state. The condition of the bonds cannot remain the same at that temperature. For example, at 100° C water must change from a liquid to a gas. That is the speed limit of liquid water molecules. At 100° C the liquid bonds can no longer hold on and all the molecules convert to gas.

Exercises Answer the questions below:

1. When a gas turns into a liquid, this is called:
    a. Convection
    b. Conduction
    c. Absorption
    d. Condensation
2. When water boils, what happens to the bonds between its molecules?

3. What is the best way to describe how the bonds between water molecules behave when in a liquid state?
    a. Solid bridges
    b. Rubber bands
    c. No bonds
    d. Brittle like chalk
4. The crystalline shape of a solid is referred to as:
    a. a matrix
    b. a vortex
    c. a crystal
    d. a cube

Answers to Exercises: Ghost Coin

1. When a gas turns into a liquid, this is called: (condensation)
2. When water boils, what happens to the bonds between its molecules? (They snap or break.)
3. What is the best way to describe how the bonds between water molecules behave when in a liquid state? (rubber bands or elastic)
4. The crystalline shape of a solid is referred to as: (a matrix)