STATES OF MATTER

OVERVIEW: This presentation consists of 5 activities. Students interact with the presenter and classmates as they cite everyday examples of states of matter and changes of states.

OBJECTIVE: To show the change of states of matter and the reasons for those changes (i.e. energy has been added or taken away).

GRADE LEVEL: 3-7

OHIO STANDARDS: PS 3-2, PS6-2, PS7-1

Physical Science Grade 3: Matter exists in different states, each of which has different properties.

Physical Science Grade 6: Change of state is explained by a model of matter composed of atoms and/or molecules that are in motion.

Physical Science Grade 7: The properties of matter are determined by the arrangement of atoms.

TIME: 30-40 minutes

VOCABULARY: Sublimation, Evaporation, Boil, Condensation, Freeze, Energy

MATERIALS: (Per Class of Students)

- 1 hot plate
- 1 flask with tube to direct steam flow
- 2 ring stands
- 1 ring clamp
- 2 beakers
- 2 bimetal thermometers
- 2 clamps to hold thermometers
- 1 paper towel for wet bulb
- Dry ice
- Ice
- Salt (for related activity)

DEVELOPED BY:

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FORT AMANDA SPECIALTIES

ASHLAND

IMPORTANT:

Read all instructions

before proceeding

PROCEDURE:

Have students identify the states of matter, characteristics and examples of each.

SOLID: definite shape, definite volume

LIQUID: no definite shape, definite volume

GAS: no definite shape, no definite volume

Write these on a blackboard and draw arrows between the states of matter to illustrate the changes of state. Students then identify the processes of each change of state (i.e. freezing, boiling or evaporation, condensation, etc.) and whether the change required energy to be input or released. Students are also encouraged to give common examples of each (weather related examples are popular).

ACTIVITY 1: MELTING

1. Take vegetable shortening. Ask the students what it is. (Cooking ideas).

2. If I put this in a pan and put it on this burner, what will happen? Adding energy (heat) to change from a solid to a liquid. Solid: definite shape, definite volume; Liquid: no definite shape, definite volume. Show kids.

3. Place pan in the cooler of dry ice for later (freezing).

4. Point out the melting ice in the beaker that will be used for condensation. What temperature does water ice melt? (32°F or 0° C).

5. Take a piece of dry ice (wearing gloves because temperature is -110°F) and water ice and place on opposite sides of a piece of construction paper. Let it sit for awhile and tell the students we'll come back to it later (and also find out more about dry ice).

ACTIVITY 2A: BOILING

1. Go to the beaker that is boiling. What is the liquid on the bottom? (water) What else do you see? (steam) How can you tell that it is boiling? (You can see the bubbles.) What temperature does water boil? (212°F or 100°C)

2. What is coming out of the tube? Real steam is colorless (invisible). What you see is tiny drops of condensed liquid water. Just like the clouds: the wind keeps these tiny droplets up in the air and you see clouds.

3. Boiling: Changing from a liquid to a gas quickly. Energy (heat) added.

ACTIVITY 2B: EVAPORATION

1. Ask for two volunteers.

2. Put alcohol on a cotton ball. Wipe the back of one hand of each volunteer. Have them wave their hands rapidly, as if you are trying to fly. How does this hand feel compared t o your other hand. (should feel colder) Why? Alcohol evaporates and pulls heat out of your body.

3. Evaporation turns liquid into a gas (vapor) more slowly and requires less heat. Energy (heat) added.

4. What else uses evaporation to cool things? Your body sweating, water puddles disappearing.

ACTIVITY 3: CONDENSATION:

Put rubber stopper in opening of beaker, causing steam to exit through tubing. Pass the tube from the boiling water over the beaker of ice water. What happens? Wipe the fog off of the beaker and put it back in front of the steam. Show the class how quickly it fogs again. The fog is steam condensing on the cold surface. What you are seeing is actually tiny droplets of condensed water. Energy (heat) is removed from the steam.

ACTIVITY 4A: SUBLIMATION:

1. Can I go directly from a solid to a gas without being a liquid first? Get a piece of dry ice from the cooler and hold it up. At this pressure, carbon dioxide is either a solid or a gas. It will take higher pressure (5.2 atmospheres) to have carbon dioxide as a liquid. You'd have to be way under the ocean to have enough pressure.

2. Place a piece of dry ice in a 35 mm film canister and set aside. (Be careful of where the canister is aimed.) Ask the students what happened when the top pops off.

3. Show how the dry ice "steams." The steam is actually tiny droplets of water that have condensed out of the air due to the closeness of the very cold (-110 f) dry ice. Gas is invisible. Like your breath in the cold weather, you are seeing liquid, not a gas. Blow the "snow" off of the dry ice. "Snow" is moisture from the air freezing. Explain the need to handle such a cold object carefully. Explain that frostbite comes from a change of state of the body (freezing a part of the body, which is made primarily of water).

4. Take the construction paper with the water ice and dry ice on it. Lift it high and ask what they see. (The water ice should be wet; the dry ice should be dry.)

5. Place a piece of dry ice in a balloon (or a long necked flask) and tie it shut. Why does the balloon grow?

6. Place the dry ice in a beaker of room temperature water. Carry it around and let the cloud go over their hands. The vapor should be cool. Energy (heat) is added. Where did the energy come from? Eventually sublimation will stop because the piece is completely coated with ice.

7. What will happen if I put dry ice in hotter water? Will it sublime faster or slower? (Faster) Remove the boiling water from its heat source and drop a piece of dry ice into the hot water. Have all the students feel the moisture (cloud) now. Does it feel cool or hot? Should feel hot. It is the water being carried up by the vigorous rubbing of their hands.

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7. What will happen if I put dry ice in hotter water? Will it sublime faster or slower? (Faster) Remove the boiling water from its heat source and drop a piece of dry ice into the hot water. Have all the students feel the moisture (cloud) now. Does it feel cool or hot? Should feel hot. It is the water being carried up by the vigorous bubbling that you see, not the gas. The room temperature beaker's mist is cool water: the flask's "steam" is hot water.

8. What are some uses for dry ice? Preserving food in storage without everything getting wet, concerts, mad scientist potions, plants inhale it, pop carbonation.

ACTIVITY 4B: DESUBLIMATION:

1. Going from a gas to a solid. We do not have the equipment to do this. Energy is taken AWAY.

ACTIVITY 5: FREEZING:

1. Take the pan of shortening out of the cooler. Ask the students what happened. Where else do we see freezing? (Ice cubes, water on a pond.) What temperature does water freeze? (32F or 0C). What did we say was the melting point of water ice? It was the same. The freezing (or melting) point is the temperature at which a substance's solid and liquid forms can co-exist indefinitely. Impurities lower freezing points. (That's why we add salt when we have ice on the roads.)

2. Take out the large beaker of dry ice and water ice. What happened? Can we still see the dry ice subliming? If the liquid water is still present in the beaker, the water will be 32F. It will still be safe to place your hand in it. Energy is taken away.

REVIEW:

Review the names of the states of matter and the changes to transfer between them. Which changes require energy (as heat) to be added? Which changes require energy (as heat) to be taken away?

FOURTH STATE OF MATTER: PLASMA

On earth, plasma occurs near electrical discharges, such as lightning, in fluorescent tubes and in electric arcs. Solar winds, driven from the surface of the sun are hydrogen plasma. When they reach the earth they are confined within the bands known as the VanAllen Radiation belts. At high latitudes, where these belts approach the upper atmosphere, they give rise to the Aurora (Aurora Borealis - northern lights). The sun and other stars are dense, highly ionized plasmas. The vast space between the stars if filled with tenuous, weakly ionized plasma (interstellar matter). Thus most of the universe exists in plasma form. Scientists are experimenting with plasma for controlled nuclear fusion and for plasma thrusters for propulsion in space. (less mass needed than a chemical rocket).

CONCLUSIONS: Relate the changes in states of matter to energy input or output. You might pose questions like: Why does ice cream melt when you leave it on the table? (Energy input)

OTHER DRY ICE ACTIVITIES (IF TIME PERMITS):

1. Place the hammer on a piece of dry ice. It should bounce up & down, due to the subliming of gas.

2. Pick up a chunk of dry ice with a pair of tongs. Listen to the "scream" and explain that it is actually a series of very fast clicks. As the "hot" room temperature tongs touch the dry ice, it sublimes. The gas formed forces the tongs away from the solid, but the force of your grip bring the tongs and ice back into contact. The "scream" is the carbon dioxide gas escaping in the narrow gap between the tongs and the dry ice; a sound similar to when you pinch the neck of a balloon. The process is repeated many times per second yielding the "scream." Note the frost that forms on the tongs as they cool from contact with the dry ice. The frost comes from the water vapor in the air that condenses on the cold tongs and then freezes immediately.

3. Why does dry ice slide (float) on the tabletop? Rides on a jet of gas from its surface as it sublimes.

4. Make a pocket change band. First, take a quarter and press it into a large chunk of dry ice with a flat top, making a notch in the ice. The "hot" quarter drills into the ice by subliming it. Let students feel how cold the quarter got in a short time. Warm the quarter in your hands (or get another quarter) and place it in the drilled groove. It flip-flops and dings while it stays warm for the same reason the tongs "screamed". Repeat the process with other coins and make a band. Each denomination of coin has its own sound.

5. Set up a dry/wet bulb thermometer. Check the temperatures before starting. Put wet towels (from the room temperature beaker water) over one thermometer and put the pan over them. Have students look at the temperature again. Why is the one with wet towels cooler? (evaporation draws heat away - heat added).

6. Does all gas weigh the same? Blow up a balloon. Take the balloon with dry ice in it. Ask: Will they both hit the floor at the same time? Will both go up in the air? What's in air? (78% nitrogen, 21% oxygen, <0.03% carbon dioxide, other inert & trace gases). Breath has carbon dioxide, nitrogen, inert gases. Carbon dioxide is heavier than air. It will sink to the floor or to the bottom of a container.

7. Put a series of lighted candles set on steps in an aquarium or large jar. Place a piece of dry ice in the bottom of the container. As the dry ice sublimes, the carbon dioxide fills the container from the bottom up; each candle will have its turn being extinguished.

8. Take a beaker of water (500ml) and add 3-5ml of ammonia solution to ensure that it is basic. Add 5ml of indicator (Yamada's universal or phenolphthalein). Have the students notice the color. Add pieces of dry ice. Ask the students to observe any changes taking place in the solutions. Explain why the colors are changing and how the color relates to the pH or the solution (acidic or basic). Add base (ammonia solution) back to the acidic solution. Vinegar may be added to return the solution to acidic.

Explanation: An acid-base indicator is a molecule that changes color as it gains a proton (as a solution becomes more acidic) or loses a proton (as a solution becomes more basic). Acidic solutions have pH values below 7, basic solutions have pH values above 7, and neutral solutions have a pH of 7. The initial indicator colors are that of a basic solution. When carbon dioxide dissolves in water, it makes the solution acidic. The acidity of carbon dioxide first neutralizes the basic solution, and then the excess carbon dioxide causes the solution to become acidic, resulting in a color change.