

Ages:

10 to 13

States of Matter - Making Edible Glass

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Main idea: What are the different states of matter? What is the difference between solids, liquids, and gasses? By working with common kitchen equipment to make hard candy, the States of Matter activity explores the transitions between different states of matter.

Objectives: Students will learn:

- q The properties of materials from a molecular point of view while at the same time cooking up some tasty candy.
- q That everything around us is made of atoms and molecules.
- q That the arrangement and interaction of these atoms lead to properties of matter that we commonly observe.

Materials:

- q Cooking or camp stove (preferably natural gas)

- q Cooking pot with lid
- q Candy thermometer
- q Oven mitts or hot pad
- q Plate
- q Wooden spoon
- q Drinking glass
- q Cookie sheet covered with oil
- q Toothpicks
- q Candy ingredients:
 - o $\frac{1}{2}$ cup water
 - o 2 cups sugar
 - o $\frac{3}{4}$ cup light corn syrup
 - o 1 tablespoon unsalted butter
 - o food coloring
 - o flavoring

Motivator: How do you think lollipops are made? What are the starting ingredients? What happens to these ingredients to make them into candy? Lets try making lollipops, and in the process find out what is happening to the ingredients that makes them change from a liquid to a solid.

Questions: Before you start the activity, ask the kids:

- q What does it take to get a solid to change to a liquid?
 - o Solids change to liquids when they are heated. This process is called melting. Each material has a different temperature at which it melts. For instance, water melts at 0°C.

- q Why are water and liquids runny, while ice is hard?
 - o The molecules in solids are bound closely together. If one molecule tries to move, all its neighbors exert a strong force to prevent it from moving. The strong bonding makes solids stiff and rigid. On the other hand, molecules in a liquid are only loosely bound to each other. They can move easily closer and further apart with little interaction. As a result, liquids have no definite shape.

- q What do you think will happen to sugar-water when it is heated?
 - o Sugar undergoes many chemical reactions as it is heated, which makes the liquid viscous and thick, and also changes its color. In the chemical reaction, sugar molecules join together to form longer and longer chains. These long chains of molecules become entangled, making the liquid viscous.

- q What do you think will happen to the temperature of the sugar-water when it is heated? Will it go up constantly, or in steps?
 - o The temperature will go up in steps as each different chemical reaction occurs. Once the solution reaches a critical temperature for one type of reaction, all the sugar in the mixture must fully react before the temperature will further increase up to the next reaction temperature.

Activity:

Use extreme caution! Syrup is very hot and can burn your skin easily.

1. Mix water, sugar and corn syrup (amounts above) in the pot until the sugar dissolves.
2. Place over heat and monitor temperature without stirring.

3. When the mixture comes to a boil, cover and cook for 3 minutes.
4. Remove pot from the heat and record the temperature.

Be careful. The syrup is very, very hot!

5. Spoon a few drops of syrup onto the plate. What happens? _____
6. Spoon a few drops into the glass of water. What happens? _____
7. Return the liquid to the heat and test it as you did in steps 4, 5 and 6 at the following temperatures. Record your results:

q 112 C – Plate: _____ Glass: _____

q 118 C – Plate: _____ Glass: _____

q 121 C – Plate: _____ Glass: _____

q 132 C – Plate: _____ Glass: _____

8. When the temperature reaches 149 C, stir in the remaining ingredients.
9. Place toothpicks on oiled cookie sheet and pour a small amount of syrup around the end of each.
10. Remove lollipops from sheet after they cool and harden.

Learning checks: Ask the kids:

q What happened to the sugar-water mixture as it was heated?

- The temperature rises; the mixture became more viscous, and eventually begins to

change to a light brown color.

q What properties did it have initially?

- The liquid is clear and looks just like water.

q Did these properties change as the syrup was heated?

- Yes. When the heated mixture is put in drops on a paper plate, it is first thick and sticky, then as it is further heated the drops become hard.

q Did the syrup change states of matter at any time during the activity?

- Yes. When the heated mixture cooled, the syrup changed from a liquid to a solid.

q What do you think happened to the syrup when it was heated?

- A chemical reaction occurred so that the sugar molecules linked up, forming longer and longer molecules. These longer molecules become entangled and stiff, turning the material into a solid.

q Review your data from the table to answer the questions.

Background:

All matter is made up of molecules – millions and millions of them smaller than the eye can see. It is molecules and their interactions with each other that give materials different properties.

In solids, molecules are packed closely and are bonded strongly to each other. The strong bonding and tight packing make solids dense and rigid.

Liquids, on the other hand, have somewhat weaker interactions. The molecules can tumble and move about freely, but still can't move apart from each other. As a result, liquids flow freely. They don't have any rigid shape like solids do.

Last, gasses have molecules, which are far apart. They barely even notice each other. The molecules fly about occasionally running into each other or the walls. Because there is so much space in between the molecules, gasses can be compressed easily, fill up the volume of the containers they occupy.

Sugar is made up of simple molecules. But as the sugars are heated, they react to form longer and longer chains. These chains become entangled, and as the liquid is cooled they become harder and harder to disentangle, leading to stiffer materials. The formation of these chains is called polymerization.

Vocabulary:

Matter: Something that has weight and occupies space. Matter can exist as a solid, liquid, or gas.

Solid: State of matter that has definite shape and volume. Molecules in solids are bound closely together, and interact strongly. If single molecule moves, it feels a strong force from its neighbors pulling it back.

Liquid: State of matter that flows. A state of matter with a definite volume but which takes the shape of its container. Molecules are weakly bonded together. They can tumble and turn, but still don't move apart from each other.

Gas: A state of matter that disperses easily, and which can expand and contract with changes in temperature and pressure. In a gas, molecules are far apart, and interact very little.

Melt: Matter changes from solid to liquid.

Freeze: Matter changes liquid to solid.

Boil: Matter changes liquid to gas.

Condense: Matter changes gas to liquid.

Polymerization: The formation of long chains made up of smaller molecules.

Extensions:

Group activities can be done to explain basic concepts of polymerization. These activities help students to visualize what is happening to sugar molecules during the heating:

One simple activity is to have 15 to 20 children stand close together, linking arms with a single partner. Then ask them to disentangle the group, moving apart until each pair is standing alone. Repeat the same activity, except next choose groups of 4 or 5 to link arms. Choose groups after everyone is standing close together, and make sure to choose partners so that the groups are well tangled. Ask the groups to disentangle. The longer the chains, the harder it is to disentangle the groups.

The candy-making activity can be made more quantitative for older students if graph paper and clocks are provided. Students can record temperatures at specific intervals (3 to 5 minutes) and make graphs of temperature vs. time. The temperature should increase through a series of plateaus, the most prominent at 100°C when the water boils off, as the sugar mixture undergoes numerous reactions.