

States of Matter

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This lecture should be given after the lectures on Speed, Table of Elements, Heat, and Orbitals and Bonds

Materials (See picture below):

White board or other writing surface

2 Thermoses or other insulated containers.

Small metal object that can fit into the thermos of hot water (e.g. an allen key)

Molecular modeling kit (e.g. The Allyn and Bacon Molecular Model Set for Organic Chemistry)

Examples of solid (e.g. small rock, salt) and liquid (e.g. water, juice)

Small plastic bag/baggie without a ziplock

Rigid tube, roughly 6 inches long with an opening that a small balloon can be fastened to

Small balloon whose open end can fit tightly around the rigid tube

Glass or cup, 6 inches in height that can fit the plastic tube



Preparation before the lesson:

Just before traveling to the class, put hot water in a thermos- **Use caution when this thermos is open.** Also put ice in another thermos or insulated container that will prevent it from melting before arriving in the classroom. Finally, place a balloon over the end of a cylindrical tube and confirm that the balloon partially inflates when the open end of the tube is lowered into a container of water.

Key Words for use by students in discussion:

Matter, solid, liquid, gas

- 1) Refer to the Neutelpro trading card and lead students to recall that the universe is made of atoms (protons and neutrons in nucleus and electrons spinning around them) found in the Table of Elements. Review the structure of Carbon on the board (6 electrons spinning around a nucleus with 6 protons and 6 neutrons).
- 2) Refer to the Peewee trading card and lead students to recall that atoms can stick together by forming bonds by sharing electrons. As an example review a water molecule= H_2O = 2 hydrogens and 1 oxygen. Discuss the atoms and bonds that the model represents. Ask the students, “what is formed when a trillion trillion molecules or atoms come together?” Conclude that “matter” is formed.
- 3) Tell the students, “Let’s use models to imagine what might be happening in matter made up of water molecules.” Using the modeling material, have the students make a number of water molecules. Have some students come together to hold the water molecules in a bunch. Refer to the Pegaspeed trading card and ask these students to show you the different ways that the water molecules can exist as matter. Guide them to show you matter with the atoms moving at a very low speed, medium speed, or very fast speed.

- 4) Instruct the students to hold the water molecules tightly packed on a surface (e.g. a desk or the floor). Have them barely move the water molecules and indicate that this is one way for water matter to exist. Then “heat” the water molecules and instruct the students to move the molecules around a little more, forming a flat puddle of liquid water on the ground or table, and note that this is a different type of water matter. Now add a lot more heat and have the students move the water molecules all over the room and indicate that here is yet another way that water molecules can exist to form matter. Conclude that there appears to be 3 ways that water molecules exist. Try to reach consensus on this with the young scientists and write on the board, “Three States of Matter.”
- 5) Show the students a small piece of ice and tell them to comment on the shape. Put the ice in a baggie and ask whether the shape has changed. When it is agreed that the shape has not changed in the container (baggie), discuss how the water molecules are moving inside the ice. Illustrate the choices using the water molecule models and conclude they are tightly packed and move very little. Call this matter solid and note on the board, “1) Solid keeps its shape.”
- 6) Add heat to the water molecules in the ice by having a student hold the baggie tightly in the hand for about 30 seconds. Lead the students to conclude that the solid is turning into a liquid. Ask the students, “how do you know it is a different state of matter called liquid?” Put some of the liquid on a flat surface and lead the class to conclude that it formed a puddle. Discuss how the water molecules are moving inside liquid water; illustrate the choices with the water molecule models and conclude they move more than in a solid but are still loosely associated. Note this second type of matter on the board; “2) Liquid forms puddles”.
- 7) Heat the metal rod in the hot water contained within the thermos. Take the metal out of the water, shake it off, and have a few students at a time note the tiny drops of liquid still on the metal, that eventually disappear. Discuss the location of the water molecules after leaving the metal rod. Mention the Heanug and Pegaspeed trading cards and conclude that their speed increased and they began to fly around the room. Ask the students if the water gas is forming a triangle or circle in the room, concluding that they are going all over the room and taking the shape of the room. Write on the board, “3) Gas takes the shape of its container.” Lead select students to demonstrate the heat induced liquid to gas transition, noting the relative speed of the water molecules, the state of the matter and the shape of the matter formed.
- 8) Ask the students if the water molecules changed when solid changed to liquid, or liquid changed to gas. Did the protons and electrons in the oxygen and hydrogens change? After discussion, note that it is not the atoms that change but the state of the matter that they form and we sense.
- 9) Note that we can easily see the solid and liquid states of matter, but it is difficult to really know if a gas really exists using our eyes or hands alone. Ask the students if they believe that there is a gas all around us right now called air. Ask the students why a scientist goes to school for 5-7 years more after earning a 4 year college bachelors degree, leading them to the conclusion that a scientist needs to learn how to prove hypotheses are correct or incorrect. Discuss how the students could prove that a gas exists or does not exist around them.
- 10) Remove the air from an open bag/baggie and pass it around for the students to squeeze, and ask them if there is anything in the baggie until they agree there is nothing. Open the baggie, scoop up some air and seal the baggie by twisting the open end. Show the baggie around the class and discuss that although they do not see anything in the baggie, there is obviously something in the baggie because it is hard to squeeze, compared to when it was empty. Ask the students the shape of the air in the baggie, until it is agreed that the gas has taken the shape of its container, the baggie. Have select students prove that a gas exists in the room using a baggie.
- 11) Utilize a cylindrical tube about 6 inches long, with a balloon attached to one end. Ask the students if there is anything inside the tube, and conclude that a gas called air is in the tube. Discuss how the class could go about proving it with the tube and attached balloon, and a glass of water about 6 inches tall. Have selected students try to prove that air exists with this equipment. Guide the students when necessary to show the class that nothing is in the tube that can be seen. But when the open end of the tube is fully submerged into the container of water the air is pushed up and forces the balloon to partially inflate. As another alternative method, the attached balloon may be partly inserted into the tube so that it is pushed out when the open end is lowered into the water. Have select students prove that a gas is in the tube. Discuss the shape of the gas in the tube.
- 12) Ask the students if these two experiments “prove” that there is matter in the room and tube even though we cannot see it, taking a vote to see if there is general agreement.
- 13) Show the students different examples of matter and have them indicate which type of matter it is and why, using the notes on the board as a reference. Include salt or another grainy matter and note that even though it might look like it is forming a puddle, if you look at the grains, it is keeping its shape and is therefore a solid.
- 14) Exhale and ask the students if matter came out in your breath, concluding that molecules in the exhaled air formed a gas that took the shape of its container, the room.

States of Matter lesson highlights checklist

- Review the atoms, orbitals, and bonds that make up matter
- Students model water molecules moving at different speeds to conclude that there is 3 types of matter
- Ice = slow moving H₂O molecules = solid = keeps its shape
- Heat ice ⇒ liquid = forms puddles (melt ice in baggie)
- Heat liquid ⇒ gas = takes shape of container (use metal and hot water)
- Water molecules do not change during heating, just the state of matter they form and we sense
- Discuss the reason scientists go to school for so long: learn to prove hypothesis
- Prove a gas (air) is in the room with a baggie, even though we cannot see it
- Prove a gas exists in a hollow tube using a balloon on one end of the tube
- Take a vote to determine if there is general agreement that the 2 experiments/demonstrations have proved a gas exists
- Challenge: Identify the state of matter
- Discuss exhaled air as a gas