The Particle Theory of Matter

Strand Matter

Topic Investigating the particle theory of matter

Primary SOL PS.2 The student will investigate and understand the nature of matter. Key concepts include
a) the particle theory of matter.

Related SOL PS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
b) length, mass, volume, density, temperature, weight, and force are accurately measured;
d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;
j) valid conclusions are made after analyzing data;
m) models and simulations are constructed and used to illustrate and explain phenomena.

PS.2 The student will investigate and understand the nature of matter. Key concepts include
c) solids, liquids, and gases.

Background Information

The particle theory of matter postulates the following:

1. All matter is made up of tiny particles called atoms.
2. Particles of matter are constantly in motion.
3. Particles of matter attract each other.
4. Particles of matter have spaces between them.
5. As temperature increases, particles of matter move faster.
6. Atoms of the same element are essentially identical.
7. Atoms of different elements are different.

Materials

- Beaker
- Food coloring
- Paper
- Cotton balls or small circles of paper
- Glue or tape
- Two 50-ml graduated cylinders
- Two 100-ml graduated cylinders
- Water
- Sand
- Isopropyl alcohol

Vocabulary

atom, gas, kinetic energy, liquid, particle theory, solid

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

In this lesson, demonstrations and activities will be used to illustrate key points of the particle theory of matter.

Demonstration 1: Particles of matter are constantly in motion

1. Place one drop of food coloring in a beaker with water. Place a white piece of paper behind the beaker so that students can easily see the color.
2. Lead a discussion of what is occurring in the beaker. Students will generally say that the food color is spreading in the water. Point out that the water is not being stirred, and ask students why the food coloring is spreading. Lead students to conclude that the molecules must be moving in order for the color to be spreading.
3. Extend the discussion to gas particles by asking students whether they have ever smelled food being cooked in the kitchen in another part of their house. Ask them how they think the smell spreads throughout the house. Again relate this back to the concept that the air particles are constantly moving. Have the students consider the ways those molecules move.
4. Ask the students to draw a diagram or picture of the molecules for both situations.

Activity 1: Particles of matter attract each other

1. Inform students that in this activity, they will examine the molecular arrangement of particles in the different phases of matter. They will observe that the level of attraction between particles changes for each phase of matter.
2. Give each student three sheets of paper, and have students draw a beaker shape on each sheet. (Display a real beaker for them to draw.)
3. Ask students to imagine putting a solid object, such as a wooden block, inside the first beaker they drew. Then, tell them to use cotton balls or small circles of paper to represent the molecules in the solid object and to arrange them inside the beaker. Students may need to draw the outline of the object first and then fill it with the molecules.
4. Walk around the classroom and check students' diagrams. Provide feedback so that they can correct mistakes. Once their diagrams are correct, tell them to glue or tape their molecules to the paper.
5. Ask students to imagine filling the second beaker with a liquid such as water. Tell them to arrange the liquid's molecules inside the beaker. Once the diagram is checked and corrected, have students glue or tape their molecules to the paper.
6. Finally, ask students to imagine filling the third beaker with a gas such as air. Tell them to arrange the air's "molecules" inside the beaker. Once the diagram is checked and corrected, have students glue or tape their molecules to the paper.

Demonstration 2: Particles of matter have spaces between them

1. Sand and Water Demonstration: Fill one graduated cylinder with 50 ml of sand and another graduated cylinder with 50 ml of water. Pour 50 ml of water into the graduated cylinder filled with 50 ml of sand and ask students why the resulting volume does not equal 100 ml. Be sure to point out the air bubbles that rise to the surface.
2. Alcohol and Water Demonstration: Pour 50 ml of water in one graduated cylinder and 40 ml of isopropyl alcohol in another graduated cylinder. Pour the alcohol into the water and have a student read the resulting volume. The level of the solution should reach approximately 88 ml. Students are often surprised in this result because they assume since both materials are liquids and have similar properties, they will add up to equal 90 ml. Facilitate a discussion that leads students to understand that the particles of water and alcohol fit in between each other and reduce the total volume.

Activity 2: As temperature increases, particles of matter move faster

1. Have students use the drawings they created in Activity 1 of this lesson. Begin by leading a discussion of what happens when the temperature of a solid object, such as an ice cube, is increased. Students will say that the ice cube melts. Ask students to describe the physical differences between ice and water. Discuss the fact that solids have definite shapes and volumes; whereas, liquids have definite volumes but take the shape of their container. Have students look at their diagrams and point out the fact that there is more space between the particles in liquid than in a solid which allows the particles to move past each other. Also discuss the reason there is space between the particles. As the temperature of the molecules increases, the particles gain kinetic energy. Particles that move faster bang into each other and create more space between them. Extend this discussion to what happens when the temperature of a liquid is increased.
2. After the discussion, have students draw motion lines on their diagrams to represent the kinetic energy of the particles. Give students an example of how to draw motion lines.

   Solid

   Liquid

   Gas

   Walk around the classroom and make sure students are completing their diagrams correctly. Have them correct any mistakes.

Assessment

- **Questions**
  - In the food coloring demonstration, you watched the food coloring spread throughout the water. Why did this happen? What can you infer about the movement of the particles in the solution?

- When arranging the particles in the beaker, what were the differences in the particle arrangement among the solid, liquid, and gas phases of matter?
- Why was the combined volume of the sand and water not equal to 100 ml?
- What was the total measurement of the combination of 50 ml of water and 40 ml of alcohol? Why did the total not measure 90 ml?
- What is the proper order of the three phases of matter an ice cube experiences as it is heated (when its kinetic energy increases)?
- How do you know that there is space between the particles in a liquid?

Extensions and Connections (for all students)

- Discuss the fourth phase of matter, plasma. Put students in groups of two and have them brainstorm possible examples of plasma. Have students share and discuss their examples. Describe why examples are correct or incorrect.
- Have students conduct research to decide which phase of matter is most common on Earth and which is the most common in the universe.

Strategies for Differentiation

- To demonstrate the need for particles to move in order to transfer energy, have a small group of eight students cluster into a circle holding a ball. The ball represents the energy that will be transferred to the outside of the circle. In order for the ball to move from the center of the circle to the outside, the students (as molecules) must move it.
- Have students stand up and create a human model of the particle theory. Tell students that the classroom is one large container. Have students stand up and act like they are molecules. Call out a phase of matter and tell students to orient themselves and move as if they were a molecule in that phase of matter. Point out where "the bottom of the container" is located in the room. When "solid" is called, all students should stand close together at the bottom of the container area and shake or hop in place. For "liquid," students should move a little faster and slide closely past one another. When "gas" is called, students should move quickly and spread throughout the room.
- Have students recreate the models of each state of matter, using different materials. Fill in the boxes below with molecules demonstrating particle arrangement in each phase of matter. Use illustrations, rice, or beans to represent the molecules.

  Solid

  Liquid

  Gas