Teacher-to-Teacher Video Series for Secondary Educators

TITLE: Kinetic Molecular Theory

PRIMARY SUBJECT AREA: Physical Science

GRADE LEVEL: 9-12

OVERVIEW: Students analyze and evaluate evidence that matter is made of tiny particles (atoms and molecules) and then observe a series of phenomena involving solids, liquids and gases to make inferences about the spacing, interactions and relative kinetic energies of particles in each of these different phases.

APPROXIMATE DURATION: four 50-minute class periods

LOUISIANA CONTENT STANDARDS:
http://www/DOE/assessment/standards/SCIENCE/pdf

Science as Inquiry
Benchmarks:
SI-H-A4 Formulating and revising scientific explanations and models using logic and evidence.
SI GLE:
7. Choose appropriate models to explain scientific knowledge or experimental results. (SI-H-A4)

Physical Science
Benchmarks:
PS-H-C3 Understanding that the physical properties of substances reflect the nature of interactions among its particles
PS-H-C7 Using the kinetic molecular theory to describe the behavior of atoms and molecules during phase changes and to describe the behavior of matter in its different phases
PS GLEs:
13. Predict how factors such as particle size and temperature influence the rate of dissolving (PS-H-C3)
20. Predict the particle motion as a substance changes phases (PS-H-C7) (PS-H-C3)

EDUCATIONAL TECHNOLOGY GUIDELINES:
http://www/DOE/LCET/curric/cats.asp.

INTERDISCIPLINARY CONNECTIONS: N/A

OBJECTIVES:

1. The student will give examples of evidence that matter is made of tiny particles (atoms and molecules) that are in constant motion.
2. The student will observe and describe the properties and behaviors of solids, liquids and gases.
3. The student will, from his/her observations, make inferences about the spacing, interaction, and motion of particles in solids, liquids and gases.
4. The student will create diagrams, pictures or other models to represent their ideas about the particle nature of solids, liquids and gases.
5. The student will use the kinetic molecular theory to explain physical phenomena such as phase changes.

LESSON MATERIALS AND RESOURCES:

Materials per set up

Activity 1

For each small group:

30X hand microscope (or strong magnifying lens)
Color picture from newspaper

Activity 2

For each small group:

Inflated balloon containing a few drops of food flavoring extract (vanilla, almond, lemon, root beer, etc.)
Beaker (250 ml or 400 mL)
Graduated cylinder (100 mL)
Sugar (at least 50 mL)
Water

Activity 2

Station 1

60-cc plastic syringe half-filled with sand with tip sealed
60-cc plastic syringe half-filled with water with tip sealed
60-cc plastic syringe half-filled with air with tip sealed

Station 2

3 different solids, same size and shape but different masses (density cubes or cylinders may be used)
balance
metric ruler

Station 3

Copper wire (50 cm)
Meter stick

Station 4

Clear plastic cup or glass beaker
Food coloring in dropper bottle
Large beaker or pitcher of water
Paper towels

Station 5

Solid room deodorizer with open-shut plastic container

Station 6
Large red alcohol thermometer
Beaker of water on hot plate on low setting
Beaker of ice water

TECHNOLOGY TOOLS AND MATERIALS:
N/A

BACKGROUND INFORMATION:
N/A

LESSON PROCEDURES:
PROCEDURE
By the time students enter high school, they have already learned (or "memorized") that matter is composed of tiny particles called atoms and molecules. The teacher introduces the lesson by asking students to provide any evidence they can to support this idea.

Each small group of students is provided a 30X hand microscope or hand lens and a color newspaper picture. The teacher has the students observe the picture with their naked eyes and notice that it appears to be solid, uninterrupted color. Then, the teacher instructs the students to view the picture through the hand lens and to describe their observations. The students discover that the picture actually consists of small colored dots separated by white space. The teacher asks the students to consider the possibility that matter is like the colored picture; while to our eyes it appears to be continuous, if we had a strong enough magnifier we might discover that it is made of discrete particles.

Activity 2
Student activity sheets (Attachment 1) and materials are distributed. Students work in their small groups to complete Part One that involves smelling an inflated balloon containing a few drops of a scented extract. Students discuss how the fact they are able to smell and identify the liquid inside the balloon provides evidence that matter is made of tiny particles.

Students complete Part Two by mixing measured amounts of sugar and water, observing changes in the characteristics of the sugar and/or water (notably the "disappearance" of the sugar and the reduction in volume of the combined sugar and water) and discussing how each of these observations provide evidence that matter is made of tiny particles.

Activity 3
Student groups rotate through a series of six stations, following the instructions printed on a Task Card at each station (see Attachment 2). If the class is large, a double set of stations may be set up. The stations have been carefully designed to allow students to observe various phenomena involving solids, liquids, and/or gases.

Upon completing the instructions at each station, students sketch a “particle picture” on their activity sheet (Attachment 3) representing what they think is happening at the particle level that accounts for their observations.

No prior instruction is given to the students as to how the particles should be represented in their drawings. Thus, the pictures drawn by the students reveal their notions—and often their misconceptions—about the nature and behavior of atoms and molecules. (At Station 6, for example, students may show particles in the expanded colored liquid as getting bigger in size or multiplying in number rather than simply moving farther apart from one another.) Direct students keep their activity sheets for the next part of the activity.

Each group is provided with a sheet of chart or poster paper and several colored markers, and is assigned one of the six stations for which to draw a large “particle picture” to share with the class. The picture should represent the consensus ideas of the group members.

When groups have completed their pictures, each, in turn, shares their picture with the whole class for critique and comment. As each group presents, the teacher asks questions, as necessary, to draw out the group’s ideas about the relative size, spacing, and speed of the particles and the attractive forces between them. At this point, the teacher may find it helpful to have the class agree on certain conventions that they could have used to represent the characteristics of particles in their pictures, such as using circles to represent the particles, drawing larger circles to represent bigger particles, shading the circles darker to represent more massive particles, attaching arrows of varying length to represent the relative speed of the particles, etc. This also provides an opportunity for the teacher to discuss the general importance of conventions in science that allow scientists to communicate universally with understanding.

Activity 4
This is a “paper and pencil” activity and is a direct follow-on to the previous activity. Students, working in their groups, are asked to consider their collective observations from Activity 2 in order to draw conclusions about the characteristics and behaviors of particles in solids, in liquids, and in gases. Students record their ideas in chart form on the activity sheet provided (Attachment 4). Students then share their ideas in a whole class discussion, during which the teacher records the class consensus ideas on a large reproduction of the chart that appears on the student activity sheet. The end result is that the class develops the Kinetic Molecular Theory (although the students may not know it by that name).

The teacher shows, on a previously prepared overhead transparency or chart, the Kinetic Molecular Theory. Students should compare the version they have developed to the one accepted by scientists.
Student groups are given an opportunity to modify or redraw their assigned particle poster from the previous activity in light of the Kinetic Molecular Theory and using the conventions for representing particles that the class has agreed upon.

Activity 5 (Evaluation)
A paper-and-pencil task serves to formatively evaluate students understanding of the Kinetic Molecular Theory and their ability to apply it in a novel situation.

ASSESSMENT PROCEDURES:

Students are assessed through responses to oral teacher questions, through written activity sheets, through group presentations, and through end-of-lesson evaluation activity.

A paper-and-pencil task serves to formatively evaluate students understanding of the Kinetic Molecular Theory and their ability to apply it in a novel situation.

At the end of the lesson, evaluation activity sheets (Attachment 6) are distributed for students to complete individually for a summative evaluation.

ACCOMMODATIONS/MODIFICATIONS:

N/A

REPRODICIBLE MATERIALS:

N/A

EXPLORATION AND EXTENSION:

N/A

LESSON DEVELOPMENT RESOURCES:

http://www.connectedteacher.com/newsletter/citeintres.asp**.**

REFLECTIONS:

N/A

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Attachment 1: Particle Nature of Matter Activity Sheet

Part One

1. Pass the balloon around and let each group member smell it. Can you identify the “mystery substance” inside?

2. How do your observations provide evidence that the “mystery substance” is made of tiny particles that are in constant motion?

3. From your observations, what can you infer about the rubber material of the balloon?

Part Two

1. In a clean and dry graduated cylinder, measure 50 mL of sugar. Transfer the sugar to the beaker.

2. Use the graduated cylinder to measure 50 mL of water. Pour the water into the beaker with the sugar. Stir thoroughly.

3. What changes do you observe in the sugar and/or water?

4. How do your observations provide evidence that matter is composed of discrete particles? What can you infer about the nature of these particles?

Particle Nature of Matter Activity Sheet (Teacher Key)

Part One

1. Pass the balloon around and let each group member smell it. Can you identify the "mystery substance" inside?

Answers vary depending on balloon contents (vanilla, lemon, rootbeer, etc.)

2. How do your observations provide evidence that the "mystery substance" is made of tiny particles that are in constant motion?

Because students were able to "smell" the substance, some of the substance must have entered their nostrils. The portion of the substance entering their nose must have been made of microscopically small (or smaller) particles since they were able to pass through the balloon wall and could not be seen. Also, these particles must have been in motion since they were able to rapidly travel from the balloon to the nose of the observer.

3. From your observations, what can you infer about the rubber material of the balloon?

There must be spaces within the rubber material of the balloon that allowed the particles of the extract to pass through. Thus, the rubber balloon material is NOT continuous and may, perhaps, also be made of tiny particles.

Part Two

1.In a clean and dry graduated cylinder, measure 50 mL of sugar. Transfer the sugar to the beaker.

2. Use the graduated cylinder to measure 50 mL of water. Pour the water into the beaker with the sugar. Stir thoroughly.

3. What changes do you observe in the sugar and/or water?

The sugar "disappears" but is still present as evidenced by the sweet taste of the solution and the fact that the total mass of sugar plus water has not changed.
The combined volume of the sugar plus water is considerably less than the sum of their individual volumes.

4. How do your observations provide evidence that matter is composed of discrete particles? What can you infer about the nature of these particles?

The fact that the combined volume was less than the sum of the individual volumes is evidence that water must be made of tiny particles with spaces between them.

The sugar must have also been made of tiny particles that were able to fit into these spaces and were so small that they could not be seen with the naked eye. The fact that the sugar-water solution was uniformly sweet is evidence that the sugar particles were in motion and able to spread out through the water. Also, it was probably the motion of the water particles bombarding the sugar crystals that broke them apart and allowed them to dissolve and disperse.

Attachment 2: MATTER CIRCUS TASK CARDS

Station 1 Task Card

Syringes

Observe the contents of each syringe. Gently try to depress the plunger on each. For each syringe, draw a before and an after "particle picture" showing your ideas about the particles of matter in the syringe that could account for your observations. Write labels or descriptions to explain your pictures.

Station 2 Task Card

Solids

Observe the different solids. How are they alike? How are they different? Draw a "particle picture" for each solid that could account for the similarities and differences you noted. Write labels or descriptions to explain your pictures.

Station 3 Task Card

Copper Wire

Measure the length of the copper wire. Holding the wire by each end, pull on it really hard. Re-measure its length. From your observations, what can you infer about the copper atoms of which the wire is made? Draw "particle pictures" that represent the copper atoms in the wire before and after you pulled on it.

Station 4 Task Card

Food Coloring and Water
Add a few drops of food coloring to a glass or beaker of clean water. DO NOT STIR. Observe what happens. Draw one "particle picture" showing the particles of food coloring and water immediately after you added the coloring, and another "particle picture" showing them after a couple of minutes. Be sure to clean your station, leaving it as you found it, for the next group.

Station 5 Task Card

Room Deodorizer
Observe the closed deodorizer. What happens when you open the deodorizer? Close the deodorizer again and notice any changes. Draw a "particle picture" that shows the particles in the open deodorizer in a way that accounts for your observations. Leave the deodorizer closed for the next group.

Station 6 Task Card

Thermometer
Place the thermometer in the beaker of ice water, then wait a few moments and notice the level of the red liquid. Place the thermometer in the warm water, then wait a few moments and notice the level of the red liquid. Draw a "particle picture" showing the particles of the red liquid in the thermometer when it is placed in the ice water, and another "particle picture" that shows the particles of the red liquid when the thermometer is placed in the warm water.

MATTER CIRCUS OBSERVATION SHEET

STATON 1: Syringes	**STATION 2: Solids**
STATION 3: Copper Wire	**STATION 4: Food Coloring**
STATION 5: Room Deodorizer	**STATION 6: Thermometer**

Attachment 3: **MAKING INFERENCES: MATTER CIRCUS**

PHASES	PARTICLE CHARACTERISTICS
SOLID	
LIQUID	
GAS	

Attachment 4:

ASSESSING UNDERSTANDING: KINETIC MOLECULAR THEORY

Use the kinetic molecular theory to explain what happens at the particle level in each of the situations below. For each situation, draw a BEFORE and AFTER particle picture that represents what has happened.

1. A crayon left on the sidewalk melts into a puddle on a hot sunny day.

EXPLAIN:

BEFORE	AFTER

2. An inflated balloon is placed in the refrigerator. When it is removed an hour later, it has shrunk to about half of its original size.

EXPLAIN:

BEFORE	AFTER

3. A woman places several moth balls in a ziplock bag and seals the bag. Several days later, she notices that the bag has become inflated and the moth balls are much smaller.

EXPLAIN:

BEFORE	AFTER

4. A pharmacist prepares a tincture of iodine by adding a few iodine crystals to a beaker containing 50 mL of liquid alcohol. After a period of time, the pharmacist notices that the liquid has become uniformly brown in color, the solid iodine crystals have disappeared, and the total volume of the tincture is only slightly more than 50 mL even though the iodine crystals were fairly large in size.

EXPLAIN:

BEFORE	AFTER

5. An aerosol can is inadvertently placed on a kitchen counter very near the stove. A stove burner is turned on and several minutes later the aerosol can explodes.

EXPLAIN:

BEFORE	AFTER

ASSESSING UNDERSTANDING: KINETIC MOLECULAR THEORY
(Teacher Key)

Use the kinetic molecular theory to explain what happens at the particle level in each of the situations below. For each situation, draw a BEFORE and AFTER particle picture that represents what has happened.

1. A crayon left on the sidewalk melts into a puddle on a hot sunny day.

EXPLAIN:
Particles in the solid crayon are very close together, strongly attracted to one another, and vibrating about a fixed position. This is why the crayon has a definite shape and volume. Heat from the sun provides the energy for the particles to break away from one another and to begin to move freely.

BEFORE	AFTER

2. An inflated balloon is placed in the refrigerator. When it is removed an hour later, it has shrunk to about half of its original size.

EXPLAIN:
The air inside the balloon is a gas, so the particles are moving very fast in random directions and separated by lots of space. They collide frequently with the inside wall of the balloon, which is what keeps the balloon fully inflated. When the balloon is placed in the refrigerator and cooled (or heat is removed), the particles of air slow down. They don't collide as frequently or as hard with the balloon wall. The balloon wall squeezes the air particles closer together as the balloon shrinks in size.

BEFORE	AFTER

3. A woman places several mothballs in a ziplock bag and seals the bag. Several days later, she notices that the bag has become inflated and the moth balls are much smaller.

EXPLAIN:
Originally, because the mothballs are solid, the particles are close together and vibrating in fixed positions. The fact that the bag becomes inflated and the mothballs become smaller indicates that part of the moth balls must have become a gas (or sublimed). As a gas, the mothball particles move freely and are separated by a great deal more space, which is why the bag became inflated.

BEFORE	AFTER

4. A pharmacist prepares a tincture of iodine by adding a few iodine crystals to a beaker containing 50 mL of liquid alcohol. After a period of time, the pharmacist notices that the liquid has become uniformly brown in color, the solid iodine crystals have disappeared, and the total volume of the tincture is only slightly more than 50 mL even though the iodine crystals were fairly large in size.

EXPLAIN:
The particles of iodine in the solid crystals are close together and vibrating in place. The particles in the liquid alcohol move freely and there is some space between them. When the alcohol particles collide with iodine particles in the crystals, they transfer some energy to them. The energy allows these iodine particles to break away from the other iodine particles in the crystal and to begin to move through the spaces between the alcohol particles.

BEFORE	AFTER

5. An aerosol can is inadvertently placed on a kitchen counter very near the stove. A stove burner is turned on and several minutes later the aerosol can explodes.

EXPLAIN:
Particles of the gas inside the aerosol can are compressed or squeezed very close together. (They may even have become a liquid.) Heat energy from the stove causes these particles to move faster and to exert greater pressure on the inside surface of the can, enough to cause the can to explode.

BEFORE	AFTER