The Structure of Matter

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Content Area: General Science/Chemistry
Grade Level: 7-12

LESSON RATIONALE

Instructional Objectives

- Understand that solids, liquids, and gases are made up of tiny atoms that are too small to see with your eye or a normal light microscope.
- Understand the structure of solids, liquids, and gases.
    - Arrangement of atoms determines structure
    - Intermolecular forces hold the structures together
    - There is "nothing" in the space between the atoms
- Atoms and molecules are in constant motion, although these motions change depending on the state of matter
    - Solids- vibrations only
    - Liquids- vibrations, slow translation and rotation
    - Gases- vibrations, fast translation and rotation

Standards

- Indiana Learning Standards:

7th Grade

7.7.2 – Use different models to represent the same thing, nothing that the kind of model and its complexity should depend on its purpose.

8th Grade

8.2.7 – Participate in group discussions on scientific topics be restating or summarizing accurately what other have said, asking for clarification or elaboration, and expressing alternative positions.

8.3.8 – Explain that all matter is made up of atoms which are far too small to see directly through an optical microscope. Understand that the atoms of any element are similar but are different from atoms of other elements. Further understand that atoms may stick together in well-defined molecules or may be packed together in large arrays. Also understand that different arrangements of atoms into groups comprise all substances.

8.3.9 – Demonstrate, using drawings and models, the movement of atoms in a solid, liquid, and gaseous state. Explain that atoms and molecules are perpetually in motion.

8.3.10 – Explain that increased temperature means that atoms have a greater average energy of motion and that most gases explain when heated.

Chemistry 1

C.1.21 – Predict how changes in temperature, surface area, and the use of catalysts will qualitatively affect the rate of a reaction.

C.1.26 – Describe physical changes and properties of matter through sketches and descriptions of the involved materials.

Physics 1

P.1.1 – Describe matter in terms of its fundamental constituents and be able to differentiate among those constituents.

P.1.3 – Describe and apply the kinetic molecular theory to the states of matter.

Integrated Chemistry – Physics

CP.1.13 – Explain that the rate of reactions among atoms and molecules depends on how often they encounter one another, which is in turn affected by the concentrations, pressures, and temperatures of the reacting materials.

CP.1.29 – Understand and explain that at the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus, are involved in all chemical reactions.

- National Science Education Standards

Content Standards 5-8

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standards 9-12

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.
- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound in formed when two or more kinds of atoms bind together chemically.
- Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.

- Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties – including shape – of the reacting species.
- Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

- Benchmarks for Science Literacy-Project 2061

Grades 6-8

4D: The Physical Setting – Structure of Matter

- All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
- Atoms and molecules are perpetually in motion. Increased temperature mans greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.
- The temperature and acidity of a solution influence reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them.

Grades 9-12

4D: The Physical Setting – Structure of Matter

- The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

LESSON PREPARATION

Materials

Item	Number/Amount
Balloons	2-3
Vanilla	2-3 drops in each balloon
Masking tape	Enough to mark off floor
Tag with atom labels that hang	1/student
100-mL beakers	3/lab group
Food coloring	3 drops/lab group
Tap water	300 mL/lab group
Bunsen burner or hot plate	1/lab group
Ice	Enough for 500-mL beaker
500-mL beaker	1/lab group
Overhead/markers or chalkboard/chalk	

Pre-Class Preparation

Getting the Materials Ready

- Put a few drops of vanilla in each balloon, blow them up and tie them (do this immediately before class or at the beginning of class if you want students to see you do it). Put the balloons in the front of class.
- Mark off a large square on the ground with masking tape; leave one side open.
- Have tags with elemental symbols on them for students to wear during the activity.
- Be sure to have beakers, food coloring, Bunsen burners, and ice ready for students.

Adaptation/Cautions

- This lesson is very much hands-on for the students; they are very involved throughout the class.
- Be careful about students who do not like being touched; maybe have these students call out directions to the others.
- Be sure all students are participating in the activities and not only a select few.
- You will need to tell students that not all atoms are the same size, that the demonstration is just a model.
- Allow students to make predictions before performing the experiment.
- When performing the mini-lecture, the students should lead the discussion, not the teacher. After doing the activities, students will have a good idea about solids, liquids, and gases, and the teacher should only need to add in a few more technical terms.

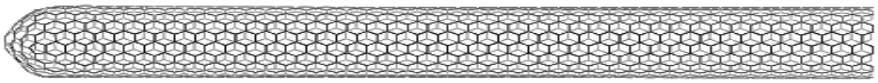
Doing the Lesson

Opening

- If a penny is made of tiny particles (atoms), why doesn't it fall apart?
- Record your observations of the balloons using your senses.

NOTE:

1. Have the questions written on the board and have students propose answers for the question, but do not give answers. After the lesson, they should have a better understanding of an answer and you will return to it then.
    - Give students 3-5 minutes at the beginning of class for these questions.
2. In the front of the room, have the balloons set-up. Ask students to use their senses to observe the balloons and determine what is in them. Tell them to continue using their senses throughout the class period to make more observations. Students should be recording their observations in a lab journal (or on a piece of paper).



Activities

1. **Activity 1 – Water in Jar activity with a twist**
    a. See Water in a Jar worksheet and perform as stated (or modify depending on student level), however, you can have students wearing tags to differentiate different atoms.
        i. On the tags you can write H_2O or depending on the advancement of the class you can have H and O atoms for students to form water and then have to hold on that way (this can be difficult). Another option is to have the students be a single metal atom bonding together.
    b. Twist on activity-helps students to show that there is nothing in the space between the atoms.
        i. Have students in the solid arrangement and ask what is in the space between the atoms.
        ii. Common answer = air
        iii. Ask students what air is composed of.
        iv. You will get, O_2, N_2, Ar, CO_2, H_2O (first two are major)
        v. Have students not in solid structure form O_2 and N_2 and the attempt to fit into the space. The will need to be holding arms to form bonds just like everything else.
        vi. The students will not fit, and this should help students to see that nothing is in the space.
    c. Be sure students understand that not all atoms are the same size which plays a role in structure as well.

2. **Activity 2 - Turn Up the Heat, I'm Slowing Down**
    a. See attached student worksheet.
    b. Before students begin the laboratory exercise have them make predictions based on Activity 1 of what they believe will happen. Have them explain their predictions.
    c. Allow students to perform Activity 2 and answer the questions.

Lesson Follow-Up

1. Mini-lecture that is a discussion based from the activities that they did.
    a. Hand out a notes page with key questions on if desired.

2. Have students go back to the balloons done at the beginning of the period and think about how these activities can show that atoms and molecules are moving.

Assessment

1. Go back to initial questions and have students write a new, more scientific answer to the questions using what they have learned.
    a. If a penny is made of tiny particles, why doesn't it fall apart?
    b. Record your observations of the balloons using your senses.

2. Have students write a list of some (10) common items they use daily. The students should then classify these substances into solids, liquids, and gases. Then, students should describe the macro- characteristics that make them that state, and then require students to go to the submicroscopic level to talk about the structure, motions, and forces involved in the states.

Resources

- Bosak, Susan V. (2000). Science Is…A source book of fascinating facts, projects, and activities. 2nd edition. Scholastic books.
- Chemistry: Connections to our changing world. Chapter 14-Liquids and Solids. Prentice Hall.