

Amazing Materials: Properties of Matter: Teacher's Guide

Grade Level: 9-12

Curriculum Focus: Physical Science

Lesson Duration: One class period

Program Description

Diamonds and gold. Graphite and carbon. What are their molecular structures? Their properties make them amazingly multifunctional and in some cases extremely valuable. A look at composite materials reveals why two can sometimes be better than one.

Onscreen Questions and Activities

- Pre-viewing questions:
 - What do you know about gold, diamonds, and graphite?
 - What are some everyday objects made from these materials?
 - As you watch the program, note how the atomic structures of these materials make them unique.
 - Also, watch how the use of composite materials is making objects lighter and safer.
 - Post-viewing questions:
 - Gold has many applications in science and in our everyday lives. Discuss the concept of a valuable material. Is a material's value determined by its usefulness or by its rarity?
 - How might today's material scientists change the value of materials such as gold and diamonds in the future?
 - Activity: Design an imaginary composite material from two or more materials. What properties should the new composite have? Propose a specific use for it based on the predicted properties.
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Lesson Plan

Student Objectives

- Understand that every element is classified as a metal, nonmetal or semimetal (metalloid) based on its individual properties.

- Be able to classify an element as a metal, nonmetal or semimetal based on experimental observations of physical and chemical properties.

Materials

- *Amazing Materials: Properties of Matter* video and VCR, or DVD and DVD player

For each group:

- Eight labels
- Seven vials with caps, filled with the following:
 - Iron filings
 - Sulfur rolls
 - Mossy zinc
 - Graphite (replacement leads for mechanical pencils work well)
 - Silicon
 - Mossy tin
 - Carbon

(If the above materials are not available, some substitutes are: paper clips, beebees, nails, fishing weights, charcoal)

- One dropper bottle
- 6M hydrochloric acid
- One hammer
- Eight pieces of paper each measuring approximately 3.5 X 5 inches
- A conductivity apparatus such as 9-volt battery, a small appliance light bulb, and three pieces of insulated copper wire to make an open circuit (the circuit will be closed with each of the seven samples)
- One test tube holder
- Seven test tubes

For each student:

- Safety goggles
- A copy of the Properties Data Chart (see Procedures)

Procedures

1. Before beginning this activity, students should already have a basic understanding of the differences in the physical properties of luster, malleability, and conductivity between metals and nonmetals. Students should understand that metalloids have characteristics of both metals



and nonmetals and that acids will react with most metals and not nonmetals. Students should always be reminded to follow proper safety procedures and guidelines when working with any chemicals.

2. Divide the class into groups of two or three, depending on class size. Use labels to number a set of vials from 1 through 7. Each group should receive a set of seven vials. Fill and label the complete set of vials as follows:
 - Vial 1 – iron filings
 - Vial 2 – sulfur
 - Vial 3 – mossy zinc
 - Vial 4 – graphite
 - Vial 5 – silicon
 - Vial 6 – mossy tin
 - Vial 7 – carbon
3. Make a 6M solution of hydrochloric acid. Label a set of dropper bottles and fill with the acid solution. There should be one dropper bottle of acid per group. At each group's lab station place a hammer, eight pieces of white paper, a set of vials containing samples 1-7, a dropper bottle of 6M hydrochloric acid, a conductivity apparatus, a test tube holder, and seven test tubes.
4. Next, hand out copies of the following chart, or have students create their own chart like the one below.

Properties Data Chart

Sample Number	Color	Luster	Malleability	Conductivity	Reaction with Acid	Classification
1						
2						
3						
4						
5						
6						
7						

5. Before students begin their experiment, make sure they are all wearing their safety goggles. Instruct a student in each group to take a piece of white paper, fold it in half, open it, and place it on the lab top. Another member of the group should then open vial 1 and shake about a pea-sized portion of the sample onto the white paper. Each student should observe the appearance

- of the sample and record his or her observations in the "color" and "luster" columns of the data chart.
- Next, have one student in each group place a second piece of paper over the top of the sample and crush the sample with the hammer. The student should then remove the top piece of paper and each student in the group should observe the sample and record his or her observations in the "malleability" column of the data chart.
 - Have one student within each group test the conductivity of the sample with the conductivity apparatus by placing the ends of the wires not attached to the power source or light bulb into the sample vial. **DO NOT LET THE WIRES TOUCH EACH OTHER.** Each student should observe the light bulb and record his or her observations in the "conductivity" column of the data chart.
 - Have one student place a test tube in the test tube rack. The student should then pour sample 1 from the paper into the test tube and add 10 to 20 drops of 6M hydrochloric acid. Each student should then wait at least three minutes before observing and then record his or her observations in the "reaction with acid" column of the data chart.
 - Each group should then repeat steps 3 through 7 above for the remaining six vial samples.
 - Each student, based on his or her group's experimental observations and the knowledge he or she has about the properties of metals and nonmetals, should then classify each of the samples as a metal, nonmetal, or semimetal. He or she should record the answer in the "classification" column of the data chart. Each student should then submit his or her data chart.
 - After submission of the data chart, discuss with the class their conclusions for each of the seven vials. What conclusions did they draw and why?

Discussion Questions

- What accounts for the observed differences between samples? Describe how these samples might be arranged with respect to other elements in the periodic table. What other tests could be performed to help identify materials as metals, nonmetals, and semimetals? What are some useful applications of such tests?
- Our society is rapidly consuming raw materials that are nonrenewable. Discuss whether we should rely on materials scientists to develop new materials to replace older ones that are no longer available or consume and discard currently available materials more wisely. Is every material replaceable?
- Discuss what types of materials are most important to recycle. Debate whether recycling should be made the law nationwide. Is the expense of enforcing such a law justified or is the money better spent on other social or scientific programs?
- Given the high quality and ready availability of substitutes, debate whether rare materials such as gold or diamonds should be used for jewelry and art or saved solely for technology and industry.



5. Discuss how our global society would change if the technology to change one element into a different element were developed. Is this a technology that, if developed, should be made public?
6. One area of great advancement in materials science is the area of medicine. Artificial joints are available, and scientists are currently developing artificial skin and blood. Discuss whether there should be limits placed on the development of physiological substitutes. Can you think of any reasons why advances in this area should be controlled?
7. Many of the greatest advances in materials science have been made accidentally. In light of this, discuss the value of following the scientific method versus chance. Is there ever room for chance when strictly adhering to the scientific method?

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Student's data chart correctly identifies the following six properties for all samples: color, luster, malleability, conductivity (the bubbles from reaction with gas can be difficult to observe); classification for each sample reflect student's observations.
- 2 points: Student's data chart correctly identifies most of the following six properties for most samples: color, luster, malleability, conductivity (the bubbles from reaction with gas can be difficult to observe); classification most samples reflect student's observations.
- 1 point: Student's data chart correctly identifies few of the following six properties for less than half of the samples: color, luster, malleability, conductivity (the bubbles from reaction with gas can be difficult to observe); classification for each sample does not reflect student's observations.

Vocabulary

brittle

Definition: Easily broken or shattered.

Context: The brittle piece of chalk shattered when the student accidentally stepped on it.

ductile

Definition: Able to be drawn into a wire.

Context: Two properties of copper metal that make it suitable for electrical wiring are that it conducts electricity and it is ductile.

electrolyte

Definition: Any substance that conducts electricity when molten or in solution.

Context: In order to stay healthy, the body must have salts to help maintain its balance of electrolytes.



insulator

Definition: Any substance that does not conduct electricity.

Context: In order to prevent short circuits, electrical wires are coated with nonconducting insulators.

luster

Definition: The quality, fact, or condition of shining by reflecting light.

Context: All metals, when polished, have very high luster.

malleable

Definition: Can be hammered or pressed without breaking.

Context: Blacksmiths are able to shape iron by hitting it with hammers because metals are malleable.

Academic Standards

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit

<http://www.mcrel.org/compendium/browse.asp>.

This lesson plan addresses the following national standards:

- Science—Physical Science: Understands the structure and properties of matter.
- Science—Physical Science: Understands forces and motion.
- Science—Nature of Science: Understands the nature of scientific inquiry.

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K-12 to promote scientific literacy. To view the standards, visit this Web site:

<http://books.nap.edu/html/nses/html/overview.html#content>.

This lesson plan addresses the following national standards:

- Physical Science: Properties and changes of properties in matter
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Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- <http://school.discovery.com/teachingtools/teachingtools.html>
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