Classifying Metals, Nonmetals, and Metalloids

Lesson Synopsis:
In this unit students will use physical properties to compare metals, nonmetals, and metalloids. In prior grades, students identified and classified matter by physical properties. This is an important foundational piece for grade 8 students which will enable them to explain how elements are arranged in the periodic table by properties. There are no TEKS to support the arrangement of the periodic table concept in grades 6 and 7. Students will use comparative and descriptive investigations to separate metals, nonmetals, and metalloids by their physical properties. Relative density (sinking and floating) was covered in previous grades. This will be the students’ first exposure to calculating density. In this lesson, they will calculate density of a regular, measurable solid. In lesson two, students will calculate the density of an irregular solid.

TEKS:

6.6 The student knows matter has physical properties that can be used for classification. The student is expected to:

6.6A Compare metals, nonmetals, and metalloids using physical properties such as luster, conductivity or malleability. 
Supporting Standard

6.6B Calculate density to identify an unknown substance. Supporting Standard

Scientific Process TEKS:

6.1 The student for at least 40% of instructional time conducts field and laboratory investigations following safety procedures and environmentally appropriate and ethical practices. The student is expected to:

6.1A Demonstrate safe practices during field and laboratory investigations as outlined in the Texas Safety Standards.

6.2 The student uses scientific inquiry methods during laboratory and field investigations. The student is expected to:

6.2A Plan and implement comparative and descriptive investigations by making observations, asking well-defined questions, and using appropriate equipment and technology.

6.2C Collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers.

6.2D Construct tables and graphs, using repeated trials and means, to organize data and identify patterns.

6.2E Analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

6.4 The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:

6.4A Use appropriate tools to collect, record, and analyze information, including journals/notebooks, beakers, Petri dishes, meter sticks, graduated cylinders, hot plates, test tubes, triple beam balances, microscopes, thermometers, calculators, computers, timing devices, and other equipment as needed to teach the curriculum.

GETTING READY FOR INSTRUCTION

Performance Indicator(s):
- Compare a sample of a metal, a nonmetal, and a metalloid using physical properties including luster, conductivity, malleability, magnetism, ductility, and state of matter. Calculate the density of each sample and explain in writing how the properties of each element relate to its classification. Display the results in a graphic organizer such as a three-flap flip book. (6.2A; 6.6A, 6.6B) 5B, 5G

Key Understandings and Guiding Questions:
- Metals and nonmetals have specific properties, which can be used to determine their identity and classification.
  — What properties help you to separate different metals and non-metals?
  — How do physical properties determine how a metal or non-metal will act?
- Metalloids are substances that may exhibit some properties of metals as well as some of nonmetals.
  — How do the properties of metalloids make them unique?
  — What is the importance of metalloids?
- Density of an unknown substance can be calculated to determine the identity of an unknown substance.
  — How can density be used to help identify and unknown substance?
Vocabulary of Instruction:
- metals
- nonmetals
- property
- metalloids

Materials:
- flashlights (1 per station)
- magnets (1 per group)
- conductivity tester (1 per group)
- strainers
- carbon or charcoal briquette
- section of iron pipe or iron filings
- section of lead pipe or fishing weights
- sulfur
- section of copper pipe or wire
- aluminum soda can for each conductivity tester
- battery
- insulated wire
- electrician tape
- paper clip
- metric ruler
- triple beam balance
- density cube set
- colored pencils
- red marker
- calculators

Appropriate materials may be substituted as needed to incorporate district resources and availability.

Attachments:
- Teacher Resource: PowerPoint: Examples and Non-examples
- Teacher Resource: Physical Properties Station Cards (There are two 2 station cards per sheet)
- Handout: Metals and Non-metals Student Data Table (1 per student)
- Handout: Physical Properties of Metals and Nonmetals (1 per student)
- Handout: Physical Properties of Metalloids (1 per student)
- Teacher Resource: Element Cards (1 set per group)
- Handout: Blank Periodic Table (1 per student)

Resources and References:
- None

Advance Preparation:
1. Make copies and cut apart one set of Teacher Resource: Physical Properties Station Cards. Place station card in a plastic sheet protector or laminate for protection.
2. Make copies and cut apart the Teacher Resource: Element Cards (1 set per group)
3. Instructions for building a conductivity tester may be found in Grade 5, Unit 02, Lesson 01. Building a tester requires that each group have a battery, 2 paperclips, 2 lengths of wire, and electrical tape.
4. Prepare attachments as necessary.

Background Information:
Elements are substances that contain only one kind of atom. Of all the elements, over three quarters are metals. Generally metals are dense, strong, and good conductors of heat and electricity. Other characteristics of metals include ductility, malleability, luster, high melting points, and conductivity. Many will exhibit magnetic attraction. At room temperature metals, are solids with the exception of mercury which is a liquid.

The sixteen naturally occurring nonmetals exist in a variety of states. At room temperature, carbon, iodine, phosphorus, and sulfur are solids. Bromine is a liquid. The following nonmetals are gases: argon, bromine, chlorine, fluorine, hydrogen, helium, krypton, neon, nitrogen, oxygen, radon, and xenon. The surfaces of nonmetals are generally dull and they don’t conduct heat and electricity. Compared to metals, they have low density and will melt at low temperatures. The shape of nonmetals cannot be changed easily because they are brittle and will break.

Metalloids have properties of both metals and nonmetals, and all are solids at room temperature. They can be shiny or dull, and their shape is easily changed. Electricity and heat can travel through metalloids but not as easily as they travel through metals. There is no unique way of distinguishing a metalloid from a true metal, but the most common is that metalloids are usually semiconductors rather than conductors. A semiconductor behaves as an insulator at very low temperature, and has some electrical conductance at room temperature.
Some metalloids are components of semiconductors which are essential to the computer, calculator, and communication industries. Depending on the source, there are seven to nine elements that are considered metalloids. They may include boron, silicon, germanium, arsenic, **selenium, antimony, tellurium, polonium**, and **astatine**. The elements with the ** are not consistent on the lists. Your classroom source should be the periodic table placed in the science notebook. For the purposes of this unit, astatine will be considered a metalloid but selenium will not.

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**GETTING READY FOR INSTRUCTION SUPPLEMENTAL PLANNING DOCUMENT**

Instructors are encouraged to supplement, and substitute resources, materials, and activities to differentiate instruction to address the needs of learners. The Exemplar Lessons are one approach to teaching and reaching the Performance Indicators and Specificity in the Instructional Focus Document for this unit. A Microsoft Word template for this planning document is located at [www.cscope.us/sup_plan_temp.doc](http://www.cscope.us/sup_plan_temp.doc). If a supplement is created electronically, users are encouraged to upload the document to their Lesson Plans as a Lesson Plan Resource in your district Curriculum Developer site for future reference.

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**INSTRUCTIONAL PROCEDURES**

**ENGAGE – Examples and Non-examples**

1. **Say:**
   - We will be talking about matter and its physical properties in this lesson.

   **Ask:**
   - What helps us distinguish the physical properties of matter?
     Answer may vary. Some student responses might be: tools help us measure different observable properties; characteristics help us observe properties; or our five senses can help us observe properties.

2. **Show the PowerPoint: Examples and Non-examples.**
   **Say:**
   - Look at the pictures, and consider the patterns found in the “Examples.”

3. **Ask a student volunteer to create an example on the board.**

4. **Instruct students to raise their hands if they agree that it is an example that fits the pattern. Only expect yes or no answers as to whether it represents an “example”. Do not require students to give reasons yet.**

5. **Ask several more volunteers to create their own “examples.” Again, ask for a show of hands only for agreement or disagreement as to whether it is an example. Deny or confirm whether or not the example is correct.** (The examples should all be uniform in pattern. These represent elements. The non-examples show mixed patterns. These may be compounds or mixtures.)

6. **Instruct students to predict what the “Example” models represent in regards to the topic of “Structure of Matter.”**

7. **Write the following definition on the board, and have students write this expanded version in their science notebooks:**
   - An element is a pure substance that is composed of the same type of matter throughout and cannot be divided into simpler substances through normal processes.

8. **Ask:**
   - Why do the “Examples” represent elements while the “Non-examples” do not? Refer back to the definition of an element. Students should recognize that only one type of shape and/or pattern

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**Notes for Teacher**

**NOTE:** 1 Day = 50 minutes

**Suggested Day 1**

**Attachments:**
- PowerPoint: Examples and Non-examples

**Instructional Note:**

This is an instructional strategy called concept attainment. It is designed to present a concept through examples and non-examples. Students will construct an operational definition of the term element by recognizing that only one type of pattern exists in the “example” arrangements. It is best to end an Example and Non-example exercise with another example. The students tend to remember the last item shown. Therefore, an example, a non-example, and another example should be given.

**Science Notebook:**

Have students write this expanded version of the definition in their science notebooks.
exists in the “Examples.” The non-examples have mixed patterns and/or shapes.

9. Review the slides again. Have students decide if there is more than one pattern in each “Example” picture. Remind the students to look for the unique pattern of the Examples that can help distinguish them from the non-examples in each picture.

EXPLORE – Comparing Metals and Nonmetals

1. Set up the six stations, and divide the class into six groups.

2. Go over safety rules and the procedures for each station and rotations.

3. Give each student a copy of the Handout: Metals and Nonmetals Student Data Table.

4. Instruct students to write “yes” or “no” in the blanks in the data table for the physical properties they test at each station. These properties are luster, magnetism, conductivity and are marked with an *. The last row titled “Part 2: Label the element as a metal or a non-metal” will be completed in the Explain section.

Suggested Days 1 (continued) and 2

Materials:
- magnets (6-1 per station)
- flashlights (6 -1 per station)
- conductivity tester (6-1 per station)
- carbon (charcoal)
- iron pipe or filings
- lead pipe or fishing weight
- sulfur
- copper pipe or wire
- aluminum soda can

Attachments:
- Teacher Resource: Physical Properties Station Cards (1 card per station)
- Handout: Metals and Nonmetals Student Data Table

Science Notebook:
The set up for the science notebook explains how to use the periodic table as a resource. The document is located under the resource section of the developer.

EXPLAIN – Metals and Nonmetals


2. Review each point for metals and non-metals with the students. Students should follow along on their data sheet. As each point is discussed, have students place a “yes” or “no” in the remaining columns on their data tables.

3. Complete the last row titled “Part 2: Label the element as a metal or a nonmetal” by looking at the data sheet and the handout to determine the correct answer.

4. When the data table is complete, Ask:
   - **Were all the materials you tested easy to separate into metals or non-metals?** Answers may vary, but most responses should indicate that it was easy.
   - **What properties helped you to separate the materials?** Answers
will vary: luster, magnetism, conductivity, etc.

- Did all metals give the same results? (No)
- Which metals did you find not to be attracted to a magnet? (Aluminum and copper)
- Which metals did not have luster? (Iron and lead)
- Why don’t all the metals behave the same way? Answers will vary.

Lead students to the conclusion that the characteristics of metals and non-metals are generalizations, and there are some that do not have all the characteristics, but most of them.

EXPLORE/EXPLAIN – Metalloids

1. Distribute a set of element cards to each group. Organize cards by physical characteristics. Lead discussions about any cards that are difficult to sort.

2. Discuss each point on the Handout: Physical Properties of Metalloids.

3. When all groups have separated the element cards, they may have questions about the placement of some of the elements. Ask some leading questions as to why students think that those particular cards do not fit.

4. After student input and discussion, give each student a copy of the Handout: Physical Properties of Metalloids. Review each point with the students.

   Ask:
   - What are the main properties that all metalloids have in common? (All are solids and they have properties of both metals and nonmetals)
   - Do their properties make them unique? (Yes)
   - Why are metalloids important? (They are semiconductors and are used in computers, calculators, and communications.)

5. Give each student a copy of the Handout: Blank Periodic Table, two different colors of colored pencils (not red), a red marker or vis-à-vis and a standard periodic table. Students need to have their copy of the Handout: Metals and Nonmetals Student Data Table available.

6. Instruct the students to:
   - Write the symbol and name of the metals they tested on the chart in the correct squares of the blank periodic table.
   - Color the labeled squares in one color of their choosing (not red).
   - Tell the students to think about the properties of silver and gold.

   Ask:
   - What are some of their properties? (Ductile, malleable, luster, conductivity, but not attracted to a magnet)
   - Would these properties classify them as metals or nonmetals? (Metals; aluminum was not attracted to a magnet either)

7. Instruct the students to:
   - Write the symbol and name of the nonmetals they tested on the chart in the correct squares of the blank periodic table.
   - Color the labeled squares in a color different from the one they used for metals (not red).
   - Tell the students to think about the properties of helium and oxygen.

   Ask:
   - What are some of their properties? (Not ductile, not malleable, low...
luster if a solid but no luster if a gas, not attracted to a magnet or exhibit conductivity)

- Would these properties classify them as metals or nonmetals? (Nonmetals; most are gases)

8. Instruct the students to:
- Write the symbol and name of the metalloid listed on the Handout: **Physical Properties of Metalloids** in the correct squares of the blank periodic table.
- Draw the stair step line that separates the metals and nonmetals in red marker or vis-à-vis.
- Tell the students to think about the properties of the metalloids. Ask:
- Are their properties different than metals or nonmetals? (They tend to have some properties of both metals and nonmetals)
- Would these properties classify them as metals or nonmetals? (Neither because they have properties of both and need to have their own category on the table)

**EXPLORE/EXPLAIN – Calculating Density of a Cube**

1. Group or pair students.

2. Have students record the formula for calculating volume in their notebook. (V= l x w x h) Discuss each part of the formula with them: V= volume, l= length, w= width, h= height.

3. Give each group or pair a cube from the density set. Tell them to measure, calculate, and record the volume of the cube.

4. Have students use a balance to measure and record the mass of the cube.

5. Write the formula for calculating density (D=m/v) on the board. Have students record the formula in the notebook. Discuss each part of the formula with them: D= density, m= mass, v= volume.

6. Give each group or pair a calculator and have them calculate the density of their cube. Check their results against the density list that comes with the density cube set.

7. Have groups switch cubes with another group so all students have a chance to measure volume and calculate density.

**Suggested Days 6 and 7**

**Materials:**
- 1 or 2 density cube sets (per class)
- metric rulers (1 per student)
- triple beam balance (1 per pair or group)
- calculator (1 per pair or group)

**Instructional Note:**
In this lesson, students will calculate the density of a cube. In lesson 02, the students will calculate the density of an irregular object by using water displacement. Make sure each student has an opportunity to measure both volume and mass of the cube.

**Science Notebook:**
Have students write the formulas for density and volume as well as the steps for calculating density in their notebook.

**Instructional Note:**
When measuring a cube, all sides will have the same measurement.

**ELABORATE – Density of an Unknown**

1. Give students a cube from the density set that they have not previously tested.

2. Have each student measure the volume and mass of the unknown cube and calculate its density.

3. Rotate groups (see Instructional Note) until all students have had an
opportunity to calculate the density of an unknown cube.

4. Students are to complete the performance indicator by writing a summary detailing how the density of the substance was determined and the process used to collect the data.

**EVALUATE – Categorize by Properties**

**Performance Indicator**

- Compare a sample of a metal, a nonmetal, and a metalloid using physical properties including luster, conductivity, malleability, magnetism, ductility, and state of matter. Calculate the density of each sample and summarize in writing how the physical properties of each element relate to its classification. Display the results in a graphic organizer such as a three-flap flip book. (6.2A; 6.6A, 6.6B)

1. Instruct students to create a graphic organizer to compare metals, nonmetals, and metalloids by their physical properties.

2. Instruct students to write a summary on their graphic organizer explaining how the physical properties of each element relate to its classification of a metal, nonmetal, or metalloid.

**Instructional Note:**
If there are insufficient balances and cubes to have the whole class complete the performance indicator at one time, have as many as can be accommodated complete the performance indicator. The remainder of the students can be given teacher generated practice density problems to solve. Rotate the students until all have completed the performance indicator and practice problems on their own.

**Suggested Day 10**

**Science Notebook:**
The graphic organizer and the summary statement can be completed in the notebook.

**Instructional Note:**
Any graphic organizer may be used such as a Venn diagram, double T-chart, bubble maps, flapped books, etc. A summary or conclusion statement should always be included with a graphic organizer. The writing component causes students to think scientifically. Students analyze their data and the organization of the data and back it up in the summary.