Lab: Metal, Nonmetal, or Metalloid?

FOR THE TEACHER

Summary
In this lab, students will classify several samples of elements as metals, nonmetals, or metalloid based on their physical and chemical properties.

Grade Level
High School

Objectives
By the end of this lab, students should be able to
- Classify an element as a metal, nonmetal, or metalloid based on its physical and chemical properties.
- Determine if a chemical change has occurred.
- Observe the physical properties of color, luster, malleability, ductility, and conductivity.

Chemistry Topics
This lab supports students’ understanding of
- Arrangement of the Periodic Table
- Physical properties
- Chemical properties

Time
Teacher Preparation: 30 minutes
Lesson: 50 minutes

Materials
- ≈20 ml 1.0 M hydrochloric acid in a small dropper bottle – one per group
- ≈20 ml 0.5 M copper (II) chloride in a small dropper bottle – one per group
- Element samples:
  - Aluminum foil - one 4 inch x 4 inch square per group
  - carbon (aquarium filter carbon works well) – 4 pellets per group
  - copper strips – one per group
  - copper strip pieces – 2 pieces per group
  - lead foil - one 4 inch x 4 inch square per group
  - magnesium ribbon – one 4 inch piece per group
  - sulfur – one medium chunk per group
  - silicon – one medium chunk per group
  - tin foil - one 4 inch x 4 inch square per group
- 12 or 24 well Reaction Plate – one per group
- Magnifying glass – one per group
- Hammer – one per group
- Conductivity meter – one per group
- Scissors – one per group
- Paper towel – eight per group
Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- When working with acids, if any solution gets on students' skin, they should immediately alert you and thoroughly flush their skin with water.
- Use care when using the conductivity testers. Avoid touching electrodes - you can get an electric shock.
- Follow the teacher's instructions for cleanup of materials and disposal of chemicals.

Teacher Notes
- During this lab students will observe the physical (color, luster, form, malleability, conductivity) and chemical properties (reaction with hydrochloric acid and copper (II) chloride) of eight elements.
- Students will use the magnifying glass to closely observe the color and form (solid, powder, etc.) and luster of each sample.
- Students will use the hammer to lightly hit each sample to determine if it is malleable. They can also make this observation based on the form (wire, strip, or foil) of the sample.
- Students will use a conductivity meter to determine if the sample conducts.
- Students will use a pipette and reaction plate to add hydrochloric acid to a small sample of each element to determine if a reaction occurs. Reactions with metal will produce hydrogen gas and bubbles will be observed. Generally, nonmetals do not react with acids.
- Students will use a pipette and reaction plate to add copper (II) chloride to a small sample of each element to determine if a reaction occurs. Many metals will react with copper (II) chloride in a single displacement reaction and copper plating will be observed. This reaction may take several minutes. Students should add a sample of each metal to the reaction plate, add copper (II) chloride, make an initial observation, and then make a final observation several minutes later.
- Generally, metals are lustrous (shiny), malleable, and conduct electricity. Many metals react with acids and with copper (II) chloride. Nonmetals are generally not lustrous, are brittle and will shatter when hit with the hammer, do not conduct electricity, and do not usually react with acids or copper (II) chloride. Instruct your students to:
  - Classify a sample as a metal if it has 4 or 5 of the metallic properties.
  - Classify a sample as a nonmetal if it has 1 or less of the metallic properties.
  - Classify a sample as a metalloid if it has 2 or 3 of the metallic properties.
- Laboratory set up: This lab works well both with individual lab groups and in a station setup. Setting up stations will take less time and require less equipment.
- Include clearly labeled waste beakers for the hydrochloric acid waste, copper (II) chloride waste, and solid waste.
- Students should use paper towel when they are using the hammer to test for malleability, as the carbon, sulfur, and silicon can become quite messy.
FOR THE STUDENT

Lesson

Metal, Nonmetal, or Metalloid?

Background
In this lab you will observe physical and chemical properties of several elements and use the observations to classify each as a metal, nonmetal, or metalloid.

Generally, metals are lustrous (shiny), malleable, and conduct electricity. Many metals react with acids and with copper (II) chloride. Nonmetals are generally not lustrous, are brittle and will shatter when hit with the hammer, do not conduct electricity, and do not usually react with acids or copper (II) chloride. Use the following guidelines to classify your samples:

- Classify a sample as a metal if it has 4 or 5 of the metallic properties.
- Classify a sample as a nonmetal if it has 1 or less of the metallic properties.
- Classify a sample as a metalloid if it has 2 or 3 of the metallic properties.

When metals react with an acid, hydrogen gas is produced and you will see bubbles that indicate a reaction is occurring. When they react with copper (II) chloride you will see copper metal plating onto the surface of your sample. This reaction occurs relatively slowly, so after making an initial observation, continue on with the next steps in the lab and return to make a final observation after several minutes have passed. You may want to use a magnifying glass to get a better observation.

Prelab Assignment
Read through the lab procedures and create a data table that will allow you to record your observations during the lab. Make sure that you have plenty of room to record a complete description of the chemical and physical properties. Get your data table approved by the teacher before beginning the lab.

Objective
The objective of this lab is to use physical and chemical properties to classify an element as a metal, nonmetal, or metalloid.

Materials
- Element samples: Aluminum wire and foil, carbon, copper wire and strips, lead foil, magnesium ribbon, sulfur, silicon, tin foil
- 1.0 M hydrochloric acid
- 0.5 M copper (II) chloride
- 12 or 24 well Reaction Plate
- Disposable pipette
- Magnifying glass
- Hammer
- Conductivity probe
- Paper towel
- Scissors
Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- When working with acids, if any solution gets on students’ skin, they should immediately alert you and thoroughly flush their skin with water.
- Use care when using the conductivity testers. Avoid touching electrodes - you can get an electric shock.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.

Procedure
1. Observing Physical Properties:
   a. Note: Use the copper strip for this part of the lab.
   b. Put a small sample of each substance on a paper towel and observe the following physical properties:
      - Appearance: Include a complete description of physical properties such as color, luster (shine) and form (powder, wire, foil, etc.).
      - Malleability: A material is malleable if it flattens without shattering when struck. It is brittle if it shatters. Gently tap each element with a hammer and decide if they are malleable or brittle.
   c. Conductivity: Touch both electrodes to the element sample and get a good connection. Some of the more rocky samples require extra effort to touch both electrodes at the same time. If the bulb lights the material is called a conductor. If the bulb fails to light, the material is a nonconductor.

2. Testing Chemical Properties:
   a. Use scissors to cut the aluminum, lead, magnesium, and tin into small pieces for this part of the lab. The carbon, sulfur, and silicon should be in small pieces. Use the hammer to break larger pieces. Use the copper pieces for this part of the lab.
   b. Test the reactivity with hydrochloric acid by placing a small sample of each element in a reaction plate and adding HCl to completely cover it. Use the magnifying glass to observe resulting mixture.
   c. Test the reactivity with copper (II) chloride by placing a small sample of each element in a reaction plate and adding CuCl₂ to completely cover it. Use the magnifying glass to observe resulting mixture. Make a second set of observations after several minutes have passed.

3. Clean Work Station:
   a. If you have unused solids, leave them for the next group.
   b. Be sure that the lids on the hydrochloric acid and copper (II) are tightly fastened.
   c. Used paper and aluminum foil can be disposed of in the trash can.
   d. Put your liquid and solid waste in the appropriate waste beaker.
   e. Wash and dry your equipment.
   f. Wipe down your lab station using a wet paper towel.
g. Have your teacher check your lab station before leaving.

**Data**
Record your observations in the data table you created before beginning the lab.

**Conclusion**
1. Use your observations to identify each element as a metal, nonmetal, or metalloid and completely explain your choice.
2. If any of your identifications do not agree with the elements correct identification on the Periodic Table, identify an error that could have led to the wrong choice.
3. How do the properties of metals, nonmetals, and metalloids relate to the elements location on the Periodic Table?
4. Choose a metal element from the Periodic Table that you use in everyday life. Use a reliable Internet source to research the element. As a result of your research, list its common uses and explain how its properties support its use. Properly cite your source(s).
5. Choose a nonmetal element from the Periodic Table that you use in everyday life. Use a reliable Internet source to research the element. As a result of your research, list its common uses and explain how its properties support its use. Properly cite your source(s).