

Properties of Elements

Metals, Nonmetals, and Metalloids

Introduction

All known elements may be classified as metals, nonmetals or metalloids based on their physical and chemical properties. What properties distinguish metals from nonmetals? What properties of metalloids make them similar to both metals and nonmetals?

Concepts

- Elements
- Physical and chemical properties
- Metals vs. nonmetals
- Metalloids

Background

Elements have unique physical and chemical properties that make them useful in our everyday lives. Aluminum, for example, is lightweight yet strong—modern air travel would be impossible without this important metal that is used to make jet engines and aircraft bodies. Chlorine combines chemically with many other elements and compounds and is a powerful disinfectant. The availability of safe drinking water all over the world depends on this reactive nonmetal. Perhaps no other element, however, stands out as a symbol of our “space-age” technology more than silicon. The ability to obtain very high purity silicon has increased the speed and the power of modern electronics and has transformed society.

Physical properties are properties that can be observed without changing the identity of a substance. Examples of physical properties include color, odor, and density. Chemical properties describe the ability of a substance to undergo changes in its identity (its chemical composition or makeup). The identity of a pure substance changes when a chemical property is observed. Flammability, the ability to form compounds, and the susceptibility to corrosion are examples of chemical properties.

Experiment Overview

The purpose of this experiment is to investigate the physical and chemical properties of eight elements and to classify the elements as metals, nonmetals or metalloids. The elements will be classified according to their physical appearance (color and luster), their malleability (brittle vs. nonbrittle), their ability to conduct electricity, and whether or not they undergo chemical reactions with hydrochloric acid and copper(II) chloride.

Pre-Lab Questions

1. What will happen if hydrochloric acid contacts the skin? How can you protect against this hazard?
2. Using a periodic table, determine the *chemical symbol* for each of the eight elements to be tested (see the *Materials* section). Write the chemical symbol for each element next to its name in the data table.

Pre-Lab Questions continued on next page

3. Identify each of the following as either a *physical* or a *chemical property*:
 - a. Butter melts in a microwave oven.
 - b. A piece of copper metal feels cold to the touch.
 - c. An apple slice turns brown in the air.
 - d. A watch dial glows in the dark.
 - e. An iron nail rusts.
 - f. Bleach is used to remove a stain from clothing.

Materials

Aluminum shot, 2 pieces	Beaker, 150-mL
Carbon lumps or powder	Beral-type pipets, 2
Iron wire or sheet, 1-cm, 2 pieces	Conductivity tester
Magnesium ribbon, 1-cm, 2 pieces	Distilled water and wash bottle
Silicon lumps or powder	Hammer or other hard, solid object
Sulfur lumps or powder	Marking pen
Tin shot or sheet, 2 pieces	Notebook paper
Zinc shot or foil, 2 pieces	Paper towels
Hydrochloric acid solution, HCl, 1 M, 10 mL	Periodic table
Copper(II) chloride solution, CuCl_2 , 0.1 M, 10 mL	Spatula or forceps
	Test tubes, small, 8
	Test tube rack

Safety Precautions

Hydrochloric acid solution is corrosive to skin and eyes. Copper chloride solution is slightly toxic by ingestion. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the lab.

Procedure

1. Draw lines on a sheet of notebook paper to divide the paper into eight “boxes,” about 3 inches wide by 2 inches long. Label each box with the chemical symbol of one of the elements to be tested.
2. Label eight small test tubes with the element symbols and place the test tubes in a test tube rack.
3. Using a spatula or forceps to handle the elements, place a small amount (2–3 pieces or a few crystals) of each element to be tested in the appropriate test tube.

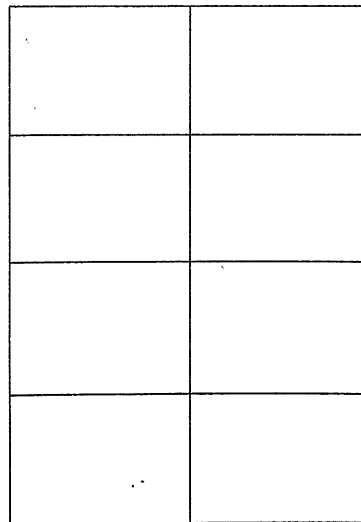


Figure 1.

4. Back at the lab bench, empty the element samples onto the “element paper” (step 1) by inverting each test tube onto the appropriate box.

Physical Properties

5. Observe and record the *physical appearance* of each element in the data table. Be specific—describe the color, luster, and form (crystalline, flakes, smooth, etc.) of each element.
6. Test the *conductivity* of each element sample by touching the wires of the conductivity tester directly to the solid. Record the results in the data table.
7. Test the *malleability* of each element: Gently rap each element sample with a small hammer. A material is *malleable* if it flattens or bends without shattering. A material is *brittle* if it shatters or cracks into small pieces when struck. Record the results in the data table.

Chemical Properties

8. Use a spatula or forceps to place one small piece (or a few crystals) of each element from the “element paper” (step 4) into the appropriately labeled test tube.
9. Test the reactivity of each element with *hydrochloric acid*: Add one pipetful (about 2 mL) of 1 M hydrochloric acid to each test tube. Observe the mixtures for 1–2 minutes for any signs of a possible chemical reaction. Record all observations in the data table.
10. Pour the liquid from the test tubes into a 150-mL beaker or into a waste container provided by the instructor. Invert the test tubes over paper towels and gently tap the test tubes to remove any remaining solids. Do NOT pour any solids directly down the drain! Discard the paper towels in the trash.
11. Thoroughly rinse each test tube with distilled water from a wash bottle.
12. Use a spatula or forceps to place one small piece (or a few crystals) of each element from the “element paper” (step 4) into the appropriately labeled test tube.
13. Test the reactivity of each element with *copper(II) chloride*: Add one pipetful (about 2 mL) of 0.1 M copper(II) chloride solution to each test tube. Observe the mixtures for 1–2 minutes for any signs of a possible chemical reaction. Record all observations in the data table.
14. Pour the liquid from the test tubes into the waste beaker (step 10) or into a waste container provided by the instructor. Invert the test tubes over paper towels and gently tap the test tubes to remove any remaining solids. Do NOT pour any solids directly down the drain! Discard the paper towels in the trash.
15. Thoroughly rinse each test tube with distilled water from a wash bottle.
16. Dispose of the liquid in the waste beaker as directed by the instructor. Any remaining solids on the “element paper” may be disposed of in the trash.

Name: _____

Class/Lab Period: _____

Properties of Elements

Data Table

Element (Symbol)	Physical Properties		
	Appearance	Malleability	Conductivity
Aluminum			
Carbon			
Iron			
Magnesium			
Silicon			
Sulfur			
Tin			
Zinc			

Element (Symbol)	Chemical Properties	
	Reaction with HCl	Reaction with CuCl_2
Aluminum		
Carbon		
Iron		
Magnesium		
Silicon		
Sulfur		
Tin		
Zinc		

Post-Lab Questions

- Review the data for the eight elements. Sort the elements into two groups, based on similarities in their physical and chemical properties. Explain the criteria that were used to separate the elements into these two groups.

*Group A**Group B**Criteria**Criteria*

- Are there any “borderline elements,” that is, do any of the elements appear to have properties of both groups? Explain.

- Metal, nonmetal or metalloid?*

Shiny, malleable, and conducts electricity _____

Some properties are common to both metals and nonmetals _____

Dull in appearance, brittle, does not conduct electricity _____

Most do not react with acids or with copper(II) chloride _____

Many do react with hydrochloric acid or with copper(II) chloride _____

- Look up the position on the periodic table for each element tested in this lab. Write a general statement describing the position of metals, nonmetals, and metalloids on the periodic table.
- Based on general knowledge of metals and the answers to Questions #1, 2, and 3, classify each element tested as a metal, nonmetal or metalloid.

Aluminum _____	Silicon _____
Carbon _____	Sulfur _____
Iron _____	Tin _____
Magnesium _____	Zinc _____
- Predict the general properties (see Question #5) of the following elements—selenium, calcium, and cobalt.