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
- Metals vs. nonmetals
- Physical and chemical properties
- 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 a s 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, order, 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, 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.

Materials

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

Safety Precautions

Hydrochloric acid solution is corrosive to skin and eyes. Copper(II) 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 few crystals) of each element to be tested in the appropriate test tube.

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 1M hydrochloric acid to each test tube. Observe the mixtures for 1–2 minuets 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 trest 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 _____ Period _____
Partner_____ Date _____

Properties of Elements

Pre-Lab Questions

1. What are the signs of a chemical reaction?

2. Using a periodic table, determine the *chemical symbol* for each of the eight elements to be tested (see the *data table*). Write the chemical symbol for each element next to its name in the data table.

Data Table

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

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

Post-Lab Questions

1. 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***

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

3. Identify the following as *Metal, nonmetal, or metalloid?*
   a) Shiny, malleable, and conducts electricity a) _____
   b) Some properties are common to both metals and nonmetals b) _____
   c) Dull in appearance, brittle, does not conduct electricity c) _____
   d) Most do not react with acids or with copper(II) chloride d) _____
   e) Many do react with hydrochloric acid or with copper(II) chloride e) _____

4. 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.

5. Based on general knowledge of metals and the answer to Questions #1, 2, and 3, classify each element tested as a metal, nonmetal, or metalloid.

   Aluminum _____ Silicon _____

   Carbon _____ Sulfur _____

   Iron _____ Tin _____

   Magnesium _____ Zinc _____

6. Predict the general properties (see Question #3) of the following elements:

	Selenium	Calcium	Cobalt
Appearance			
Malleability			
Conductivity			
Reaction with HCl			
Reaction with $CuCl_2$			