



Activity 6

Metals and Nonmetals



GOALS

In this activity you will:

- Observe some chemical and physical properties of various materials.
- Classify the materials as metals or nonmetals.
- Identify the metals that make up common alloys and learn about some special properties and uses of the alloys.
- Make generalizations about the properties that differentiate metals from nonmetals.
- Explore how heat treatments can alter the properties of metals.

What Do You Think?

If you look around your house you will see hundreds of objects made from dozens of kinds of materials. Have you ever wondered why the manufacturer chose the materials they did for each item?

- **Why are frying pans made of metal and baking dishes often made of glass or ceramic?**
- **Could a baking dish be made of metal? Could a frying pan be made of glass or ceramic?**

Record your ideas about these questions in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Your teacher will provide you with samples of a number of materials: iron, copper, zinc, magnesium, tin, aluminum, brass, solder, chalk, graphite or charcoal, wood, glass, plastic, and concrete.

Choose two of the materials that are obviously different. In your group, brainstorm at least five characteristics or properties of each material.

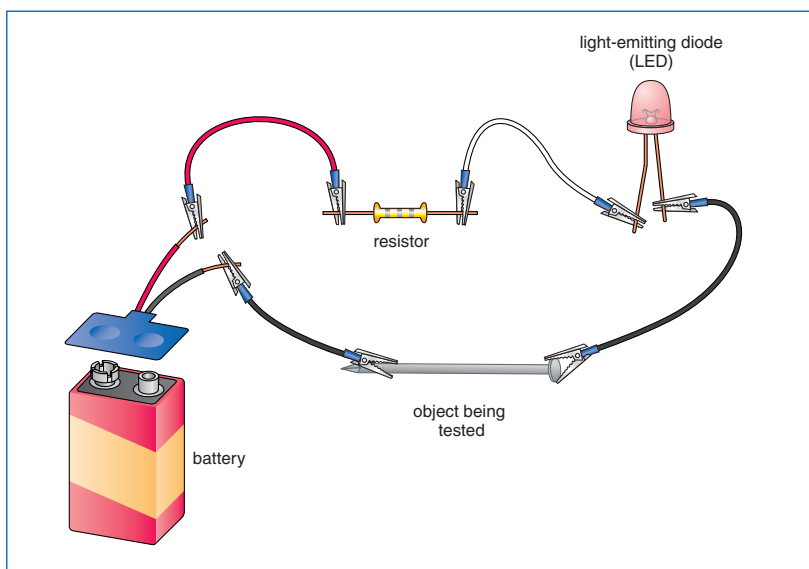
- a) In your *Active Chemistry* log, use the characteristics to describe each material. Could someone else reading your log be able to identify the material?
2. Chemists use specific characteristics or properties to describe and distinguish among materials. You investigated some of these properties in **Activity 4** and **Activity 5**. Additional properties used by chemists are described below.
 - a) In your log, prepare a table for recording your observations.
3. **Luster:** Is the material shiny or dull in appearance? Does it look more like a mirror or more like mud? If a material has lots of luster it reflects light and you may be able to see images reflected from the surface. Polished metal has high luster. Dull

surfaces don't reflect as much light. They appear flat and no images can be reflected.

- a) In the table in your log, record whether the material has a high or low luster.
4. **Electrical conductivity:** Test each substance with a conductivity tester or multi-meter. To test each substance, touch the two leads to each end of the sample. Do not allow the leads to touch each other, or it will give a false reading. In the example shown in the diagram, the bulb will glow if the material is conductive. Your teacher will demonstrate how the specific conductivity tester used in your lab works.
 - a) In the table in your log, record whether the material is conductive. You can use words to reflect this like nonconductive, slightly conductive, or very conductive. If you are using a meter, you can record the reading.



Safety goggles and a lab apron must be worn.





5. **Malleability:** Wrap the material being tested in heavy plastic or a cloth to prevent pieces from flying off the sample. Place the material on a hard, flat surface. Using a hammer, try to pound the material flat. If the sample can be pounded into a flatter shape it is called malleable. If it breaks or doesn't change it is called nonmalleable.
 - a) In the table in your log, record whether the material is malleable or nonmalleable.
6. **Reactivity:** Try scraping or sanding a small part of each sample. Is the surface underneath the same in appearance or different? If the surface is different, that means the sample has reacted with the air.
 - a) In the table in your log, record whether the material is highly reactive, slightly reactive or nonreactive.
7. **Ductility:** Ductility refers to how easily the substance can be pulled out into a wire or how bendable it is. Try bending each piece to determine how ductile it is.
 - a) In the table in your log, record whether or not the material is ductile.
8. **Color**
 - a) Record the color of each sample material in the table in your log.
9. Once you have completed the table, compare your list of characteristics of each substance with those recorded by the other students in your class. Have each member of your group pair off with a student from another group. If there is a difference in the results go back to the material and review your observations until everyone agrees on the most accurate list of properties for each material.
 - a) Be sure to record any changes you make in your log.
10. Classify the substances into two groups. Use any property you have observed to divide the samples into groups that have the most in common. For example, you could divide the materials into those that do have a luster and those that do not.
 - a) Record your classification of the materials in your log.
11. Metals have a shiny and lustrous surface. They conduct electricity and heat. They are malleable and ductile and they are often relatively reactive. Nonmetals have characteristics that are generally opposite to metals in every way. Instead of being lustrous their surfaces are dull in appearance. They are nonconductive, brittle, and nonductile. Now separate your samples into metals and nonmetals. If you have any samples that do not fit clearly as either a metal or a nonmetal, set them aside.
 - a) Make a list of the samples in each category in your *Active Chemistry* log.

ChemTalk

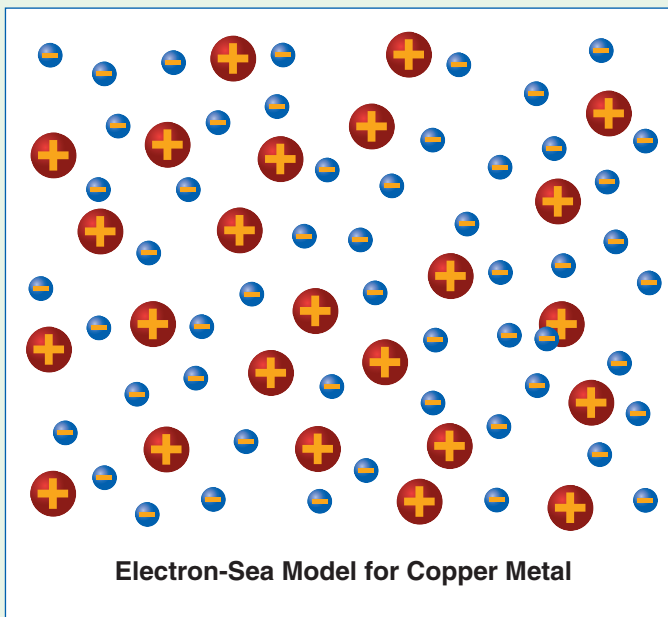
METALS, NONMETALS, AND METALLOIDS

In this activity you investigated specific properties of materials. You then used your observations to classify a material as a **metal** or a **nonmetal**. Metals have **luster**. They exhibit **conductivity**. They conduct electricity and heat. They are malleable and **ductile** and they are often relatively **reactive**. Many metals form a compound on their surface that results from reactions with air. When you scrape or sand a piece of

metal you are removing that coating of metal compound. Sometimes that natural coating can prevent further reacting and will preserve the metal underneath.

Looking at the drawing at the right, you can see that in solid copper metal the centers of the copper atoms are in fixed locations but they are surrounded by a sea of electrons. If an electric circuit is set up, the electrons are free to move.

This is the basis of the metallic property of electrical conductivity.



Chem Words

metal: classes of materials that exhibit the properties of conductivity, malleability, reactivity, and ductility. Metal elements readily lose electrons to form positive ions.

nonmetal: elements that do not exhibit the properties of conductivity, malleability, reactivity, and ductility. These elements tend to form negative ions. The oxides of the elements are acidic.

luster: the reflection of light from the surface of a material described by its quality and intensity.

conductivity: the property of transmitting heat and electricity.

ductility: a property that describes how easy it is to pull a substance into a new permanent shape, such as, pulling into wires.

reactivity: a property that describes how readily a material will react with other materials.





Chem Words

oxidation: the process of a substance losing one or more electrons.

alloy: a substance that has metal characteristics and consists of two or more different elements.

Checking Up

1. List five properties of metals and five properties of nonmetals.
2. Why is it important to prevent the oxidation of metals used in construction?
3. Explain the meaning of an alloy.
4. Why are alloys used?

On the other hand, silicon dioxide is an amorphous solid; you know it as glass. In glass, electrons are fixed into position and are held tightly by each atom due to covalent bonding (sharing of electrons) between silicon and oxygen atoms. Since the electrons are not mobile, the glass does not conduct an electric current like copper metal does. Glass is a nonconductor of electricity.

Preserving metal and preventing its reaction with some of the components in the air is a major task. When metals react with oxygen in the air it is called **oxidation**. This type of reaction is what happens when things rust. Preventing rust is important. While a metal like steel is very strong and makes excellent building material, once it rusts it loses all strength and flakes away. Millions of structures, tools, and vehicles are made primarily of metal. Preventing rust (also called corrosion) is essential if they are to remain in good operating condition. In order to prevent oxidation, metal surfaces can be painted, coated, or combined with another metal to make them less reactive.

Nonmetals have characteristics that are generally opposite to those of metals in every way. Instead of being lustrous, their surfaces are dull in appearance. They are nonconductive, brittle, and nonductile. Over the past 150 years, chemists have developed a chart for classifying and organizing the chemical elements. Elements are classified as metals and as nonmetals. Some other elements are called metalloids. They share some characteristics of metals and some of nonmetals.

Brass and solder are not elements but they are still classified as metals. They are commonly called **alloys**. Alloys are materials that contain more than one metal element and still maintain the characteristic properties of metals. Many metals are not practically useful because they may be too soft and are hard to work with. Gold is a good example of a metal that is too soft for jewelers to work with so they make an alloy of gold, silver, and copper. The alloy is harder and will hold its shape. Iron combined with chromium, nickel, and carbon makes the alloy called steel. This gives it the strength that it needs in construction. The brass that you investigated contains 67% copper and 33% zinc. Solder contains 67% lead and 33% tin. Alloys are classified as metal solutions and if they are uniformly mixed then they are homogeneous mixtures called solution alloys.

Reflecting on the Activity and the Challenge

As you are creating your movie special effect, you may have to build a stage set, model, or prop. It is important to consider the nature of the materials you choose before you start construction. You need to match the characteristics of the material you choose with the object you are trying to build. You need to decide if the building material should be heavy or light, flexible or rigid. Each of

the characteristics of the substance is important. The characteristics required will probably vary with each construction project. Whichever materials you do choose, you will strengthen your report by discussing the specific properties of the materials and classifying them as metals, nonmetals, or metalloids.

Chemistry to Go

- List the names of three metals you are familiar with in your daily life.
 - For each metal you listed in (a), describe two different uses for each.
- List the names of three nonmetals you are familiar with in your daily life.
 - For each nonmetal you listed in (a), describe two different uses for each.
- Examine the following objects or machines that you use every day:
 - backpack
 - bicycle
 - car

Make a list of the metals and nonmetals that make up the major components of the object. List the function and characteristics of each component.

- List two properties of a material that you can observe using your senses.
 - List two properties of a material that require tests to observe.
- Classify each of the following as a metal or nonmetal:
 - aluminum (Al)
 - iron (Fe)
 - oxygen (O)
 - carbon (C)
 - mercury (Hg)
- The way materials are used can change with time. Milk was originally delivered in glass bottles. Now cartons made from wax-coated paper and plastic jugs are used for milk. Snow skis used to be made of wood. Now they are made from fiberglass or graphite. What factors go into decisions about changing what materials should be used when building a product?



Inquiring Further

The effect of heat treatment on the property of a metal

It is possible to change the characteristics of a material by treating them in various ways. Determine the effect of heat on a metal. Obtain a few paper clips or bobby pins from your teacher. As a control, determine how many times it takes to bend the clip or pin back and forth in order to break it. The stress at the point of bending causes the paper clip or bobby pin to break.

Now try some various types of heat treatment to see what effect they have on the metal. Try heating the piece in the flame of a burner until it is red. To do this, hold the piece with tongs or forceps. Allow the piece to cool on its

own until it is safe to handle. Then try to break it again, being careful to bend it back and forth exactly as you did with the control. Record your results and try another heating scheme.

Consider treatments such as heating to redness and then cooling by plunging into water, or heating and cooling several times, or heating, but not to redness, only heating to a moderate amount.

Record your observations and summarize what seems to be the relationship of heat treatment to the characteristics of the metal.

What characteristic of metals do you think is demonstrated by bending the metals back and forth until breaking?

