Metallic Bonds Metallic bonds are found in metals such as copper, gold, aluminum, and silver. In this type of bond, electrons are free to move from one positively charged ion to another. This free movement of electrons is responsible for key characteristics of metals. The movement of electrons, or conductivity, allows metals like copper, shown in **Figure 9,** to pass an electric current easily.

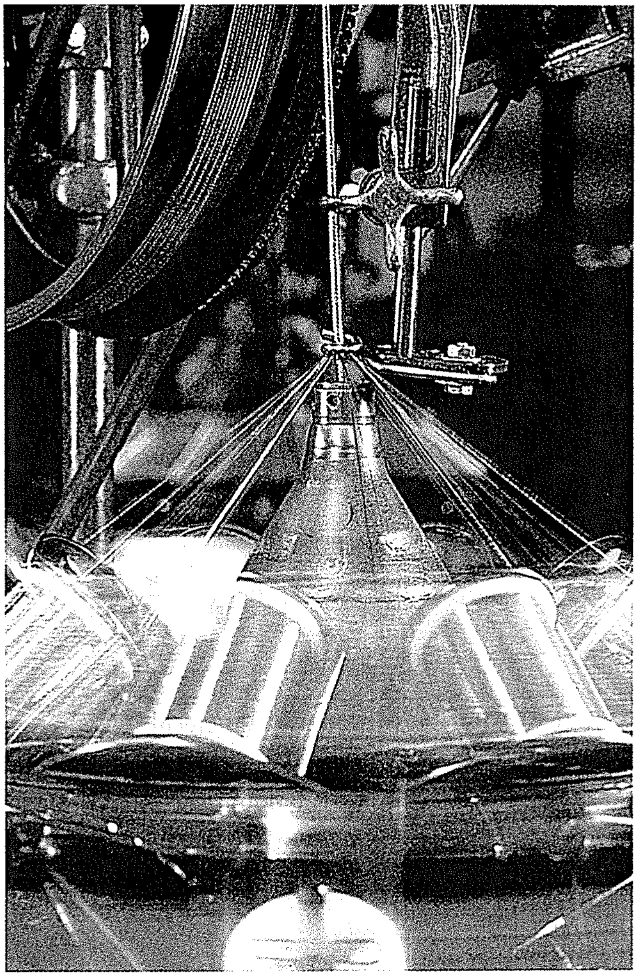
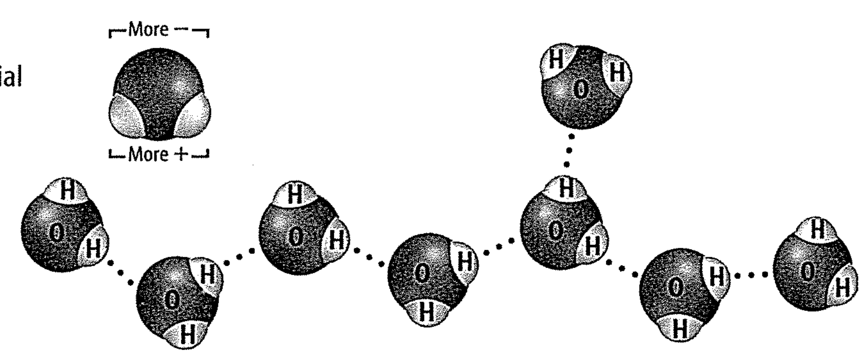


Figure 9 This machine is making cable from spools of wire. Electrons move freely along this wire, passing from one copper ion to another.
Identify *What type of bond holds copper atoms together?*

Hydrogen Bonds Some bonds, called hydrogen bonds, can form without the interactions of electrons. The arrangement of hydrogen and oxygen atoms in water molecules causes them to be polar molecules. A polar molecule has a positive end and a negative end. This happens because the atoms do not share electrons equally. When hydrogen and oxygen atoms form a molecule with covalent bonds, the hydrogen atoms produce an area of partial positive charge and the oxygen atom produces an area of partial negative charge. The positive end of one molecule is attracted to the negative end of another molecule, as shown in **Figure 10,** and a weak hydrogen bond is formed. The different parts of the water molecule are slightly charged, but as a whole, the molecule has no charge. This type of bond is easily broken, indicating that the charges are weak.

Hydrogen bonds are responsible for several properties of water, some of which are unique. Cohesion is the attraction between water molecules that allows them to form raindrops and to form beads on flat surfaces. Hydrogen bonds cause water to exist as a liquid, rather than a gas, at room temperature. As water freezes, hydrogen bonds force water molecules apart, into a structure that is less dense than liquid water.

Figure 10 The ends of polar molecules, such as water, have opposite partial charges. This allows molecules to be held together by hydrogen bonds.



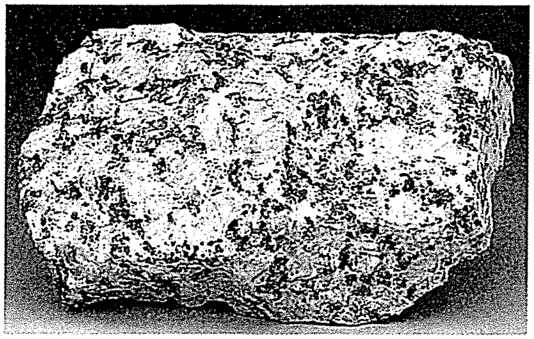


Figure 11 This rock contains a variety of mineral compounds that, together, form a mixture.

Mixtures

Sometimes compounds and elements mix together but do not combine chemically. A **mixture** is composed of two or more substances that are not chemically combined. There are two different types of mixtures—heterogeneous and homogeneous. The components of a **heterogeneous mixture** are not mixed evenly and each component retains its own properties. Maybe you've seen a rock like the one in **Figure 11.** Several different minerals are mixed together, but if you were to examine the minerals separately, you would find that they have the same properties and appearance as they have in the rock.

The components of a **homogeneous mixture** are evenly mixed throughout. You can't see the individual components. Another name for a homogeneous mixture is a **solution.** The properties of the components of this type of mixture often are different from the properties of the mixture. Ocean water is an example of a liquid solution that consists of salts mixed with liquid water.

Reading Check *What is a solution?*

Separating Mixtures

The components of a mixture can be separated by physical means. For example, you can sit at your desk and pick out the separate items in your backpack, or you can let the water evaporate from a saltwater mixture and the salt will remain.

Separating the components of a mixture is a relatively easy task compared to separating those of a compound. The substances in a compound cannot be separated by physical means. An existing compound can be changed to one or more new substances by chemically breaking down the original compound. For example, a drop of dilute hydrochloric acid (HCl) can be placed on calcium carbonate ($CaCO_3$) and carbon dioxide (CO_2) is released. Can you think of an example of a substance that could be chemically broken down?

Mini LAB

Classifying Forms of Matter

Procedure

1. Make a chart with the columns *Mixtures, Compounds,* and *Elements.*
2. Classify each of these items into the proper column on your chart: **air, sand, hydrogen, muddy water, sugar, ice, sugar water, water, salt, oxygen, copper.**
3. Make a solution using two or more of the items listed above.

Analysis

1. How does a solution differ from other types of mixtures?
2. How does an element differ from a compound?

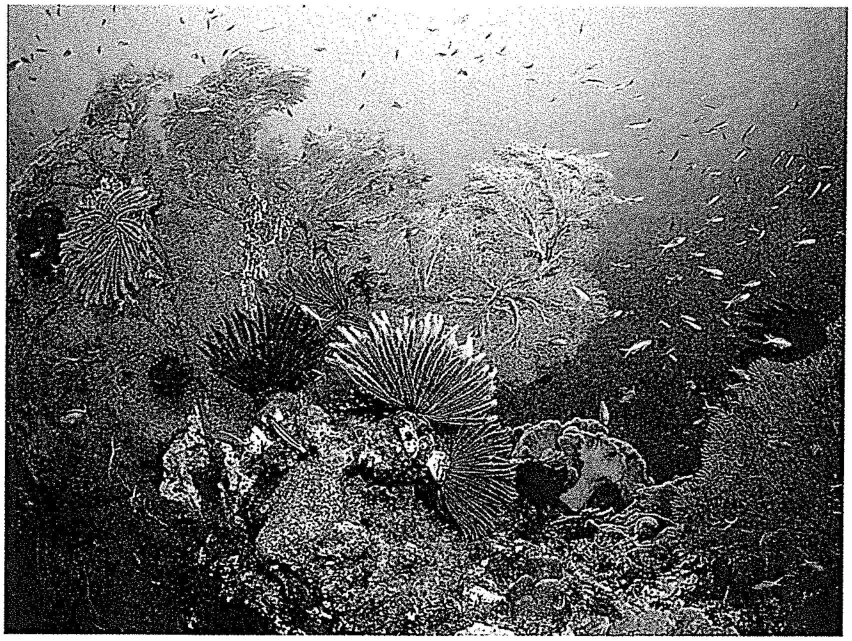


Figure 12 The ocean is a mixture of many different forms of matter. The ocean water itself is a solution, a homogeneous mixture.

Exploring Matter

Air, sweetened tea, salt water, and the contents of your backpack are examples of mixtures. The combination of rocks, fish, and coral shown in **Figure 12** also is a mixture. In each case, the materials within the mixture are not chemically combined. The individual components are made of compounds or elements. The atoms in these compounds lost their individual properties when they combined.

INTEGRATE Life Science Seashells and coral reefs contain calcium carbonate, which has the formula $CaCO^3$. Properties of $CaCO^3$ differ greatly from those of its elements, calcium, carbon, and oxygen. For example, calcium is a soft, silvery metal, oxygen is a gas, and carbon can be a black solid. In contrast, calcium carbonate is hard and white. For example, it also is found in limestone and marble.

section 2 review

Summary

Interactions of Atoms

- A compound contains atoms of more than one type of element that are chemically bonded.

Bonding

- Atoms share electrons in covalent bonds.
- Atoms lose or gain electrons in ionic bonds.
- In metallic bonds electrons move freely from one metal ion to another.
- Hydrogen bonds can form between polar molecules.

Mixtures

- A combination of two or more substances that are not chemically combined is a mixture.
- Components of a heterogeneous mixture are not mixed evenly.
- Components of a homogeneous mixture or solution are evenly mixed.

Self Check

1. **Explain** how atoms or ions combine to form compounds.
2. **Classify** sweetened tea as a solution or a compound.
3. **Infer** Why do metals transmit electricity so well?
4. **Identify** What does the formula tell you about a chemical compound?
5. **Think Critically** How can you determine whether salt water is a solution or a compound?

Applying Skills

6. **Infer** You have seen how the Na^+ ion attracts the Cl^- ion forming the compound sodium chloride, NaCl. What compound would form from Ca^{+2} and Cl^-?
7. **Design** How would you separate a mixture of sugar and sand? Devise an experiment to do this. Discuss your procedure with your teacher. Perform the experiment and write the results.

Science Online earth.msscience.com/self_check_quiz

LAB

Scales of Measurement

How would you describe some of the objects in your classroom? Perhaps your desktop is about one-half the size of a door. Measuring physical properties in a laboratory experiment will help you make better observations.

Real-World Question

How are physical properties of objects measured?

Goals

- **Measure** various physical properties in SI.
- **Determine** sources of error.

Materials

triple beam balance	rock sample
100-mL graduated cylinder	string
metersticks (2)	globe
non-mercury thermometers (3)	water
stick or dowel	

Safety Precautions

WARNING: *Never "shake down" lab thermometers.*

Procedure

1. Go to every station and determine the measurement requested. Record your observations in a data table and list sources of error.
   - **a.** Use a balance to determine the mass, to the nearest 0.1 g, of the rock sample.
   - **b.** Use a graduated cylinder to measure the water volume to the nearest 0.5 mL.
   - **c.** Use three thermometers to determine the average temperature, to the nearest 0.5°C, at a selected location in the room.
   - **d.** Use a meterstick to measure the length, to the nearest 0.1 cm, of the stick or dowel.
   - **e.** Use a meterstick and string to measure the circumference of the globe. Be accurate to the nearest 0.1 cm.

Measurement and Error

Sample at Station	Value of Measurement	Causes of Error
a.	mass = ____ g	**Do not write in this book.**
b.	volume = ____ mL	
c. (location)	average temp. = ____ °C	
d.	length= ____ cm	
e.	circumference= ____ cm	

Conclude and Apply

1. **Compare** your results with those provided by your teacher.
2. **Calculate** your percentage of error in each case. Use this formula.

$$\% \text{ error} = \frac{\text{your val.} - \text{teacher's val.}}{\text{teacher's val.}} \times 100$$

3. Being within five to seven percent of the correct value is considered good. If your error exceeds ten percent, what could you do to improve your results and reduce error?

Communicating Your Data

Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**

section 3

Properties of Matter

as you read

What You'll Learn

- **Describe** the physical properties of matter.
- **Identify** what causes matter to change state.
- **List** the four states of matter.

Why It's Important

You can recognize many substances by their physical properties.

Review Vocabulary

energy: the ability to cause change

New Vocabulary

- density

Physical Properties of Matter

In addition to the chemical properties of matter that you have already investigated in this chapter, matter also has other properties that can be described. You might describe a pair of blue jeans as soft, blue, and about 80 cm long. A sandwich could have two slices of bread, lettuce, tomato, cheese, and turkey. These descriptions can be made without altering the sandwich or the blue jeans in any way. The properties that you can observe without changing a substance into a new substance are physical properties.

One physical property that you will use to describe matter is density. **Density** is a measure of the mass of an object divided by its volume. Generally, this measurement is given in grams per cubic centimeter (g/cm^3). For example, the average density of liquid water is about 1 g/cm^3. So 1 cm^3 of pure water has a mass of about 1 g.

An object that's more dense than water will sink in water. On the other hand, an object that's not as dense as water will float in water. When oil spills occur on the ocean, as shown in **Figure 13,** the oil floats on the surface of the water and washes up on beaches. Because the oil floats, even a small spill can spread out and cover large areas.

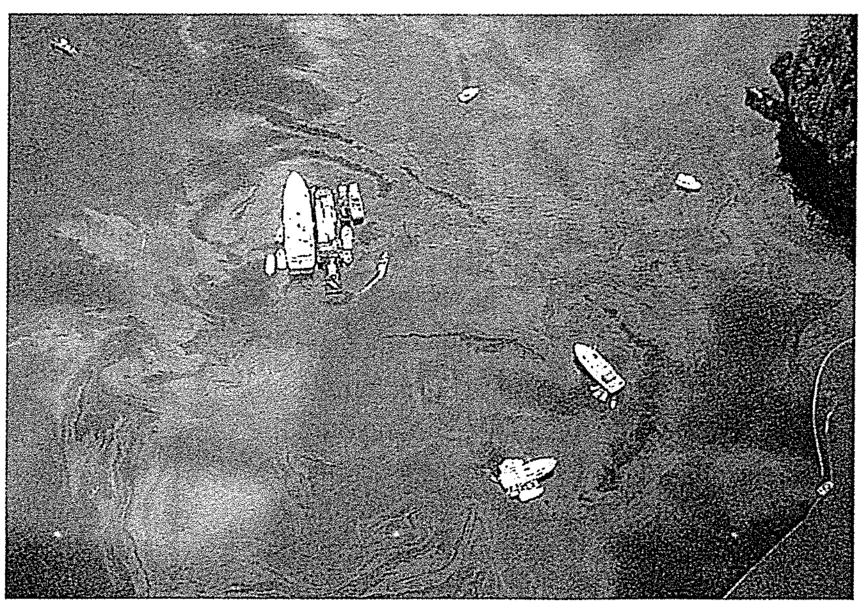


Figure 13 Oil spills on the ocean spread across the surface of the water.
Infer *How does the density of oil compare to the density of water?*

States of Matter

On Earth, matter occurs in four physical states. These four states are solid, liquid, gas, and plasma. You might have had solid toast and liquid milk or juice for breakfast this morning. You breathe air, which is a gas. A lightning bolt during a storm is an example of matter in its plasma state. What are the differences among these four states of matter?

Solids The reason some matter is solid is that its particles are in fixed positions relative to each other. The individual particles vibrate, but they don't switch positions with each other. Solids have a definite shape and take up a definite volume.

Suppose you have a puzzle that is completely assembled. The pieces are connected so one piece cannot switch positions with another piece. However, the pieces can move a little, but stay attached to one another. The puzzle pieces in this model represent particles of a substance in a solid state. Such particles are strongly attracted to each other and resist being separated.

Applying Math — Solve One-Step Equations

CALCULATING DENSITY You want to find the density of a small cube of an unknown material. It measures 1 cm × 1 cm × 2 cm. It has a mass of 8 g.

Solution

1. *This is what you know:*
   - mass: $m = 8$ g
   - volume: $v = 1 \text{ cm} \times 1 \text{ cm} \times 2 \text{ cm} = 2 \text{ cm}^3$
   - $d = m/v$
2. *This is what you need to find out:* density: d
3. *This is the procedure you need to use:*
   - substitute: $d = 8 \text{ g}/2 \text{ cm}^3$
   - Divide to solve for d: $d = 4 \text{ g/cm}^3$
   - The density is 4 g/cm^3
4. *Check your answer:* Multiply by the volume. You should get the given mass.

Practice Problems

1. You discover a gold bar while exploring an old shipwreck. It measures 10 cm × 5 cm × 2 cm. It has a mass of 1,930 g. Find the density of gold.
2. A bar of soap measures 8 cm × 5 cm × 2 cm. Its mass is 90 g. Calculate its density. Predict whether this soap will float.

Science Online — For more practice, visit earth.msscience.com/math_practice