What Are Elements?

Elements and Atoms

All matter is made up of elements, substances that cannot be broken apart into other substances. An atom is the smallest particle of an element that still has the properties of that element. Atoms can only be seen with a microscope.

Organization of Atoms

Atoms contain negatively charged particles called electrons. Atoms also have a small core in the middle called the nucleus. Electrons move quickly around the nucleus, which is made of particles called protons and neutrons. Protons have a positive charge. Neutrons have no charge.

Atoms have the same number of protons and electrons. Atoms of a certain element all have the same number of protons in the nucleus, but the number of neutrons may vary.

Carbon is found in nature in many forms with different properties. This happens because carbon atoms can be put together in many different ways. Graphite, the "lead" in most pencils, is a form of carbon. The carbon atoms are grouped in rings of six atoms each.

Diamond is another form of pure carbon. It is the hardest natural substance on Earth because the carbon atoms are packed tightly together. No matter what form it takes, the element carbon is made up of atoms that all have the same number of protons.

Elements Alone and Joined

Most atoms join with other atoms to form molecules. A molecule is two or more atoms joined together by forces called chemical bonds. In a molecule, the atoms in some ways act together as one part. Some molecules are made up of one or more than one element. The oxygen in the air you breathe has two oxygen atoms. A molecule of water has two hydrogen atoms and one oxygen atom.

An element's properties come from the atoms that make up that element. Some properties are color, hardness, and density. The element copper is a shiny metal that can be stretched into wires. The element silver is a shiny metal that is soft enough to be formed into things like bracelets and rings. The element helium in balloons is less dense than air, causing the balloons to float. The element aluminum is a shiny metal. It is strong, but it does not weigh very much.

The Periodic Table

Scientists have named more than 100 elements. The elements are organized, or sorted out, in the periodic table.

Long ago, people in ancient Greece put forth the idea that all matter is made up of four elements: earth, air, fire, and water. But people began to understand that there must be more than just those four elements.

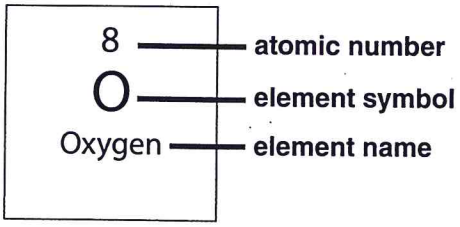
In the 1600s, an English scientist said that earth, air, fire, and water could not be real elements. In the late 1700s, a French scientist made one of the first lists of chemical elements.

By the 1800s, scientists had begun to name many new elements. They were also learning that some elements had properties that were alike. They began to organize elements into families, or groups, with properties that were alike. However, not all scientists grouped elements in the same way.

In 1869, Russian scientist Dmitri Mendeleev came up with a way to list and group the elements. He listed elements with similar properties together.

Today, scientists use a table called the periodic table. It is much like Mendeleev's table. It is called the periodic table because properties of the elements have a repeating pattern. *Periodic* means "repeating."

In the periodic table, elements are listed in order of increasing atomic number. This number tells how many protons are in an element's nucleus. The box for each element lists the atomic number, chemical symbol, and name. The chemical symbol is a shorter form of the element's name.



Classification of Elements

Colors on the periodic table show whether elements are metals, nonmetals, or semimetals. Metals are shiny, can be bent or stretched, and conduct electricity. Most elements are metals. Many nonmetals are gases. Solid nonmetals are usually dull in color. They do not conduct electricity, bend, or stretch very much. They break easily. Semimetals are like both metals and nonmetals.

Name _____ Date _____

What Are Elements?

Match each definition to its term.

Definitions

____ **1.** a substance that cannot be broken apart into other substances

____ **2.** the smallest particle of an element that still has the properties of that element

____ **3.** the negatively charged particles that make up part of every atom

____ **4.** the central core of an atom

____ **5.** a particle in the nucleus with a positive charge

____ **6.** a particle in the nucleus with no charge

____ **7.** two or more atoms joined by chemical bonds

Terms

a. electrons

b. nucleus

c. proton

d. molecule

e. neutron

f. element

g. atom

Fill in the blanks.

8. In 1869, Russian chemist Dmitri Mendeleev developed a way to classify

_____.

9. The modern periodic table is a table in which the elements are arranged by their

_____.

10. Elements are arranged in order of increasing _____ number, which is the number of protons in the nucleus.

11. The colors of the boxes show whether elements are _____,

_____, or _____.

12. _____ have properties of both metals and nonmetals.

Name _____ Date _____

13. Main Idea What are the tiny particles that make up an atom?

_____

14. Vocabulary What information about each element is contained in its box in the periodic table?

_____

_____

15. Reading Skill: Compare and Contrast Explain how diamond and graphite are similar and how they are different.

_____

_____

16. Critical Thinking: Analyze Suppose you are given a sample of an element. You are asked to identify the element as a metal or a nonmetal. What are some properties you would look for? Explain.

_____

_____

17. Inquiry Skill: Predict A uranium atom has 92 protons in its nucleus. Use what you know about atoms to predict how many electrons a uranium atom has.

_____

_____

18. Test Prep The properties of semimetals are

A more like metals.

B more like nonmetals.

C somewhat like metals and somewhat like nonmetals.

D somewhat like gases.

What Are Compounds?

Combining Elements

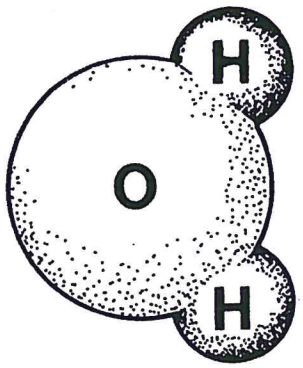
When two or more elements are chemically joined, they form a compound. Compounds, like elements, are pure substances. They have different properties from the elements that make them. In many compounds, atoms come together to form molecules. Each molecule of a compound has the same chemical properties.

At one time, people thought water was an element. However, an element cannot be broken down into other substances. Scientists figured out that water is not an element when they broke it down into other substances.

Water is a compound made of the elements hydrogen and oxygen. A compound is a substance made up of two or more elements that are chemically joined. Every molecule of water has two hydrogen atoms and one oxygen atom.

A compound has its own chemical properties. In many compounds, atoms come together to form molecules. Each molecule of a compound acts in the exact same way. They all have the same chemical properties.

All water molecules are made up of two hydrogen atoms and one oxygen atom. Every molecule of water has the properties of water. These properties are different from the properties of hydrogen and oxygen.



water molecule

Many Compounds

Many compounds are found in nature, and many are made of two elements. When you breathe out, your breath contains a compound called carbon dioxide. Molecules of carbon dioxide are made up of one carbon atom and two oxygen atoms.

Rust is a compound called iron oxide. It is made of iron and oxygen. When iron joins with oxygen in the air, rust forms. Water makes this change happen even faster.

Making and Breaking Compounds

To form a compound, atoms of the elements in the compound must take part in a chemical reaction. A chemical reaction is a process in which one or more substances are changed into one or more different substances.

Energy is an important part of all chemical reactions. Energy is needed to break apart compounds. When elements join to form compounds, energy is let go.

Compounds and Formulas

A chemical formula is a short way to describe a chemical compound. Chemical formulas use chemical symbols to show which elements are in a compound. For example, the chemical symbol for iron is Fe. The chemical symbol for sulfur is S. The chemical formula for iron sulfide is FeS. There is one iron atom for every sulfur atom.

Often a compound has more of one element than another element. A number in the chemical formula tells you how many atoms of that element are in the compound. The chemical formula for water is H_2O. This means that there are two hydrogen atoms for every one oxygen atom.

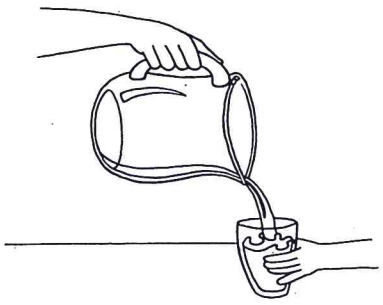
Water

Water is everywhere on Earth. About three-fourths of Earth's surface is covered with water. All forms of life depend on water to live.

Water is different from other compounds. It is one of the few compounds that is liquid at room temperature. It is also able to dissolve, or break down, more substances than any other liquid.

One reason water has these properties is because of its shape. Water molecules have a bent shape. This gives the oxygen end of the molecule a bit of a negative charge and the hydrogen end a bit of a positive charge. These differences make water able to dissolve many compounds.

The charges also draw the hydrogen and oxygen ends of different water molecules together. This is why water is a liquid at many temperatures.



Name _____ Date _____

What Are Compounds?

Write answers to the questions on the lines below.

1. What is a compound?

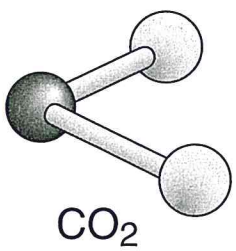
2. What happens during a chemical reaction?

3. What is the chemical formula that has two hydrogen atoms and one oxygen atom?

4. What elements does the compound iron oxide (Fe_2O_3) have?

5. What is needed to create chemical reactions?

6. What unique properties does the compound water have?



CO_2

chemical formula for carbon dioxide

Name _____ Date _____

7. **Main Idea** Why can elements be called the building blocks of matter?

_____

_____

8. **Vocabulary** In your own words, define *chemical formula*.

_____

_____

9. **Reading Skill: Compare and Contrast** How are elements and compounds alike? How are they different?

_____

_____

_____

10. **Critical Thinking: Apply** Research some compounds other than the ones mentioned in this lesson. Pick one example and explain how you know it is a compound.

_____

_____

11. **Inquiry Skill: Infer** Ty added water to a mixture of two other substances. A short time later, he observed that one substance had turned green and another had turned orange. What might Ty infer?

_____

_____

12. **Test Prep** Elements and compounds

A are pure substances.

B are made up of atoms.

C have specific properties.

D are all of the above.

How Can Materials Be Identified?

Using Your Senses

Every kind of material is some form of matter with specific properties, or traits. Properties can be used to help identify pure substances like elements and compounds and to tell one kind of matter from another.

Two kinds of properties can be used to describe and group matter—physical properties and chemical properties. Think about a sheet of paper and a sheet of tin foil. Both are thin, flat, and bend easily. These are physical properties. Also note that paper will burn and tin will not. Burning is a chemical property.

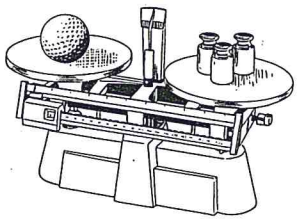
A physical property can be measured or noticed by the senses. Some physical properties are state, size, color, and smell. Many physical properties, such as volume, mass, and density, can be measured.

A chemical property is the ability of a material to change its chemical makeup. Materials are made of much smaller parts—atoms and molecules. When there are changes in the way that the atoms and molecules are put together, a new material is formed. The new material has different properties from the first material.

You can discover a material's chemical properties by noticing how it changes when different things happen to it. When a piece of paper is held in a flame, the paper will burn. Burning is a chemical change in which matter joins with oxygen. Burning paper makes new matter that is very different from the paper and oxygen.

Mass, Volume, and Density

Mass is a measure of the amount of matter in an object or material. It can be measured on a scale in grams (g) or kilograms (kg). A large object has more matter, and more mass, than a smaller object of the same material.



Volume is the amount of space matter takes up. The volume of a solid can be measured in cubic centimeters (cm^3). Liquid volumes can be measured in liters (L) or milliliters (mL). One cubic centimeter equals one milliliter. You can find the volume of a rectangular solid by multiplying its length, width, and height.

Density is not the same as mass. The density of a material is its mass per unit volume. To find the density of a material, divide the measurement of mass by the volume.

All amounts of an element or compound that are kept in the same way have the same density. That means that a drop of pure water and a large amount of pure water both have a density of 1 g/mL. This is the density of pure liquid water. Liquids with other densities are not pure water.

Melting and Boiling Points

State of matter is another physical property. The three states of matter are solid, liquid, and gas.

Solids are firm. They have an exact shape and volume. Liquids flow. They take on the shape of their container but keep the same volume. Gases have no real shape or volume. They can move and fill any container.

When enough energy is added to a solid, it melts to make a liquid. The temperature at which a solid changes to a liquid is its melting point. When enough energy is taken away from a liquid, it freezes to make a solid. A substance always has the same freezing point and the same melting point. When enough energy is added to a liquid, it changes to a gas. The temperature at which this happens is its boiling point.

Solubility

The measure of how much of one substance can dissolve in another is called solubility, another physical property of matter. Some substances are very soluble in water but not in other liquids, such as alcohol.

Conductivity

Another physical property of matter is conductivity. The conductivity of a material is its ability to carry energy. Electrical conductivity has to do with carrying electricity. Thermal conductivity has to do with carrying heat.

Most metals are good conductors of both electricity and heat. Copper is used both in pots and pans and in electrical wires.

Materials that have low conductivity, such as rubber and plastic, are used to protect conductors. In an electric cord, plastic around the metal wire keeps the electricity and heat from leaving.