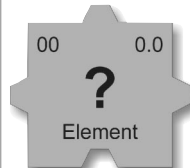


Integrated Physics & Chemistry



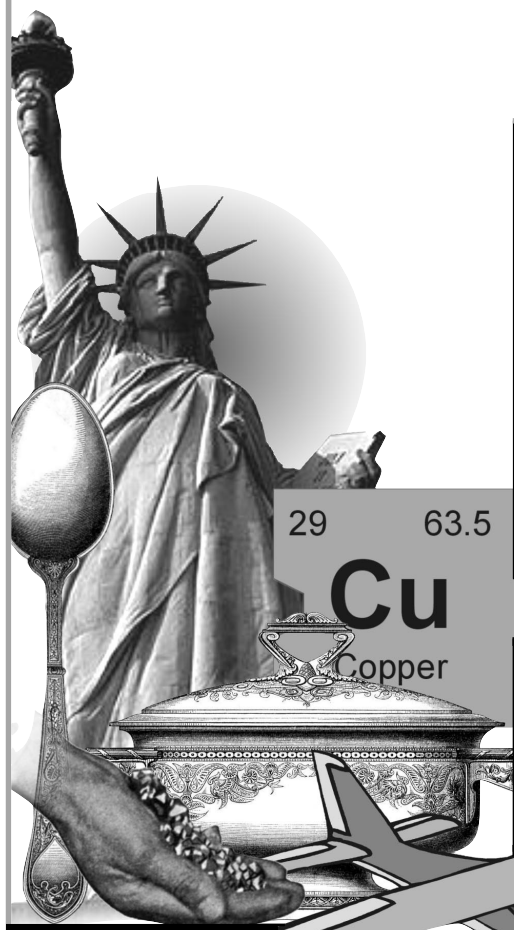
Lesson 4 Elements

Chapter 1

Section 1

Lessons 1-5

THE MONEY METALS



When Robert Boyle's definition of an element was accepted, chemists began searching for true chemical elements. They found that nine substances, known since ancient times, were elements. Seven of them are *metals*: gold, silver, copper, iron, lead, tin and mercury. Two are *nonmetals*: carbon and sulfur.

Three of the ancient metals are gold, silver and copper. As the result of their long history as mediums of exchange, these three metals are sometimes known as the *money metals*.

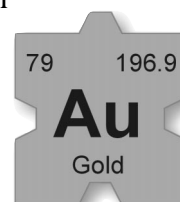
GOLD

Gold is a soft, dense and bright yellow metallic element. It is the most valuable of the money metals. The chemical symbol is *Au* from the Latin

(Roman) word for gold, *aurum*. In a chemical symbol, the first letter is always written in upper case, and the second letter, if any, is always written in lowercase. Notice the chemical symbol, *Au*, above.

Most metals are *malleable*. They are easily beaten into thin sheets. Most metals are also *ductile*, meaning they are easily drawn to form thin wires. Pure gold is the most malleable and ductile of all metals. An ounce of gold can be drawn into a wire 62 miles in length.

Gold is heavy. A cubic foot of gold weighs more than 1,200 pounds. Gold's *specific gravity* is 19.3. Specific gravity compares the weight of gold to that of water. With a specific gravity of 19.3, gold weighs 19.3 times as much as an equal volume of water.



VOCABULARY

Ductile: easily drawn into a wire

Emulsion: a mixture of liquids that do not dissolve in each other; a colloidal mixture

Impurity: component in a substance that is not expected or wanted; a contaminant



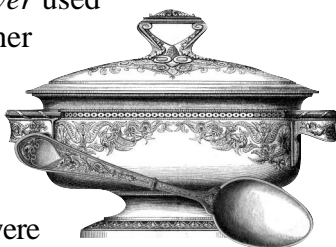
Gold is relatively inactive chemically. Most acids do not react with it. However, the acid *aqua regia* (Latin for *water royal*) will react vigorously with gold. Aqua regia is a mixture of nitric acid and hydrochloric acid. When they mix, chlorine is freed. The chlorine attacks the gold and dissolves it.

SILVER

After gold, *silver* is the most ductile and malleable metal. Silver is a white, lustrous metallic element. The most common ore of silver is *Argentite*, a silver sulfide. The chemical symbol for silver is Ag from its Latin (Roman) name *argentum*. It is the most efficient conductor of heat and electricity. During World War II, when copper came in short supply, silver was used for some electrical wiring for national defense applications. Silver has a specific gravity of 10.5. A cubic foot of silver weighs more than 600 pounds.

Consider the properties of silver. It is shiny, can be hammered into different shapes and conducts electricity. Silver is both beautiful and rare. It has a long history for use as tableware, ornaments and money. Joseph, during biblical times, was sold into slavery for twenty pieces of silver. Later, when he became governor of Egypt, Joseph sold grain to people who paid in silver, copper and gold coins.

Silver is harder than gold but softer than copper. To help silver resist wear, a small amount of copper is added. An alloy is a mixture of two or more metals melted together. *Sterling silver* used for tableware and other objects is 92.5 percent silver and 7.5 percent copper. For many years in the United States, coins were



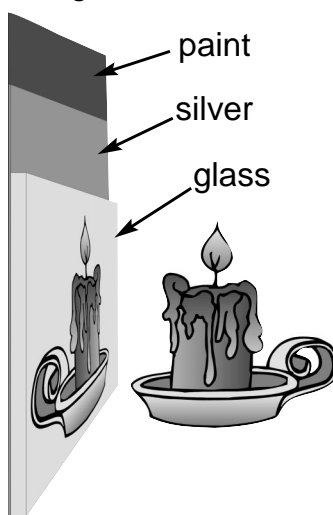
made of silver alloy, which consists of 90 percent silver and 10 percent copper. In 1965, silver was eliminated from dimes and quarters.

Like gold, silver is relatively inert. It does not unite with oxygen in the air, even when heated. Silver does not rust; however, it will tarnish when exposed to sulfur. Eggs, which contain a considerable quantity of sulfur, tarnish silver very quickly. Sulfur coats the surface of silver with a brownish-black layer of the compound, silver sulfide. The chemical formula for silver sulfide is Ag_2S . The subscript 2 shows that two silver atoms are present for each sulfur atom.

Sulfur is found naturally in the air. Factories that burn coal add more sulfur to the air. Sulfur is added to natural gas as a safety signal. In case of a gas leak, a sulfur compound is added to natural gas to give gas a penetrating odor like the smell of rotten eggs.

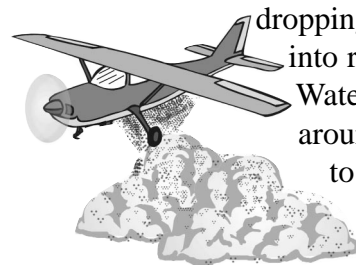
Pure silver has a brilliant, white luster. It reflects visible light better than any other metal. In ancient times, mirrors were made of polished silver. In the 1800s, with the start of the industrial age, the extra sulfur in the air from factories caused silver mirrors to tarnish quickly. To keep the silver shiny, it was coated with paint on the backside, and the front layer of silver was protected with a glass. Sealed against the air in this way, the silver mirror was protected from tarnish caused by sulfur.

Diagram of ancient mirror



One of the most important uses of silver is in photographic film. A compound of silver with the nonmetal bromide becomes sensitive to light. Most photographic **emulsions** contain silver bromide. When light strikes the film, a latent (hidden) image is formed. The latent image can be made visible by the application of a development solution.

Scientists use silver to make rain. Cloud seeding is done from an aircraft by dropping silver iodide flares into rain-bearing clouds. Water vapor condenses around the silver iodide to form tiny droplets. The smaller droplets then merge into larger raindrops that eventually fall to the Earth. Because of the unpredictable nature of this process, rain made by seeding clouds is not guaranteed to succeed.

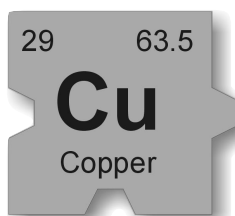


Usually, silver is extracted from raw ore while other metals are processed. Silver is often found with copper, lead and zinc. Because it is so valuable, silver is recycled. Most new silver products are the result of recycling existing silver objects. Photographic film is saved and processed so the silver can be recovered and used again.

COPPER

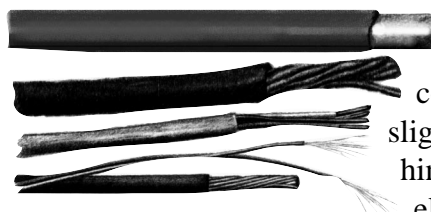
Copper is a metallic element. It is an excellent conductor of heat and electricity. The chemical symbol of copper is *Cu*, from the Latin (Roman) word *cuprum*. Cuprum is the ancient name for the island of Cyprus, famous in earlier times for its copper mines.

Pure copper has a reddish brown color. Pure copper and gold are the only two colored metals. All other metallic elements are silver white in color.



Copper's specific gravity is 8.96. A cubic foot of copper weighs more than 500 pounds. Gold's specific gravity is 19.3. A bar of copper weighs about half as much as a bar of gold the same size ($8.96/19.3 = 0.464$, or about $\frac{1}{2}$ as expressed in fraction form).

Copper has many uses. It conducts electricity and heat, resists corrosion, can be hammered and drawn and has a pleasing luster. Copper's principal use today is in electrical applications. Copper is not the best conductor of electricity. Silver is better, but copper is a close second. If silver were rated as 100 for its conductive properties, then copper would be a 96. Gold is 67. Copper is almost as good as silver and considerably cheaper; therefore, copper is used for electric wires. Copper is very ductile and can be drawn into wires of almost any size (from wires one inch thick to wires only $\frac{1}{1000}$ inch in diameter).



Wires must be made of pure copper because the slightest **impurity** will hinder the flow of electricity. An

impurity is a part in a substance that is not expected or wanted. Two of the impurities usually found in copper are silver and gold. The cost of mining and refining copper is offset by the recovery of these more expensive impurities.

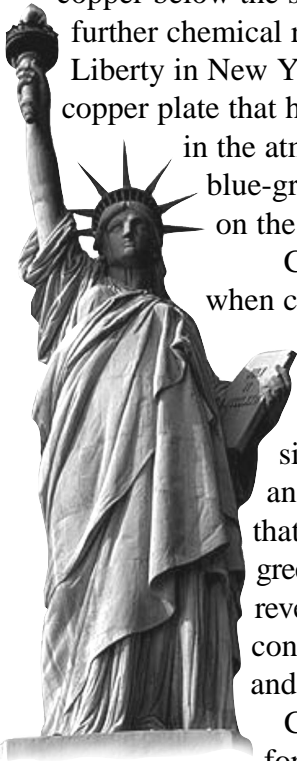
Malachite is the best known copper ore. Freeing copper from malachite is not difficult. A hot fire made by burning wood will do it. Malachite has a rich, green color. It can be polished and used as an ornament or in making jewelry.

Copper is not as inert as gold or silver. Copper slowly turns green as it combines with sulfur compounds in the air, especially in moist climates. This green tarnish forms a protective coating that shields the

copper below the surface from any further chemical reaction. The Statue of Liberty in New York Harbor is made of copper plate that has reacted with sulfur in the atmosphere causing a blue-green coating to form on the copper.

Care must be taken when copper is alloyed with other metals such as silver. If too much copper is used, the silver alloy will tarnish and turn green. A ring that turns your finger green, for example, reveals the fact that it contains a cheaper alloy and is not pure silver.

Copper has been used for coins throughout recorded history and has also been fashioned into utensils such as knives and swords.



Pure copper is too soft for good knife blades or other cutting tools. It dulls too easily. As an alloy with other metals, however, copper becomes very useful. *Bronze* is an alloy of copper mixed with tin. *Brass* is an alloy of copper with zinc. Either alloy gives copper superior strength. Knives made of bronze have a hard edge.

In ancient times, bronze was used to make knives, swords, shields and tools. In Egypt, bronze tools were used to cut and shape stones used to make the pyramids. In Greece, one of the great statues of the ancient world, the Colossus of Rhodes, was made of bronze. The Colossus, a one hundred-foot high statue, was considered one of the seven wonders of the ancient world. The Colossus was located on a small island in the Aegean Sea off the port of Rhodes, Greece.



The next lesson tells why iron rusts and how tin cans caused the death of explorers in the South Pole.

Life Principle

“The will to win,
the desire to succeed,
the urge to reach
your full potential. . .
these are the keys that
will unlock the door
to personal excellence.”

—Eddie Robinson

