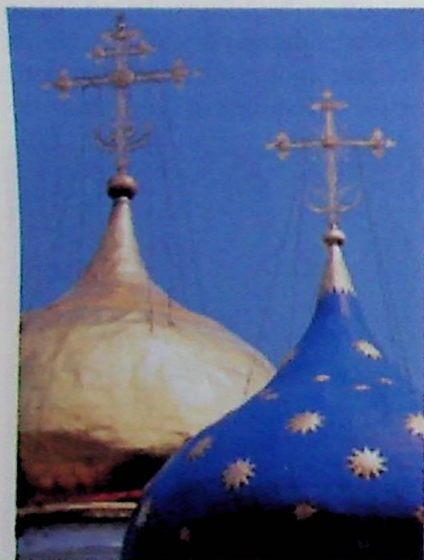




(a)



(b)

Figure 1.21 (a) Gold can be hammered so thin that light passes through it, as illustrated here, where you can see the light of a candle through a thin sheet of gold. (b) Gold leaf can be used to coat cathedral domes, adding not only beauty but also protection from corrosion. (Part a, Chip Clark; part b, Thierry Borredon/Stone. Both from L. L. Jones and P. W. Atkins, *Chemistry*, 4th ed. © 2000 by L. L. Jones and P. W. Atkins. W. H. Freeman and Company, 2000.)

gold jewelry sold in North America is 14-carat gold. We can see what fraction of the alloy is actually gold by rearranging the above formula:

$$\text{fraction that is gold} = \text{carats}/24 = 14/24 = 0.58$$

In other words, a 14K gold brooch is 58% gold. The other components are 26% copper, 13% silver, and 3% zinc. The alloy having the smallest fraction of gold that is allowed in jewelry is 10K in the United States, 9K in Great Britain and 18K in France.

Exercise 1.4

- Calculate the number of carats in alloys that contain 50% and 33% gold by mass respectively.
- Calculate the fraction of gold in alloys that are called 10-carat and 22-carat gold respectively.

Summarizing the Main Ideas

Matter is anything that has mass and occupies space. About 100 substances are elements. Elements cannot be separated into two or more components and are the fundamental components of all materials. Most elements are metals; the remainder are collectively known as nonmetals. Each element is assigned its own symbol, usually an abbreviation of its English name.

At the smallest level of subdivision, matter is found to consist of individual atoms, each of which is about 10^{-10} meters, or a tenth of a nanometer, in diameter. Atoms are indestructible by ordinary means.

Compounds are substances composed of two or more elements in a fixed ratio. Compounds cannot be easily separated into their component elements. Compounds usually behave very differently from their constituent elements. Together, elements and compounds comprise the class of materials known as pure substances. Many materials consist of two or more pure substances that are simply mixed together. The mixtures can be separated into components without using drastic conditions. A homogeneous mixture, also called a solution, has a uniform composition throughout. A mixture without uniform properties is called a heterogeneous mixture. Mixtures that to the unaided eye appear homogeneous but that actually consist of microscopic particles of one substance dispersed in another are called colloids.

Mixtures of metals are called alloys; some are homogeneous and others are heterogeneous. The characteristic properties of metals are that they are shiny, opaque, malleable, ductile, and good conductors of heat and electricity.

In liquid and solid states of matter, neighboring particles touch, and they move relatively little. In the gaseous state, the individual particles are on average very distant from one another. Thus gases are mainly empty space in which the particles move.

Many pure substances consist of small numbers of atoms held tightly together in independent particles called molecules. The number of atoms of each type is the same in all the molecules of a substance. The formula for a molecule lists the symbol for each of its atoms, followed in each case by a subscript that indicates the number of them that are present. The alternative to the occurrence of pure substances as molecules is an extended network, in which a gigantic number of atoms are held together in a single particle.

The terms *element* and *compound* are used to describe the composition of the two types of pure substances. In contrast, the terms *molecule* and *extended network* describe the structure of substances at the atomic level and can apply to either elements or compounds.

Key Terms

matter	amorphous	insoluble	diatomic
element	compound	heterogeneous mixture	polyatomic
metal	pure substance	colloid	molecular formula
nonmetal	metalloid	emulsion	liquid crystal state
atom	mixture	emulsifying agent	alloy
nearest neighbor	homogeneous mixture	condensed state of matter	interstitial alloy
extended network	solution	pressure	substitutional alloy
crystal	soluble	molecule	carat

Websites of Interest

To link to websites of interest, go to www.whfreeman.com/chemistryinyourlife, Chapter 1, and select the site you want.

Elements

[WebElements](#). This site has an interactive periodic table, pictures of elements in their pure form, crystal structures, expanded lattice structures, links to more pictures, information about compounds, biological occurrences and uses, and miscellaneous information about each element. It is maintained at the University of Sheffield (England).

Mercury

[Agency for Toxic Substances and Disease Registry](#). This site contains information about various forms of mercury, routes of exposure to mercury, how mercury enters and leaves the body, effects of mercury on health, exposure levels and harmful health effects, medical tests to measure mercury exposure, and federal government recommendations, standards, and regulations regarding mercury exposure.

[Michigan State University Office of Radiation, Chemical, and Biological Safety](#). This site links to a table of mercury-containing products and uses of mercury. It also provides details on mercury history, uses, exposure scenarios, metabolism, toxicity, and regulations governing use and exposure.

[Minnesota Pollution Control Agency](#). This site contains information about mercury in fish, health issues relating to fish consumption, environmental factors and mercury levels in fish, mercury production as a by-product of burning coal and garbage, and links to other sites.

[Office of Air and Radiation of the United States Environmental Protection Agency](#). This site contains a mercury study report to Congress with information about mercury presence in the environment, emissions and deposition in the United States, public health impacts, environmental impacts, control technologies, and links to other government documents.

United States Environmental Protection Agency. This site contains mercury fact sheets, information about mercury in medical waste, Great Lakes mercury presence and monitoring information, United States–Canadian strategies for dealing with mercury emissions, emission inventories, a case study of mercury product substitution in Broward County, Florida, and links to other sites.

Liquid Crystal Displays

How Stuff Works. Type in keyword “LCD” for an article that discusses how LCDs work, types of liquid crystals, and how to build an LCD.

Dental Amalgam

Alberta Dentist Association. This page contains fact sheets about mercury amalgams. Included is information about absorption of mercury from dental amalgams and its potential biological effects.

American Dental Association. This page contains information about dental amalgams. It also has links to research articles, news releases, and current information about issues surrounding mercury and mercury-free dental amalgams.

Nickel Sensitivity and Hypoallergenic Jewelry

SimplyWhispers. This website is maintained by a company that conducts research on and produces hypoallergenic jewelry. This site links to news articles, current research, the Academy of Dermatology, and other sources for current information about nickel allergies, hypoallergenic jewelry, and even the hazards of body piercing.

Gold

Chard Jewelers. This site contains a lot of information on gold, gold alloys, properties of gold and gold alloys, tables of information, and facts about gold jewelry.

For Further Reading

M. D. Lemonick, “Will Tiny Robots Build Diamonds One Atom at a Time?” *Time*, June 19, 2000, pp. 64–67. A look at nanotechnology and the potential for molecular-level manipulation of materials.

“Why Doesn’t Stainless Steel Rust?” *Scientific American*, August 2001, p. 96. A metallurgical engineer answers the question in a short article. The complete text can also be accessed by going to www.whfreeman.com/chemistryinyourlife and choosing Scientific American: Ask the Experts.

Review Questions

1. What is the primary concern of the subject of chemistry?
2. Which of the following properties are characteristic of metals?
 - a) They are brittle.
 - b) They conduct heat.
 - c) They are ductile.
3. What are three other characteristic properties of metals, as listed by scientists?
4. Name five metallic elements and five nonmetallic ones, and give the symbol for each.
5. What does *nanotechnology* deal with?
6. What is a *pure substance*?
7. Are the characteristics of a compound the same as those of its elemental components? Provide an example to support your answer.
8. What is a *metalloid*?
9. How does a homogeneous mixture differ from a heterogeneous mixture?
10. Explain what a *colloid* is, and give an example of one.
11. Explain the difference between an *emulsion* and a *gel*. From your experience, provide an example of each.
12. What does an *emulsifying agent* do? Name one.
13. Identify the three common states of matter and provide an everyday example of each.
14. How are solids similar to liquids? How are they different?
15. How does a gas differ from solids and liquids?
16. What is a *condensed state*? What are the two common condensed states of matter?
17. Describe the scientific model of gases.
18. What is *pressure*?

19. How is a molecule different from an atom?
20. Define the term *diatomic molecule*. Give two examples, including their formulas.
21. What is a *polyatomic molecule*?
22. What information does the *chemical formula* of a molecule contain?
23. Explain what each of the chemical formulas below tells you:
 - a) H_2
 - b) O_2
 - c) H_2O
24. What can you say about the composition of the compound called glucose from knowing that the formula for a molecule of it is $C_6H_{12}O_6$?
25. What is a *liquid crystal*?
26. Identify some potential consequences of the contact of metals with the human body.
27. Where is mercury found in the environment?
28. In what form is mercury most toxic? What are some symptoms of mercury poisoning?
29. What is an *alloy*?
30. What is an *interstitial alloy*?
31. What is a *substitutional alloy*? Give two examples, including the names of the elements that they contain.
32. What are *amalgams*? What metal elements can be found in dental amalgams?
33. Identify the following as elements or alloys:
 - a) gold
 - b) bronze
 - c) silver
 - d) brass
34. How are compounds, mixtures, and alloys different from one another? How are they the same?
35. From your experience, provide an example of:
 - a) a compound
 - b) a mixture
 - c) an alloy
36. Explain what is meant by the term *carat* as applied to gold alloys.
37. What are the other elements commonly included in alloys of gold?

Understanding Concepts

38. What accounts for the ductility and malleability of metals?
39. Explain the difference between:
 - a) an *element* and a *compound*
 - b) a *compound* and a *mixture*
40. Classify each of the following as a likely element, compound, solution, or heterogeneous mixture based upon what you know about the substance. Specify the reasoning you use to decide on the classification in each case:
 - a) white sugar b) your skin c) wood
 - d) nickel e) salty water
 - f) a well-stirred mixture of salt and pepper
41. Pure alcohol and water can be mixed in any proportion to produce a liquid that is homogeneous. Would the resulting liquid be classified as a compound or as a solution?
42. Is air a pure substance, a homogeneous mixture, or a heterogeneous mixture? Explain your reasoning.
43. Classify each of the following as a likely element, compound, solution, or heterogeneous mixture based upon what you know about the substance. Specify the reasoning you use to decide on the classification in each case:
 - a) smog
 - b) helium gas
 - c) soup
 - d) cream
 - e) copper wire
 - f) soil
 - g) oil-and-vinegar salad dressing
44. Write the molecular formula for the pure substances whose molecules each contain
 - a) two atoms of hydrogen and two of oxygen
 - b) one atom of carbon and four atoms of hydrogen
 - c) two atoms of bromine
 - d) two atoms of carbon, six atoms of hydrogen, and one atom of oxygen

45. Sucrose is a pure substance whose molecules each contain 12 atoms of carbon, 22 of hydrogen, and 11 of oxygen. What is its formula?
46. Is a colloid the same as an emulsion? Explain.
47. What is the difference in structure at the atomic level between a material that forms a crystal and one that is amorphous?
48. Using circles, draw a diagram to represent each of the following:
- a) element having an extended network
 - b) pure substance composed of diatomic molecules
 - c) pure substance composed of polyatomic molecules
 - d) solution of two molecular substances
 - e) heterogeneous mixture of two molecular substances
49. Compare the characteristics of a liquid crystal to the liquid state and to the solid state.
50. Use the web resources at the end of the chapter to determine the type of mercury produced by the following activities:
- a) burning coal
 - b) burning garbage
 - c) medical and dental waste
 - d) agricultural practices
 - e) industrial activities
51. Use the web resources at the end of the chapter to determine what forms of mercury are found most commonly in:
- a) air
 - b) water
 - c) food
52. If a gold alloy is 70% gold and 30% silver, what is its carat rating?
53. Determine the percent gold in each of the following:
- a) 24-carat gold
 - b) 20-carat gold
 - c) 12-carat gold

Synthesizing Ideas

54. Which do you think is heavier, 100 aluminum atoms or 100 lead atoms? Explain your answer using both information in the text and what you know about each of these elements from your own experience.
55. Read the section in the text about dental amalgams. If you were designing a material for dental fillings, what properties would you want it to have?
56. Use the websites listed at the end of the chapter or other resources to answer the following questions: What form of mercury is most likely to be found in sport fish? Based upon the recommendations made by government agencies, how much fish from the Great Lakes could *you* safely eat in a one-year period?