

**CHAPTER 4****The Chemical Basis of Life****Summary of Key Concepts****Concept 4.1** Life requires about 25 chemical elements. (pp. 72–73)

*Matter* is anything that takes up space and has mass. The different types of matter are made up of one or more chemical elements. An *element* is a pure substance that cannot be broken down into other substances by chemical means. About 25 elements are essential to life. Four elements—oxygen, carbon, hydrogen, and nitrogen—make up about 96 percent of the living matter in your body. *Trace elements* make up less than 0.01 percent of your body mass. Most elements can combine chemically with other elements, forming *compounds*. Water ( $H_2O$ ) is an example of a compound. It always contains the same ratio of hydrogen (H) combined with oxygen (O).

1. What are the four most common elements in living things? \_\_\_\_\_  
\_\_\_\_\_
2. What is a difference between an element and a compound? \_\_\_\_\_  
\_\_\_\_\_

**Concept 4.2** Chemical properties are based on the structure of atoms. (pp. 74–77)

An *atom* is the smallest possible particle of an element. Atoms are made up of three even smaller parts. *Protons* have a single unit of positive electrical charge (+). *Electrons* have a single unit of negative electrical charge (–). *Neutrons* have no electrical charge. Protons and neutrons are tightly packed together in the center of the atom, forming the *nucleus*. Electrons move around the outside of the nucleus at great speed. The physical and chemical properties of an element depend on the number and arrangement of protons, electrons, and neutrons. All atoms of a particular element have the same number of protons, known as the element's *atomic number*. Some elements have different forms called *isotopes*, which differ in their numbers of neutrons. The nucleus of a *radioactive isotope* is unstable and breaks down over time, giving off matter and energy.

Chemists describe an atom's electrons as belonging to certain energy levels. For example, the lowest energy level, nearest the nucleus, can hold 2 electrons, and the second energy level can hold 8 electrons. Usually, it is the electrons in the highest occupied energy level of an atom that determine how an atom reacts with other atoms. Atoms with partly filled energy levels tend to react with other atoms, filling their highest energy levels.

3. Describe the three types of small particles within an atom and explain how they are arranged. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. How do an isotope and a radioactive isotope differ? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

5. Which atom is likely to be more chemically reactive, an atom with a partly filled energy level or an atom with all energy levels completely filled? Explain. \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

**Concept 4.3 Chemical bonds join atoms to one another. (pp. 78–80)**

When atoms share or transfer electrons, an attraction, or chemical bond, forms that holds the atoms together. An *ionic bond* is a chemical bond that occurs when an atom transfers an electron to another atom. The two atoms are now electrically charged and are called *ions*. The attraction between two oppositely charged ions holds the two ions together in an ionic bond. In contrast, a *covalent bond* forms when two atoms share electrons. The number of covalent bonds an atom can form usually equals the number of electrons needed to fill its highest occupied energy level. Two or more atoms held together by covalent bonds form a *molecule*. A *chemical reaction* occurs when chemical bonds break and new bonds form, producing one or more new substances. A chemical equation describes a chemical reaction. The equation shows the starting materials for the reaction, or *reactants*, and the ending materials, or *products*.

6. Contrast an ionic bond and a covalent bond. \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

7. What is a molecule? \_\_\_\_\_

\_\_\_\_\_

8. What happens during a chemical reaction? \_\_\_\_\_

\_\_\_\_\_

**Concept 4.4 Life depends on the unique properties of water. (pp. 81–87)**

A water molecule is made up of two hydrogen atoms each joined to one oxygen atom by a single covalent bond. Oxygen pulls electrons much more strongly than hydrogen, causing the oxygen atom to be slightly negative and the hydrogen atoms to be slightly positive. Water is a *polar molecule* because the opposite ends of the molecules have opposite electric charges. Being polar, water molecules have a weak attraction to each other and form hydrogen bonds with each other. A *hydrogen bond* is a chemical bond between two molecules formed by the attraction of a slightly positive hydrogen atom to a slightly negative atom.

Water has many unusual properties because of its polar nature and ability to form hydrogen bonds. Water has strong *cohesion*, which is the tendency of molecules of the same kind to stick together. Water molecules are also attracted to other molecules, which is called *adhesion*. Cohesion and adhesion help move water up from the roots of a plant. Water can also absorb more *thermal energy*, the energy of the motion of particles in a substance, without a large increase in temperature. *Temperature* is the measure of the average thermal energy in a substance. Unlike other substances, solid water is less dense than liquid water,

causing ice to float. Water is an important *solvent*—a substance that dissolves other substances—and forms many *solutions*. When water is the solvent, a solution is called an *aqueous solution*. In some aqueous solutions, the substance that is dissolved, called the *solute*, breaks apart into ions. A compound that adds hydrogen ions ( $H^+$ ) to a solution is an *acid*. A compound that removes  $H^+$  ions from a solution is a *base*. The *pH scale* describes how acidic or basic a solution is. Many cells are sensitive to slight changes in pH. Many biological fluids contain *buffers*, substances that resist changes in pH.

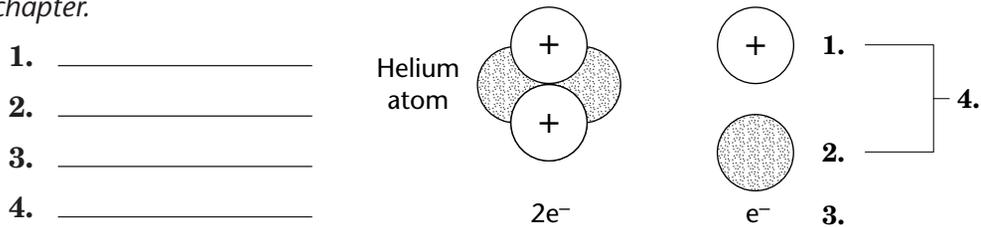
9. What causes water to be a polar molecule? \_\_\_\_\_  
\_\_\_\_\_
10. What properties of water help move it upward from the roots of a plant?  
\_\_\_\_\_
11. How does a base differ from an acid? \_\_\_\_\_  
\_\_\_\_\_

### Reading Skills Practice

**Writing an outline** Write an outline of Concept 4.4 on pages 81–86. Use the blue headings in the concept as the headings in your outline. Include the most important facts and main ideas in your outline. Be sure to include the Key Terms.

### Vocabulary Review and Reinforcement

In 1–6, study the diagram. Then fill in the blanks with the appropriate terms from the chapter.



1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. This diagram shows a(n) \_\_\_\_\_, the smallest possible particle of an element.
6. The number of protons in the atom of an element is known as the element's \_\_\_\_\_.

In 7–13, write the letter of the correct definition on the line next to each term.

- |                    |  |
|--------------------|--|
| _____ 7. solution  | a. substance that causes a solution to resist changes in pH                    |
| _____ 8. ion       | b. substance that dissolves another substance                                  |
| _____ 9. buffer    | c. electrically charged atom or group of atoms                                 |
| _____ 10. solvent  | d. range of numbers that is used to describe how acidic or basic a solution is |
| _____ 11. matter   | e. anything that takes up space and has mass                                   |
| _____ 12. pH scale | f. uniform mixture of two or more substances                                   |
| _____ 13. solute   | g. substance that is dissolved in a solution                                   |

In 14–17, write true if the statement is true. If the statement is false, replace the underlined term with a term that makes the statement true.

- \_\_\_\_\_ 14. A(n) covalent bond is a weak attraction between a hydrogen atom of one molecule and a slightly negative atom of another molecule.
- \_\_\_\_\_ 15. The starting materials for a chemical reaction are products.
- \_\_\_\_\_ 16. A(n) aqueous solution is a uniform mixture of water and another substance.
- \_\_\_\_\_ 17. Trace elements make up less than 0.01 percent of your body mass.

**WordWise**

Use the clues to identify Key Terms from the chapter. Write the terms on the lines, putting one letter in each blank. When you finish, the word enclosed in the diagonal lines will reveal the type of attraction that occurs between unlike molecules.

**Clues**

1. a molecule in which opposite ends have opposite electric charges
2. a compound that adds H<sup>+</sup> ions to a solution
3. the tendency of molecules of the same kind to stick to one another
4. a pure substance that cannot be broken down into other substances by chemical means
5. a compound that removes H<sup>+</sup> ions from a solution
6. a chemical bond that occurs when an atom transfers electrons
7. a different form of an element that has a different number of neutrons
8. a substance containing two or more elements that are chemically combined in a fixed ratio

**Key Terms**

1.	—	—	—	—	—	—	—	—	—
2.	—	—	—	—	—	—	—	—	—
3.	—	—	—	—	—	—	—	—	—
4.	—	—	—	—	—	—	—	—	—
5.	—	—	—	—	—	—	—	—	—
6.	—	—	—	—	—	—	—	—	—
7.	—	—	—	—	—	—	—	—	—
8.	—	—	—	—	—	—	—	—	—