

AP  
Biology  
Student  
Interactive  
Learning  
Guide

**North Salem University**

**MISSION:** *Engage students to continuously learn, question, define and solve problems through critical and creative thinking.*

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*This chapter covers the basics that you should have learned in your previous Chemistry class. The College Board and the Advanced Placement Program refer to this as “**prior knowledge.**” We will be going through this chapter VERY quickly. The questions and activities that follow in this Interactive Learning Guide should help you focus on the most important points of the chapter.*

*If you have any problems – feel free to drop me an email.*

**Chapter 2:**  
*The Chemical  
Context of Life*

## Chapter 2: The Chemical Context of Life

### OBJECTIVES:

#### Chemical Elements and Compounds

\_\_\_1. Distinguish between an element and a compound.

#### Exploring Life on its Many Levels

\_\_\_2. Identify the four elements that make up 96% of living matter.

#### Atoms and Molecules

\_\_\_3. Describe the structure of an atom.

\_\_\_4. Define and distinguish among atomic number, mass number, atomic weight, and valence.

\_\_\_5. Given the atomic number and mass number of an atom, how do you determine the number of its neutrons?

\_\_\_6. Explain why radioactive isotopes are important to biologists.

\_\_\_7. Explain how its electron configuration influences the chemical behavior of an atom.

\_\_\_8. Distinguish among nonpolar covalent, polar covalent, and ionic bonds.

\_\_\_9. Explain why weak bonds are important to living organisms.

\_\_\_10. Describe and compare hydrogen bonds and van der Waals interactions.

\_\_\_11. Explain how a molecule's shape influences its biological function.

\_\_\_12. Describe how the relative concentrations of reactants and products affect a chemical reaction.

### KEY TERMS:

|                   |               |                        |                      |
|-------------------|---------------|------------------------|----------------------|
| anion             | atom          | atomic nucleus         | atomic number        |
| atomic weight     | cation        | chemical bond          | chemical equilibrium |
| chemical reaction | compound      | covalent bond          | double covalent bond |
| electron shell    | electron      | electronegativity      | element              |
| energy level      | energy        | hydrogen bond          | ionic compound       |
| ionic bond        | ion           | isotope                | mass number          |
| matter            | neutron       | nonpolar covalent bond | potential energy     |
| product           | proton        | radioactive isotope    | reactant             |
| salt              | trace element | valence electron       | valence shell        |

### WORD ROOTS:

**an-** = not (*anion*: a negatively charged ion)

**co-** = together; **-valent** = strength (*covalent bond*: an attraction between atoms that share one or more pairs of outer-shell electrons)

**electro-** = electricity (*electronegativity*: the tendency for an atom to pull electrons towards itself)

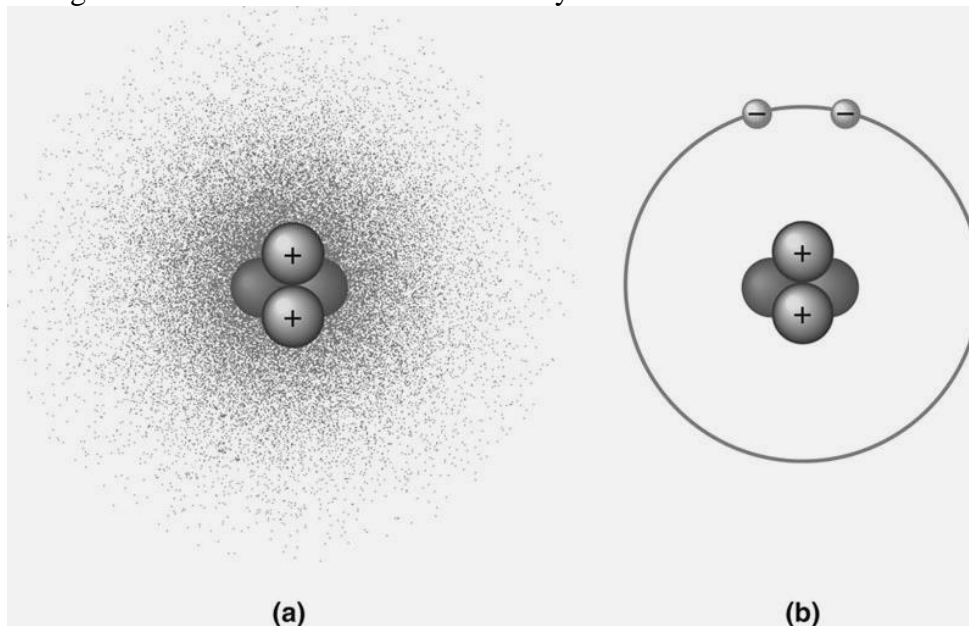
**iso-** = equal (*isotope*: an element having the same number of protons and electrons but a different number of neutrons)

**neutr-** = neither (*neutron*: a subatomic particle with a neutral electrical charge)

**pro-** = before (*proton*: a subatomic particle with a single positive electrical charge)

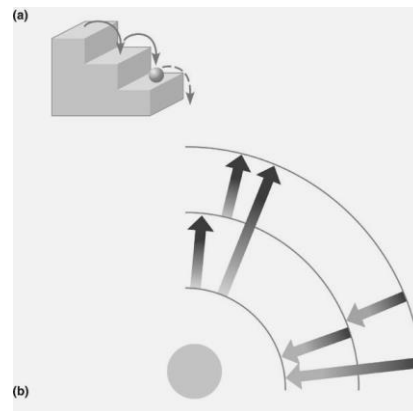
## Guided Reading: Chapter 2

1. Contrast the term element with compound.
2. Label the diagram below and define the terms that you label.



3. Contrast the terms atomic mass and atomic number.
4. What is an isotope and what is “special” about radioactive isotopes?
5. Explain how radioactive tracers (isotopes) are used in scientific research?

6. Explain how the movement of electrons relates to the concept of potential energy – use the diagram to the right to help answer the question.



7. What determines interactions between atoms and why are valence electrons important?

8. Define the following terms:

a. **Chemical bond** -

b. **Covalent bond** -

c. **Single bond** -

d. **Double bond** -

e. **Valence** -

f. **Nonpolar covalent bond** -

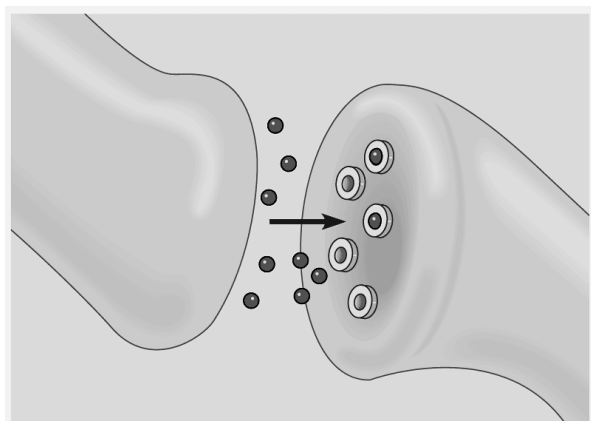
g. **Polar covalent bond** -

9. What is the difference between a structural and molecular formula?

10. Compare and contrast with ionic and covalent bonds?

11. Compare and contrast hydrogen bonds and van der Waals interactions.

12. Label the diagram and use it as an example of how molecular shape is critical to its function?



13. Define a dynamic chemical equilibrium in terms of quantities of reactants and products.  
**(This is a critical concept!)**

## Chapter 2 - Summary of Key Concepts

### CHEMICAL ELEMENTS AND COMPOUNDS

- Matter consists of chemical elements in pure form and in combinations called compounds (**pp. 26-27, FIGURE 2.2**) Elements cannot be broken down to other substances. A compound contains two or more elements in a fixed ratio.
- Life requires about 25 chemical elements (**pp. 27-28, TABLE 2.1**) Carbon, oxygen, hydrogen, and nitrogen make up approximately 96% of living matter.

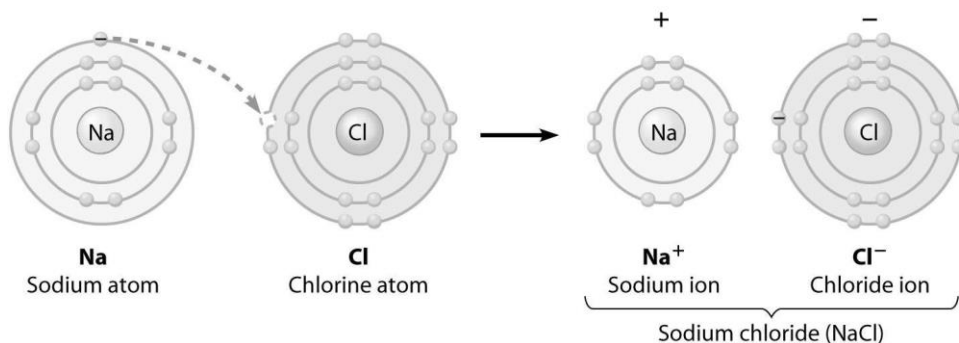
### ATOMS AND MOLECULES

- Atomic structure determines the behavior of an element (**pp. 28-33, FIGURE 2.10**) An atom is the smallest unit of an element. An atom has a nucleus made up of positively charged protons and uncharged neutrons, as well as a surrounding cloud of negatively charged electrons. The number of electrons in an electrically neutral atom equals the number of protons. Most elements have two or more isotopes, different in neutron number and therefore mass. Some isotopes are unstable and give off particles and energy as radioactivity. Electron configuration determines the chemical behavior of an atom. Electrons occupy specific energy levels, or shells, of the atom. Chemical behavior depends on the number of valence electrons, those in the outermost shell. An atom with an incomplete valence shell is reactive. Electrons move within orbitals, three-dimensional spaces with specific shapes located within successive shells.
- Atoms combine by chemical bonding to form molecules (**pp. 33-36, FIGURES 2.12 and 2.14**) Chemical bonds form when atoms interact and complete their valence shells. A covalent bond is the sharing of a pair of valence electrons by two atoms. Molecules consist of two or more covalently bonded atoms. Electrons of a polar covalent bond are pulled closer to the more electronegative atom. A covalent bond is nonpolar if both atoms are equally electronegative.  
Two atoms may differ so much in electronegativity that one or more electrons are actually transferred from one atom to the other. The result is a negatively charged ion (anion) and a positively charged ion (cation). The attraction between two ions of opposite charge is called an ionic bond.
- Weak chemical bonds play important roles in the chemistry of life (**pp. 36-37, FIGURE 2.16**) A hydrogen bond is a weak attraction between one electronegative atom and a hydrogen atom that is covalently linked to another electronegative atom. Van der Waals interactions occur when transiently positive and negative regions of molecules attract each other. Weak bonds reinforce the shapes of large molecules and help molecules adhere to each other.
- A molecule's biological function is related to its shape (**pp. 37-38, FIGURE 2.17**) A molecule's shape is determined by the positions of its atoms' valence orbitals. When covalent bonds form, the s and p orbitals in the valence shell of an atom may combine to form four hybrid orbitals that extend to the corners of a tetrahedron; such orbitals are responsible for the shapes of H<sub>2</sub>O, CH<sub>4</sub>, and many more complex biological molecules. Shape is usually the basis of the recognition of one biological molecule by another.
- Chemical reactions make and break chemical bonds (**pp. 38-39**) Chemical reactions change reactants into products while conserving matter. Most chemical reactions are reversible. Chemical equilibrium is reached when the forward and reverse reaction rates are equal.

## Chapter 2 - Review Questions

- \_\_\_1) The four most common elements in living organisms are -  
A) C, H, O, Fe. C) C, H, O, N.  
B) C, H, O, Na. D) C, N, O, Na.
- \_\_\_2) Which of the following is a trace element in the human body?  
A) nitrogen C) oxygen  
B) zinc D) hydrogen
- \_\_\_3) Which of the following trace elements needed by humans is commonly added to table salt?  
A) iodine C) magnesium  
B) iron D) fluoride
- \_\_\_4) In the equation  $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$ ,  
A)  $\text{H}_2$ ,  $\text{O}_2$ , and  $\text{H}_2\text{O}$  are all compounds. C) only  $\text{H}_2\text{O}$  is a compound.  
B)  $\text{H}_2$ ,  $\text{O}_2$ , and  $\text{H}_2\text{O}$  are all elements. D) only  $\text{H}_2$  and  $\text{O}_2$  are compounds.
- \_\_\_5) Which of the following particles is found in the nucleus of an atom?  
A) protons and neutrons C) only protons  
B) protons and electrons D) only electrons
- \_\_\_6) Electrons move about the nucleus of an atom in the same way that -  
A) insects fly around a bright lamp at night. C) boats cross a lake.  
B) cars are parked along the sides of a street. D) birds migrate to a new winter home.
- \_\_\_7) What is the atomic mass of an atom that has 6 protons, 6 neutrons, and 6 electrons?  
A) 6 B) 8 C) 12 D) 18
- \_\_\_8) An uncharged atom of boron has an atomic number of 5 and an atomic mass of 11. How many electrons does boron have?  
A) 11 B) 15 C) 5 D) 2
- \_\_\_9) The sodium atom contains 11 electrons, 11 protons, and 12 neutrons. What is the mass number of sodium?  
A) 11 B) 22 C) 23 D) 34
- \_\_\_10) Which of the following best describes the atomic number of an atom?  
A) the number of protons in the atom C) the number of neutrons in the atom  
B) the number of electrons in the atom D) the number of protons, electrons, and neutrons in the atom
- \_\_\_11) Typically, nitrogen atoms are composed of electrons, protons, and neutrons. An isotope of nitrogen could -  
A) be positively charged. C) have more protons than the usual nitrogen atom.  
B) be negatively charged. D) have more neutrons than the usual nitrogen atom.
- \_\_\_12) Radioactive isotopes -  
A) are frequently added to foods as nutritional supplements.  
B) can be used in conjunction with PET scans to diagnose diseases.  
C) do not occur naturally.  
D) are never incorporated into organic compounds.

- \_\_\_13) When full, the innermost electron shell of argon contains \_\_\_\_\_ electrons, and the outermost shell contains \_\_\_\_\_ electrons.  
 A) 2 . . . 2                      B) 2 . . . 8                      C) 4 . . . 8                      D) 8 . . . 8
- \_\_\_14) What happens to an atom if the electrons in the outer shell are altered?  
 A) The atom becomes radioactive.                      C) The properties of the atom will change.  
 B) The atom will disintegrate.                      D) The atom's characteristics change and it becomes a different element.
- \_\_\_15) A(n) \_\_\_\_\_ forms when two atoms share electrons.  
 A) ion                      C) ionic bond  
 B) covalent bond                      D) hydrogen bond
- \_\_\_16) A hydrogen atom has one electron. How many covalent bonds can hydrogen form?  
 A) one covalent bond                      C) four covalent bonds  
 B) two covalent bonds                      D) no covalent bonds
- \_\_\_17) Table salt is formed when -  
 A) chlorine gives an electron to sodium.  
 B) a hydrogen bond forms between sodium and chlorine.  
 C) sodium and chlorine share electrons to form a bond.  
 D) sodium donates its single outer electron to chlorine.
- \_\_\_18) \_\_\_\_\_ are weak bonds that are not strong enough to hold atoms together to form molecules but are strong enough to form bonds within and around large molecules.  
 A) Ionic bonds                      C) Polar covalent bonds  
 B) Covalent bonds                      D) Hydrogen bonds
- \_\_\_19) In the equation  $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$ , the  $\text{H}_2$  molecules are \_\_\_\_\_ and the  $\text{H}_2\text{O}$  molecules are \_\_\_\_\_.  
 A) reactants . . . products                      C) created . . . destroyed  
 B) products . . . reactants                      D) used . . . stored
- \_\_\_20) What change is occurring in this figure?



- A) Chlorine is losing an electron.  
 B) Sodium is becoming negatively charged.  
 C) Sodium is filling its third electron shell.  
 D) Chlorine is filling its third electron shell.