CHAPTER 6 REVIEW

CHAPTER SUMMARY

6-1 • Most atoms are chemically bonded to other atoms.
   • The three major types of chemical bonding are ionic, covalent, and metallic.

Vocabulary
- chemical bond (161)
- ionic bonding (161)
- covalent bonding (161)
- nonpolar covalent bond (162)
- polar bond (162)
- polar covalent bond (162)

6-2 • Atoms in molecules are joined by covalent bonds.
   • The bond length between two atoms in a molecule is the distance at which the potential energy of the bonded atoms is minimized.
   • The octet rule states that many chemical compounds tend to form bonds so that each atom, by gaining, losing, or sharing electrons, shares or has eight electrons in its highest occupied energy level.

Vocabulary
- bond energy (167)
- bond length (167)
- electron-dot notation (170)
- chemical formula (164)
- Lewis structure (171)
- diatomic molecule (164)
- lone pair (171)
- multiple bond (173)
- octet rule (169)
- molecular compound (164)
- resonance (179)

6-3 • An ionic compound is a three-dimensional network of positive and negative ions mutually attracted to one another.
   • Because of the strong attraction between positive and negative ions, ionic compounds tend to be harder and more brittle and to have higher boiling points than materials containing only covalently bonded atoms.
   • Polyatomic ions are charged groups of atoms held together by covalent bonds.

Vocabulary
- formula unit (176)
- ionic compound (176)
- lattice energy (178)
- polyatomic ion (180)

6-4 • Metallic bonding is a type of chemical bonding that results from the attraction between metal atoms and a surrounding sea of mobile electrons.
   • The electron sea formed in metallic bonding gives metals their properties of high electrical and thermal conductivity, malleability, ductility, and luster.

Vocabulary
- ductility (182)
- malleability (182)
- metallic bonding (181)

6-5 • In general, atoms of metals bond ionically with atoms of nonmetals, atoms of metals bond covalently with each other, and atoms of nonmetals bond covalently with each other.

Vocabulary
- bond energy (167)
- bond length (167)
- electron-dot notation (170)
- chemical formula (164)
- Lewis structure (171)
- diatomic molecule (164)
- lone pair (171)
- multiple bond (173)
- octet rule (169)
- molecular compound (164)
- resonance (179)

- polar bond (162)
- polar covalent bond (162)
- molecular formula (164)
- single bond (171)
- structural formula (171)
- triple bond (173)
- unshared pair (171)

- hybrid orbitals (188)
- bonds within an atom can mix to form orbitals of equal energy.
- Interionic forces, such as dipole-dipole forces and London dispersion forces, exist between certain types of molecules. Hydrogen bonding is a special case of dipole-dipole forces.

- intermolecular forces (189)
- molecular polarity (183)
- London dispersion forces (191)
- VSEPR theory (183)

REVIEWING CONCEPTS

1. What is a chemical bond? (6-1)
2. Identify and define the three major types of chemical bonding. (6-1)
3. What is the relationship between electronegativity and the ionic character of a chemical bond? (6-1)
4. a. What is the meaning of the term polar as applied to chemical bonding? b. Distinguish between polar covalent and nonpolar covalent bonds. (6-1)
5. In general, what determines whether atoms will form chemical bonds? (6-1)
6. What is a molecule? (6-2)
7. a. What determines bond length? b. In general, how are bond energies and bond lengths related? (6-2)
8. Describe the general location of the electrons in a covalent bond. (6-2)
9. As applied to covalent bonding, what is meant by an unshared or lone pair of electrons? (6-2)
10. Describe the octet rule in terms of noble-gas configurations and potential energy. (6-2)
11. Determine the number of valence electrons in an atom of each of the following elements: a. H b. F c. Mg d. O (6-3)
12. When drawing Lewis structures, which atom is usually the central atom? (6-2)
13. Distinguish between single, double, and triple covalent bonds by defining each and providing an illustration of each type. (6-2)
14. In writing Lewis structures, how is the need for multiple bonds generally determined? (6-2)
15. a. What is an ionic compound? b. In what form do most ionic compounds occur? (6-3)
16. a. What is a formula unit? b. What are the components of one formula unit of CaF₂? (6-3)
17. a. What is lattice energy? b. In general, what is the relationship between lattice energy and the strength of ionic bonding? (6-3)
18. a. In general, how do ionic and molecular compounds compare in terms of melting points, boiling points, and ease of vaporization? b. What accounts for the observed differences in the properties of ionic and molecular compounds? c. Cite three physical properties of ionic compounds. (6-3)
31. a. What is hydrogen bonding? b. What accounts for its extraordinary strength? (6-5)
32. What are London dispersion forces? (6-5)

PROBLEMS

Chemical Bond Character
33. Determine the electronegativity difference, the probable bond type, and the more-electronegative atom with respect to bonds formed between the following pairs of atoms. (Hint: See Problem 6-1.)
   a. H and I
   b. S and O
   c. K and Br
   d. Si and Cl
   e. H and F
   f. Se and S
   g. C and H
   h. Be
34. List the bonding pairs described in item 33 in order of increasing covalent character. (6-5)
35. Use orbital notation to illustrate the bonding in each of the following molecules: a. chlorine, Cl₂
   b. oxygen, O₂
   c. hydrogen fluoride, HF
36. The lattice energy of sodium chloride, NaCl, is −787.5 kJ/mol. The lattice energy of potassium chloride, KCl, is −715 kJ/mol. In which compound is the bonding between ions stronger? Why? (6-5)

Electron-Dot Notation and Lewis Structures
37. Use electron-dot notation to illustrate the number of valence electrons present in one atom of each of the following elements. (Hint: See Sample Problem 6-2.)
   a. Li
   b. Ca
   c. Cl
   d. O
38. Use electron-dot structures to demonstrate the formation of ionic compounds involving the following elements:
   a. Na and S
   b. Ca and O
   c. Al and S
39. Draw Lewis structures for each of the following molecules. (Hint: See Sample Problem 6-4.)
   a. H₂O
   b. Cl₂
   c. CO₂
   d. NH₃
   e. CO₃
40. Draw Lewis structures for each of the following molecules. Show resonance structures, if they exist.
   a. O₂
   b. N₂
   c. CO
   d. SO₂
41. Draw Lewis structures for each of the following molecules. Show resonance structures, if they exist.
   a. OH⁻
   b. H₂O₂
   c. BrO₃⁻

VSEPR Theory and Molecular Geometry
42. According to the VSEPR theory, what molecular geometries are associated with the following types of molecules?
   a. AB₃E
   b. AB₄E₂
   c. AB₄E
43. Use hybridization to explain the bonding in methane, CH₄.
44. For each of the following polar molecules, indicate the direction of the resulting dipole:
   a. H₂O
   b. H₂Cl
   c. H₂Br
   d. HI

50. Arrange the following pairs from strongest to weakest attraction:
   a. polar molecule and polar molecule
   b. nonpolar molecule and nonpolar molecule
   c. polar molecule and ion
   d. ion and ion
51. Determine the geometry of the following molecules:
   a. \( \text{CCl}_4 \)
   b. \( \text{BeCl}_2 \)
   c. \( \text{PH}_3 \)

52. What types of atoms tend to form the following types of bonding?
   a. ionic
   b. covalent
   c. metallic

53. What happens to the energy level and stability of two bonded atoms when they are separated and become individual atoms?

54. Draw the three resonance structures for sulfur trioxide, \( \text{SO}_3 \).

55. a. How do ionic and covalent bonding differ?
   b. How does an ionic compound differ from a molecular compound?
   c. How does an ionic compound differ from a metal?

56. Write the electron-dot notation for each of the following elements:
   a. He
   b. Cl
   c. O
   d. P
   e. B

57. Write the structural formula for methanol, \( \text{CH}_3\text{OH} \).

58. How many \( K^+ \) and \( S^{2-} \) ions would be in one formula unit of the ionic compound formed by these ions?

59. Explain metallic bonding in terms of the sparsely populated outermost orbitals of metal atoms.

60. Explain the role of molecular geometry in determining molecular polarity.

61. How does the energy level of a hybrid orbital compare with the energy levels of the orbitals it was formed from?

62. Aluminum's heat of vaporization is 284 kJ/mol. Beryllium's heat of vaporization is 224 kJ/mol. In which element is the bonding stronger between atoms?

63. Determine the electronegativity difference, the probable bonding type, and the more-electronegative atom for each of the following pairs of atoms:
   a. Zn and O
   b. Br and I
   c. S and Cl

64. Draw the Lewis structure for each of the following molecules:
   a. \( \text{PCl}_3 \)
   b. \( \text{CCl}_2\text{F}_2 \)
   c. \( \text{CH}_4\text{NH}_3 \)

65. Write the Lewis structure for \( \text{BeCl}_2 \). (Hint: Beryllium atoms do not follow the octet rule.)

66. Draw a Lewis structure for each of the following polyatomic ions and determine their geometries:
   a. \( \text{NO}_2^- \)
   b. \( \text{NO}_3^- \)
   c. \( \text{NH}_4^+ \)

67. Why are most atoms chemically bonded to other atoms in nature?

### CRITICAL THINKING

68. Inferring Relationships
   The length of a bond varies depending on the type of bond formed. Predict and compare the lengths of the carbon-carbon bonds in the following molecules.
   Explain your answer. (Hint: See Table 6.2.)

   \[
   \begin{array}{cccc}
   \text{H} & \text{H} & \text{H} & \text{H} \\
   \text{H} & \text{C} & \text{C} & \text{H} \\
   \text{H} & \text{H} & \text{H} & \text{H} \\
   \text{H} & \text{C} & \text{C} & \text{C} \\
   \text{C}_2\text{H}_6 & \text{C}_3\text{H}_4 & \text{C}_2\text{H}_2 \\
   \end{array}
   \]

69. Graphing Calculator
   Classify Bonding Type
   According to Difference in Electronegativity
   The graphing calculator can run a program that classifies bonding between atoms according to the difference between the atoms' electronegativities. Use this program to determine the electronegativity difference between the bonded atoms and to classify bonding type.

   Go to Appendix C. If you are using a TI 83 Plus, you can download the program and data sets and run the application as directed. If you are using another calculator, your teacher will provide you with the keystrokes and data sets to use. Remember that you will need to name the program and check the display, as explained in Appendix C. You will then be ready to run the program. After you have graphed the data, answer these questions:
   a. Which element pair(s) have a pure covalent bond?
   b. What type of bond does the pair H, O have?
   c. What type of bond does the pair Ca, O have?

### ALTERNATIVE ASSESSMENT

70. Figure 6-18 on page 181 shows a model for a body-centered cubic crystal. Review the Properties tables for all of the metals in the Elements Handbook (pages 728-749). What metals exist in body-centered cubic structures?

71. Group 14 of the Elements Handbook (pages 754-769) contains a discussion of the band theory of metals. How does this model explain the electrical conductivity of metals?

### RESEARCH & WRITING

72. Prepare a report on the work of Linus Pauling.
   a. Discuss his work on the nature of the chemical bond.
   b. Linus Pauling was an advocate of the use of vitamin C as a preventative for colds. Evaluate Pauling's claims. Determine if there is any scientific evidence that indicates whether vitamin C helps prevent colds.
   c. Covalently bonded solids, such as silicon, an element used in computer components, are harder than pure metals. Research theories that explain the hardness of covalently bonded solids and their usefulness in the computer industry. Present your findings to the class.