7 IONIC AND METALLIC BONDING

Reviewing Content

30. by gaining or losing electrons

31. **a.** gain of 1 electron
b. loss of one electron
c. gain of 3 electrons
d. loss of 2 electrons
e. loss of 1 electron
f. gain of 1 electron

32. **a.** bromide, anion **b.** sodium, cation
c. arsenide, anion **d.** calcium, cation
e. copper, cation **f.** hydride, anion

33. electrons in the highest occupied energy level

34. **a.** 7, 5A **b.** 3, 1A
c. 15, 5A **d.** 56, 2A
e. 35, 7A **f.** 6, 4A

35. **a.** $\cdot\ddot{\underset{\cdot\cdot}{\text{Cl}}}\cdot$ **b.** $\cdot\ddot{\underset{\cdot\cdot}{\text{S}}}\cdot$
c. $\cdot\text{Al}\cdot$ **d.** $\text{Li}\cdot$

36. **a.** 2 **b.** 3
c. 1 **d.** 2

37. **a.** Al^{3+} **b.** Li^{+}
c. Ba^{2+} **d.** K^{+}
e. Ca^{2+} **f.** Sr^{2+}

38. Most nonmetals gain 1, 2, or 3 electrons to achieve a noble-gas electron configuration.

39. **a.** S^{2-} **b.** Na^{-}
c. F^{-} **d.** P^{3-}

40. **a.** 3 **b.** 2
c. 1 **d.** 3

41. a, c, e

42. **a.** Ca^{2+}, F^{-} **b.** Al^{3+}, Br^{-}
c. Li^{+}, O^{2-} **d.** Al^{3+}, S^{2-}
e. K^{+}, N^{3-}

43. The positive charges balance the negative charges.

44. a, b, d

45. **a.** K^{+}, Cl^{-} **b.** Ba^{2+}, SO_4^{2-}
c. Mg^{2+}, Br^{-} **d.** Li^{+}, CO_3^{2-}

46. Their network of electrostatic attractions and repulsions forms a rigid structure.

47. Ions are free to move in molten $MgCl_2$.

48. They have many mobile valence electrons. Electrons in the current replace the electrons leaving the metal.

49. body-centered cubic: Na, K, Fe, Cr, or W; face-centered cubic: Cu, Ag, Au, Al, or Pb; hexagonal close-packed: Mg, Zn, or Cd

50. Answers will vary and could include tableware, steel in cars and buses, high-speed dental drill bits, solder in stereos and televisions, and structural steel in buildings.

51. The properties of the steel will vary according to its composition. In addition to iron, steel can contain varying amounts of carbon and such metals as chromium, nickel, and molybdenum.

Understanding Concepts

52.

Group number	Valence electrons lost or gained of ion	Formula
1A	1	Na^{+}
2A	2	Ca^{2+}
3A	3	Al^{3+}
5A	3	N^{3-}
6A	2	S^{2-}
7A	1	Br^{-}

53. **a.** $\cdot\dot{\underset{\cdot}{\text{C}}}\cdot$ **b.** $\cdot\text{Be}\cdot$
c. $\cdot\ddot{\underset{\cdot\cdot}{\text{O}}}\cdot$ **d.** $\cdot\ddot{\underset{\cdot\cdot}{\text{F}}}\cdot$
e. $\text{Na}\cdot$ **f.** $\cdot\dot{\underset{\cdot}{\text{P}}}\cdot$

54. For the representative elements the number of electrons in the electron dot structure is the group number.

55. It has lost valence electrons.

56. It has gained valence electrons.

57. **a.** oxygen atom, sulfur atom, oxide ion, sulfide ion
b. sodium ion, potassium ion, sodium atom, potassium atom

58. **a.** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

59. **a.** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$
c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

60. They have little chemical reactivity; their outermost occupied energy levels are filled.

61. **a.** Br^- **b.** H^-
c. As^{3-} **d.** Se^{2-}

62. All have the noble-gas configuration of $1s^2 2s^2 2p^6 3s^2 3p^6$.

63. All are $1s^2 2s^2 2p^6$. All have the same configuration as neon.

64. fluorine, chlorine, bromine, and iodine; Group 7A, 7 valence electrons

65. **a.** $1s^2 2s^2 2p^6 3s^2 3p^6$
b. $1s^2 2s^2 2p^6$; Each has a noble-gas electron configuration

66. The positively charged cations exactly balance the negatively charged anions.

67. a, c, e, f

68. No, the packing of ions in a crystalline structure depends on a number of factors including the relative sizes of the ions. The coordination number of an element can vary from compound to compound.

69. 12

70. Hexagonal close-packed units cells have twelve neighbors for every atom or ion. Face-centered cubic unit cells also have twelve neighbors for every atom or ion, with an atom or ion in the center of each face. Body-centered cubic units cells have eight neighbors for every atom or ion, with an atom or ion at the center of each cube.

71. Brass is a mixture of copper and zinc. The properties of a particular sample of brass will vary with the relative proportions of the two metals.

Critical Thinking

72. Each dot in the electron dot structure represents a valence electron in the electron configuration diagram.

73. By gaining or losing electrons the atoms of elements achieve a noble-gas electron configuration.

74. An atom of silver has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2 4p^6 4d^{10} 5s^1$. To achieve the configuration of the preceding noble gas, krypton, a silver atom would have to lose eleven electrons and form Ag^{11+}. To achieve the configuration of the following noble gas xenon, a silver atom must gain seven electrons and form Ag^{7-}. Because ions with such high charges are unlikely, silver does not achieve a noble-gas configuration. However, if a silver atom loses its $5s^1$ electron, the result is an outer electron configuration of eighteen electrons, written as $4s^2 4p^6 4d^{10}$. This configuration is favored and stable. It is known as a pseudo-noble-gas configuration.

75. No, sodium chloride is composed of equal numbers of sodium ions and chloride ions; the ions are in a 1:1 ratio. Each sodium ion is surrounded by chloride ions, and each chloride is surrounded by sodium ions.

76. In sodium chloride crystals the sodium and chloride ions vibrate about fixed points; in the molten state, the ions are free to move.

77. The spheres are more closely packed in (a); there is less empty space in (a), and a rough count shows 25 spheres in (a) compared with 22 spheres in (b).

78. Metals are ductile (can be drawn into wires) and malleable (can be hammered into shapes). These changes are possible because a metal consists of metal cations in a sea of valence electrons. When subjected to pressure, the cations easily slide past one another.

79. Both metals and ionic compounds are composed of ions. Both are held together by electrostatic bonds. Metals always conduct electricity, and ionic compounds conduct only when melted or in water solution. Ionic compounds are composed of cations and anions, but metals are composed of cations and free-floating valence electrons. Metals are ductile, but ionic compounds are brittle.

Concept Challenge

80. **a.** cation: lose $1e^-$ **b.** cation: lose $1e^-$
c. unreactive **d.** anion: gain $1e^-$
e. cation: lose 2e

81. Na^+ and Cs^+ differ greatly in size. Na^+ and Cl^- are similar in size to Mn^{2+} and S^{2-}.

82. 0.1445 nm

83. **a.** copper and zinc
b. silver and copper
c. copper and tin
d. iron, chromium, nickel, and carbon
e. iron, chromium, nickel, and molybdenum
f. iron, chromium, and carbon

Cumulative Review

84. Organic chemistry is the study of chemicals containing carbon; inorganic chemistry is the study of chemicals that do not contain carbon.

85. an analytical chemist

86. use insulation

87. a, b, and d are chemical changes. c is a physical change.

88. b and e; c is not a mixture, it is a pure substance

89. **a.** liquid, vapor
b. vapor,
c. vapor liquid,
d. liquid vapor

90. **a.** 56.6 g
b. 0.0048 m
c. 1.81 L
d. 4.0×10^3 mg

91. a

92. –269°C

93. 27.0 cm^3

94. **a.** $^{64}_{30}Zn$ **b.** $^{37}_{17}Cl$
c. $^{3}_{1}H$ **d.** $^{40}_{20}Ca$

95. 14 amu

96. Each of the isotopes has 8 protons and 8 electrons; oxygen-16 also has 8 neutrons, oxygen-17 has 9 neutrons, and oxygen-18 has 10 neutrons.

97. **a.** 1
b. 3
c. 1
d. 5

98. **a.** N, $1s^2 2s^2 2p^3$
b. Be, $1s^2 2s^2$
c. P, $1s^2 2s^2 2p^6 3s^2 3p^2$
d. K, $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

99. chlorine, Cl, $1s^2 2s^2 2p^6 3s^2 3p^5$

100. **a.** 5×10^{-7} m
b. the visible region, green

101. **a.** K, $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
b. Al, $1s^2 2s^2 2p^6 3s^2 3p^1$
c. S, $1s^2 2s^2 2p^6 3s^2 3p^4$
d. Ba, $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^2$

102. the electron

103. sodium (Na), cesium (Cs), rubidium (Rb), lithium (Li)