Reviewing Content

6.1 Organizing the Elements

24. Why did Mendeleev leave spaces in his periodic table?

25. What effect did the discovery of gallium have on the acceptance of Mendeleev's table?

26. What pattern is revealed when the elements are arranged in a periodic table in order of increasing atomic number?

27. Based on their locations in the periodic table, would you expect carbon and silicon to have similar properties? Explain your answer.

28. Identify each property below as more characteristic of a metal or a nonmetal.
a. a gas at room temperature
b. brittle
c. malleable
d. poor conductor of electric current
e. shiny

29. In general, how are metalloids different from metals and nonmetals?

6.2 Classifying the Elements

30. Where are the alkali metals, the alkaline earth metals, the halogens, and the noble gases located in the periodic table?

31. Which of the following are symbols for representative elements: Na, Mg, Fe, Ni, Cl?

32. Which noble gas does not have eight electrons in its highest occupied energy level?

33. Which of these metals isn't a transition metal?
a. aluminum   b. silver
c. iron   d. zirconium

34. Use Figure 6.12 to write the electron configurations of these elements.
a. boron
b. arsenic
c. fluorine
d. zinc
e. aluminum

35. Write the electron configuration of these elements.
a. the noble gas in period 3
b. the metalloid in period 3
c. the alkali earth metal in period 3

6.3 Periodic Trends

36. Which element in each pair has atoms with a larger atomic radius?
a. sodium, lithium
b. strontium, magnesium
c. carbon, germanium
d. selenium, oxygen

37. Explain the difference between the first and second ionization energy of an element.

38. Which element in each pair has a greater first ionization energy?
a. lithium, boron
b. magnesium, strontium
c. cesium, aluminum

39. Arrange the following groups of elements in order of increasing ionization energy.
a. Be, Mg, Sr
b. Bi, Cs, Ba
c. Na, Al, S

40. Why is there a large increase between the first and second ionization energies of the alkali metals?

41. How does the ionic radius of a typical metal compare with its atomic radius?

42. Which particle has the larger radius in each atom/ion pair?
a. Na, Na^+ b. S, S^{2-}
c. I, I^- d. Al, Al^{3+}

43. Which element in each pair has a higher electronegativity value?
a. Cl, F   b. C, N   c. Mg, Ne   d. As, Ca

44. Why are noble gases not included in Table 6.2?

45. When the elements in each pair are chemically combined, which element in each pair has a greater attraction for electrons?
a. Ca or O   b. O or F
c. H or O   d. K or S

46. For which of these properties does lithium have a larger value than potassium?
a. first ionization energy
b. atomic radius
c. electronegativity
d. ionic radius

41. The ionic radius of a cation is smaller than the atomic radius of the metal atom.

42. a. Na   **b.** S^{2-} **c.** I^- **d.** Al

43. a. F   **b.** N   **c.** Mg   **d.** As

44. Noble gases, with rare exception, do not form compounds.

45. a. O   **b.** F   **c.** O   **d.** S

**46.** a and c

Reviewing Content

24. so that undiscovered elements with similar properties could be placed in the same group

25. The close match between the predicted properties and actual properties of gallium helped gain wider acceptance for Mendeleev's periodic table.

26. a periodic repetition of their physical and chemical properties

27. Yes; both carbon and silicon are in Group 4A, and each has four electrons in the highest occupied energy level.

28. a. nonmetal **b.** nonmetal **c.** metal **d.** nonmetal **e.** metal

29. Metalloids have properties that are similar to those of metals and nonmetals. How a metalloid behaves depends on the conditions.

30. Group 1A, Group 2A, Group 7A, and Group 8A, respectively

31. Na, Mg, Cl

32. helium

33. aluminum

34. a. $1s^2 2s^2 2p^1$
b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$
c. $1s^2 2s^2 2p^5$
d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
e. $1s^2 2s^2 2p^6 3s^2 3p^1$

35. a. Ar: $1s^2 2s^2 2p^6 3s^2 3p^6$
b. Si: $1s^2 2s^2 2p^6 3s^2 3p^2$
c. Mg: $1s^2 2s^2 2p^6 3s^2$

36. a. sodium   **b.** strontium
c. germanium   **d.** selenium

37. The first ionization energy is the energy needed to remove a first electron from an atom. The second ionization energy is the energy needed to remove a second electron.

38. a. boron   **b.** magnesium
c. aluminum

39. a. Sr, Mg, Be   **b.** Cs, Ba, Bi
c. Na, Al, S

40. It is relatively easy to remove the first electron from an alkali metal atom; it is much more difficult to remove the second.

Understanding Concepts

47. **a.** 1801–1850
b. Mendeleev's periodic table helped scientists predict the existence of undiscovered elements.
c. 75%
48. **a.** C **b.** La **c.** Ne, P, Br
d. Sb, Bi
49. b; Nitrogen and phosphorus are in the same group (Group 5A).
50. Fluorine has a smaller atomic radius than oxygen because fluorine has a larger nuclear charge. Fluorine has a smaller radius than chlorine because it has eight fewer electrons.
51. Nonmetals; The trend is for ionization energy to increase from left to right across a period.
52. **a.** Ca^{2+} **b.** P^{3-} **c.** Cu^+
53. **a.** H, Li, Na, K, Rb, Cs, Fr
b. O, S, Se, Te, Po
c. Zn, Cd, Hg, Uub
54. An element's electron configuration determines its location (group) in the periodic table.
55. c
56. 170 pm
57. First ionization energy increases across a period.
58. It is relatively easy to remove two electrons from magnesium; it is much more difficult to remove a third electron. It is relatively easy to remove three electrons from aluminum; it is much more difficult to remove a fourth.
59. **a.** The atomic radius increases from top to bottom within the group. **b.** Cations are smaller than their corresponding atoms. The attraction between the nucleus and any remaining electron is greater. There is one fewer occupied energy level.


Understanding Concepts

47. The bar graph shows how many elements were discovered before 1750 and in each 50-year period between 1750 and 2000.
    a. In which 50-year period were the most elements discovered?
    b. How did Mendeleev's work contribute to the discovery of elements?
    c. What percent of the elements were discovered by 1900?

Discovery of Elements
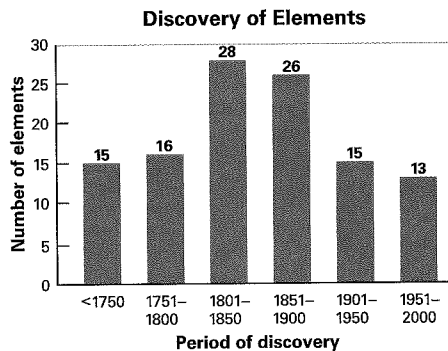
48. Write the symbol of the element or elements that fit each description.
    a. a nonmetal in Group 4A
    b. the inner transition metal with the lowest atomic number
    c. all of the nonmetals for which the atomic number is a multiple of five
    d. a metal in Group 5A.

49. In which pair of elements are the chemical properties of the elements most similar? Explain your reasoning.
    a. sodium and chlorine
    b. nitrogen and phosphorus
    c. boron and oxygen

50. Explain why fluorine has a smaller atomic radius than both oxygen and chlorine.

51. Would you expect metals or nonmetals in the same period to have higher ionization energies? Give a reason for your answer.

52. In each pair, which ion is larger?
    a. Ca^{2+}, Mg^{2+} **b.** Cl^-, P^{3-} **c.** Cu^+, Cu^{2+}

53. List the symbols for all the elements with electron configurations that end as follows. Each n represents an energy level.
    a. ns^1 **b.** ns^2np^4 **c.** ns^2nd^{10}

54. Explain why there should be a connection between an element's electron configuration and its location on the periodic table?

55. Which equation represents the first ionization of an alkali metal atom?
    a. $Cl \longrightarrow Cl^+ + e^-$
    b. $Ca \longrightarrow Ca^+ + e^-$
    c. $K \longrightarrow K^+ + e^-$
    d. $H \longrightarrow H^+ + e^-$

56. Use the graph in Figure 6.14 to estimate the atomic radius of the indium atom.

57. What trend is demonstrated by the following series of equations?
    $$Li + 520 \text{ kJ/mol} \longrightarrow Li^+ + e^-$$
    $$O + 1314 \text{ kJ/mol} \longrightarrow O^+ + e^-$$
    $$F + 1681 \text{ kJ/mol} \longrightarrow F^+ + e^-$$
    $$Ne + 2080 \text{ kJ/mol} \longrightarrow Ne^+ + e^-$$

58. There is a large jump between the second and third ionization energies of magnesium. There is a large jump between the third and fourth ionization energies of aluminum. Explain these observations.

59. The bar graph shows the relationship between atomic and ionic radii for Group 1A elements.
    a. Describe and explain the trend in atomic radius within the group.
    b. Explain the difference between the size of the atoms and the size of the ions.

Comparing Radii of Alkali Metals
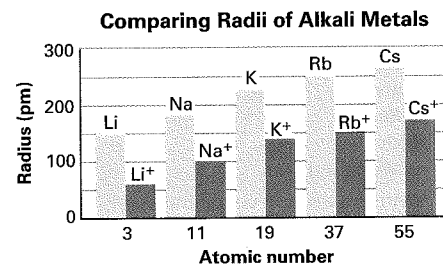
60. Do you think there are more elements left to discover? If so, what is the lowest atomic number a new element could have? Explain your answers.

61. The graphs show the relationship between the electronegativities and first ionization energies for period 2 and period 3 elements.
    a. Based on data for these two periods, what is the general trend between these two values?
    b. Use nuclear charge and shielding effect to explain this trend.

Period 2

Period 3
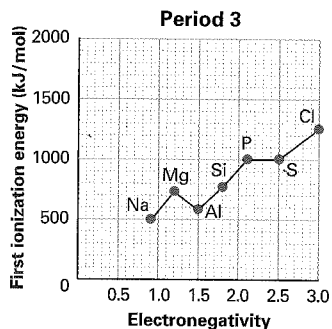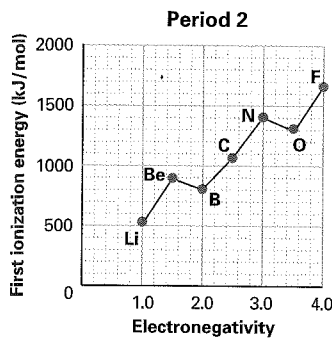
62. Explain why it takes more energy to remove a 4s electron from zinc than from calcium.

63. Explain each of the following comparisons.
    a. Calcium has a smaller second ionization energy than does potassium.
    b. Lithium has a larger first ionization energy than does cesium.
    c. Magnesium has a larger third ionization energy than does aluminum.

64. The Mg^{2+} and Na^+ ions each have ten electrons. Which ion would you expect to have the smaller radius? Explain your choice.

65. The ions S^{2-}, Cl^-, K^+, Ca^{2+}, and Sc^{3+} have the same total number of electrons as the noble gas argon. How would you expect the radii of these ions to vary? Would you expect to see the same variation in the series O^{2-}, F^-, Na^+, Mg^{2+}, and Al^{3+}, in which each ion has the same total number of electrons as the noble gas neon? Explain your answer.

66. Make a graph of average atomic mass versus atomic number. Choose 11 points (atomic numbers 1, 10, 20, and so forth up to atomic number 100) to make your graph. Use the graph to describe the relationship between average atomic mass and atomic number. Is there a 1:1 correspondence between average atomic mass and atomic number? Explain how you reached your conclusion.

67. The ionization energies for the removal of the first six electrons in carbon are, starting with the first electron, 1086 kJ/mol, 2352 kJ/mol, 4619 kJ/mol, 6220 kJ/mol, 37,820 kJ/mol, and 47,260 kJ/mol.
    a. Make a graph of ionization energy versus ionization number. The ionization number indicates which electron is lost.
    b. Between which two ionization numbers does the ionization energy have the largest increase? Explain why this behavior is predictable.

68. Atoms and ions with the same number of electrons are called isoelectronic.
    a. Write the symbol for a cation and an anion that are isoelectronic with krypton.
    b. Is it possible for a cation to be isoelectronic with an anion from the same period? Explain.

69. Electron affinity is a measure of an atom's ability to gain electrons. Predict the trend for electron affinity across a period. Explain your answer.

60. Yes, 113; 1 through 112 are known.
61. a. Electronegativity increases as first ionization energy increases.
    b. Both properties depend on the attraction between the nucleus and electrons in the highest occupied energy level. Across a period, the nuclear charge increases, but the shielding effect is constant.
62. Zinc has a greater nuclear charge (more protons) than calcium.
63. a. The electrons in calcium are removed from the same energy level. In potassium, the second electron is removed from a lower energy level.
    b. Because cesium has a larger atomic radius than lithium, the nuclear charge in a cesium atom has a smaller effect on the electrons in the highest occupied energy level.
    c. The third electron removed from a magnesium atom is in a lower energy level.

64. Mg^{2+} has more protons; its attraction for electrons is greater.
65. The ionic radii decrease from S^{2-} to Sc^{3+}. The number of electrons and the shielding effect do not change, but the number of protons increases from left to right in this series. So the ionic size decreases. The same is true for the series O^{2-} to Mg^{2+}.
66. There is not a 1:1 correspondence. Explanations will vary.
67. a.

67. b. The largest increase is between numbers 4 and 5 because carbon easily loses the first four electrons from the second energy level. The fifth electron is removed from the first energy level.
68. a. Possible cations are Rb^+ and Sr^{2+}; possible anions are Br^-, Se^{2-}, and As^{3-}.
    b. No; a cation is isoelectronic with the noble gas in the preceding period, and an anion is isoelectronic with the noble gas in the same period.
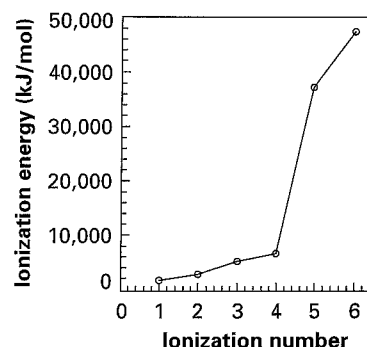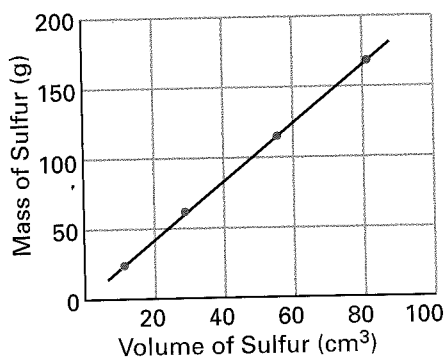
69. Electron affinity increases (becomes more negative) from left to right across a period because the nuclear charge increases and the shielding effect is constant.

Cumulative Review

70. Answers will vary but are likely to mention the scientific method.

71. **a.** physical change
b. chemical change
c. physical change
d. chemical change

72. Use a magnet; iron beads are attracted to magnet, copper beads are not. Use tweezers and a magnifying glass; iron beads are silvery black, copper beads are dull red.

73. 4

74. **a.** 3
b. 8, the tenths place

75. The density of the cube is 0.984 g/cm^3. The cube will float.

76. **a.** 2.24×10^{-9} m
b. 8.13×10^{-2} m
c. 7.4×10^{-12} m
d. 9.37×10^{-3} m

77. 5.2%

78. 5.2×10^3 g

79. The density of the olive is 1.05 g/cm^3. The olive will sink.

80. 173

81. The slope and the density should be about 2.1 g/cm^3.

82. 2.57×10^2 mL
83. 4.54 g/cm^3
84. **a.** 48
b. 44
c. 114
d. 110

85. **a.** silver, 62 neutrons
b. tin, 50 protons
c. molybdenum, 42 electrons
d. scandium, 21 electrons
86. **a.** none
b. one, 2*p*
c. none
d. none

Cumulative Review

70. Explain why science today depends less on chance discoveries than it did in the past. *(Chapter 1)*

71. Identify each process as a chemical or physical change. *(Chapter 2)*
a. melting of iron   **b.** lighting a match
c. grinding corn   **d.** souring of milk

72. Describe at least two methods to separate a mixture of small copper and iron beads. *(Chapter 2)*

73. In the United States a typical can of "cola" holds 355 mL. How many 2.00-L bottles could be filled from a 24-can case of cola? *(Chapter 3)*

74. The volume of the liquid in the graduated cylinder is reported as 31.8 mL. *(Chapter 3)*
a. How many significant figures are there in the measurement?
b. In which digit is there uncertainty?
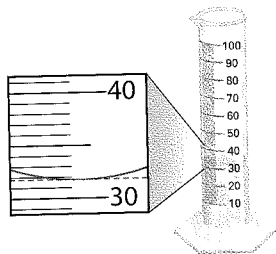
75. A cube of plastic 1.20×10^{-5} km on a side has a mass of 1.70 g. Show by calculation whether this plastic cube will sink or float in pure water. *(Chapter 3)*

76. Convert the measurements to meters. Express your answers in scientific notation. *(Chapter 3)*
a. 2.24 nm   **b.** 8.13 cm
c. 7.4 pm   **d.** 9.37 mm

77. An apprentice jeweler determines the density of a sample of pure gold to be 20.3 g/cm^3. The accepted value is 19.3 g/cm^3. What is the percent error of the jeweler's density measurement? *(Chapter 3)*

78. What is the mass of 7.7 L of gasoline at 20°C? Assume the density of gasoline to be 0.68 g/cm^3. *(Chapter 3)*

79. A black olive containing its seed has a mass of 4.5 g and a volume of 4.3 cm^3. Will the olive sink or float on the water? *(Chapter 3)*

80. The distance is 1.50×10^8 km from the sun to Earth. The speed of light is 3.00×10^8 m/s. How many round trips between Earth and the sun could a beam of light make in one day? *(Chapter 3)*

81. Make a graph of mass versus volume for sulfur. Determine the density of sulfur from the slope of the line. *(Chapter 3)*

Mass of Sulfur Versus Volume of Sulfur	
Mass of sulfur (g)	Volume of sulfur (cm³)
23.5	11.4
60.8	29.2
115	55.5
168	81.1

82. Calculate the volume of acetone with the same mass as 15.0 mL of mercury? The density of mercury is 13.59 g/mL. The density of acetone is 0.792 g/mL. *(Chapter 3)*

83. A rectangular container has inside dimensions of 15.2 cm by 22.9 cm and is about 1 meter tall. Water is poured into the container to a height of 55.0 cm. When a jagged rock with a mass of 5.21 kg is placed in the container, it sinks to the bottom. The water level rises to 58.3 cm. What is the density of the rock? *(Chapter 3)*

84. How many neutrons does an atom of each isotope contain? *(Chapter 4)*
a. $^{84}_{36}\text{Kr}$ **b.** $^{79}_{35}\text{Br}$ **c.** $^{190}_{76}\text{Os}$ **d.** $^{185}_{75}\text{Re}$

85. Name the element and calculate the number of requested subatomic particles in each isotope. *(Chapter 4)*
a. neutrons in $^{109}_{47}\text{Ag}$ **b.** protons in $^{118}_{50}\text{Sn}$
c. electrons in $^{96}_{42}\text{Mo}$ **d.** electrons in $^{45}_{21}\text{Sc}$

86. How many filled *p* orbitals do atoms of these elements contain? *(Chapter 5)*
a. carbon   **b.** phosphorus
c. oxygen   **d.** nitrogen

Test-Taking Tip

Interpreting Data Tables Tables present a large amount of data in a small space. Before you try to answer questions based on a table, look at the table. Read the title, if there is one, and the column headings. Then read the questions. As you read each question, decide which data you will need to use to answer the question. You may need to focus on a single entry or column. You may need to find a relationship between data from multiple columns.

lect the choice that best answers each question or mpletes each statement.

Which of the following properties increases as you move across a period from left to right?
I. electronegativity
II. ionization energy
III. atomic radius
a. I and II only
b. I and III only
c. II and III only
d. I, II, and III

List the symbols for sodium, sulfur, and cesium in order of increasing atomic radii.
a. Na, S, Cs   b. Cs, Na, S
c. S, Na, Cs   d. Cs, S, Na

The electron configuration for an element in the halogen group should always end with
a. ns^2np^6.   b. ns^2np^5.
c. ns^2np^4.   d. ns^2np^2.

Use the spheres to answer Questions 4–6.

a.   b.

4. Which sphere would most likely represent a potassium atom, K?
5. Which sphere would most likely represent a potassium ion, K^+?
6. If the spheres represent an atom and an anion of the same element, which sphere represents the atom and which represents the anion?

Use the data table to answer Questions 7–9.

Alkali metal	Atomic radius (pm)	First ionization energy (kJ/mol)	Electronegativity value
Li	152	520	1.0
Na	186	495.8	0.9
K	227	418.8	0.8
Rb	244	250	0.8
Cs	262	210	0.7

7. If you plotted atomic radius versus first ionization energy, would the graph reveal a direct or inverse relationship?
8. If you plotted atomic radius versus electronegativity, would the graph reveal a direct or inverse relationship?
9. If you plotted first ionization energy versus electronegativity, would the graph reveal a direct or inverse relationship?

r each question there are two statements. Decide whether each statement is true false. Then decide whether Statement II is a correct explanation for Statement I.
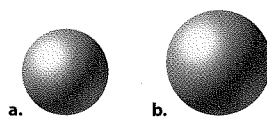
Statement I		Statement II
Electronegativity values are higher for metals than for nonmetals.	BECAUSE	Atoms of nonmetals are among the largest atoms.
A calcium atom is larger than a calcium ion.	BECAUSE	Ions are always larger than the atoms from which they are formed.
The element hydrogen is a metal.	BECAUSE	Hydrogen is on the left in the periodic table.
Among all the elements in a period, the noble gas always has the smallest ionization energy.	BECAUSE	Within any period, atomic radii tend to decrease moving from right to left.

1. a
2. c
3. b
4. The larger sphere represents the potassium atom.
5. The smaller sphere represents the potassium ion.
6. The smaller sphere represents the atom; the larger sphere represents the anion.
7. inverse
8. inverse
9. direct
10. false, false
11. true, false
12. false, true
13. false, false