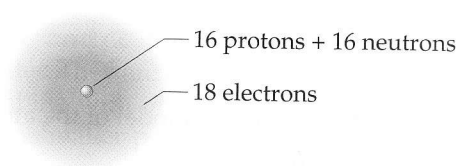2.4 Does the following drawing represent a neutral atom or
CQ an ion? Write its complete chemical symbol including mass number, atomic number, and net charge (if any). [Sections 2.3 and 2.7]

— 16 protons + 16 neutrons

— 18 electrons

2.5 Which of the following diagrams most likely represents
CQ an ionic compound, and which represents a molecular one? Explain your choice. [Sections 2.6 and 2.7]

(i) (ii)
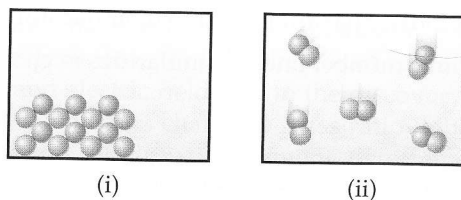
2.6 Write the chemical formula for the following com-
CQ pound. Is the compound ionic or molecular? Name the compound. [Sections 2.6 and 2.8]

F

F   F

I

F   F
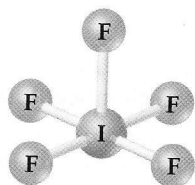
2.7 Five of the boxes in the following periodic table are col-
CQ ored. Predict the charge on the ion associated with each of these elements. [Section 2.7]

2.8 The following diagram represents an ionic compound in
CQ which the red spheres represent cations and blue spheres represent anions. Which of the following formulas is consistent with the drawing: KBr, K_2SO_4, $Ca(NO_3)_2$, $Fe_2(SO_4)_3$? Name the compound. [Sections 2.7 and 2.8]
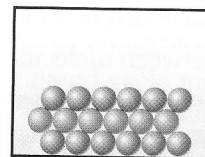
EXERCISES

Atomic Theory and the Discovery of Atomic Structure

2.9 How does Dalton's atomic theory account for the fact
CQ that when 1.000 g of water is decomposed into its elements, 0.111 g of hydrogen and 0.889 g of oxygen are obtained regardless of the source of the water?

2.10 Hydrogen sulfide is composed of two elements: hydro-
CQ gen and sulfur. In an experiment, 6.500 g of hydrogen sulfide is fully decomposed into its elements. (a) If 0.384 g of hydrogen is obtained in this experiment, how many grams of sulfur must be obtained? (b) What fundamental law does this experiment demonstrate? (c) How is this law explained by Dalton's atomic theory?

2.11 A chemist finds that 30.82 g of nitrogen will react with 17.60 g, 35.20 g, 70.40 g, or 88.00 g of oxygen to form four different compounds. (a) Calculate the mass of oxygen per gram of nitrogen in each compound. (b) How do the numbers in part (a) support Dalton's atomic theory?

2.12 In a series of experiments, a chemist prepared three different compounds that contain only iodine and fluorine and determined the mass of each element in each compound:

Compound	Mass of Iodine (g)	Mass of Fluorine (g)
1	4.75	3.56
2	7.64	3.43
3	9.41	9.86

(a) Calculate the mass of fluorine per gram of iodine in each compound. (b) How do the numbers in part (a) support the atomic theory?

2.13 Summarize the evidence used by J. J. Thomson to argue
CQ that cathode rays consist of negatively charged particles.

2.14 An unknown particle is caused to move between two
CQ electrically charged plates, as illustrated in Figure 2.8. Its path is deflected by a smaller magnitude in the

opposite direction from that of a beta particle. What can you conclude about the charge and mass of this unknown particle?

2.15 **(a)** Figure 2.5 shows the apparatus used in the Millikan
CQ oil-drop experiment with the positively charged plate above the negatively charged plate. What do you think would be the effect on the rate of oil drops descending if the charges on the plates were reversed (negative above positive)? **(b)** In his original series of experiments, Millikan measured the charge on 58 separate oil drops. Why do you suppose he chose so many drops before reaching his final conclusions?

2.16 Millikan determined the charge on the electron by
CQ studying the static charges on oil drops falling in an electric field. A student carried out this experiment using several oil drops for her measurements and calcu-

lated the charges on the drops. She obtained the following data:

Droplet	Calculated Charge (C)
A	1.60×10^{-19}
B	3.15×10^{-19}
C	4.81×10^{-19}
D	6.31×10^{-19}

(a) What is the significance of the fact that the droplets carried different charges? **(b)** What conclusion can the student draw from these data regarding the charge of the electron? **(c)** What value (and to how many significant figures) should she report for the electronic charge?

Modern View of Atomic Structure; Atomic Weights

2.17 The radius of an atom of krypton (Kr) is about 1.9 Å. **(a)** Express this distance in nanometers (nm) and in picometers (pm). **(b)** How many krypton atoms would have to be lined up to span 1.0 mm? **(c)** If the atom is assumed to be a sphere, what is the volume in cm^3 of a single Kr atom?

2.18 An atom of tin (Sn) has a diameter of about 2.8×10^{-8} cm. **(a)** What is the radius of a tin atom in angstroms (Å) and in meters (m)? **(b)** How many Sn atoms would have to be placed side by side to span a distance of 6.0 μm? **(c)** If you assume that the tin atom is a sphere, what is the volume in m^3 of a single atom?

2.19 Answer the following questions without referring to Table 2.1: **(a)** What are the main subatomic particles that make up the atom? **(b)** What is the relative charge (in multiples of the electronic charge) of each of the particles? **(c)** Which of the particles is the most massive? **(d)** Which is the least massive?

2.20 Determine whether each of the following statements is
CQ true or false. If false, correct the statement to make it true: **(a)** The nucleus has most of the mass and comprises most of the volume of an atom; **(b)** every atom of a given element has the same number of protons; **(c)** the number of electrons in an atom equals the number of neutrons in the atom; **(d)** the protons in the nucleus of the helium atom are held together by a force called the strong nuclear force.

2.21 **(a)** Define atomic number and mass number. **(b)** Which of these can vary without changing the identity of the element?

2.22 **(a)** Which two of the following are isotopes of the same element: $^{31}_{16}X$, $^{31}_{15}X$, $^{32}_{16}X$? **(b)** What is the identity of the element whose isotopes you have selected?

2.23 How many protons, neutrons, and electrons are in the following atoms: **(a)** ^{40}Ar, **(b)** ^{65}Zn, **(c)** ^{70}Ga, **(d)** ^{80}Br, **(e)** ^{184}W, **(f)** ^{243}Am?

2.24 Each of the following isotopes is used in medicine. Indicate the number of protons and neutrons in each isotope: **(a)** phosphorus-32, **(b)** chromium-51, **(c)** cobalt-60, **(d)** technetium-99, **(e)** iodine-131; **(f)** thallium-201.

2.25 Fill in the gaps in the following table, assuming each column represents a neutral atom:

Symbol	^{52}Cr				
Protons		25			82
Neutrons		30	64		
Electrons			48	86	
Mass no.				222	207

2.26 Fill in the gaps in the following table, assuming each column represents a neutral atom:

Symbol	^{65}Zn				
Protons		44			92
Neutrons		57	49		
Electrons			38	47	
Mass no.				108	235

2.27 Write the correct symbol, with both superscript and subscript, for each of the following. Use the list of elements inside the front cover as needed: **(a)** the isotope of platinum that contains 118 neutrons, **(b)** the isotope of krypton with mass number 84, **(c)** the isotope of arsenic with

mass number 75, **(d)** the isotope of magnesium that has an equal number of protons and neutrons.

2.28 One way in which Earth's evolution as a planet can be understood is by measuring the amounts of certain isotopes in rocks. One quantity recently measured is the ratio of ^{129}Xe to ^{130}Xe in some minerals. In what way do these two isotopes differ from one another? In what respects are they the same?

2.29 **(a)** What isotope is used as the standard in establishing
CQ the atomic mass scale? **(b)** The atomic weight of boron is reported as 10.81, yet no atom of boron has the mass of 10.81 amu. Explain.

2.30 **(a)** What is the mass in amu of a carbon-12 atom?
CQ **(b)** Why is the atomic weight of carbon reported as 12.011 in the table of elements and the periodic table in the front inside cover of this text?

2.31 Only two isotopes of copper occur naturally, ^{63}Cu (atomic mass = 62.9296 amu; abundance 69.17%) and ^{65}Cu (atomic mass = 64.9278 amu; abundance 30.83%). Calculate the atomic weight (average atomic mass) of copper.

2.32 Rubidium has two naturally occurring isotopes, rubidium-85 (atomic mass = 84.9118 amu; abundance = 72.15%) and rubidium-87 (atomic mass = 86.9092 amu; abundance = 27.85%). Calculate the atomic weight of rubidium.

2.33 **(a)** In what fundamental way is mass spectrometry relat-
CQ ed to Thomson's cathode-ray experiments (Figure 2.4)? **(b)** What are the labels on the axes of a mass spectrum? **(c)** To measure the mass spectrum of an atom, the atom must first lose one or more electrons. Why is this so?

2.34 **(a)** The mass spectrometer in Figure 2.13 has a magnet
CQ as one of its components. What is the purpose of the magnet? **(b)** The atomic weight of Cl is 35.5 amu. However, the mass spectrum of Cl (Figure 2.14) does not show a peak at this mass. Explain. **(c)** A mass spectrum of phosphorus (P) atoms shows only a single peak at a mass of 31. What can you conclude from this observation?

**2.35** Naturally occurring magnesium has the following isotopic abundances:

Isotope	Abundance	Atomic mass (amu)
^{24}Mg	78.99%	23.98504
^{25}Mg	10.00%	24.98584
^{26}Mg	11.01%	25.98259

(a) What is the average atomic mass of Mg? **(b)** Sketch the mass spectrum of Mg.

2.36 Mass spectrometry is more often applied to molecules than to atoms. We will see in Chapter 3 that the *molecular weight* of a molecule is the sum of the atomic weights of the atoms in the molecule. The mass spectrum of H_2 is taken under conditions that prevent decomposition into H atoms. The two naturally occurring isotopes of hydrogen are ^1H (atomic mass = 1.00783 amu; abundance 99.9885%) and ^2H (atomic mass = 2.01410 amu; abundance 0.0115%). **(a)** How many peaks will the mass spectrum have? **(b)** Give the relative atomic masses of each of these peaks. **(c)** Which peak will be the largest, and which the smallest?

The Periodic Table; Molecules and Ions

2.37 For each of the following elements, write its chemical symbol, locate it in the periodic table, and indicate whether it is a metal, metalloid, or nonmetal: **(a)** chromium, **(b)** helium, **(c)** phosphorus, **(d)** zinc, **(e)** magnesium, **(f)** bromine, **(g)** arsenic.

2.38 Locate each of the following elements in the periodic table; indicate whether it is a metal, metalloid, or nonmetal; and give the name of the element: **(a)** Ca, **(b)** Ti, **(c)** Ga, **(d)** Th, **(e)** Pt, **(f)** Se, **(g)** Kr.

2.39 For each of the following elements, write its chemical symbol, determine the name of the group to which it belongs (Table 2.3), and indicate whether it is a metal, metalloid, or nonmetal: **(a)** potassium, **(b)** iodine, **(c)** magnesium, **(d)** argon, **(e)** sulfur.

2.40 The elements of group 4A show an interesting change in properties moving down the group. Give the name and chemical symbol of each element in the group, and label it as a nonmetal, metalloid, or metal.

2.41 What can we tell about a compound when we know the
CQ empirical formula? What additional information is conveyed by the molecular formula? By the structural formula? Explain in each case.

2.42 Two compounds have the same empirical formula. One
CQ substance is a gas, the other is a viscous liquid. How is it possible for two substances with the same empirical formula to have markedly different properties?

2.43 Write the empirical formula corresponding to each of the following molecular formulas: **(a)** Al_2Br_6, **(b)** C_8H_{10}, **(c)** $C_4H_8O_2$, **(d)** P_4O_{10}, **(e)** $C_6H_4Cl_2$, **(f)** $B_3N_3H_6$.

2.44 Determine the molecular and empirical formulas of the following: **(a)** The organic solvent *benzene*, which has six carbon atoms and six hydrogen atoms; **(b)** the compound *silicon tetrachloride*, which has a silicon atom and four chlorine atoms and is used in the manufacture of computer chips; **(c)** the reactive substance *diborane*, which has two boron atoms and six hydrogen atoms; **(d)** the sugar called *glucose*, which has six carbon atoms, twelve hydrogen atoms, and six oxygen atoms.

2.45 How many hydrogen atoms are in each of the following: **(a)** C_2H_5OH, **(b)** $Ca(CH_3COO)_2$, **(c)** $(NH_4)_3PO_4$?

2.46 How many of the indicated atoms are represented by each chemical formula: **(a)** carbon atoms in $C_2H_5COOCH_3$, **(b)** oxygen atoms in $Ca(ClO_4)_2$, **(c)** hydrogen atoms in $(NH_4)_2HPO_4$?
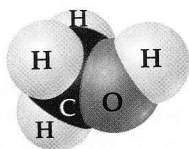
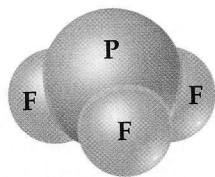**2.47** Write the molecular and structural formulas for the compounds represented by the following molecular models:
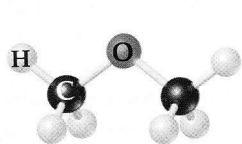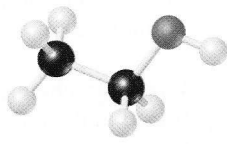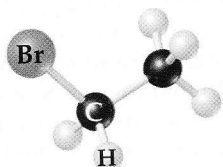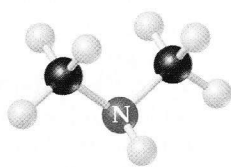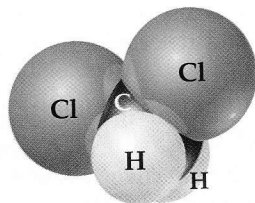

(a)   (b)

(c)   (d)

2.48 Write the molecular and structural formulas for the compounds represented by the following models:

(a)   (b)
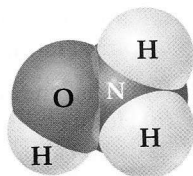
(c)   (d)

2.49 Fill in the gaps in the following table:

Symbol	$^{59}Co^{3+}$			
Protons		34	76	80
Neutrons		46	116	120
Electrons		36		78
Net charge			2+	

2.50 Fill in the gaps in the following table:

Symbol	$^{31}P^{3-}$			
Protons		35	49	
Neutrons		45	66	118
Electrons			46	76
Net charge		1−		3+

2.51 Each of the following elements is capable of forming an ion in chemical reactions. By referring to the periodic table, predict the charge of the most stable ion of each: **(a)** Mg, **(b)** Al, **(c)** K, **(d)** S, **(e)** F.

2.52 Using the periodic table, predict the charges of the ions of the following elements: **(a)** Ga, **(b)** Sr, **(c)** As, **(d)** Br, **(e)** Se.

2.53 Using the periodic table to guide you, predict the chemical formula and name of the compound formed by the following elements: **(a)** Ga and F, **(b)** Li and H, **(c)** Al and I, **(d)** K and S.

2.54 The most common charge associated with silver in its compounds is 1+. Indicate the chemical formulas you would expect for compounds formed between Ag and **(a)** iodine, **(b)** sulfur, **(c)** fluorine.

2.55 Predict the chemical formula for the ionic compound formed by **(a)** Ca^{2+} and Br^-, **(b)** K^+ and CO_3^{2-}, **(c)** Al^{3+} and CH_3COO^-, **(d)** NH_4^+ and SO_4^{2-}, **(e)** Mg^{2+} and PO_4^{3-}.

2.56 Predict the chemical formulas of the compounds formed by the following pairs of ions: **(a)** Cu^{2+} and Br^-, **(b)** Fe^{3+} and O^{2-}, **(c)** Hg_2^{2+} and CO_3^{2-}, **(d)** Ca^{2+} and AsO_4^{3-}, **(e)** NH_4^+ and CO_3^{2-}.

2.57 Complete the table by filling in the formula for the ionic compound formed by each pair of cations and anions, as shown for the first pair.

Ion	K^+	NH_4^+	Mg^{2+}	Fe^{3+}
Cl^-	KCl			
OH^-				
CO_3^{2-}				
PO_4^{3-}				

2.58 Complete the table by filling in the formula for the ionic compound formed by each pair of cations and anions, as shown for the first pair.

Ion	Na^+	Ca^{2+}	Fe^{2+}	Al^{3+}
O^{2-}	Na_2O			
NO_3^-				
SO_4^{2-}				
AsO_4^{3-}				

2.59 Predict whether each of the following compounds is molecular or ionic: **(a)** B_2H_6, **(b)** CH_3OH, **(c)** $LiNO_3$, **(d)** Sc_2O_3, **(e)** CsBr, **(f)** NOCl, **(g)** NF_3, **(h)** Ag_2SO_4.

2.60 Which of the following are ionic, and which are molecular? **(a)** PF_5, **(b)** NaI, **(c)** SCl_2, **(d)** $Ca(NO_3)_2$, **(e)** $FeCl_3$, **(f)** LaP, **(g)** $CoCO_3$, **(h)** N_2O_4.

Naming Inorganic Compounds; Organic Molecules

2.61 Give the chemical formula for (a) chlorite ion, (b) chloride ion, (c) chlorate ion, (d) perchlorate ion, (e) hypochlorite ion.

2.62 Selenium, an element required nutritionally in trace quantities, forms compounds analogous to sulfur. Name the following ions: (a) SeO_4^{2-}, (b) Se^{2-}, (c) HSe^-, (d) $HSeO_3^-$.

2.63 Give the names and charges of the cation and anion in each of the following compounds: (a) CaO, (b) Na_2SO_4, (c) $KClO_4$, (d) $Fe(NO_3)_2$, (e) $Cr(OH)_3$.

2.64 Give the names and charges of the cation and anion in each of the following compounds: (a) CuS, (b) Ag_2SO_4, (c) $Al(ClO_3)_3$, (d) $Co(OH)_2$, (e) $PbCO_3$.

2.65 Name the following ionic compounds: (a) MgO, (b) $AlCl_3$, (c) Li_3PO_4, (d) $Ba(ClO_4)_2$, (e) $Cu(NO_3)_2$, (f) $Fe(OH)_2$, (g) $Ca(C_2H_3O_2)_2$, (h) $Cr_2(CO_3)_3$, (i) K_2CrO_4, (j) $(NH_4)_2SO_4$.

2.66 Name the following ionic compounds: (a) K_2O, (b) $NaClO_2$, (c) $Sr(CN)_2$, (d) $Co(OH)_2$, (e) $Fe_2(CO_3)_3$, (f) $Cr(NO_3)_3$, (g) $(NH_4)_2SO_3$, (h) NaH_2PO_4, (i) $KMnO_4$, (j) $Ag_2Cr_2O_7$.

2.67 Write the chemical formulas for the following compounds: (a) aluminum hydroxide, (b) potassium sulfate, (c) copper(I) oxide, (d) zinc nitrate, (e) mercury(II) bromide, (f) iron(III) carbonate, (g) sodium hypobromite.

2.68 Give the chemical formula for each of the following ionic compounds: (a) sodium phosphate, (b) zinc nitrate, (c) barium bromate, (d) iron(II) perchlorate, (e) cobalt(II) hydrogen carbonate, (f) chromium(III) acetate, (g) potassium dichromate.

2.69 Give the name or chemical formula, as appropriate, for each of the following acids: (a) $HBrO_3$, (b) HBr, (c) H_3PO_4, (d) hypochlorous acid, (e) iodic acid, (f) sulfurous acid.

2.70 Provide the name or chemical formula, as appropriate, for each of the following acids: (a) hydrobromic acid, (b) hydrosulfuric acid, (c) nitrous acid, (d) H_2CO_3, (e) $HClO_3$, (f) $HC_2H_3O_2$.

2.71 Give the name or chemical formula, as appropriate, for each of the following binary molecular substances: (a) SF_6, (b) IF_5, (c) XeO_3, (d) dinitrogen tetroxide, (e) hydrogen cyanide, (f) tetraphosphorus hexasulfide.

2.72 The oxides of nitrogen are very important components in urban air pollution. Name each of the following compounds: (a) N_2O, (b) NO, (c) NO_2, (d) N_2O_5, (e) N_2O_4.

2.73 Write the chemical formula for each substance mentioned in the following word descriptions (use the front inside cover to find the symbols for the elements you don't know). (a) Zinc carbonate can be heated to form zinc oxide and carbon dioxide. (b) On treatment with hydrofluoric acid, silicon dioxide forms silicon tetrafluoride and water. (c) Sulfur dioxide reacts with water to form sulfurous acid. (d) The substance phosphorus trihydride, commonly called phosphine, is a toxic gas. (e) Perchloric acid reacts with cadmium to form cadmium(II) perchlorate. (f) Vanadium(III) bromide is a colored solid.

2.74 Assume that you encounter the following sentences in your reading. What is the chemical formula for each substance mentioned? (a) Sodium hydrogen carbonate is used as a deodorant. (b) Calcium hypochlorite is used in some bleaching solutions. (c) Hydrogen cyanide is a very poisonous gas. (d) Magnesium hydroxide is used as a cathartic. (e) Tin(II) fluoride has been used as a fluoride additive in toothpastes. (f) When cadmium sulfide is treated with sulfuric acid, fumes of hydrogen sulfide are given off.

2.75 (a) What is a hydrocarbon? (b) Butane is the alkane with a chain of four carbon atoms. Write a structural formula for this compound, and determine its molecular and empirical formulas.

2.76 (a) What ending is used for the names of alkanes? (b) Hexane is an alkane whose structural formula has all its carbon atoms in a straight chain. Draw the structural formula for this compound, and determine its molecular and empirical formulas. (Hint: You might need to refer to Table 2.6.)

2.77 (a) What is a functional group? (b) What functional group characterizes an alcohol? (c) With reference to Exercise 2.75, write a structural formula for 1-butanol, the alcohol derived from butane, by making a substitution on one of the end carbon atoms.

2.78 (a) What do ethane and ethanol have in common? (b) How does 1-propanol differ from propane?

2.79 Describe a major contribution to science made by each of the following scientists: **(a)** Dalton, **(b)** Thomson, **(c)** Millikan, **(d)** Rutherford.

2.80 How did Rutherford interpret the following observa-
CQ tions made during his α-particle scattering experi-
ments? **(a)** Most α particles were not appreciably deflected as they passed through the gold foil. **(b)** A few α particles were deflected at very large angles. **(c)** What differences would you expect if beryllium foil were used instead of gold foil in the α-particle scattering experiment?

2.81 Suppose a scientist repeats the Millikan oil-drop experi-
CQ ment, but reports the charges on the drops using an un-
usual (and imaginary) unit called the *warmomb* (wa). He obtains the following data for four of the drops:

Droplet	Calculated Charge (wa)
A	3.84×10^{-8}
B	4.80×10^{-8}
C	2.88×10^{-8}
D	8.64×10^{-8}

(a) If all the droplets were the same size, which would fall most slowly through the apparatus? **(b)** From these data, what is the best choice for the charge of the elec-
tron in warmombs? **(c)** Based on your answer to part (b), how many electrons are there on each of the droplets? **(d)** What is the conversion factor between warmombs and coulombs?

2.82 The natural abundance of ^{3}He is 0.000137%. **(a)** How many protons, neutrons, and electrons are in an atom of ^{3}He? **(b)** Based on the sum of the masses of their sub-
atomic particles, which is expected to be more massive, an atom of ^{3}He or an atom of ^{3}H (which is also called *tritium*)? **(c)** Based on your answer for part (b), what would need to be the precision of a mass spectrometer that is able to differentiate between peaks that are due to ^{3}He$^+$ and ^{3}H$^+$?

2.83 An α particle is the nucleus of an ^{4}He atom. **(a)** How many protons and neutrons are in an α particle? **(b)** What force holds the protons and neutrons together in the α particle? **(c)** What is the charge on an α particle in units of electronic charge? **(d)** The charge-to-mass ratio of an α particle is 4.8224×10^4 C/g. Based on the charge on the particle, calculate its mass in grams and in amu. **(e)** By using the data in Table 2.1, compare your answer for part (d) with the sum of the masses of the individual sub-
atomic particles. Can you explain the difference in mass? (If not, we will discuss such mass differences further in Chapter 21.)

2.84 A cube of gold that is 1.00 cm on a side has a mass of 19.3 g. A single gold atom has a mass of 197.0 amu. g/mol
(a) How many gold atoms are in the cube? **(b)** From the

information given, estimate the diameter in Å of a single gold atom. **(c)** What assumptions did you make in arriv-
ing at your answer for part (b)?

2.85 The diameter of a rubidium atom is 4.95 Å. We will con-
CQ sider two different ways of placing the atoms on a sur-
face. In arrangement A, all the atoms are lined up with one another. Arrangement B is called a *close-packed* arrangement because the atoms sit in the "depressions" formed by the previous row of atoms:


(a)   (b)
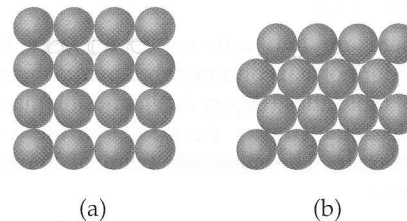
(a) Using arrangement A, how many Rb atoms could be placed on a square surface that is 1.0 cm on a side? **(b)** How many Rb atoms could be placed on a square surface that is 1.0 cm on a side, using arrangement B? **(c)** By what factor has the number of atoms on the sur-
face increased in going to arrangement B from arrange-
ment A? If extended to three dimensions, which arrangement would lead to a greater density for Rb metal?

2.86 (a) Assuming the dimensions of the nucleus and atom shown in Figure 2.12, what fraction of the *volume* of the atom is taken up by the nucleus? **(b)** Using the mass of the proton from Table 2.1 and assuming its diameter is 1.0×10^{-15} m, calculate the density of a proton in g/cm^3.

2.87 Identify the element represented by each of the follow-
ing symbols and give the number of protons and neutrons in each: **(a)** $^{74}_{33}$X, **(b)** $^{127}_{53}$X, **(c)** $^{152}_{63}$X, **(d)** $^{209}_{83}$X.

2.88 The element oxygen has three naturally occurring iso-
CQ topes, with 8, 9, and 10 neutrons in the nucleus, respec-
tively. **(a)** Write the full chemical symbols for these three isotopes. **(b)** Describe the similarities and differences be-
tween the three kinds of atoms of oxygen.

2.89 Use Coulomb's law, $F = kQ_1Q_2/d^2$, to calculate the elec-
tric force on an electron ($Q = -1.6 \times 10^{-19}$ C) exerted by a single proton if the particles are 0.53×10^{-10} m apart. The constant k in Coulomb's law is 9.0×10^9 N·m^2/C^2. (The unit abbreviated N is the Newton, the SI unit of force.)

2.90 The element lead (Pb) consists of four naturally occur-
ring isotopes with atomic masses 203.97302, 205.97444, 206.97587, and 207.97663 amu. The relative abundances of these four isotopes are 1.4, 24.1, 22.1, and 52.4%, re-
spectively. From these data, calculate the atomic weight of lead.

2.91 Gallium (Ga) consists of two naturally occurring isotopes with masses of 68.926 and 70.925 amu. **(a)** How many protons and neutrons are in the nucleus of each isotope? Write the complete atomic symbol for each, showing the atomic number and mass number. **(b)** The average atomic mass of Ga is 69.72 amu. Calculate the abundance of each isotope.

2.92 Using a suitable reference such as the *CRC Handbook of Chemistry and Physics* or http://www.webelements.com, look up the following information for nickel: **(a)** the number of known isotopes, **(b)** the atomic masses (in amu) and the natural abundance of the five most abundant isotopes.

2.93 There are two different isotopes of bromine atoms. Under normal conditions, elemental bromine consists of Br_2 molecules (Figure 2.19), and the mass of a Br_2 molecule is the sum of the masses of the two atoms in the molecule. The mass spectrum of Br_2 consists of three peaks:

Mass (amu)	Relative Size
157.836	0.2569
159.834	0.4999
161.832	0.2431

(a) What is the origin of each peak (of what isotopes does each consist)? **(b)** What is the mass of each isotope? **(c)** Determine the average molecular mass of a Br_2 molecule. **(d)** Determine the average atomic mass of a bromine atom. **(e)** Calculate the abundances of the two isotopes.

2.94 It is common in mass spectrometry to assume that the mass of a cation is the same as that of its parent atom. **(a)** Using data in Table 2.1, determine the number of significant figures that must be reported before the difference in mass of ^1H and $^1H^+$ is significant. **(b)** What percentage of the mass of an ^1H atom does the electron represent?

2.95 From the following list of elements—Ar, H, Ga, Al, Ca, Br, Ge, K, O—pick the one that best fits each description. Use each element only once: **(a)** an alkali metal, **(b)** an alkaline earth metal, **(c)** a noble gas, **(d)** a halogen, **(e)** a metalloid, **(f)** a nonmetal listed in group 1A, **(g)** a metal that forms a 3+ ion, **(h)** a nonmetal that forms a 2− ion, **(i)** an element that resembles aluminum.

2.96 The first atoms of seaborgium (Sg) were identified in 1974. The longest-lived isotope of Sg has a mass number of 266. **(a)** How many protons, electrons, and neutrons are in an ^{266}Sg atom? **(b)** Atoms of Sg are very unstable, and it is therefore difficult to study this element's properties. Based on the position of Sg in the periodic table, what element should it most closely resemble in its chemical properties?

2.97 From the molecular structures shown here, identify the one that corresponds to each of the following species:
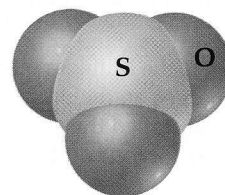
(a) chlorine gas; **(b)** propane, **(c)** nitrate ion; **(d)** sulfur trioxide; **(e)** methyl chloride, CH_3Cl.
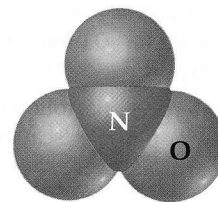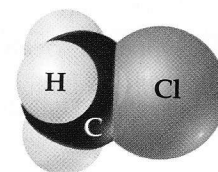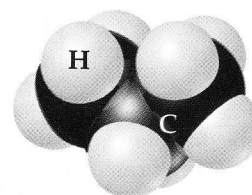
(i)
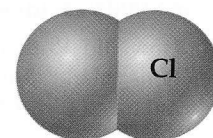
(ii)

(iii)

(iv)

(v)

2.98 Name each of the following oxides. Assuming that the compounds are ionic, what charge is associated with the metallic element in each case? **(a)** NiO, **(b)** MnO_2, **(c)** Cr_2O_3, **(d)** MoO_3.

2.99 Iodic acid has the molecular formula HIO_3. Write the formulas for the following: **(a)** the iodate anion, **(b)** the periodate anion, **(c)** the hypoiodite anion, **(d)** hypoiodous acid, **(e)** periodic acid.

2.100 Elements in the same group of the periodic table often form oxyanions with the same general formula. The anions are also named in a similar fashion. Based on these observations, suggest a chemical formula or name, as appropriate, for each of the following ions: **(a)** BrO_4^-, **(b)** SeO_3^{2-}, **(c)** arsenate ion, **(d)** hydrogen tellurate ion.

2.101 Carbonic acid occurs in carbonated beverages. When allowed to react with lithium hydroxide it produces lithium carbonate. Lithium carbonate is used to treat depression and bipolar disorder. Write chemical formulas for carbonic acid, lithium hydroxide, and lithium carbonate.

2.102 Give the chemical names of each of the following familiar compounds: **(a)** NaCl (table salt) , **(b)** $NaHCO_3$ (baking soda), **(c)** NaOCl (in many bleaches), **(d)** NaOH (caustic soda), **(e)** $(NH_4)_2CO_3$ (smelling salts), **(f)** $CaSO_4$ (plaster of Paris).

2.103 Many familiar substances have common, unsystematic names. For each of the following, give the correct

systematic name: **(a)** saltpeter, KNO_3; **(b)** soda ash, Na_2CO_3; **(c)** lime, CaO; **(d)** muriatic acid, HCl; **(e)** Epsom salts, $MgSO_4$; **(f)** milk of magnesia, $Mg(OH)_2$.

2.104 Many ions and compounds have very similar names, and there is great potential for confusing them. Write the correct chemical formulas to distinguish between **(a)** calcium sulfide and calcium hydrogen sulfide, **(b)** hydrobromic acid and bromic acid, **(c)** aluminum nitride and aluminum nitrite, **(d)** iron(II) oxide and iron(III) oxide, **(e)** ammonia and ammonium ion, **(f)** potassium sulfite and potassium bisulfite, **(g)** mercurous chloride and mercuric chloride, **(h)** chloric acid and perchloric acid.

2.105 The compound *cyclohexane* is an alkane in which six carbon atoms form a ring. The partial structural formula of the compound is as follows:
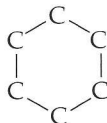
(a) Complete the structural formula for cyclohexane. **(b)** Is the molecular formula for cyclohexane the same as that for *n*-hexane, in which the carbon atoms are in a straight line? If possible, comment on the source of any differences. **(c)** Propose a structural formula for *cyclohexanol*, the alcohol derived from cyclohexane.

2.106 The periodic table helps organize the chemical behaviors of the elements. As a class discussion or as a short essay, describe how the table is organized, and mention as many ways as you can think of in which the position of an element in the table relates to the chemical and physical properties of the element.