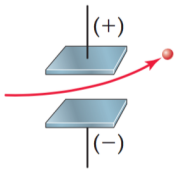
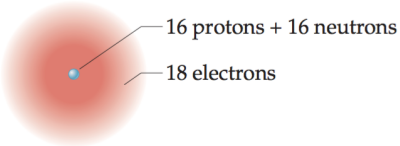
Atoms, Molecules, and Ions
Problem Set

2.1 A charged particle is caused to move between two electrically charged plates, as shown here.

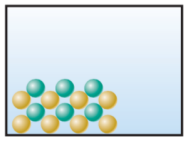


(a) Why does the path of the charged particle bend? **(b)** What is the sign of the electrical charge on the particle? **(c)** As the charge on the plates is increased, would you expect the bending to increase, decrease, or stay the same? **(d)** As the mass of the particle is increased while the speed of the particles remains the same, would you expect the bending to increase, decrease, or stay the same? [Section 2.2]

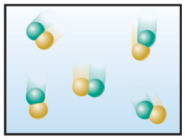
2.4 Does the following drawing represent a neutral atom or an ion? Write its complete chemical symbol including mass number, atomic number, and net charge (if any). [Sections 2.3 and 2.7]



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

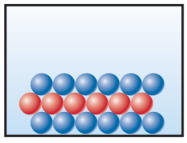


(i)



(ii)

2.8 The following diagram represents an ionic compound in 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]



2.9 How does Dalton's atomic theory account for the fact 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: hydrogen 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?

2.15 How did Rutherford interpret the following observations made during his α-particle scattering experiments? **(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?

2.16 Millikan determined the charge on the electron by studying the static charges on oil drops falling in an electric field (Figure 2.5). A student carried out this experiment using several oil drops for her measurements and calculated 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?

2.17 The radius of an atom of gold (Au) is about 1.35 Å. **(a)** Express this distance in nanometers (nm) and in picometers (pm). **(b)** How many gold 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 Au atom?

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?

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

Symbol	^{65}Zn				
Protons		38			92
Neutrons		58	49		
Electrons			38	36	
Mass no.				81	235

2.29 (a) What isotope is used as the standard in establishing 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.

2.31 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.

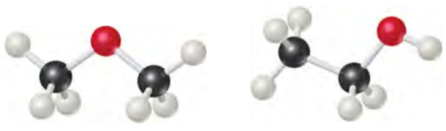
2.39 For each of the following elements, write its chemical symbol, determine the name of the group to which it belongs (Table 2.3), and indicate whether it is a metal, metalloid, or nonmetal: (a) potassium, (b) iodine, (c) magnesium, (d) argon, (e) sulfur.

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

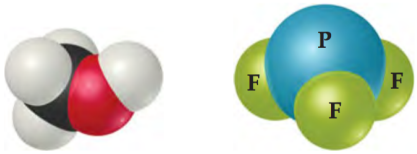
2.43 Write the empirical formula corresponding to each of the following molecular formulas: (a) Al_2Br_6, (b) C_8H_{10}, (c) $C_4H_8O_2$, (d) P_4O_{10}, (e) $C_6H_4Cl_2$, (f) $B_3N_3H_6$.

2.46 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)

2.50 Fill in the gaps in the following table:

Symbol	$^{31}P^{3-}$			
Protons		34	50	
Neutrons		45	69	118
Electrons			46	76
Net charge		2−		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.

2.54 The most common charge associated with scandium in its compounds is 3+. Indicate the chemical formulas you would expect for compounds formed between scandium and (a) iodine, (b) sulfur, (c) nitrogen.

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.

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

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) $Cr(OH)_3$.

2.65 Name the following ionic compounds: (a) Li_2O, (b) $FeCl_3$, (c) NaClO, (d) $CaSO_3$, (e) $Cu(OH)_2$, (f) $Fe(NO_3)_2$, (g) $Ca(CH_3COO)_2$, (h) $Cr_2(CO_3)_3$, (i) K_2CrO_4, (j) $(NH_4)_2SO_4$.

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.

2.69 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) hydroiodic acid, (b) chloric acid, (c) nitrous acid, (d) H_2CO_3, (e) $HClO_4$, (f) CH_3COOH

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.

2.74 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.