

Answers

- (a) ionic; yes
- (b) NaCl
- (c) molecular; ICl_3 ; iodine trichloride; no
- (d) Atomic number of Na is 11; atomic number of Cl is 17.
- (e) $\frac{1}{2}\text{Na}$
- (f) Na: Group 1, period 3; metal
Cl: Group 17, period 3; nonmetal

- (g) 20
- (h) 36.96 amu
- (i) 1.31×10^{23}
- (j) 5.887×10^{-11} g
- (k) AlCl_3 ; aluminum chloride
- (l) ClO_2 ; chlorine dioxide
 ClO_2^- : chlorite ion
 HClO_2 : chlorous acid
 NaClO_2 : sodium chlorite

CHAPTER 2

Questions and Problems

Blue-numbered questions have answers in Appendix 5 and fully worked solutions in the *Student Solutions Manual*.

OWL Interactive versions of these problems are assignable in OWL.

Atomic Theory and Laws

1. State in your own words the law of conservation of mass. State the law in its modern form.
2. State in your own words the law of constant composition.
3. Two basic laws of chemistry are the law of conservation of mass and the law of constant composition. Which of these laws (if any) do the following statements illustrate?
 - (a) Lavoisier found that when mercury(II) oxide, HgO , decomposes, the total mass of mercury (Hg) and oxygen formed equals the mass of mercury(II) oxide decomposed.
 - (b) Analysis of the calcium carbonate found in the marble mined in Carrara, Italy, and in the stalactites of the Carlsbad Caverns in New Mexico gives the same value for the percentage of calcium in calcium carbonate.
 - (c) Hydrogen occurs as a mixture of two isotopes, one of which is twice as heavy as the other.
4. Which of the laws described in Question 3 do the following statements illustrate?
 - (a) A sealed bag of popcorn has the same mass before and after it is put in a microwave oven. (Assume no breaks develop in the bag.)
 - (b) Hydrogen has three isotopes. One has a mass number A equal to its atomic number Z . In another isotope, $A = 2Z$, and in a third, $A = 3Z$.
 - (c) A teaching assistant writes "highly improbable" on a student's report that states that her unknown is $\text{Cu}_{13}\text{O}_{14}$.

Nuclear Symbols and Isotopes

5. Who discovered the electron? Describe the experiment that led to the deduction that electrons are negatively charged particles.
6. Who discovered the nucleus? Describe the experiment that led to this discovery.
7. Selenium is widely sold as a dietary supplement. It is advertised to "protect" women from breast cancer. Write the nuclear symbol for naturally occurring selenium. It has 34 protons and 46 neutrons.
8. Yttrium-90 is used in the treatment of cancer, particularly non-Hodgkin's lymphoma.
 - (a) How many protons are there in an atom of Y-90?
 - (b) How many neutrons?
 - (c) Write the nuclear symbol (${}^A_Z\text{X}$) for Y-90.
9. How do the isotopes of Cu-63 and Cu-65 differ from each other? Write nuclear symbols for both.
10. Consider two isotopes Fe-54 and Fe-56.
 - (a) Write the nuclear symbol for both isotopes.
 - (b) How do they differ from each other?

11. Uranium-235 is the isotope of uranium commonly used in nuclear power plants. How many
 - (a) protons are in its nucleus?
 - (b) neutrons are in its nucleus?
 - (c) electrons are in a uranium atom?
12. An isotope of americium (Am) with 146 neutrons is used in many smoke alarms.
 - (a) How many electrons does an atom of americium have?
 - (b) What is the isotope's mass number A ?
 - (c) Write its nuclear symbol.
13. Consider the following nuclear symbols. How many protons, neutrons, and electrons does each element have? What elements do R, T, and X represent?
 - (a) ${}^{55}_{24}\text{R}$ (b) ${}^{137}_{54}\text{T}$ (c) ${}^{133}_{54}\text{X}$
14. Consider the following nuclear symbols. How many protons, neutrons, and electrons does each element have? What elements do A, L, and Z represent?
 - (a) ${}^{33}_{15}\text{A}$ (b) ${}^{111}_{47}\text{L}$ (c) ${}^{131}_{53}\text{Z}$
15. Nuclei with the same mass number but different atomic numbers are called *isobars*. Consider Ca-40, Ca-41, K-41 and Ar-41.
 - (a) Which of these are isobars? Which are isotopes?
 - (b) What do Ca-40 and Ca-41 have in common?
 - (c) Correct the statement (if it is incorrect): Atoms of Ca-41, K-41, and Ar-41 have the same number of neutrons.
16. See the definition for isobars in Question 15. Consider boron-12, and write the nuclear symbol for
 - (a) an isobar of boron-12 with atomic number 6.
 - (b) a nucleus with 4 protons and 8 neutrons.
Is this nucleus an isotope or an isobar of boron-12?
 - (c) a nucleus with 5 protons and 6 neutrons.
Is this nucleus an isotope or an isobar of boron-12?

Atomic Masses and Isotopic Abundances

17. Calculate the mass ratio of a bromine atom to an atom of
 - (a) neon (b) calcium (c) helium
18. Arrange the following in order of increasing mass.
 - (a) a sodium ion (b) a selenium atom
 - (c) a sulfur (S_8) molecule (d) a scandium atom
19. Cerium is the most abundant rare earth metal. Pure cerium ignites when scratched by even a soft object. It has four known isotopes: ${}^{136}\text{Ce}$ (atomic mass = 135.907 amu), ${}^{138}\text{Ce}$ (atomic mass = 137.905 amu), ${}^{140}\text{Ce}$ (atomic mass = 139.905 amu), and ${}^{142}\text{Ce}$ (atomic mass = 141.909 amu). Ce-140 and Ce-142 are fairly abundant. Which is the more abundant isotope?
20. Consider the three stable isotopes of oxygen with their respective atomic masses: O-16 (15.9949 amu), O-17 (16.9993 amu), O-18 (17.9992 amu). Which is the most abundant?

21. Gallium has two naturally occurring isotopes: ^{69}Ga , with atomic mass 68.9257 amu, and ^{71}Ga , with atomic mass 70.9249 amu. The percent abundance of ^{69}Ga can be estimated to be which of the following?

- (a) 0% (b) 25% (c) 50% (d) 75%

22. Rubidium has two naturally occurring isotopes: ^{85}Rb (atomic mass = 84.9118 amu) and ^{87}Rb (atomic mass = 86.9092 amu). The percent abundance of ^{87}Rb can be estimated to be which of the following?

- (a) 0% (b) 25% (c) 50% (d) 75%

23. Strontium has four isotopes with the following masses: 83.9134 amu (0.56%), 85.9094 amu (9.86%), 86.9089 amu (7.00%), and 87.9056 amu (82.58%). Calculate the average atomic mass of strontium.

24. Silicon is widely used in the semiconductor industry. Its isotopes and abundances are:

Si-28	27.977 amu	92.34%
Si-29	28.977 amu	4.70%
Si-30	29.974 amu	2.96%

What is the average atomic mass of silicon?

25. Naturally occurring silver (Ag) consists of two isotopes. One of the isotopes has a mass of 106.90509 amu and 51.84% abundance. What is the atomic mass of the other isotope?

26. Copper has two naturally occurring isotopes. Cu-63 has an atomic mass of 62.9296 amu and an abundance of 69.17%. What is the atomic mass of the second isotope? What is its nuclear symbol?

27. Chromium (average atomic mass = 51.9961 amu) has four isotopes. Their masses are 49.94605 amu, 51.94051 amu, 52.94065 amu, and 53.93888 amu. The first two isotopes have a total abundance of 87.87%, and the last isotope has an abundance of 2.365%. What is the abundance of the third isotope? Estimate the abundances of the first two isotopes.

28. Magnesium (average atomic mass = 24.305 amu) consists of three isotopes with masses 23.9850 amu, 24.9858 amu, and 25.9826 amu. The abundance of the middle isotope is 10.00%. Estimate the abundances of the other isotopes.

29. Neon consists of three isotopes, Ne-20, Ne-21, and Ne-22. Their abundances are 90.48%, 0.27%, and 9.22%, respectively. Sketch the mass spectrum for neon.

30. Chlorine has two isotopes, Cl-35 and Cl-37. Their abundances are 75.53% and 24.47%, respectively. Assume that the only hydrogen isotope present is H-1.

- How many different HCl molecules are possible?
- What is the sum of the mass numbers of the two atoms in each molecule?
- Sketch the mass spectrum for HCl if all the positive ions are obtained by removing a single electron from an HCl molecule.

31. Lead is a heavy metal that remains in the bloodstream, causing mental retardation in children. It is believed that 3×10^{-7} g of Pb in 1.00 mL of blood is a health hazard. For this amount of lead how many atoms of lead are there in one mL of a child's blood?

32. Silversmiths are warned to limit their exposure to silver in the air to 1×10^{-8} g Ag/L of air in a 40-hour week. What is the allowed exposure in terms of atoms of Ag/L/week?

33. Determine

- the number of atoms in 0.185 g of palladium (Pd).
- the mass of 127 protons of palladium.

34. How many protons are in

- ten atoms of platinum?
- ten grams of platinum?

35. The isotope Si-28 has a mass of 27.977 amu. For ten grams of Si-28, calculate

- the number of atoms.
- the total number of protons, neutrons, and electrons.

36. Consider an isotope of yttrium, Y-90. This isotope is incorporated into cancer-seeking antibodies so that the cancer can be irradiated by the yttrium and destroyed. How many neutrons are in

- twenty-five atoms of yttrium?
- one nanogram (10^{-9} g) of yttrium?

37. A cube of sodium has length 1.25 in. How many atoms are in that cube? (Note: $d_{\text{Na}} = 0.968 \text{ g/cm}^3$.)

38. A cylindrical piece of pure copper ($d = 8.92 \text{ g/cm}^3$) has diameter 1.15 cm and height 4.00 inches. How many atoms are in that cylinder? (Note: the volume of a right circular cylinder of radius r and height h is $V = \pi r^2 h$.)

Elements and the Periodic Table

39. Give the symbols for

- potassium
- cadmium
- aluminum
- antimony
- phosphorus

40. Name the elements represented by

- S
- Sc
- Se
- Si
- Sr

41. Classify the elements in Question 39 as metals (main group, transition, or post-transition), nonmetals, or metalloids.

42. Classify the elements in Question 40 as metals (main group, transition, or post-transition), nonmetals, or metalloids.

43. How many metals are in the following groups?

- Group 1
- Group 13
- Group 17

44. How many nonmetals are in the following periods?

- period 2
- period 4
- period 6

45. Which group in the periodic table

- has one metalloid and no nonmetals?
- has no nonmetals or transition metals?
- has no metals or metalloids?

46. Which period of the periodic table

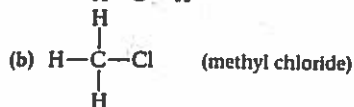
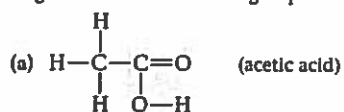
- has no metals?
- has no nonmetals?
- has one post-transition metal and two metalloids?

Molecules and Ions

47. Given the following condensed formulas, write the molecular formulas for the following molecules.

- dimethylamine $(\text{CH}_3)_2\text{NH}$
- propyl alcohol $\text{CH}_3(\text{CH}_2)_2\text{OH}$

48. Write the condensed structural formulas and molecular formulas for the following molecules. The reactive groups are shown in red.



49. Give the number of protons and electrons in

- an N_2 molecule (identified in 1772).
- an N_3^- unit (synthesized in 1890).
- an N_5^+ unit (synthesized in 1999).
- an N_5N_5 salt (a U.S. Air Force research team's synthesis project).

50. Give the number of protons and electrons in the following:

- S_8 molecule.
- SO_4^{2-} ion.
- H_2S molecule.
- S^{2-} ion.

51. Complete the table below. If necessary, use the periodic table.

Nuclear Symbol	Charge	Number of Protons	Number of Neutrons	Number of Electrons
	0	9	10	
^{31}P	0		16	
	+3	27	30	
		16	16	18

52. Complete the table below. Use the periodic table if necessary.

Nuclear Symbol	Charge	Number of Protons	Number of Neutrons	Number of Electrons
^{79}Br	0			
	-3	7	7	
	+5	33	42	
$^{90}\text{Zr}^{4+}$				

53. Classify the following compounds as electrolytes or nonelectrolytes.

- (a) potassium chloride, KCl (b) hydrogen peroxide, H_2O_2
 (c) methane, CH_4 (d) barium nitrate, $\text{Ba}(\text{NO}_3)_2$

54. Which (if any) of the following compounds are nonelectrolytes?

- (a) citric acid ($\text{C}_6\text{H}_8\text{O}_7$)
 (b) calcium nitrate, $\text{Ca}(\text{NO}_3)_2$
 (c) ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3$
 (d) iodine tribromide (IBr_3)

Names and Formulas of Ionic and Molecular Compounds

55. Write the formulas for the following molecules.

- (a) methane (b) carbon tetraiodide
 (c) hydrogen peroxide (d) nitrogen oxide
 (e) silicon dioxide

56. Write the formulas for the following molecules.

- (a) water (b) ammonia
 (c) hydrazine (d) sulfur hexafluoride
 (e) phosphorus pentachloride

57. Write the names of the following molecules.

- (a) ICl_3 (b) N_2O_5 (c) PH_3 (d) CBr_4 (e) SO_3

58. Write the names of the following molecules.

- (a) Se_2Cl_2 (b) CS_2 (c) PH_3 (d) IF_7 (e) P_4O_6

59. Give the formulas of all the compounds containing no ions other than K^+ , Ca^{2+} , Cl^- , and S^{2-} .

60. Give the formulas of compounds in which

- (a) the cation is Ba^{2+} , the anion is I^- or N^{3-} .
 (b) the anion is O^{2-} , the cation is Fe^{2+} or Fe^{3+} .

61. Write the formulas of the following ionic compounds.

- (a) iron(III) carbonate (b) sodium azide (N_3^-)
 (c) calcium sulfate (d) copper(I) sulfide
 (e) lead(IV) oxide

62. Write formulas for the following ionic compounds:

- (a) potassium hydrogen phosphate (b) magnesium nitride
 (c) lead(IV) bromide (d) scandium(III) chloride
 (e) barium acetate

63. Write the names of the following ionic compounds.

- (a) $\text{K}_2\text{Cr}_2\text{O}_7$ (b) $\text{Cu}_3(\text{PO}_4)_2$ (c) $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2$
 (d) AlN (e) $\text{Co}(\text{NO}_3)_2$

64. Write the names of the following ionic compounds.

- (a) ScCl_3 (b) $\text{Sr}(\text{OH})_2$ (c) KMnO_4
 (d) Rb_2S (e) Na_2CO_3

65. Write the names of the following ionic compounds.

- (a) $\text{HCl}(\text{aq})$ (b) $\text{HClO}_3(\text{aq})$ (c) $\text{Fe}_2(\text{SO}_3)_3$
 (d) $\text{Ba}(\text{NO}_2)_2$ (e) NaClO

66. Write formulas for the following ionic compounds.

- (a) nitric acid (b) potassium sulfate
 (c) iron(III) perchlorate (d) aluminum iodate
 (e) sulfurous acid

67. Complete the following table.

Name	Formula
nitrous acid	
	$\text{Ni}(\text{IO}_3)_2$
gold(III) sulfide	
	$\text{H}_2\text{SO}_3(\text{aq})$
nitrogen trifluoride	

68. Complete the following table.

Name	Formula
sodium dichromate	
	BrI_3
copper(II) hypochlorite	
	S_2Cl_2
potassium nitride	

Unclassified

69. Write the formulas and names of the following:

- (a) An ionic compound whose cation is a transition metal with 25 protons and 22 electrons and whose anion is an oxoanion of nitrogen with two oxygen atoms.
 (b) A molecule made up of a metalloid in Group 13 and three atoms of a halogen in period 2.
 (c) An ionic compound made up of an alkaline earth with 20 protons, and an anion with one hydrogen atom, a carbon atom, and 3 oxygen atoms.

70. Identify the following elements:

- (a) A member of the same period as selenium but with two fewer protons than selenium.
 (b) A transition metal in group 6, period 6.
 (c) An alkaline earth with 38 protons.
 (d) A post-transition metal in group 15.

71. Hydrogen-1 can take the form of a molecule, an anion (H^-), or a cation (H^+).

- (a) How many protons, electrons, and neutrons are in each possible species?
 (b) Write the name and formula for the compound formed between hydrogen and a metal in Group 2 with 12 protons.
 (c) What is the general name of the aqueous compounds in which hydrogen is a cation?

72. A molecule of ethylamine is made up of two carbon atoms, seven hydrogen atoms, and one nitrogen atom.

- (a) Write its molecular formula.
 (b) The reactive group in ethylamine is NH_2 . Write its condensed structural formula.

73. Criticize each of the following statements.
- In an ionic compound, the number of cations is always the same as the number of anions.
 - The molecular formula for strontium bromide is SrBr_2 .
 - The mass number is always equal to the atomic number.
 - For any ion, the number of electrons is always more than the number of protons.

74. Which of the following statements is/are always true? Never true? Usually true?

- Compounds containing chlorine can be either molecular or ionic.
- An ionic compound always has at least one metal.
- When an element in a molecule has a "di" prefix, it means that the element has a +2 charge.

75. Some brands of salami contain 0.090% sodium benzoate ($\text{NaC}_7\text{H}_5\text{O}_2$) as a preservative. If you eat 6.00 oz of this salami, how many atoms of sodium will you consume, assuming salami contains no other source of that element?

76. Carbon tetrachloride, CCl_4 , was a popular dry-cleaning agent until it was shown to be carcinogenic. It has a density of 1.589 g/cm^3 . What volume of carbon tetrachloride will contain a total of 6.00×10^{25} molecules of CCl_4 ?

Conceptual Problems

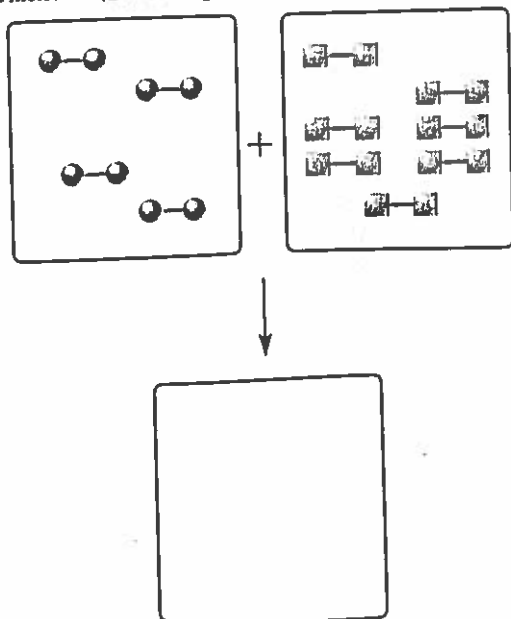
77. Which statements are true?

- Neutrons have neither mass nor charge.
- Isotopes of an element have an identical number of protons.
- C-14 and N-14 have identical neutron/proton (n/p^+) ratios.
- The vertical columns in a periodic table are referred to as "groups."
- When an atom loses an electron, it becomes positively charged.

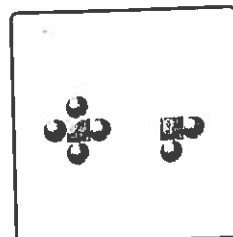
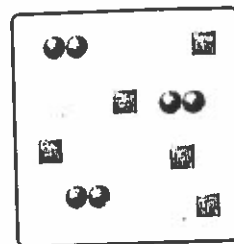
78. A student saw the following nuclear symbol for an unknown element: ${}_{11}^{\text{X}}$. Which of the following statements about X and ${}_{11}^{\text{X}}$ are true?

- X is sodium.
- X is vanadium.
- X has 23 neutrons in its nucleus.
- X^{2+} has 13 electrons.
- ${}_{11}^{\text{X}}$ has a proton/neutron ratio of about 1.1.

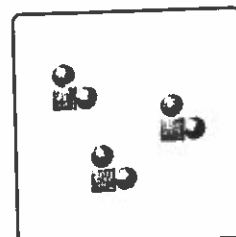
79. Using the laws of constant composition and the conservation of mass, complete the molecular picture of hydrogen molecules ($\text{O}-\text{O}$) reacting with chlorine molecules ($\text{Cl}-\text{Cl}$) to give hydrogen chloride ($\text{Cl}-\text{O}$) molecules.



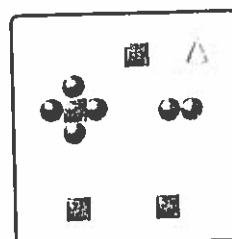
80. Use the law of conservation of mass to determine which numbered box(es) represent(s) the product mixture after the substances in the box at the top of the next column undergo a reaction.



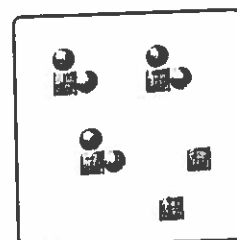
(1)



(2)



(3)



(4)

81. If squares represent carbon and spheres represent chlorine, make a representation of liquid CCl_4 .

82. If squares represent Cl atoms and spheres represent K atoms, make a representation of a KCl crystal.

83. Scientists are trying to synthesize elements with more than 114 protons. State the expected atomic number of

- the newest inert gas.
- the new element with properties similar to those of the alkaline earth metals.
- the new element that will behave like the halogens.
- the new (nontransition) metal whose ion will have a +2 charge.
- the new element that will start period 8.

84. Write the nuclear symbol for the element whose mass number is 234 and has 60% more neutrons than protons.

85. Mercury(II) oxide, a red powder, can be decomposed by heating to produce liquid mercury and oxygen gas. When a sample of this compound is decomposed, 3.87 g of oxygen and 48.43 g of mercury are produced. In a second experiment, 15.68 g of mercury is allowed to react with an excess of oxygen and 16.93 g of red mercury(II) oxide is produced. Show that these results are consistent with the law of constant composition.

86. Write the atomic symbol for the element whose ion has a -2 charge, has 20 more neutrons than electrons, and has a mass number of 126.

87. Consider the elements oxygen, fluorine, argon, sulfur, potassium, and strontium. From this group of elements, which ones fit the descriptions below?

- Two elements that are metals.
- Four elements that are nonmetals.
- Three elements that are solid at room temperature.
- An element that is found in nature as X_8 .
- One pair of elements that may form a molecular compound.
- One pair of elements that may form an ionic compound with formula AX .
- One pair of elements that may form an ionic compound with formula AX_2 .
- One pair of elements that may form an ionic compound with formula A_2X .
- An element that can form no compounds.
- Three elements that are gases at room temperature.

Challenge Problems

88. Three compounds containing only carbon and hydrogen are analyzed. The results for the analysis of the first two compounds are given below:

Compound	Mass of Carbon (g)	Mass of Hydrogen (g)
A	28.5	2.39
B	34.7	11.6
C	16.2	—

Which, if any, of the following results for the mass of hydrogen in compound C follows the law of multiple proportions?

- 5.84 g
- 3.47 g
- 2.72 g

89. Ethane and ethylene are two gases containing only hydrogen and carbon atoms. In a certain sample of ethane, 4.53 g of hydrogen is combined with 18.0 g of carbon. In a sample of ethylene, 7.25 g of hydrogen is combined with 43.20 g of carbon.

- Show how the data illustrate the law of multiple proportions.
- Suggest reasonable formulas for the two compounds.

90. Calculate the average density of a single Al-27 atom by assuming that it is a sphere with a radius of 0.143 nm. The masses of a proton, electron, and neutron are 1.6726×10^{-24} g, 9.1094×10^{-28} g, and 1.6749×10^{-24} g, respectively. The volume of a sphere is $\frac{4\pi r^3}{3}$, where r is its radius. Express the answer in grams per cubic centimeter. The density of aluminum is found experimentally to be 2.70 g/cm³. What does that suggest about the packing of aluminum atoms in the metal?

91. The mass of a beryllium atom is 1.4965×10^{-23} g. Using that fact and other information in this chapter, find the mass of a Be^{2+} ion.

92. Each time you inhale, you take in about 500 mL (two significant figures) of air, each milliliter of which contains 2.5×10^{19} molecules. In delivering the Gettysburg Address, Abraham Lincoln is estimated to have inhaled about 200 times.

- How many molecules did Lincoln take in?
- In the entire atmosphere, there are about 1.1×10^{44} molecules. What fraction of the molecules in the earth's atmosphere was inhaled by Lincoln at Gettysburg?
- In the next breath that you take, how many molecules were inhaled by Lincoln at Gettysburg?

Summary Problem

Consider titanium. It is a metal with the same strength as steel, but it is 45% lighter. It is also resistant to corrosion by seawater and is used in the propeller shafts of boats.

- How many grams of titanium are there in 0.0217 mol?
- Write the formula for titanium(III) chloride. What is its molar mass?
- A 175.0-mL solution is made up of 20.0 g of titanium(III) chloride and water. What is its molarity? What is the molarity of the chloride ion in solution?
- When titanium reacts with bromine gas, titanium(IV) bromide is obtained. Write a balanced equation for this reaction.
- How many grams of bromine are required to completely react with 22.1 g of titanium?
- Thirteen grams of titanium react with 60.0 g of bromine. How many grams of titanium(IV) bromide are produced, assuming 100% yield? How many grams of excess reactant are present after the reaction?

- The reaction in (f) is later found to have 79.3% yield. How many grams of titanium(IV) bromide are actually obtained?
- The mineral perovskite is an excellent source for titanium. It is made up of 29.4% Ca, 35.2% Ti, and 35.3% O. What is the simplest formula for perovskite?
- How many kilograms of the mineral are required to produce 5.00 kg of titanium?

Answers

- (a) 1.04 g (b) TiCl_3 ; 154.22 g/mol (c) 0.741 M; 2.22 M
(d) $\text{Ti}(s) + 2 \text{Br}_2(g) \longrightarrow \text{TiBr}_4(s)$ (e) 148 g
(f) 69.0 g TiBr_4 ; 4.01 g of Ti left after reaction
(g) 54.7 g (h) CaTiO_3 (i) 14.2 kg

CHAPTER 3

Questions and Problems

Blue-numbered questions have answers in Appendix 5 and fully worked solutions in the *Student Solutions Manual*.

OWL Interactive versions of these problems are assignable in OWL.

The Mole, Molar Mass, and Mole-Gram Conversions

- One chocolate chip used in making chocolate chip cookies has a mass of 0.324 g.
 - How many chocolate chips are there in one mole of chocolate chips?
 - If a cookie needs 15 chocolate chips, how many cookies can one make with a billionth (1×10^{-9}) of a mole of chocolate chips? (A billionth of a mole is scientifically known as a *nanomole*.)
- The meat from one hazelnut has a mass of 0.985 g.
 - What is the mass of a millionth of a mole (10^{-6}) of hazelnut meats? (A millionth of a mole is also called a *micromole*.)
 - How many moles are in a pound of hazelnut meats?
- Determine
 - the mass of 0.357 mol of gold.
 - the number of atoms in 0.357 g of gold.
 - the number of moles of electrons in 0.357 g of gold.
- How many electrons are in
 - an ion of Sc^{3+} ?
 - a mol of Sc^{3+} ?
 - a gram of Sc^{3+} ?
- A cube of sodium has length 1.25 in. How many atoms are in that cube? (Note: $d_{\text{Na}} = 0.968 \text{ g/cm}^3$.)
- A cylindrical piece of pure copper ($d = 8.92 \text{ g/cm}^3$) has diameter 1.15 cm and height 4.00 inches. How many atoms are in that cylinder? (Note: the volume of a right circular cylinder of radius r and height h is $V = \pi r^2 h$.)
- Calculate the molar masses (in grams per mole) of
 - cane sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.
 - laughing gas, N_2O .
 - vitamin A, $\text{C}_{20}\text{H}_{30}\text{O}$.

- Calculate the molar mass (in grams/mol) of
 - osmium metal, the densest naturally occurring element.
 - baking soda, NaHCO_3 .
 - vitamin D, $\text{C}_{28}\text{H}_{44}\text{O}$, required for healthy bones and teeth.
- Convert the following to moles.
 - 4.00×10^3 g of hydrazine, a rocket propellant
 - 12.5 g of tin(II) fluoride, the active ingredient in fluoride toothpaste
 - 13 g of caffeine, $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$
- Convert the following to moles.
 - 35.00 g of CF_2Cl_2 , a chlorofluorocarbon that destroys the ozone layer in the atmosphere
 - 100.0 mg of iron(II) sulfate, an iron supplement prescribed for anemia
 - 2.00 g of Valium[®] ($\text{C}_{15}\text{H}_{13}\text{ClN}_2\text{O}$ — diazepam)
- Calculate the mass in grams of 2.688 mol of
 - chlorophyll, $\text{C}_{55}\text{H}_{72}\text{N}_4\text{O}_5\text{Mg}$, responsible for the green color of leaves.
 - sorbitol, $\text{C}_6\text{H}_{14}\text{O}_6$, an artificial sweetener.
 - indigo, $\text{C}_{16}\text{H}_{10}\text{N}_2\text{O}_2$, a blue dye.
- Calculate the mass in grams of 1.35 mol of
 - titanium white, TiO_2 , used as a paint pigment.
 - sucralose, $\text{C}_{12}\text{H}_{19}\text{O}_8\text{Cl}_3$, the active ingredient in the artificial sweetener, Splenda[™].
 - strychnine, $\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$, present in rat poison.
- Complete the following table for TNT (trinitrotoluene), $\text{C}_7\text{H}_5(\text{NO}_2)_3$.

	Number of Grams	Number of Moles	Number of Molecules	Number of N Atoms
(a)	127.2	_____	_____	_____
(b)	_____	0.9254	_____	_____
(c)	_____	_____	1.24×10^{28}	_____
(d)	_____	_____	_____	7.5×10^{22}

14. Complete the following table for citric acid, $C_6H_8O_7$, the acid found in many citrus fruits.

	Number of Grams	Number of Moles	Number of Molecules	Number of O Atoms
(a)	0.1364	_____	_____	_____
(b)	_____	1.248	_____	_____
(c)	_____	_____	4.32×10^{22}	_____
(d)	_____	_____	_____	5.55×10^{19}

Moles in Solution

15. Household ammonia used for cleaning contains about 10 g (two significant figures) of NH_3 in 100 mL (two significant figures) of solution. What is the molarity of the NH_3 in solution?
16. The average adult has about 16 g of sodium ions in her blood. Assuming a total blood volume of 5.0 L, what is the molarity of Na^+ ions in blood?
17. What is the molarity of each ion present in aqueous solutions prepared by dissolving 20.00 g of the following compounds in water to make 4.50 L of solution?
- cobalt(III) chloride
 - nickel(III) sulfate
 - sodium permanganate
 - iron(II) bromide
18. What is the molarity of each ion present in an aqueous solution prepared by dissolving 1.68 g of the following compounds in enough water to make 275 mL of solution?
- iron(III) nitrate
 - potassium sulfate
 - ammonium phosphate
 - sodium hydrogen carbonate
19. How would you prepare from the solid and pure water
- 0.400 L of 0.155 M $Sr(OH)_2$?
 - 1.75 L of 0.333 M $(NH_4)_2CO_3$?
20. Starting with the solid and adding water, how would you prepare 2.00 L of 0.685 M
- $Ni(NO_3)_2$?
 - $CuCl_2$?
 - $C_6H_8O_6$ (vitamin C)?
21. You are asked to prepare a 0.8500 M solution of aluminum nitrate. You find that you have only 50.00 g of the solid.
- What is the maximum volume of solution that you can prepare?
 - How many milliliters of this prepared solution are required to furnish 0.5000 mol of aluminum nitrate to a reaction?
 - If 2.500 L of the prepared solution are required, how much more aluminum nitrate would you need?
 - Fifty milliliters of a 0.450 M solution of aluminum nitrate are needed. How would you prepare the required solution from the solution prepared in (a)?
22. A reagent bottle is labeled 0.255 M K_2SO_4 .
- How many moles of K_2SO_4 are present in 25.0 mL of this solution?
 - How many mL of this solution are required to supply 0.0600 mol of K_2SO_4 ?
 - Assuming no volume change, how many grams of K_2SO_4 do you need to add to 1.50 L of this solution to obtain a 0.800 M solution of K_2SO_4 ?
 - If 40.0 mL of the original solution are added to enough water to make 135 mL of solution, what is the molarity of the diluted solution?

23. A student combines two solutions of KOH and determines the molarity of the resulting solution. He records the following data:

Solution I:	30.00 mL of 0.125 M KOH
Solution II:	40.00 mL of KOH
Solution I + Solution II:	70.00 mL of 0.203 M KOH

What is the molarity of KOH in Solution II?

24. Twenty-five mL of a 0.388 M solution of Na_2SO_4 is mixed with 35.3 mL of 0.229 M Na_2SO_4 . What is the molarity of the resulting solution? Assume that the volumes are additive.

Mass Relations in Chemical Formulas

25. Turquoise has the following chemical formula: $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$. Calculate the mass percent of each element in turquoise.
26. Diazepam is the addictive tranquilizer also known as Valium®. Its simplest formula is $C_{16}H_{13}N_2OCl$. Calculate the mass percent of each element in this compound.
27. Deer ticks are known to cause Lyme disease. The presence of DEET (diethyltoluamide) in insect repellents protects the user from the ticks. The molecular formula for DEET is $C_{12}H_{17}NO$. How many grams of carbon can be obtained from 127 g of DEET?
28. Allacin is responsible for the distinctive taste and odor of garlic. Its simplest formula is $C_6H_{10}O_2S$. How many grams of sulfur can be obtained from 25.0 g of allacin?
29. A tablet of Tylenol™ has a mass of 0.611 g. It contains 251 mg of its active ingredient, acetaminophen, $C_8H_9NO_2$.
- What is the mass percent of acetaminophen in a tablet of Tylenol?
 - Assume that all the nitrogen in the tablet is in the acetaminophen. How many grams of nitrogen are present in a tablet of Tylenol?
30. The active ingredient in some antiperspirants is aluminum chlorohydrate, $Al_2(OH)_3Cl$. Analysis of a 2.000-g sample of antiperspirant yields 0.334 g of aluminum. What percent (by mass) of aluminum chlorohydrate is present in the antiperspirant? (Assume that there are no other compounds containing aluminum in the antiperspirant.)
31. Combustion analysis of 1.00 g of the male sex hormone, testosterone, yields 2.90 g of CO_2 and 0.875 g H_2O . What are the mass percents of carbon, hydrogen, and oxygen in testosterone?
32. Hexachlorophene, a compound made up of atoms of carbon, hydrogen, chlorine, and oxygen, is an ingredient in germicidal soaps. Combustion of a 1.000-g sample yields 1.407 g of carbon dioxide, 0.134 g of water, and 0.523 g of chlorine gas. What are the mass percents of carbon, hydrogen, oxygen, and chlorine in hexachlorophene?
33. A compound XCl_3 is 70.3% (by mass) chlorine. What is the molar mass of the compound? What is the symbol and name of X?
34. A compound R_2O_3 is 32.0% oxygen. What is the molar mass of R_2O_3 ? What is the element represented by R?
35. Phosphorus reacts with oxygen to produce different kinds of oxides. One of these oxides is formed when 1.347 g of phosphorus reacts with 1.744 g of oxygen. What is the simplest formula of this oxide? Name the oxide.
36. Nickel reacts with sulfur to form a sulfide. If 2.986 g of nickel reacts with enough sulfur to form 5.433 g of nickel sulfide, what is the simplest formula of the sulfide? Name the sulfide.
37. Determine the simplest formulas of the following compounds:
- the food enhancer monosodium glutamate (MSG), which has the composition 35.51% C, 4.77% H, 37.85% O, 8.29% N, and 13.60% Na.
 - zircon, a diamond-like mineral, which has the composition 34.91% O, 15.32% Si, and 49.76% Zr.
 - nicotine, which has the composition 74.0% C, 8.65% H, and 17.4% N.

38. Determine the simplest formulas of the following compounds:
- tetraethyl lead, the banned gasoline anti-knock additive, which is composed of 29.71% C, 6.234% H, and 64.07% Pb.
 - citric acid, present in most sour fruit, which is composed of 37.51% C, 4.20% H, and 58.29% O.
 - cisplatin, a drug used in chemotherapy, which is composed of 9.34% N, 2.02% H, 23.36% Cl, and 65.50% Pt.
39. Ibuprofen, the active ingredient in Advil™, is made up of carbon, hydrogen, and oxygen atoms. When a sample of ibuprofen, weighing 5.000 g, burns in oxygen, 13.86 g of CO₂ and 3.926 g of water are obtained. What is the simplest formula of ibuprofen?
40. Methyl salicylate is a common "active ingredient" in liniments such as Ben-Gay™. It is also known as oil of wintergreen. It is made up of carbon, hydrogen, and oxygen atoms. When a sample of methyl salicylate weighing 5.287 g is burned in excess oxygen, 12.24 g of carbon dioxide and 2.505 g of water are formed. What is the simplest formula for oil of wintergreen?
41. DDT (dichlorodiphenyltrichloroethane) was the first chlorinated insecticide developed. It was used extensively in World War II to eradicate the mosquitoes that spread malaria. Its use was banned in the United States in 1978 because of environmental concerns. DDT is made up of carbon, hydrogen, and chlorine atoms. When a 5.000-g sample of DDT is burned in oxygen, 8.692 g of CO₂ and 1.142 g of H₂O are obtained. A second five-gram sample yields 2.571 g of HCl. What is the simplest formula for DDT?
42. Saccharin is the active ingredient in many sweeteners used today. It is made up of carbon, hydrogen, oxygen, sulfur, and nitrogen. When 7.500 g of saccharin are burned in oxygen, 12.6 g CO₂, 1.84 g H₂O, and 2.62 g SO₂ are obtained. Another experiment using the same mass of sample (7.500 g) shows that saccharin has 7.65% N. What is the simplest formula for saccharin?
43. Hexamethylenediamine (MM = 116.2 g/mol), a compound made up of carbon, hydrogen, and nitrogen atoms, is used in the production of nylon. When 6.315 g of hexamethylenediamine is burned in oxygen, 14.36 g of carbon dioxide and 7.832 g of water are obtained. What are the simplest and molecular formulas of this compound?
44. Dimethylhydrazine, the fuel used in the Apollo lunar descent module, has a molar mass of 60.10 g/mol. It is made up of carbon, hydrogen, and nitrogen atoms. The combustion of 2.859 g of the fuel in excess oxygen yields 4.190 g of carbon dioxide and 3.428 g of water. What are the simplest and molecular formulas for dimethylhydrazine?
45. A certain hydrate of potassium aluminum sulfate (alum) has the formula KAl(SO₄)₂ · xH₂O. When a hydrate sample weighing 5.459 g is heated to remove all the water, 2.583 g of KAl(SO₄)₂ remains. What is the mass percent of water in the hydrate? What is x?
46. Sodium borate decahydrate, Na₂B₄O₇ · 10H₂O is commonly known as borax. It is used as a deodorizer and mold inhibitor. A sample weighing 15.86 g is heated until a constant mass is obtained indicating that all the water has been evaporated off.

- What percent, by mass of Na₂B₄O₇ · 10 H₂O is water?
- What is the mass of the anhydrous sodium borate, Na₂B₄O₇?

Balancing Equations

47. Balance the following equations:
- $\text{CaC}_2(s) + \text{H}_2\text{O}(l) \longrightarrow \text{Ca}(\text{OH})_2(s) + \text{C}_2\text{H}_2(g)$
 - $(\text{NH}_4)_2\text{Cr}_2\text{O}_7(s) \longrightarrow \text{Cr}_2\text{O}_3(s) + \text{N}_2(g) + \text{H}_2\text{O}(g)$
 - $\text{CH}_3\text{NH}_2(g) + \text{O}_2(g) \longrightarrow \text{CO}_2(g) + \text{N}_2(g) + \text{H}_2\text{O}(g)$
48. Balance the following equations:
- $\text{H}_2\text{S}(g) + \text{SO}_2(g) \longrightarrow \text{S}(s) + \text{H}_2\text{O}(g)$
 - $\text{CH}_4(g) + \text{NH}_3(g) + \text{O}_2(g) \longrightarrow \text{HCN}(g) + \text{H}_2\text{O}(g)$
 - $\text{Fe}_2\text{O}_3(s) + \text{H}_2(g) \longrightarrow \text{Fe}(l) + \text{H}_2\text{O}(g)$
49. Write balanced equations for the reaction of sulfur with the following metals to form solids that you can take to be ionic when the anion is S²⁻.
- potassium
 - magnesium
 - aluminum
 - calcium
 - iron (forming Fe²⁺ ions)

50. Write balanced equations for the reaction of scandium metal to produce the scandium(III) salt with the following nonmetals:
- sulfur
 - chlorine
 - nitrogen
 - oxygen (forming the oxide)
51. Write a balanced equation for
- the combustion (reaction with oxygen gas) of glucose, C₆H₁₂O₆, to give carbon dioxide and water.
 - the reaction between xenon tetrafluoride gas and water to give xenon, oxygen, and hydrogen fluoride gases.
 - the reaction between aluminum and iron(III) oxide to give aluminum oxide and iron.
 - the formation of ammonia gas from its elements.
 - the reaction between sodium chloride, sulfur dioxide gas, steam, and oxygen to give sodium sulfate and hydrogen chloride gas.
52. Write a balanced equation for
- the reaction between fluorine gas and water to give oxygen difluoride and hydrogen fluoride gases.
 - the reaction between oxygen and ammonia gases to give nitrogen dioxide gas and water.
 - the burning of gold(III) sulfide in hydrogen to give gold metal and dihydrogen sulfide gas.
 - the decomposition of sodium hydrogen carbonate to sodium carbonate, water, and carbon dioxide gas.
 - the reaction between sulfur dioxide gas and liquid hydrogen fluoride to give sulfur tetrafluoride gas and water.

Mole-Mass Relations in Reactions

53. Cyanogen gas, C₂N₂, has been found in the gases of outer space. It can react with fluorine to form carbon tetrafluoride and nitrogen trifluoride.



- How many moles of fluorine react with 1.37 mol of cyanogen?
 - How many moles of CF₄ are obtained from 13.75 mol of fluorine?
 - How many moles of cyanogen are required to produce 0.8974 mol of NF₃?
 - How many moles of fluorine will yield 4.981 mol of nitrogen trifluoride?
54. The mineral fluorapatite, Ca₁₀F₂(PO₄)₆, reacts with sulfuric acid according to the following equation:
- $$\text{Ca}_{10}\text{F}_2(\text{PO}_4)_6(s) + 7\text{H}_2\text{SO}_4(l) \longrightarrow 2\text{HF}(g) + 3\text{Ca}(\text{HPO}_4)_2(s) + 7\text{CaSO}_4(s)$$
- How many moles of CaSO₄ are obtained when 0.738 mol of fluorapatite are used up?
 - How many moles of H₂SO₄ are required to produce 3.98 mol of Ca(HPO₄)₂?
 - How many moles of fluorapatite will react with 0.379 mol of H₂SO₄?
 - How many moles of HF are obtained when 1.899 mol of H₂SO₄ are made to react with the fluorapatite?
55. One way to remove nitrogen oxide (NO) from smoke stack emissions is to react it with ammonia.



Calculate

- the mass of water produced from 0.839 mol of ammonia.
- the mass of NO required to react with 3.402 mol of ammonia.
- the mass of ammonia required to produce 12.0 g of nitrogen gas.
- the mass of ammonia required to react with 115 g of NO.

56. Phosphine gas reacts with oxygen according to the following equation:

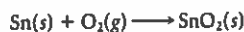


Calculate

- the mass of tetraphosphorus decaoxide produced from 12.43 mol of phosphine.
 - the mass of PH_3 required to form 0.739 mol of steam.
 - the mass of oxygen gas that yields 1.000 g of steam.
 - the mass of oxygen required to react with 20.50 g of phosphine.
57. The combustion of liquid chloroethylene, $\text{C}_2\text{H}_3\text{Cl}$, yields carbon dioxide, steam, and hydrogen chloride gas.
- Write a balanced equation for the reaction.
 - How many moles of oxygen are required to react with 35.00 g of chloroethylene?
 - If 25.00 g of chloroethylene react with an excess of oxygen, how many grams of each product are formed?
58. Diborane, B_2H_6 , can be prepared according to the following reaction:

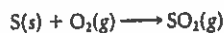


- How many moles of diborane are formed from 12.66 g of BF_3 ?
 - How many grams of NaBH_4 are required to produce 10.85 g of diborane?
59. Ethanol, $\text{C}_2\text{H}_5\text{OH}$, is responsible for the effects of intoxication felt after drinking alcoholic beverages. When ethanol burns in oxygen, carbon dioxide, and water are produced.
- Write a balanced equation for the reaction.
 - How many liters of ethanol ($d = 0.789 \text{ g/cm}^3$) will produce 1.25 L of water ($d = 1.00 \text{ g/cm}^3$)?
 - A wine cooler contains 4.5% ethanol by mass. Assuming that only the alcohol burns in oxygen, how many grams of wine cooler need to be burned to produce 3.12 L of CO_2 ($d = 1.80 \text{ g/L}$ at 25°C , 1 atm pressure) at the conditions given for the density?
60. When tin comes in contact with the oxygen in the air, tin(IV) oxide, SnO_2 , is formed.



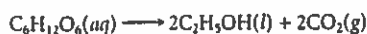
A piece of tin foil, $8.25 \text{ cm} \times 21.5 \text{ cm} \times 0.600 \text{ mm}$ ($d = 7.28 \text{ g/cm}^3$), is exposed to oxygen.

- Assuming that all the tin has reacted, what is the mass of the oxidized tin foil?
 - Air is about 21% oxygen by volume ($d = 1.309 \text{ g/L}$ at 25°C , 1 atm). How many liters of air are required to completely react with the tin foil?
61. A crude oil burned in electrical generating plants contains about 1.2% sulfur by mass. When the oil burns, the sulfur forms sulfur dioxide gas:



How many liters of SO_2 ($d = 2.60 \text{ g/L}$) are produced when $1.00 \times 10^4 \text{ kg}$ of oil burns at the same temperature and pressure?

62. When corn is allowed to ferment, the fructose in the corn is converted to ethyl alcohol according to the following reaction



- What volume of ethyl alcohol ($d = 0.789 \text{ g/mL}$) is produced from one pound of fructose?
- Gasohol can be a mixture of 10 mL ethyl alcohol and 90 mL of gasoline. How many grams of fructose are required to produce the ethyl alcohol in one gallon of gasohol?

63. Consider the hypothetical reaction



When 10.0 g of A_2B_3 ($\text{MM} = 255 \text{ g/mol}$) react with an excess of X_4 , 4.00 g of A_4X_3 are produced.

- How many moles of A_4X_3 are produced?
 - What is the molar mass of A_4X_3 ?
64. When three moles of a metal oxide, MO_2 , react with ammonia gas, the metal (M), water, and nitrogen gas are formed.
- Write a balanced equation to represent the reaction.
 - When 13.8 g of ammonia react with an excess of metal oxide, 126 g of M are formed. What is the molar mass for M? What is the identity of M?
65. A gaseous mixture containing 4.15 mol of hydrogen gas and 7.13 mol of oxygen gas reacts to form steam.
- Write a balanced equation for the reaction.
 - What is the limiting reactant?
 - What is the theoretical yield of steam in moles?
 - How many moles of the excess reactant remain unreacted?
66. Chlorine and fluorine react to form gaseous chlorine trifluoride. Initially, 1.75 mol of chlorine and 3.68 mol of fluorine are combined. (Assume 100% yield for the reaction.)
- Write a balanced equation for the reaction.
 - What is the limiting reactant?
 - What is the theoretical yield of chlorine trifluoride in moles?
 - How many moles of excess reactant remain after reaction is complete.
67. When potassium chlorate is subjected to high temperatures, it decomposes into potassium chloride and oxygen.
- Write a balanced equation for the decomposition.
 - In this decomposition, the actual yield is 83.2%. If 198.5 g of oxygen are produced, how much potassium chlorate decomposed?
68. When iron and steam react at high temperatures, the following reaction takes place.



How much iron must react with excess steam to form 897 g of Fe_3O_4 if the reaction yield is 69%?

69. Oxyacetylene torches used for welding reach temperatures near 2000°C . The reaction involved in the combustion of acetylene is



- Starting with 175 g of both acetylene and oxygen, what is the theoretical yield, in grams, of carbon dioxide?
 - If 68.5 L ($d = 1.85 \text{ g/L}$) of carbon dioxide is produced, what is the percent yield at the same conditions of temperature and pressure?
 - How much of the reactant in excess is unused? (Assume 100% yield.)
70. The first step in the manufacture of nitric acid by the Ostwald process is the reaction of ammonia gas with oxygen, producing nitrogen oxide and steam. The reaction mixture contains 7.60 g of ammonia and 10.00 g of oxygen. After the reaction is complete, 6.22 g of nitrogen oxide are obtained.
- Write a balanced equation for the reaction.
 - How many grams of nitrogen oxide can be theoretically obtained?
 - How many grams of excess reactant are theoretically unused?
 - What is the percent yield of the reaction?

71. Aspirin, $C_9H_8O_4$, is prepared by reacting salicylic acid, $C_7H_6O_3$, with acetic anhydride, $C_4H_6O_3$, in the reaction



A student is told to prepare 45.0 g of aspirin. She is also told to use a 55.0% excess of acetic anhydride and to expect to get an 85.0% yield in the reaction. How many grams of each reactant should she use?

72. A student prepares phosphorous acid, H_3PO_3 , by reacting solid phosphorus triiodide with water.



The student needs to obtain 0.250 L of H_3PO_3 ($d = 1.651 \text{ g/cm}^3$). The procedure calls for a 45.0% excess of water and a yield of 75.0%. How much phosphorus triiodide should be weighed out? What volume of water ($d = 1.00 \text{ g/cm}^3$) should be used?

Unclassified

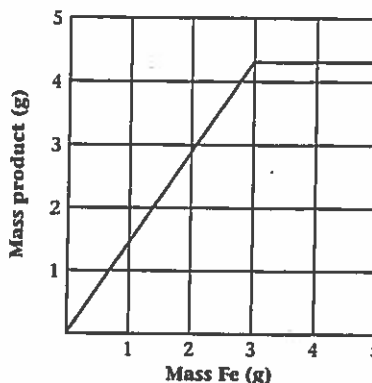
73. Cisplatin, $Pt(NH_3)_2Cl_2$, is a chemotherapeutic agent that disrupts the growth of DNA. If the current cost of Pt is \$1118.0/troy ounce (1 troy oz = 31.10 g), how many grams of cisplatin can you make with three thousand dollars worth of platinum? How many pounds?

74. Magnesium ribbon reacts with acid to produce hydrogen gas and magnesium ions. Different masses of magnesium ribbon are added to 10 mL of the acid. The volume of the hydrogen gas obtained is a measure of the number of moles of hydrogen produced by the reaction. Various measurements are given in the table below.

Experiment	Mass of Mg Ribbon (g)	Volume of Acid Used (mL)	Volume of H_2 Gas (mL)
1	0.020	10.0	21
2	0.040	10.0	42
3	0.080	10.0	82
4	0.120	10.0	122
5	0.160	10.0	122
6	0.200	10.0	122

- Draw a graph of the results by plotting the mass of Mg versus the volume of the hydrogen gas.
- What is the limiting reactant in experiment 1?
- What is the limiting reactant in experiment 3?
- What is the limiting reactant in experiment 6?
- Which experiment uses stoichiometric amounts of each reactant?
- What volume of gas would be obtained if 0.300 g of Mg ribbon were used? If 0.010 g were used?

75. Iron reacts with oxygen. Different masses of iron are burned in a constant amount of oxygen. The product, an oxide of iron, is weighed. The graph below is obtained when the mass of product obtained is plotted against the mass of iron used.



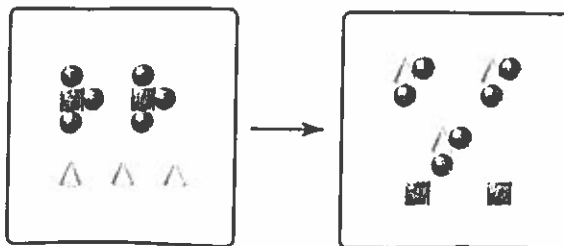
- How many grams of product are obtained when 0.50 g of iron are used?
 - What is the limiting reactant when 2.00 g of iron are used?
 - What is the limiting reactant when 5.00 g of iron are used?
 - How many grams of iron react exactly with the amount of oxygen supplied?
 - What is the simplest formula of the product?
76. Most wine is prepared by the fermentation of the glucose in grape juice by yeast:



How many grams of glucose should there be in grape juice to produce 725 mL of wine that is 11.0% ethyl alcohol, C_2H_5OH ($d = 0.789 \text{ g/cm}^3$), by volume?

Conceptual Problems

77. Given a pair of elements and their mass relation, answer the following questions.
- The mass of 4 atoms of A = the mass of 6 atoms of B. Which element has the smaller molar mass?
 - The mass of 6 atoms of C is less than the mass of 3 atoms of the element D. Which element has more atoms/gram?
 - Six atoms of E have larger mass than six atoms of F. Which has more atoms/gram?
 - Six atoms of F have the same mass as 8 atoms of G. Which has more atoms/mole?
78. The reaction between compounds made up of A (squares), B (circles), and C (triangles) is shown pictorially below. Using smallest whole-number coefficients, write a balanced equation to represent the picture shown.

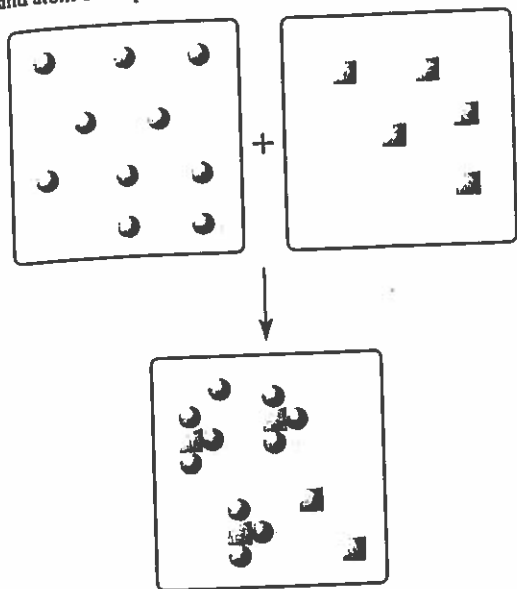


79. Represent the following equation pictorially (see Problem 78), using squares to represent A, circles to represent B, and triangles to represent C.

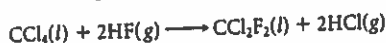


After you have "drawn" the equation, use your drawing as a guide to balance it.

80. Nitrogen reacts with hydrogen to form ammonia. Represent each nitrogen atom by a square and each hydrogen atom with a circle. Starting with five molecules of both hydrogen and nitrogen, show pictorially what you have after the reaction is complete.
81. Consider the following diagram, where atom X is represented by a square and atom Y is represented by a circle.



- (a) Write the equation for the reaction represented by the diagram.
- (b) If each circle stands for a mole of Y and each square a mole of X, how many moles of X did one start with? How many moles of Y?
- (c) Using the same representation described in part (b), how many moles of product are formed? How many moles of X and Y are left unreacted?
82. When 4.0 mol of CCl_4 reacts with an excess of HF, 3.0 mol of CCl_2F_2 (Freon) is obtained. The equation for the reaction is

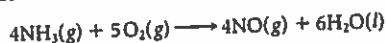


State which of the statements are true about the reaction and make the false statements true.

- (a) The theoretical yield for CCl_2F_2 is 3.0 mol.
- (b) The theoretical yield for HCl is 71 g.
- (c) The percent yield for the reaction is 75%.
- (d) The theoretical yield cannot be determined unless the exact amount of HF is given.
- (e) From just the information given above, it is impossible to calculate how much HF is unreacted.
- (f) For this reaction, as well as for any other reaction, the total number of moles of reactants is equal to the total number of moles of product.
- (g) Half a mole of HF is consumed for every mole of CCl_4 used.
- (h) At the end of the reaction, no CCl_4 is theoretically left unreacted.
83. Suppose that the atomic mass of C-12 is taken to be 5.000 amu and that a mole is defined as the number of atoms in 5.000 kg of carbon-12. How many atoms would there be in one mole under these conditions? (Hint: There are 6.022×10^{23} C atoms in 12.00 g of C-12.)
84. Suppose that N-14 (^{14}N) is taken as the standard for expressing atomic masses and assigned an atomic mass of 20.00 amu. Estimate the molar mass of aluminum sulfide.
85. Answer the questions below, using LT (for *is less than*), GT (for *is greater than*), EQ (for *is equal to*), or MI (for *more information required*) in the blanks provided.
- (a) The mass (to three significant figures) of 6.022×10^{23} atoms of Na _____ 23.0 g.
- (b) Boron has two isotopes, B-10 (10.01 amu) and B-11 (11.01 amu). The abundance of B-10 _____ the abundance of B-11.

- (c) If S-32 were assigned as the standard for expressing relative atomic masses and assigned an atomic mass of 10.00 amu, the atomic mass for H would be _____ 1.00 amu.
- (d) When phosphine gas, PH_3 , is burned in oxygen, tetraphosphorus decaoxide and steam are formed. In the balanced equation (using smallest whole-number coefficients) for the reaction, the sum of the coefficients on the reactant side is _____ 7.
- (e) The mass (in grams) of one mole of bromine molecules is _____ 79.90.

86. Determine whether the statements given below are true or false.
- (a) The mass of an atom can have the unit mole.
- (b) In N_2O_4 , the mass of the oxygen is twice that of the nitrogen.
- (c) One mole of chlorine atoms has a mass of 35.45 g.
- (d) Boron has an average atomic mass of 10.81 amu. It has two isotopes, B-10 (10.01 amu) and B-11 (11.01 amu). There is more naturally occurring B-10 than B-11.
- (e) The compound $\text{C}_6\text{H}_{12}\text{O}_2\text{N}$ has for its simplest formula $\text{C}_3\text{H}_6\text{ON}_{1/2}$.
- (f) A 558.5-g sample of iron contains ten times as many atoms as 0.5200 g of chromium.
- (g) If 1.00 mol of ammonia is mixed with 1.00 mol of oxygen the following reaction occurs,

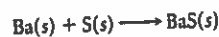


All the oxygen is consumed.

- (h) When balancing an equation, the total number of moles of reactant molecules must equal the total number of moles of product molecules.

Challenge Problems

87. Chlorophyll, the substance responsible for the green color of leaves, has one magnesium atom per chlorophyll molecule and contains 2.72% magnesium by mass. What is the molar mass of chlorophyll?
88. By x-ray diffraction it is possible to determine the geometric pattern in which atoms are arranged in a crystal and the distances between atoms. In a crystal of silver, four atoms effectively occupy the volume of a cube 0.409 nm on an edge. Taking the density of silver to be 10.5 g/cm³, calculate the number of atoms in one mole of silver.
89. A 5.025-g sample of calcium is burned in air to produce a mixture of two ionic compounds, calcium oxide and calcium nitride. Water is added to this mixture. It reacts with calcium oxide to form 4.832 g of calcium hydroxide. How many grams of calcium oxide are formed? How many grams of calcium nitride?
90. Consider the reaction between barium and sulfur:



Both barium and sulfur also combine with oxygen to form barium oxide and sulfur dioxide. When 95.0 g of Ba react with 50.0 g of sulfur, only 65.15 g of BaS are obtained. Assuming 100% yield for the oxides, how many grams of BaO and SO_2 are formed?

91. A mixture of potassium chloride and potassium bromide weighing 3.595 g is heated with chlorine, which converts the mixture completely to potassium chloride. The total mass of potassium chloride after the reaction is 3.129 g. What percentage of the original mixture was potassium bromide?
92. A sample of an oxide of vanadium weighing 4.589 g was heated with hydrogen gas to form water and another oxide of vanadium weighing 3.782 g. The second oxide was treated further with hydrogen until only 2.573 g of vanadium metal remained.

- (a) What are the simplest formulas of the two oxides?
- (b) What is the total mass of water formed in the successive reactions?
93. A sample of cocaine, $\text{C}_{17}\text{H}_{21}\text{O}_4\text{N}$, is diluted with sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$. When a 1.00-mg sample of this mixture is burned, 1.00 mL of carbon dioxide ($d = 1.80 \text{ g/L}$) is formed. What is the percentage of cocaine in this mixture?