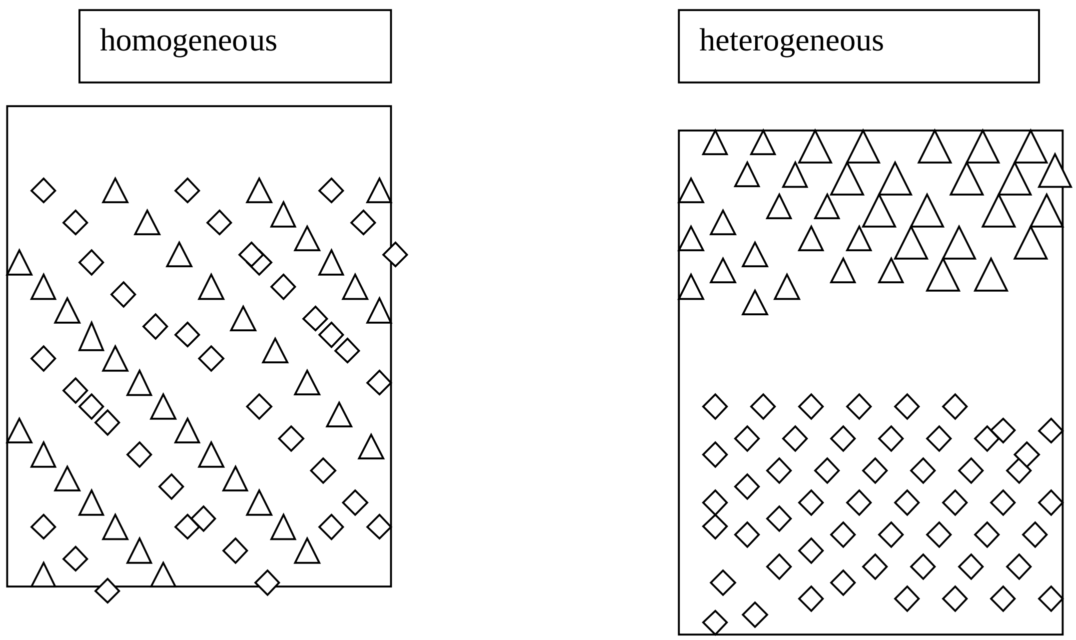
Chapter 1

Introduction to Forensic Chemistry

2. An *element* is the simplest form of a pure substance and consists of atoms of a single type. A *compound* is a substance that is made up of two or more elements that are chemically bonded together.

4. A homogeneous mixture is one in which the substances that compose it are so evenly distributed that a sample from any one part of the mixture will be chemically identical to a sample from any other part. A heterogeneous mixture is one in which the composition varies from one region of a sample to another.

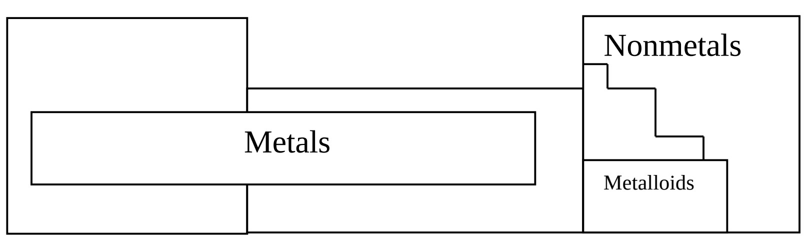


6. Iced tea is a homogeneous mixture; adding sugar or ice cubes to it will make it heterogeneous.

8. The periodic table places an extensive amount of information at your fingertips; it can help predict the formula of many compounds, relative sizes of atoms and molecules, shapes of molecules and whether compounds will dissolve in water or oil (based on polarity).

10. There are 92 naturally occurring elements.

12.



14. a. gasoline - mixture
    b. air - mixture
    c. pure substance
    d. steel - mixture

16. a. silicon - element
    b. carbon dioxide - compound
    c. arsenic - element
    d. water - compound

18. a. Li - lithium
    b. Cl - chlorine
    c. C - carbon
    d. Al - aluminum

20. a. Cr - chromium
    b. Mg - magnesium
    c. Cu - copper
    d. Kr - krypton

22. a. helium – He
    b. manganese – Mn
    c. potassium – K
    d. chlorine – Cl

24. a. tin – Sn
    b. aluminum – Al
    c. boron – B
    d. sulfur – S

26. a. calcium
    b. potassium
    c. correct
    d. Zn

28. a. silicon – metalloid
    b. phosphorus – nonmetal
    c. potassium – metal
    d. antimony – metalloid (but could be considered nonmetal)

30. a. Ba – metal
    b. Co – metal
    c. Te – metal (but could be considered metalloid)
    d. N – nonmetal

32. $MgSO_4$ is answer d

34. a. soil – heterogeneous
    b. air – homogeneous
    c. diesel fuel – homogeneous
    d. concrete – heterogeneous

36. Hematite's formula is Fe_2O_3.

Chapter 2

Evidence Collection and Preservation

2. An example of a chemical process is converting carbohydrates into ATP (usable energy) to "run" your body. An example of a physical process is when rain freezes and turns into snow/ice.

4. Examples of chemical properties include flammability, rusting, and explosiveness.

6. Many professions use the scientific method in order to solve a problem by gathering information, forming a hypothesis, and then testing it.

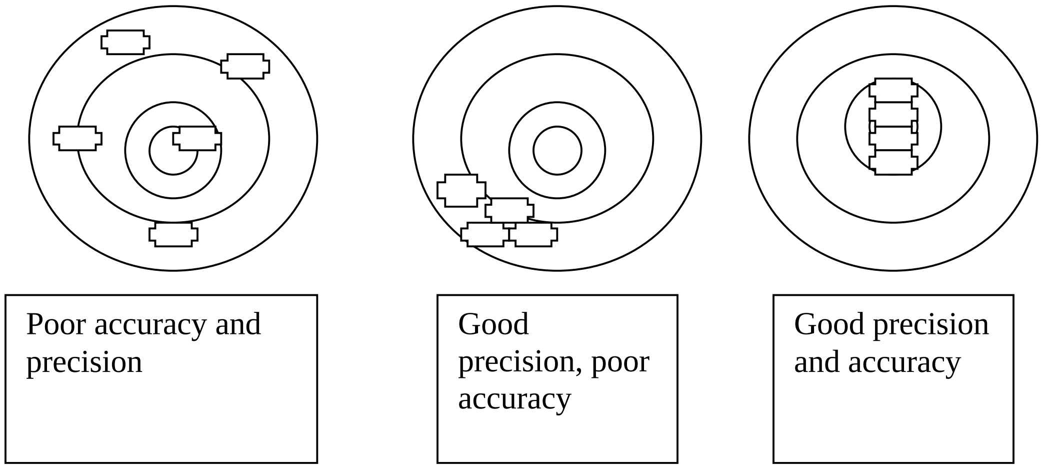
8. The unit of a measurement contains critical information about what system of measurement is used and whether the base unit is modified with a prefix.

10. 1 mL = 1 cc = 1 cm^3

12. A conversion factor is used by dividing by the units you wish to cancel and multiplying by the units you want in the final answer.

14. Whenever you make a measurement, you basically are sure of all digits except the last, which can change based on observations between people.

16.



18. a. physical
    b. physical
    c. chemical
    d. chemical

20. a. physical
    b. physical
    c. chemical
    d. chemical

22. b

24. a. weight
    b. weight
    c. mass
    d. mass

26. a. mega = M = 10^6
    b. deci = d = 10^{-1}
    c. milli = m = 10^{-3}

28. a. 0.01 = centi = c
    b. 1,000,000 = mega = M
    c. 0.000001 = micro = μ

30. a. $1\times10^6 \text{ g}\times\frac{1\text{ Mg}}{10^6\text{ g}}=1\text{ Mg}$

b. $1.56\text{ m}\times\frac{100\text{ cm}}{1\text{ m}}=156\text{ cm}$

c. $9.5\times10^{-4}\text{ s}\times\frac{1000\text{ ms}}{1\text{ s}}=9.5\times10^{-1}\text{ ms}$

d. $1.75\text{ g}\times\frac{1000\text{ mg}}{1\text{ g}}=1750\text{ mg}$

32. a. $34.0\text{ ft.}\times\frac{12\text{ in.}}{1\text{ ft.}}\times\frac{2.54\text{ cm.}}{1\text{ in.}}=1036.32\text{ cm.}$

b. $238\text{ cm.}\times\frac{1\text{ in.}}{2.54\text{ cm.}}\times\frac{1\text{ ft.}}{12\text{ in.}}\times\frac{1\text{ yd.}}{3\text{ ft.}}=2.60\text{ yd.}$

c. $71.7\text{ in}\times\frac{1\text{ foot}}{12\text{ inches}}\times\frac{1\text{ yard}}{3\text{ feet}}=1.99\text{ yards}$

d. $2.98\text{ yd.}\times\frac{36\text{ in.}}{1\text{ yd.}}\times\frac{2.54\text{ cm.}}{1\text{ in.}}\times\frac{1\text{ m.}}{100\text{ cm.}}=2.72\text{ m.}$

34. a. 3
b. 4
c. 3
d. 4

36. a. 2.5×10^{3}
b. 8.5×10^{1}
c. 3.29×10^{-3}
d. 4.77×10^{-8}

38. a. 700000
b. 0.4401
c. 90
d. 0.000002279

40. a. 85.4°
b. 57.6°
c. 70.7°
d. 85.4°

42. a. 100,200 = 4 significant digits; 1.00×10^{-5}
b. 0.010 = 2 significant digits; 0.0100
c. 0.1000 = 4 significant digits; 0.100
d. 1.010×10^{-11} = 4 significant digits; 1.01×10^{-11}

44. a. $0.000038520 = 3.8620 \times 10^{-5}$
b. $102883 = 1.0288 \times 10^{5}$
c. $5837930 = 5.838 \times 10^{6}$
d. $0.0010025 = 1.003 \times 10^{-3}$

46. d

48. a. 45.5 (3 sig digs) + 0.0023 (2 sig digs) + 17 (2 sig digs) = 63
b. 34.4 (3 sig digs) – 7.92 (3 sig digs) + 16.10 (4 sig digs) = 26.4
c. 56 (2 sig digs) + 17.98 (4 sig digs) + 0.02 (1 sig dig) = 38
d. 1.45 (3 sig digs) + 101 (2 sig digs) + 12.02 (4 sig digs) = 90

50. a. 642 (3 sig digs) ÷ 32.90 (4 sig digs) ÷ 100.0 (4 sig digs) = 0.195
b. 47 (2 sig digs) × 23.3 (3 sig digs) × 10.1 (3 sig digs) = 11000
c. 82.901 (5 sig digs) ÷ 26.8 (3 sig digs) × 3.33 (3 sig digs) = 10.5
d. 3967 (4 sig digs) × 0.022 (2 sig digs) ÷ 9.09 (3 sig digs) = 9.6

52. a. 76.3 (3 sig digs) - 23.345 (5 sig digs) ÷ 16.0 (3 sig digs) = 74.8
b. 8.240 (4 sig digs) × 37.2 (3 sig digs) - 119.00 (5 sig digs) = 188
c. (1.003 (4 sig digs) × 23.0 (3 sig digs)) + 173.90 (5 sig digs) = 197
d. 56.2 (3 sig digs) ÷ 2.300 (4 sig digs) + 9 (1 sig dig) = 33

54. There are two glasses that fit the range of $819^{o}C – 833^{o}C$: borosilicate and potash borosilicate. The densities of both of these are 2.28 and 2.16, respectively. The identity of the glass is borosilicate.

56. a. $D = 12.82\ g / 13.28\ cm^3 = 0.9653\ g/cm^3$
b. $D = 2.34\ g / 1.11\ mL = 2.11\ g/mL = 2.11\ g/cm^3$
c. $D = 9.23\ g / 6.67\ cm^3 = 1.38\ g/cm^3$
d. $D = 4.73\ g / 5.72\ mL = 0.827\ g/mL = 0.0827\ g/cm^3$

58. a. V = 44.99 g / 0.864 g/mL = 52.1 mL
b. V = 21.4 g / 2.77 g/ cc = 7.73 cc = 7.73 mL
c. V = 5.76 / 11.0 g/mL = 0.524 mL
d. $V = 2.003\ g / 8.76\ g/cm^3 = 0.229\ cm^3 = 0.229\ mL$

60. a. m = (3.91 g/mL) × (9.44 mL) = 36.9 g
b. m = (0.791 g/mL) × (10.9 mL) = 8.62 g
c. m = (2.34 g/cc) × (8.45 cc) = 19.8 g
d. $m = (7.44\ g/cm^3) \times (11.08\ cm^3) = 82.4\ g$

62. Physical properties that are used to compare soils could be color, odor, hardness, and texture. If a soil sample from the suspect matches that from the crime scene, then water and nutrient concentrations need to be determined and matched as well.

64. $\frac{0.08\,\text{g}}{1\,\text{dL}} \times \frac{1000\,\text{mg}}{1\,\text{g}} \times \frac{1\,\text{dL}}{100\,\text{mL}} = 0.8\,\text{mg/mL}$
This value also equals 0.8 g/L and 80 g/dL.

66. If the legal BAC is $\frac{0.08\,\text{g}}{1\,\text{dL}} \times \frac{1000\,\text{mg}}{1\,\text{g}} = 80\,\text{mg/dL}$, then it is possible to mistake a sober victim as legally drunk.

68. If ?V = 27.54 mL – 24.30 mL = 3.54 mL, and the mass of the glass is 7.89 g, then the density is equal to: 7.89 g / 3.54 mL = 2.23 g/mL. The glass that matches this density is borosilicate.

70. This is a chemical change because the gun powder has been ignited and isn't the same solid; it's a heterogeneous mixture because the smoke clearly has different regions.

72. a. The scientific method is applied - you're observing and drawing hypotheses.
    b. The scientific method is applied - you have to observe everything before making a theory.
    c. This could be argued as both cases.

74. It was not reasonable to convict the suspect based on the evidence given. The scientific method was only applied to the second case.

Chapter 3

Atomic Clues

2. Leucippus and Democritus believed that there was a void or vacuum wherever atoms did not exist.

4. Gassendi's work reopened atomic theory and stated that atomic theory was not contradictory to a Christian belief system. His work was important because it allowed people to engage in open debate about atomic theory without fear of retribution.

6. The law of conservation of mass answers the question of what happens to matter during a chemical reaction.

8. The law of definite proportions states that a compound is always made up of the same relative mass of the elements that compose it.

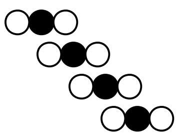
10. Proust did his experimental work very carefully so that he was able to obtain both accurate and precise work.

12. A theory can be disproved with data that contradicts the theory.

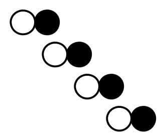
14. The law of conservation of mass states that atoms are rearranged to form new compounds, but the number of atoms remain the same.

16. The law of multiple proportions states that anytime two or more elements combine in different ratios, different compounds are formed.

18.



CO_2 (2 Oxygens per 1 carbon atom)



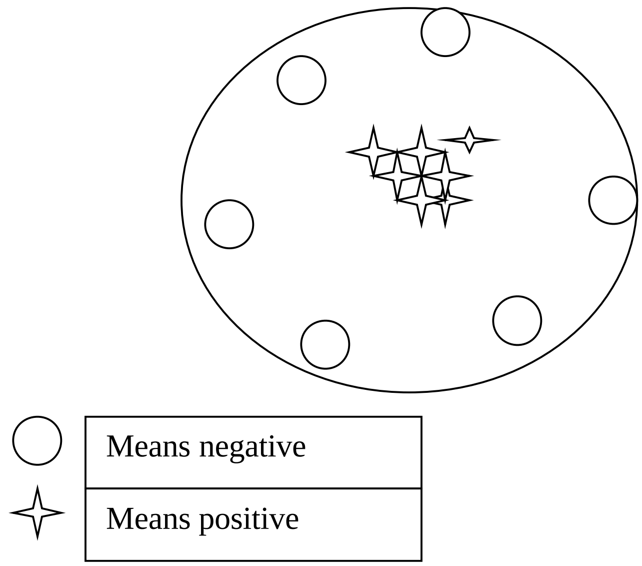
CO (1 oxygen per 1 carbon atom)

In the law of definite proportions, it is stated that in a molecule of CO_2, there will be 1 carbon atom and 2 oxygen atoms, so that the molecule will be roughly 72% oxygen and 28% carbon. In CO, the ratio will change so that roughly 57% of CO will be oxygen, and 43% will be carbon.

20 A cathode ray tube is a partially evacuated tube with an anode at one end and a cathode at the other. When high voltage is applied, cathode rays flow from the cathode to the anode.

22. (1) The vast majority of alpha particles passed directly through the solid gold foil.
(2) Occasionally an alpha particle would veer from a straight line path and hit the detector on the side.
(3) Rarely, an alpha particle would bounce directly back toward the alpha particle source after striking the gold foil.

24.

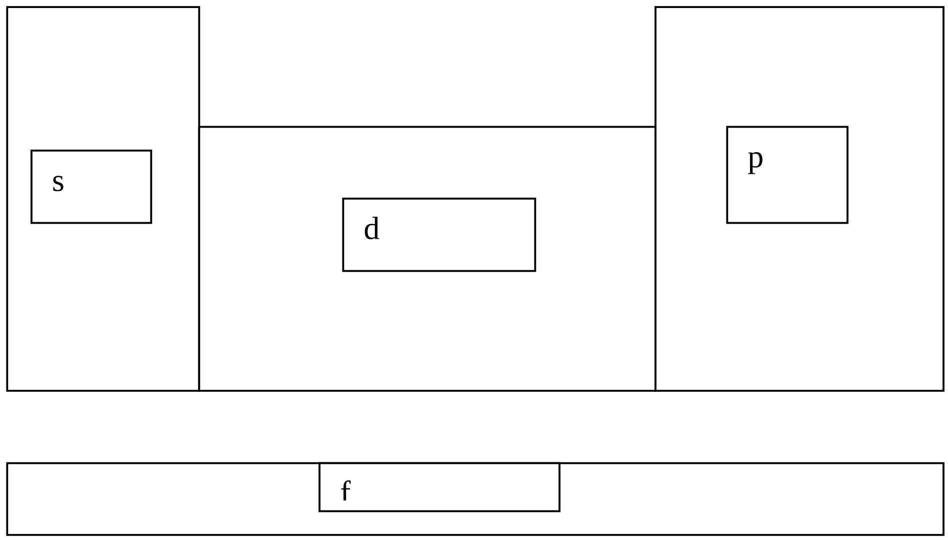


26. Isotopes are used to investigate how each step of a chemical reaction occurs.

28. Atoms produce light when placed in a flame or when electricity is passed through a gas vapor of the element.

30. Heisenberg’s uncertainty principle states that “the more precisely the position of an electron is determined, the less precisely the momentum is known in this instant.”

32.



34. SEM-EDS stands for scanning electron microscope – energy dispersive X-ray spectrometer. The general process for how this works is the following:
(1) The electron from the SEM strikes an atom with enough energy to force an inner core electron to leave the atom.
(2) There is a vacancy in the inner core.
(3) An electron from an outer shell drops down to fill the vacancy and releases a photon of light.

36. The order is: Gassendi, Proust, Rutherford, and Chadwick.

38. C is false.

40.
a. 93 g carbonic acid – 27.0 g water = 66 g CO_2
b. 16.0 g NaOH + 8.0 g HF = 24.0 g reactants
24.0 g reactants – 16.8 g NaF = 7.2 g water
c. 0.4 g $CaCO_3$ + 0.32 g NaOH = 0.72 g reactants
0.72 g reactants – 0.30 g $CaCO_3$ = 0.42 g Na_2CO_3
d. 2.65 g NaOH + 1.85 g CO_2 = 4.50 g reactants = 4.50 g $NaHCO_3$

42. A, B, and D are true.

44.

Particle	Charge	Mass	Symbol
proton	+1	1	p or p^+ or H^+
neutron	0	1	n or n^o
electron	- 1	0.0005444	e^-

46.

proton	neutron	electron	isotope symbol
92	146	92	$^{146}_{92}U$
80	120	80	$^{200}_{80}Hg$
28	30	28	$^{58}_{28}Ni$
32	40	32	$^{40}_{32}Ge$

48.
a. $^{40}_{18}Ar$
b. $^{87}_{37}Rb$
c. $^{120}_{50}Sn$
d. $^{110}_{46}Pd$

50. C

52. B and D

54
a. ? = 3.00×10^{8} m/s / 1.075×10^{-6} m = 2.79×10^{14} Hz
b. ? = 3.00×10^{8} m/s / 5.10×10^{-7} m = 5.88×10^{14} Hz
c. ? = 3.00×10^{8} m/s / 7.20×10^{-7} m = 3.90×10^{14} Hz
d. ? = 3.00×10^{8} m/s / 2.12×10^{-7} m = 1.42×10^{15} Hz

56.
a. ? = 3.00×10^{8} m/s / 1.00 x 10^{15} Hz = 3.00×10^{-7} m = 300 nm
b. ? = 3.00×10^{8} m/s / 1.66 x 10^{15} Hz = 1.80×10^{-7} m = 181 nm
c. ? = 3.00×10^{8} m/s / 1.39 x 10^{15} Hz = 2.15×10^{-7} m = 216 nm
d. ? = 3.00×10^{8} m/s / 1.14 x 10^{15} Hz = 2.63×10^{-7} m = 263 nm

58. Using data from problem 54:
a. E = (6.636×10^{-34} Js) $\times$ (2.79×10^{14} Hz) = 1.85×10^{-19} J
b. E = (6.636×10^{-34} Js) $\times$ (5.88×10^{14} Hz) = 3.90×10^{-19} J
c. E = (6.636×10^{-34} Js) $\times$ (3.896×10^{14} Hz) = 2.59×10^{-19} J
d. E = (6.636×10^{-34} Js) $\times$ (1.415×10^{14} Hz) = 9.42×10^{-19} J

60. Using data from problem 56:
a. E = (6.636×10^{-34} Js) $\times$ (1.00×10^{15} Hz) = 6.64×10^{-19} J
b. E = (6.636×10^{-34} Js) $\times$ (1.66×10^{15} Hz) = 1.10×10^{-19} J
c. E = (6.636×10^{-34} Js) $\times$ (1.39×10^{15} Hz) = 9.22×10^{-19} J
d. E = (6.636×10^{-34} Js) $\times$ (1.14×10^{15} Hz) = 7.57×10^{-19} J

62.
a. Mg = $1s^2 2s^2 2p^6 3s^2$
b. Ni = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
c. K = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
d. Al = $1s^2 2s^2 2p^6 3s^2 3p^1$

64. a. $P = [Ne]\ 3s^2\ 3p^3$
    b. $Sr = [Kr]\ 5s^2$
    c. $Be = [He]\ 2s^2$
    d. $Co = [Ar]\ 4s^2\ 3d^7$

66. a. Cd
    b. Ca
    c. Rb
    d. O

68. a. V
    b. Kr
    c. N
    d. Li

70. a. $Ca = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
    b. $P = [Ne]\ 3s^2\ 3p^3$
    c. $Ge = [Ar]\ 4s^2\ 3d^{10}\ 4p^2$
    d. $Sn = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^2$

72. Thallium-203 contains 81 protons, 81 electrons, and 122 neutrons; Thallium-205 contains 81 protons, 81 electrons, and 124 neutrons.

74. If ? = 223.1 nm = 2.231×10^{-7} m, then

    ? = c / ? = 3.00×10^{8} m/s / 2.231×10^{-7} m = 1.34×10^{15} Hz, and
    E = h? = $(6.636 \times 10^{-34}$ Js$) \times (1.344 \times 10^{15}$ Hz$) = 8.91 \times 10^{-19}$J

76. By analyzing the unburned firework, it is possible to determine which elements were present in the burned firework. It could also tell how the firework was burned.

Chapter 4

Chemical Evidence

2. Metals tend to form cations (they tend to lose electrons, which leaves them with a positive charge); they are located on the left-hand side of the periodic table.

Nonmetals tend to form anions (they tend to gain electrons, which leaves them with a negative charge); they are located on the right-hand side of the periodic table.

4. Cations are formed when an atom loses one or more electrons. Anions are formed when an atom gains one or more electrons.

6. Polyatomic ions are ions composed of more than one atom bonded together. Examples include NH_4^+, NO_3^-, SO_4^{2-}, PO_4^{3-}, and $CH_3CO_2^-$.

8. In MgS, there are Mg^{2+} cations and S^{2-} anions. In NaF, there are Na^+ cations and F^- anions. The divalent ions (Mg^{2+} and S^{2-}) have stronger electrostatic attraction than the monovalent ions (Na^+ and F^-) do.

10. Covalent bonds typically form between nonmetallic elements.

12. There are numerous potential answers to this question. Here are answers taken from this chapter:

Common Name	Scientific Name	Formula
Water	dihydrogen monoxide	H_2O
Alcohol	ethanol	C_2H_5OH
(Table) Salt	sodium chloride	NaCl
Muriatic Acid	hydrochloric acid	HCl
Lye	sodium hydroxide	NaOH

14. If the subscripts in the formulas of compounds are changed, that changes the ratio of one type of atom to another – making a different compound. By changing the coefficients in front of compounds, the amount of compound present is modified but not its identity.

16. Precipitation reactions begin with reagents dissolved in solution and produce a solid as a product. Combustion reactions involve the reaction of a substance with oxygen (often with applied heat); carbon-containing compounds then produce carbon dioxide and hydrogen-containing compounds then produce water as a result. Neutralization reactions occur when an acid and a base react to form a salt and water. Redox reactions occur when one substance gains electrons (decreases its oxidation state) and another substance loses electrons (increases its oxidation state).

18. Numerous factors can cause the actual yield to be less than the theoretical yield. Some chemical reactions take place slowly, so insufficient time would cause the actual yield to be lower. Sometimes the products of a reaction will adhere to the sides of the reaction vessel, making it impossible to remove all of the product that was formed. Sometimes a product is difficult to separate from the remaining reaction mixture, lowering the actual yield.

20. By adding pyridine and pyralozone, a blue-colored molecule with the formula $C_{25}H_{24}N_4O_2$ is formed, and the amount of this molecule present can be analyzed using spectrophotometry.

Problems

22. a. Mg b. Ca c. Sr d. none

24. a. 1, alkali metals b. 17, halogens c. 16, chalcogens d. 11, coinage metals

26. a. Tc, technetium b. Na, sodium c. Te, tellurium d. Al, aluminum

28. a. -2 b. -3 c. +1 d. multiple (+2, +3 most common)

30. a. Ca_3P_2 b. BaO c. $AlBr_3$ d. CaF_2

32. a. NH_4^+ b. $C_2H_3O_2^-$ c. CO_3^{2-} d. SO_4^{2-}

34. a. $CaCO_3$ b. $Ba(OH)_2$ c. $Sr(CN)_2$ d. $Be(NO_3)_2$

36. a. Fe^{2+} b. Co^{3+} c. Cu^+ d. Cr^{3+}

38. a. sodium sulfide b. barium nitrate c. barium chloride d. potassium bromide

40. a. iron(II) oxide b. cobalt(III) phosphate c. copper(I) nitrate d. chromium(III) cyanide

42. a. phosphorus trichloride b. carbon dioxide c. oxygen difluoride d. sulfur dioxide

44. a. PCl_5 b. P_2I_3 c. BrF d. Br_3O_8

46. $Ca(s) + 2\ H_2O(l)$? $Ca(OH)_2(aq) + H_2(g)$

48. Balance the following reactions.

a.___$AgNO_3$ + ___LiBr à ___AgBr + ___$LiNO_3$

b.__ammonium chloride +__potassium permanganate à __ammonium permanganate + __potassium chloride.

c.___H_2O_2 à ___H_2O + ___O_2

d.__ H_2SO_4 +__NaOH à __water + __Na_2SO_4

a. 1, 1, 1, 1 (no coefficients) b. 1, 1, 1, 1 (no coefficients) c. 2, 2, 1 d. 1, 2, 2, 1

50. a. 32.6 g $CuNO_3$ ÷ (63.546 g/mol Cu + 14.00674 g/mol N + 3×(15.9994 g/mol O)) = 0.260 mol $CuNO_3$

b. 150.0 g Ca ÷ (40.078 g/mol Ca) = 3.743 mol Ca

c. 3.58 g O_2 ÷ (2×(15.9994 g/mol O)) = 0.112 mol O_2

d. 14.45 g F_2 ÷ (2×(18.9984032 g/mol F)) = 0.3803 mol F_2

52. a. 0.0525 mol KBr × (39.0983 g/mol K + 79.904 g/mol Br) = 6.248 g KBr

b. 0.126 mol NH_3 × (14.0067 g/mol N + 3×(1.00794 g/mol H)) = 2.146 g NH_3

c. 1.00 mol SO_3 × (32.066 g/mol S + 3×(15.9994 g/mol O)) = 80.064 g SO_3

d. 0.667 mol SF_6 × (32.066 g/mol S + 6×(18.9984032 g/mol F)) = 97.420 g SF_6

54. 57.5 g $BaSO_4$ ÷ (137.327 g/mol Ba + 32.066 g/mol S + 4×(15.9994 g/mol O)) = 0.246 mol $BaSO_4$

0.246 mol $BaSO_4$ × (1 mol Na_2SO_4 ÷ 1 mol $BaSO_4$) = 0.246 mol Na_2SO_4

0.246 mol Na_2SO_4 × (2×(22.98977 g/mol Na) + 32.066 g/mol S + 4×(15.9994 g/mol O)) = 34.995 g Na_2SO_4

56. 17.7 g H_2O ÷ (4×(1.00794 g/mol H) + 15.9994 g/mol O) = 0.982 mol H_2O

0.982 mol H_2O × (1 mol C_3H_8 ÷ 4 mol H_2O) = 0.246 mol C_3H_8

0.246 mol C_3H_8 × (3×(12.0115 g/mol C) + 8×(1.00794 g/mol H)) = 10.832 g C_3H_8

58. a. combustion b. neutralization c. precipitation d. oxidation-reduction

60. 15.0 g $Fe(NO_3)_3$ ÷ (55.845 g/mol Fe + 3×(14.0067 g/mol N) + 9×(15.9994 g/mol O)) = 0.0620 mol $Fe(NO_3)_3$

0.0620 mol $Fe(NO_3)_3$ × (1 mol $Fe(OH)_3$ ÷ 1 mol $Fe(NO_3)_3$) = 0.0620 mol $Fe(OH)_3$

0.0620 mol $Fe(OH)_3$ × (55.845 g/mol Fe + 3×(15.9994 g/mol O) + 3×(1.00794 g/mol H)) = 6.628 g $Fe(OH)_3$

15.0 g KOH ÷ (39.0983 g/mol K + 15.9994 g/mol O + 1.00794 g/mol H) = 0.267 mol KOH

0.267 mol KOH × (1 mol $Fe(OH)_3$ ÷ 3 mol KOH) = 0.0891 mol $Fe(OH)_3$

0.246 mol $Fe(OH)_3$ × (55.845 g/mol Fe + 3×(15.9994 g/mol O) + 3×(1.00794 g/mol H)) = 9.524 g $Fe(OH)_3$

Since $Fe(NO_3)_3$ produces less $Fe(OH)_3$, it must be the limiting reactant.

Therefore, the theoretical yield is 6.628 g $Fe(OH)_3$.

Forensic Chemistry Problems

62. a. sodium ion, potassium ion, calcium ion, magnesium ion, chloride ion, bromide ion, nitrate ion

b. There are 18 different ionic compounds that can be formed (only 12 are binary ionic compounds): NaCl (sodium chloride), NaBr (sodium bromide), $NaNO_3$ (sodium nitrate), KCl (potassium chloride), KBr (potassium bromide), KNO_3 (potassium nitrate), $CaCl_2$ (calcium chloride), CaClBr (calcium chloride bromide), $CaClNO_3$ (calcium chloride nitrate), $CaBr_2$ (calcium bromide), $CaBrNO_3$ (calcium bromide nitrate), $Ca(NO_3)_2$ (calcium nitrate), $MgCl_2$ (magnesium chloride), MgClBr (magnesium chloride bromide), $MgClNO_3$ (magnesium chloride nitrate), $MgBr_2$ (magnesium bromide), $MgBrNO_3$ (magnesium bromide nitrate), and $Mg(NO_3)_2$ (magnesium nitrate).

64. 200.0 g $C_7H_5N_3O_6$ ÷ (7×(12.0115 g/mol C) + 5×(1.00794 g/mol H) + 3×(14.0067 g/mol N) + 6×(15.9994 g/mol O)) = 0.881 mol $C_7H_5N_3O_6$

0.881 mol $C_7H_5N_3O_6$ × (12 mol CO ÷ 2 mol $C_7H_5N_3O_6$) = 5.283 mol CO

5.283 mol CO × (12.0115 g/mol C + 15.9994 g/mol O) = 147.986 g CO

66. 247.4 g CO ÷ (12.0115 g/mol C + 15.9994 g/mol O) = 8.832 mol CO

8.832 mol CO × (3 mol CO ÷ 1 mol $C_3H_6N_6O_6$) = 26.497 mol $C_3H_6N_6O_6$

26.497 mol $C_3H_6N_6O_6$ × (3×(12.0115 g/mol C) + 6×(1.00794 g/mol H) + 6×(14.0067 g/mol N) + 6×(15.9994 g/mol O)) = 5885.442 g $C_3H_6N_6O_6$

68. The equation is: TlCl + $AgNO_3$ à $TlNO_3$ + AgCl

In order to determine the limiting reagent, we have to figure out how many

Amount of moles of AgCl produced by TlCl:

$$0.54\text{ g TlCl}\times\frac{1\text{ mol TlCl}}{239.8\text{ g TlCl}}\times\frac{1\text{ mol AgCl}}{1\text{ mol TlCl}}=0.002\text{ g AgCl}$$

Amount of moles of AgCl produced by $AgNO_3$:

$$1.18\text{ g AgNO}_3\times\frac{1\text{ mol AgNO}_3}{169.8\text{ g AgNO}_3}\times\frac{1\text{ mol AgCl}}{1\text{ mol AgNO}_3}=0.007\text{ g AgCl}$$

Because TlCl produced the least amount of AgCl, TlCl is the limiting reagent. The amount of AgCl produced by this reaction is:

$$0.002\text{ mol AgCl}\times\frac{143.3\text{ g AgCl}}{1\text{ mol AgCl}}=0.323\text{ g AgCl}$$

70. If H_2 was not the limiting reactant, then there would be As_2O_3 in solution. As a result, the amount of AsH_3 produced (and the results of the Marsh test) would be lower than they should be.

72. The killer's fingerprints would have to be found on the inside of the Tylenol® bottle. The average customer does not open their over-the- counter medicine

bottles in the store, especially not those that have the "tamper resistant" seals.