Answers to Selected Exercises

The answers listed here are from the *Complete Solutions Guide,* in which rounding is carried out at each intermediate step in a calculation in order to show the correct number of significant figures for that step. Therefore, an answer given here may differ in the last digit from the result obtained by carrying extra digits throughout the entire calculation and rounding at the end (the procedure you should follow).

Chapter 1

17. No, it is useful whenever a systematic approach of observation and hypothesis testing can be used. **19.** Volume readings are estimated to one decimal place past the markings on the glassware. The assumed uncertainty is ±1 in the estimated digit. **a.** The volume would be estimated to the tenths place since the markings are to ones place. A sample reading would be 4.2 with an uncertainty of ±0.1. This reading has two significant figures. **b.** 10.52 ± 0.01 would be a sample reading and the uncertainty; this reading has four significant figures. **c.** 18 ± 1 would be a sample reading and uncertainty, with the reading having two significant figures. **21.** Chemical changes involve the making and breaking of chemical forces (bonds). Physical changes do not. The identity of a substance changes after a chemical change, but not after a physical change. **23. a.** Inexact; **b.** Exact; **c.** Exact; 36 in/yd × 2.54 cm/in × 1 m/100 cm = 0.9144 m/yd (All conversion factors used are exact.) **d.** Inexact; the announced attendance is generally the number of tickets sold, not the number who were actually in the stadium. Some people who paid may not have gone, some may sneak in without paying, etc. **e.** Exact; **f.** Inexact **25. a.** 2; **b.** 4; **c.** 4; **d.** 4; **e.** 3; **f.** 3; **g.** 4; **h.** 7 **27. a.** 3.13×10^2; **b.** 3.13×10^{-4}; **c.** 3.13×10^7; **d.** 3.13×10^{-1}; **e.** 3.13×10^{-2}. **29. a.** 102.623; **b.** 236.2; **c.** 3.0814; **d.** 4.67 **31. a.** 467; **b.** 0.24; **c.** 33.04; **d.** 75; **e.** 0.12; **f.** 0.21; **g.** 4.9; **h.** 0.01 **33. a.** 84.3 mm; **b.** 2.41 m; **c.** 2.945×10^{-5} cm; **d.** 14.45 km; **e.** 2.353×10^5 mm; **f.** 0.9033 μm **35. a.** 8 lb and 9.9 oz; $20\frac{1}{4}$ in; **b.** 4.0×10^4 km, 4.0×10^7 m; **c.** 1.2×10^{-2} m^3, 12 L, 730 in^3, 0.42 ft^3 **37. a.** 4.00×10^2 rods; 10.0 furlongs; 2.01×10^3 m; 2.01 km; **b.** 8390.0 rods; 209.75 furlongs; 42,195 m; 42.195 km **39. a.** 0.373 kg, 0.822 lb; **b.** 31.1 g, 156 carats; **c.** 19.3 cm^3 **41.** 2.95×10^9 knots **43.** The spouse's car, with 33 mi/gal, has the better gas mileage. **45.** $1.59 **47.** 39.2°C, 312.4 K **49. a.** 351.3 K; 173°F; **b.** 248 K; −13°F; **c.** 0 K; −459°F; **d.** 1074 K; 1470°F **51.** 69.1 ± 0.2°F **53.** 2.70×10^3 kg/m^3, 169 lb/ft^3 **55.** 1×10^6 g/cm^3 **57.** 0.28 cm^3 **59.** 3.8 g/cm^3 **61. a.** Both are the same mass; **b.** 1.0 mL mercury; **c.** Both are the same mass; **d.** 1.0 L benzene **63.** 2.77 cm **65.** Solid: own volume, own shape, does not flow. Liquid: own volume, takes shape of container, flows. Gas: takes volume and shape of container, flows **67. a.** Picture iv represents a gaseous compound. Pictures ii and iii also contain a gaseous compound but have a gaseous element present. **b.** Picture vi represents a mixture of two elemental gases. **c.** Picture v represents a solid element. **d.** Pictures ii and iii both represent a mixture of a gaseous element and a gaseous compound. **69. a.** physical; **b.** chemical; **c.** physical; **d.** chemical **71.** 6.02×10^{17} atoms; 2.08×10^{-4} mol **73.** 1.0×10^5 bags **75.** 7×10^5 kg **77. a.** Volume × density = mass; the orange block is more dense. Since mass (orange) > mass (blue) and volume (orange) < volume (blue), then the density of the orange block must be greater to account for the larger mass of the orange block. **b.** Which block is more dense cannot be determined. Since mass (orange) > mass (blue) and volume (orange) > volume (blue), then the density of the orange block may or may not be larger than the blue block. If the blue block is more dense, then its density cannot be so large that the mass of the smaller blue block becomes larger than the orange block mass. **c.** The blue block is more dense. Since mass (blue) = mass (orange) and volume (blue) < volume (orange), then the density of the blue block must be larger to equate the masses. **d.** The blue block is more dense. Since mass (blue) > mass (orange) and the volumes are equal, then the density of the blue block must be larger to give the blue block the larger mass. **79.** 8.5 ± 0.5 g/cm^3 **81.** In a subtraction, the result gets smaller, but the uncertainties are added. If the two numbers are very close, the uncertainty may be larger than the result. **83.** d_{old} = 8.8 g/cm^3, d_{new} = 7.17 g/cm^3; d_{new}/d_{old} = mass$_{new}$/mass$_{old}$ = 0.81; The difference in mass is accounted for by the difference in the alloy used (if the assumptions are correct). **85. a.** One possibility is that rope B is not attached to anything and rope A and rope C are connected via a pair of pulleys and/or gears; **b.** Try to pull rope B out of the box. Measure the distance moved by C for a given movement of A. Hold either A or C firmly while pulling on the other rope.

Chapter 2

15. a. Atoms have mass and are neither destroyed nor created by chemical reactions. Therefore, mass is neither created nor destroyed by chemical reactions. Mass is conserved. **b.** The composition of a substance depends on the number and kinds of atoms that form it. **c.** Compounds of the same elements differ only in the numbers of atoms of the elements forming them, i.e., NO, N_2O, NO_2. **17.** Deflection of cathode rays by magnetic and electric fields led to the conclusion that they were negatively charged. The cathode ray was produced at the negative electrode and repelled by the negative pole of the applied electric field. **19.** The proton and the neutron have similar mass, with the mass of the neutron being slightly larger than that of the proton. Each of these particles has a mass approximately 1800 times greater than that of an electron. The combination of the protons and the neutrons in the nucleus make up the bulk of the mass of an atom, but the electrons make the greatest contribution to the chemical properties of the atom. **21.** The atomic number of an element is equal to the number of protons in the nucleus of an atom of that element. The mass number is the sum of the number of protons and neutrons in the nucleus. The atomic mass is the actual mass of a particular isotope (including electrons). As we will see in Chapter 3, the average mass of an atom is taken from a measurement made on a large number of atoms. The average atomic mass value is listed in the periodic table. **23.** A compound will always contain the same numbers (and types) of atoms. A given amount of hydrogen will react only with a specific amount of oxygen. Any excess oxygen will remain unreacted. **25. a.** The composition of a substance depends on the number of atoms of each element making up the compound (depends on the formula of the compound) and not on the composition of the mixture from which it was formed. **b.** Avogadro's hypothesis implies that volume ratios are equal to molecule ratios at constant temperature and pressure. $H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g)$; from the balanced equation, the volume of HCl produced will be twice the volume of H_2 (or Cl_2) reacted. **27.** The F-to-S mass ratios are simple whole numbers, 1:2:3. **29.** O, 7.94; Na, 22.8; Mg, 11.9; O and Mg are incorrect by a factor of ≈2; correct formulas are H_2O, Na_2O, and MgO. **31.** Using $r = 5 \times 10^{-14}$ cm, $d_{nucleus} = 3 \times 10^{15}$ g/cm^3; using $r = 1 \times 10^{-8}$ cm, d_{atom} = 0.4 g/cm^3 **33.** 37 **35.** sodium, Na; beryllium, Be; manganese, Mn; chromium, Cr; uranium, U **37.** Sn: tin, Pt: platinum, Co: cobalt, Ni: nickel, Mg: magnesium, Ba: barium, K: potassium. **39.** The noble gases are He, Ne, Ar, Kr, Xe, and Rn (helium, neon, argon, krypton, xenon, and radon). All isotopes of radon are radioactive. **41. a.** 8; **b.** 8; **c.** 18; **d.** 5 **43. a.** 94 p, 144 n; **b.** 29 p, 36 n; **c.** 24 p, 28 n; **d.** 2 p, 2 n; **e.** 27 p, 33 n; **f.** 24 p, 30 n **45. a.** $^{12}_{5}B$; **b.** $^{15}_{7}N$; **c.** $^{35}_{17}Cl$; **d.** $^{235}_{92}U$; **e.** $^{14}_{6}C$; **f.** $^{31}_{15}P$ **47.** $^{151}_{63}Eu^{3+}$; $^{118}_{50}Sn^{2+}$ **49.** $^{75}_{33}As^{3+}$, 30 e; $^{128}_{52}Te^{2-}$, 52 p, 76 n, 2−; $^{32}_{16}S$, 0; $^{204}_{81}Ti^{+}$, 80 e; $^{195}_{78}Pt$, 78 p, 117 n, 78 e, 0 **51.** Metals: Mg, Ti, Au, Bi, Ge, Eu, Am; Nonmetals: Si, B, At, Rn, Br **53.** a, d **55.** Metallic character increases down a group. **57. a.** lose, Na^+; **b.** lose, Sr^{2+}; **c.** lose, Ba^{2+}; **d.** gain, I^-; **e.** lose, Al^{3+}; **f.** gain, S^{2-} **59. a.** sodium chloride; **b.** rubidium oxide; **c.** calcium sulfide; **d.** aluminum iodide **61. a.** chromium(VI) oxide; **b.** chromium(III) oxide; **c.** aluminum oxide; **d.** sodium hydride; **e.** calcium bromide; **f.** zinc chloride **63. a.** potassium perchlorate; **b.** calcium phosphate; **c.** aluminum sulfate; **d.** lead(II) nitrate **65. a.** nitrogen triiodide; **b.** sulfur difluoride; **c.** phosphorus trichloride; **d.** dinitrogen tetrafluoride **67. a.** copper(I) iodide; **b.** copper(II) iodide; **c.** cobalt(II) iodide; **d.** sodium carbonate; **e.** sodium hydrogen carbonate or sodium bicarbonate; **f.** tetrasulfur tetranitride; **g.** sulfur hexafluoride; **h.** sodium hypochlorite; **i.** barium chromate; **j.** ammonium nitrate **69. a.** CsBr; **b.** $BaSO_4$; **c.** NH_4Cl; **d.** ClO; **e.** $SiCl_4$; **f.** ClF_3; **g.** BeO; **h.** MgF_2 **71. a.** Na_2O; **b.** Na_2O_2; **c.** KCN; **d.** $Cu(NO_3)_2$; **e.** $SeBr_4$; **f.** PbS; **g.** PbS_2; **h.** CuCl; **i.** GaAs (from the positions in the periodic table, Ga^{3+} and As^{3-} are the predicted ions); **j.** CdSe; **k.** ZnS; **l.** HNO_2; **m.** P_2O_5 **73.** Yes, 1.0 g H would react with 37.0 g ^{37}Cl and 1.0 g H would react with 35.0 g ^{35}Cl. No, the mass ratio of H/Cl would always be 1 g H/37 g Cl for ^{37}Cl and 1 g H/35 g Cl for ^{35}Cl. As long as we had pure ^{35}Cl or pure ^{37}Cl, these ratios will always hold. If we have a mixture (such as the natural abundance of chlorine), the ratio will also be constant as long as the composition of the mixture of the two isotopes does not change. **75. a.** nitric acid; **b.** perchloric acid; **c.** acetic acid; **d.** sulfuric acid; **e.** phosphoric acid **77. a.** lead(II) acetate; **b.** copper(II) sulfate; **c.** calcium oxide; **d.** magnesium sulfate; **e.** magnesium hydroxide; **f.** calcium sulfate; **g.** dinitrogen monoxide or nitrous oxide (common) **79.** All contain 12 hydrogen atoms. **81. a.** Ca_3N_2; calcium nitride; **b.** K_2O; potassium oxide; **c.** RbF; rubidium fluoride; **d.** MgS; magnesium sulfide; **e.** BaI_2; barium iodide; **f.** Al_2Se_3; aluminum selenide; **g.** Cs_3P; cesium phosphide; **h.** $InBr_3$; indium(III) bromide (In forms compounds with +1 and +3 ions. You would predict a +3 ion from the position of In in the periodic table.) **83.** Cu, Ag, and Au **85.** The ratio of the masses of R that combine with 1.00 g Q is 3:1, as expected by the law of multiple proportions. R_3Q is the formula of the first compound. **87. a.** The compounds are isomers of each other. Isomers are compounds with the same formula but the atoms are attached differently, resulting in different properties. **b.** When wood burns, most of the solid material is converted to gases, which escape. **c.** Atoms are not an indivisible particle. Atoms are composed of electrons, neutrons, and protons. **d.** The two hydride samples contain different isotopes of either hydrogen and/or lithium. Isotopes may have different masses but have similar chemical properties.

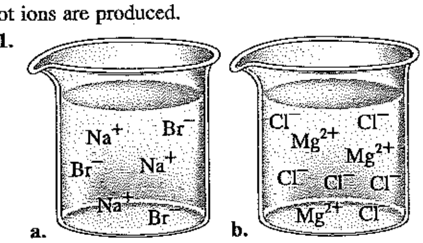
Chapter 3

19. The molecular formula gives the actual number of atoms of each element in a molecule (or formula unit) of a compound. The empirical formula gives the simplest whole-number ratio of atoms of each element in a molecule. The molecular formula is a whole number multiple of the empirical formula. If that multiplier is one, the molecular and empirical formulas are the same. **21.** 24.31 amu **23.** 48% ^{151}Eu and 52% ^{153}Eu **25.** There are three peaks in the mass spectrum, each 2 mass units apart. This is consistent with two isotopes, differing in mass by two mass units. **27.** 4.64×10^{-20} g Fe **29.** 1.00×10^{22} atoms C **31.** Al_2O_3, 101.96 g/mol; Na_3AlF_6, 209.95 g/mol **33. a.** 17.03 g/mol; **b.** 32.05 g/mol; **c.** 252.08 g/mol **35. a.** 0.0587 mol NH_3; **b.** 0.0312 mol N_2H_4; **c.** 3.97×10^{-3} mol $(NH_4)_2Cr_2O_7$ **37. a.** 85.2 g NH_3; **b.** 160. g N_2H_4; **c.** 1260 g $(NH_4)_2Cr_2O_7$ **39. a.** 70.1 g N; **b.** 140. g N; **c.** 140. g N **41. a.** 3.54×10^{22} molecules NH_3; **b.** 1.88×10^{22} molecules N_2H_4; **c.** 2.39×10^{21} formula units $(NH_4)_2Cr_2O_7$ **43. a.** 3.54×10^{22} atoms N; **b.** 3.76×10^{22} atoms N; **c.** 4.78×10^{21} atoms N **45.** 176.12 g/mol; 2.839×10^{-3} mol; 1.710×10^{21} molecules **47. a.** 4.13×10^{-4} mol; **b.** 9.40×10^{-2} mol; **c.** 1.661×10^{-22} mol; **d.** 6.592×10^{-5} mol **49. a.** 5.59×10^{-2} g; **b.** 4.00 g; **c.** 0.433 g; **d.** 4.653×10^{-23} g; **e.** 1.00×10^4 g **51. a.** 294.30 g/mol; **b.** 3.40×10^{-2} mol; **c.** 459 g; **d.** 1.0×10^{19} molecules; **e.** 4.9×10^{21} atoms; **f.** 4.9×10^{-13} g; **g.** 4.887×10^{-22} g **53.** 13.35% Y, 41.22% Ba, 28.62% Cu, 16.81% O **55.** $NO_2 = N_2O_4 < NO < N_2O$ **57.** 1360 g/mol **59. a.** 39.99% C, 6.713% H, 53.30% O; **b.** 40.00% C, 6.714% H, 53.29% O; **c.** 40.00% C, 6.714% H, 53.29% O (all the same except for rounding differences) **61. a.** NO_2; **b.** CH_2; **c.** P_2O_5; **d.** CH_2O **63.** TiO_2 **65.** compound I: HgO; compound II: Hg_2O **67.** NO_2, N_2O_4 **69.** $C_3H_5O_2$; $C_6H_{10}O_4$ **71.** C_3H_8 **73.** C_3H_4, C_9H_{12} **75. a.** $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$; **b.** $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$; **c.** $Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$ **77. a.** $Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$; **b.** $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$; **c.** $Au_2S_3(s) + 3H_2(g) \rightarrow 2Au(s) + 3H_2S(g)$ **79. a.** $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(g)$; **b.** $C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$; **c.** $C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(g)$; **d.** $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$; **e.** $4FeO(s) + O_2(g) \rightarrow 2Fe_2O_3(s)$ **81. a.** $SiO_2(s) + 2C(s) \rightarrow Si(s) + 2CO(g)$; **b.** $SiCl_4(l) + 2Mg(s) \rightarrow Si(s) + 2MgCl_2(s)$; **c.** $Na_2SiF_6(s) + 4Na(s) \rightarrow Si(s) + 6NaF(s)$ **83.** $C_{12}H_{22}O_{11}(aq) + H_2O(l) \rightarrow 4C_2H_5OH(aq) + 4CO_2(g)$ **85.** 6.51 g Cr_2O_3, 1.20 g N_2, 3.09 g H_2O **87.** 4.355 kg **89.** 7.2×10^4 g coke **91. a.** 65.01% Pt; 9.337% N; 2.015% H; 23.63% Cl; **b.** 72.3 g $Pt(NH_3)_2Cl_2$; 35.9 g KCl **93. a.** stoichiometric mixture; **b.** I_2; **c.** Mg; **d.** Mg; **e.** stoichiometric mixture; **f.** I_2; **g.** stoichiometric mixture; **h.** I_2; **i.** Mg **95. a.** 18.0 g $HgBr_2$; 1.03 g Br_2 excess; **b.** 35.0 g $HgBr_2$ **97.** 1300 g $CaSO_4$, 630 g H_3PO_4 **99.** 82.8% **101.** 1.20×10^3 kg = 1.20. metric tons **103.** Mn, 54.94 amu **105.** 9.25×10^{22} H atoms **107.** 4.30×10^{-2} mol; 2.50 g **109.** 5 **111.** 42.8% **113.** 86.2% **115.** $C_{20}H_{30}O$ **117.** $C_7H_5N_3O_6$ **119.** 1.8×10^6 g $Cu(NH_3)_4Cl_2$; 5.9×10^5 g NH_3 **121.** 207 amu, Pb **123.** Al_2Se_3 **125.** 0.48 mol

Chapter 4

9. Solubility refers to how much dissolves. Electrolyte refers to whether or not ions are produced.

11.



a. **b.**

c. For answers c–i, we will describe what should be in each solution. For c, the drawing should have three times as many NO_3^- anions as Al^{3+} cations. **d.** The drawing should have twice as many NH_4^+ cations as SO_4^{2-} anions. **e.** The drawing should have equal numbers of Na^+ cations and OH^- anions. **f.** The drawing should have equal numbers of Fe^{2+} cations and SO_4^{2-} anions. **g.** The drawing should have equal numbers of K^+ cations and MnO_4^- anions. **h.** The drawing should have equal numbers of H^+ cations and ClO_4^- anions. **i.** The drawing should have equal numbers of NH_4^+ cations and $C_2H_3O_2^-$ anions. **13.** $CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$ **15. a.** 0.2677 M; **b.** 1.255×10^{-3} M; **c.** 8.065×10^{-3} M **17. a.** $M_{Ca^{2+}} = 0.15\ M$, $M_{Cl^-} = 0.30\ M$; **b.** $M_{Al^{3+}} = 0.26\ M$, $M_{NO_3^-} = 0.78\ M$; **c.** $M_{K^+} = 0.50\ M$, $M_{Cr_2O_7^{2-}} = 0.25\ M$; **d.** $M_{Al^{3+}} = 4.0 \times 10^{-3}\ M$, $M_{SO_4^{2-}} = 6.0 \times 10^{-3}\ M$ **19.** 100.0 mL of 0.30 M $AlCl_3$ **21.** 41.7 mL **23. a.** Place 20.0 g NaOH in a 2-L volumetric flask; add water to dissolve the NaOH and fill to the mark. **b.** Add 500. mL of the 1.00 M NaOH stock solution to a 2-L volumetric flask; fill to the mark with water. **c.** As in a, instead using 38.8 g K_2CrO_4. **d.** As in b, instead using 114 mL of 1.75 M K_2CrO_4 stock