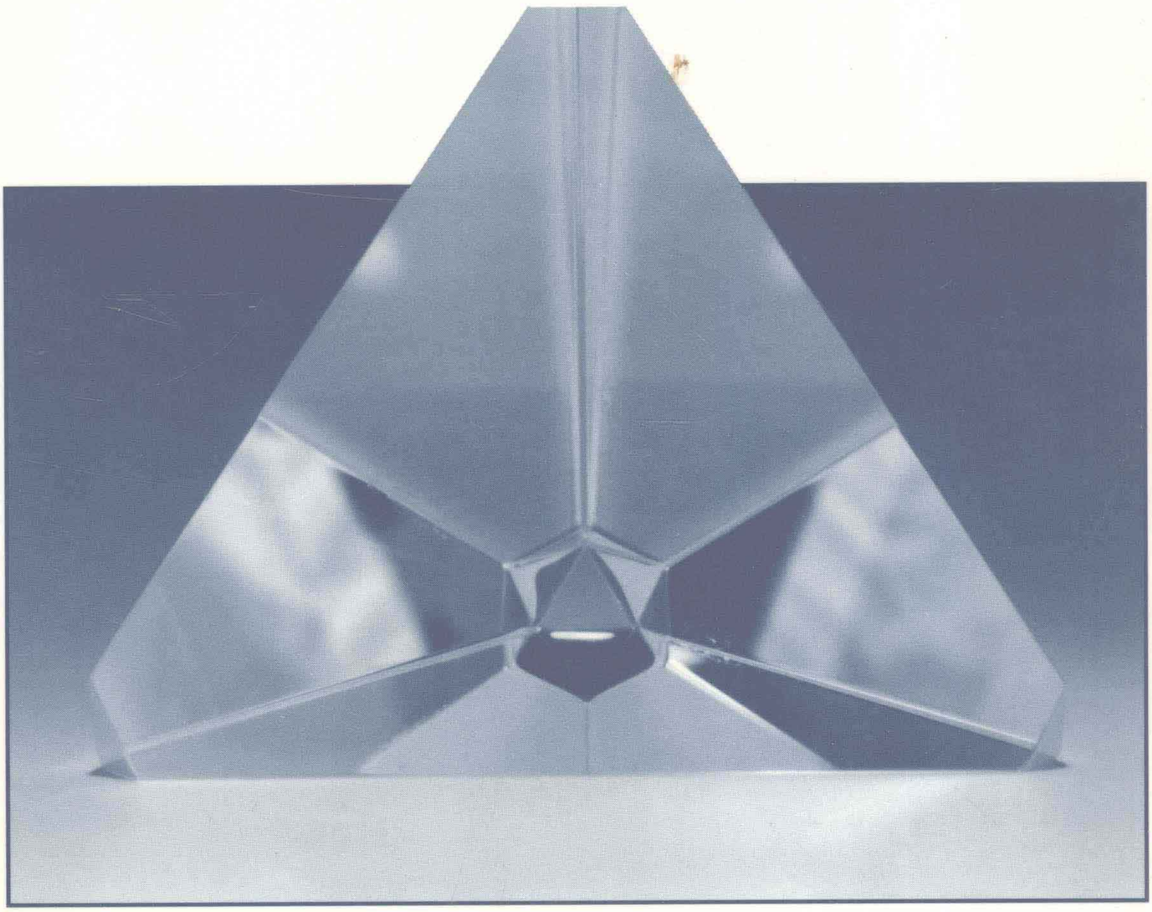
SOLUTIONS TO BLACK EXERCISES

ROXY WILSON

CHEMISTRY

THE CENTRAL SCIENCE



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SIXTH EDITION

Solutions to Black Exercises

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Sixth Edition

CHEMISTRY
The Central Science

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Introduction

Chemistry: The Central Science, 6th edition, contains nearly 2000 end-of-chapter exercises. Much attention has been given to these exercises because one of the best ways for students to master chemistry is by solving problems. Grouping the exercises according to subject matter is intended to aid the student in selecting and recognizing particular types of problems. Within each subject matter group, similar problems are arranged in pairs. This provides the student with an opportunity to reinforce a particular kind of problem. There are also a substantial number of general exercises in each chapter to supplement those grouped by topic. Answers to the odd numbered topical exercises and selected general exercises, about 900 in all, are provided in the text. These appendix answers help to make the text a useful self-contained vehicle for learning.

This manual, **Solutions to Black Exercises in Chemistry: The Central Science, 6th edition**, was written to enhance the end-of-chapter exercises by providing documented solutions to those problems not answered in the appendix of the text. The manual assists the instructor by saving time spent generating solutions for assigned problem sets and aids the student by offering an independent source to check their understanding of the material. Most solutions have been worked in the same detail as the in-chapter sample exercises to help guide the students in their studies.

Extraordinary efforts have been made to keep this manual as error-free as possible. All exercises were worked by at least two chemists and proofread by a third to ensure clarity in methods and accuracy in mathematics. However, the typo virus seems to find its way into all written work and notification of sightings would be appreciated. We hope that both instructors and students will find this manual accurate, helpful and instructive.

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Contents

CHAPTER ***1***

Introduction: Some Basic Concepts

Introduction to Matter

1.2 (a) gas (b) solid (c) liquid (d) solid

1.4 (a) chemical (b) physical (c) physical (The production of H_2O is a chemical change, but its **condensation** is a physical change.) (d) physical (The production of soot is a chemical change, but its **deposition** is a physical change.)

1.6 (a) physical (b) physical (c) chemical (d) physical (e) physical
(f) chemical (g) physical (h) physical (i) chemical

1.8 (a) homogeneous mixture (b) homogeneous mixture (c) pure substance
(d) heterogeneous mixture (This applies to dressings such as Italian, Thousand Island, etc.; homogeneous looking dressings such as French are really emulsions which are classified somewhere between homogeneous and heterogeneous mixtures.)

Elements and Compounds

1.10 (a) helium (b) magnesium (c) lead (d) sulfur
(e) fluorine (f) zinc (g) copper (h) argon

1.12 $A(s) \xrightarrow{\text{heat}} B(s) + C(g)$

When carbon(s) is burned in excess oxygen the two elements combine to form a gaseous compound, carbon dioxide. Clearly substance C is this compound.

Since C is produced when A is heated in the absence of oxygen (from air), both the carbon and oxygen in C must have been present in A originally. A is, therefore, a compound composed of two or more elements chemically combined. Without more information on the chemical or physical properties of B, we cannot determine absolutely whether it is an element or compound. However, few if any elements exist as white solids, so B is probably also a compound.

Units and Measurement

1.14 (a) $(\text{meters})^2$ (b) $(\text{meters})^3$ (c) kilograms (d) seconds (e) meters (f) Kelvins

1.16 (a) 3.4 <u>p</u>m (b) 4.8 <u>n</u>L (c) 7.23 <u>k</u>g (d) 2.35 cm^3 (1×10^{-6} m^3 = $(1 \times 10^{-2})^3$ cm^3)
(e) 5.8 <u>n</u>s (f) 3.45 <u>m</u>mol

1.18 (a) time (b) density (c) length (d) area
(e) temperature (f) volume (g) temperature

1.20 (a) $$3.05 \times 10^5 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 3.05 \times 10^2 \text{ kg} \quad (305 \text{ kg})$$

(b) $$0.0025 \text{ µm} \times \frac{1 \times 10^{-6} \text{ m}}{1 \text{ µm}} \times \frac{1 \text{ pm}}{1 \times 10^{-12} \text{ m}} = 2.5 \times 10^3 \text{ pm}$$

(c) $$3.45 \times 10^{-8} \text{ s} \times \frac{1 \text{ ns}}{1 \times 10^{-9} \text{ s}} = 34.5 \text{ ns}$$

(d) $$4.5 \times 10^8 \text{ pm}^3 \times \frac{(1 \times 10^{-12} \text{ m})^3}{1 \text{ pm}^3} = 4.5 \times 10^{-28} \text{ m}^3$$

1.22 (a) Strategy: change length to cm, volume = length^3 (cm^3), density = mass/volume (g/cm^3)

$$1.2 \times 10^{-5} \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} = 1.2 \text{ cm}$$

volume = $(1.2 \text{ cm})^3 = 1.7 \text{ cm}^3$

$$\text{density} = \frac{1.1 \text{ g}}{1.7 \text{ cm}^3} = \frac{0.64 \text{ g}}{\text{cm}^3}$$

The plastic is less dense than water (1.0 g/cm^3), so the object will float.

(b) $$3.12 \frac{\text{g}}{\text{mL}} \times \frac{1 \text{ mL}}{1 \times 10^{-3} \text{ L}} \times 0.500 \text{ L} = 1.56 \times 10^3 \text{ g} = 1.56 \text{ kg}$$

(c) $$8.74 \text{ kg} \times \frac{1000 \text{ g}}{\text{kg}} \times \frac{1 \text{ cm}^3}{1.20 \text{ g}} = 7.28 \times 10^3 \text{ cm}^3 = 7.28 \text{ L}$$

1.24 (a) °C = 5/9 (92°F - 32°) = 33°C (b) 804°C + 273.15 = 1077 K
(c) 234.28 K - 273.15 = -38.87°C; °F = 9/5 (-38.87°C) + 32 = 37.97°F

Uncertainty in Measurement

1.26 Exact: (b), (e), (f)

1.28 (a) 4 (b) 2 (c) 5, 6 or 7 (the trailing zeros may or may not be significant)
(d) 4 (e) 5

1.30 (a) 1.00×10^1 (b) 5.00×10^{-2} (c) 2.30×10^4 (d) 1.56×10^1 (e) 9.83×10^3
(f) -1.24×10^3

1.32 (a) 51 (the intermediate quotient has three significant figures and zero decimal places, so the answer also has zero decimal places)

(b) 6.532×10^9 (the intermediate result has one decimal place and four significant figures)

(c) 140 (two significant figures) + 3400 (two significant figures) = 3500 (only the third digit to the left of the implied decimal point is significant) or 3.5×10^3

(d) -1.91×10^6 (the intermediate result has two decimal places and three significant figures)

Dimensional Analysis

1.34 (a) $7.5\ \text{ft} \times \dfrac{12\ \text{in}}{1\ \text{ft}} \times \dfrac{2.54\ \text{cm}}{1\ \text{in}} = 2.3 \times 10^2\ \text{cm}$

(b) $4.45\ \text{qt} \times \dfrac{0.946\ \text{L}}{1\ \text{qt}} \times \dfrac{1000\ \text{mL}}{1\ \text{L}} = 4.21 \times 10^3\ \text{mL}$

(c) $\dfrac{35.7\ \text{in}}{\text{hr}} \times \dfrac{2.54\ \text{cm}}{1\ \text{in}} \times \dfrac{10\ \text{mm}}{1\ \text{cm}} \times \dfrac{1\ \text{hr}}{60\ \text{min}} \times \dfrac{1\ \text{min}}{60\ \text{s}} = \dfrac{0.252\ \text{mm}}{\text{s}}$

(d) $2.00\ \text{yd}^3 \times \dfrac{1\ \text{m}^3}{(1.094)^3\ \text{yd}^3} = 1.53\ \text{m}^3$

(e) $\dfrac{\$3.99}{\text{lb}} \times \dfrac{100\ ¢}{1\ \$} \times \dfrac{1\ \text{lb}}{453.6\ \text{g}} = \dfrac{0.880\ ¢}{\text{g}}$

(f) $\dfrac{1.57\ \text{g}}{\text{mL}} \times \dfrac{1\ \text{kg}}{1000\ \text{g}} \times \dfrac{1000\ \text{mL}}{1\ \text{L}} \times \dfrac{1\ \text{L}}{1\ \text{dm}^3} \times \dfrac{10^3\ \text{dm}^3}{1\ \text{m}^3} = \dfrac{1.57 \times 10^3\ \text{kg}}{\text{m}^3}$

1.36 (a) $31\ \text{gal} \times \dfrac{4\ \text{qt}}{1\ \text{gal}} \times \dfrac{0.946\ \text{L}}{1\ \text{qt}} = 1.2 \times 10^2\ \text{L}$

(b) $\dfrac{6\ \text{mg}}{\text{kg}} \times \dfrac{1\ \text{kg}}{2.205\ \text{lb}} \times 170\ \text{lb} = 5 \times 10^2\ \text{mg}$ (500 mg, the zeros are not significant)

(c) $\dfrac{244\ \text{mi}}{11.2\ \text{gal}} \times \dfrac{1.609\ \text{km}}{1\ \text{mi}} \times \dfrac{1\ \text{gal}}{4\ \text{qt}} \times \dfrac{1.057\ \text{qt}}{1\ \text{L}} = \dfrac{9.26\ \text{km}}{\text{L}}$

1.38 $8\ \text{ft} \times 12\ \text{ft} \times 20\ \text{ft} = 1920\ \text{ft}^3$

$$1920\ \text{ft}^3 \times \frac{(1\ \text{yd})^3}{(3\ \text{ft})^3} \times \frac{(1\ \text{m})^3}{(1.094\ \text{yd})^3} \times \frac{10\ \text{mg CO}}{1\ \text{m}^3} \times \frac{1\ \text{g}}{1000\ \text{mg}} = 0.54\ \text{g CO}$$

(rounding to one significant figure gives 0.5 g CO)

1.40 (a) $26.73\ \text{g total} \times \dfrac{0.90\ \text{g Ag}}{1\ \text{g total}} \times \dfrac{1\ \text{lb}}{453.59\ \text{g}} \times \dfrac{16\ \text{oz}}{1\ \text{lb}} \times \dfrac{\$1.18}{1\ \text{oz}} = \$1.0$

(b) $\$25.00 \times \dfrac{1\ \text{oz}}{\$6.10} \times \dfrac{1\ \text{lb}}{16\ \text{oz}} \times \dfrac{453.59\ \text{g}}{1\ \text{lb}} \times \dfrac{1\ \text{g total}}{0.90\ \text{g Ag}} \times \dfrac{1\ \text{coin}}{26.73\text{g}} = 4.8\ \text{coins}$

1.42 $\dfrac{50\ \text{cups}}{1\text{lb}} \times \dfrac{8\ \text{oz}}{1\ \text{cup}} \times \dfrac{1\ \text{qt}}{32\ \text{oz}} \times \dfrac{1000\ \text{mL}}{1.057\ \text{qt}} \times \dfrac{1\ \text{lb}}{453.59\ \text{g}} = \dfrac{26\ \text{mL}}{\text{g}}$

Additional Exercises

1.44 Intensive: (b), (c) and (e). Density (a ratio), temperature and color do not depend on amount.

1.46 (a) A **hypothesis** is a possible explanation for certain phenomena based on preliminary experimental data. A **theory** may be more general, and has a significant body of experimental evidence to support it; a theory has withstood the test of experimentation.
(b) A scientific **law** is a summary or statement of natural behavior; it tells how matter behaves. A **theory** is an explanation of natural behavior, it attempts to explain why matter behaves the way it does.

1.47 Any sample of vitamin C has the same relative amount of carbon and oxygen; the ratio of oxygen to carbon in the isolated sample is the same as the ratio in synthesized vitamin C.

$$\frac{2.00 \text{ g O}}{1.50 \text{ g C}} = \frac{x \text{ g O}}{6.35 \text{ g C}}; \quad x = \frac{(2.00 \text{ g O})(6.35 \text{ g C})}{1.50 \text{ g C}} = 8.47 \text{ g O}$$

This illustrates the *law of constant composition.*

1.49 Magnesium is *less dense* than steel. That is, a unit volume of magnesium weighs less than a unit volume of steel.

1.51 (a) Inappropriate - The circulation of a widely read publication would vary over a year's time, and could simply not be counted to the nearest single subscriber. Probably about four significant figures would be appropriate. (b) Appropriate - It might be possible to do better than two significant figures, but an estimate to two significant figures should be easily possible. (c) Rainfall can be measured to within 0.02 in., but it is probably not possible to record an entire year's rainfall to the nearest 0.01 in. Further, the variation from year to year is sufficiently large that it does not make much sense to report the average to this significant number of figures. Probably two significant figures would be appropriate. (d) Inappropriate - The population of a city is not constant during a year, and probably cannot be counted at any one time to an accuracy of one person. An appropriate estimate would be 51,000.

1.53 density = (5.26 g - 3.01 g)/ 2.36 mL = 0.953 g/mL

1.54 mass of benzene = 24.54 g - 8.47 g = 16.07 g

$$\text{volume of benzene} = 16.07 \text{ g} \times \frac{1 \text{ mL}}{0.879 \text{ g}} = 18.3 \text{ mL}$$

volume of solid = 25.00 mL - 18.3 mL = 6.7 mL

$$\text{density of solid} = \frac{8.47 \text{ g}}{6.7 \text{ mL}} = 1.3 \text{ g/mL}$$

1.56 (a) $$575 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{10 \text{ mm}}{1 \text{ cm}} \times \frac{1 \text{ quarter}}{1.55 \text{ mm}} = 1.13 \times 10^5 \text{ quarters}$$

(b) $$1.13 \times 10^5 \text{ quarters} \times \frac{5.67 \text{ g}}{1 \text{ quarter}} = 6.41 \times 10^5 \text{ g (641 kg)}$$

(c) 1.13×10^5 quarters $\times \frac{1 \text{ dollar}}{4 \text{ quarters}} = \$2.83 \times 10^4$
($28,250 but the result has only 3 significant figures)

(d) $\$4.2 \times 10^{12} \times \frac{1 \text{ stack}}{\$2.83 \times 10^4} = 1.5 \times 10^8$ stacks
(approximately 150 million stacks)

1.58 Calculate the volume of the aluminum foil:

$$5.175\text{g} \times \frac{1 \text{ cm}^3}{2.70 \text{ g}} = 1.92 \text{ cm}^3$$

Divide volume by area to get thickness

$$1.92 \text{ cm}^3 \times \frac{1}{12.0 \text{ in}} \times \frac{1}{15.5 \text{ in}} \times \frac{1 \text{ in}^2}{(2.54)^2 \text{ cm}^2} \times \frac{10 \text{ mm}}{1 \text{ cm}} = 1.60 \times 10^{-2} \text{ mm}$$

1.60 $9.64 \text{ g ethanol} \times \frac{1 \text{ cm}^3}{0.789 \text{ g ethanol}} = 12.2 \text{ cm}^3$, volume of cylinder

$$V = \pi r^2 h \; ; \; r = (V/\pi h)^{\frac{1}{2}} \times \left[\frac{12.2 \text{ cm}^3}{\pi \times 15.0 \text{ cm}}\right]^{\frac{1}{2}} = 0.509 \text{ cm}$$

$d = 2r = 1.02$ cm

1.62 The separation is successful if two distinct spots are seen on the paper. To quantify the characteristics of the separation, calculate a reference value for each spot that is

$$\frac{\text{distance travelled by spot}}{\text{distance travelled by solvent}}$$

If the values for the two spots are fairly different, the separation is successful. (One could measure the distance between the spots, but this would depend on the length of paper used and be different for each experiment. The values suggested above are independent of the length of paper.)

1.63 A solution could be separated into components by physical means, so separation would be attempted. If the liquid is a solution, the solute could be a solid or a liquid; these two kinds of solutions would be separated differently. Therefore, divide the liquid into several samples and do different tests on each. Try evaporating the solvent from one sample. If a solid remains, the liquid is a solution and the solute is a solid. If the result is negative, try distilling a sample to see if two or more liquids with different boiling points are present. If this result is negative, the liquid is probably a pure substance, but negative results are never entirely conclusive. We might not have tried the appropriate separation technique.

1.64 (a) osmium, density = 22.6 g/cm^3
(b) tungsten, m.p. = 3410°C
(c) helium, b.p. = -268.9°C
(d) mercury and bromine - both have freezing points below room temperature and boiling points above it

CHAPTER 2

Atoms, Molecules, and Ions

Atomic Theory

2.2 Postulate 3 of the atomic theory is the *law of constant composition*. It states that the relative number and kinds of atoms in a compound are constant, regardless of the source. Therefore, 1.0 g of pure water should always contain the same relative amounts of hydrogen and oxygen, no matter where or how the sample is obtained.

2.4 (a) $\frac{17.37 \text{ g oxygen}}{15.20 \text{ g nitrogen}} = \frac{1.143 \text{ g O}}{1 \text{ g N}} \div 1.143 = 1.0 \times 2 = 2$

$\frac{34.74 \text{ g oxygen}}{15.20 \text{ g nitrogen}} = \frac{2.286 \text{ g O}}{1 \text{ g N}} \div 1.143 = 2.0 \times 2 = 4$

$\frac{43.43 \text{ g oxygen}}{15.20 \text{ g nitrogen}} = \frac{2.857 \text{ g O}}{1 \text{ g N}} \div 1.143 = 2.5 \times 2 = 5$

(b) These masses of oxygen per one gram nitrogen are in the ratio of 2:4:5 and thus obey the *law of multiple proportions*.

2.6 In the first case, all reactants and products are enclosed in the glass flash bulb. Thus, all reactants are weighed before reaction and all products weighed after reaction. In the second case, only one reactant, Mg ribbon, is weighed before reaction. The second observation does not violate the law of conservation of mass because the law requires that we consider the sum of the masses of all reactants and compare it with the sum of the masses of all products.

Atomic Structure

2.8 (a) The electron itself has a negative charge so it is repelled by the negatively charged plate and attracted to the positively charged plate.

(b) As the charge on the plates is increased, the respective repulsion and attraction of the electron increases (Coloumb's Law) and the amount of bend should increase.

(c) As the mass of the particle increases, a greater force is required to deflect it. If the strength of the magnetic field is constant, the bend should decrease as the mass increases.

2.10 The droplets contain different charges because there may be 1, 2, 3 or more excess electrons on the droplet. The electronic charge is likely to be the lowest common factor in all the observed charges. Assuming this is so, we calculate the apparent electronic charge from each drop as follows:

$$A: 1.60 \times 10^{-19} \div 1 = 1.60 \times 10^{-19} \text{ C}$$

$$B: 3.15 \times 10^{-19} \div 2 = 1.58 \times 10^{-19} \text{ C}$$

$$C: 4.81 \times 10^{-19} \div 3 = 1.60 \times 10^{-19} \text{ C}$$

$$D: 6.31 \times 10^{-19} \div 4 = 1.58 \times 10^{-19} \text{ C}$$

The reported value is the average of these four values. Since each calculated charge has three significant figures, the average will also have three significant figures.

$$(1.60 \times 10^{-19} \text{ C} + 1.58 \times 10^{-19} \text{ C} + 1.60 \times 10^{-19} \text{ C} + 1.58 \times 10^{-19} \text{ C}) \div 4 = 1.59 \times 10^{-19} \text{ C}$$

2.12 The Mg nuclei have a much smaller volume and positive charge than the Au nuclei; the charge repulsion between the alpha particles and the Mg nuclei will be less, and there will be fewer direct hits because the Mg nuclei have even a smaller volume than the Au nuclei. Fewer alpha particles will be scattered in general and fewer will be strongly back scattered.

2.14 $$\frac{3.1 \text{ cm}}{1.0 \times 10^8 \text{ Na atoms}} = \frac{3.1 \times 10^{-8} \text{ cm}}{\text{Na atom}}$$

$$3.1 \times 10^{-8} \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ Å}}{1 \times 10^{-10} \text{ m}} = 3.1 \text{ Å (or 310 pm)}$$

2.16 (a) ^{60}Co, 27 p, 33 n (b) ^{131}I, 53 p, 78 n (c) ^{99}Tc, 43 p, 56 n

(d) ^{32}P, 15 p, 17 n (e) ^{51}Cr, 24 p, 27 n (f) ^{59}Fe, 26 p, 33 n

2.18

Symbol	^{31}P	^{56}Fe	^{119}Sn	^{127}I	^{201}Hg
Protons	15	**26**	50	53	**80**
Neutrons	16	**30**	69	74	121
Electrons	15	26	50	**53**	80
Atomic No.	15	26	**50**	53	80
Mass No.	31	56	**119**	**127**	**201**

2.20 $^{235}_{92}U$, $^{238}_{92}U$

The Periodic Table; Molecules and Ions

2.22 (a) sulfur (nonmetal) (b) selenium (nonmetal) (c) mercury (metal)
(d) calcium (metal) (e) neon (nonmetal) (f) beryllium (metal)
(g) zinc (metal)

2.24 O (nonmetal); S (nonmetal); Se (nonmetal); Te (metalloid); Po (metal); although Po is in the position of a metalloid, its properties are those of a metal.

2.26 No. Two molecules with the same empirical formula can have different molecular formulas if the integer number of empirical formula units in the two molecules is different. For example, CH_2O is the empirical formula for both formaldehyde, CH_2O, and glucose, $C_6H_{12}O_6$.

2.28 **CH:** C_2H_2, C_6H_6
CH_2: C_2H_4, C_3H_6, C_4H_8
NO_2: N_2O_4, NO_2

2.30

Symbol	$^{17}O^{2-}$	$^{52}Cr^{3+}$	$^{88}Sr^{2+}$	$^{79}Se^{2-}$	$^{127}I^{-}$
Protons	8	24	**38**	**34**	53
Neutrons	9	28	**50**	**45**	**74**
Electrons	10	21	36	**36**	**54**
Net Charge	2-	3+	**2+**	2-	**1-**

2.32 Unlikely ions: (a) F^+, (c) Be^-, (f) K^{2+}

2.34 (a) Na_2S (b) CaF_2 (c) MgO (d) Al_2O_3 (e) BeS (f) Li_3N

2.36 Molecular (all elements are nonmetals or metalloids): (b) $SiCl_4$, (d) NOCl, (e) B_2H_6, (f) CH_3OH

Ionic (formed from ions, usually contain a metal cation): (a) CaO, (c) $Mg(NO_3)_2$, (g) Ag_2SO_4

Naming Ionic Compounds

2.38 (a) ClO_2^- (b) Cl^- (c) ClO_3^- (d) ClO_4^- (e) ClO^-

2.40 (a) aluminum oxide (b) copper (II) perchlorate (or cupric perchlorate)
(c) nickel carbonate (d) tin (II) bromide (or stannous bromide)
(e) iron (II) hydroxide (or ferrous hydroxide) (f) potassium permanganate
(g) lead (II) acetate (or plumbous acetate) (h) zinc dihydrogenphosphate
(i) lithium sulf<u>ite</u> (j) ammonium dichromate

2.42 (a) Fe_2O_3 (b) $Mg_3(PO_4)_2$ (c) Na_2O_2 (d) $Fe(NO_3)_2$ (e) CaH_2 (f) $Zn(HSO_4)_2$

2.44 (a) hydrobromic acid (b) perbromic acid (c) nitrous acid (d) HClO
(e) HIO_3 (f) H_2SO_4

2.46 (a) sulfur hexafluoride (b) dichlorine heptoxide (c) iodine trichloride (d) CS_2
(e) HCN (f) N_2O_4

2.48 (a) $KClO_3(s)$, $O_2(g)$ (b) NaClO(aq) (c) $NH_3(g)$, $NH_4NO_3(s)$ (d) HF(aq)
(e) $H_2S(g)$ (f) HCl(aq), $NaHCO_3(s)$, $CO_2(g)$

Additional Exercises

2.49 (a) Based on data accumulated in the late eighteenth century on how substances react with one another, **Dalton** postulated the atomic theory. Dalton's theory is based on the indivisible atom as the smallest unit of an element that can combine with other elements.

(b) By determining the effects of electric and magnetic fields on cathode rays, **Thomson** measured the mass-to-charge ratio of the electron. He also proposed the "plum pudding" model of the atom in which most of the space in an atom is occupied by a diffuse positive charge in which the tiny negatively charged electrons are imbedded.

(c) By observing the rate of fall of oil drops in and out of an electric field, Millikin measured the charge of an electron.

(d) After observing the scattering of alpha particles at large angles when the particles struck gold fail, **Rutherford** postulated the nuclear atom. In Rutherford's atom, most of the mass of the atom is concentrated in a small dense region called the nucleus and the tiny negatively charged electrons are moving through empty space around the nucleus.

2.51

Symbol	^{35}Cl	$^{55}Mn^{2+}$	^{33}S	$^{76}As^{3-}$	$^{87}Sr^{2+}$
Protons	17	25	**16**	33	**38**
Neutrons	18	30	**17**	**43**	**49**
Electrons	17	23	16	**36**	**36**
Net Charge	0	2+	**0**	**3-**	2+

2.52 (a) deuterium - ${}^{2}_{1}H$, tritium - ${}^{3}_{1}H$

(b) Both deuterium and tritium have 1 proton and 1electron; their atomic number is 1. They differ in their number of neutrons and, therefore, have different mass numbers and nuclear composition.

2.54 (a) K (b) Ca (c) Ar (d) Br (e) Ge (f) H (g) Al (h) O (i) Ga

2.55 (a) $\frac{0.077 \text{ g H}}{0.923 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.083 g H/1 g C

(b) methane: $\frac{0.250 \text{ g H}}{0.750 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.333 g H/1 g C

ethylene: $\frac{0.143 \text{ g H}}{0.857 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.167 g H/1 g C

ethane: $\frac{0.200 \text{ g H}}{0.800 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.250 g H/1 g C

propane: $\frac{0.182 \text{ g H}}{0.818 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.222 g H/1 g C

butane: $\frac{0.172 \text{ g H}}{0.828 \text{ g C}} = \frac{\text{x g H}}{1.000 \text{ g C}}$; 0.208 g H/1 g C

(c) If 0.083 g H/1 g C is a 1:1 combining ratio, dividing the g H/1 g C obtained in (b) by 0.083 should indicate the ratio of H:1C in the other compounds. (d) Empirical formulas follow:

methane: $\frac{0.333 \text{ g H/1 g C}}{0.083 \text{ g H/1 g C}}$ = 4H : 1C ; CH_4

ethylene: $\frac{0.167 \text{ g H/1 g C}}{0.083 \text{ g H/1 g C}}$ = 2H : 1C ; CH_2

ethane: $\frac{0.250 \text{ g H/1 g C}}{0.083 \text{ g H/1 g C}}$ = 3H : 1C ; CH_3

propane: $\frac{0.222 \text{ g H/1 g C}}{0.083 \text{ g H/1 g C}}$ = 2.67H : 1C = 8/3 H : 1C = 8H : 3C ; C_3H_8

butane: $\frac{0.208 \text{ g H/1 g C}}{0.083 \text{ g H/1 g C}}$ = 2.5 H : 1C = 5/2 H : 1C = 5H : 2C ; C_2H_5

2.57 (a) sodium chloride (b) sodium bicarbonate (or sodium hydrogen carbonate) (c) sodium hypochlorite (d) sodium hydroxide (e) ammonium carbonate (f) calcium sulfate

2.58 (a) potassium nitrate (b) sodium carbonate (c) calcium oxide (d) hydrochloric acid (e) magnesium sulfate (f) magnesium hydroxide

2.60 (a) IO_3^- (b) IO_4^- (c) IO^- (d) HIO (e) HIO_4 or (H_5IO_6)

2.61 (a) There are 10 known isotopes of sulfur, ranging from ^{29}S to ^{38}S.

(b) The four most abundant are: $^{32}_{16}S$ - 95.0%, $^{34}_{16}S$ - 4.22%,

$^{33}_{16}S$ - 0.76%, $^{36}_{16}S$ - 0.14%

2.62 PF_3 - phosphorus trifluoride; density = 3.907 g/mL; m.p. = -151.5°C; b. p. = -101.5°C