CHAPTERS 1–3 BRINGING IT TOGETHER

Many of the fundamental concepts and problem-solving skills that were developed in the preceding chapters will carry forward into the rest of this book. Therefore, we recommend that you pause here to see how well you have grasped the concepts, how familiar you are with important terms, and how able you are at working chemical problems. Don't be discouraged if some of the problems seem to be difficult at first. Where necessary, take some time to review the concepts and problem-solving tools required.

Some of the problems here require data or other information found in tables in this book, including those inside the covers. Freely use these tables as needed. For problems that require mathematical solutions, we recommend that you first assemble the necessary information in the form of equivalencies and then use them to set up appropriate conversion factors needed to obtain the answers.

1. A rectangular box was found to be 24.6 cm wide, 0.35140 m high, and 7,424 mm deep.
   (a) How many significant figures are in each measurement?
   (b) Calculate the volume of the box in units of cm^3. Be sure to express your answer to the correct number of significant figures.
   (c) Use the answer in part (b) to calculate the volume of the box in cubic feet.
   (d) Suppose the box was solid and composed entirely of zinc, which has a density of 7.140 g/cm^3. What would be the mass of the box in kilograms?

2. What is the difference between an atom and a molecule? What is the difference between a molecule and a mole?

3. If a 10 g sample of element *X* contains twice as many atoms as a 10 g sample of element *Y*, how does the atomic mass of *X* compare with the atomic mass of *Y*?

4. How did Dalton's atomic theory account for the law of conservation of mass? How did it explain the law of definite proportions?

5. If atom *A* has the same number of neutrons as atom *B*, must *A* and *B* be atoms of the same element? Explain.

6. Construct a conversion factor that would enable you to convert a volume of 3.14 ft^3 into cubic centimeters (cm^3).

7. The atoms of an isotope of plutonium, Pu, each contain 94 protons, 150 neutrons, and 94 electrons. Write a symbol for this element that incorporates its mass number and atomic number. Write the symbol for a different isotope of plutonium.

8. An atom of an isotope of nickel has a mass number of 60. How many protons, neutrons, and electrons are in this atom?

9. A solution was found to contain particles consisting of 12 neutrons, 10 electrons, and 11 protons. Write the chemical symbol for this particle, consulting the periodic table as needed.

10. For each of the following, indicate whether it is possible to see the item specified with the naked eye. If not, explain.
   (a) A molar mass of iron
   (b) An atom of iron
   (c) A molecule of water
   (d) A mole of water
   (e) An ion of sodium
   (f) A formula unit of sodium chloride

11. Make a sketch of the general shape of the modern periodic table and mark off those areas where we find the metals, metalloids, and nonmetals.

12. Which of the following elements would most likely be found together in nature: Ca, Hf, Sn, Cu, Zr?

13. Match an element on the left with a description on the right.

Calcium	Halogen
Iron	Noble gas
Helium	Alkali metal
Gadolinium	Alkaline earth metal
Iodine	Transition metal
Sodium	Inner transition metal

14. Define *ductile* and *malleable*.

15. Which metal is a liquid at room temperature? Which metal has the highest melting point?

16. What is the most important property that distinguishes a metalloid from a metal or a nonmetal?

17. Give the symbols of the post-transition metals.

18. Give chemical formulas for the following.
   (a) potassium nitrate
   (b) calcium carbonate
   (c) cobalt(II) phosphate
   (d) magnesium sulfite
   (e) iron(III) bromide
   (f) magnesium nitride
   (g) aluminum selenide
   (h) copper(II) perchlorate
   (i) bromine pentafluoride
   (j) dinitrogen pentaoxide
   (k) strontium acetate
   (l) ammonium dichromate
   (m) copper(I) sulfide

19. Give chemical names for the following.
   (a) $NaClO_3$
   (b) $Ca_3(PO_4)_2$
   (c) $NaMnO_4$
   (d) AlP
   (e) ICl_3
   (f) PCl_3
   (g) K_2CrO_4
   (h) $Ca(CN)_2$
   (i) $MnCl_2$
   (j) $NaNO_2$
   (k) $Fe(NO_3)_2$

20. Why do we always write empirical formulas for ionic compounds?

21. Which of the following are binary substances: Al_2O_3, Cl_2, MgO, NO_2, $NaClO_4$?

22. A sample of a compound with a mass of 204 g consists of 1.00×10^{23} molecules. What is its molar mass?

23. Calculate the mass in grams of one formula unit of $K_4Fe(CN)_6$.

24. How many grams of copper(II) nitrate trihydrate, $Cu(NO_3)_2 \cdot 3H_2O$, are present in 0.118 mol of this compound?

25. A sample of 0.5866 g of nicotine was analyzed and found to consist of 0.4343 g C, 0.05103 g H, and 0.1013 g N. Calculate the percentage composition of nicotine.

26. A compound of potassium had the following percentage composition: K, 37.56%; H, 1.940%; P, 29.79%. The rest was oxygen. Calculate the empirical formula of this compound (arranging the atomic symbols in the order K H P O).

27. How many molecules of ethyl alcohol, C_2H_5OH, are in 1.00 fluid ounce of the liquid? The density of ethyl alcohol is 0.798 g/mL (1 oz = 29.6 mL).

28. What volume in liters is occupied by a sample of ethylene glycol, $C_2H_6O_2$, that consists of 5.00×10^{24} molecules. The density of ethylene glycol is 1.11 g/mL.

29. If 2.56 g of chlorine, Cl_2, will be used to prepare dichlorine heptoxide, how many moles and how many grams of molecular oxygen are needed?

30. Balance the following equations.

(a) $Fe_2O_3 + HNO_3 \longrightarrow Fe(NO_3)_3 + H_2O$

(b) $C_{21}H_{30}O_2 + O_2 \longrightarrow CO_2 + H_2O$

31. How many moles of nitric acid, HNO_3, are needed to react with 2.56 mol of Cu in the following reaction?

$$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

32. Under the right conditions, ammonia can be converted to nitrogen monoxide, NO, by the following reaction.

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

How many moles and how many grams of O_2 are needed to react with 56.8 g of ammonia by this reaction?

33. Dolomite is a mineral consisting of calcium carbonate and magnesium carbonate. When dolomite is strongly heated, its carbonates decompose to their oxides (CaO and MgO) and carbon dioxide is expelled.

(a) Write separate equations for the decompositions of calcium carbonate and magnesium carbonate.

(b) When a dolomite sample with a mass of 5.78 g was heated strongly, the residue had a mass of 3.02 g. Calculate the masses in grams and the percentages of calcium carbonate and magnesium carbonate in this sample of dolomite.

34. Adipic acid, $C_6H_{10}O_4$, is a raw material for making nylon, and it can be prepared in the laboratory by the following reaction between cyclohexene, C_6H_{10}, and sodium dichromate, $Na_2Cr_2O_7$, in sulfuric acid, H_2SO_4.

$$3C_6H_{10}(l) + 4Na_2Cr_2O_7(aq) + 16H_2SO_4\ (aq) \longrightarrow 3C_6H_{10}O_4(s) + 4Cr_2(SO_4)_3\ (aq) + 4Na_2SO_4(aq) + 16H_2O$$

There are side reactions. These plus losses of product during its purification reduce the overall yield. A typical yield of purified adipic acid is 68.6%.

(a) To prepare 12.5 g of adipic acid in 68.6% yield requires how many grams of cyclohexene?

(b) The only available supply of sodium dichromate is its dihydrate, $Na_2Cr_2O_7 \cdot 2H_2O$. (Since the reaction occurs in an aqueous medium, the water in the dihydrate causes no problems, but it does contribute to the mass of what is taken of this reactant.) How many grams of this dihydrate are also required in the preparation of 12.5 g of adipic acid in a yield of 68.6%?

35. One of the ores of iron is hematite, Fe_2O_3, mixed with other rock. One sample of this ore is 31.4% hematite. How many tons of this ore are needed to make 1.00 ton of iron if the percentage recovery of iron from the ore is 91.5% (1 ton = 2000 lb)?

36. Gold occurs in the ocean in a range of concentration of 0.1 to 2 mg of gold per ton of seawater. Near one coastal city the gold concentration of the ocean is 1.5 mg/ton.

(a) How many tons of seawater have to be processed to obtain 1.0 troy ounce of gold if the recovery is 65% successful? (The troy ounce, 31.1 g, is the standard "ounce" in the gold trade.)

(b) If gold can be sold for $625.10 per troy ounce, what is the breakeven point in the dollar-cost per ton of processed seawater for extracting gold from the ocean at this location?

37. *C.I. Pigment Yellow 45* ("sideran yellow") is a pigment used in ceramics, glass, and enamel. When analyzed, a 2.164 g sample of this substance was found to contain 0.5259 g of Fe and 0.7345 g of Cr. The remainder was oxygen. Calculate the empirical formula of this pigment. What additional data are needed to calculate the molecular mass of this compound?

38. When 6.584 g of one of the hydrates of sodium sulfate was heated so as to drive off all of its water of hydration, the residue of anhydrous sodium sulfate had a mass of 2.889 g. What is the formula of the hydrate?

39. In an earlier problem we described the reaction of ammonia with oxygen to form nitrogen monoxide, NO.

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

How many moles and how many grams of NO could be formed from a mixture of 45.0 g of NH_3 and 58.0 g of O_2? How many grams of which reactant would remain unreacted?

40. A sample of 14.0 cm^3 of aluminum, in powdered form, was mixed with an excess of iron(III) oxide. A reaction between them was initiated that formed aluminum oxide and metallic iron. How many cubic centimeters of metallic iron were formed?