CHAPTER 3 PROBLEM SET

1. Balance the following equations:

   (a) $Ca_3P_2(s) + 6\ H_2O(l) \rightarrow 3\ Ca(OH)_2(aq) + 2\ PH_3(g)$

   (b) 2 $Al(OH)_3(s) + 3\ H_2SO_4\ (aq) \rightarrow Al_2(SO_4)_3(aq) + 6\ H_2O(l)$

   (c) 2 $AgNO_3(aq) + Na_2CO_3(aq) \rightarrow Ag_2CO_3(s) + 2\ NaNO_3(aq)$

   (d) 2 $C_2H_5NH_2(g) + 15/2\ O_2(g) \rightarrow 4\ CO_2(g) + 7\ H_2O(g) + N_2(g)$

2. Calculate the percentage by mass of the indicated element in the following compounds:

   (**a**) carbon in acetylene, C_2H_2, a gas used in welding; (Answer: 92.3 %)

   (**b**) hydrogen in ascorbic acid, $HC_6H_7O_6$, also known as vitamin C; (Answer: 4.5 %)

   (**c**) hydrogen in ammonium sulfate, $(NH_4)_2SO_4$, a substance used as a nitrogen fertilizer; (Answer: 6.1 %)

   (**d**) platinum in $PtCl_2(NH_3)_2$, a chemotherapy agent called cisplatin; (Answer: 65.0 %)

   (**e**) oxygen in the female sex hormone estradiol, $C_{18}H_{24}O_2$; (Answer: 11.8 %)

   (**f**) carbon in capsaicin, $C_{18}H_{27}NO_3$, the compound that gives the hot taste to chili peppers. (Answer: 70.8 %)

3. (**a**) What is the mass, in grams, of 1.223 mol of iron (III) sulfate? (Answer: 489.2 g)

   (b) How many moles of ammonium ions are in 6.955 g of ammonium carbonate? (Answer: 0.146 mol)

   (c) What is the mass, in grams, of 1.50×10^{21} molecules of aspirin, $C_9H_8O_4$? (Answer: 0.449 g)

   (d) What is the molar mass of diazepam (Valium®) if 0.05570 mol has a mass of 15.86 g? (Answer: 284.74 g/mol)

4. The molecular formula of aspartame, the artificial sweetener marketed as NutraSweet®, is $C_{14}H_{18}N_2O_5$. (**a**) What is the molar mass of aspartame? (**b**) How many moles of aspartame are present in 1.00 mg of aspartame? (**c**) How many molecules of aspartame are present in 1.00 mg of aspartame? (**d**) How many hydrogen atoms are present in 1.00 mg of aspartame? (Answer: a) 274 g/mol, b) 3.65×10^{-6} mol, c) 2.20×10^{18} molecules, d) 3.96×10^{19} hydrogen atoms)

5. The allowable concentration level of vinyl chloride, C_2H_3Cl, in the atmosphere in a chemical plant is 2.0×10^{-6} g/L. How many moles of vinyl chloride in each liter does this

represent? How many molecules per liter? (Answer: 3.2×10^{-8} mol/L, 1.93×10^{16} molecules/L)

6. (a) The characteristic odor of pineapple is due to ethyl butyrate, a compound containing carbon, hydrogen, and oxygen. Combustion of 2.78 mg of ethyl butyrate produces 6.32 mg of CO_2 and 2.58 mg of H_2O. What is the empirical formula of the compound? (Answer: C_3H_6O)

   (**b**) Nicotine, a component of tobacco, is composed of C, H, and N. A 5.250-mg sample of nicotine was combusted, producing 14.242 mg of CO_2 and 4.083 mg of H_2O. What is the empirical formula for nicotine? If nicotine has a molar mass of 160 ± 5 g/mol, what is its molecular formula? (Answer: C_5H_7N, $C_{10}H_{14}N_2$)

7. Epsom salts, a strong laxative used in veterinary medicine, is a hydrate, which means that a certain number of water molecules are included in the solid structure. The formula for Epsom salts can be written as $MgSO_4 \cdot xH_2O$, where *x* indicates the number of moles of H_2O per mole of $MgSO_4$. When 5.061 g of this hydrate is heated to 250 °C, all the water of hydration is lost, leaving 2.472 g of $MgSO_4$. What is the value of *x*? (Answer: x: 7)

8. The complete combustion of octane, C_8H_{18}, a component of gasoline, proceeds as follows:

   $$2\ C_8H_{18}\,(l) + 25\ O_2\,(g) \rightarrow 16\ CO_2\,(g) + 18\ H_2O\,(g)$$

   (a) How many moles of O_2 are needed to burn 1.50 mol of C_8H_{18}? (Answer: 18.75 mol)

   (b) How many grams of O_2 are needed to burn 10.0 g of C_8H_{18}? (Answer: 35.1 g)

   (c) Octane has a density of 0.692 g/mL at 20 °C. How many grams of O_2 are required to burn 15.0 gal of C_8H_{18} (the capacity of an average fuel tank)? (Answer: 138035 g)

   (d) How many grams of CO_2 are produced when 15.0 gal of C_8H_{18} are combusted? (Answer: 121471 g)

9. Solutions of sulfuric acid and lead(II) acetate react to form solid lead(II) sulfate and a solution of acetic acid. If 5.00 g of sulfuric acid and 5.00 g of lead(II) acetate are mixed, calculate the number of grams of sulfuric acid, lead(II) acetate, lead(II) sulfate, and acetic acid present in the mixture after the reaction is complete. ((Answer: $PbSO_4$: 5.2 g, CH_3COOH: 2.04 g, H_2SO_4: 3.33 g)

10. When ethane (C_2H_6) reacts with chlorine (Cl_2), the main product is C_2H_5Cl, but other products containing Cl, such as $C_2H_4Cl_2$, are also obtained in small quantities. The formation of these other products reduces the yield of C_2H_5Cl.

(**a**) Calculate the theoretical yield of C_2H_5Cl when 125 g of C_2H_6 reacts with 255 g of Cl_2, assuming that C_2H_6 and Cl_2 react only to form C_2H_2Cl and HCl. (Answer: 234.78 g)

(**b**) Calculate the percent yield of C_2H_5Cl if the reaction produces 206 g of C_2H_5Cl. (Answer: 87.7 %)

11. An organic compound was found to contain only C, H, and Cl. When a 1.50-g sample of the compound was completely combusted in air, 3.52 g of CO_2 was formed. In a separate experiment the chlorine in a 1.00-g sample of the compound was converted to 1.27 g of AgCl. Determine the empirical formula of the compound. (Answer: C_6H_5Cl)