CH1020 Exercises (Worksheet 2)

1. Complete and balance the following chemical equations describing the complete combustion of several hydrocarbons.

   a. $2C_5H_{10}(\ell) + 15\ O_2(g) \rightarrow 10\ CO_2(g) + 10\ H_2O(g)$

   b. $2\ C_6H_{14}(\ell) + 19\ O_2(g) \rightarrow 12\ CO_2(g) + 14\ H_2O(g)$

   c. $2\ C_8H_{10}(\ell) + 21\ O_2(g) \rightarrow 16\ CO_2(g) + 10\ H_2O(g)$

   d. $C_9H_{12}(\ell) + 12\ O_2(g) \rightarrow 9\ CO_2(g) + 6\ H_2O(g)$

2. PbCl(OH) is one of several lead compounds used in ancient Egyptian cosmetics. It is prepared from PbO according to the following ancient recipe:

$$PbO(s) + NaCl(aq) + H_2O(\ell) \rightarrow PbCl(OH)(s) + NaOH(aq)$$

   How many grams of PbO and how many grams of NaCl would be required to produce 10.0 g PbCl(OH)?

   Mass(NaCl) = 2.25 g

   Mass(PbO) = 8.59 g

3. Chromium metal can be produced from high-temperature reactions of chromium(III) oxide with silicon or aluminum:

$$Cr_2O_3(s) + 2\ Al(\ell) \rightarrow 2\ Cr(\ell) + Al_2O_3(s)$$

$$2\ Cr_2O_3(s) + 3\ Si(\ell) \rightarrow 4\ Cr(\ell) + 3\ SiO_2(s)$$

   a. Calculate the mass of aluminum required to prepare 400.0 grams of chromium metal by the first reaction.

      207.5 g Al

   b. Calculate the mass of silicon required to prepare 400.0 grams of chromium metal by the second reaction.

      162.1 g Si

4. Charcoal (C) and propane (C_3H_8) are used as fuel in backyard grills.

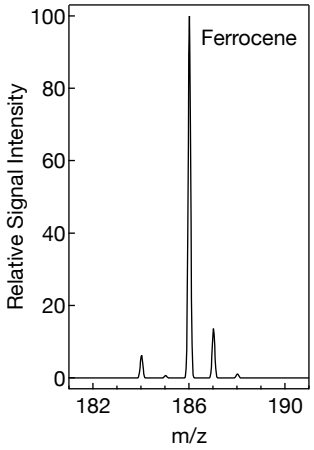
   a. Write balanced chemical equations for the complete combustion reactions of C and C_3H_8.

   $C(s) + O_2(g) \rightarrow CO_2(g)$
   $C_3H_8(g) + 5O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$

   b. How many grams of carbon dioxide are produced from burning 500.0 grams of each of the two fuels?

   Carbon: 1832 g CO_2
   Propane: 1497 g CO_2

5. The very first *organometallic* molecule discovered was an iron-containing hydrocarbon called *ferrocene*. Combustion analysis and mass spectrometry were essential in ascertaining its structure.



   a. You burn 21.31 g of ferrocene and capture 50.41 g of CO_2 and 10.32 g of H_2O. Determine an *empirical formula* for ferrocene.

   $C_{10}H_{10}Fe$

   b. From the mass spectrum on the right and the empirical formula above, find the *molecular formula* of this compound.

   $C_{10}H_{10}Fe$

6. You *really* want to know what chemical causes the foul odor of rancid butter, which you suspect contains carbon, hydrogen, and oxygen. You isolate and combust a 4.30 g sample, which produces 8.59 g of CO_2 and 3.52 g of H_2O. The most intense peak in the mass spectrum of the compound occurs at 88.1 *m/z*. Determine the formula of this smelly compound!

   Empirical Formula: C_2H_4O
   Molecular Formula: $C_4H_8O_2$

   In case you are wondering, the name of the substance is butyric acid $CH_3CH_2CH_2COOH$

7. For each of the reactions, calculate the mass (in grams) of the product that forms when 3.67 g of the underlined reactant completely reacts. Assume that there is more than enough of the other reactant.

   a. $\underline{Ba(s)} + Cl_2(g) \rightarrow BaCl_2(s)$ — 5.56g $BaCl_2$

   b. $\underline{CaO(s)} + CO_2(g) \rightarrow CaCO_3(s)$ — 6.55g $CaCO_3$

   c. $\underline{2\ Mg(s)} + O_2(g) \rightarrow 2MgO(s)$ — 6.09g MgO

   d. $\underline{4\ Al(s)} + 3\ O_2(g) \rightarrow 2\ Al_2O_3\ (s)$ — 6.93g Al_2O_3

8. Hydrobromic acid dissolves solid iron according to the reaction:

   $Fe(s) + 2\ HBr(aq) \rightarrow FeBr_2(aq) + H_2(g)$

   What mass of HBr (in grams) do you need to dissolve a 3.2 g pure iron bar on a padlock? What mass of H_2 would the complete reaction of the iron bar produce?

   9.3 g HBr ; 0.12 g H_2