Che 111: Chapter 10 Practice Problems Key

1. The equation for one process for making aluminum fluoride follows.

$$2\ Al(OH)_3 + H_2SiF_6 \rightarrow 2\ AlF_3 + SiO_2 + 4\ H_2O$$

   a. What is the maximum mass, in grams, of AlF_3 that can be made from the reaction of 1.4×10^3 g aluminum hydroxide with 1.0×10^3 g of H_2SiF_6?

$$1.4\times10^3\ g\ Al(OH)_3 \left(\frac{1\ mol\ Al(OH)_3}{78\ g\ Al(OH)_3}\right)\left(\frac{2\ mol\ AlF_3}{2\ mol\ Al(OH)_3}\right)\left(\frac{84\ g\ AlF_3}{1\ mol\ AlF_3}\right) = 1.5 \times 10^3\ g\ AlF_3$$

$$1.0\times10^3\ g\ H_2SiF_6 \left(\frac{1\ mol\ H_2SiF_6}{144\ g\ H_2SiF_6}\right)\left(\frac{2\ mol\ AlF_3}{1\ mol\ H_2SiF_6}\right)\left(\frac{84\ g\ AlF_3}{1\ mol\ AlF_3}\right) = 1.2 \times 10^3\ g\ AlF_3$$

   b. If 1.1×10^3 g of AlF_3 are isolated from the product mixture of the reaction of 1.4×10^3 g aluminum hydroxide with 1.0×10^3 g of H_2SiF_6, what is the percent yield?

$$\left(\frac{1.1\times10^3 g}{1.2\times10^3 g}\right)(100) = 92\%$$

2. Calcium carbide, CaC_2, reacts with water to form acetylene, C_2H_2, and calcium hydroxide.

   a. Write a balanced equation for this reaction. (You do not need to write the states.)

$$CaC_2 + 2\ H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

b. If you were designing the procedure for producing acetylene from calcium carbide and water, which of the reactants would you have as the limiting reactant? Why?

CaC_2 because the other reactant, H_2O, is inexpensive and can easily be evaporated from the products

c. Assuming 100% yield from the limiting reactant, what are the approximate amounts of CaC_2 and water that you would combine to form 127 g of C_2H_2?

$$127\ g\ C_2H_2 \left(\frac{1\ mol\ C_2H_2}{26\ g\ C_2H_2}\right)\left(\frac{1\ mol\ CaC_2}{1\ mol\ C_2H_2}\right)\left(\frac{64\ g\ CaC_2}{1\ mol\ CaC_2}\right) = 312\ g\ CaC_2$$

$$127\ g\ C_2H_2 \left(\frac{1\ mol\ C_2H_2}{26\ g\ C_2H_2}\right)\left(\frac{2\ mol\ H_2O}{1\ mol\ C_2H_2}\right)\left(\frac{18\ g\ H_2O}{1\ mol\ H_2O}\right) = 176\ g\ H_2O$$

3. Because carbon and silicon are both elements in group 14 on the periodic table, we expect them to react with other elements in similar ways. To some extent, they do, but in some cases, carbon and silicon compounds that seem to have analogous structures have very different chemical characteristics. For example, carbon tetrachloride, CCl_4, is very stable in the presence of water, but silicon tetrachloride, $SiCl_4$, reacts quickly with water. The unbalanced equation for this reaction is

$$\_\_\_\_ SiCl_4 + \_4\_ H_2O \rightarrow \_\_\_\_ Si(OH)_4 + \_4\_ HCl$$

a. Balance this equation.

b. Write a conversion factor that could be used to convert between moles of $SiCl_4$ and moles of H_2O.

$$\left(\frac{4\ mol\ H_2O}{1\ mol\ SiCl_4}\right)$$

c. How many moles of $SiCl_4$ react with 24 moles of water?

$$24 \text{ mol } H_20 \left(\frac{1 \text{ mol } SiCl_4}{4 \text{ mol } H_2O} \right) = 6 \text{ mol } SiCl_4$$

d. Write a conversion factor that could be used to convert between moles of $Si(OH)_4$ and moles of water.

$$\left(\frac{4 \text{ mol } H_2O}{1 \text{ mol } Si(OH)_4} \right)$$

e. How many moles of $Si(OH)_4$ form when 4.01 moles of H_2O react with an excess of $SiCl_4$?

$$4.01 \text{ mol } H_20 \left(\frac{1 \text{ mol } Si(OH)_4}{4 \text{ mol } H_2O} \right) = 1 \text{ mol } Si(OH)_4$$

4. A precipitation reaction takes place when a water solution of potassium phosphate, K_3PO_4, is added to a water solution of cobalt(II) chloride, $CoCl_2$.

a. Write a balanced equation for this reaction.

$$2\, K_3PO_{4\,(aq)} + 3\, CoCl_{2\,(aq)} \rightarrow 6\, KCl_{\,(aq)} + Co_3(PO_4)_{2\,(s)}$$

b. What is the maximum mass of cobalt(II) phosphate that will precipitate from a solution prepared by adding an excess of a K_3PO_4 solution to 5.0 mL of 1.0 M $CoCl_2$?

$$5.0 \text{ mL } CoCl_2 \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{1 \text{ mol } CoCl_2}{1 \text{ L solution}} \right) \left(\frac{1 \text{ mol } Co_3(PO_4)_2}{3 \text{ mol } CoCl_2} \right) \left(\frac{367 \text{ g } Co_3(PO_4)_2}{1 \text{ mol } Co_3(PO_4)_2} \right) = 0.61 \text{ g } Co_3(PO_4)_2$$