Chemistry Unit 6
Gas Stoichiometry – HW #4

1. What are the names of the following compounds? NH_4Cl. CaF_2. Al_2O_3.
   Ammonium chloride, calcium fluoride, aluminum oxide
2. What is the formula for calcium carbonate? What is its molar mass?
   $CaCO_3$ $40.08+12.01+(3\cdot16)=100.1\,g$
3. Hydrogen and oxygen produce water according to the following reaction.
   $2H_2 + O_2 \rightarrow 2H_2O$. Balance this reaction.
4. Sodium chloride is produced according to the following reaction:
   $2Na + Cl_2 \rightarrow 2NaCl$. Balance this reaction.
5. Ammonium hydroxide reacts with hydrogen chloride (hydrochloric acid) to produce ammonium chloride and water. Write the balanced equation for this.
   $NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

***For questions 6-11*: Methane (CH_4) burns to produce water and carbon dioxide.**

6. Write the balanced equation.
   $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
7. If 5 moles of methane burn, how many moles of oxygen will be consumed?
   $(5\ mol\ CH_4)\left(\frac{2\ mol\ O_2}{1\ mol\ CH_4}\right) = 10\ mol\ O_2$
8. How many moles of methane must burn to produce 10 moles of water?
   $(10\ mol\ H_2O)\left(\frac{1\ mol\ CH_4}{2\ mol\ H_2O}\right) = 5\ mol\ CH_4$
9. If the methane burns at STP, how many liters of methane will this be?
   $(5\ mol\ CH_4)\left(\frac{22.4\ L}{mol}\right) = 112\ L\ CH_4$
10. Often, methane will be compressed in storage tanks. What volume would the methane from the last question occupy under 10 atm pressure and a temperature of 25°C?
    $\frac{nRT}{P} = V = \frac{(5\ mol)(.0821\ \frac{L\cdot atm}{mol\cdot K})(298\ K)}{10\ atm} = 12.2\ L\ CH_4$
11. After the combustion, the water will be in vapor form. If the water vapor (gas) is at a temperature of 300°C, and if the pressure is 1atm, what volume would the vapor occupy?
    $V = \frac{nRT}{P} = \frac{(10\ mol)(.0821\ \frac{atm\cdot L}{mol\cdot K})(573\ K)}{1\ atm} = 470\ L$ $\quad 1\ mol = 22.4\ L$
12. Carbon monoxide reacts with oxygen to produce carbon dioxide at STP.
    a. Write the balanced equation for this process.
    $2CO + O_2 \rightarrow 2CO_2$
    b. If 1.0 L of carbon monoxide react, how many liters of oxygen are required?
    $(1\ L\ CO)\left(\frac{1\ mol}{22.4\ L}\right) = (.0446\ mol\ CO)\left(\frac{1\ mol\ O_2}{2\ mol\ CO}\right) = .0223\ mol\ O_2$
    $(.0223\ mol\ O_2)\left(\frac{22.4\ L}{mol}\right) = .5\ L\ O_2$
    c. How many liters of carbon dioxide are produced?
    $(1\ L\ CO)\left(\frac{1\ mol}{22.4\ L}\right) = (.0446\ mol\ CO)\left(\frac{2\ mol\ CO_2}{2\ mol\ CO}\right) = .0446\ mol\ CO_2$
    $(.0446\ mol\ CO_2)\left(\frac{22.4\ L}{mol}\right) = 1\ L\ CO_2$

13. Acetylene gas (C_2H_2) undergoes combustion to produce carbon dioxide and water vapor.

a. Write the balanced equation for this process.

$2\,C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

b. How many moles of C_2H_2 are required to produce 3.0 moles of CO_2?

$(3\ mol\ CO_2)\left(\frac{2\ mol\ C_2H_2}{4\ mol\ CO_2}\right) = 1.5\ mol\ C_2H_2$

c. If the reaction occurs at STP, how many liters of C_2H_2 must have been present?

$(1.5\ mol\ C_2H_2)\left(\frac{22.4\ L}{1\ mol}\right) = 33.6\ L\ C_2H_2$

d. How many liters of oxygen must have been used in the reaction?

$(3\ mol\ CO_2)\left(\frac{5\ mol\ O_2}{4\ mol\ CO_2}\right) = (3.75\ mol\ O_2)\left(\frac{22.4\ L}{1\ mol}\right) = 84\ L\ O_2$

14. Assume that 5.60 L of hydrogen gas at STP react with copper (II) oxide to produce copper and water.

a. Write the balanced equation for this process.

$H_2 + CuO \rightarrow Cu + H_2O$

b. How many moles of hydrogen react?

$(5.6\ L\ H_2)\left(\frac{1\ mol}{22.4\ L}\right) = .25\ mol\ H_2$

c. How many moles of copper are produced?

$(.25\ mol\ H_2)\left(\frac{1\ mol\ Cu}{1\ mol\ H_2}\right) = .25\ mol\ Cu$

d. How many grams of water are produced?

$(.25\ mol\ H_2O)\left(\frac{18.02\ g}{1\ mol}\right) = 4.5\ g\ H_2O$

15. Balance the chemical equation: $2Mg + O_2 \rightarrow 2MgO$.

a. If 10 g of Mg react, how many moles oxygen will be required?

$(10\ g\ Mg)\left(\frac{1\ mol\ Mg}{24.3\ g}\right) = (.411\ mol\ Mg)\left(\frac{1\ mol\ O_2}{2\ mol\ Mg}\right) = .205\ mol\ O_2$

b. What mass of magnesium oxide will be produced?

$(.411\ mol\ Mg)\left(\frac{1\ mol\ MgO}{1\ mol\ Mg}\right) = (.411\ mol\ MgO)\left(\frac{40.31\ g}{1\ mol\ MgO}\right) = 16.57\ g\ MgO$

c. What volume of oxygen is needed if the reaction takes place at 20°C and a pressure of 620 mmHg?

$V = \frac{nRT}{P} = \frac{(.205\ mol\ O_2)\left(.0821\ \frac{atm \cdot L}{mol \cdot K}\right)(293\ K)}{.82\ atm} = 6.01\ L\ O_2$

16. If liquid carbon disulfide reacts with 450. mL of oxygen to produce the gases carbon dioxide and sulfur dioxide, what volume of each product is produced at 25°C and 0.8 atm? (hint: you will need to start by converting to moles)

$CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$

$\frac{PV}{RT} = n = \frac{(.8\ atm)(.45\ L)}{\left(.0821\ \frac{atm \cdot L}{mol \cdot K}\right)(298\ K)} = (.015\ mol\ O_2)\left(\frac{1\ mol\ CO_2}{3\ mol\ O_2}\right) = .005\ mol\ CO_2$ (OVER)

$= (.015\ mol\ O_2)\left(\frac{2\ mol\ SO_2}{3\ mol\ O_2}\right) = .01\ mol\ SO_2$

#16 (CONTINUED)

$V = \frac{nRT}{P} = \frac{(.005 \text{ mol } CO_2)(.0821 \frac{\text{ATM} \cdot \text{L}}{\text{mol} \cdot \text{K}})(298\text{K})}{.8 \text{ ATM}}$

$= .15 \text{ L } CO_2$

$= \frac{(.01 \text{ mol } SO_2)(.0821 \frac{\text{ATM} \cdot \text{L}}{\text{mol} \cdot \text{K}})(298\text{K})}{.8 \text{ ATM}}$

$= .31 \text{ L } SO_2$