Chemistry 68 - Exam 2 Name ___________________________

20 July 2017

Show all work for credit. State any assumptions made to solve a problem. Give all numerical answers with the correct number of significant figures and the correct units. All answers in scientific notation must be in correct scientific notation (i.e., 6.022×10^{23} not 6.022E23 or 6.022e23). Each instance of incorrect scientific notation will result in the loss of 3 points. All numbers that require units should have the units written. All instances of numbers without units will result in the loss of 3 points each.

1. (2 points each) ***Balance*** the following chemical equations:

a. 2 Na_2O_2 + 2 H_2O → 4 NaOH + O_2

b. 2 NaOH + Cl_2 → NaCl + NaClO + H_2O

c. 4 Si_2H_3 + 11 O_2 → 8 SiO_2 + 6 H_2O

d. H_2SO_4 + 8 HI → H_2S + 4 I_2 + 4 H_2O

2. (28 points) A binary compound of magnesium and nitrogen is analyzed, and 1.2791 g of the compound is found to contain 0.9240 g of magnesium. When a second sample of this compound is treated with water and heated, the nitrogen is driven off as ammonia, leaving a compound that contains 60.31% magnesium and 39.69% oxygen by mass. Calculate the empirical formulas of the two magnesium compounds. Write the chemical equation that occurs between the first magnesium compound and water. Calculate the mass of ammonia produced in the reaction.

$$0.9240\ g\ Mg \times \frac{1\ mol\ Mg}{24.3050\ g\ Mg} = 0.038017\ mol\ Mg$$

$$(1.2791\ g\ compound - 0.9240\ g\ Mg) \times \frac{1\ mol\ N}{14.0067\ g\ N} = 0.025352\ mol\ N$$

$$\frac{0.025352\ mol\ N}{0.025352\ mol} = 1\ N \times 2 = 2 \qquad \frac{0.038017\ mol\ Mg}{0.025352\ mol} = 1.49955 \cong 1.5\ Mg \times 2 = 3$$

The first compound is Mg_3N_2.

$$60.31\ g\ Mg \times \frac{1\ mol\ Mg}{24.3050\ g\ Mg} = 2.48138\ mol\ Mg$$

$$39.69\ g\ O \times \frac{1\ mol\ O}{15.9994\ g\ O} = 2.48072\ mol\ O$$

$$\frac{2.48138\ mol\ Mg}{2.48072\ mol} = 1.00027 \cong 1 \qquad \frac{2.48072\ mol\ O}{2.48072\ mol} = 1$$

The second compound is MgO. The chemical equation is:

$$Mg_3N_2 + 3\ H_2O \rightarrow 2\ NH_3 + 3\ MgO$$

The amount of ammonia produced is:

$$1.2791\ g\ Mg_3N_2 \times \frac{1\ mol\ Mg_3N_2}{100.9284\ g\ Mg_3N_2} \times \frac{2\ mol\ NH_3}{1\ mol\ Mg_3N_2} \times \frac{17.0305\ g\ NH_3}{1\ mol\ NH_3} = 0.4137\ g\ NH_3$$

3. (20 points) Calculate the following. **SHOW ALL WORK FOR FULL CREDIT.** (Conversion factors are on the last page.)

a. The ***number of fluorine atoms*** in 35.00 g of $C_3H_4F_2$.

$$35.00\text{ g } C_3H_4F_2 \times \frac{1\text{ mol } C_3H_4F_2}{78.0627\text{ g } C_3H_4F_2} \times \frac{2\text{ mol F}}{1\text{ mol } C_3H_4F_2} \times \frac{6.022141 \times 10^{23}\text{ at F}}{1\text{ mol F}} = 5.400 \times 10^{23}\text{ at F}$$

b. the number of ***grams of dinitrogen pentasulfide*** needed to have 164.783 g of sulfur.

$$164.783\text{ g S} \times \frac{1\text{ mol S}}{32.06\text{ g S}} \times \frac{1\text{ mol } N_2S_5}{5\text{ mol S}} \times \frac{188.314\text{ g } N_2S_5}{1\text{ mol } N_2S_5} = 193.5\text{ g } N_2S_5$$

c. the number of ***molecules of $C_{10}H_{22}O_3$*** needed to have 75.03 g of oxygen.

$$75.03\text{ g O} \times \frac{1\text{ mol O}}{15.999\text{ g O}} \times \frac{1\text{ mol } C_{10}H_{22}O_3}{3\text{ mol O}} \times \frac{6.02214 \times 10^{23}\text{ molc } C_{10}H_{22}O_3}{1\text{ mol } C_{10}H_{22}O_3} = 9.414 \times 10^{23}\text{ molc } C_{10}H_{22}O_3$$

d. the number of ***grams of chromium(III) dichromate*** needed to have the same number of chromium atoms that are in 250.0 g of lead(II) chromate

$$250.0\text{ g } PbCrO_4 \times \frac{1\text{ mol } PbCrO_4}{323.2\text{ g } PbCrO_4} \times \frac{1\text{ mol Cr, } PbCrO_4}{1\text{ mol } PbCrO_4} \times \frac{6.02214 \times 10^{23}\text{ at Cr, } PbCrO_4}{1\text{ mol Cr, } PbCrO_4}$$

$$\times \frac{1\text{ at Cr, } Cr_2(Cr_2O_7)_3}{1\text{ at Cr, } PbCrO_4} \times \frac{1\text{ mol Cr, } Cr_2(Cr_2O_7)_3}{6.02214 \times 10^{23}\text{ at Cr, } Cr_2(Cr_2O_7)_3} \times \frac{1\text{ mol } Cr_2(Cr_2O_7)_3}{8\text{ mol Cr, } Cr_2(Cr_2O_7)_3}$$

$$\times \frac{751.947\text{ g } Cr_2(Cr_2O_7)_3}{1\text{ mol } Cr_2(Cr_2O_7)_3} = 72.71\text{ g } Cr_2(Cr_2O_7)_3$$

4. (19 points) 163.883 g of manganese(VI) chloride reacts with ammonium oxalate in a double replacement reaction. Calculate the ***number of grams of solid produced*** if there is a 96.10 % yield.

$$MnCl_6 + 3\ (NH_4)_2C_2O_4 \rightarrow 6\ NH_4Cl + Mn(C_2O_4)_3$$

$$163.883\text{ g }MnCl_6 \times \frac{1\text{ mol }MnCl_6}{267.656\text{ g }MnCl_6} \times \frac{1\text{ mol }Mn(C_2O_4)_3}{1\text{ mol }MnCl_6} \times \frac{318.9950\text{ g }Mn(C_2O_4)_3}{1\text{ mol }Mn(C_2O_4)_3} \times \frac{96.10\text{ g }Mn(C_2O_4)_3\text{ actual}}{100.00\text{ g }Mn(C_2O_4)_3\text{ theoretical}}$$

$$= 187.7\text{ g }Mn(C_2O_4)_3$$

5. (25 points) Calcium nitrate and ammonium phosphate solutions react in a double replacement reaction. Write the ***balanced chemical, ionic and net ion equations*** for the reaction. Calculate the ***mass of the solid produced*** if 250.3 mL of 0.1544 M calcium nitrate solution is added to 164.8 mL of 0.3347 M ammonium phosphate solution.

$$3\ Ca(NO_3)_{2\,(aq)} + 2\ (NH_4)_3PO_{4\,(aq)} \rightarrow Ca_3(PO_4)_{2\,(s)} + 6\ NH_4NO_{3\,(aq)}$$

$$3\ Ca^{2+}{}_{(aq)} + 6\ NO_3^{-}{}_{(aq)} + 6\ NH_4^{+}{}_{(aq)} + 2\ PO_4^{3-}{}_{(aq)} \rightarrow Ca_3(PO_4)_{2\,(s)} + 6\ NH_4^{+}{}_{(aq)} + 6\ NO_3^{-}{}_{(aq)}$$

$$3\ Ca^{2+}{}_{(aq)} + 2\ PO_4^{3-}{}_{(aq)} \rightarrow Ca_3(PO_4)_{2\,(s)}$$

$$?\ \text{g Ca}_3\left(\text{PO}_4\right)_2 = 250.3\ \text{mL Ca}\left(\text{NO}_3\right)_2\ \text{sol'n} \times \frac{0.1544\ \text{mol Ca}\left(\text{NO}_3\right)_2}{1000\ \text{mL Ca}\left(\text{NO}_3\right)_2\ \text{sol'n}} \times \frac{1\ \text{mol Ca}_3\left(\text{PO}_4\right)_2}{3\ \text{mol Ca}\left(\text{NO}_3\right)_2} \times \frac{310.173\ \text{g Ca}_3\left(\text{PO}_4\right)_2}{1\ \text{mol Ca}_3\left(\text{PO}_4\right)_2} = 3.996\ \text{g Ca}_3\left(\text{PO}_4\right)_2$$

$$?\ \text{g Ca}_3\left(\text{PO}_4\right)_2 = 164.8\ \text{mL}\ \left(\text{NH}_4\right)_3\text{PO}_4\ \text{sol'n} \times \frac{0.3347\text{mol}\ \left(\text{NH}_4\right)_3\text{PO}_4}{1000\ \text{mL}\ \left(\text{NH}_4\right)_3\text{PO}_4\ \text{sol'n}} \times \frac{1\ \text{mol Ca}_3\left(\text{PO}_4\right)_2}{2\ \text{mol}\ \left(\text{NH}_4\right)_3\text{PO}_4} \times \frac{310.173\ \text{g Ca}_3\left(\text{PO}_4\right)_2}{1\ \text{mol Ca}_3\left(\text{PO}_4\right)_2} = 8.554\ \text{g Ca}_3\left(\text{PO}_4\right)_2$$

3.996 g of the solid can be produced.