Practice Final Exam

1. Calculate the mass of silver atoms in a sphere that contains 35.26 mol% silver and the rest is copper. The sphere has a radius of 6.493 inches and has a density of 9.999 g mL^{-1}.

$$V=\frac{4}{3}\pi r^3=\frac{4}{3}\pi\left(6.493\text{ in}\right)^3\times\left(\frac{2.540\text{ cm}}{1\text{ in}}\right)^3\times\frac{1\text{ mL}}{1\text{ cm}^3}\times\frac{9.999\text{ g}}{1\text{ mL}}=187\ \underline{8}80.85\text{ g}=m_{Ag}+m_{cu}$$

$$\frac{n_{Ag}}{n_{Ag}+n_{cu}}=0.3526=\frac{m_{Ag}/M_{Ag}}{m_{Ag}/M_{Ag}+m_{Cu}/M_{Cu}}$$

$$m_{Cu}=187\ 880.85\text{ g}-m_{Ag}$$

$$0.3526=\frac{m_{Ag}/M_{Ag}}{m_{Ag}/M_{Ag}+\left(187\ 880.85\text{ g}-m_{Ag}\right)/M_{Cu}}=\frac{m_{Ag}/M_{Ag}}{m_{Ag}/M_{Ag}+\left(m_{sphere}-m_{Ag}\right)/M_{Cu}}$$

$$0.3526\left(m_{Ag}/M_{Ag}+\left(m_{sphere}-m_{Ag}\right)/M_{Cu}\right)=m_{Ag}/M_{Ag}$$

$$0.3526\left(\frac{m_{Ag}M_{Cu}+\left(m_{sphere}-m_{Ag}\right)M_{Ag}}{M_{Cu}M_{Ag}}\right)=\frac{m_{Ag}}{M_{Ag}}$$

$$M_{Ag}\left(0.3526\right)\left(m_{Ag}M_{Cu}+\left(m_{sphere}-m_{Ag}\right)M_{Ag}\right)=m_{Ag}M_{Ag}M_{Cu}$$

$$\left(0.3526\right)\left(m_{Ag}M_{Cu}+\left(m_{sphere}-m_{Ag}\right)M_{Ag}\right)=m_{Ag}M_{Cu}=0.3526m_{Ag}M_{Cu}+0.3526m_{sphere}M_{Ag}-0.3526m_{Ag}M_{Ag}$$

$$m_{Ag}M_{Cu}=m_{Ag}\left(0.3526M_{Cu}-0.3526M_{Ag}\right)+0.3526m_{sphere}M_{Ag}$$

$$m_{Ag}M_{Cu}-m_{Ag}\left(0.3526M_{Cu}-0.3526M_{Ag}\right)=0.3526m_{sphere}M_{Ag}$$

$$m_{Ag}\left(M_{Cu}-0.3526M_{Cu}+0.3526M_{Ag}\right)=0.3526m_{sphere}M_{Ag}$$

$$m_{Ag}=\frac{0.3526m_{sphere}M_{Ag}}{\left(M_{Cu}-0.3526M_{Cu}+0.3526M_{Ag}\right)}$$

$$=\frac{0.3526\left(187\ \underline{8}80.85\text{ g}\right)\left(107.8682\text{ g mol}^{-1}\right)}{\left(\left(63.456\text{ g mol}^{-1}\right)-0.3526\left(63.456\text{ g mol}^{-1}\right)+0.3526\left(107.8682\text{ g mol}^{-1}\right)\right)}$$

$$=90\ 3\underline{2}2.37\text{ g}=9.032\times10^{3}\text{ g Ag}$$

2. Write a ***balanced chemical equation*** for the double replacement reaction that occurs in aqueous solution, a ***total ionic equation***, and a ***net ionic equation***. (Solubility rules are on the back of the periodic table.)

a. lead(II) nitrate added to ammonium phosphate.

$3\ Pb(NO_3)_2 + 2\ (NH_4)_3PO_4 \rightarrow 6\ NH_4NO_3 + Pb_3(PO_4)_2$

$3\ Pb^{2+} + 6\ NO_3^{-} + 6\ NH_4^{+} + 2\ PO_4^{3-} \rightarrow 6\ NO_3^{-} + 6\ NH_4^{+} + Pb_3(PO_4)_2$

$3\ Pb^{2+} + 2\ PO_4^{3-} \rightarrow Pb_3(PO_4)_2$

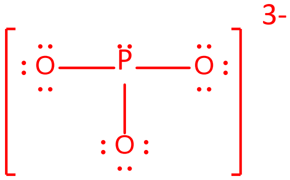
b. rubidium oxalate added to chromium(VI) acetate

$3\ Rb_2C_2O_4 + Cr(C_2H_3O_2)_6 \rightarrow 6\ RbC_2H_3O_2 + Cr(C_2O_4)_3$

$6\ Rb^{+} + 3\ C_2O_4^{2-} + Cr^{6+} + 6\ C_2H_3O_2^{-} \rightarrow 6\ Rb^{+} + 6\ C_2H_3O_2^{-} + Cr(C_2O_4)_3$

$3\ C_2O_4^{2-} + Cr^{6+} \rightarrow Cr(C_2O_4)_3$

3. Write a ***Lewis electron dot structure*** that follows the octet rule for PO_3^{3-}. Name the ***electron pair and molecular geometries***. Is this a ***polar*** ion?



Electron group geometry = tetrahedral
Molecular geometry = trigonal pyramidal
It is polar

4. Calculate the percent yield of a reaction if 0.104 L of carbon dioxide at 1.023 bar and 21.5 °C reacts with 250.0 mL of a 0.0200 M solution of calcium hydroxide and produces 0.322 g of solid calcium carbonate. The other product of the reaction is liquid water.

$CO_{2\,(g)} + Ca(OH)_{2\,(aq)} \rightarrow CaCO_{3\,(s)} + H_2O_{(l)}$

$$\frac{(0.104\ \text{L})(1.023\ \text{bar})}{(0.083144\ \text{L bar mol}^{-1}\ \text{K}^{-1})(294.7\ \text{K})} \times \frac{1\ \text{mol CaCO}_3}{1\ \text{mol CO}_2} \times \frac{100.087\ \text{g CaCO}_3}{1\ \text{mol CaCO}_3} = 0.435\ \text{g CaCO}_3$$

$$250.0\ \text{mL Ca(OH)}_2 \times \frac{0.0200\ \text{mol Ca(OH)}_2}{1000\ \text{mL}} \times \frac{1\ \text{mol CaCO}_3}{1\ \text{mol CO}_2} \times \frac{100.087\ \text{g CaCO}_3}{1\ \text{mol CaCO}_3} = 0.500\ \text{g CaCO}_3$$

$$\%\text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{0.322\ \text{g}}{0.435\ \text{g}} \times 100 = 74.0\%$$

5. Calcium fluoride phosphate ($Ca_{10}F_2(PO_4)_6$) reacts with sulfuric acid to produce calcium dihydrogen phosphate, calcium sulfate and hydrofluoric acid. If 100.0 g of calcium fluoride phosphate reacts with 200.0 mL of 0.8934 M sulfuric acid, how many grams of calcium sulfate will be produced and what will be the molarity of the calcium dihydrogen phosphate?

$$Ca_{10}F_2(PO_4)_6 + 7\ H_2SO_4 \rightarrow 3\ Ca(H_2PO_4)_2 + 7\ CaSO_4 + 2\ HF$$

$$100.0\text{ g } Ca_{10}F_2(PO_4)_6 \times \frac{1\text{ mol } Ca_{10}F_2(PO_4)_6}{1008.605\text{ g } Ca_{10}F_2(PO_4)_6} \times \frac{7\text{ mol } CaSO_4}{1\text{ mol } Ca_{10}F_2(PO_4)_6} \times \frac{136.141\text{ g } CaSO_4}{1\text{ mol } CaSO_4} = 94.48\text{ g } CaSO_4$$

$$200.0\text{ mL } H_2SO_4 \times \frac{0.8934\text{ mol } H_2SO_4}{1000\text{ mL } H_2SO_4} \times \frac{7\text{ mol } CaSO_4}{7\text{ mol } H_2SO_4} \times \frac{136.141\text{ g } CaSO_4}{1\text{ mol } CaSO_4} = 24.33\text{ g } CaSO_4$$

24.32 g of $CaSO_4$ will be produced.

$$\frac{24.33\text{ g } CaSO_4}{200.0\text{ mL solution}} \times \frac{1\text{ mol } CaSO_4}{136.141\text{ g } CaSO_4} \times \frac{3\text{ mol } Ca(H_2PO_4)_2}{7\text{ mol } CaSO_4} \times \frac{1\text{ mL}}{10^{-3}\text{ L}} = 0.3829\text{ M } Ca(H_2PO_4)_2$$

6. Write ***chemical formulas or names*** for the following (2 pts each)

a. ammonium chloride
NH_4Cl

b. Na_3N
sodium nitride

c. $HCN_{(aq)}$
hydrocyanic acid

d. nitrogen tribromide
NBr_3

e. carbon disulfide
CS_2

f. $Ni_3(PO_3)_2$
nickel(II) phosphite

g. lithium oxalate
$Li_2C_2O_4$

h. $Hg_2(N_3)_2$
mercury(II) azide

7. Here are the heat constants for a substance:

Normal melting point	-15.3 °C
Normal boiling point	156.7 °C
Molar heat of fusion	165 J/g
Molar heat of vaporization	2597 J/g
Specific heat of the solid	1.22 J/g °C
Specific heat of the liquid	0.867 J/g °C
Specific heat of the vapor	0.246 J/g °C

a. Calculate the quantity of heat required to heat 5.00 g of the substance from -10.0 °C to 50.0 °C.

$$q = ms\Delta T = (5.00\text{ g})(0.867\text{ J g}^{-1}\ ^\circ\text{C}^{-1})(50.0\ ^\circ\text{C} - (-10.0\ ^\circ\text{C})) = 260.\text{ J}$$

b. Calculate the quantity of heat required to melt 100.0 g of the substance at its normal melting point.

$$q = m\Delta H_{fus} = (100.0\text{ g})(165\text{ J g}^{-1}) = 1.65 \times 10^4\text{ J}$$

c. Calculate the quantity of heat required to vaporize 200.0 g of the substance at its normal boiling point.

$$q = m\Delta H_{vap} = (200.0\text{ g})(2597\text{ J g}^{-1}) = 5.194 \times 10^5\text{ J}$$

d. Calculate the amount of heat required to change 100.0 g of the solid substance at its -50.0 °C to the vapor at its 200.0 °C.

$$q_1 = ms\Delta T = (100.0\text{ g})(1.22\text{ J g}^{-1}\ ^\circ\text{C}^{-1})(-15.3\ ^\circ\text{C} - (-50.0\ ^\circ\text{C})) = 42\underline{3}3.4\text{ J}$$

$$q_2 = m\Delta H_{fus} = (100.0\text{ g})(165\text{ J g}^{-1}) = 16\underline{5}00.0\text{ J}$$

$$q_3 = ms\Delta T = (100.0\text{ g})(0.867\text{ J g}^{-1}\ ^\circ\text{C}^{-1})(156.7\ ^\circ\text{C} - (-15.3\ ^\circ\text{C})) = 14\underline{9}12.4\text{ J}$$

$$q_4 = m\Delta H_{vap} = (100.0\text{ g})(2597\text{ J g}^{-1}) = 259\underline{7}00.0\text{ J}$$

$$q_5 = ms\Delta T = (100.0\text{ g})(0.246\text{ J g}^{-1}\ ^\circ\text{C}^{-1})(200.0\ ^\circ\text{C} - 156.7\ ^\circ\text{C}) = 10\underline{6}5.18\text{ J}$$

$$q = \sum_{i=1}^{5} q_i = 296410.98\text{ J} = 2.964 \times 10^5\text{ J}$$

8. ***Balance*** each of the following chemical reactions

_______ $C_4H_8O_2$ + 10 O_2 → 4 CO_2 + 4 H_2O

H_3PO_4 + 12 $(NH_4)_2MoO_4$ + 21 HNO_3

→ $(NH_4)_3PO_4 \cdot 12\ MoO_3$ + 21 NH_4NO_3 + 12 H_2O

9. Write a balanced chemical equation for the reaction of sodium hydroxide reacting with phosphoric acid in a double replacement reaction. What would the ***molarity of the sodium hydroxide*** solution have to be if it requires 22.67 mL of the sodium hydroxide solution to completely neutralize 33.57 mL of 0.5678 M phosphoric acid solution?

$3\ NaOH + H_3PO_4 \rightarrow 3\ H_2O + Na_3PO_4$

$$?\frac{\text{mol NaOH}}{\text{L NaOH sol'n}} = \frac{33.57\ \text{mL}\ H_3PO_4\ \text{sol'n}}{22.67\ \text{mL NaOH sol'n}} \times \frac{0.5678\ \text{mol}\ H_3PO_4}{1\ \text{L}\ H_3PO_4\ \text{sol'n}} \times \frac{3\ \text{mol NaOH}}{1\ \text{mol}\ H_3PO_4} = 2.522\ \text{M NaOH}$$

10. The following reaction

$Fe_2O_3 + 3\ C \rightarrow 2\ Fe + 3\ CO$

was started with 100.0 g of iron(III) oxide (formula weight = 159.7 g mol^{-1}) and 1.000 g of carbon. If the reaction produces 15.65 L of carbon monoxide gas at 42.3°C and 855.9 mmHg, what is the ***percent yield***?

$$100.0\ \text{g}\ Fe_2O_3 \times \frac{1\ \text{mol}\ Fe_2O_3}{159.7\ \text{g}\ Fe_2O_3} \times \frac{3\ \text{mol CO}}{1\ \text{mol}\ Fe_2O_3} \times \frac{(62.634\ \text{L mmHg mol}^{-1}\ \text{K}^{-1})(315.5\ \text{K})}{855.9\ \text{mmHg}} = 43.18\ \text{L CO}$$

$$100.0\ \text{g C} \times \frac{1\ \text{mol C}}{12.0107\ \text{g C}} \times \frac{3\ \text{mol CO}}{3\ \text{mol C}} \times \frac{(62.634\ \text{L mmHg mol}^{-1}\ \text{K}^{-1})(315.5\ \text{K})}{855.9\ \text{mmHg}} = 18.08\ \text{L CO}$$

$$\%\text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{15.65\ \text{L CO}}{18.08\ \text{L CO}} \times 100 = 86.57\%$$