Practice Questions for Chapter 3 AK

Section 3.1 & 3.2

1. Balance the following equations, for this question, if the coefficient is 1[one], put that in the line as well. You will lose points if you leave the lines blank:
   a) **2**CCl_4 +**1**O_2→ **2**$COCl_2$ +**2**Cl_2
   b) **1**$C_9H_8O_4$ +**9**O_2 →**4**H_2O+**9**CO_2
   c) **1**Mg_2C_3 +**4**H_2O → **2**$Mg(OH)_2$ +**1**C_3H_4
   d) Do any of these reactions represent the decomposition process? Explain in one or two sentences why or why not.

   None of the above reactions represent a decomposition. A decomposition occurs when a (only one) reactant breaks down to form many smaller, stable products. The first and third reactions are REDOX reactions. although we will study this type of reaction in chapter 4, you did not need to know that to answer this question. The second reaction is a combustion.

2. Balance the following equations, for this question, if the coefficient is 1[one], put that in the line as well. You will lose points if you leave the lines blank:

   a. 4 BCl_3 + 1 P_4 + 6 H_2→ 4 BP + 12 HCl
   b. 1$C_9H_8O_4$ + 9 O_2 → 4 H_2O + 9 CO_2
   c. 1 NCl_3 + 3 H_2O → 1 NH_3+ 3 HOCl
   d. Do any of these reactions represent decomposition? Explain in one or two sentences.

   No, a decomposition is represented by the breakdown of the reactant (only one compound) to form smaller, more stable molecules.

   e. Do any of these reactions represent combustion? Explain in one or two sentences.

   Reaction B represents a combustion. Combustion reactions involve organic molecules reacting with oxygen to form carbon dioxide and water. When we exam reaction b, we see that the molecule is broken down to form the simpler molecules of water and carbon dioxide, only in the presence of oxygen.

Section 3.3

3. (4 points) One of the newly discovered materials that is a superconductor at about 90K is called a "123 compound" because its formula is $YBa_2Cu_3O_{(9-x)}$. Calculate the formula mass of the compound $YBa_2Cu_3O_7$using the following atomic masses: Y 88.90585 amu, Ba 137.327 amu, Cu 63.546 amu, O 15.9994 amu respectively (Your answer will be wrong if you do not use these masses).

   1 Y x 88.90585 amu/Y+2 Ba x 137.327 amu/Ba+3Cux63.546 amu/Cu+7Ox15.9994 amu/Ox
   88.90585 amu+274.354 amu+190.638 amu+111.9958 amu = 665.89365 amu to the proper sig figs, 665.894 amu

4. **(6 points)**Torbernite is a mineral structurally similar to mica, The formula unit is $Cu(UO_2)_2(PO_4)\cdot 10H_2O$. [There are 10 waters in the formula]

   a) What is formula mass of torbernite? Use the following atomic masses for your calculation.

   - Cu=63.546 amu
   - U=238.02891 amu
   - O=15.9994 amu
   - P=30.973762 amu
   - H=1.00794 amu

1•63.546amu+2•238.02891amu+18•15.9994 amu+1•30.973762 amu+20•1.00794 amu
878.724982 amu $Cu(UO_2)_2(PO_4)\cdot 10H_2O$
rounding to 878.725 amu $Cu(UO_2)_2(PO_4)\cdot 10H_2O$
Hint: when you add numbers with decimal places, count the smallest number of decimal places. This will determine the places you must use for significant figures. Anything to the LEFT of the decimal is significant; anything to the RIGHT of the decimal has to be counted for significance.

Section 3.4

5. (5 points) Novocain, $C_{13}H_{21}N_2O_2Cl$, is a local anesthetic. A sample of Novocain contains 6.000×10^{25} atoms of carbon. Please show your setups for full credit.
   a. How many molecules of Novocain does the sample contain?

6.000×10^{25} C	1 $C_{13}H_{21}N_2O_2Cl$,	$= 4.615 \times 10^{24}$ $C_{13}H_{21}N_2O_2Cl$
	13 C	

   b. How many moles of Novocain does this sample contain?

4.615×10^{24} $C_{13}H_{21}N_2O_2Cl$	1 mole $C_{13}H_{21}N_2O_2Cl$,	$= 7.664$ mol$C_{13}H_{21}N_2O_2Cl$
	6.022×10^{23} $C_{13}H_{21}N_2O_2Cl$	

   c. What is the molar mass of Novocain? Use the following atomic masses to calculate your molar mass: Carbon: 12.010 7, nitrogen: 14.006 7, hydrogen: 1.007 94, oxygen: 15.999 4, chlorine: 35.452 7. (Your answer will be considered wrong if you do not use these masses; watch your units)

13•12.010 7g+2•14.0067g+21•1.007 94g+2•15.999 4g+1•35.452 7g =272.8526 g $C_{13}H_{21}N_2O_2Cl$

6. **(5 points)** Aspartame is used as an artificial sweetener. Answer the following question using the correct significant figures and units.
   a. What is the formula for Aspartame: 14 carbons; 18 hydrogens, 2 nitrogens and 5 oxygens?

$C_{14}H_{18}N_2O_5$

   b. A sample of aspartame has 5.00×10^{28} oxygen atoms. How many aspartame molecules does this represent?

5.00×10^{28} O	$C_{14}H_{18}N_2O_5$	$= 1.00 \times 10^{28}$ $C_{14}H_{18}N_2O_5$
	5 O	

c. Using the following values for atomic masses, calculate the molecular mass of aspartame: C: 12.01078 amu, H: 1.007947 amu, N: 14.00672 amu, O: 15.99943 amu

14•12.010 78g+2•14.006 72g+18•1.007 947g+5•15.999 43g= 294.30456 g $C_{14}H_{18}N_2O_5$

d. A sample of aspartame has a mass of 3.6 mg. How many moles does this represent?

3.6 mg $C_{14}H_{18}N_2O_5$	1 mol $C_{14}H_{18}N_2O_5$	10^{-3} g	$1.2 \bullet 10^{-5}$mol $C_{14}H_{18}N_2O_5$
	294.30456 g $C_{14}H_{18}N_2O_5$	1 mg	

7. **(5 points)** Capsaicin is the pungent component of various species of *Capsicum,* including red and green chili peppers, especially *c. annum* and is the active component of *paprika.* It has several actions in the body when ingested, such as stimulation of the formation of endorphins in the brain and increased salivation when eating spicy food. The formula of capsaicin is $C_{18}H_{27}O_3N$. A sample of capsaicin contains 6.79 $x10^{20}$ molecules of capsaicin.

a. How many moles of capsaicin does the sample contain?

6.79 $X10^{20}$ $C_{18}H_{27}O_3N$	1 mol $C_{18}H_{27}O_3N$	$= 0.00113$ mol $C_{18}H_{27}O_3N$
	$6.022x10^{23}$ $C_{18}H_{27}O_3N$	

b. How many atoms of hydrogen does the sample contain?

6.79 $X10^{20}$ $C_{18}H_{27}O_3N$	27 H atoms	$= 1.67x10^{24}$ H atoms
	1 mol $C_{18}H_{27}O_3N$	

c. What is the molecular mass of capsaicin? Use the following values: C-12.011 amu; H-1.0079 amu; Cl-35.453 amu; O-15.9994 amu

305.412 amu

d. What is the mass of this sample in grams?

$= 0.00113$ mol $C_{18}H_{27}O_3N$	305.412 g $C_{18}H_{27}O_3N$	$= 0.345$ g $C_{18}H_{27}O_3N$
	1 mol $C_{18}H_{27}O_3N$	

Section 3.5

8. (**8 points)** The characteristic odor of pineapple is due to ethyl butyrate, a compound containing carbon, hydrogen, and oxygen. Combustion of a 2.78 g sample of ethyl butyrate produces 6.32 g of carbon dioxide and 2.58 g of water. What is the empirical formula for this compound? [CO_2 = 44.01 amu; H_2O = 18.02 amu] C_3H_6O

6.32 g CO_2	1 mol CO_2	1 mol C	= 0.1436 mol C
	44.01 g CO_2	1 mol CO_2	
0.1436 mol C	12.01 g C	=1.725 g C	
	1 mol C		
2.58 g H_2O	1 mol H_2O	2 mol H	= 0.2863 mol H
	18.02 g H_2O	1 mol H_2O	
0.2863 mol H	1.008 g H	= 0.2886g H	
	1 mol H		

2.78 g -1.725 g- 0.2886 g = 0.7687oxygen

0.7687 g O_x	1 mol O_x	=0.04804 mol O_x
	16.00g O_x	
Mol C	0.1436 mol C	3 C
Mol O	0.04804 O	1 O_x
MolH	0.2863 H	6H
Mol O	0.04804	1 O_x

9. Eugenol is the major component in oil of cloves. It has a molar mass of 164.2 g/mol and is composed of 73.14% C and 7.37% H; the remainder is oxygen. What is the empirical and molecular formula for Eugenol?

73.14 g C	1 mol C	= 6.089 mol C
	12.011 g C	
7.37 g H	1 mol H	= 7.31 mol H
	1.0079 g H	
19.49 g O	1 mol O	1.218 mol O
	15.999 g O	
Mol C	6.089 mol C	4.999 C
Mol O	1.218 mol O	1 O_x
Mol H	7.31mol H	6 H
Mol O	1.218 mol O	1 O_x
8164.2	2 empirical formula	$C_{10}H_{12}O_2$
82.0	1 molecular formula	

10. The analysis of aniline, a common organic base used in some varnishes, is: 77.44%C, 15.0% N and the rest is hydrogen. What is the empirical formula for aniline?

77.14 g C	1 mol C	= 6.422 mol C
	12.011 g C	
7.56 g H	1 mol H	= 7.501 mol H
	1.0079 g H	
15.00 g N	1 molN	1.071 mol N
	15.999 gN	
Mol C	6.089 mol C	5.999 C
Mol N	1.218 molN	1 N
Mol H	7.31mol H	6.00 H
Mol N	1.218 mol N	1 N

C_6H_6N

11. **10 points)** A sample of an organic compound containing C, H, and O, which weights 1.213 g gives 3.06 g of CO_2 and 0.536 g of H_2O in combustion. Determine the empirical formula for this compound.

3.06 g CO_2	1 mol CO_2	1 mol C	= 0.06953 mol C
	44.01 g CO_2	1 mol CO_2	
0.06953 mol C	12.01 g C	=0.8351 g C	
	1 mol C		
0.536 g H_2O	1 mol H_2O	2 mol H	= 0.05949 mol H
	18.02 g H_2O	1 mol H_2O	
0.05949 mol H	1.008 g H	= 0.05997g H	
	1 mol H		

1.213 g -0.8351 g- 0.05997 g = 0.3179 oxygen

0.3179 g O_x	1 mol O_x	=0.01987 mol O_x
	16.00g O_x	
Mol C	0.06953 mol C	3.5 C
Mol O	0.01987mol O	1 O_x
MolH	0.05949mol H	3.0H
Mol O	0.01987 mol O	1 O_x

Section 3.6

12. **(6 point)** A metal, symbol M, was converted to the chloride, MCl_2. Then, a solution of the metal chloride was treated with silver nitrate to give silver chloride crystals, which were filtered from the solution. [MM $AgNO_3$ = 107.88 amu; MM Cl = 35.453 amu]

$$MCl_{2(aq)} + 2\ AgNO_{3(aq)} \rightarrow M(NO_3)_{2(aq)} + 2AgCl_{(s)}$$

If 2.434 g of metal gave 7.964 g of silver chloride:

(a) (2 point) How many moles of silver chloride were made?

7.964g AgCl	1 mol AgCl / 143.32 g AgCl	0.05557 mol AgCl

(b) (1 point) How many moles of $MCl_{2(aq)}$ were used?

0.05557 mol AgCl	1 mol MCl_2 / 2 mol AgCl	0.02778 mol MCl_2

(c) (1 point) What is the mole relationship between the moles of metal and the moles of $MCl_{2(aq)}$?

1:1

(d) (2 point)What is the atomic weigh of the metal?

2.434 g metal / 0.02778 mol metal	87.60 g/mol

Section 3.7

13. Acrylonitrile, C_3H_3N, is used to make acrylics. It can be made from propylene, C_3H_6, and nitric oxide, NO.

$$4\ C_3H_6 + 6\ NO \rightarrow 4\ C_3H_3N + 6\ H_2O + N_2$$

How many grams of acrylonitrile are obtained from 2.50 g of nitric oxide?
[NO = 30.0 amu; C_3H_3N = 53.06 amu]

2.50 g NO	**1 mol NO / 30.0 g NO**	**4 mol C_3H_3N / 6 mol NO**	**53.06 g C_3H_3N / 1 mol C_3H_3N**	**=2.95 g C_3H_3N**

14. **(5 points)** The decomposition of ammonium dichromate occurs as follows:

$$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3\ (green) + N_2 + 4\ H_2O$$

The green compound, chromium(III) oxide, is the pigment used in paper money dye. How many grams of ammonium dichromate would a counterfeiter have to use to produce 50.0 g of chromium(III) oxide?

50.0 g Cr_2O_3	**1 mol Cr_2O_3 / 152.0 g Cr_2O_3**	**1 mol $(NH_4)_2Cr_2O_7$ / 1 mol Cr_2O_{32}**	**252.08 g$(NH_4)_2Cr_2O_7$ / 1 mol $(NH_4)_2Cr_2O_7$**	**=82.9 g $(NH_4)_2Cr_2O_7$**

15. **(6 points)** The complete combustion of nonane, $C_9H_{20}(l)$, proceeds as follows. $C_9H_{20}(l) + 14\ O_2(g) \rightarrow 9\ CO_2(g) + 10\ H_2O(l)$

Nonane,$C_9H_{20}(l)$, has a density of 0.789 g/mL at 20°C. How many grams of oxygen are required to burn 2.00 m^3 of nonane? (MM nonane = 128.295 amu)

2.00 m^3 C_9H_{20}	**1dm^3**	**1L**	**1000 mL**	**0.789g C_9H_{20}**	**1 mol C_9H_{20}**	**14 mol O_2**	**32.0 g O_2**	**= 5.51g O_2**
	$(10^{-1})^3 m^3$	**1dm^3**	**1L**	**1 mL C_9H_{20}**	**128.295 g C_9H_{20}**	**1 mol C_9H_{20}**	**1 mol O_2**	

16. **(5 points)** When iron metal is reacted with potassium permanganate in acid, the following reaction occurs.

$$5Fe_{(s)} + 3KMnO_{4(aq)} + 24HCl_{(aq)} \rightarrow 3MnCl_{2(aq)} + 5FeCl_{3(aq)} + 12\ H_2O_{(l)} + 3KCl_{(aq)}$$

(5 points) What mass of iron (III) chloride, in grams, is made from the complete reaction of excess iron and hydrochloric acid with 2.56 g potassium permanganate?

2.56 g $KMnO_4$	**1 mol $KMnO_4$**	**5 mol $FeCl_3$**	**162.20 g $FeCl_3$**	**= 4.38 $FeCl_3$**
	158.03 g $KMnO_4$	**3 mol $KMnO_4$**	**1mol $FeCl_3$**	

Section 3.7

17. **(10 points)** The reaction of 750. g of each of NH_3 and O_2 was found to produce 560 g NO by the reaction below.

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)}\ 6H_2O_{(l)}$$

(a) **(4 points)** Which is the limiting reagent. Show your reasoning (i.e. work) for full credit.

750.gNH_3	**1 mol NH_3**	**5 mol O_2**	**32.0 g O_2**	**= 1,765 g O_2 needed**
	17.0 g NH_3	**4 mol NH_3**	**1mol O_2**	

Since this is more than the amount of oxygen present, I know the O_2 is the LR

(a) **(2 points)** What is the mass of NO, in grams that is produced in the theoretical reaction?

750.g O_2	**1 mol O_2**	**4 mol NO**	**30.0 g NO**	**= 563 g NO**
	32.0 g O_2	**5 mol O_2**	**1mol NO**	

(b) **(2 points)** How many grams of excess reagent remains?

750.g O_2	**1 mol O_2**	**4 mol $NH_{3(g)}$**	**17.0 g $NH_{3(g)}$**	**= 319 g NH_3**
	32.0 g O_2	**5 mol O_2**	**1mol $NH_{3(g)}$**	

750.-319g =431 g NH_3remain

(c) **(2 points)** What is the percent yield? 560/563 X100 =99.5%

18. **(8 points)** One of the steps in the commercial process for collecting copper metal involves the reaction of bornite (Cu_3FeS_3) with oxygen.

$$Cu_3FeS_{3\,(s)} + 7\ O_{2(g)} \rightarrow 6\ Cu_{(s)} + 2\ FeO_{(s)} + 6\ SO_{2(g)}$$

In a certain experiment 3.00 g of $Cu_3FeS_{3(s)}$ reacts with 3.00 g of O_2.

a. Which reactant is the limiting reactant?(show your reasoning)

3.00 g Cu_3FeS_3	**1 mol Cu_3FeS_3**	**7 mol O_2**	**32.0g O_2**	**= 0.9805g O_2 needed**
	342.68 g Cu_3FeS_3	**2 mol Cu_3FeS_3**	**1molO_2**	

Since this is less than the amount of oxygen present, I know the bornite is the LR

b. How many grams of copper form?

3.00 g Cu_3FeS_3	**1 mol Cu_3FeS_3**	**6 mol Cu**	**63.546g Cu O_2**	**=1.67 g Cu made**
	342.68 g Cu_3FeS_3	**2 mol Cu_3FeS_3**	**1 mol Cu**	

c. How many grams of the excess reagent remain after the limiting reactant is completely consumed?

3.00 g – 0.981 g = 2.02 g O_2 remain

19. A mixture of 7.45 g of iron(II) oxide and 0.111 mol of aluminum metal is placed in a crucible and heated in a high temperature oven, where the reduction of the oxide occurs. The reaction 2.4 g of iron.

$$3\ FeO_{(s)} + 2\ Al_{(s)} \rightarrow 3\ Fe_{(s)} + Al_2O_{3(s)}$$

(4 points) Which is the limiting reagent. Show your reasoning (i.e. work) for full credit.

7.45 g FeO	**1 mol FeO**	**2 mol Al**	**= 0.0691 mol Al needed**
	71.85 g FeO	**3 mol FeO**	

Since I have more Aluminium than needed, FeO is the LR

a. **(2 points)** What is the mass of Fe, in grams that is produced in the theoretical reaction?

7.45 g FeO	**1 mol FeO**	**3 mol Fe**	**55.846 g Fe**	**=3.86 g Fe made**
	71.85 g FeO	**3 mol FeO**	**1 mol Fe**	

b. **(2 points)** How many grams of excess reagent remains?

0.111 mol Al – 0.0691 mol Al needed = 0.0419 mol Al remain

0.0419 mol Al	**26.9815 g Al**	**= 1.1 g Al remain**
	1 mol Al	

c. **(2 points)** What is the percent yield?

2.4 g Fe actually made/3.86 g Fe expected X100= 62%