CH 101 Fall 2018
Discussion #5
Chapter 5, Mahaffy 2e

Your name: ____________________ TF's name:____________________ Discussion Day/Time: __________________

Things you should know when you leave Discussion today:

- Balancing reactions by inspection Mahaffy, 2e sections 5.2-5.4, 5.6
- Calculations using limiting reactants. Mahaffy, 2e section 5.7
- Theoretical yield and Percent yield. Mahaffy, 2e section 5.8

1. Octanitrocubane (ONC) is a powerful explosive that, like TNT, is shock-insensitive (not readily detonated by shock). First synthesized by Philip Eaton and Mao-Xi Zhang in 1999 (Angewandte Chemie International Edition 39 (2): 401–404.), ONC is the most explosive chemical compound ever made (only nuclear weapons are more powerful). It detonates through the (unbalanced) reaction below.

$$C_8(NO_2)_8\ (s) \rightarrow\ CO_2\ (g) +\ N_2\ (g)$$

a. Balance the chemical reaction for the detonation of ONC.

b. If we wanted to synthesize ONC from carbon dioxide and nitrogen gas (i.e. reverse the reaction) and we had 56.0 g of nitrogen gas and as much carbon dioxide as we wanted (it's "in excess"), how many moles ONC could you make if all nitrogen gas was used assuming 100% yield? Hint: write balance chemical reaction for making ONC.

c. If we wanted to synthesize ONC from carbon dioxide and nitrogen gas (i.e. reverse the reaction) and we had 88.0 g of carbon dioxide and as much nitrogen gas as we wanted, how many moles ONC could you make assuming 100% yield? Note the difference from part b!

d. If we wanted to synthesize ONC from carbon dioxide and nitrogen gas (i.e. reverse the reaction) and we had 88.0 g of carbon dioxide and 56.0 g nitrogen gas, how many grams ONC could you make assuming 100% yield?

e. How many moles of the non-limiting reagent are left in excess?

f. If we synthesized ONC from carbon dioxide and nitrogen gas using the amounts in part d and our yield was 87 grams, calculate the percent yield.

g. What mass of a non-limiting reagent was used assuming percent yield from part f? Assume that no additional reactions take place.

h. What mass of a limiting reagent was used assuming percent yield from part f? Assume that no additional reactions take place.

i. Using the information in questions a-h fill in the following table. What is conserved during reaction? Number of grams? Number of moles?

	CO_2 (g)	N_2 (g)	$C_8(NO_2)_8$ (s)
Starting amount in grams			
Starting amount in moles			
Change in moles Assuming 100% yield.			
Final amount in moles Assuming 100% yield.			
Change in grams Assuming 100% yield.			
Final amount in grams Assuming 100% yield.			
Change in grams Assuming 75% yield.			
Final amount in grams (Assuming 75% yield.)			

2. Consider a gas cylinder filled with 2.1 grams of $N_2(g)$ and 0.60 grams of $H_2(g)$. When reaction proceeds it forms ammonia.

   a. Write balanced chemical reaction:

   b. How many moles of reaction are in 2.1grams of $N_2(g)$?

   c. How many moles of reaction are in 0.60 grams of $H_2(g)$?

   d. If the reaction goes to completion, how many grams of NH_3 are produced?

   e. What is the mass of the cylinder contents after the reaction goes to completion? Does the mass of the cylinder change throughout the reaction?

   f. If only 62% of the product formed in the reaction, what was the actual yield of the product?

3. Ammonia NH_3, (M_{NH3} = 17.0 g/mol) can be synthesized from the decomposition of urea, $(NH_2)_2CO$ (M_{urea} = 60.0 g/mol), according to the reaction below. If the yield of the reaction is 55.0%, what mass (in g) of urea is required to form 8.50 g of ammonia? Hint: always check if reaction is balanced

$$(NH_2)_2CO(s) \rightarrow NH_2CONHCONH_2(s) + NH_3(g).$$

4. During plant respiration, glucose ($C_6H_{12}O_6$) and oxygen react to form carbon dioxide and water.

   a. Write the balanced chemical reaction:

   b. What mass (in g) of O_2 is needed to fully react with 36.0 grams of glucose (M = 180 g/mol) assuming 100% yield.

   c. How many grams of CO_2 will be formed assuming 100% yield?

d. How many grams of water form assuming 100% yield?

e. What is the total mass of the reactants? How does that compare to the total mass of products?

f. What is the sum of the moles of reactants? How does that compare to the total moles of products?

g. How many grams of CO_2 will be formed assuming 58% yield?

h. What mass (in g) of O_2 is needed to react with 36.0 grams of glucose with 58% yield?

i. How many grams of water form assuming 79% yield?

5. An iron bar weighed **533 g**. After the bar had been standing in moist air for a month, exactly **one-eighth** of the iron turned to **rust** (**Fe_2O_3**). Calculate the final **total mass**: of the **iron bar + rust**.
Road map: Calculate the mass of Fe_2O_3 that can be made from $1/8^{th}$ of the mass of the original iron and add this to the mass of $7/8^{th}$ of the mass of the original iron.

a. Write balanced chemical reaction: Fe(s) + ☐ → Fe_2O_3 (s)

6. If 4.88 g of 'barium chloride hydrate' is treated with sulfuric acid, it gives 4.66 g of anhydrous barium sulfate. How many water molecules were attached to the original barium chloride molecule?

Numerical Answers:

1.
   a. $C_8(NO_2)_8(s) \rightarrow 8\ CO_2(g) + 4\ N_2(g)$
   b. 0.500 mol ONC
   c. 0.250 mol ONC
   d. 116 g ONC
   e. 1 mol N_2 excess
   f. 75% yield
   g. 21 g N_2
   h. 66 g CO_2
   i. N_2 is conserved w/ 28g excess (1 mol excess)

	$CO_2(g)$	$N_2(g)$	$C_8(NO_2)_8(s)$
Starting amount in grams	88	56	0
Starting amount in moles	2	2	0
Change in moles*	-2	-1	+0.25
Final amount in moles*	0	1	0.25
Change in grams*	-88	-28	+116
Final amount in grams*	0	28	116
Change in grams√	-66	-21	+87
Final amount in grams√	22	35	87

*Assume 100. % yield √Assume 75% yield

2.
   a. $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
   b. 0.075 mol rxn
   c. 0.1 mol rxn
   d. 2.6 g NH_3
   e. Mass does not change
   f. 1.6 g NH_3
3. 109 g urea needed
   $2\ (NH_2)_2CO(s) \rightarrow NH_2CONHCONH_2(s) + NH_3(g)$
4.
   a. $C_6H_{12}O_6(s) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$
   b. 38.4 g O_2
   c. 52.8 g CO_2
   d. 21.6 g H_2O
   e. Same
   f. Different
   g. 30.6 g CO_2
   h. 22.3 g O_2 needed
   i. 17.1 g H_2O
5. 562 g
   a. $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$
6. 2 water molecules