Chem 121 **SOLUTIONS to Extra Practice Problems Dealing with Moles, Grams, Stoichiometry**
Fall 2006

This is not meant to be a tutorial, just some extra practice problems. Presumably if you are reading this page, you have ***already*** *tried out these problems yourself, checked the answers posted and cannot figure out why yours is/are different than mine. After viewing the solutions provided below if you still cannot understand why your answer or setup is incorrect, please get help, by coming to see me or a tutor.*

1. How many H atoms are in 78.9 g of C_6H_{14}?

$$x\ H = 78.9\ g\ C_6H_{14}\left(\frac{1\ mol\ C_6H_{14}}{86.17\ g\ C_6H_{14}}\right)\left(\frac{6.022x10^{23}\ C_6H_{14}}{1\ mol\ C_6H_{14}}\right)\left(\frac{14\ H}{1\ C_6H_{14}}\right) = 7.72x10^{24}\ H$$

2. How many anions are in 375 mg of $CaCl_2$?
$CaCl_2$ is an ionic compound. It is NOT an anion. Which part of $CaCl_2$ is the "anion"?
You should remember the "anion" part is the negative ion which is the ***non****metallic part: Cl^- (chloride ion).*
Note also, that we are going from macroscopic (mg) to submicroscopic (tiny little anions.

$$x\ Cl^- = 375\ mg\ CaCl_2\left(\frac{1\ g\ CaCl_2}{10^3\ mg\ CaCl_2}\right)\left(\frac{1\ mol\ CaCl_2}{111.0\ g\ CaCl_2}\right)\left(\frac{6.022x10^{23}\ CaCl_2}{1\ mol\ CaCl_2}\right)\left(\frac{2\ Cl^-}{1\ CaCl_2}\right)$$

$$= 4.07x10^{21}\ Cl^-$$

3. How many ions are in 375 mg of $CaCl_2$?
Where are the "ions?" It doesn't specify which type of ions, so it must be both cations and anions. In one $CaCl_2$, there are 3 ions in total: Ca^{2+} and two Cl^-.

$$x\ Cl^- = 375\ mg\ CaCl_2\left(\frac{1\ g\ CaCl_2}{10^3\ mg\ CaCl_2}\right)\left(\frac{1\ mol\ CaCl_2}{111.0\ g\ CaCl_2}\right)\left(\frac{6.022x10^{23}\ CaCl_2}{1\ mol\ CaCl_2}\right)\left(\frac{3\ ions}{1\ CaCl_2}\right)$$

$$= 6.10x10^{21}\ ions$$

4. How many moles of cations are in 375 mg of $CaCl_2$?
So by now, you should know what to do... where are the cations? Ca^{2+} is the cation we are referring to.

$$x\ Ca^{2+} = 375\ mg\ CaCl_2\left(\frac{1\ g\ CaCl_2}{10^3\ mg\ CaCl_2}\right)\left(\frac{1\ mol\ CaCl_2}{111.0\ g\ CaCl_2}\right)\left(\frac{6.022x10^{23}\ CaCl_2}{1\ mol\ CaCl_2}\right)\left(\frac{1\ Ca^{2+}}{1\ CaCl_2}\right)$$

$$= 3.38x10^{-3}\ Ca^{2+}$$

5. How many grams are in 583 molecules of CO_2?

$$x\ g\ CO_2 = 583\ CO_2\left(\frac{1\ mol\ CO_2}{6.022x10^{23}\ CO_2}\right)\left(\frac{44.02\ g\ CO_2}{1\ mol\ CO_2}\right) = 4.26x10^{-20}\ g\ CO_2$$

Did you wonder why the answer is such a small number? 583 is a very small number of molecules! Remember that molecules are submicroscopic. It takes a HUGE number of molecules before we can weigh them on a balance in grams!

6. Fermentation is a complex chemical process of wine making in which glucose is converted into ethanol and carbon dioxide:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

Starting with 500.4 g of glucose, what is the theoretical yield of ethanol?

Basically we are asking for the mass of C_2H_5OH *expected from 500.4 g of glucose.*

$$\text{x g } C_2H_5OH = 500.4 \text{ g } C_6H_{12}O_6\left(\frac{1 \text{ mol } C_6H_{12}O_6}{180.2 \text{ g } C_6H_{12}O_6}\right)\left(\frac{2 \text{ mol } C_2H_5OH}{1 \text{ mol } C_6H_{12}O_6}\right)\left(\frac{46.07 \text{ g } C_2H_5OH}{1 \text{ mol } C_2H_5OH}\right)$$

$$= 256 \text{ g } C_2H_5OH$$

7. When $CuSO_4{\bullet}5H_2O$ (which is blue) is heated, it loses its water molecules and becomes white:

$$CuSO_4{\bullet}5H_2O \longrightarrow CuSO_4 \quad + \quad 5H_2O$$

If 9.60 g of $CuSO_4$ are left after heating 15.01 g of the blue compound, calculate the number of moles of water originally present in the compound.

There are two ways to approach this problem. If you subtract the mass of $CuSO_4$ *from the mass of the blue* $CuSO_4{\bullet}5H_2O$*, you would have the mass of the water. Convert that to moles and you are have the answer.*

$15.01 \text{ g } CuSO_4{\bullet}5H_2O - 9.60 \text{ g } CuSO_4 = 5.41 \text{ g } H_2O$

$$\text{x mol } H_2O = 5.41 \text{ g } H_2O\left(\frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O}\right) = 0.300 \text{ mol } H_2O$$

OR

You can treat this strictly as a stoichiometry problem and ask how many moles of H_2O *would you expect to produce from 15.01 g of* $CuSO_4{\bullet}5H_2O$*. First copy down the equation and gather the information you have:*

$$\begin{array}{lll} CuSO_4{\bullet}5H_2O \longrightarrow & CuSO_4 \quad + & 5H_2O \\ 15.01 \text{ g} & & ? \text{ g} \end{array}$$

$$\text{x mol } H_2O = 15.01 \text{ g } CuSO_4{\bullet}5H_2O\left(\frac{1 \text{ mol } CuSO_4{\bullet}5H_2O}{249.7 \text{ g } CuSO_4{\bullet}5H_2O}\right)\left(\frac{5 \text{ mol } H_2O}{1 \text{ mol } CuSO_4{\bullet}5H_2O}\right)$$

$$= 0.300 \text{ mol } H_2O$$

8. Consider the reaction

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$$

If 0.86 mole of MnO_2 and 48.2 g of HCl react, which reagent will be used up first? How many g of Cl_2 will be produced?

First copy the equation and gather the information you have:

$$\begin{array}{llll} MnO_2 & + 4HCl \longrightarrow & MnCl_2 + Cl_2 + 2H_2O \\ 0.86 \text{ mol} & 48.2 \text{ g} & \quad ? \text{ g} \end{array}$$

The reagent that is used up first is the "limiting reactant." One way of determining which is the limiting reactant is to ask how many g of the product would you get if all of MnO_2 *is used up, and then ask how many g of the product would you get if all of the HCl is used up and then compare the two answers.*

Useful Tip: If the <u>amounts</u> (either moles or g) of 2 or more reactants are provided in the question, that means you have to figure out which is the limiting reactant first before you can proceed.

$$x\ g\ Cl_2 = 0.86\ mol\ MnO_2\left(\frac{1\ mol\ Cl_2}{1\ mol\ MnO_2}\right)\left(\frac{70.90\ g\ Cl_2}{1\ mol\ Cl_2}\right) = 61.0\ g\ Cl_2$$

$$x\ g\ Cl_2 == 48.2\ g\ HCl\left(\frac{1\ \ mol\ HCl}{36.46\ g\ HCl}\right)\left(\frac{1\ mol\ Cl_2}{4\ mol\ HCl}\right)\left(\frac{70.90\ g\ Cl_2}{1\ mol\ Cl_2}\right) = 23.4\ g\ Cl_2$$

ANS. The smaller of the two answers (**23.4 g Cl_2**) is the "theoretical yield," the grams of Cl_2 that will be produced.
HCl is the limiting reactant, the reagent that will be used up first.

9. How many grams of each product would you expect from the following reaction, and how many grams of which reactant is left over if we start with 2.65 g of barium chloride and 6.78 g of H_2SO_4. If 1.25 g of $BaSO_4$ is obtained, what is the percent yield?

$$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$$

Here, again the amounts of both reactants are given, so that means you need to figure out which is the limiting reactant first. Once again we will figure out the mass of $BaSO_4$ expected if we use up all the barium chloride, and then figure out the mass of $BaSO_4$ based on using up all of the H_2SO_4. We begin with copying the equation and gathering the information:

$BaCl_2$	+	H_2SO_4	$\longrightarrow$	$BaSO_4$	+ 2HCl
2.65 g		6.78 g		1.25 g	

$$x\ g\ BaSO_4 = 2.65\ g\ BaCl_2\left(\frac{1\ mol\ BaCl_2}{208.2\ g\ BaCl_2}\right)\left(\frac{1\ mol\ BaSO_4}{1\ mol\ BaCl_2}\right)\left(\frac{233.3\ g\ BaSO_4}{1\ mol\ BaSO_4}\right) = 2.97\ g\ BaSO_4$$

$$x\ g\ BaSO_4 = 6.78\ g\ H_2SO_4\left(\frac{1\ mol\ H_2SO_4}{98.09\ g\ H_2SO_4}\right)\left(\frac{1\ mol\ BaSO_4}{1\ mol\ H_2SO_4}\right)\left(\frac{233.3\ g\ BaSO_4}{1\ mol\ BaSO_4}\right) = 16.1\ g\ BaSO_4$$

16.1 g is the smaller number so that means H_2SO_4 is the limiting reactant. **Note that the question is asking which reactant is left over and how many grams, so you haven't answered the question yet.**
If H_2SO_4 is the limiting reactant, then **<u>$BaCl_2$ is the one that is left over</u>**. How many grams?... First you need to calculate how many grams are used up.

$$x\ g\ H_2SO_4 = 2.65\ g\ BaCl_2\left(\frac{1\ mol\ BaCl_2}{208.2\ g\ BaCl_2}\right)\left(\frac{1\ mol\ H_2SO_4}{1\ mol\ BaCl_2}\right)\left(\frac{98.09\ g\ H_2SO_4}{1\ mol\ H_2SO_4}\right) = 1.25\ g\ H_2SO_4$$

Total mass – mass used up = 6.78 g – 1.25 g = **<u>5.53 g H_2SO_4 left over</u>**
Reread the question. Have you answered all part of the question???
We need to know the percent yield. That determine that we need to have the theoretical yield. We actually already have that…. 2.97 g $BaSO_4$.

$$\%\ yield = \frac{actual\ yield}{theoretical\ yield}\ x\ 100 = \frac{1.25\ g}{5.53\ g} x100 = 42.1\ \%\ yield$$

10. Cisplatin [$Pt(NH_3)_2Cl_2$], a compound used in cancer treatment, is prepared by reaction of ammonia with potassium tetrachloroplatinate:

$$K_2PtCl_4\ +\ 2NH_3 \longrightarrow 2\ KCl\ +\ Pt(NH_3)_2Cl_2$$

How many g of cisplatin are formed from 55.8 g of K_2PtCl_4 and 35.6 g of NH_3 if the reaction takes place in 95% yield.
*This time we are not calculating % yield since it's given. We are asking how many g of cisplatin are formed...this is the "**<u>actual</u>** yield." Remember that an "actual yield" cannot be calculated from stoichiometry, not based on the amounts of the reactants as it generally differs from the*

theoretical *yield due to experimental error of some sort. However we can calculate it from the % yield given:*

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \text{ x } 100$$ Solving for actual yield we get...

$$\text{actual yield} = \frac{\text{theoretical yield x \% yield}}{100}$$

We are given % yield, so once we determine the theoretical yield we can calculate the actual yield. Once again, we start by copying the equation and gathering the information:

K_2PtCl_4	+	$2NH_3$	$\longrightarrow$	2 KCl	+	$Pt(NH_3)_2Cl_2$
55.8 g		35.6 g				? g "cis"

$$\text{x g cis} = 55.8 \text{ g } K_2PtCl_4\left(\frac{1 \text{ mol } K_2PtCl_4}{415.1 \text{ g } K_2PtCl_4}\right)\left(\frac{1 \text{ mol cis}}{1 \text{ mol } K_2PtCl_4}\right)\left(\frac{300.1 \text{ g cis}}{1 \text{ mol cis}}\right) = 40.3 \text{ g cis}$$

$$\text{x g cis} = 35.6 \text{ g } NH_3\left(\frac{1 \text{ mol } NH_3}{17.03 \text{ g } NH_3}\right)\left(\frac{1 \text{ mol cis}}{2 \text{ mol } NH_3}\right)\left(\frac{300.1 \text{ g cis}}{1 \text{ mol cis}}\right) = 313.9 \text{ g cis}$$

40.3 g is the smaller number, so that is the theoretical yield.

$$\text{actual yield} = \frac{\text{theoretical yield x \% yield}}{100} = \frac{40.3 \text{ g x } 95}{100} = 38.3 \text{ g}$$

ANS. 38.3 g of cis is obtained.