NS J3 (pg 1 of 3) **Stoichiometry − % Yield** Name___________________________Per_____

Since the job of many chemists is to make chemicals, it is useful to watch the results and keep track of how much product they actually are making (experimental amount) compared to what they expect or should be making (theoretical amount). Just as a farmer would want to know how many potatoes each acre of his farm is producing. The farmer might call this "the yield of the field." Similarly, a shopkeeper would like to know the profit yield of their store. In chemistry we will make calculations to determine the % yield of an experiment.

All of the stoichiometric calculations so far have been calculating theoretical amounts of products. When you are in the lab, the amount of products measured on the balance is called the experimental amount of products. By making a ratio of the experimental amount that you did produce to the theoretical amount that you expect or should produce, you can calculate % yield.

Percent Yield Formula in contrast to Percent Error Formula

$$\frac{\text{Experimental}}{\text{Theoretical}} \times 100$$

Experimental ← what you did get in the lab

Theoretical ← what you should get the expected value

$$\frac{\text{Experimental} - \text{Theoretical}}{\text{theoretical}} \times 100$$

Suppose you took a quiz and scored 17 out of 20 points. What is your percent yield? What is your percent error?

$$\frac{17}{20} \times 100 = 85\%$$

$$\frac{17-20}{20} \times 100 = 15\% \text{ (or } -15\%)$$

OR 100% − 85% yield = 15% error

No Naked Numbers!

Again let me again emphasize that there is no substitute for reading the problem carefully. There will be several numbers in each problem, (some of which may not even be necessary) and you must be sure and use the appropriate numbers at the appropriate times. Each number in all of these problems should have three labels associated with it.

1. the units (g, mole, etc)
2. the identity label – who the substance is (H_2O , carbon dioxide, Al, lead, etc)
3. descriptive label - words that provide more information since often there is more than one mass of the same substance in a problem – (mass before the reaction, mass after, mass theoretically produced, experimental mass, etc)

For you to have success you need to keep track of the labels on every number both at the start of the problem and throughout the problem. If you lose track of what's what, you may use the wrong number at the wrong time, or waste time having to go back and rethink the problem to remember which number is which

See the Pattern – Steps to Follow:

As before there is a basic pattern to all stoichiometry problems, with variations depending on what information is given and what questions must be answered. Aa s minimum, a percent yield problem will give you the mass of a reactant as well as the *experimental* mass of a product. You will use the mass of the reactant given to determine the *theoretical* mass of some product. Using the *theoretical* mass of product with the given *experimental* mass of product, a percent yield can be calculated.

A. You must start with a balanced equation.

B. Convert the starting substances into moles. (Since the stoichiometric LINK – coefficients from the balanced equation – is in moles, you must work the problem in moles.)

C. Reread the problem to determine the question you are being asked which will help you decide what information that you need to calculate.

- Use the stoichiometric LINK to convert from a known substance to a desired substance needed to answer the question.
- Remember that the LINK is always set up with the known substance on the bottom (so it will cancel out) and with the desired substance on the top.

D. If necessary, convert any answers back into grams.

E. Use the given *experimental* mass of product given in the problem or measured in the lab and the calculated *theoretical* mass of product in the formula below to calculate percent yield of product produced.

Follow the steps above in the sample problem on the next page. →

 Stoichiometry - % Yield

Use the following problem as an example.

Do all your rounding off at the end of the problem, carrying all the digits along in your calculator.

1. Juan and Eva reacted aluminum foil with copper(II) chloride. What type of reaction does this appear to be?

A + BX should look like single replacement

2. Predict the products, and write out a balanced chemical equation in the space below.

$$2Al + 3CuCl_2 \rightarrow 3Cu + 2AlCl_3$$

3. Eva measured out 6.36 g of aluminum and Juan said he dissolved enough copper(II) chloride in the water to complete the reaction. After washing and drying the copper metal, the result was 17.2 g of copper recovered. Calculate Juan and Eva's percent yield. of copper

experimental

$$\underbrace{\underbrace{6.36\,g\,\cancel{Al} \times \frac{1\,\cancel{mol\,Al}}{26.98\,g\,\cancel{Al}}}_{\#\,mol\,Al} \times \frac{3\,mol\,Cu}{2\,\cancel{mol\,Al}}}_{\#\,mol\,Cu} \times \frac{63.55\,g\,Cu}{1\,mol\,Cu} = 22.5\,g\,Cu \text{ should be produced (theor)}$$

$$\frac{17.2\,g\,Cu\,exp}{22.5\,g\,Cu\,theor} \times 100 = 76.4\%\text{ yield}$$

4. Juan was in charge of calculating putting enough copper(II) chloride in the flask to run the reaction. He told Eva that he used 47.6 g of copper(II) chloride. Eva checked the bottle and found out the copper(II) chloride was actually copper(II) chloride dihydrate. Could this have accounted for their poor percent yield?

dihydrate $CuCl_2 \cdot 2H_2O$

1. Was 47.6 g $CuCl_2 \cdot 2H_2O$ enough to go with Eva's 6.36 g of foil? We could work backwards from 47.6 g $CuCl_2 \cdot 2H_2O$ to determine how much foil would react.

2. How much Cu could 47.6 g $CuCl_2 \cdot 2H_2O$ produce?

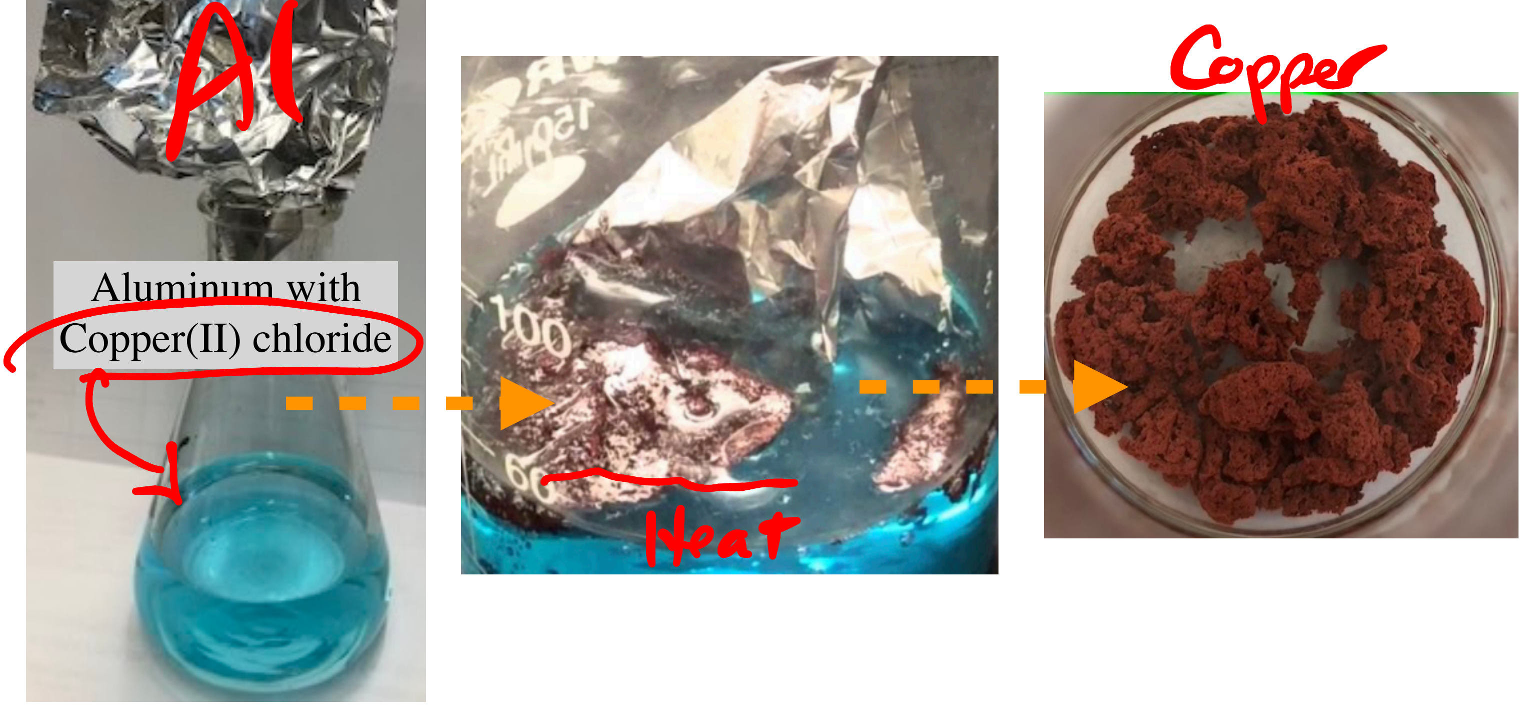
3. We could recalculate for Juan to see just how much $CuCl_2 \cdot 2H_2O$ is needed to react with all the Aluminum.

$$\underbrace{\underbrace{6.36\,g\,\cancel{Al} \times \frac{1\,\cancel{mol\,Al}}{26.98\,g\,\cancel{Al}}}_{\#\,mol\,Al} \times \frac{3\,mol\,\cancel{CuCl_2 \cdot 2H_2O}}{2\,\cancel{mol\,Al}}}_{\#\,mol\,CuCl_2 \cdot 2H_2O} \times \frac{170.49\,g\,CuCl_2 \cdot 2H_2O}{1\,mol\,\cancel{CuCl_2 \cdot 2H_2O}} =$$

60.4 g $CuCl_2 \cdot 2H_2O$ is needed to react with all the Al

Clearly Juan did not use enough!

oops! Juan used a molar mass of 134.45 g/mol for $CuCl_2$ since he did not notice this was a dihydrate :(


Al
Aluminum with
Copper(II) chloride
Heat
Copper