**Title of Lesson:** Stoichiometry

**UFTeach Students’ Names:** Amber Pettit and Ashlie Kinnaman

**Teaching Date and Time:** November 16/ 11:55 AM-12:45 PM and 1:45 PM-2:40 PM

**Length of Lesson:** 50 minutes

**Grade / Topic:** High School/ Chemistry Honors

**Source of the Lesson:** Ms. Booher

**Concepts**

Stoichiometry deals with relative quantities of reactants and products in chemical reactions. For a given balanced reaction, the relationships between amounts of reactants and products are seen represented as ratios of whole numbers. Stoichiometry is useful in chemistry in that it can be used to find the amount of product (in mass, moles, volumes, etc.) that could be produced by given reactants and a given percentage of given reactant that is made into product. Stoichiometry was created on the law of conservation of matter that states that mass of the products must equal mass of the reactants.

For a given reaction, there is almost always a limiting reagent (reactant) and an excess reactant. The limiting reagent is the reactant that limits the amount of product that can be formed. When all of this reactant is used up, the reaction will no longer continue. The excess reactant is the reactant that is in excess when the reaction has come to an end. This reactant remains in excess because there is nothing that it can react with.

http://en.wikipedia.org/wiki/Stoichiometry

http://www.chem.tamu.edu/class/majors/tutorialnotefiles/limiting.htm

**Florida State Standards (NGSSS):**

* Grade 912, SC.912.P.8.9, Big Idea 8: Matter - Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions. Cognitive Complexity: Level 3: Strategic Thinking & Complex Reasoning.

**Performance Objectives**

Students will be able to:

* Calculate the moles of reactants
* Use molar ratios and law of conservation of mass to calculate the mass of product that should be formed
* Calculate percent yield

**Materials List and Student Handouts**

* At least 30 grams of iron fillings
* At least 2 liters of copper (II) sulfate
* 6 graduated cylinders and 6 beakers (one for each group)
* 3 scales for students to weigh iron fillings
* 25 Stoichiometry Lab worksheets, stoichiometry worksheets, and post assessment worksheets

**Advance Preparations**

* Make sure beakers and graduated cylinders are clean and dry.
* Make sure scales are calibrated and working correctly.
* Make sure the reactants are out on the distribution table.
* Worksheets will be handed out individually at their seats at the appropriate times.

**Safety**

* Students will need to wear safety glasses when dealing with chemicals.
* Students will need to wear pants and close toed shoes when dealing with glassware.
* Students will need to be careful when handling the chemicals.

**5E Lesson**

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| **ENGAGEMENT Time: 5 minutes** |
| **What the Teacher Will Do** | **Teacher Directions and Probing Questions** | **Student Responses and Potential Misconceptions** |
| Introduce recipe analogy. Write recipe on board before class starts.Ingredients:6 eggs2 tbsp milkPinch salt & pepper1 tbsp butter | A balanced chemical equation is essentially a recipe for a chemical change. Like any recipe, it tells us what reactants are needed, and in what ratio, in order to produce a certain amount of product.Now let’s look at a scrambled egg recipe for two. Two tablespoons of milk are needed for every 6 eggs.How many tablespoons of milk are needed for scrambling 18 eggs?How would you set this up as a stoic problem?So cooking is just stoichiometry. Just think of it this way and make sure to match up your labels. | [6 tbsp][18 eggs x 2 tbsp/6 eggs = 6 tbsp |

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| **EXPLORATION Time: \_25 minutes\_\_\_** |
| **What the Teacher Will Do** | **Teacher Directions and Probing/Eliciting Questions** | **Student Responses and Misconceptions** |
| Teacher will explain the lab. | You are going to begin a three day experiment. You will be in groups. For this experiment, you are going to react iron with copper II sulfate. Since iron can have three different oxidation states, the purpose of this lab is to determine which iron was produced in this experiment. |  |
| Teacher will hand out lab worksheet and have students write reactions. | Before we move to the back, I am going to hand out the worksheets for the lab. Each of you will write the objective for this lab and write three possible balanced reactions on your worksheet by yourselves. Make sure to have your periodic tables and keep in mind that iron can have three different oxidation states.What are those three oxidation states? | [+2, +3, and +6] |
| Teacher will give directions for the experiment. | Today you will label a beaker with your lab group’s name. You will obtain 100 mL of copper II sulfate, weigh between 1.10 and 1.20 grams of iron fillings, and place them into the beaker with the CuSO4. Record the mass of iron and place the beaker with iron and CuSO4 onto the window sill. After doing this, using the actual mass of iron that your group used, you will calculate the mass of copper you should get from the three balanced reactions. Make sure you identify each (Fe+2, Fe+3, or Fe+6) reaction. |  |
| Teacher will have students move to the lab tables. Teacher will ask probing questions. Teacher will place stoichiometry worksheet on their desk as they work. | Let’s move to the lab tables. You will only do what is listed under day 1.What is the molar mass of Fe and CuSO4?What mole ratios did you get for Fe and Cu in each of your three reactions? | [55.85 g/mol/ 159.62 g/mol][Fe2+ is 1:1, Fe3+ is 2:3, Fe6+ is 1:3] |
| Teacher will have students go back to their seats and do another stoichiometric problem that was placed on their desks. Teacher will ask probing questions. | When you finish, go back to your seats and work on the problem at your desk. Please work individually.What is the molar mass of aluminum?Of HCl?What is the mole ratio between Al and H2?Between HCl and H2?What is the limiting reactant? How do you know? | [26.98 g/mol][36.46 g/mol][2:3][6:3, 2:1][HCl, it produces less H2] |

Stoichiometry

When aluminum is added to hydrochloric acid, hydrogen gas and aluminum chloride will be produced. Write the balanced equation.

If 90.00 g of HCl was reacted, how many moles of HCl are there?

Using the moles of HCl, what mass of AlCl3 should be produced?

In the lab, the actual amount of aluminum chloride that was produced was 96.4 g. What is the ratio of the actual mass of aluminum chloride produced to the mass of aluminum chloride that should be produced? Write this as a decimal.

What is this decimal as a percent?

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| **EXPLANATION Time: 10 minutes** |
| **What the Teacher Will Do** | **Teacher Directions and Probing/Eliciting Questions** | **Student Responses and Misconceptions** |
| Teacher will go over lab work. Write work on board as students walk through it. | What is the process you used to calculate the amount of copper you should get from the reaction?Ask more questions as students tell the process. | [Convert to moles and use the mole ratio to calculate the amount of copper and covert that amount to grams] |
| Go over worksheet. Write work on the board as the students walk through it. | What was the balanced equation you came up with?How did you find the amount of moles of Aluminum and HCl?Using the moles of HCl, what mass of AlCl3 should be produced?How did you find the mass?How do you know the mole ratio?This mass of aluminum chloride that should be produced is called the theoretical yield, where yield is just the amount of product obtained.Knowing this, what do you think the actual amount of product would be called?What did you get for the ratio?How did you determine this ratio?Using the terms we mentioned earlier, how would you reword that?So then the percentage would be…?Great! This is called the percent yield. This is the percent of product obtained in the lab compared to the theoretical amount. The equation, as we have basically already seen is$\% yield=\frac{actual yield}{theoretical yield}×100$. | [2Al + 6HCl 🡪 3H2 + 2AlCl3][Convert the grams of Al and HCl to moles using their molar weights][109.7 grams][use mole ratio to calculate the moles of H2 from the moles of Al, convert the moles to grams using the molar mass][from the coefficients of reactants and products that make up the ratio][actual yield][0.879][Actual yield divided by theoretical yield or actual amount divided amount of product there should be][Actual yield divided by theoretical yield.][87.9%] |
| Teacher will pose a problem and allow students to work on it. | Using this equation, calculate the percent yield of hydrogen gas if 2.00 g were produced in the lab. You will have about 3 minutes.What did you get?Come to the board and show us how you determined that. | [80.4%] |

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| **ELABORATION Time: \_\_\_\_\_\_\_\_\_** |
| **What the Teacher Will Do** | **Probing/Eliciting Questions** | **Student Responses and Misconceptions** |
| Give stoichiometry problem with more than two reactants | Chlorine is used by textile manufacturers to bleach cloth. Excess chlorine is destroyed by its reaction with sodium thiosulfate, Na2S2O3:Na2S2O3(aq) + 4Cl2(g) + 5H2O(aq) 🡪 2NaHSO4(aq) + 8HCl(aq)How many moles of Na2S2O3 are needed to react with 0.12mol of Cl2?How many moles of HCl can form from 0.12mol of Cl2?How many moles of H2O are required for the reaction of 0.12mol of Cl2?How many moles of H2O react if 0.24mol HCl is formed? | [0.030mol Na2S2O3] [0.24mol HCl][0.15mol H2O][0.15mol H2O] |

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| **EVALUATION Time: \_10 minutes\_\_** |
| **What the Teacher Will Do** | **Assessment** | **Student Responses** |
| Give post-assessment to students | I have a post assessment for you all to do. This shows me how I did today in teaching you all. Please work individually and quietly. Try the best you can and it is okay if you do not know or do not finish. |  |

Post Assessment

15 grams of copper (II) chloride is reacted with sodium nitrate and 10.7 grams of sodium chloride are produced.

Write the balanced reaction.

What is the percent yield of sodium chloride?

Post Assessment Key

15 grams of copper (II) chloride is reacted with sodium nitrate and 8.94 grams of sodium chloride are produced.

Write the balanced reaction.

**CuCl2 + 2 NaNO3 🡪 Cu(NO3)2 + 2 NaCl**

What is the percent yield of sodium chloride?

$$15 g CuCl\_{2}\*\frac{1 mol}{134.45 g}\*\frac{2 mol NaCl}{1 mol CuCl\_{2}}\*\frac{58.44 g}{1 mol}=13 g$$

$$\% yield=\frac{8.94 g}{13 g}×100=69\%$$