Lesson Plan: A Scaffold Approach to Teaching Stoichiometry

FOR THE TEACHER

Summary
In this lesson, students will learn the basics of stoichiometry including determining the amount of reactant needed or product produced, determining the limiting reactant and finally determining percent yield. Additionally they will design their own stoichiometry lab and interpret their collected results.

Grade Level
High School

NGSS Alignment
This lesson will help prepare your students to meet the performance expectations in the following standards:

- **HS-PS1-7**: Use mathematical representation to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- **Scientific and Engineering Practices**:
  - Using Mathematics and Computational Thinking
  - Analyzing and Interpreting Data
  - Planning and Carrying Out Investigations

Objectives
By the end of this lesson, students should be able to

- Perform a basic stoichiometry calculation to determine the amount of reactant needed or the amount of product produced given initial parameters.
- Find the limiting reactant of a reaction given initial amounts of reactants.
- Find the percent yield of a chemical reaction.

Chemistry Topics
This lesson supports students’ understanding of

- Stoichiometry
- Mole conversions
- Dimensional analysis
- Limiting reactant
- Percent yield

Time

**Teacher Preparation**: 20 minutes

**Lesson**: 3 hours

- Hour/Day 1: Engage 20 minutes, Discuss 40 minutes
- Hour/Day 2: Demonstration 10-15 minutes, Animation 10-15 minutes, Discuss 30 minutes
- Hour/Day 3: Discuss 20 minutes, Lab Activity 30-40 minutes

Materials
Hour/Day 1:

- A copy of the S'more Activity for each group (part 1 only)
  - Alternatively you could use this activity
- A copy of the Stoichiometry Practice worksheet for each student
Hour/Day 2:
- Materials needed for AACT demonstration, Understanding Limiting Reactants:
  - 2.50g, 7.50g, 12.50g baking soda (sodium bicarbonate, NaHCO₃)
  - 300ml store bought vinegar (5% acetic acid solution, HC₂H₃O₂) divided into 3 portions of 100ml
  - 3 empty plastic water bottles (700 ml or, larger volume will work as well. Another option is to use an Erlenmeyer flask)
  - Funnel
  - 3 Balloons, 12 inch diameter (having backup balloons is suggested)
  - Electronic scale
  - Graduated cylinder
  - Scoopula
- 1 copy of the Limiting Reactant worksheet for each student

Hour/Day 3: (except for the worksheet, all materials are per group)
- 1 copy of the Percent Yield worksheet for each student
- 2 grams NaHCO₃
- 1 M HCl, approximately 1 dropper full
- 1 ring stand with ring clamp
- 1 clay triangle
- 1 evaporating dish and watch glass
- 1 bunsen burner
- Electronic scale (2-3 per class would be good)

Safety
- Food in the lab should be considered a chemical not for consumption.
- Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required.
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Always use caution around open flames. Keep flames away from flammable substances.
- Always be aware of an open flame. Do not reach over it, tie back hair, and secure loose clothing.
- Open flames can cause burns.
- An operational fire extinguisher should be in the classroom.
- When working with acids, if any solution gets on students’ skin, they should immediately alert you and thoroughly flush their skin with water.
- When diluting acids, always add acid to water.

Teacher Notes
- The order and speed that I present would be appropriate for an advanced class that catches on quickly. Adjust this based on the needs of your class.

Hour/Day 1:
- Engage: Using only part 1 of from the AACT Activity S’more Stoichiometry to introduce stoichiometry. Have students work in pairs to answer the questions.
- Explain: After students have completed part 1 of the activity, discuss responses as a class. Slides 1-7 of the provided PowerPoint can be used.
- Complete this discussion by working the “Stoichiometry Practice Worksheet” together. This worksheet presents questions in a scaffold format, and provides an easy way to set up
stoichiometry equations. The structure is intended to gradually prepare students to work the problem on their own. The set of worksheets presented with this lesson plan uses the same information throughout so each one builds on the last. An answer key has also been provided for teacher reference.

- When students balance equations for me, I also have them fill in any coefficients that have a value of “1” as this signals to me they find it balanced and reinforces for them that each molecule is involved.
- Evaluate: (optional) For homework (and to refresh how they would use their previously learned knowledge of identifying types of chemical equations) you could have students work through this simulation.

**Hour/Day 2:**

- Engage: Perform the AACT demonstration, Understanding Limiting Reactants. If time is limited there is also a video of the demonstration provided, though I find students are more engaged with the live demonstration.
- Explain: Discuss Limiting Reactants using slide 8 of the PowerPoint presentation provided.
- Use the Limiting Reactant animation to further demonstrate and discuss limiting reactants. Stop the animation along the way to discuss what is being shown.
- Evaluate: Use the worksheet, “Limiting Reactant”, to begin teaching students how to solve these problems on their own. This should gradually prepare them to solve these problem on their own. Answer key is provided for teacher reference.

**Hour/Day 3:**

- Explain: Today start with discussion, using slide 9 in the Power Point presentation provided.
- Evaluate: Walk the students through the scaffolded worksheet titled Percent Yield, gradually leaving them to complete the problems on their own. Answer key is provided for teacher reference.
- Explore: Students will complete the Stoichiometry Lab. Prepare all materials for student use in advance (see lab handout). You should engage students in a discussion starting with the balloon demonstration from yesterday and leading up to the reaction they will be doing today. Students will be designing their own procedure based on this discussion.
- Students will need help determining how to find the mass of HCl used. The density is provided for the students. Point this out. Alternatively, you could find the volume of a drop from one of your droppers and provide them with this information.
- If you do not have an electronic balance, a triple beam balance can be substituted.
- If time allows, students could finish the lab the next day by drying the sample in a drying oven.
- If students choose to dry the sample with the Bunsen burner, keep in mind that the solution could bubble violently and boil over easily if they are trying to heat it too fast. Stress that they should heat the sample gently.
- Students generally get around 90-95% yield. Typically I have some students get over 100%, and it is important to point out that this is not possible. We talk about possible reasons why they might get this result—usually the sample is not dried completely.
- An Answer Key including expected results is included for teacher reference.