Unit Plan: Stoichiometry

FOR THE TEACHER

Summary
The AACT high school classroom resource library has everything you need to put together a unit plan for your classroom: lessons, activities, labs, projects, videos, simulations, and animations. We constructed a unit plan using AACT resources that is designed to teach the concepts of stoichiometry and limiting reactants to your students.

Grade Level
High School

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

- Apply a specific problem solving method to successfully answer any stoichiometry problem.
- Balance a chemical equation using whole number coefficients.
- Classify a reaction as either: synthesis, decomposition, single replacement, double replacement or combustion, based on its chemical equation.
- Define and determine the limiting and excess reactants in a chemical reaction.
- Determine the amount of a reactant or product given the amount of a product or reactant.
- Extend the idea of limiting reactant from a real-life scenario to a chemical equation.
- Identify a reaction as endothermic or exothermic based on lab observations.
- Identify and calculate the mass and moles of the excess reactant in a chemical reaction.
- Identify and understand the implications of a limiting reactant in a chemical reaction.
- Understand the concept of stoichiometry and perform mole-mole, mole-mass, and mass-mass stoichiometry problems.
- Understand the importance of stoichiometry in an industrial setting.
- Use a graphic organizer to construct a solution to a stoichiometry problem.
- Use dimensional analysis to complete stoichiometry, percent yield, and theoretical yield calculations.
- Use stoichiometry to confirm the reaction observed.
- Visualize what is occurring in a chemical reaction in terms of limiting and excess reactants using particulate diagrams.

Chemistry Topics
This unit supports students’ understanding of

- Balancing Equations
- Chemical Reactions
- Classification of Reactions
- Decomposition
- Dimensional analysis
- Endothermic and Exothermic reactions
- Law of Conservation of Mass
- Limiting Reactant
- Molarity
- Mole Concept
- Mole to mole ratios
- Observations
- Percent yield
- Stoichiometry
- Theoretical Yield
Time
Teacher Preparation: See individual resources.
Lesson: 8-12 class periods, depending on class level.

Materials
- Refer to the materials list given with each individual activity.

Safety
- Refer to the safety instructions given with each individual activity.

Teacher Notes
- The activities shown below are listed in the order that they should be completed.
- The number of activities you use will depend upon the level of students you are teaching.
- The teacher notes, student handouts, and additional materials can be accessed on the page for each individual activity.
- Please note that most of these resources are AACT member benefits.

Classroom Resources:

Stoichiometry
- Depending upon the level of your students, choose one of the following lesson plans to teach them how to solve stoichiometry problems.
  o The lesson, Map It Out!, shows students how to solve stoichiometry problems using a graphic organizer and Cornell notes. This six step process includes writing a balanced equation, identifying the known and unknown substances, selecting the correct mole ratio, determining the path to a solution, using conversion factors and calculating the theoretical yield.
  o The Stoichiometry Set-up Method lesson plan shows students how to follow a process of visual cues in combination with a step-by-step problem solving method for different types of stoichiometric problems. This method can be particularly beneficial for students who struggle with completing multi-step calculations. Read more about this lesson in the September 2015 issue of Chemistry Solutions.
  o For more advanced students, use the How to do Stoichiometry Problems lesson, which includes a series of templates for performing stoichiometry problems. The lesson also includes a practice worksheet for students to use to practice using the templates.

- Use the simulation Chemical Reactions and Stoichiometry to give your students extra practice on the topics of reaction types, balancing equations, and stoichiometry calculations. The simulation is set up as a short quiz that includes five types of chemical reaction that students have to identify and balance. They are then asked to complete one of the following types of stoichiometry problems: mole-mole, mass-mole, mole-mass, mass-mass, mole-molecule, atoms-mass, or molecule-mass.

- Follow up your lesson with the Baking Soda Stoichiometry lab which allows students to decompose baking soda and use stoichiometry to determine the proper balanced chemical equation of its decomposition.

- Then use the Chemical Reactions and Stoichiometry simulation to give your students some more practice using a quiz that challenges their knowledge of reaction types, balancing equations and solving stoichiometry problems. During this quiz based activity, students are presented with five different reactions to analyze, each having three related questions to answer. The questions are randomized so students will not have the same order as their peers. Additionally, there are 20
possible chemical equations in the quiz, so students can complete it several times without receiving the same problems.

- Finally, connect stoichiometry to real life with the Stoichiometry of Air Bags lesson plan which connects the concept of gram to gram stoichiometry calculations through a scenario related to air bags. Students are tasked with calculating the amount of sodium gas (NaN₃) that must be produced to inflate a vehicle air bag to the correct size. Follow-up practice problems are also provided.

Limiting Reactant

- Introduce the topic with the Limiting Reactant Animation which allows students to visualize at the particulate level what happens in a limiting reactant problem. A number of limiting reactant scenarios are animated, including a simple example of how to build a bike to introduce the concept of limiting reactant. Conservation of mass is also demonstrated by calculating masses from the mole quantities of the reactants and products.

- You might prefer to use one of our teacher demonstrations to introduce the topic to your students.
  - Students observe a series of reactions between acetic acid and sodium bicarbonate in Zip-lock bags with the Introducing Limiting Reactants demonstration. After observing the reactions, students analyze the quantities of reactants used as well as the results in order to understand the concept of limiting reactants. They will also determine if the reaction is an endothermic or exothermic process based on their observations.
  - The demonstration, Understanding Limiting Reactants is a similar resource, performing a series of reactions between acetic acid and varying amounts of sodium bicarbonate in order to inflate several balloons. Students observe the reactions and analyze the quantities of reactants used as well as the results in order to understand the concept of limiting reactants.

- Follow up with one or more of these hands-on activities for your students.
  - The lab, Limiting Reactant in a Balloon, allows students to perform a reaction between acetic acid and sodium bicarbonate to determine the amount of product formed and the limiting reactant.
  - Students can also investigate the idea of limiting reactant using a brownie recipe with the activity, Limiting Reactants in Brownies.
  - In a similar lab, Limiting Reactant Candy, students use candy to help them understand what is meant by the term, "limiting reactant" and identify it in a non-chemistry situation.
  - One more activity, Cookie Stoichiometry, has students answer stoichiometry related questions using a chocolate chip cookie recipe.

- If you teach students who struggle with completing calculations, they may benefit from the Map to Solving Limiting Reactant Problems lesson, which shows them how to follow a step-by-step problem solving method for limiting reactant stoichiometry problems.

- Follow up calculations with the Limiting Reactant Activity to give your students practice drawing particle diagrams to demonstrate stoichiometry and limiting reactants.

- Finish the topic with the Limiting Reactant Lab, where students react copper (II) chloride with aluminum to determine the limiting reactant and then isolate one product to determine the percent yield.
Summary Activities

- One or more of these activities can be used as an assessment or culminating activity for a stoichiometry unit.
  - Use the activity, **Calculating Your Carbon Footprint** to assess your student’s understanding of the topic. In this activity, students apply their knowledge of writing and balancing chemical equations as well as stoichiometry calculations to estimate their carbon footprint and then reflect on their carbon footprint and what it means. Read more about this lesson in the May 2017 issue of *Chemistry Solutions*.
  - Students create a stoichiometric mixture of hydrogen and oxygen gases to launch a soda bottle rocket in the **Launching Rockets** lab. In addition to student activity sheets, this resource includes comprehensive teacher notes, video instructions and NGSS alignment.
  - The lesson plan, **Mechanisms and Properties of Airbags**, teaches students about the mechanisms and properties of airbags, and examines the choice of airbag inflator from several points of view. This lesson is part of the resources put together by the 2016 AACT-Ford Content Writing Team and includes NGSS alignment along with links to several short videos about airbags.