Unit Plan: Chemical Measurements

FOR THE TEACHER

Summary
The AACT High School Classroom Resource library and multimedia collection has everything you need to put together a unit plan for your classroom: lessons, activities, labs, projects, videos, simulations, and animations. We searched through our resource library and constructed a unit plan for introducing the concepts needed for students to collect and use chemical measurements: Percent Composition, Metric Units, Accuracy and Precision, Percent Error, Density, Scientific Notation, Significant Figures, and Unit Conversion. These math based topics are very important for your students to master before they dig into other chemistry concepts. This unit is designed to be used at beginning of the school year. You may want to leave some activities out, based on the math abilities of your incoming students and the level of the class.

Grade Level
High School

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

- Critically analyze a given problem, and complete appropriate calculations for mass and volume.
- Define percent composition.
- Calculate the percent composition of a substance in a sample.
- Take measurements using metric units.
- Determine the accuracy of different pieces of glassware.
- Accurately use laboratory equipment to gather data.
- Explain why some pieces of glassware produce better accuracy than others.
- Construct and analyze a line graph using Excel.
- Determine a method to measure the mass and volume of an irregular object.
- Calculate density and be able to explain why the density of an object does not change.
- Calculate the density of an irregular object using their data.
- Calculate the percentage error of their results using both the experimentally determined value and the accepted value for density.
- Convert very large and very small values into proper scientific notation.
- Recognize the benefit of using scientific notation to solve large scale problems.
- Use dimensional analysis for mass, length, volume, temperature, and density unit conversion problems.
- Convert between units of measurement using dimensional analysis.
- Understand the purpose of using dimensional analysis for converting between units of measurement.
- Use lab equipment to measure volume, mass, and length to the correct number of significant figures.

Chemistry Topics
This unit supports students’ understanding of

- Measurement
- Percent Composition
- Dimensional Analysis
- Metric Units
- Accuracy and Precision
- Percent Error
- Density
- Scientific Notation
- Significant Figures
- Unit Conversion

**Time**

**Teacher Preparation:** See individual resources.

**Lesson:** 10 - 15 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 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:**

**Percent Composition**
- **Keys for Success in Teaching Chemistry: Imagination and Resourcefulness:** Before you begin the unit, take a few minutes to read this article from our March 2016 issue of *Chemistry Solutions*. This article discusses several labs that the author uses to help teach his students to be creative and resourceful when collecting and using lab data.

- **Mineral Investigation:** Start your year off with this great introductory lab that familiarizes students with data collection and manipulation while also incorporating engineering principles and guided inquiry. In this lab, students put their problem solving skills to work as a team to determine how many specific samples of ore can be made from a lode equivalent to the size of their classroom using percent composition. This lab is perfect for the start of the school year to engage students in real-life applications of chemistry, as well as essential mathematic and measurement skills.

You can then choose from one of these two labs to give your students more practice with percent composition calculations.
- **Percent Composition of Bubble Gum:** In this lab students determine the amount of sweetener in various brands of gum by determining the mass difference of the gum before and after it is chewed. By the end of this lesson, students should be able to define and calculate percent composition.

- **Percent Composition:** In this lab students calculate the percent composition of sugar in gum and the percent composition of water in popcorn kernels. By the end of this lab, students should be able to calculate the percent composition of a substance in a sample.

**Metric Units**
- **Mysteriously Melodramatic & Maniacal Metric Measurements:** Introduce the metric system and units with this activity, which asks students to predict the measurements of objects using metric
Accuracy, Precision, and Percent Error

- **Measuring Volume**: This simulation shows students an image of a graduated cylinder and asks them to report an accurate volume measurement with the correct number of significant figures. They then are asked to determine the uncertainty value of the graduated cylinder. The simulation includes several different sizes of graduated cylinders, each containing unique markings, so students will be challenged to analyze each individually.

- **Glassware Accuracy**: Follow the simulation with this laboratory activity, which allows students to further explore the concepts of accuracy, precision, and percent error. Students use different types of laboratory glassware to measure 50 mL of water and determine the accuracy of each piece of glassware. By the end of this lesson, students should be able to determine the accuracy of different pieces of glassware and calculate percent error.

- **The Chemistry Composition Challenge**: Your students will be challenged to design a method to solve three chemistry problems with this lab. One problem requires students to determine the thickness of a piece of aluminum foil and compare their value to the actual one. Another has them determine the identity of an unknown metal by calculating its density. This resource includes extensive teacher notes to help you guide your students through this inquiry activity.

Density

- **Density**: Use this animation to introduce the concept of density and help your students visualize density on the particulate level. There are opportunities to make qualitative and quantitative comparisons between substances.

- **Density**: You can then use this lab to allow your students to determine the density of several liquids and solids. They then identify an unknown metal by determining its density and calculate the percent error within the class for a specific sample. By the end of this activity, students should be able to calculate the density of a liquid by measuring volume and mass, calculate the density of a solid using the displacement method for finding volume, identify an unknown substance by determining its density, calculate percent error, and explain if their results are accurate or precise.

- **Graphing Density**: Finish up the topic of density with this lab, which requires students to collect data and use graphing to determine the density values of unknown metal samples. This activity will help your students learn to construct a line graph using Excel and analyze a linear equation to help determine density.

- **Investigating the Density of an Irregular Solid Object Lab**: If you think your students need another activity to solidify their understanding, try out this lab. Students use common laboratory equipment to devise a method to measure the density of several irregular objects. They will then create a formal laboratory report using both their own data and data from the entire class. Read an article about this activity in the September 2016 issue of Chemistry Solutions.

- Use the lab, Colors of the Rainbow to assess your students’ understanding of the concept of density. In this lab, students calculate the density of several unknown liquids and then use their findings to build a density column. There are eight unknown solutions that are grouped nine different ways so that each of the lab groups will have a unique combination of liquids to build their density column.
Scientific Notation
- **Bringing Real-Life Context to Chemical Math**: Before moving on to the topic of scientific notation, read this article in the March 2016 issue of *Chemistry Solutions*.

- **Scientific Notation**: Then use this activity to introduce the topic to your students. Students have a button, which they move like a decimal point, to be actively involved in putting numbers into and taking numbers out of scientific notation format.

- **Using Scientific Notation in Chemistry**: Follow up with this lesson, which has students solve a variety of real-world problems using scientific notation. Students listen to a convoluted radio conversation about coffee which will relate to a math-based problem that this lesson is developed around. Students begin to recognize the benefits of using scientific notation in their calculations. This lesson includes a formative quiz, summative quiz, slides, and a radio conversation on YouTube.

Significant Figures
- **The Significant Figures and Lab Data**: Many students seem to struggle with significant figures, especially when it is taught out of context. This activity allows students to use laboratory equipment of different precision to collect data for several different metals, and then use the data to calculate the density of each. They then compare their calculated densities to accepted values and determine the combination of equipment that leads to the most accurate calculation of density.

Unit Conversion
- The **Measurement Animation** allows students to review the fundamentals of measurement in length, mass, and volume. Various units of measurement will be presented for comparison, and several conversion calculations will be demonstrated using dimensional analysis.

- **The Temperature Guys**: Open your discussion of unit conversion with this video from our *Founders of Chemistry* series. It tells the story of how temperature as we currently know it evolved. The first thermometers invented in the early 1600s are very different than ones we use today! An activity sheet that includes question for students to answer as they watch the video is available to download.

- **Dimensional Analysis and Unit Conversion**: Follow the video with this lesson plan to introduce the process of unit conversion. This resource includes a PowerPoint Presentation and student handout with practice problems.

- **Unit Conversion Online Tutorial**: Next, use this activity to have your students interact with a web-based tutorial that uses a drag and drop interface in order to learn how to convert between units of measurement using dimensional analysis. The tutorial allows students to learn at their own pace, and also provides feedback while they are solving problems. You may want to read the March 2016 issue of *Chemistry Solutions* article, *A Student-Centered, Web-Based Approach to Teaching Unit Conversions* before using the activity.

- **Math and Measurement**: Get your students ready for a unit assessment with this lab, which allows students to practice introductory math skills that will be used in chemistry all year. This includes metric conversion, significant figures, scientific notation, dimensional analysis, density, percent error, accuracy and precision, as well as using lab equipment.

- **Nanoscale & Self-Assembly**: An option for an advanced culminating lab or extension for the unit could be this lab, which incorporates measurements, and dimensional analysis. In this activity, students determine both the diameter of one single BB and the length of an oleic acid molecule using simple measurements and volume/surface area relationships.