CHEM 1402: GENERAL CHEMISTRY 1 LAB

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Chem 1402: General Chemistry 1 Lab

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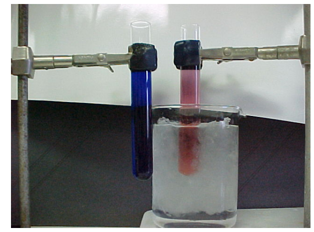
1: GENERAL CHEMISTRY 1 LAB (2021 SPRING)

INTRODUCTION



This is the Spring 2021 online general chemistry lab course at UA Little Rock that was initially developed by Dr. Belford and Elena Lisitsyna as a response to the COVID-19 pandemic and was taught completely online with a mix of virtual labs (Chemcollective and Phet) and IOT (Internet of Things) data streams. Dr. Baillie modified this course to fit the Fall 2020 semester, and we are building off of his work for Spring 2021. While this page will help students determine what needs to be done, the assignments must be submitted in your Google Classroom. We will facilitate group work using Zoom break out rooms.

1.1: Course Technology Information

Accessing Zoom

This class will use Zoom as the live interactive platform for class, lab, and workshop. If you plan on using your smart phone to connect with video and audio, please download the Zoom app.

https://zoom.us/

Starting this fall (2020), all UALR students, faculty, and staff should have free access to the Zoom pro accounts (meaning you can use zoom for your personal meetings, group work, etc). If your computer has apps, please download the zoom app there as well. Make sure that you have a functional video camera, microphone, and speakers on the device you will use to connect for CHEM1402 as we want to see and hear you. This will make it seem more like a community.

If you have a home computer that doesn't have a video camera and microphone, you can find one for under $20 (walmart.com or amazon.com have many to choose from).

Accessing Google Classroom

If you open your Google Mail you will see 9 dots by your name which opens the Google Suite. If you scroll to the bottom you will find Google Classroom, and if you open the Drive you will also find a folder called Classroom where you can find your assignments.

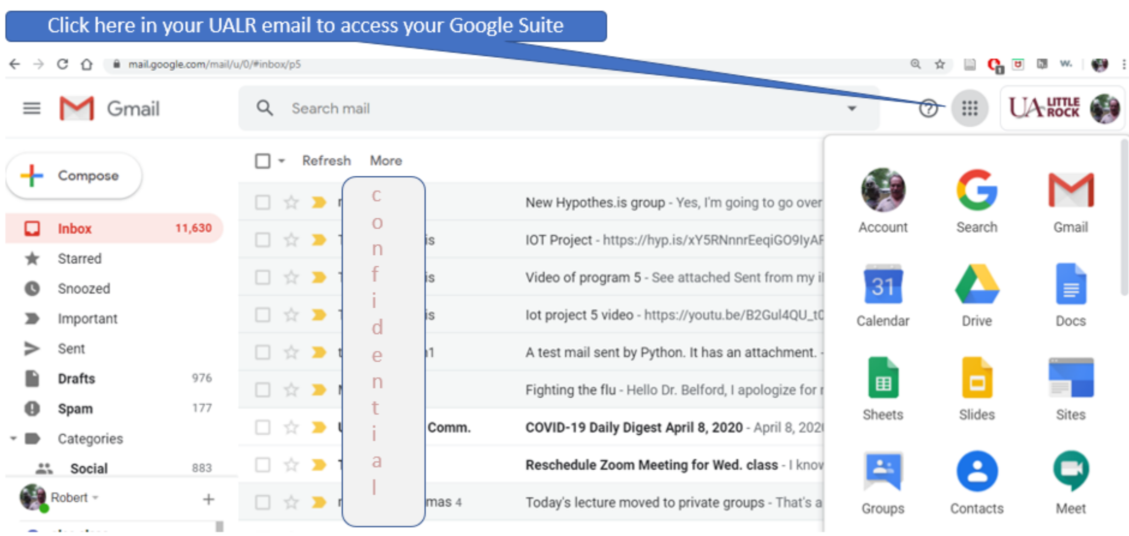


Figure 1.1.1: How to access the Google suite.

Contributors and Attributions

- Robert E. Belford (University of Arkansas Little Rock; Department of Chemistry) led the creation of this page. You can contact him if you have any questions rebelford@ualr.edu.
- Elena Lisitsyna contributed to the creation and implementation of this page.

1.2: Safety

General Information

Chemical Safety is one of the most important topics covered in the general chemistry laboratory. There are two different types of goals in the safety curriculum. First are the obvious goals of keeping the students safe during the lab and not creating hazards for others. The second is to develop the proper protocols and procedures for performing experimental activities so that when the student enters advanced courses or the work force, they have the skills needed to function in a safe and prudent manner. In fact safety is the biggest complication to running an online lab where students will be working at home, sometimes alone and in their kitchens. So you will see two components to the safety content of this class, those associated with maintaining a safe laboratory experience at home, and those with teaching you the safe operating procedures you would have learned if you were at a university laboratory.

Chemical Hygiene Plan

Every university has a CHP (Chemical Hygiene Plan) as required by OSHA standard 29 CFR 1910.1450 and a CHO (Chemical Hygiene Officer) who is responsible for its implementation, and UALR's CHP can be found at this Facilities Management Web Page. Within the CHP are a set of standard SOPs (Safe Operating Procedures) that represent the minimum safe practices for the handling of hazardous chemicals. Every research lab at the university is required to develop and maintain SOPs for the laboratory practices that are performed within their labs, and here is a link to the template for developing laboratory specific SOPs. The CHP also defines the PPE (Personal Protective Equipment) needed to perform work in a laboratory, and in the university teaching laboratory the instructor would be responsible for ensuring students abide by the established SOPs, and wear proper PPE, like safety glasses and closed toe shoes (no flip-flops in the chemistry laboratory), and do not perform any unauthorized experiments. Unfortunately, it will be impossible for an instructor to ensure students abide by the SOPs in an online course where lab work is being performed remotely, and thus for reasons of safety we will not be able to perform many of the experiments that could be done remotely in a kitchen.

Chemical Safety Resources

Prudent Practices

The National Research Council of the National Academies of Sciences has published a book "Prudent Practices in the Laboratory" that can be downloaded for free and has a wealth of information on chemical safety, including a copy of OSHA's Laboratory Standard (29 CFR 1910.1450). There is also an accompanying zip file of a CD that contains Laboratory Chemical Safety Summaries (LCSS) and additional information.

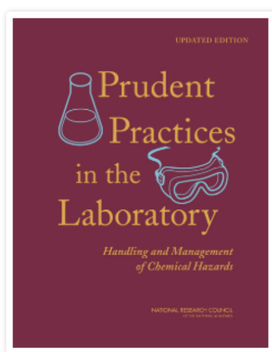
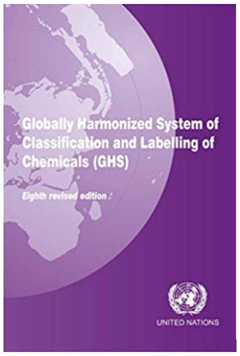


Figure 1.2.1: NRC Prudent Practices in the Laboratory

UN GHS

OSHA's laboratory standard is actually integrated into the United States implementation of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and the 8th edition can be downloaded as a PDF. Within the GHS are the requirements for Safety Data Sheets (SDS) which have superseded the MSDS (Material Safety Data Sheets) that are required for any chemical transported or sold within the US.



1.5.3.2.1 The information in the SDS should be presented using the following 16 headings in the order given below:

1. Identification
2. Hazard(s) identification
3. Composition/information on ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties and safety characteristics
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information.

Figure 1.2.2: On left is an image of the 2019, 8th edition of the UN GHS and on right are the 16 GHS mandated categories for chemical SDS.

MSDS HyperGlossary

The MSDS hyperglossary is a glossary of terms used in SDS and MSDS sheets, and the demystifier is a web tool developed by Dr. Toreki of Interactive Learning Paradigms almost 20 years ago parses SDS and MSDS sheets, connecting them to the definitions within the hyperglossary. The following YouTube demonstrates how to use the MSDS/SDS demystifier.

PubChem LCSS

The National Institute of Health's (NIH) National Library of Medicine's (NLM) PubChem have developed LCSS that model the LCSS of the NRC, but extract data from multiple chemical compound databases. As of May 2020 there are LCSS for 141,993 chemical substances that can be obtained through PubChem. This is a very valuable resource for finding safety information on chemicals.

COVID-19 Pandemic Issues

To complicate matters this course is being taught in an online environment where students may need to purchase items directly through a store, or through an online service. Students are expected to follow CDC guidelines when in public, which includes covering your mouth and nose when in public. The following YouTube went viral (no pun intended) and if you have not seen it, you may want to watch and think about it. The last thing you need to do is catch COVID-19 because you had someone deliver supplies, and they coughed on the box.

Video 1.2.1: https://youtu.be/sjDuwc9KBps

UALR Online Lab Material

For this lab we will be using Google Classroom. If you already familiar with it - great! If not, don't worry, it is very easy to navigate. There are two types of assignments that you could encounter during this online lab: group assignments and individual assignments. You can learn some more about each type below.

Group Assignments

In this lab, most of the work you will do during the lab will be a group assignment. For the group assignments, you will be divided into Zoom Breakout Rooms. Each group will have a shared Google Doc that all group members have access to and can edit at the same time. Each student is required to submit their copy of the group assignment by the due date to get credit. For group assignments, your participation levels will be evaluated by each of your group members to ensure you are all working together. Your participation counts towards your overall grade! It is important to attend the full lab and interact with your group.

Individual Assignments

In this lab, individual assignments will include Pre-Lab Assignments, Post-Lab Problem Sets, and some In-Lab Assignments. Each person will have their own copy of the assignment to work on. You are welcome to discuss the problems in the individual assignments with your group members, but the final answer has to be written in your own words. Each student is required to submit their individual assignments by the due date to get credit.

Lab Procedures

Safety Agreement

You will need to sign the safety agreement. It is a standard procedure for all students who are working in the lab. The agreement that you will be introduced to during this safety lab is the same agreement you would have signed if you were taking an in-person lab, but there are a few points that were added to ensure your safety during this remote lab. Your safety is our number one priority during this lab. Make sure you understand every single statement and if you have any questions or concerns feel free to ask for clarification.

This is a preview only. You will be able to find your assignment to work on in Google Classroom.

Safety Video

While you will not be in a physical laboratory doing experiments this semester, it is still important to introduce you to proper lab safety protocols. You are required to watch this video and answer the questions of the Safety Video Quiz in Google Classroom on your own. This will be an individual assignment for you to complete by the due date in your Google Classroom.

While this video covers everything you need to know about lab safety, we wanted to show you one of the labs at UALR. Due to COVID-19 you will be taking this class at home, but it is important that you are familiar with the setup for your future labs.

Figure 1.2.2: UALR lab

Let's take a closer look at the eyewash. To operate the eye wash open the dust covers and push the handle located immediately to the right from it. Just in case some debris has settled on the water spout you should always flush out the water from the nozzle before flushing your eye with it.

Figure 1.2.3: Eye wash

When you start working in a lab make sure you know where all the safety equipment is located and how to use it.

Figure 1.2.4: Safety shower

Figure 1.2.5: First aid wool blanket and fire extinguisher

Always remember to dispose of chemicals in the way indicated in your lab manual. In the lab you will find waste jars labeled for each experiment.

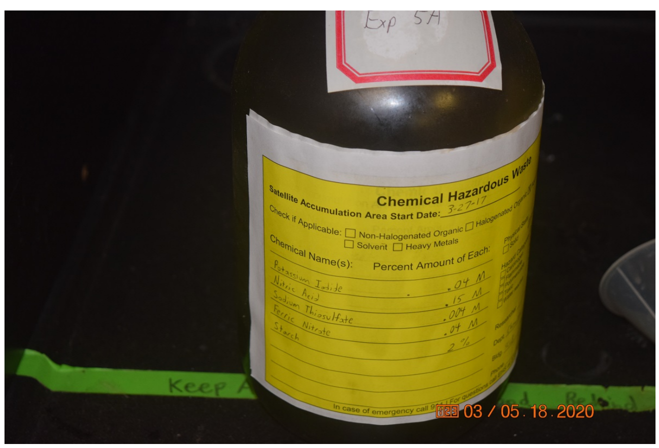
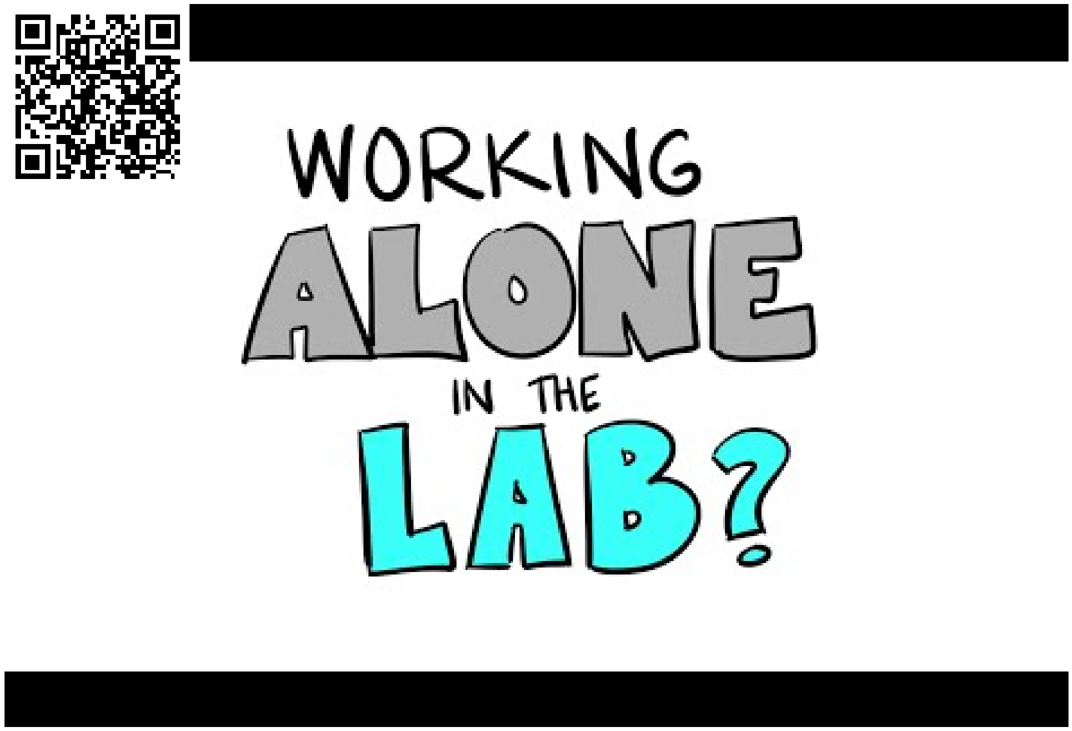


Figure 1.2.6: Chemical Hazardous Waste jar

Always remember to ask your instructor if you're not sure about something!

Never Work Alone in the Lab

Although we will not be doing in-person experiments, we will mimic being in a lab together by working on assignments in Zoom. Most of these will be Group Assignments and you will also be graded on your participation. Therefore, it is important for you to turn on your cameras and get to know your group members. Please watch this video to understand why you should never work in a lab on your own.



SDS Worksheet

Using information provided on this page, complete the SDS Worksheet. This is a group assignment where you collaboratively develop this in a Google Doc within your Google Classroom. You will find this assignment in your Google Classroom. Use MSDS HyperGlossary to answer the questions asking for definitions.

This is a preview only. You will be able to find your assignment to work on in Google Classroom.

Contributors and Attributions

Robert E. Belford (University of Arkansas Little Rock; Department of Chemistry). The breadth, depth and veracity of this work is the responsibility of Robert E. Belford, rebelford@ualr.edu. You should contact him if you have any concerns. This material has both original contributions, and content built upon prior contributions of the LibreTexts Community and other resources, including but not limited to:

- Elena Lisitsyna

1.3: Experiment 1 - Measurements

Measurements and the Irrational Number Pi

Learning Objectives

By the end of this lab, students should be able to:

- Accurately measure materials using a home made ruler.
- Select appropriate measuring device for each application.
- Select appropriate number of significant figures for each measurement.
- Convert between units or measurement using dimensional analysis.
- Differentiate between accurate and precise measurements in an aggregate set of data.
- Graph a set of data and determine the slope with Google sheets.

Prior Knowledge:

- 1B.1: Units of Measurement
- 1B.2: Making Measurements: Experimental Error, Accuracy, Precision, Standard Deviation and Significant Figures
- 1B.3: Mathematics in Chemistry
- 1B.5: Graphs and Graphing

Introduction

In this lab, students will work in groups of 3-5 people using Zoom breakout groups while collaborating on a Google Doc, and will create two scales based on the width of their own pointer finger (PF) as a base unit to determine the value of Pi. Students will use their PF unit to create a scale of the Fist, where 1 Fist (F) unit is equal to the width of 5 PF units. Once this scale is completed, students will then create a more precise scale, called the deciFist scale, where each deciFist (dF) unit is equal to 1/10th the length of the Fist unit (10 dF is equal to 1 F). After creating these two scales, students will then find 5 circular objects of varying sizes around their house, measure the circumference and diameter of each object with their homemade scales, and then use Google Sheets to plot these measurements and determine the value of Pi.

- **Week 1**: Students work in their group to design a protocol for building a ruler based on the width of their pointer finger. Each student individually performs the experiment and plots their data in Google Sheets.
- **Week 2**: Students pool all of the data from their group, plot with Google Sheets, and work up their data and turn in individual worksheets.

Supplies:

In this lab you may need to obtain supplies, so if you go to the store be sure to follow proper COVID-19 hygienic protocols, wear a mask, wash your hands thoroughly and maintain safe distance from fellow shoppers. Please review these protocols from the CDC.

- two strings or shoe laces that can be marked on
- two different colored markers that will show up on your string (such as red and blue)
- firm paper (thin cardboard from food packaging can be used)
- scissors
- tape
- 5 circular objects of varying sizes (e.g. large coin, dinner plate, Lysol can, etc.)
  - one object needs to have a diameter larger than the width of two of your fists
  - one object needs to have a diameter smaller than the width of three of your fingers
  - the other three object need to be various sizes
- ruler with metric units (cm)
- cell phone with camera
- laptop or computer with camera, speakers and microphone hooked up to internet

Pre-Lab Primer

This assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. The assignment will be due 10 minutes before your lab begins. Late work will not be accepted.

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignments

Week 1: February 1st - February 4th

Measurements Experiment Design Proposal

Using Zoom breakout groups, collaboratively work with your group on the assignment in your Google Classroom called "**Measurements Experiment Design Proposal**". You can see a preview of this document below. Your group needs to develop a protocol for how to build the two rulers mentioned above (one with Fist Scale and one with deciFist Scale) by using the width of your pointer finger (PF) as a base unit. Since you will be measuring circular objects, the rulers need to be made of a flexible material. Use the information on this LibreTexts page to help you complete the assignment. **NOTE**: You are not making the actual rulers yet. Your group is only brainstorming how those rulers could possibly be made.

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Building and Using Your Rulers

Each group will share their experiment design proposal with the class. After each group has shared, the lab instructor will generate a **Standardized Experimental Protocol**, which everyone will follow to create their own rulers. This document will be posted in your Google Classroom. You will then use your two rulers to make circumference and diameter measurements of the five circular objects that you found around your house.

> **Note**
>
> You will be in contact with your group via Zoom. You can help each other with the ruler building process and you can discuss your Google Sheets data and graphs, but **each individual person will be making their own ruler and measurements.**
>
> These two scales measure the same unit of length (the width of 5 pointer fingers, which we call the Fist unit), but they both have different precision. When making measurements, students must report the correct number of significant digits based on the scale they are using (all certain values and the first "guestimate", section 1B.2.1.2 of your LibreTexts).

Graphing your Data to Determine the Value of Pi

You will use a Google Sheet in your Google Classroom called "**Group Graphing Assignment**" to record the measurement data of each of the 5 objects from both of your rulers. It is called a group assignment, but each individual student will have their own tab to input their data on. Make sure you are reporting your measurements with the correct number of significant digits based on the ruler you used to make those measurements. **NOTE:** The Google Sheet may not allow you to put the correct number of significant digits. If this happens, there are two buttons at the top of the Google Sheet that you can use to add or remove decimal places. If you need help finding these buttons, ask your group members or your lab instructor.

As you enter your data, the Google Sheet will make a graph of the data for you. The slope for each of your graphs should be very close to the value of Pi (3.14159...) once you have entered all of your measurements. If this is not the case, you may have made your rulers incorrectly or you may not have read the correct measurement value from the ruler. Double check your work. If there is error this week that doesn't get corrected, there will still be error next week since you will be using the same measurements again.

The sheet below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Week 2: February 8th - February 11th

Individual Graphing Assignment

Last week, when you input your measurement data into Google Sheets, a graph was automatically created for you. This week you will be responsible for making your own graphs. Before you begin, take 5 minutes to watch the **"Graphing with Google Sheets"** video below. In your graphs, you will be required to include all of the graphical elements that are mentioned in the video.

Video 1.3.1: Tutorial on using Google sheets for linear graphs created by Bob Belford (https://youtu.be/muF0eJkN9CQ)

After watching the video, you can open the assignment in your Google Classroom called **Individual Graphing Assignment**. For this assignment, you will be combining the Week 1 measurement data from yourself and each of your group members, and then creating **four** graphs.

- Graph 1: Use all group members' data from the **Fist Scale** and include the origin point (0,0)
- Graph 2: Use all group members' data from the **Fist Scale** and do not include the origin point (0,0)
- Graph 3: Use all group members' data from the **deciFist Scale** and include the origin point (0,0)
- Graph 4: Use all group members' data from the **deciFist Scale** and do not include the origin point (0,0)

The sheet below is a preview only. You will be able to find your assignment to work on in Google Classroom.

Individual Lab Report

After you finish your individual graphs, you will be asked to complete the **Individual Lab Report**. This assignment is an individual assignment to be completed on your own during lab. It will be due at the end of your lab period. You can discuss questions with your group members, but all work must be your own, including the images of your supplies and rulers.

For some problems, you will be asked to show your work. You should keep track of your work on a piece of paper and label with the question number it belongs to. There will be a box at the **end** of the document for you to insert an image of your work. **Do not** insert the image under each individual question.

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Post-Lab Problem Set

After you have had a chance to work on data analysis with your group during lab, you will be given the **Measurements Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignments. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

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Contributors and Attributions

- Robert E. Belford (University of Arkansas Little Rock; Department of Chemistry) led the creation of this page for a 5 week summer course.
- Elena Lisitsyna contributed to the creation and implementation of this page.
- Mark Baillie coordinated the modifications of this activity for implementation in a 15 week fall course, with the help of Elena Lisitsyna and Karie Sanford.

1.4: Experiment 2 - Atomic Theory

Learning Objectives

By the end of this lab, students should be able to:

- Compare the Bohr model of the atom with the Schrödinger's model.
- Explain how light interacts with matter to produce line spectrum.
- Calculate the relationship between wavelength and energy of a photon.

Prior knowledge:

- 6.1: Electromagnetic Radiation
- 6.2: Quantization: Planck, Einstein, Energy, and Photons
- 6.3: Atomic Line Spectra and Niels Bohr
- 6.4: Wave-Particle Duality
- 6.5: The Modern View of Electronic Structure

The smallest piece of an element that maintains the identity of that element is called an atom. Individual atoms are extremely small. It would take about fifty million atoms in a row to make a line that is 1 cm long. The period at the end of a printed sentence has several million atoms in it. Atoms are so small that it is difficult to believe that all matter is made from atoms-but it is.

Pre-Lab Primer

This assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignments

Individual Lab Report

Using Zoom breakout groups, you can work together with your group members to answer the questions in the **"Atomic Theory Lab Report".** This is an individual assignment, so while you can work with your peers, all work must be in your own words. Use the PhET simulation below to answer the questions in your Lab Report.

Part I: White light

1. Turn on the gun.
2. Make sure you selected "White".
3. Select "Show spectrometer"
4. Answer the questions in Part I of the Lab Report.

Part II: Prediction with Bohr's Model

1. Switch from **Experiment** to **Prediction** in the upper left hand corner of the simulation.
2. Switch to the **Bohr** model and turn on the **Show electron energy level diagram** in the upper right hand corner. Watch to see what happens in the simulation, the electron energy level diagram and the spectrometer.
3. Answer the questions in your report regarding this model.

Part III: Prediction with Schrödinger's Model

1. Make sure **Prediction** is selected in the upper left hand corner of the simulation
2. Switch to the **Schrödinger** model.
3. Answer the questions in your report regarding this model.

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Post-Lab Problem Set

After you have had a chance to use the PhET simulation and complete your assignment with your group during lab, you will be given the **Atomic Theory Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignment. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Contributors

- Stephen Lower, Professor Emeritus (Simon Fraser U.) Chem1 Virtual Textbook
- CK-12 Foundation by Sharon Bewick, Richard Parsons, Therese Forsythe, Shonna Robinson, and Jean Dupon.

Contributors and Attributions

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1.5: Experiment 3 - Nomenclature

Learning Objectives

By the end of this lab, students should be able to:

- Name mono- and polyatomic ions, according to IUPAC rules.
- Differentiate between ionic and covalent compounds and their naming conventions, according to IUPAC rules.
- Convert between the formula of a compound and its name, vice versa.
- Identify and name weak and strong acids.

Prior knowledge:

- 2.5: Chemical Compounds
- 2.6: Ionic Compounds and Formulas
- 2.7: Nomenclature

Chemical Nomenclature is a set of rules that was developed to ensure generation of systematic names for chemical compounds. In other words, we need to follow nomenclature rules to make sure that we use the same name for the same compounds so other people can understand us. The nomenclature used most frequently worldwide is the one created and developed by the International Union of Pure and Applied Chemistry (IUPAC).

Ionic compounds consist of cation (positively charged) and anions (negatively charged) that are held together by electrostatic attraction. Most of the time in an ionic compound you will find a metal bonded to non-metal. These compounds can be made out of monoatomic or polyatomic ions.

Covalent compounds are two or more non-metals that are held together by covalent bonds. Acids are also covalent compounds.

Molecular formula is a way of presenting information about the chemical proportions of atoms that constitute a particular chemical compound or molecule, using chemical element symbols, numbers, and sometimes also other symbols, such as parentheses, dashes, brackets, commas and plus and minus signs. When multiple atoms are held together by covalent bonds they form a single chemical entity, which we call a molecule. As postulated in Dalton's atomic theory, the ratio of the atoms of the different elements are whole numbers, and this can be described by the molecule's molecular formula.

Pre-Lab Assignment

This pre-lab assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignment

In this one week lab, you will be working on your own Individual Assignment while in Zoom Breakout Rooms with your group members. Each person must work on their own assignment, but your group members and your lab instructor will be available for help. You must use the correct formatting for writing formulas, names, and ions (i.e. use superscripts, subscripts, parentheses, and capital/lowercase letters when appropriate.) This assignment will be due by the end of your lab period. **No late work is accepted.**

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Post-Lab Problem Set

After you have had a chance to complete your assignment during lab, you will be given the Nomenclature Post-Lab Problem Set. This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignment. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

The document below is a preview only. You will be able to find your assignment to work on in your Google Classroom.

Practice Exercises

The worksheet linked here is optional to complete, but it is very good practice, especially if you will be continuing on to other chemistry courses. The answer key to this worksheet can be found here.

You can also use the quiz below to practice activities to help you with this topic.

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- Modifications of this activity for implementation in a 15 week fall course were made by Elena Lisitsyna and Karie Sanford.

1.6: Experiment 4 - Molecular Shape

Learning Objectives

By the end of this lab, students should be able to:

- Draw the Lewis Dot structures for molecules that obey the octet rule.
- Draw Lewis Dot structures for molecules that don't obey the octet rule.
- Predict the electron geometry and molecular shape of individual molecules using VSEPR theory.

Prior Knowledge and Helpful Links:

- 8.1: Chemical Bond Formation
- 8.2: Covalent Bonding and Lewis Structures
- 8.5: Drawing Lewis Dot Structures
- 8.6: Molecular Geometries
- AXE Method

Introduction

Molecular compounds are formed when two non-metals share valence electrons forming a covalent bond. This results in two types of orbitals; bonding orbitals, where the valence electrons are shared between two nuclei, and non-bonding orbitals (lone pairs), where the valence electrons are localized to one nucleus. Molecules have definite geometric shapes which influence their chemical properties and behavior. The first step in understanding a molecule's geometry is in determining the connectivity of the atoms, and the types of orbitals each atom possesses. This can be conveniently done with Lewis dot structures, which account for all valence electrons by using lines between atoms to represent bonding electron pairs and dots to represent lone electrons.

Pre-Lab Primer

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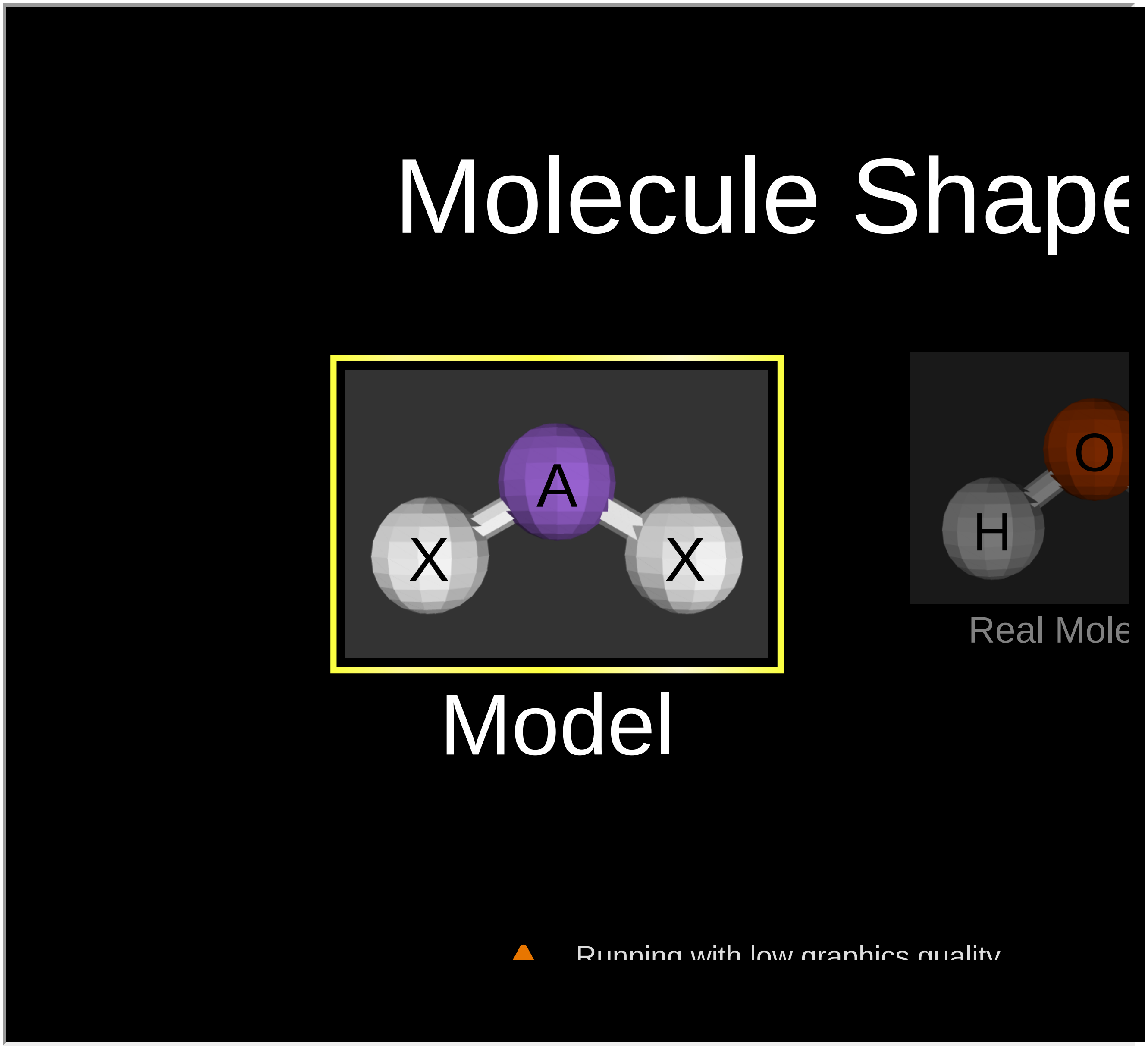
The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignment

Group Molecular Theory Worksheet

Using Zoom Breakout rooms, you will work collaboratively with your group on a Google Doc worksheet called **"Group Molecular Theory Worksheet"**. Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

Use the PhET simulation below to complete the worksheet with your group.



The document below is a preview only. Please **do not** try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom during lab.

Post-Lab Problem Set

After you have had a chance to view the PhET simulation and complete the worksheet with your group during lab, you will be given the **Molecular Theory Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignment. You may use the PhET simulation to help you as well. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

The document below is a preview only. Please **do not** try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom once you have finished your in-lab assignment.

Contributors and Attributions

- Robert E. Belford (University of Arkansas Little Rock; Department of Chemistry) led the creation of this page for a 5 week summer course.
- Elena Lisitsyna contributed to the creation and implementation of this page, including generation of the HP5 questions.
- Mark Baillie coordinated the modifications of this activity for implementation in a 15 week fall course, with the help of Elena Lisitsyna and Karie Sanford.

Practice Exercises

1.7: Experiment 5 - The Mole

Learning Objectives

By the end of this lab, students should be able to:

- Explain the concept of the Mole and its relationship between mass, number of atoms, number of molecules, and formula units.
- Perform mole-mass calculations and determine the number of atoms, molecules, or formula units of several substances.

Prior knowledge:

- 2.8: Atoms and the Mole
- 2.9: Calculations Determining the Mass, Moles and Number of Particles

Introduction

The basic counting unit used in chemistry is the "Mole". In this lab, you will perform calculations using molar relationships, which is essential to understanding chemistry. The lab activities start with conversions involving elements, followed by compounds. You will also review basic scientific notation and rules for significant figures.

Can you imagine real world Moles?

- There are approximately one hundred trillion cells in a human body and there are roughly six billion people on Earth. Therefore, the total number of human cells on the planet is approximately (100 x 10^{12} cells per human) * (6 x 10^{9} humans per Earth) = 6 x 10^{23} cells on the planet. This number is very close to one mole.
- If you had exactly one mole of pennies, you could share enough money with everyone in the world that each person could spend a million dollars every hour for the rest of their lives.
- If someone wanted to use trial and error to find the combination of a password containing six alphanumeric characters, it would take that person 6^{36} different tries, which is approximately 10^{28}. This is over 17,000 moles.

Pre-Lab Primer

This pre-lab assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignment

The Mole Group Worksheet

Using Zoom Breakout rooms, you will work collaboratively with your group on a Google Doc worksheet called **"The Mole Group Worksheet"**. For this assignment, your group will need to watch a lab video on YouTube and then complete the questions accordingly. The link for the YouTube video will be given to your group on the day of your lab.

Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

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Post-Lab Problem Set

After you have had a chance to work on the data analysis with your group during lab, you will be given the **Mole Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignment. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

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1.8: Experiment 6 - Polarity and Solubility

Learning Objectives

By the end of this lab, students should be able to:

- Explore the relationship between polarity and solubility.
- Determine the solubility of polar and nonpolar solutes, and an ionic solute in different solvents.

Prior knowledge:

- 8.7: Bond Polarity and Electronegativity
- 8.8: Bond and Molecular Polarity

Introduction

Have you noticed the common solubility problems in our everyday life? If you get sap from a pine tree on your clothes, or wax from a candle on the table, or bike chain grease on your pants, these substances will not be easily removed with just water. Do you think this demonstrates a solubility problem?

In this lab, you will explore how polarity affects whether substances dissolve in each other. What is the meaning of "like dissolves like"? Why are nonpolar and polar substances immiscible? You will explore what it means chemically for a substance to be polar or nonpolar and how you can use this to eventually get the stains out of your clothes.

Pre-Lab Primer

This pre-lab assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

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In-Lab Assignments

Individual Assignment

The first assignment for this week will be an individual assignment. Your lab instructor will play a video for everyone at the beginning of lab. Based on the contents of the video, you will answer the questions in the document. After everyone has finished and turned this assignment in, your instructor will put you into your Breakout Room with your group on Zoom to complete the second assignment.

The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

Group Assignment

The second assignment will be a worksheet that you complete with your group members. You will use the data collected from the Individual Assignment to complete the questions for this assignment.

Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

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Post-Lab Problem Set

After you have had a chance to work on the data analysis with your group during lab, you will be given the Post-Lab Problem Set. This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignments. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. No late work is accepted.

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1.9: Experiment 7 - Hydration of Salt

Learning Objectives

By the end of this lab, students should be able to:

- Design an experiment to accurately determine the empirical formula of a given hydrate.
- Predict how experimental factors will impact the accuracy and precision of results.
- Calculate the molar ratio of water to anhydrous solid to determine the hydrate's formula.
- Explain why the experimentally determined empirical formula may not match the actual formula of Epsom salt (propose at least 2 ideas).

Prior Knowledge:

- 2.8: Atoms and the Mole
- 2.9: Calculations Determing the Mass, Moles and Number of Particles
- 2.10: Percent Composition
- 2.11: Empirical and Molecular Formulas
- 2.12: Hydrates

Introduction

Epsom salt ($MgSO_4{\cdot}7H_2O$) is a heptahydrate of magnesium sulfate: within one mole of magnesium sulfate heptahydrate are seven moles of water. This water can be driven off by heat to form the anhydrous (dehydrated) ionic compound, magnesium sulfate. The mass of water evaporated is obtained by subtracting the mass of the anhydrous solid from the mass of the original hydrate (1.9.1):

$$m_{\mathrm{H_2O}} = m_{\mathrm{Hydrate}} - m_{\mathrm{Anhydrous\ Solid}} \tag{1.9.1}$$

From the masses of the water and anhydrous solid and the molar mass of the anhydrous solid, the number of moles of water and moles of the anhydrous solid are calculated as shown below (1.9.2, 1.9.3):

$$n_{\mathrm{H_2O}} = \frac{m_{\mathrm{H_2O}}}{MM_{\mathrm{H_2O}}} \tag{1.9.2}$$

$$n_{\mathrm{Anhydrous\ Solid}} = \frac{m_{\mathrm{Anhydrous\ Solid}}}{MM_{\mathrm{Anhydrous\ Solid}}} \tag{1.9.3}$$

In order to determine the formula of the hydrate, [$\mathrm{Anhydrous\ Solid} \cdot x\mathrm{H_2O}$], the number of moles of water per mole of anhydrous solid (x) will be calculated by dividing the number of moles of water by the number of moles of the anhydrous solid (Equation 1.9.4).

$$x = \frac{n_{\mathrm{H_2O}}}{n_{\mathrm{Anhydrous\ Solid}}} \tag{1.9.4}$$

Pre-Lab Assignment

This pre-lab assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

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In-Lab Assignment

Group Assignment

Using Zoom Breakout rooms, you will work collaboratively with your group on a Google Doc worksheet called **"Hydrated Salt Procedure/Analysis"**. Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

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Post-Lab Problem Set

After you have had a chance to work on the data analysis with your group during lab, you will be given the **Hydrated Salt Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignment. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

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1.10: Experiment 8 - Gas Laws

Learning Objectives

By the end of this lab, students should be able to:

- Plot real data provided by your TA.
- Determine trends from imperfect data.
- Transform data into a format that can allow you to solve a problem.
- Predict pressure at a given volume, or vice versa, using Boyle's Law.
- Identify the dependent and independent variables in an experimental system.
- Calculate the ideal gas constant using Boyle's Law and real data.

Prior Knowledge:

- 10.2: Gas Laws
- 10.6: Diffusion and Effusion

Pre-Lab Primer

This pre-lab assignment is an individual assignment to be completed on your own with the help of the "Prior Knowledge" links at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

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In-Lab Assignments

Group Assignment

Using Zoom Breakout rooms, you will work collaboratively with your group on a Google Doc worksheet called **"Gas Laws Group Worksheet"**. Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

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Individual Graphing Assignment

After your group has finished the first assignment, you will work individually on a graphing assignment using real experimental data. Your lab instructor will assign a data set to you that can be found on a Google Sheet linked within the assignment. Make sure you open the correct tab since there are five different sets of data! You will need to copy and paste this data into your own Google Sheet to make some calculations and build the graph for this assignment. **Save your Google Sheet!** You will also use it for your Post-Lab Problem set to make additional calculations and graphs. This worksheet will be done by the end of your lab period, so make sure you turn it in on Google Classroom. **Late work will not be accepted.**

The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

Post-Lab Problem Set

After you have had a chance to work on the data analysis with your group during lab, you will be given the **Gas Laws Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it builds off of your Individual

Graphing In-Lab Assignment. You will need to use the same data set that your instructor assigned to you, and the same Google Sheet that you worked on during lab. You will have a little bit of extra time for this Post-Lab Problem Set: it will be due by 8:00 am two days after your lab meets. For example, if your lab is on Monday, the Post-Lab will be due on Wednesday at 8:00 am. If your lab is on Tuesday, the Post-Lab will be due on Thursday at 8:00 am. **No late work is accepted.**

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1.11: Experiment 9 - Precipitation

Learning Objectives

By the end of this lab, students should be able to:

- Describe precipitation reactions from the molecular perspective
- Record detailed observations for a reaction.
- Predict if a precipitate will form when combining two solutions.
- Write molecular, ionic, and net ionic equations for various reactions.

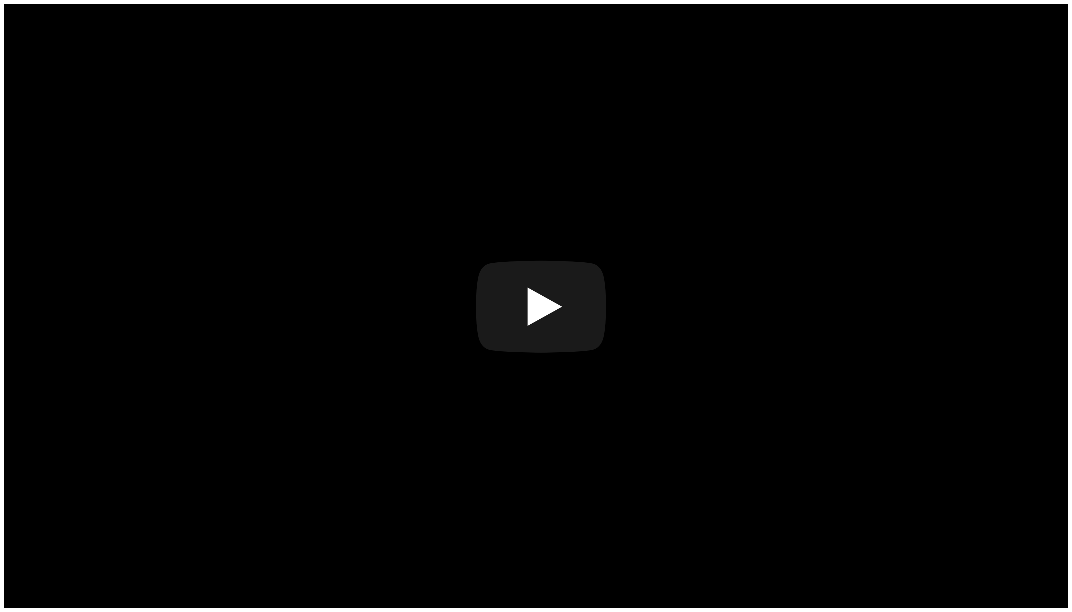
Prior Knowledge:

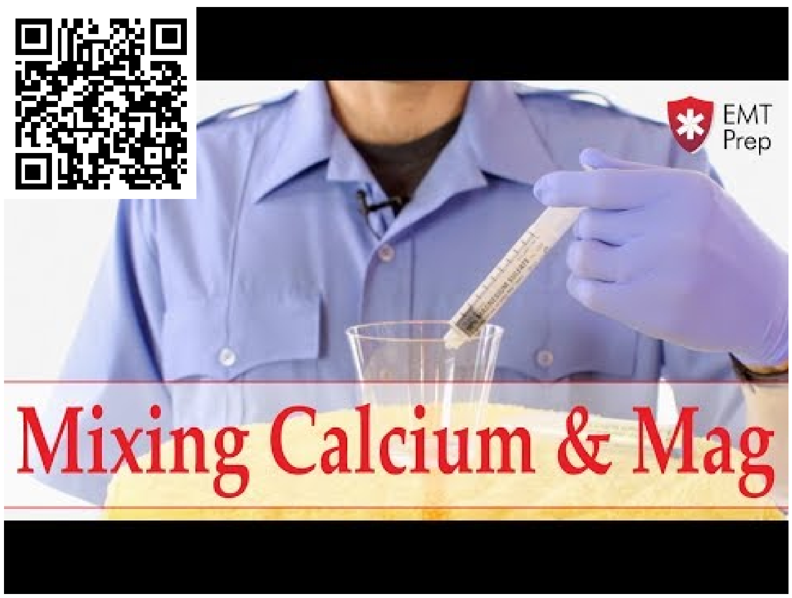
- 3.1: Introduction to Chemical Equations
- 3.2: Types of Chemical Reactions
- 3.3: Balancing Chemical Equations
- 3.4: Aqueous Reactions

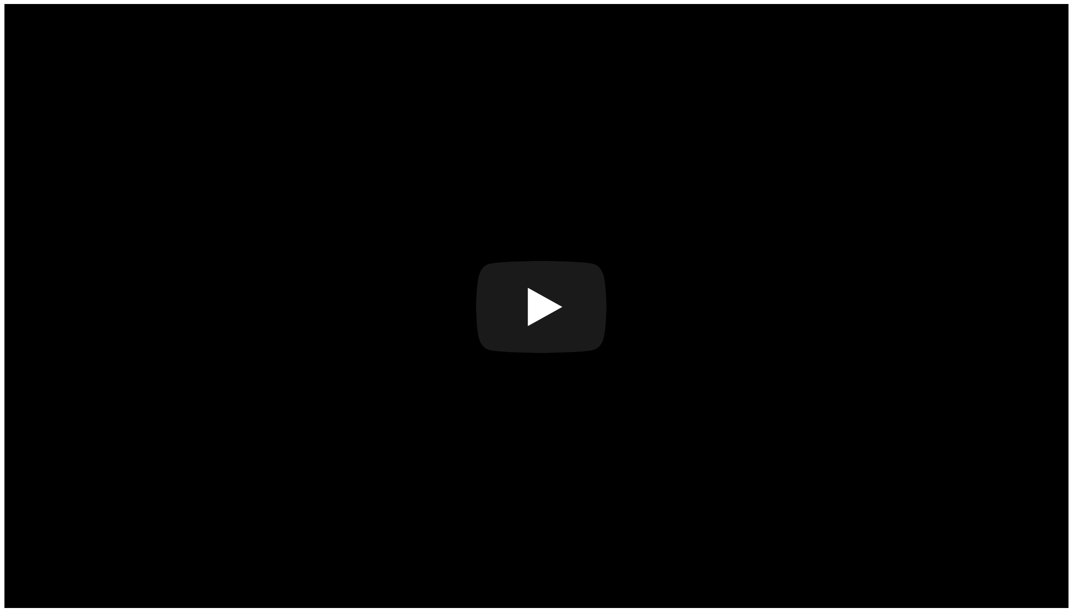
Introduction

Aqueous solution is any solution where water is present as a solvent. Rain, vinegar, orange juice are all examples of aqueous solutions that you come across in your everyday life. In chemistry, aqueous solution is indicated by adding "(aq)" to the reactant formula. For example, NaCl(aq) present as individual ions Na^+ and Cl^- dissolved in water. You might have heard that water is the universal solvent, however, water only dissolves substances that are hydrophilic (from the Greek "hydros" - water and "philia" - bonding or friendship). Compounds that do not dissolve in water remain a solid and indicated by "(s)", for example, AgCl(s).

Solubility rules could be useful in our everyday life, but they are also extremely important in medicine. Sometimes doctors prescribe more than one solution to be administered by the intravenous (IV) route. Mixing two solutions that form a precipitate can lead to very serious consequences. For example, magnesium sulfate is used as an electrolyte replenisher or anticonvulsant, calcium chloride is indicated in the immediate treatment of hypocalcemic tetany (abnormally low levels of calcium in the body that cause muscle spasm), and intravenous sodium bicarbonate is a medication primarily used to treat severe metabolic acidosis. But what will happen if you mix them?




EMT
Prep
Mixing Calcium & Mag



Pre-Lab Primer

This pre-lab assignment is an individual assignment to be completed on your own with the help of the links in the document and at the top of this page. All work must be in your own words. Do not copy and paste information from the internet. The assignment will be due 10 minutes before your lab begins. **Late work will not be accepted.**

The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

In-Lab Assignments

Safety if you were to complete this lab in person:

- Obtain and wear goggles and gloves!!!
- Do not ingest any chemicals or inhale the vapors.
- Clean up all spills immediately! **If contact with skin, rinse with water for 15 minutes.**
- Before proceeding with this or any other experiment, students must sign the chemical lab safety form.

In these assignments, you will look at some aqueous reactions, and record your observations, molecular equation, total ionic equation and net ionic equation. Make sure to write any evidence of a chemical reaction with sufficient detail to help you distinguish between similar precipitation reactions. Don't write “became cloudy” or “white solid”. Indicate if a gel is produced or crystals form, if the solid was powdery, etc. Keep in mind that some reactions will not occur and you should write NR (for No Reaction). You will know that a reaction occurred if a precipitate, a gas, or color change occurred. Heat (whether it was consumed or evolved) can also be an indicator that reaction occurred, but you may not be able to tell in these videos.

Individual Assignment

Part A: Aqueous Reactions Simulation

Your instructor will play a simulation for you during lab and guide you through the questions in the first part of this assignment. You should answer these questions based on what you observe in the simulation. Be as specific as possible in your answers. **You MUST use the correct formatting when writing chemical equations and formulas. Use superscripts, subscripts, and parentheses when necessary.**

Part B. Predictions using the solubility table

You will be given a document called a "solubility table" like the one below to use to answer the questions in Part B of your assignment. Your instructor will show you how to use this table to predict whether a reaction will form a precipitate or not. **You MUST use the correct formatting when writing chemical equations and formulas. Use superscripts, subscripts, and parentheses when necessary.**

	Na^+	K^+	Mg^{2+}	Ca^{2+}	Sr^{2+}	Ba^{2+}	Mn^{2+}	Fe^{2+}	Co^{2+}	Ni^{2+}	Cu^{2+}	Ag^+	Zn^{2+}	Cd^{2+}	Hg_2^{2+}	Al^{3+}	Sn^{4+}	Pb^{2+}	NH_4^+
NO_3^-																			
ClO_3^-																			
ClO_4^-																			
$C_2H_3O_2^-$																			
Cl^-												■			■			■	
Br^-												■			■			■	
I^-												■			■			■	
SO_4^{2-}				■	■	■						■			■			■	
OH^-			■	■ ◊	■ ◊		■	■	■	■	■	■	■	■	■	■	■	■	
SO_3^{2-}			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
PO_4^{3-}			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
CO_3^{2-}			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
CrO_4^{2-}			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	

□ Soluble
■ Insoluble compound (less than 0.05M at room temperature)
■ ◊ Only soluble in acidic conditions

Figure 1.11.1: Solubility Table (LibreTexts, Elena Lisitsyna)

The document below is a preview only. Please do not try to screenshot or print it off. You will be able to find your assignment to work on in your Google Classroom.

Group Worksheet

Before watching each video, predict the outcome of the reaction (precipitate or no reaction). Then, watch the video with your group and fill out your worksheet with 1) your observations, 2) molecular equation, 3) ionic equation and 4) net ionic equation for each reaction before moving to the next video.

1. Copper(II)* sulfate and sodium phosphate

* The video says Cu_2SO_4, but the reaction shown in this video is between copper (II) sulfate and sodium phosphate.

Query 1.11.2

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVic
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

2. Cadmium (II) chloride and sodium sulfide

Query 1.11.3

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVic
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

3. Nickel (II) chloride and sodium carbonate

Query 1.11.4

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVic
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

4. Lead (II) nitrate** and sodium sulfide

** The video says Pb_2NO_3, but the reaction shown is between lead (II) nitrate and sodium sulfide

Query 1.11.5

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVi
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

5. Nickel(II) chloride and sodium phosphate

Query 1.11.6

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVi
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

6. Silver nitrate and sodium carbonate

Query 1.11.7

The website encountered an unexpected error. Please try again later.

Drupal\Core\Database\IntegrityConstraintVi
SQLSTATE[23000]: Integrity constraint violation: 1048 Column 'library_id' cannot be null: INSERT INTO {h5p_content_libraries} (content_id,

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Post-Lab Problem Set

After you have had a chance to work with your group during lab, you will be given the **Precipitation Reactions Post-Lab Problem Set.** This is an individual assignment that must be completed on your own, and it is based on your Pre-Lab Primer and your In-Lab Assignments. This assignment will be due the day after your lab meets by 5 p.m. For example, if your lab is on Monday, the Post-Lab Problem Set will be due on Tuesday at 5 p.m. **No late work is accepted.**

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1.12: Experiment 10 - Calorimetry

Learning Objectives

By the end of this lab, students should be able to:

- Design an experiment to determine the calorimeter constant.
- Predict factors that might influence your experimental results, and how to minimize error.
- Correlate variability in data to limitations in the physical set up of our lab.

Prior knowledge:

- 5.2: Specific Heat Capacity
- 5.4: First Law of Thermodynamics
- 5.5: Enthalpy Changes of Chemical Reactions
- 5.6: Calorimetry
- 5.7: Enthalpy Calculations

Introduction

Calorimetry is the science of measuring heat flow. Heat is defined as thermal energy flowing from an object at a higher temperature to one at a lower temperature. For example, if you drop a coin into a cup with hot water, the temperature of the coin will go up until it is at the same temperature as the boiling water. This will happen because the coin will be absorbing the heat from the water.

Calorimetry is based on the First Law of Thermodynamics that states that energy cannot be created nor destroyed. The heat of neutralization that is lost in the chemical reaction (the system) is gained by the calorimeter and its contents (the surroundings).

Pre-Lab Primer

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In-Lab Assignment

Group Assignment

In the ideal world, we would have a calorimeter that is so well insulated, that all of the heat gained or lost during the reaction is contained inside the calorimeter completely. You can read more about the heat transfer in an ideal calorimeter here. In reality some of it "escapes", since the calorimeter we have isn't a perfect insulator. Our calorimeter will absorb and lose heat. Keep that in mind when you are doing your worksheet.

To make sure you get accurate results you need to calculate the calorimeter constant, which is the calorimeter's heat capacitance. We use capital C to represent the heat capacitance of an object, so for the calorimeter constant we will use C_{cal}. Calorimeter constant has to be measured for every calorimeter and this is going to be the first part of this lab.

If we look at the equation $q_C = -q_H$ and apply it to our real calorimeter we will see, that there are two cold objects that contribute to q_C - the cold substance and the calorimeter itself. This means that

$$q_C = (m_C \times c_C \times \Delta T_C) + (C_{cal} \times \Delta T_C) \tag{1.12.1}$$

Using Zoom Breakout rooms, you will work collaboratively with your group on a Google Doc worksheet called **"Group Calorimeter Constant Worksheet"**. Each person can type in this document at the same time. Remember, part of your grade comes from your participation during lab, so there will be a Peer Evaluation this week. Make sure you are contributing to discussion and to the completion of the worksheet. The worksheet will be due by the end of your lab session, and late work is not accepted. Be sure to turn your assignment in on Google Classroom.

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1.13: Appendix 1 - Precision of Measuring Devices

General Information

Analytical instruments are calibrated to a specified precision and if you were told to transfer 5 ml of water you would consider that value to have one significant digit, but if you were told to use a 5 ml pipet to transfer water the number of significant digits would depend on the calibration value of that instrument. In our teaching lab a 5 ml pipet is calibrated to the centiliter and so the value would have 3 significant digits, but if you were working in an analytical lab that need a higher precision, you would be using more expensive equipment and there would be more significant digits. So always look at your instruments and determine their calibration value and then record those values to the proper number of significant digits.

There are two ways to calibrate volumetric instruments depending on if you want the instrument to contain the volume or transfer it.

TC Volumetric Calibration

TC stands for To Contain. These are devices that contain the stated volume. **A volumetric flask is a TC device** and when it is properly filled it contains the stated volume of a fluid. If you then pour that fluid and any remains behind, the amount you transfer is less than the stated. A graduated cylinder may be TC, but it also may be TD, and you must look at it. The graduated cylinders in the general chemistry labs are usually TC, but you must look. Note when empty the scale reads zero (it contains nothing) and when full it contains the quantity it is calibrated to contain (this may not be true for graduated cylinders).

TD Volumetric Calibration

TD stands for To Deliver. These devices deliver the stated volume. A **burette and pipet are TD** as they are designed to transfer fluid, while a graduated cylinder may or may not be TD. A pipet has no scale and is designed to deliver only one volumetric quantity of liquid and you must read the calibration value on the pipet to determine the number of significant digits. A burette has a scale and the number of significant digits is determined by the scale (report one more unit than the number of certain units, as you can guess how far between the lowest unit of the scale the value is). Because the burette has a scale, it can transfer multiple values, you simply calculate the difference between the initial and final values. But the scale of a burette is to deliver, so when it is full, the value is zero, and the numbers go up as the volume in the burette goes down. Typically, you do not blow out the last bit of fluid in a TD device, but you must always look at the manufacturer's instructions, as sometimes you do. (In this class we do not blow out the last bit of fluid).

Precision in Chemistry Lab

The following values you will need to know, and these are the values that will be associated with these instruments in this class. Realize these are not universal values and you may find other instruments that are calibrated to a different precision.

Burette

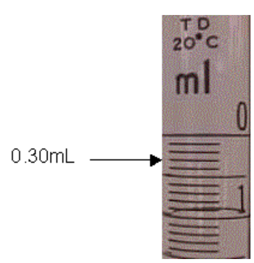


Figure 1.13.1: Precision Based on Equipment

Pipet

Figure 1.13.2: Precision Based on Equipment

Value	Precision
5mL	5.00mL
10mL	10.00mL
25mL	25.00mL
50mL	50.00mL

Volumetric Flask

Figure 1.13.3: Precision Based on Equipment

Value	Precision
25mL	25.00mL
50mL	50.00mL
100mL	100.0mL
250mL	250.0mL
500mL	500.0mL

All other devices we will use have a precision based on the scale

Note, the actual value for the precision of volumetric apparatus depends on the calibration of the equipment, and in general, the more expensive equipment will be more precise. We will use these values in this class, but upper level courses may have more precise equipment.

1.14: Appendix 2 - Quantitative Techniques

Using a Pipet

Step 1

Figure 1.14.1: Step 1

Keep the index finger of your dominant hand near the mouth of the pipet. Then place pipet tip into container where liquid is to be removed. Do not let the tip touch the bottom or sides of the container.

Step 2

Figure 1.14.2: Step 2

Using your other hand, squeeze the rubber bulb and place it over the mouth of the pipet. **NEVER PLACE YOUR MOUTH ON THE PIPET!**

Step 3

Figure 1.14.3: Step 3

Release the bulb slowly in order for the pipet to obtain a specific amount of liquid. Allow the liquid level to rise so that it is 1-2cm above the calibration mark. If not enough liquid enters the pipet, *quickly* remove and squeeze the bulb and then place it back on the pipet and release. **DO NOT LET THE LIQUID ENTER THE BULB. THIS MAY CAUSE CONTAMINATION.**

Step 4

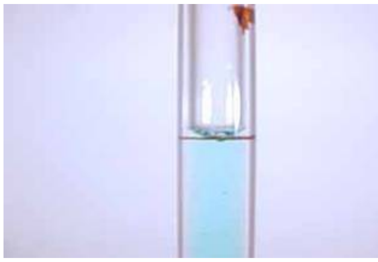
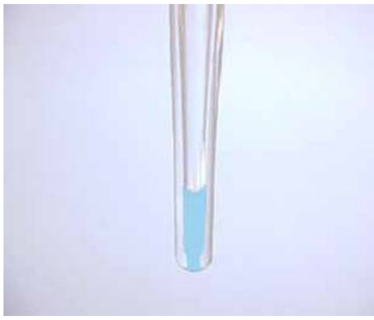


Figure 1.14.4: Step 4

Quickly remove the bulb and simultaneously place your index finger tightly over the top of the pipet to prevent any liquid from escaping. Now slightly move your finger in order to release the liquid until the meniscus is even with the calibration mark.

Step 5



Some liquid remains in the tip of a volumetric TD pipet

Figure 1.14.5: Step 5

Place the pipet, with your finger still on the mouth, over the container to which you will transfer the liquid. Release your finger and let the liquid drain completely out of the pipet. If a drop of liquid remains in the pipet tip, *do not blow into the pipet to force the liquid out.* The pipet is calibrated to deliver an accurate volume in spite of some liquid remaining in the tip.

Note: Some TD pipets you will use in upper level courses (mohr and serological pipets) are calibrated to require blowout, but in this class TD pipets do not require blowout.

Using the Analytical Balance

Step 1

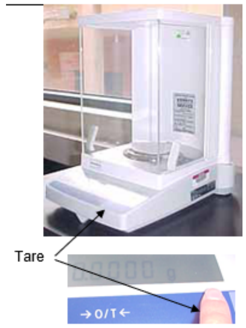


Figure 1.14.6: Step 1

-The analytical balance measures the mass of substances to within 0.0001g.

-The balance must be dry and contain no extraneous materials that may affect the accuracy of the measurement.

-Place the weighing paper onto the balance pan and close the side doors. To make sure the weight is stable, wait for the mass to stop changing or for a green triangle to appear.
-Press the “tare” button to recalibrate the balance to read 0.0000g. This prevents the mass of the weighing container from being included in the measurementFigure 1.14.1: Copy and Paste Caption here

Step 2

Figure 1.14.7: Step 2

-Open the door and use a spatula to add the substance up to the desired mass. NEVER PLACE CHEMICALS ON THE BALANCE PAN

-Once again, close the door and then record the mass once the scale has stabilized.

-*Do not to lean on the balance while weighing!*

Step 3

Figure 1.14.8: Step 3

-After finishing the measurements, brush the area around the balance pan to clean it of any remaining substance particles or spills.

-Discard any weighing paper.

-Keep the balance room clean!

Using A Burette

Step 1

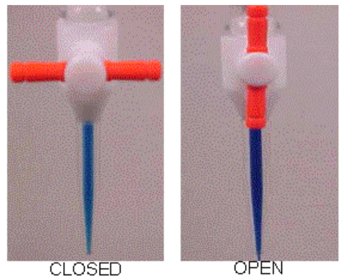


Figure 1.14.9: Step 1

A vertical stopcock means the buret is closed and a horizontal stopcock means the buretet is open. **A helpful tip: the direction of the stopcock follows the direction of the flow.**

Step 2

Figure 1.14.10: Step 2

Rinse the burette and glassware with the titrant a few times to prevent contamination. Attach the buret to the stand. *Close the stopcock* at the bottom of the buret and pour the titrant through a funnel at the mouth of the burette. Slightly lift the funnel to prevent the liquid from overflowing.

Step 3

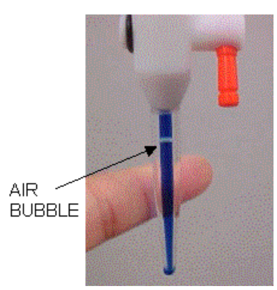


Figure 1.14.11: Step 3

If any air bubble appears, open the stopcock, and tap the side of the burette until the bubble disappears.

Step 4

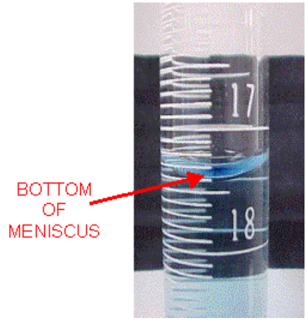


Figure 1.14.12: Step 4

Note that the burette reads in ascending order with the 0.00 mark at the top. You must be at eye level with the **bottom** of the meniscus (curved surface of liquid) to read the burette. **Reading from above or below the meniscus will result in a parallax error.** In order to better read the meniscus, keep a dark piece of paper behind the buret.

Step 5

Figure 1.14.13: Step 5

During a Titration, keep the liquid flowing normally until a few mL from the endpoint (the point at which the color changes). Around the endpoint, allow the liquid to flow drop-by-drop. After reaching the endpoint, rinse and dry the tip of the burette.

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Glossary

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