CHEMISTRY

100 Lab

Miramar

LABORATORY PACKET

Dr. Fred O. Garces

Spring 2024

Miramar Chem. Laboratory Policy and Procedure **1/20/24 -FG**

Welcome to Miramar College's Chemistry 100 laboratory. There are several policies that should for the online lab. Please be sure to read everything carefully and to practice these policies so your safety is not compromised.

1. All students are required to have, and wear, safety goggles when conducting experiments. There are NO exceptions to this rule. Goggles are available for purchase at the bookstore, home depot, Harbor Freight or Amazon. If you are not wearing your goggles, do not proceed with the experiments. If you violate any safety rules, then we assume no liability for injuries. You should use safety goggles for all experiments, even if you believe there are no chemicals being used.

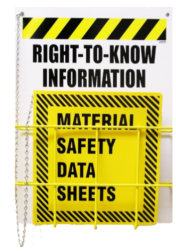
2. All student will need to purchase a lab kit from KLM BioScientific. https://labsuppliesusa.com/chem-100l/

Chemicals and specific equipment (i.e., digital scale) will be supplied by Miramar College and must be returned if you drop the course or complete the course. If you do not, your transcript will be held back, you will be billed and you will drop a letter grade. Please make sure upon returning the equipment and Chemicals provided to you from Miramar College are in separate baggies upon return so that the lab tech can sort the chemicals for proper disposal and so that the equipment can be repackage for the next term.

3. Students are not allowed work on any experiment or procedure not described in this lab manual. Students should always have another adult in the near vicinity when carrying out experiments.

4. The department has a very strong HAZMAT policy. **Absolutely no chemicals**—not even things like sodium chloride and sucrose are allowed down the sinks. Contamination of the sewer system with toxic chemicals cannot be compromised. All spent chemicals should be placed in a plastic (water) bottle and turn in to the Chem Department at Miramar College. Violation of this rule will result in a grade adjustment and a hold on your transcript.

5. The MSDS library contains hazardous information for all chemicals used in this course and can be via the Google search engine. https://www.msdsonline.com/sds-search/



6. Students should not be distracted when working on experiments. Do not multi-task. Cell phones should be turned off when working on this lab. Small children should be far away as to not be in contact with any chemicals or supplies. Another adult must be present. If it is an emergency, call 911 immediately. If a hospital visit is required, being along the lab manual so doctors know what chemicals you were exposed to or so they know the content of what caused the accident. Contact your instructor when it is safe to do so and describe the events that led to the emergency.

7. You may be using the alcohol burner or your stove. Be careful when handling these items and be sure there are no children in harm-way. Have a fire extinguisher near-by. There is direction in Canvas on how to use the alcohol burner. The alcohol burner will require rubbing alcohol as a source of fuel.

8. One of the safety equipment needed for this course is a first-aid kit. Be sure you have access to the kit. You should also have a hand broom and dustpan available in case spills or broken glass occur. Contact a lab tech or your instructor in the event of any chemical spill. It is mandatory to report all accidents to the instructor.

09. It is the responsibility of all students to clean the laboratory when completing the lab procedure. Do not push the responsibility to others such as your spouse or significant other. All students should clean messy work area and sink areas and in general, pick-up after themselves. Regularly leaving your work area without consideration will eventually catch up with you and your experimental results.

Special Thanks to Dr. Leigh Plesniak for reviewing and correcting the lab manual.

If you need to contact the lab tech for this course, please email them.

Bryce Thompson.   ***(619) 388-7826***   bthompson001@sdccd.edu
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Website: http://fogarces.com/Chem.htm

Table of Contents

Check-in and Safety

DESCRIPTION KLM CHEM 100LSupply Kit

(1) Alcohol Burner
(1) Alcohol Burner Stand
(3) 100 ml Glass Beaker
(1) 250 ml Glass Beaker
(2) 400 ml Glass Beaker
(1) Thermometer (alcohol)
(1) Spatula
(1) Watch Glass (90 mm)
(1) Test tube brush
(5) 13 x 100mm Test tubes
(5) 13 x 100mm Test Tube Stopper
(5) 18 x 100mm Test tubes
(5) 18 X 150mm Test Tube Stopper
(1) 5 mL (or 10mL) PP Grad Cylinder
(1) 50 ml PP Graduated Cylinder
(1) 100 ml PP Graduated Cylinder
(3) Petri Dish
(1) 250 ml Wash Bottle

Supply Equipment from Miramar College

()1 Forceps
(1) Wire Gauze
(1 Stirring Rod with Rubber Policeman
(1) Evaporating Dish
(4) weigh boats (~ 2")
(1) Metric Ruler, 15 cm
(6) Berel Pipets (disposable plastic)
(1) Crucible Tongs
(1) Plastic Straw
(1) Spatula
(1) Digital Scale

Equipment and Supplies from KLM and Miramar College for Chem 100 Online Lab

Some of these items may have changed.

Equipment and Supplies from KLM for Chem 100 Online Lab

You must purchase lab coats, safety goggles and nitrile gloves. You can find these at the bookstore or Amazon. Miramar College will supply the digital scales other supplies and chemicals.

Chem100L, Procedure guide to complete an experiment and upload to Canvas.

Checklist: All Canvas upload must be a **single pdf file** containing all pertinent information such as college ID.
All upload documents must have the correct file name.

Prelab

- ☐ 1. Prelab Questions in Canvas
- ☐ 2. Prelab Worksheet upload

Datasheet

- ☐ 1. Complete Datasheet with experiment photo and ID.
- ☐ 2. Datasheet upload

Post-Lab

- ☐ Prelab Questions in Canvas
- ☐ Prelab Worksheet upload

Details of what to do for each experiment.

Preparation for Experiment

1. a) In the module page in canvas, go to the information section and download the experiment which should include the prelab, data sheet and post-lab.
   b) Alternatively, you can go to the lab manual for that experiment where you will find the prelab, datasheet and post-lab.
2. Read the entire experiment and pay attention to the safety notes.
3. Check your equipment and chemicals to make sure you have all items necessary to complete the experiment.

Prelab

1. Complete the prelab worksheet. Place your ID on top of the page of your worksheet (making sure you do not block any of your answer).
2. Take a photo (or scan) each page. If there are multiple pages, convert to a single pdf with proper filename.
3. Go to Canvas and answer the canvas questions for the prelab. Note that the questions may be slightly different from the worksheet.
4. On the last question of the canvas prelab, upload the prelab worksheet.
5. Upon completion, submit the canvas prelab quiz.

Datasheet

1. Work on the experiment procedure paying to any safety notes
2. Fill in the datasheet as measurements are taken. Be sure to include your observations.
3. Take photos of the critical procedure as directed in the lab instructions. Place your ID in front of all photos taken.
4. Complete calculations and any other questions in the datasheet.
5. Scan your datasheet (which shows your ID) and combine with photos. Each photo should be in its own page.
6. Convert the scan pages to one pdf file and give it the proper filename
7. Upload the datasheet pdf file. Remember that experiment photos must be included, each page should have your ID shown.

Post-lab

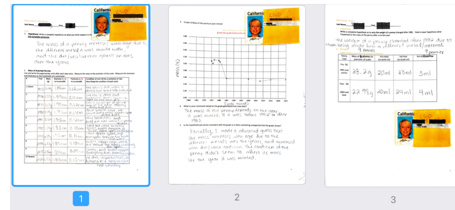
1. Complete the post-lab worksheet. Place your ID on top of the page of your worksheet (making sure you do not block any of your answer).
2. Take a photo (or scan) each page. If there are multiple pages, convert to a single pdf with proper filename.
3. Go to Canvas and answer the canvas questions for the post-lab. Note that the questions may be slightly different from the worksheet.
4. On the last question of the canvas post-lab, upload the prelab worksheet.
5. Upon completion, submit the canvas prelab quiz.

To see how to create scan pages, jpg or png files to a single pdf,
see next page or go to the Pdf conversion video in the module page (you must be in Canvas)
To see how to include ID with worksheet or photo, see the syllabus.
Filenames should be in the format: Lastnamefirstinital_AssignmentTitle_Date

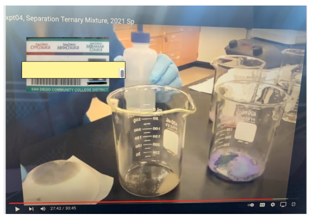
Showing college ID photos in your datasheet and experiment photos.

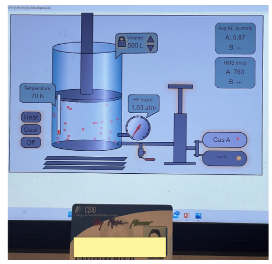
Submitting your lab (Experiments & Activity). The following is the procedure to uploading your work in Canvas. and the format to follow-

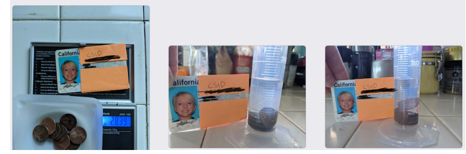
A. Always show College ID or redacted driver's license on all paper submitted. See example
B. Be sure that the file name is correct.
   lastnamefirstinital_title_monthdate i.e., IndobM_A1mathBasic_Jun27
C. Work must be legible including the photos submitted.
D. The submitted pages must be pdf format & compiled to one file. See examples.



For more information on this, please go to the orientation video from last semester and go to the 39:30 Mark [Orientation Video]







Convert files to PDF.

PC	Mac
MS Word	
Click the Microsoft Office Button, point to the arrow next to Save As, and then click **PDF** or XPS. In the File Name list, type or select a name for the **document**. In the Save as type list, click **PDF**. If you want to open the file immediately after saving it, select the Open file after publishing the check box.	On your **Mac**, open the **document** you want to save as a **PDF**. Choose File > Print. Click the **PDF** pop-up menu, then choose Save as **PDF**.
Google Doc	
Select a **document** that you wish to download as a **PDF** and open it. Go to "File", next click "Download as" and finally choose "**PDF Document**". It should download into your Downloads, or it will have an option to save into your desired folder.	1. Open **Google** Chrome and browse to the webpage you wish to save as a **PDF**. ... 2. In the "Print" window, click on the "**Change**" button underneath the print "Destination." 3. Under "Local Destinations", select "Save as **PDF.**" 4. Click on "Save".
Image of photo	
Open the **image** on your **computer**. Go to File > Print or use the Command+P keyboard shortcut. In the Print dialog box, select the **PDF** drop-down menu and choose Save as **PDF**. Choose a name for the new **PDF** and select Save.	1. Open the **image** you'd like to **convert** with the Preview app on your **Mac**. 2. In the top left corner, click File → Export as **PDF**… 3. Choose a file name or use the default, pick a save to location, click Save.
Jpg to pdf on a PC, multiple pages https://www.youtube.com/watch?v=ZO7RjdRARl0	Jpg to pdf Trick on a mac https://www.youtube.com/watch?v=u-wV3OlFUGg
Several Images (Batch Process) https://windowsreport.com/images-pdf-windows-10/	Several Images (Batch Process) https://www.macrumors.com/how-to/convert-images-to-pdf-macos-preview/
Scan Documents with your phone	
Scan documents using your Android. https://www.youtube.com/watch?v=FWlVYd2Zc-E	Scan documents using your iPhone. https://www.youtube.com/watch?v=7JNmdFtvNv8

Proper Lab Techniques and Safety Rules

Proper lab techniques ensures that your carry out the experiment so that you obtain the best possible results (and report) while conducting the procedure in a safe manner. Part of the umbrella of proper lab technique is conducting the experiment in a safe manner. The safety of yourself and your classmates is of paramount importance while in the laboratory. In the laboratory the chemist works with many potentially dangerous substances and equipment. The most general rules for safe laboratory operations are, be alert, stay alert, and take the trouble to understand what you are doing, and the potential hazards associated with the operation you are performing. The primary safety rule is to familiarize yourself with the handling with the hazards and then to do nothing that will endanger you or others.

1. Always wear safety glasses to protect your eyes from chemicals and broken glassware.
2. Shoes covering the tops of feet must be worn while working on experiments.
3. Never work alone in the laboratory - another adult should be able to be present when you are conducting the experiment.
4. Use ventilated area or turn on the vent over the stove when working with procedure that generates gases and fumes, or when conducting procedures involving flames. You can turn on the fan vent on your kitchen stove.
5. Never heat excess organic solvents (alcohol, hexanes, etc.) in an open vessel over an open flame. Excess is considered greater than 1 tablespoon. Organic solvents are highly flammable so only hot plates, or a heating mantle should be used around these flammable liquids.
6. Avoid pointing the mouth of a vessel that is being heated toward any person in the vicinity, including yourself.
7. Never heat chemicals of any kind in a fully closed system - the system must be open to air to prevent pressure build-up & explosion. An example of what **not to do** is placing a stopper on a test tube and then heating the content.
8. Never add anything (including water) to concentrated acid - instead **slowly** add acid to other substances to avoid acid splashing.
9. Lubricate glass tubes & thermometers with cooking oil then hold with a towel or thick gloves when pushing through a rubber stopper.
10. Never pipet anything by **mouth** - especially toxic or corrosive substances.
11. Immediately sweep up spill on the digital scale. Clean up all spills immediately in your work area.
12. Be sure to label all chemical containers correctly and as soon as you prepare the containers.
13. Do not perform any unauthorized experiments. These are experiments not described in this manual.
14. Beware of hot glassware – heated glass looks cool long before it can be handled safely.
15. Never throw matches, litmus, or any insoluble solids in the sink.
16. Avoid using excessive amounts of reagents - 1 to 3 mL is usually ample for test tube reactions.
17. Do not lay down the bottle stoppers. Impurities may be picked up and contaminate the solution when the stopper is returned. Always lay down paper towels or towels in the area you are working, that way you do not contaminate your work area. Wash the towel if contaminated.
18. Do not heat thick glassware such as volumetric flasks, graduated cylinders, or bottles; they break easily with heat. Always check glassware for stress and fatigue such as stars and cracks before using. Do not use the glassware if you suspect it will break upon usage.
19. Never pour anything back into a reagent stock bottle - take out only the amount that is to be used.
20. Tie back long hair and refrain from wearing flowing, fluffy clothing - both are fire hazards in the laboratory.
21. Be sure you have knowledge of exits, PPE, fire extinguishers, first aid kits, & other safety devices in the laboratory. You must have in possession or have access to, fire extinguisher, PPE (**personal protective equipment**) and first aid kit before you start the experimental procedures. If you do not show evidence of the safety equipment, you will lose in your experimental score.
22. Go to the grocery store and purchase a jug of distilled water for this course. Do not use tap water, it contains chlorine and other minerals that may interfere with some of your experimental results. You can boil water for 5 min and allow to cool for 30 minutes as a substitute to get chlorine free water. If the instructions call for deionized water, you could use distilled water.
23. Never use the thermometer as a stirrer. You may break the thermometer, and if the thermometer is a mercury type, some toxic mercury may be released.

24. Never use the thermometer as a stirrer. You may break the thermometer, and if the thermometer is a mercury type, some toxic mercury may be released.
25. Do not eat, drink, or chew gum while conducting experiments in this course. If you need to eat or hydrate, step outside of your work area to do so.
26. Do not use thermometers as a stirring rod. Use the glass stirring rod with the rubber policeman.
27. Pour all spent chemicals (waste) in a plastic bottle and seal with cap. Label the bottle properly and keep out of reach from others, especially children.
28. After using a piece glassware or other equipment, clean the equipment and return to its storage place.
29. When trying to detect by smell, the recommended method is by the wafting technique. In "wafting" a person takes an open hand with the palm towards the body and moves their hand over the substance in a gentle circular motion to lift vapors of the substance towards the nose.
30. Read the laboratory procedure completely before starting any experiment and pay attention to any precautions
31. Broken glassware must be clean up immediately. If the glassware contains chemicals, then the chemicals should be rinsed before collecting the broken glassware. Roll the glassware in several layers of newspaper and place in a plastic bag and label the bag. Turn this in with your spent chemicals and equipment at the end of the term.
32. Do not weigh hot items on the scale. The reading will not be accurate, and you may damage the scale. Wait until the item is at room temperature before weighing.

Safety regulations must always be observed as it only takes one accident to cause blindness or serious permanent injury. **Safety glasses, lab coats and nitrile gloves must be worn at all times.** In all photos you submit in which you are in the photo must show you wearing these PPE (personal protective equipment, especially the safety goggles) otherwise your lab technique score will be affected.

SAFETY STATEMENT: I am aware that there are hazards associated with being in a chemistry laboratory. I have been made aware of the safety equipment available in the laboratory room and how it is to be used. I have also been made aware of some common hazardous such as: broken glass fire, acids, bases, and the poisonous nature of most chemicals. I will always wear my PPE when working on the experiments. I understand that special precautions for individual experiments will appear in the lab manual in a section entitled "Safety". (Please sign below).

______________________________	______________________
Signature	*Date*
______________________________	______________________
Print name	*(CSID) College Student ID Number*

Safety Quiz (Sample quiz, the online safety quiz may vary)

____/ __ Score

Name last: ____________________ First _____________ Date ___________

Indicate in the space provided whether each of the following lab safety statements is True (T) or false (F). These questions will be different in Canvas. You are responsible for the version in Canvas.

1_____ Students must purchase and use protection eyewear when conducting experiments. Eyewear equipment must meet the standards of the American National Standards Institute for "Practice for Occupational and Educational Eye and Face Protection" (ANZI Z87.1). Safety eyewear cannot be removed until the whole experiment is done and all chemical and equipment are put away. Only when it is safe are you allowed to remove the PPE.

2_____ Before working on an experiment, students must possess and have handy fire extinguisher, first-aid kit, baking soda, phone to call 911, and other safety equipment in the laboratory.

3_____ It is okay to eat or drink in the lab while conducting experiments, but it is never permissible to smoke in class.

4_____ It is never permissible to taste chemicals that is used in this course. All chemicals that are to be used in the experiments are to be considered hazardous unless instructed otherwise.

5_____ Wafting is a technique to smell gas, by placing the odorous material directly under your nose.

6_____ If any chemicals contact your skin or eyes, flush immediately with water.

7_____ Although most rules indicate you should never place material used in this course into your mouth, there are some exceptions that allow some materials to be place in your mouth such as a pipette.

8_____ Perform all reactions that involve gases with an unpleasant odor in a well-ventilated area or under a stove with the ventilator turned on.

9_____ When heating a test tube, make sure the test tube is completely closed so that nothing spills.

10____ Thick, heavy gloves should be used, and glassware should be lubricated with cooking oil or water when inserting glass tubing (i.e., thermometer) into a stopper.

11____ It is okay to perform unauthorized experiments in this course.

12____ Immediately clean balances/scales after use. In other words, do not leave the scale uncleaned until the next time you use it. Clean while you work.

13____ It is okay to dispose of all solutions including all organic chemicals down the sink.

14____ Pour acids into water (not water into acid) because the heat release will be absorbed by the water so that splattering is avoided.

15____ It is okay to disregard or ignore the special safety precautions mentioned in each experiment.

16 ____ Wear closed-toe shoes always when working experiments in this course.

17 ____ If glassware breaks while in use, it is okay to leave it alone, not clean it up, and not tell anyone.

18 ____ Read all parts of an experiment (Objectives, Discussion, Procedure, & Pre-lab Assignment), before performing each lab.

19 ____ It is okay to use an excess amount of chemicals for an experimental procedure. If the chemical is unused, it can always be returned to the original container.

20 ____ An important general rule when performing experiments in this course to be alert, stay alert, and take the trouble to understand the potential hazard associated with each experiment.

21 ____ It is okay to heat organic, flammable solvents directly over the alcohol burner rather than a hot plate.

22 ____ All glassware should be inspected for stars, cracks, or stress before usage and especially before heating.

23 ____ It is permissible to place chemicals directly on the metal platform of the balance pan when using the balance scale.

24 ____ When an experiment calls for water, use distilled or deionized water, it is okay use water directly from the faucet (tap water).

25 ____ When completing the experiment, all equipment is to be returned to its the lab kit; all excess solid chemical waste should be placed in a designated waste container; work area should be straightened-out and clean; and students should wash their hands.

This quiz is your contract that you will abide by all safety rules of the laboratory. Failure to comply will reduce your grade on this safety quiz and may result in being asked to drop the course for your own safety or the safety of others is at risk.

Initials__________

01Lab | Activity 01: Math Basics and Dimensional Analysis

Last Name________________________**First**_________________________ ___ **/** __ **pts**

For this activity you are to input answers in Canvas via the quiz app.

After showing your work on this page, upload this worksheet in the quiz app in Canvas.

Note that these questions may be slightly different from those found in Canvas. Numerical questions will have different data, but the concept of the question is the same. Answer these questions here with the given data. In the Canvas version, you use the same strategy in solving the problems but use the numerical value and conditions given in Canvas. Yes, you are solving the problem twice, but applying the concept once. Please review the following before working on this activity. Rules of Significant figures: https://www.youtube.com/watch?v=9WFxkxFXb20

Answer all questions when instructed with the correct number of significant figures and in scientific notation.

I. Rounding off Numbers.

a. Round to the hundredth place: 21.46499 = ___________

b. Round to the tenth place: 482.4506 = ___________

c. Round to the thousandths place: 4.150479 = ___________

d. Round to the first place: 101.45154 = ___________

e. Round to the hundredth place: 21.873451 = ___________

f. Round to the ten-thousandths place: 111.432101 = ___________

II. Significant figures. Write the number of significant figures for each of the numbers below.

a.	0.0180	___3___	b.	9.70	___________
c.	0.090	___________	d.	405.00	___________
e.	0.001	___________	f.	16.90	___________
g.	9040	___________	h.	60	___________
i.	40210	___________	j.	0.000640	___________

III. Scientific Notation. Rewrite the numbers below in scientific notation.

a.	5	___________	b.	0.000 000 110	___________
c.	7,100	___________	d.	600,600,000	___________
e.	67,000	___________	f.	0.010 2	___________
g.	0.000 100	___________	h.	0.001 49	___________
i.	0.000 63	___________	j.	1,106,140,000	___________

IV. Math operations using significant figures.

Answer the following using the correct number of significant figures. For each, write the raw answer first (write the raw answer **up to 5 places after decimal place**, to the hundred-thousandth of place)
then rewrite the rounded-off answer in the parenthesis. Use scientific notation where appropriate.

To enter an answer in Canvas with scientific notation, use '**e**' to represent '**×10^**'. e.g. Enter 6.022×10^{23} as 6.022e23 or 4.163×10^{-4} should be entered as 4.163e-4.

It is important to keep to this format because other formats will not be recognized by Canvas & it will be marked wrong.

a. $1.0 + 3.88 =$ 4.88 (4.9e0)

b. $64.0 - 2.15 =$ ________ (________)

c. $6.944 + 4.3 =$ ________ (________)

d. $114.45 - 20. =$ ________ (________)

e. $5.386 - 3.11 =$ ________ (________)

f. $\frac{0.24}{68.00} =$ ________ (________)

g. $\frac{0.6140}{0.00093} =$ 660.21505 (________)

h. $(2.3 \bullet 10^{-3}) \times (2.501) =$ ________ (________)

i. $\frac{1.320\bullet10^{6}}{6.01} =$ ________ (________)

j. $(4000) \times (2.6789 \bullet 10^{-6}) =$ ________ (________)

V Math operations using power-of-ten:

Calculate each and write your answers in scientific notation .

a. $(2.50 \times 10^{-1}) \times (0.300 \times 10^{-2}) =$ ____________

b. $(100.1 \times 10^{3}) \div (0.200 \times 10^{-3}) =$ ____________

c. $\frac{2.0\ x\ 10^{2}}{4x10^{-1}} =$ ____________

d. $2.0 \times 10^{2} \div 4 \times 10^{-1} =$ ____________

e. $(8.00 + 1) \times (10^{-1}) =$ ____________

f. $8.00 \times 10^{-1} + 1 \times 10^{-1} =$ ____________

g. $(10.62 \times 10^{2}) + (1.63 \times 10^{3}) =$ ____________

*HINT: Answers c & d should be different. Answers e & f should be the same.

VI Determine the following conversion factors.

Use only the conversions found in the **appendix** and write your answers to at least 3 significant figures.

a. 1.00 lb = ____________ g

b. 1.00 lb = ____________ kg

c. 1.00 oz = ____________ g

d. 1.00 qt = ____________ ml

e. 1.00 qt = ____________ L

f. 1.00 gal = ____________ L

g. 1.00 in = ____________ cm

h. 1.00 m = ____________ in

i. 1.00 cup = ____________ ml

j. 1.00 fl. oz = ____________ ml

VI Answer the following using dimensional analysis.
Note that the values in this exercise may be different from the version found in Canvas.
Show all calculations in the space, below the question. You will not receive credit for showing work if it is not show in this area.

a. How many kilograms in 155.5 lb?

b. How long in centimeter is a 30.5-inch waist?

c1. A Prius automobile requires 11.9 gallons of gasoline (gas) for a full tank. How many mL of gasoline is needed for a full tank in this Prius?

c2 Refer to the above question. If gasoline has a density of 0.750 grams per mL, what is the mass (in grams) of this volume of gasoline? (Remember that 0.750 g/ml is a measured conversion factor.)

d. How fast is a car moving in cm / sec if its speedometer reads 65.00 mph?

e. How many pennies are needed (1.95 cm diameter) to stretch from the earth to the sun? It takes 8.00 minutes and 25.0 seconds for light to travel from the sun to the earth traveling at 186,282 mi/sec.

f. How much is this worth in dollars?

Do not forget to upload this activity worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)
No credit will be given if this worksheet is not uploaded. It must show your answer and show your work.

For next week,
Check to make sure you have all the chemicals and supplies for next week's experiment.

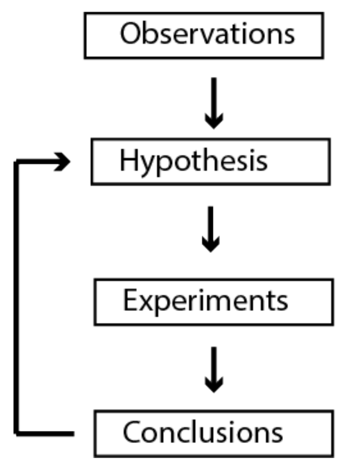
02Lab | Experiment 01: A Penny for Your Thought; Scientific Method Introduction

Objective
This experiment aims to familiarize students with the Scientific Method, to learn to distinguish between chemical and physical properties, and to write a supported conclusion based on their experimental data & observations. Students will form a hypothesis, test it, revise it, and test it again. Students learn about laboratory equipment and solutions, including balances, rulers, and working with strong acids in the hood during this process. In addition, critical thinking skills will be developed as the students formulate a conclusion from their data.

Equipment and Chemicals

KLM Equipment	100-ml graduated cylinder	Petri Dish berel pipet	Wash bottle
Miramar supply	10% HCH_3CO_2 (Acetic Acid)	Forceps	Digital Pocket Scale
	Pre-cut pennies, pre-80 and post-83	Metric ruler	Weighing boat
You supply	Pennies (1960 – 2000)		

Introduction
Begin by Reading: Ch 1.2 *Chemistry in our Lives* Timberlake 5th Edition. "Scientific Method: Thinking Like a Scientist." Familiarize yourself with Questions 1.7 and 1.9 at the end of this section. In addition, read Chapter 2.7, "Density" & Chapter 3.2, "States and Properties of Matter."



Pennies & Mass
For this experiment, we begin with the question, "What happens to the mass of a coin as it ages?" A hypothesis is written for what is predicted to happen to the mass of a penny as it ages. The mass may increase with dirt and oils adhering to the surface. It may also wear and lose mass. You will be asked to make a prediction. Experiments will follow that may or may not support your hypothesis.

Physical & Chemical Properties
In the following experiments, you will be asked to record observations about pennies' physical and chemical properties. Physical properties include color, size, density, and hardness. Chemical properties describe the reactivity of a substance, including flammability. In a chemical change, a chemical reaction occurs, and a substance is converted into one or more new substances.

One physical property that will be determined in this lab is the density of the penny. This is calculated based on the equation-

$$Density = \frac{mass\ (g)}{volume\ (mL)}$$

Note that mL = cm^3 = cc

Conclusions
You will be asked to write a conclusion based on the data and observations from your experiments. You must cite your conclusion's physical properties and chemical changes to support it. If your conclusion does not support your hypothesis, you may need to revise it and design new experiments.

Note: It is your responsibility that you upload the correct file in Canvas. If you upload the wrong file or extraneous pages, i.e., a description of the experiment rather than the worksheet, you will lose lab technique points at best or receive zero for that portion of the lab.

For **all experiments**, you will need to write your observations as you perform the experiment. The written observations will be part of the grade for each experiment.

The basis of your grade in this lab will depend on how well you follow oral and written directions. For example, if you are instructed to show your work, then show your numerical calculations either on the margins of the datasheet of the lab manual or some scratch paper. You will need to upload the scratch paper. If the directions call for writing the answers in scientific notation with units, be sure you do so; otherwise, your answer may not receive credit, even if the numerical answer is correct.

Read the directions below and be sure to answer the questions as you progress through the experiment.

If you cannot find pre-1982 pennies, use the data that is found in the Canvas. You must be logged in to Canvas to access the data.
https://sdccd.instructure.com/courses/2458176/quizzes/5558074?wrap=1

Procedure – Part I

1 **Write a hypothesis** using complete sentences on how the mass of a penny changes with age.

2 **Sort Pennies.**

Photo1: Take a picture of ten pennies, all in the weighing pan of the digital pocket scale.

a. Gather your pennies station and sort the pennies based on the year minted.

b. **Note** the condition for each side of the coin. For example, place pennies minted before 1981 in one pile, pennies minted between 1982 - 1983 in another pile, and finally, pennies minted after 1983 in the third pile. Keep these piles until the end of the lab.

c. Find two pennies minted in each of the decades 1960s, 70s, 80s... and sort them in increasing order according to the year the coin was minted. If you do not find pennies from each decade, especially those minted in the 60s, ensure you have an even number of older pennies to newer ones. Older pennies are those minted before 1983.

3 **Determine the mass** of various pennies.

a. Weigh each of the 10 pennies on the scale and record the mass in your datasheet from oldest to newest. Write the mass and the unit in your datasheet. Use the forceps (tweezers) when handling the pennies here after. 5 pennies need to be minted before 1982 and 5 pennies minted after 1983.

b. Record the detailed condition for each of the coin, citing the physical properties.

c. Prepare a graph with proper labels including units. **Write a descriptive title for your graph**.

d. **What are the axes labels in the graph and write the units in parenthesis**?

e. Take the information you collected and place a "o" for the mass of each penny with its year minted.

f. See the class data by clicking on this link. Class Data

4 What conclusion can you draw from your data? Be sure to cite specific evidence from your data to support your conclusion. Use the class result to provide an overall view of how the mass of a penny changes with age. Does your graph show a gradual increase or decrease of the mass with age? Is something unexpected found from the data?

5 Does your conclusion support your hypothesis? Answer this question in your data sheet.

Photos: Take these photos during the procedure.

Photo1: Take a picture of ten pennies all in the weighing pan of the digital pocket scale. Part 1

Photo2: Take a picture of the pennies submerged in the graduated cylinder with the volume of the water shown. Part 2

Photo3: Pic of the penny halves in the acetic solution. This is in Part 2

Submit the photos with the datasheet (please do not embed photo in the datasheet, each photo must be its own page.
In addition, each photo should show your college ID in the foreground.

Experiment 2: Data Sheets

Last Name________________________First_________________________ **____ / _____ pts**

Part I

1 **Hypothesis**: Write a complete hypothesis on what you think happens to the mass of a penny with age.
<u>Use complete sentences</u>.
If your hypothesis proves true, sketch a graph of what it would look like in the graph chart in the next page. Assume the average mass of a penny centers around 2.80 g If your hypothesis states newer pennies weigh less than older ones because of grime and oxidation to the older pennies then start with new pennies having less mass than 2.80 g and older pennies having mass more than 2.80 g. (See 3 on the next page)

2 **Mass of Assorted Pennies**
Use and write the appropriate units after each data entry. Measure the mass to the precision of the scale. Measure the diameter and thickness to the <u>hundredth</u> of a centimeter. Use the star * rating to rate the condition. In addition, write a description of the condition of the penny.

Remember that the data must have 5 pennies minted before 1982 & 5 pennies after 1983. No two pennies can have the same minted year.

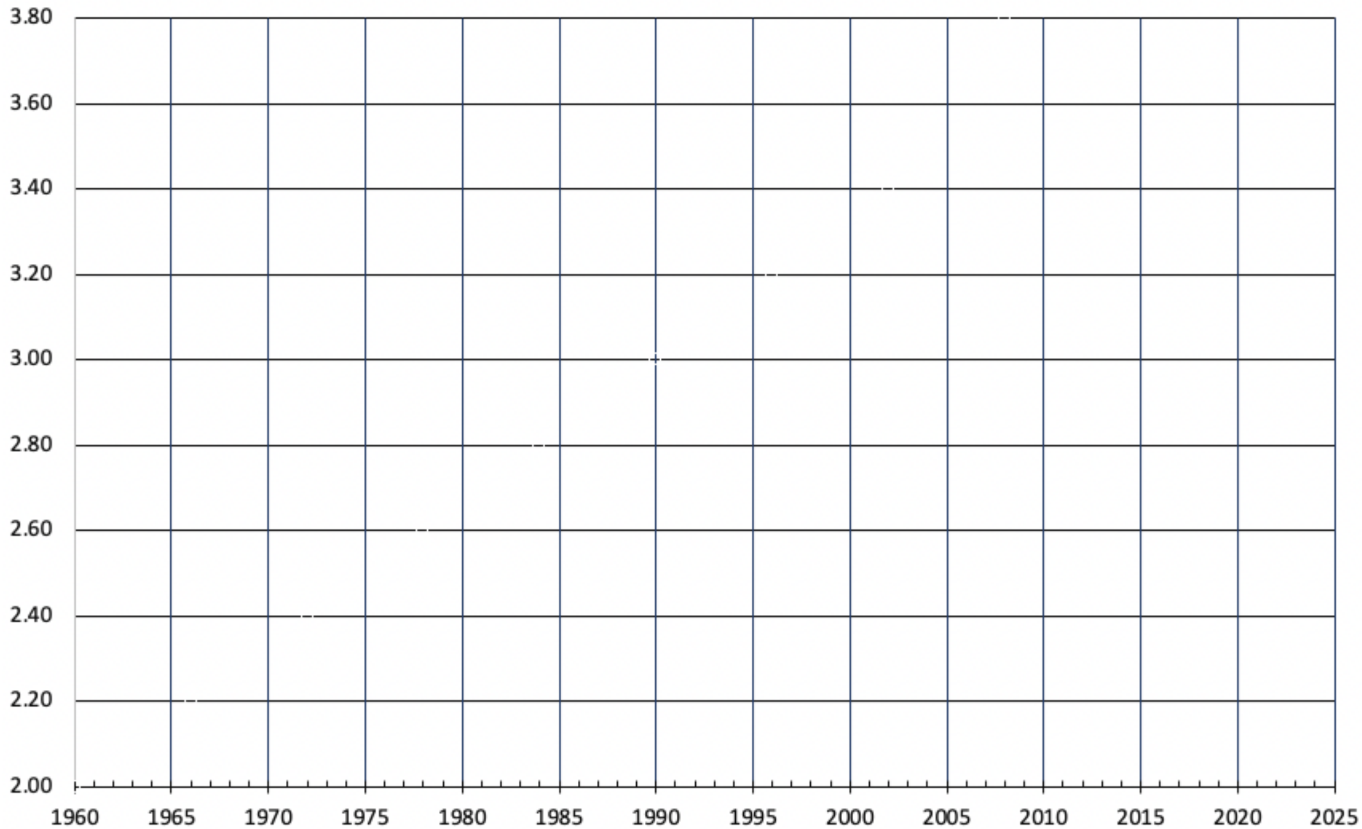
#	Year	Mass	Diameter (**cm**) to hundredth Two digits past the decimal.	Thickness (**cm**) to hundredth Two digits past the decimal.	Star Rating: * = V. Poor *** = Medium ***** = Mint	Condition of coin. (Write a sentence or two describing the condition of each coin)
1 Oldest						
2						
3						
4						
5						
6						
7						
8						
9						
10 Newest						

3 Sketch a graph of what your hypothesis graph based on your hypothesis then-

4 Graph of Mass of the penny vs year minted.

(**Label the graph axis below with proper description labels and units and write a descriptive title.**)

See the example in the prelab.



5 What is your conclusion based on your graph and that generated from the class data?

6 Is the hypothesis you wrote consistent with the graph or is there something unexpected that the graph shows? Discuss the difference between (if any) between your graph and the data graph.

Procedure – Part II

1 **Write a hypothesis** about *why* the pennies' mass changes that is consistent with the unexpected result found in the first part of this lab.

2 **Determine the Density of the Pennies** Sort 25 pennies, all of which are either older (minted before 1982) or newer (minted after 1983).

Photo2: Take a picture of the pennies submerged in the grad cylinder with the volume of the water shown.

If you cannot find 25 pennies for each group, use the data that is found in the Canvas. Use the following link. You must be logged in to Canvas to access the data. https://sdccd.instructure.com/courses/2458176/quizzes/5558074?wrap=1

a. Take the stack of 25 pre-1982 pennies, place these on the scale and record the total mass of the 25-pennies. Repeat this for the newer pennies and record the mass.

b. Calculate the average mass of the pre- and post-pennies by dividing the total mass by 25. Show this calculation in your worksheet.

c. Fill a 100-ml grad cylinder with water to the 20.0-ml mark. Use a dropper to get the meniscus exactly to 20.0 mL. When reading the initial and final volume, the measurements should be read to the nearest 0.1 mL. This will be explored in more details in the next experiment.

d. Carefully place 25 pre-1982 pennies into the cylinder. Avoid trapping air bubbles under the pennies or splashing water up the sides of the cylinder.

e. Accurately measure the total volume of the water and the pennies. Record this measurement in your datasheet. Show this calculation in your worksheet.

f. Remove the pennies and thoroughly dry them with paper towel. Return the dry pennies to their original container.

g. Calculate the average volume of the pre-1982 pennies by dividing the total volume of the pennies by 25. Repeat this for the post-1983 pennies. Show this calculation in your worksheet.

h. Calculate the average density of pre-1982 and post 1983-pennies. Show this calculation in your worksheet.

3 **Physical Observations of Appearance**

a. Find the precut pennies in the material provided by Miramar College. Place these in two separate Petri dishes. Your instructor may demonstrate this part for you in a YouTube video to save on pennies.

b. Examine the interior of the two half-pennies and record your observations in your datasheet. Cut Pennies Click on the link. The penny to the left is pre-1982 and the penny to the right is post 1983.

4 **Chemical Properties of the Pennies**

If you do not want to handle the acid, you can watch the video showing how each penny reacts with the HCl. However, when you perform this experiment, you will use vinegar (5% acetic acid). The link of two pennies is given. The penny on top was minted 2012 and the penny on the bottom was minted in 1975. https://www.youtube.com/watch?v=gIRFiR4vSPU The penny on the left is minted in 2012. The penny to the right was minted in 1975.

a. Using forceps, take half of each type and put them in a Petri dish. Place the Petri dish with the pieces of pennies under the hood.

b. Add a small amount of 5% acetic acid. Although acetic acid is considered safe, handle all acids used in this lab with caution. Observe any difference in chemical reactivity between each of the halves for the two pennies. Such differences, if they occur, can be taken as evidence of differences in composition. *To save on pennies, your instructor may demonstrate this part for you.*

Photo3: Pic of the penny halves in the acetic solution

5 **Conclusions.** What conclusion can you make based on your data? Use the evidence in this experiment to support your conclusion. Write your answers in complete sentences.

6 Draw a flowchart of the scientific method you employed in this experiment **with specifics as it relates** to this experiment for each block in your flowchart. To see an example of a flowchart, go to: https://courses.lumenlearning.com/wmopen-geology/chapter/scientific-processes-in-geology/

Photos: Take these photos during the procedure.

Photo1: Take a picture of ten pennies, all in the weighing pan of the digital pocket scale. Part 1

Photo2: Take a picture of the pennies submerged in the graduated cylinder with the volume of the water shown. Part 2

Photo3: Pic of the penny halves in the acetic solution. This is in Part 2

Submit the photos with the datasheet. Each photo should show your college ID in the foreground.

For next week,

Check to make sure you have all the chemicals and supplies for next week's experiment.

Data Sheets - Part II

Last Name_________________________**First**__________________________

1. **Hypothesis**:
   Write a complete hypothesis as to why the weight of a penny changed after 1982. Your hypothesis must provide an explanation of what happened to the mass of the penny after a certain year.

2. **Density –**

   Table of Measured Mass & Volume of Pennies

Penny Type	Mass of 25 pennies (to the precision of scale)	Vol initial (to **tenth ml**)	Vol final (to **tenth ml**)	Vol of 25 pennies
* Pre- '82 1981 and earlier (Use Canvas Data)				
Post - '83 1983 and later				

* Use the data provided in Canvas if you do not have enough pre-1982 pennies. You are responsible for weighing 25 post-1983 pennies for this procedure.

Observations: Write what you observed when you looked inside the pennies and how did the pieces of the penny react with acid. You should also write any other observations while performing this experiment.

Calculation of Density- Avg. mass, volume, and density of pre-'82 and post-'83 pennies.

Show the calculation in the space provided.

Type of penny	Average Volume	Average Mass	Density
pre – 1982			
post – 1983			

Show calculations for the average volume, average mass, & density. Use the correct number of significant figures & write units.
Show all calculations in the space below the question. You will not receive credit for showing work if it is not shown in this area.

Calculation of average volume.

Calculation of average mass.

Calculation of density.

Photos: Take these photos during the procedure.

Photo1: Take a picture of ten pennies all in the weighing pan of the digital pocket scale. Part 1

Photo2: Take a picture of the pennies submerged in the graduated cylinder with the volume of the water shown. Part 2

Photo3: Picture of the cut side of the two penny-halves submerged in acids. This is in Part 2

Submit the photos with the datasheet. Remember there is two parts of this lab and two sets of data sheet.

Each photo should show your college ID in the foreground.

02Lab.| Experiment 01: Scientific Method: Penny Lab, Pre-Lab

Last Name _________________________First__________________________ ____ / _____ **pts**

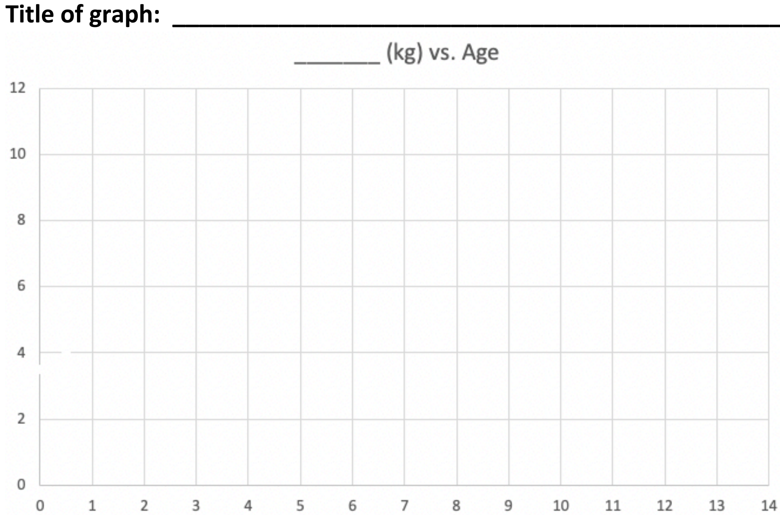
Pre-Lab Questions

1. Graph the following data and label it properly. Use the metric units and choose any gender.
   Label the x-axis age and the y-axis mass with **proper units**, then **give a proper descriptive title for the graph**.

Age:	50th percentile Male babies	50th percentile Female babies
At Birth	7.8 lbs. (3.5 kg)	7.5 lbs. (3.4 kg)
0.5 months	8.8 lbs. (4.0 kg)	8.4 lbs. (3.8 kg)
1.5 months	10.8 lbs. (4.9 kg)	9.9 lbs. (4.5 kg)
2.5 months	12.6 lbs. (5.7 kg)	11.5 lbs. (5.2 kg)
4.5 months	15.4 lbs. (7.0 kg)	14.1 lbs. (6.4 kg)
6.5 months	18 lbs. (8.2 kg)	16.5 lbs. (7.5 kg)
8.5 months	20.1 lbs. (9.1 kg)	18.3 lbs. (8.3 kg)
10.5 months	21.6 lbs. (9.8 kg)	19.8 lbs. (9.0 kg)
12.5 months	23.1 lbs. (10.5 kg)	21.4 lbs. (9.7 kg)

Use this prelab question to prepare you for the type of graph you are to create in this experiment.

Title of graph: ____



2. Read the following passage and then write a hypothesis based on this passage.

Water can stick to other water molecules by a special glue called intermolecular force. This happens because water is polar and polar chemicals stick to other polar chemicals. On the other hand, chemicals like organic solvents such as vegetable oil are nonpolar. Nonpolar chemicals will stick with other nonpolar chemicals. Dirt and grease for example are also nonpolar, that is why dirt and grease mix well. Water not good enough to wash away dirty material.

Write a hypothesis on why a penny that is clean can hold more drops of water compared to a penny that is dirty.

Do not forget to upload this prelab worksheet to Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

02Lab.| Experiment 1: Scientific Method: Penny Lab, Post-Lab

Last Name ________________________First_________________________ **____ / _____ pts**

Post Lab Questions

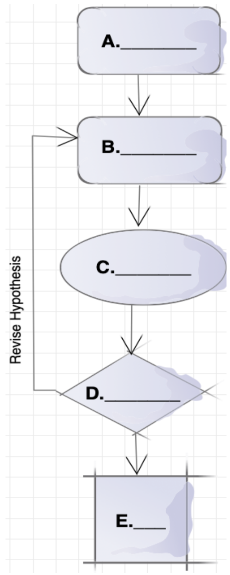
Answer these postlab Questions in Canvas.

1. Describe the inside of the pre-1982 and the post-1983 pennies. They should be different.
   (Use complete sentences in your description)

2 Describe your observations of what occurs when the pre-1982 and the post-1983 cut pennies are exposed to acetic acid.
   (Use complete sentences in your description)

3. Based on your Observations, Experimental Data, and Calculations, write a conclusion for Part II of this experiment.
   Be sure to cite all the evidence from your data to support your conclusion. Be as specific as possible. State the values calculated or the exact observations made. There are a minimum of three pieces of evidence obtained in this experiment.

4 . Flowchart:
Below is a flow chart template illustrating how the scientific method was used in Part I and II.



(2pts)
Label the flowchart with the proper heading based on the tenant of the Scientific Method.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

Choose from the following for each letter.

Experiment	Conclusion	Abstract	Hypothesis
Chance	Faith	Observation	History
Law	Vision	Validation	Theory

(4 pts) Match the statements to the tenet of the Scientific Method. The tenet of the Scientific Method shown are represented by letters in the flowchart, see previous problem. Each tenet can have more than one statement match. If there is no match simply write **None** in the blank. Also, note that not all Letters in the flowchart might have a match.

#	Letter	Statement
i	_______	The year of minting, mass, thickness, and diameter measurements were recorded for five pennies minted before 1982 and five pennies minted after 1982.
ii	_______	Pieces of pre-1982 and post-1983 pennies were cut up and exposed to acid to determine if they reacted differently.
iii	_______	Pennies minted after 1983 have less mass because they were minted with different material.
iv	_______	The reason why pennies minted after 1982 weigh less than pre-1982 pennies is that they have smaller volumes.
v	_______	What happens to the mass of pennies with age?
vi	_______	Based on the difference in densities, the reaction with acid and what the inside color of pre-1982 and post-1982, it is concluded that pennies are made from different material.
vii	_______	The mass of a penny decreases with age due to wear and tear on the older pennies.
viii	_______	The densities of the pre-1982 and post-1983 pennies were determined by measuring their mass and volume.

Do not forget to upload this postlab worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

03Lab | Experiment 02: Measurements, the Metric System & Density

Objective

The experiment aims to become familiar with the metric system by taking measurements using metric units. Additionally, in this experiment, different measurements will be taken using different devices, and then report these measurements to the correct precision based on the apparatus used. Finally, each measure will be converted to other units using dimensional analysis, and the answers will be written to the correct number of significant figures.

Equipment and Chemicals

KLM Equipment	100-mL beaker 250-mL beakers 400-mL beaker	5 mL grad cylinder* 50 mL grad cylinder 100 mL grad cylinder	13 x 100mm small test-tube Thermometer Evaporating Dish	wash bottle
Miramar supply	Cube (use plastic)	Digital Pocket Scale Metric Ruler	Berel pipet	Weighing boat
You supply	Measuring tape	Scientific Calculator	String or piece of paper	

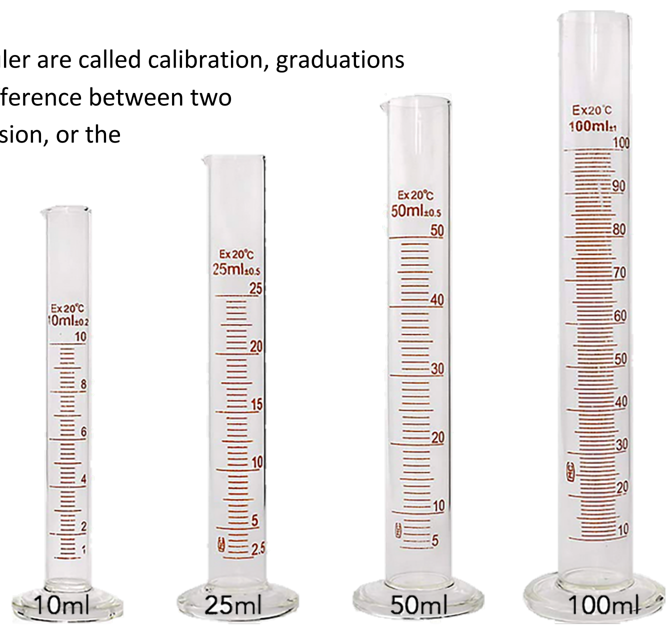
* If the KLM kit does not have a 5-mL graduated cylinder or vice-versa. You can use one or the other. Both have graduated of 0.1mL and will work in this experiment.

Introduction

Additional Reading: Ch 2.1 – 2.7, *Chemistry in our Lives, 6th Edition* Timberlake. *"*Chemistry and Measurements." For this experiment, you will be taking measurements with several different laboratory tools. Emphasis in grading will be placed on recording measurements with proper significant figures and with proper units. Please review the YouTube on "Measurements and Significant Figures".

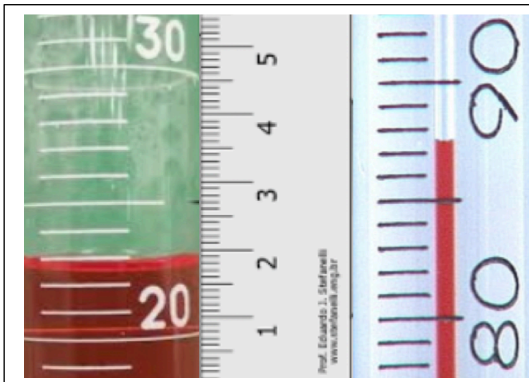
Notes on how to determine precision:

The fine lines that run along a thermometer, graduated cylinder or ruler are called calibration, graduations or hash marks. The precision of the measurement is based on the difference between two consecutive hash marks. This difference is called delta (Δ). The precision, or the uncertainty is calculated to 10% of Δ.



Graduated Cylinder: The calibration for graduated cylinders varies depending on the size. Click on the image (if you are on your computer) to download the full size of the image to see the calibrations more clearly. The 100mL and 50mL graduated cylinders have calibrations of 1-ml and measurements should be read to the nearest 0.1 mL The 10mL graduated cylinder has a calibration of 0.1-mL and should be read to the nearest 0.01 mL. The 25-mL graduated cylinder's precision is a bit confusing but because the graduation is 0.2 mL (look at the magnified view for this cylinder by clicking on the image), then the readings must be every 0.05 mL +/- 0.05 mL increments. This is discussed more in this video. https://youtu.be/3NefD8UQ6y0?list=PLF34FCDB88DEF731B&t=381

The figure to the right show four sizes of graduated cylinders, each with different calibrations. For the graduated cylinder shown, Δ = 1 ml, so 10% of 1 ml is 0.1 mL. The reading for the graduated cylinder is 22.5 mL +/- 0.1 mL. The volume is read at the bottom of the meniscus which is where the dark red meets the light red. Noticed that the .5 mL reading in 22.5 is the uncertainty, the reading could easily have been read 22.4 mL or 22.6 mL, that is why the +/- 0.1 mL is written, to indicate the uncertainty or the measurement.



Grad. Cylinder Ruler Thermometer

Ruler: For the ruler, the units are centimeter and Δ = 0.1 cm, so 10% of 0.1 cm is 0.01 cm. If the ruler is used to measure the 20-mL mark of the adjacent graduated cylinder, then the reading would be 0.74 cm +/- 0.01 cm.

Thermometer: For the thermometer, the units is °C. (the degree character can be accessed by command+shift+8 in your computer). The Δ for the thermometer is 1°C, so 10% is 0.1°C. The temperature reading is 87.7°C +/- 0.1°C.

You will also make estimates in each of these measurements. The precision when you estimate a measurement should not be to the same degree as your measurements above since this is an estimate. It should only be to the first place., i.e. How much time does it take to drive from Petco to Dodger Stadium. You will not give an answer like 2hr, 14mi, 36 sec. An estimate of ~ 2 hr would be the acceptable answer.

Photos

Take these photos during the procedure and don't forget to include your ID in the foreground of the photo.

Photo 1: Take a digital close-up photo of the temperature reading of the thermometer in the beaker of water.

Photo 2: Take a digital close-up photo of the mass reading of the cube on the scale.

Photo 3: Take a digital close-up photo of you measuring the width of your palm.

Photo 4: Take a digital close-up photo of the three graduated cylinders with ¾ full of liquid water.

Photo 5: Take a digital close-up photo of the graduated cylinder with cube submerged showing the water level and the cube.

For next week, check to make sure you have all the chemicals and supplies for next week's experiment.

Procedure

Part I – Metric Measurements & Estimates

Measuring Temperature

Go to the link here before you start and read the proper procedure on how to read a thermometer. Thermometer Reading. Temperature is measured in Celsius in a laboratory setting. The lines or graduation marks (Delta, Δ) on the thermometer represent 1˚C increments in temperature. Your recorded measurement of the temperature should estimate between the lines and carry with it one decimal places (tenth) or precision to 0.1 ˚C (10 % of the Delta, Δ).

Fill a 250 ml beaker 3/4 full (125 mL) with tap water and allow it to reach room temperature, about 30 minutes.

Proceed with other parts of the laboratory while you wait for the temperature to equilibrate.

Record the temperature of the water with the correct number of significant figures and proper units. Be sure you use the abbreviation of the unit and do not spell it out. Furthermore, do not include the error, i.e., +/- 0.001, when writing the magnitude.

Photo 1: Take a close-up photo of the temperature reading of the thermometer in water.

A **meniscus** as seen in a burette of colored water. '20.00 mL' is the correct depth measurement.

By PRHaney (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia

Source: File:Meniscus.jpg - https://en.wikipedia.org

Measuring Mass

Go to the link here and read the proper procedure on how to read a scale. Scale Reading. Measure the mass of the following objects. You must record all significant figures from the balance. This means measurements to 0.01 g. If the numbers on the scale fluctuate, keep perfectly still when recording the mass. Be sure you use the abbreviation of the unit and do not spell it out. Furthermore, do not include the error, i.e., +/- 0.001, when writing the magnitude.

a. Cube
b. 100 mL beaker
c. 5 mL graduated cylinder

Photo 2: Take a digital close-up photo of the mass reading of the cube on the scale.

d. Estimate the mass of your scientific calculator to the nearest gram. Do **not** measure it on the scale just estimate the weight. The precision should not be to the same degree as your measurements above since this is an estimate.

Measuring Length

Go to the link here and read the proper procedure on how to read a ruler. Ruler Reading.

Measure the following lengths, in centimeters, using a ruler or measuring tape (that has metric units), and record the measurements in your datasheet with the correct number of significant figures and units. Record the measurement to the precision of the ruler. On the ruler the lines represent millimeters or 0.1 cm. Therefore, your measurements should be recorded to the 0.01 cm. Be sure you use the abbreviation of the unit and do not spell it out. Furthermore, do not include the error, i.e., +/- 0.001, when writing the magnitude.

a. The width of your palm centimeters
(Trace your right palm on a piece of paper and then measure the width from this trace)
b. The length of one side of the plastic cube
c. The circumference of a 400 mL beaker
(Use a string or paper to wrap the circumference of the beaker,
mark the point in which the sting or paper first intersects and then measure that length)

Photo 3: Take a photo of you palm traced on a piece of paper and a ruler showing the width.

d. Estimate the length of your calculator to the nearest centimeters. Do **not** measure, just estimate. The precision should not be to the same degree as your measurements above since this is an estimate.

Measuring Volume

Go to the link here and read the proper procedure on how to read a graduated cylinder. Graduated Cylinder Reading.

For each of the 3 graduated cylinders, do the following procedure.

1. Determine the value of each increment in milliliters.
2. Fill each cylinder three fourth (3/4) way. The exact amount is not important.

3. Read and record the volume in milliliters for each of the three graduated cylinders that you just filled with water. Record the volume from the bottom of the meniscus. Be sure you use the abbreviation of the unit and do not spell it out. Furthermore, do not include the error, i.e., +/- 0.001, when writing the magnitude.
    a. 100 ml graduated cylinder (to nearest 0.1 ml)
    b. 50 ml graduated cylinder (to nearest 0.1 ml)
    c. 5 ml (or 10-mL) graduated cylinder (to nearest 0.01 ml)

Photo 4: Take a digital photo of all three graduated cylinder filled with water.

d. Estimate Fill one of your test tubes to the top and estimate the volume of liquid to the nearest ml. Do **not** measure, just estimate. The precision should not be to the same degree as your measurements above since this is an estimate.

Part II – Determination of Density & Identity of an Unknown object.

Obtain the plastic cube from your material kit from Miramar college. Do not use the metal cube.

To determine the density first measure the mass using the laboratory scale.

I. Volume by direct measurement

Measure the length (l), width (w) and height (h) of the cube in centimeters.

Calculate the volume using the formula, V = w x l x h, which should have units of cm^3. Note that 1 cm^3 = 1cc = 1ml. Show your measurement in your datasheet and show your calculations. Use correct significant figures with proper units.

Calculate the density of the cube using the equation below.

$$density = \frac{mass\ (g)}{volume\ (ml)}$$

Volume by displacement

Take a graduated cylinder and fill it half-way to a convenient volume (~ 20 mL or 80-ml).

Read the volume of the water to the **precision** of the graduated cylinder.

Slowly slide the cube down the graduated cylinder being careful not to splash the water to the side.

If the cube does not go all the way to the bottom, just make sure it is completely submerged before the next step.

Measure the new displaced volume to the precision of the graduated cylinder. *

Using the mass from step1, calculate the density using this volume measured by displacement. Record your work and data in your datasheet.

* Remember that the volume of the cube is the difference between $V_f - V_i$. This difference is the amount of water volume that is displaced by the volume of the cube.

Photo 5: Take a digital close-up photo of the graduated cylinder with cube submerged showing the water level and the cube.

For the Post Lab Questions

Identify your unknown based on the experimental density from a list of possible metals.

Table of Possible Unknowns

Material	**[Theoretical Value] Density (g/mL)**
Acrylic	1.19
Cellulose Acetate	1.28
Glass Pyrex	2.21
Glass common	2.60
Granite	2.70
Alabaster carbonate	2.75

Calculate the percent error of the density you just measured from the listed density of the cube you have.

$$\%\ error\ = \left|\frac{experimental - theoretical}{theoretical}\right|\ x\ 100$$

Remember this equation. It will be used for all percent error (% error) calculation throughout this course.

Write this equation somewhere that you can retrieve it for future experiments.

03Lab | Experiment 2: Measurements, the Metric System & Density, Data Sheets

Last Name__________________________**First**___________________________ _____ / ______ **pts**

Part I – Metric Measurements & Estimates

	magnitude	Units (use abbreviation)
Temperature		

Mass

	magnitude	Units (use abbreviation)
Cube		
100 mL beaker		
5 mL graduated cylinder		
Scientific Calculator ** estimate**		

Length

	magnitude	Units (use abbreviation)
Width of your right palm. (Trace you right hand on a piece of paper and measure the width)		
Cube one of the side length		
Circumference of 400 mL beaker		
Calculator length **estimate**		

Volume

	magnitude	Units (use abbreviation)
100 ml graduated cylinder		
50 ml graduated cylinder This is the equipment provided by KLM		
5 ml (or 10mL) graduated cylinder		
Full test tube **estimate**		

Magnitude is the numerical value of the measurement.

Part II – Determination of Density & Identity of an Unknown object.

Description of cube (please write detail observations):

When writing units, please use the unit's abbreviation.

Mass	**Magnitude**	**units**
Cube		

Calculation of Density. (show)

I. Direct Volume	**Magnitude**	**units**
Length		
Width		
Heights		

Base on the geometric item you measured: $L\ x\ W\ x\ H$ (for a cube)

Volume	
Density	

II. Volume by Displacement	**Magnitude**	**Unit**
Volume initial		
Volume Final		

Calculation of Density. (show)

Base on the volume displacement item you measured: $Vol\ final\ -\ vol\ inital$ (for a cube)

Volume	
Density	

Photos

Take these photos during the procedure and don't forget to include your ID in the foreground of the photo.

Photo 1: Take a digital close-up photo of the temperature reading of the thermometer in the beaker of water.

Photo 2: Take a digital close-up photo of the mass reading of the cube on the scale.

Photo 3: Take a digital close-up photo of you measuring the width of your palm.

Photo 4: Take a digital close-up photo of the three graduated cylinders with ¾ full of liquid water.

Photo 5: Take a digital close-up photo of the graduated cylinder with cube submerged showing the water level and the cube.

For next week, check to make sure you have all the chemicals and supplies for next week's experiment.

Last Name _________________________First_________________________ **____ / _____ pts**

Pre-Lab Questions

Answer these prelab questions in Canvas before you begin the experiment.
You are graded based on your answer in Canvas so please make sure you complete the exercise.
(Show your work in this worksheet and then upload your answer file in the last question in Canvas.

Use the following link to get some conversion factors that you may use for this exercise.
Use the conversion factors found in the **appendix** of the lab manual.

1. Calculate the following metric conversion (express answers in scientific notation):

$1.0 \bullet 10^9$ nm = __________ m 1.0 km = __________ m

$1.0 \bullet 10^6$ μm = __________ m 1.0 Mm = __________ m

$1.0 \bullet 10^3$ mm = __________ m 1.0 Gm = __________ m

$1.0 \bullet 10^2$ cm = __________ m 1.0 Tm = __________ m

2. Complete the table below with the correct temperature:

__________ °F	=	__________ °C	=	0.00 K
__________ °F	=	105.0 °C	=	__________ K
98.7 °F	=	__________ °C	=	__________ K

3. Complete the table below by finding by English to Metric or vice-versa:

4.000 oz	=	__________ mg	=	__________ g
__________ qt	=	454.0 ml	=	__________ L
__________ in	=	__________ cm	=	3.05 m

Do not forget to upload this prelab worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

03Lab | Experiment 02: Measurements, the Metric System & Density, Post-Lab

Last Name ________________________First_________________________ **____ / _____ pts**

Post-Lab Questions

1. Explain why the two density values from your calculations might be different. Inspect the number of significant figures for each measurement and speculate which method for the determination of the volume of the cube may be more precise.

2. Based on the measured densities, identify the metal that your cube is made of. Calculate the percent error in your measurement.

________Identity of Unknown

_________ % Error

Temperature Conversion. Do the following conversions for the temperature of the water.

measurement from part I	Fahrenheit Equation: °F = (180/100 x °C) + 32 °F	Kelvin Equation K = °C + 273.15 K
Water Temp. ___________		

Show your calculations for the temperature of the water.

Mass Conversions. Do the following conversions for the mass of the **cube** and the **100-mL Beaker**.
Use the conversion factors found in the appendix of the lab manual.

measurement from part I (Write the conversion factor values)	Conversion factor: ____mg = ____g milligrams	Conversion factor: ____g = ___kg kilograms	Conversion factor: ____lb = ___g pounds
Cube ___________			
100mL Beaker ________			

Show calculations for the mass of the **cube**. Show the dimensional analysis technique with units canceling. Circle your answer.

Length Conversions. Do the following conversions for the length of the **shoe** and the circumference of the **400-mL Beaker**. Use the conversion factors found in the **appendix** of the lab manual.

measurement from part I (Write the conversion factor values)	Conversion factor: ____mm = ____cm millimeters	Conversion factor: ____m = ___cm meters	Conversion factor: ____in = ___cm inches
Length of Cube ___________			
Circumference 400 mL beaker ___________			

Show your calculations with the circumference of the **400 mL beaker.** Show the dimensional analysis technique in which units cancel.

Volume Conversions. Do the following conversions for the volume of the **10-mL cylinder** and the **100-mL cylinder**. Use the conversion factors found in the **appendix** of the lab manual.

measurement from part I (Write the conversion factor values)	Conversion factor: ______mL = ______L Liters	Conversion factor: ______mL = _____gal gallons
10 mL graduated cylinder ___________		
100 mL graduated cylinder ______________		

Show your calculations for the volume of the **100 mL graduated cylinder**. Show the dimensional analysis technique in which units cancel.

Do not forget to upload this postlab worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

04Lab | Experiment 03: Studying Density and Miscibility of liquids.

Objective

The goal of this experiment is to determine the densities of three unknown liquid, test the miscibility of each liquid to each other and the solubility of water in each liquid.

Instructor's Note: The emphasis of your grade will be making correct measurements and making detail observations.

Equipment and Chemicals

KLM Equipment	(3) 13 x 100 mm TT w/ +stoppers	(1) 15 x 150mm TT w/ +stoppers	5-mL grad cylinder	Test tube brush
Miramar supply	Different Unknown Liquid A, B and C Colored water	Digital Scale Forceps	Stirring rod w/ policeman	Berel Pipettes
You supply				

Introduction

Reading: Please review the topic on solubility, miscibility and density.

Density, Miscibility and Solubility

How does oil and water mix at the molecular level? Does oil sink or float in water? Are the two liquids miscible in each other? The answer to these questions will be investigated in this experiment. Physical properties such as densities and miscibility of various liquids in water may help provide answers to these questions.

An observable (or measurable) property of matter i.e., color, bpt, mpt, conductivity, texture, miscibility specific heat and density are important in helping identify different substances and how they interact with each other. Consider what occurs when vinegar and oil are mixed in Italian salad dressing. The oil floats on top and the vinegar and the herbs sinks to the bottom. We say that the oil is less dense than the vinegar. We can also state that oil and vinegar are immiscible.

Density (d or ρ) is defined as the mass per unit volume. Density relates the mass to the volume for a given substance and is usually unique for that particular substances. The table below shows the density of various substances.

Table II; Densities for various substances

Substance	Formula	Density (g/cc)
Hexanes	C_6H_{14}	0.655
Ethanol	C_2H_5OH	0.789
isopropanol	C_3H_7OH	0.786
Mineral Oil	Hydrocarbons	0.89
Water	H_2O	1.00
30% Salt water	H_2O + NaCl	1.20
Glycol	$C_2H_6O_2$	1.26

Substance	Formula	Density (g/cc)
Aluminum	Al	2.70
Iron	Fe	7.86
Brass	Cu/Zn Alloy	8.73
Silver	Ag	10.5
Lead	Pb	11.34
Copper	Cu	8.96
Gold	Au	19.3

The ratio between the densities of the sample over the density of water (20 °C) is referred to as specific gravity.
(s.g. = d [g/cc] $_{(sample)}$ / ρ [g/cc] $_{(H2O@20°C)}$). Specific gravity is a unitless quantity.
s.g. is an indicator of how much denser a substance is relative to water.

s.g. > 1 (more dense than H_2O) Sinks in water

s.g. < 1 (less dense than H_2O) Floats in water

When a solute completely dissolves in a solvent the mixture is called a "true" solution. They are:

- Distribution of particles is uniform
- Components in solution do not separate upon standing
- Components cannot be separated by filtration.
- Solute / Solvent mixes in ratios - up to the solubility limit.
- Solution is almost always transparent.
- Compounds of solution may be separated by other methods i.e., distillation or chromatography.

A solid solute in a liquid solvent is one of the most common types of solution. The solubility of the solute is the maximum amount of that solute that dissolves in a given amount of solvent at a given temperature. A solution in which more solute can dissolve in the solvent is considered unsaturated. A solution that contains all the solute it can dissolve is called saturated. A solution that contains more solute, in the dissolved form, than normal is considered supersaturated.

Consider a NaCl solute with a solubility (s) of 35.7 g per 100cc water. The volume in the diagram is 50 mL.

unsaturated solution	saturated solution	supersaturated solution	miscible liquid-liquid mixture	Immiscible liquid – liquid mixture
s = 10 g / 50 cc	s= 17.8 g / 50 cc	s = 20 g / 50 cc		

Mixed- liquids solutions that are soluble in each other are considered miscible and if the mixed-liquids are not soluble in each other, the mixture is considered immiscible.

Miscible and **immiscible** are term used for liquid solute- liquid solvent system, whereas soluble and insoluble are used for solid solute and liquid solvent systems. Miscible liquids are liquids that are soluble in each other, and immiscible liquids form separate layers, see the illustrations above.

The factors affecting the solubility (miscibility) of substances to each other are: 1) the solute-solvent characteristics, 2) the temperature factor and 3) the pressure factor. The pressure factor is only a factor when the solute is a gas. In aqueous solution, water as the solvent will dissolve only in other polar molecules. (Note that although there will always be minuscule amount of solute dissolved in any solvent in such a situation, the amount is negligible for this class) Oil for example is a nonpolar substance that will only dissolve other nonpolar substances such as organic solvent, i.e., grease and gasoline. A rule of thumb for solubility or miscibility is "Like Dissolves Like".

Photos

Take these photos during the procedure.

Photo1: Take a Photo of the graduated cylinder on the scale with the mass of the graduated cylinder and Unknown A shown in the scale display.

Photo2: Take a Photo of the 3 liquids forming 3 separate layers in the 18 x 150mm (large) test tube. The photo should show three distinct layers.

Photo3: Take a Photo of the three liquids with the colored water added to the mixture but before the mixture is shaken.

Photo4: Take a Photo of the three liquids with the water after shaking the content and waiting at least an hour for the moisture to settle.

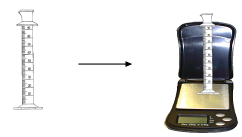
At this point check to make sure you have all the chemicals and supplies for next week's experiment.

Procedure –

Be sure to record your observations in the data sheet under the heading “observations”. If you forget this, you will lose points. All liquids used in this experiment are considered safe and are found in the kitchen or medicine cabinet. You should however practice safe science by wearing safety goggles when conducting this experiment. Finally, even though these liquids are household items, chemicals used in the lab should never be inhaled or ingested.

Glycerol: Avoid inhalation. People use as medicine. Not expected to be a health hazard
Mineral Oil: Cooking Oil: Handle carefully. Not expected to be a health hazard
Dish Soap. Cooking Oil: Handle carefully. Not expected to be a health hazard
Cooking Oil: Handle carefully. Not expected to be a health hazard
Corn Syrup: Handle carefully. Not expected to be a health hazard
Hexanes: Handle carefully. Flammable, irritant and toxic
Ethanol: Handle carefully. Flammable and toxic

Caution: Some of the unknown liquids you will use in this experiment are flammable, toxic, and irritants. Do not use these liquids near an open flame. Prevent contact with eyes, skin, combustible material, and clothing. Avoid inhaling vapors and ingesting the compounds.



Use different volume for liquid A, B and C. Using different volumes allow you to determine which layer is which in the last step of this experiment.

1. Pre-wash three 13x100mm (small) test tubes, one 18 x 150mm (large) test tube, and a 5 mL graduated cylinder. Dry in a 100 mL beaker.

2. Determine the mass of a clean dry 5-mL graduated cylinder. Record the mass on your data sheet.

3. Remove the graduated cylinder from the balance and then add between 1 to 2 mL of liquid A into the graduated cylinder. Record the volume in your data sheet with the correct precision. Place the graduated cylinder on the digital balance and record the mass of the liquid and graduated cylinder. Record this value in your data sheet.

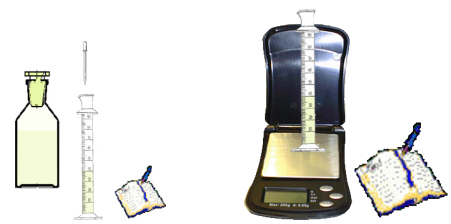
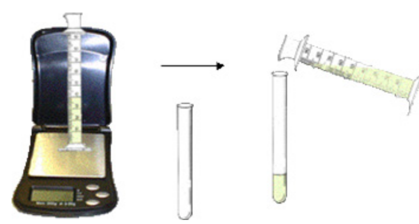


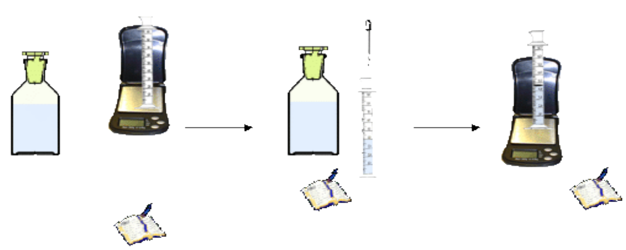
Photo1: Take a Photo of the graduated cylinder on the scale with the mass of the graduated cylinder and Unknown A shown in the scale display.

4. Remove the graduated cylinder from the balance and pour the content into the first of three 13x100mm (small) test tubes. Be sure to pour all the content into the test tube. Label this test tube “liquid A”. Save the container of liquid A and add 0.5 mL of colored water. Determine if the two liquids are miscible to each other.

5. Wash the graduated cylinder with soap and water using your test tube brush. Do a final rinse with deionized water and then dry completely.



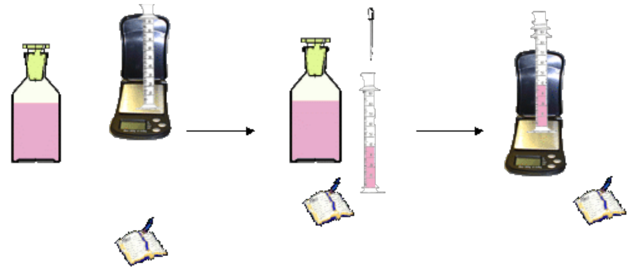
6. Weigh the graduated cylinder on the balance again to make sure the mass did not drift, (Record the mass in your data sheet). Add between 1 - 3 mL of liquid B into the graduated cylinder and record the volume in your data sheet. Place the graduated cylinder with liquid B on the balance and record the mass.



7. Remove the graduated cylinder from the balance and pour the content into the second of three 13x100mm (small) test tubes. Be sure to pour all the content into the test tube. Label this test tube “liquid B”. Save the container of liquid B and add 0.5 mL of colored water. Determine if the two liquids are miscible to each other.

8. Wash the graduated cylinder with soap and water using your test tube brush. Be sure to do a final rinse with deionized water and then dry the graduated cylinder.

9. Weigh the graduated cylinder on the balance again to make sure the mass did not drift, (Record the mass in your data sheet). Add between 2 - 4 mL of liquid C into the graduated cylinder and record the volume in your data sheet. Place the graduated cylinder with liquid C on the balance and record the mass. Save the container of liquid C and add .05 mL of colored water. Determine if the two liquids are miscible to each other.

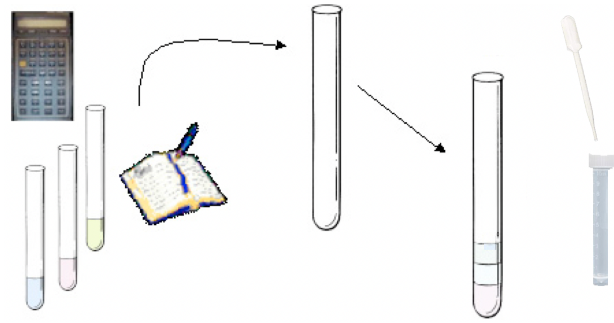


10. Remove the graduated cylinder from the balance and leave the content in the graduated cylinder and be sure to label this "liquid C". You can also pour the content in another 13x100mm (small) test tubes and label "liquid C" . Set this aside.

11. Calculate the densities of liquids A, B, and C using the data you have obtained for these liquids. Show your work on the data sheet.

12 Starting with the most, dense liquid and ending with the least dense liquid, slowly pour the most, dense liquid into a clean, dry 18 x 150-mm test tube followed by the next dense followed by the least dense. Record on your Data Sheet in the order in which you poured the liquids.

Caution: Do not handle any of the liquids with your hands. Use the berel pipet handle all the liquids.



13 **Photo2**: Take a Photo of the three liquids forming three separate layers in the 18 x 150mm (large) test tube. Be sure that the photo shows three distinct layers.

Next add 0.5 mL (10 drops) of colored water into the mixture using a berel pipet. After adding the water to the liquids in the large test tube, allow the liquid to settle. Indicate the levels of the liquid layers in the figure on your data sheet, label each layer with the appropriate letter, and label the color of each layer after you have added the water. Write your observation of what happens to the water droplets as it settles in the liquid.

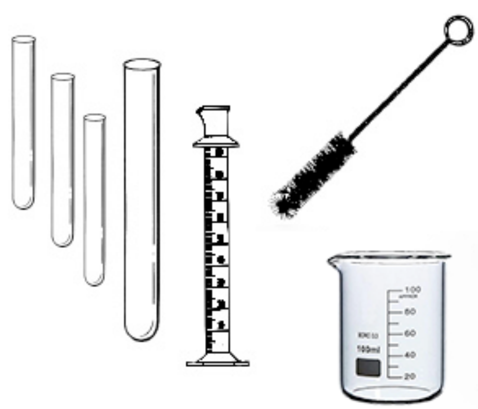
Photo3: Take a Photo of the three liquids with the colored water added to the mixture but before the mixture is shaken.

14. Place a stopper on the 18 x 150mm test tube and then mix the content. Observe what happens to the mixture. Indicate the levels of the liquid layers in the figure on your data sheet, label each layer with the appropriate letter, and label the color of each layer after you mixed the content.

Photo4: Take a Photo of the three liquids with the water after shaking the content and waiting at least an hour for the moisture to settle.

15. Dispose of the contents of the large test tube in a plastic water and labeled this "Waste". Wash your glassware with detergent, rinse, and drain to dry.

Caution: Clean up your work area and wash your hands thoroughly with soap or detergent before leaving your work area.



04Lab | Experiment 03: Studying Density, Miscibility and Solubility, Data Sheets

Last Name________________________**First**_________________________ ____ / _____ **pts**

Observations: Write your observations here**.**

Data Sheet- Write units abbreviation after each measurement entry.

	Liquid A	Liquid B	Liquid C
(1) mass of 5-mL graduated cylinder in grams			
(2) mass of 5-mL graduated cylinder and liquids in grams			
(3) mass of liquid in grams			
(4) volume of liquid in milliliters to hundredth of mL.			
(5) density of liquid. Be sure to include units.			

Show density calculations which also shows in the space provided. Indicate the units in your calculations.

(6) Write the order that you poured liquids into the large test tube. Write a description of the layers next to each test tube.

First (mix)

(7) Step 12: Draw lines in the figure to indicate the levels of the liquid layers in your large test tube. Label each layer with the appropriate letter.

Second (label)

(8) Step 13: Label the color of each layer after you have added the water. But do not shake the solution yet.

Third (shake)

(9) Step 14: Stopper the test tube and shake. Draw the levels of the liquid layer and try and identify the layers. Indicate the colors of the layers.

In addition, be sure to turn in the following with your report:

Photo1: Take a Photo of the graduated cylinder on the scale with the mass of the graduated cylinder and Unknown A shown in the scale display.

Photo2: Take a Photo of the 3 liquids forming 3 separate layers in the 18 x 150mm (large) test tube. The photo should show three distinct layers.

Photo3: Take a Photo of the three liquids with the colored water added to the mixture but before the mixture is shaken.

Photo4: Take a Photo of the three liquids with the water after shaking the content and waiting at least an hour for the moisture to settle.

Each photo should show your college ID in the foreground.

Your next experiment is a video simulation. There are no chemicals or equipment needed for this experiment.

Last Name ________________________First_________________________ ____ / _____ pts

Prelab Questions

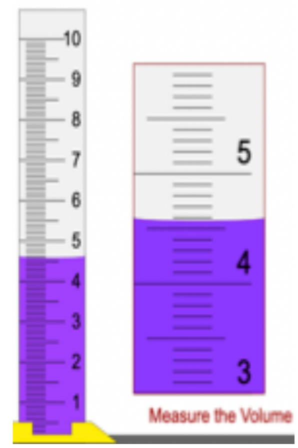
Answer these prelab questions and in canvas before you begin the experiment.
Read in your textbook or click on these link to learn about density, miscibility, and solubility.

1. What precautions must you take when handling the unknowns mentioned in the procedure of this experiment?

2. Write the mathematical expression for density.

3. A student collected the following data in the laboratory.
Note that these measurements will be different from the Canvas version.

unknown liquid	Chemical-X
mass of graduated cylinder	35.54 g
mass of graduated cylinder and liquid	39.34g



Volume of unknown liquid

a) What is the volume of the liquid in the graduated cylinder?
(Use the correct precision)

(b) Calculate the density of the unknown liquid.
(Use the correct number of significant figures)

4. Describe the following combinations of the substances as miscible, immiscible, soluble, or insoluble.
(Use the correct term in your answer.)
(a) sand sinks to the bottom of a beaker of water

(b) rubbing alcohol and grain alcohol mix completely

(c) liquid mercury sinks to the bottom of a beaker of water

(d) an aluminum boat floats on a lake

(e) sugar disappears when stirred into hot water

5. (a) Based on your personal experience, predict what would happen if you put cooking oil, water, and an ice cube in a tall glass.

(b) Draw a representation of what you predict. Be sure to illustrate the different layers and the ice placement in the layers.

(c) Go to your kitchen and test your prediction. Do the results of your experiment match your prediction? Briefly explain.
Go to your kitchen and do this experiment and take a photo of the results. Draw a picture and upload the photo into the canvas question. Form layers of water should be 6 cm thick; the oil must be 4 cm thick, and the ice needs to be at least 2 cm thick.

Do not forget to upload this prelab worksheet in Canvas with photo of ID in foreground.

04Lab | Experiment 03: Studying Density, Miscibility and Solubility, Post-Lab

Last Name ________________________First_________________________ ____ / _____ pts

Post Lab Questions:

Answer these post lab questions as part of the report you turn in for this experiment.

1. State if the following liquids are miscible or immiscible in each other and justify your answer to each question below based on the diagrams you drew in the previous page.

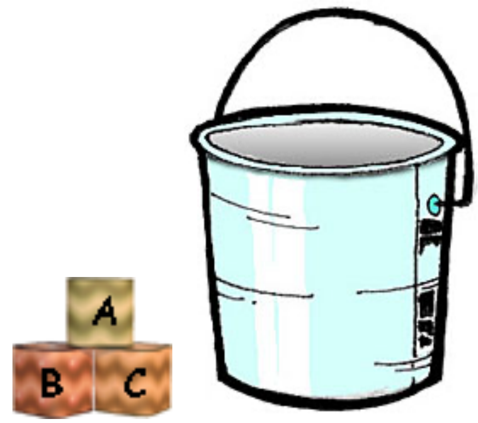
Liquids being Mixed	Miscible or Immiscible	Justification Cite your observations from this lab
a) Liquid A and Liquid B		
b) Liquid B and Liquid C		
c) Liquid C and Liquid A		

2. State if the colored water is miscible in each liquid.

Liquids	Miscible or immiscible	Justification of Miscibility	***Identity of Liquid See Table II***
a) Liquid A			
b) Liquid B			
c) Liquid C			

3. Given the following data, determine how the following solid blocks will settle upon adding all of the solids to a bucket full of water. (Show calculations and indicate units in your calculations. Draw a sketch of the results when the blocks are placed in the bucket and write a justification for your answer.

Substance	Mass, g	Volume, mL
Solid -A	68. g	60.0 mL
Solid -B	39.5 g	50.0 ml
Solid -C	35.45 g	35.5 mL



Do not forget to upload this prelab worksheet in Canvas with photo of ID in foreground.

05Lab | Experiment 04: Separation of a Ternary Mixture

Objective

In this experiment, students create a mixture of 3 substances, iodine, sand, and cobalt (II) chloride hexahydrate and then separate them using a variety of separation methods. The goal of this experiment is to familiarize students with the methods of separation, identify the isolated substance at each step and to identify physical and chemical changes that may occur during the separation of the mixture.

Instructor's Note: The emphasis of this lab is to write detailed observations and to document these observations on the datasheet. Making careful observations should lead to the correct conclusion based on separation throughout the experiment.

Material and Chemicals. This is a video simulation. **No materials are required.**

KLM Equipment	~~Alcohol burner w/ stand (rubbing alcohol for fuel)*~~	~~(3) 13 x 100mm Test tube 100 mL beaker~~	~~Wash bottle 250mL beaker~~	400mL beaker Spatula
Miramar supply	~~Cobalt (II) chloride Hexahydrate $CoCl_2•6H_2O$~~ ~~Cobalt (II) Chloride (Anhydrous). $CoCl_2$~~ ~~Iodine crystals (I_2)~~ ~~Sand (SiO_2)~~		~~Evaporating dish~~ ~~Crucible tong~~ ~~Forceps~~	Berel pipet wire gauze Stirring rod w/ policeman
You supply:	~~distilled water~~	~~ice cubes~~	~~oven mitts~~	

* As an option, you can use the burner from your stove to heat mixtures in this experiment.

The amount use for this experiment are -

* No more that 500 mg of $CoCl_2•6H_2O$.

The size of the crystal of Iodine crystal used should be no more than a few millimeters.

The amount of Sand or SiO_2 should be a few grams, or about the amount of two dimes.

Introduction

The three substances that will be components in our heterogeneous mixture have some unique chemical and physical properties that will be exploited in the process of isolating each. Here are some relevant definitions for this experiment:

Sublimation - the phase change when solid changes to a gas without passing through a liquid. One compound that sublimates at atmospheric pressure is CO_2, also known as dry ice. This happens in step 2 of this experiment.

Solubility - the ability of a substance to dissolve in water, creating an aqueous solution. When a substance is dissolved in water, its physical state is termed aqueous and is denoted (aq). It is NOT in a liquid state. This happens in step 3 of this experiment.

Density – Density is mass divided by volume (g/ml), and it impacts the ability of a substance to sink or float in a liquid or gas. This is used in step 4 of this experiment.

Volatility – The tendency or ease by which a substance changes to the vapor phase. This happens in steps 2 & 5.

Miscibility – The ability of two liquids to mix homogeneously in all proportions. Water and ethanol are miscible.

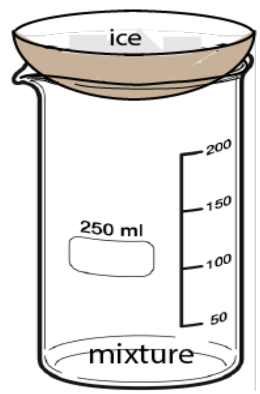
Isolated – A substance is isolated when it has been removed from all other substances. This is the theme of this experiment.

Decantation – The technique of decantation exploits the difference in solubility and density between two or more substances for separation. In a heterogeneous aqueous mixture, where one substance is insoluble and resting on the bottom of the container, the liquid is poured out of the container without transferring the insoluble dense substance, which rests on the bottom. This is used in step 4 of this experiment.

Hydrate – In this experiment, cobalt (II) chloride is seen in two forms, the anhydrous (without water) form ($CoCl_2$) and the hydrated form ($CoCl_2•6H_2O$). Both forms of cobalt (II)chloride are solids, but they have a very noticeable difference in physical properties. Hexahydrate means that there are six waters in the basic formula of the substance.

Procedure –

Observation of the Starting material. Obtain three substances, iodine (I_2), sand (mostly SiO_2), and cobalt (II) chloride hexahydrate ($CoCl_2 \cdot 6H_2O$), and place these in three small test tubes. In general, measure out two crystals of iodine about 1- 2 mm in size (tip of spatula) Please do not use more than this amount. Use an amount of cobalt(II) chloride about 5mm diameter. The amount of sand should be the size of a nickel (1/4 teaspoon). Write a description of the appearance of each substance individually. At each stage of the procedure be sure to identify the isolated species and the physical property that facilitated the isolation. **In your observation, circle the basis of separation. Underline the compound that was isolated. Underline none if nothing was isolated in that step.**

Steps.	**Procedure (**The steps here, 1 – 5, are color coded to the data sheet, basis of separation**)**
Step 1	**Observe the starting material.** Write a description of each of substance in your data sheet. **Create the mixture.** Thoroughly mix the three substances in a 250 ml beaker. Write a description of the appearance of the mixture in your datasheet in Row 1. Note if the evaporating dish is too small for the beaker, use the 100mL beaker in this step. **Photo1:** Screenshot of the three substances that are isolated substances in the wax paper. **Photo2**: Screenshot of the three mix substances in the beaker.
Step 2	**Sublimation of Substance A**. Place crushed ice in an evaporating dish over the 250ml beaker. Place the beaker with the evaporating dish on a warm hot plate or your alcohol burner and observe the mixture while it is heated. Continue to heat the beaker until there is no more signs of gas in the beaker. If you still see gas, in the beaker, you are not done. It must be clear and colorless before you can proceed to the next step. Observe what happens to all three components of the mixture. To make careful observation, it is best to follow either iodine or the cobalt substance during the heating process. Inspect the underside of the evaporating dish during this step.  **Observations.** When nothing else appears to be happening, remove the beaker from the alcohol burner. Be careful that the ice does not melt to the point that some of the ice leaks down into the beaker. Allow the beaker to cool for 2-5 minutes before handling it. Use oven mitts to remove the evaporating dish from the 250-mL beaker. Pour the water and ice from the evaporating dish to a 50mL beaker. Place a paper towel on top of your work area and then invert the evaporating dish on the paper towel. What is the identity of the residue that accumulated at the bottom of the evaporating dish? Which substance has been isolated? Record your answer and observation on your datasheet (in row 2 if the data sheet table). **Photo3:** Screenshot of the purple gas subliming to the bottom of the evaporating dish. Stop when there are no purple vapors present. Do not overheat the beaker. To make careful observation, it is best to follow either iodine or the cobalt substance during the heating process. **Photo4:** Screenshot of the solid at the bottom of the evaporating dish

Step 3

Adding water to B & C. Record observations of the remaining mixture. Add approximately 10 mL of water to the 250mL beaker and stir. What is happening? Record the color of the solution and solid inside this beaker. Write your observation on your datasheet (row 3). Make sure you use a minimum amount of water otherwise step 5 will be tedious and long.

Note, that if the color of the solution is other than lavender, i.e., brown, or black, then you had stopped the heating in part 2 prematurely. Your instructor may ask you to repeat the procedure with smaller quantities of iodine and cobalt(II) chloride hexahydrate.

Photo5: Screenshot of the remaining mixture when water is added to mixture B and C.

Step 4

Isolated substance B via decantation of C

Decant the liquid from the solid in the 250-mL beaker into a 400mL beaker. Add an additional 15mL back to the solid residue that remains in the 250mL beaker to wash the solid. Decant the rinse into the 400mL beaker. What substance is separated in this step? What color is the solid component? Write your observations in row 4.

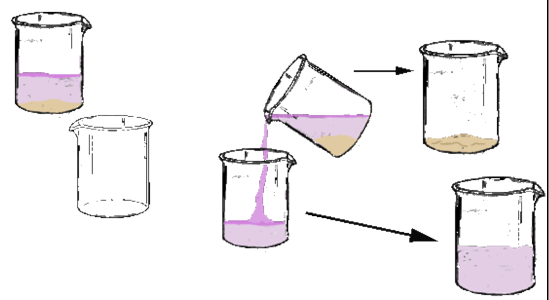


Photo6: Screenshot of the two beakers containing substance B (isolated) and C (still dissolved in water).

Step 5

Evaporating water to recover substance C. Put the content of the 400 mL beaker on the alcohol burner. Heat until all the liquid has evaporated. Observe and record what happens as the liquid evaporates. Pay close attention to the color change as the last drop of liquid evaporates away. What is the color of the remaining solid? As soon as the last bit of liquid evaporates turn off the hot plate and allow the 400mL beaker to cool for a minute or two. After recording your observation, add a small drop of water to the solid, what do you observe? Record all observations from this step in Row 5.

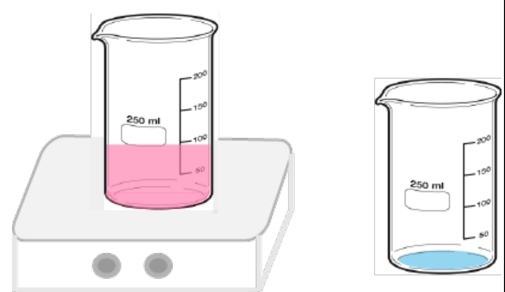
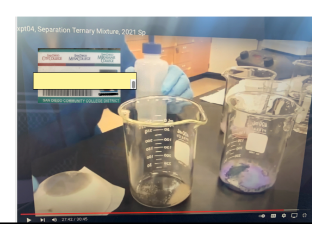


Photo7: Screenshot of the solid residue remaining after evaporating the water from substance C.

Write your detail observations.

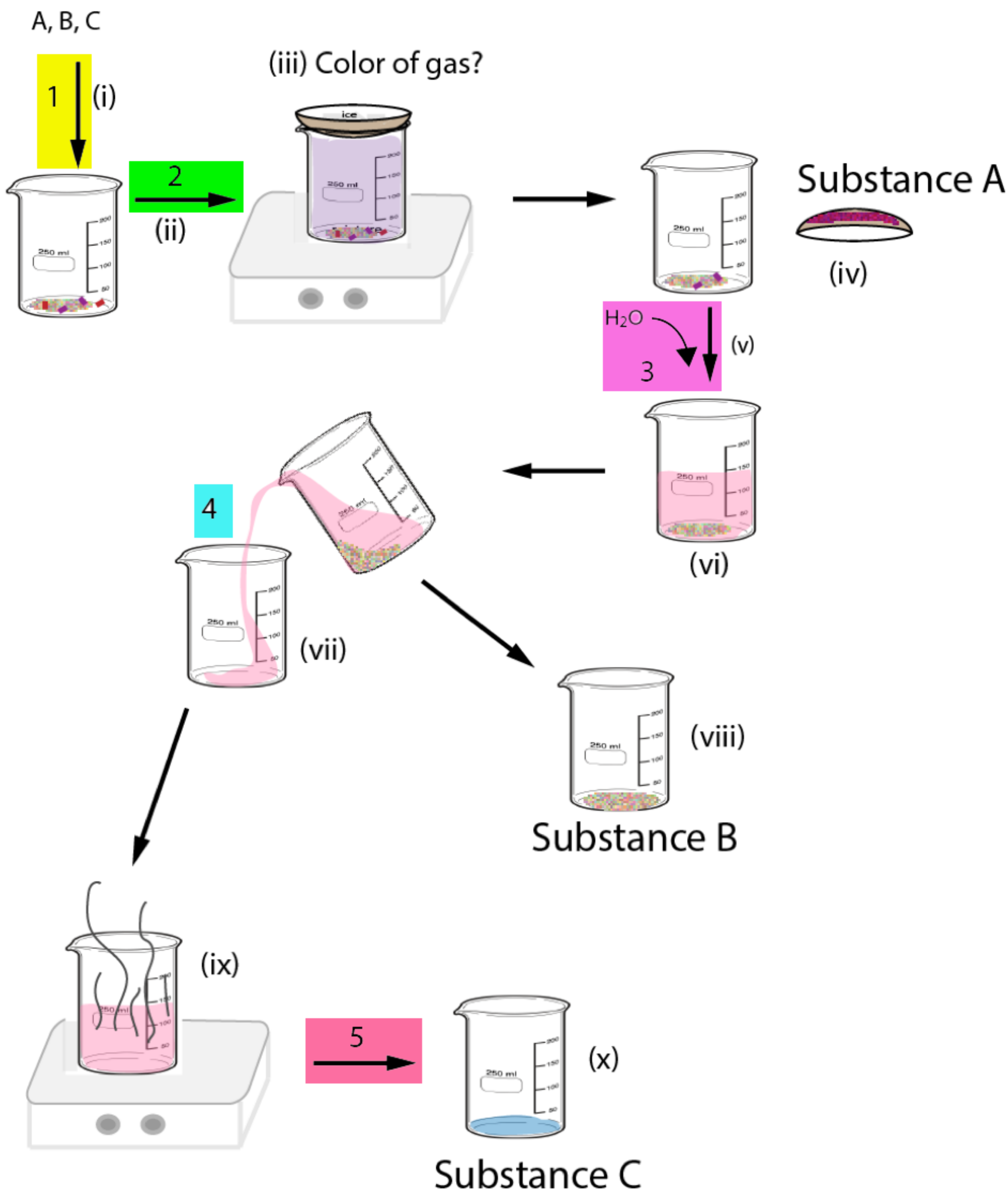
Cleaning Up. Dispose of substances in waste container (plastic water bottle) and wash all your glassware. Wipe down your work area. Wash your hands thoroughly with soap and water before leaving your work area.

Photo8: Screenshot of the separated substances A, B and C **with each chemical identified**. Be sure to place your ID in front of your computer monitor so that your student ID is clearly displayed. See example to the right. Notice that student placed ID in the screenshot.



Flowchart of Separation

Scheme I



Important: Note the color code in this scheme for the five steps.

Use the color in this scheme to guide you as your answer the questions in the datasheet.

05Lab | Experiment 4: Separation of a Ternary Mixture, Datasheet

Last Name ________________________**First**_________________________ ____ / _____ **pts**

(1). Observations Table: Match your observations with the steps below, otherwise your results will be marked incorrect.

Please follow directions for this datasheet for maximum credit. Use the color code to guide you on the steps of the procedure.

Steps	**Observations**: • Write down what is seen in each procedure. • Be as detailed as possible in your observation. • State what component is being isolated in each step, if any.	**Basis of separation:** You must circle the **basis of separation**. [Solubility, density, volatility, miscibility, none] You must underline the **isolated** substance (or none).
Step 1		***Circle the correct choice.** *[Solubility-density-volatility-miscibility-none]* *-**Underline the correct choice*** *a) Isolated I_2* *b) Isolated $CoCl_2 \bullet 6H_2O$* *c) Isolated $CoCl_2$* *d) Isolated Sand* *e) Isolated H_2O* *f) None*
Step 2		**Circle the correct choice.** *[Solubility-density-volatility-miscibility-none]* *-**Underline the correct choice*** *a) Isolated I_2* *b) Isolated $CoCl_2 \bullet 6H_2O$* *c) Isolated $CoCl_2$* *d) Isolated Sand* *e) Isolated H_2O* *f) None*
Step 3		***Circle the correct choice.** *[Solubility-density-volatility-miscibility-none]* *-**Underline the correct choice*** *a) Isolated I_2* *b) Isolated $CoCl_2 \bullet 6H_2O$* *c) Isolated $CoCl_2$* *d) Isolated Sand* *e) Isolated H_2O* *f) None*
Step 4		***Circle the correct choice.** *[Solubility-density-volatility-miscibility-none]* *-**Underline the correct choice*** *a) Isolated I_2* *b) Isolated $CoCl_2 \bullet 6H_2O$* *c) Isolated $CoCl_2$* *d) Isolated Sand* *e) Isolated H_2O* *f) None*
Step 5		**Circle the correct choice.** *[Solubility-density-volatility-miscibility-none]* *-**Underline the correct choice*** *a) Isolated I_2* *b) Isolated $CoCl_2 \bullet 6H_2O$* *c) Isolated $CoCl_2$* *d) Isolated Sand* *e) Isolated H_2O* *f) None*

Flowchart Questions

(2) The flow chart has detailed steps labeled **i – x, see scheme 1 and the color guide for each step**. Follow the labels i to x to answer these questions. Again, answer the following questions concerning procedures labeled i – x and support your explanation using your experimental observations. For example, you may need to describe the color of the gas generated in step 2, question iii. If you are naming a chemical, be sure you spell-out the correct name and do not abbreviate when referring to the chemical. Use extra sheet if necessary but start your answer in the worksheet.

i) What are the three substances that are mixed? Describe their appearance.

ii) Which chemical is in the majority in the mixture? How do you know?

iii) What is the color of the gas? What is the identity of this gas? How do you know?

iv) What color is the bottom of the dish? Be descriptive in its appearance and texture. What is the identity of the chemical?

v) What substance is added to the remaining mixture? What happened to one of the two remaining substance?

vi) What is the color of the aqueous solution? What was dissolved in the aqueous phase?

vii) What techniques is used to isolate the solid from the liquid in this step? Why did the other substance remain in the beaker?

viii) **What is the color of the solid residue? What is the chemical identity of this residue?**

ix) **What chemical is removed in order to isolate chemical C? How was this chemical removed? What property was exploited to remove this chemical.**

x) Step What is the color of the solid residue at the end of step 5? What is the chemical identity of the residue (write the formula). What is the identity when water is added to this residue (write the formula)?

Additional Questions

3. i) Describe one separation technique that you learned about in this experiment and how it was used. ii)What step (refer to the pictorial flowchart in Scheme I) was this technique used. iii) Explain what happened.

4. In this experiment, physical properties were exploited in the separation of I_2, sand and $CoCl_2$. In the separation methods, physical changes were observed with these substances. It is NOT possible to separate cobalt from chloride in $CoCl_2$ using physical changes. i) What kind of change would be required to separate cobalt from chloride? ii) Please explain what needs to occur for the separation to take place.

5. i) How does the addition of water change the physical properties of the cobalt(II) chloride substance?
ii) Write a chemical reaction that illustrates this process.

Your ID must be included in the screenshot of each of these. Place ID in front of screen of video and take photo.

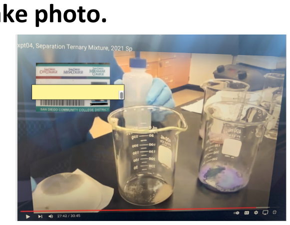


Photo1: Screenshot of the three substances that are isolated substances in the wax paper.
Photo2: Screenshot of the three mix substances in the beaker.
Photo3: Screenshot of the purple gas subliming to the bottom of the evaporating dish.
Photo4: Screenshot of the solid at the bottom of the evaporating dish
Photo5: Screenshot of the remaining mixture when water is added to mixture B and C.
Photo6: Screenshot of the two beakers containing substance B (isolated) and C (still dissolved in water).
Photo7: Screenshot of the solid residue remaining after evaporating the water from substance C.
Photo8: Screenshot of the separated substances A, B and C **<u>with each chemical identified</u>**.

At this point check to make sure you have all the chemicals and supplies for the next experiment, scheduled in 4 weeks.

05Lab | Experiment 04: Separation of a Ternary Mixture, Prelab

Last Name ________________________First_________________________ **____ / _____ pts**

Prelab Questions

Try to answer the following prelab in your lab journal before beginning the experiment.

1. Define the following terminology (especially as it is referred to in this experiment).

a) sublimation

b) volatility

c) solubility

d) hydrate

2. Explain in words and a pictorial flow chart illustrating how you would isolate each substance individually from a mixture of pepper, salt, and water. Each must be isolated in separate containers.

Last Name________________________First_________________________ ____ / _____ pts

Post lab Questions

Answer these post lab questions and turn in to your instructor before you leave lab.

1. What is the chemical identity of the purple gas when substance A, B and C are all heated? (**Write the formula**)
 Justify your answer by citing the evidence as written in your observations in the datasheet.

2. Which one of the three substances do we know is not soluble in water? (**Write the formula**)
 Justify your answer by citing the evidence as written in your observations in the datasheet.

3. What is the chemical identity of the powder blue solid in the last step? (**Write the formula**)
 What color does it change to when water is added? Your answer must be unambiguous, so use detailed chemical formulas, and the terms anhydrous and hydrate. Justify your answer by citing the evidence as written in your observations in the datasheet.

06Lab | Activity 02: Nomenclature.

For this activity you are to type in your answers in Canvas via the quiz app.

Last Name ________________________First_________________________ ____ / _____ **pts**

1. Naming Type I Ionic Compounds – One metal and a nonmetal

Rb_2S ______________________ $Al(HSO_4)_3$ ______________________

$Ca(HCO_3)_2$ ______________________ Sr_3N_2 ______________________

$Cd_3(PO_3)_2$ ______________________

2. Naming Type II Ionic Compounds – Containing Variable-Charge Metals

$Cu(C_2H_3O_2)_2$ ______________________ Hg_2S ______________________

$Co_2(CO_3)_3$ ______________________ CuO ______________________

$Pb(ClO_3)_4$ ______________________

3. Naming Type III - Binary Compounds with 2 Nonmetals

N_2O_2 ______________________ IF_4 ______________________

SCl_2 ______________________ SF_6 ______________________

SiO_2 ______________________

4. Name the following Mixture of Different Types of Compounds

$NaHCO_3$ ______________________ NI_3 ______________________

$Co_2(HPO_3)_3$ ______________________ $(NH_4)_2CO_3$ ______________________

$Pt(CN)_2$ ______________________

5. Formulas of Type I Ionic Compounds - One metal and a nonmetal

magnesium chloride ____________________ barium nitrate ____________________

silver sulfite ____________________ aluminum arsenite ____________________

beryllium hydroxide ____________________

6. Formulas of Type II Ionic Compounds - Containing Variable Charge Metals

vanadium(III) nitride ____________________ chromium(III) bisulfite ____________________

molybdenum(VI) oxide ____________________ copper(II) dichromate ____________________

platinum(IV) perbromate ____________________

7. Formulas of Type III Compounds - Binary Compounds with 2 Nonmetals

dinitrogen tetrafluoride ____________________ sulfur hexachloride ____________________

diboron trioxide ____________________ dihydrogen monoxide ____________________

Tetraphosphorous heptaoxide ____________________

8. Write the formulas for the following List of Different Types of Compounds.

calcium carbonate ____________________ ammonium selenide ____________________

cadmium permanganate ____________________ thallium(I) telluride ____________________

tungsten(V) oxalate ____________________

07Lab | Activity 03: Lewis Structure and VSEPR Theory

For this activity, you are to type in your answers in Canvas via the quiz app.

Last Name _________________________First__________________________ ____ / _____ pts

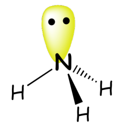
1. Valence Electrons & Group Number

Element	**N**	**O**	**P**	**Ca**	**Cl**	**Ga**
Group Number						
# of Valence electrons						

2. Complete the Lewis structure for the following. Place a square bracket around ions.

Compound, Chemical formula	**1.Total Valence electrons**	**2. Number of Bonds**	**3. e- pair, Number of Lone pair(s), 2e = 1 pair**	**4 & 5. Connectivity and Lewis Structure**
2a) Ammonia, NH_3				
2b) Fluoromethane, CH_3F				
2c) Carbon disulfide, CS_2				
2d) Formic acid, HCOOH				O H C O H
2e) Hydroxylamine, NH_2OH				H H N O H
2f) Nitrate ion, NO_3^-				
2g) Acetate Ion, CH_3COO^{-1}				H [H C C O]$^-$ H O

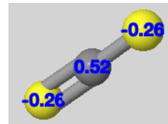
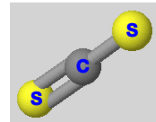
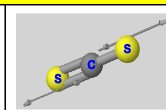
3. Shapes of Molecules VSEPR Theory

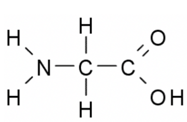
Compound	1. Total Valence electrons	2.Lewis Structure	3a. Electronic Geometry AE_n 3b. Electronic Geometry Name 3c. Electronic Geometry Shape	4a. Molecular Geometry AE_nB_m 4b. Molecular Geometry Name 4c. Molecular Geometry Shape	5.Bond angles Hybridization
NH_3	8 e-		AE_4, Tetrahedral Tetrahedral	AB_3E Pyramidal Pyramidal	< 109.5˚ sp^3
1) CS_2					
2) HOI					
3) SiH_4					
4) SiO_2					
5) NO_2^-					
6) OF_2					
7) PCl_3					
8) NO_3^-					

4. 3D Molecular Modeling ChemDL.

http://chemdata.umr.umn.edu/resources/models360/models.php

Skip the molecules highlighted in gray.

	3D Structure: Chemed DL: Model 360				
	Bond length	Bond angle	Partial charge	Molecular dipole	Bond dipole
1) **Carbon disulfide**	C – S: 0.157 nm	S - C - S = 180°		 Dipole 0 Debye	 Dipole cancels
2) **Hypoiodous acid**	H - I = I - O =	H - I - O =			
3) **Silicon tetrahydride**	H - Si =	H - Si - H =			
4) **Silicon Dioxide**	Si - O =	O - Si - O =			
5) **Nitrite ion**	N - O =	O - N -O =			
6) **Oxygen difluoride**	F - O =	F - O - F =			
7) **Phosphorus trichloride**	P - Cl =	Cl - P - Cl =			
8) **Nitrate ion**	N - O =	O - N - O =			

9) 	N - H = N - C = C - H = C - C = C - O = O - H =	H - N - H = H - N - C = N - C - C = N - C - H = C - C - O = C - O - H =			

Resources for Lewis Structure and VSEPR (Accessed Jan 2023)

Chem Digital Library: https://www.chemedx.org/page/activity

Model 360 from Chemed DL: http://chemdata.umr.umn.edu/resources/models360/models.php

PubChem Compounds: http://pubchem.ncbi.nlm.nih.gov/

Lewis's structure made easy, Flash program: http://www.chemistry24.com/college_chemistry/lewis-structure.html

Lewis Structure Tutorial: http://www.ausetute.com.au/lewisstr.html

MolView Molecular Modeling Software: http://molview.org/

Google Links: http://www.google.com/search?hl=en&lr=&q=Lewis+Structures&btnG=Search

VSEPR help page: http://www.chem.purdue.edu/gchelp/vsepr/

Google Links: http://www.google.com/search?hl=en&lr=&q=VSEPR+models&btnG=Search

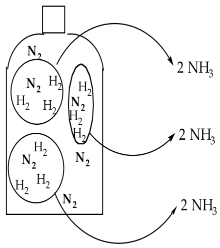
08Lab | Activity 04: Balancing Equations and Stoichiometry Exercise

Objective. The purpose of this activity is to become familiar in writing and balancing chemical equations. The second part of the activity is to give you some practice on stoichiometry calculations.

Discussion on Balancing Equations: The heart of chemistry is the chemical reaction which portrays how new compounds form. The basis of a chemical reaction is the "Law of conservation of mass". That is, the total atoms of the reactant are equal to the total atoms of the product. The general form of a chemical reaction is illustrated as: Reactant $\xrightarrow{\text{yield}}$ Product.

Consider the reaction between molecular nitrogen and molecular oxygen. This is shown below.

Chemical Reaction:



$9\ H_2 + 6\ N_2 \rightarrow 6\ NH_3 + 3N_2$ (excess)

atoms reactant = atoms product

<u>The net molecular equation is</u>:

$9\ H_2\ (g) + 3\ N_2\ (g) \rightarrow 6\ NH_3\ (g)$

Note: 18 H and 6 N in each side!!

In general, a chemical reaction can be expressed as:

$a\ A + b\ B \rightarrow c\ C + d\ D$

where a, b - coefficient of reactant (how many).

c, d - coefficient of product (how many).

\# atoms (reactant) = # atoms product : Balance

Example # 1: Combination reaction between magnesium metal and molecular oxygen.

First write the correct formula of each chemical-

$Mg + O_2 \rightarrow MgO$

↑Oxygen from air ↓Product

<u>To balance:</u>

$Mg + O_2 \rightarrow MgO_2$ No!! (never since MgO_2 is different from MgO)

$Mg + O_2 \rightarrow 2MgO$ Oxygen is now okay but Mg is now not balance.

$2\ Mg + O_2 \rightarrow 2MgO$ Now oxygen okay and Mg okay.

↑Coefficient ↑Subscript

e #2: Decomposition reaction of H_2O

$H_2O \rightarrow H_2 + O_2$

2H↑ ↑1 O 2H↑ ↑2 O

Chemicals are identified, but oxygen is not balanced.

H_2O_2 ?

Change H_2O to H_2O_2 ? No! Since now the identity has changed.

Can only change coefficient when balancing a reaction.

Change coefficient of waters (H_2O) to 2

$2\ H_2O \rightarrow H_2 + O_2$

4H 2O 2 H 2 O

Oxygens are balanced but now hydrogens are not.

Balanced by changing coefficient in front of H_2 to 2

$2\ H_2O \rightarrow 2\ H_2 + O_2$

4H 2O 4H 2O

2 O's, and now 4 H's, in each side of equation.

The equation is now balance !!!

$2\ H_2O \rightarrow 2\ H_2 + O_2$

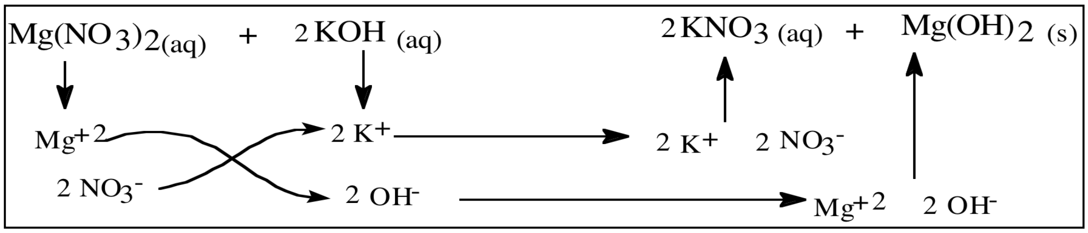
Summary: Balancing chemical reaction

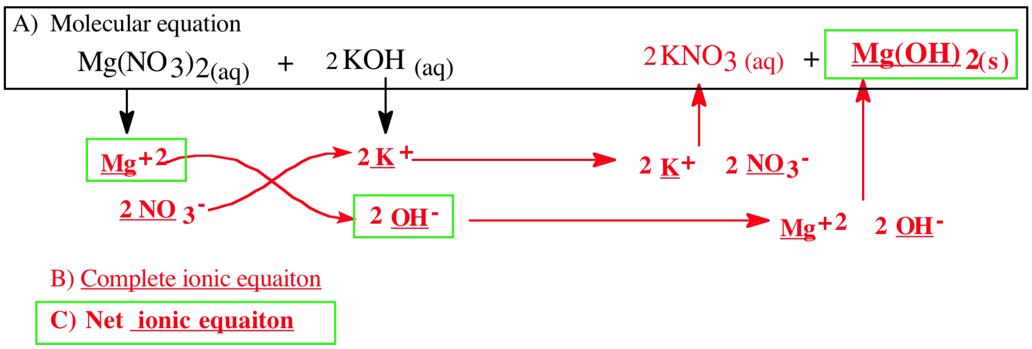
- Once chemical formula of species is determined you can never change the subscript of the chemical.
- To start, assign a coefficient of 1 (one) to most complicated chemicals.
- Balance the homogeneous atomic molecules last i.e., H_2, N_2, O_2.
- Balance cation/anion as a single unit (i.e., if occurs in reactant and product unchanged)
- Convert the fraction coefficients to integers.

Example # 3: Balancing a double displacement (metathesis)

Consider the reaction: $Mg(NO_3)_2$ + KOH → Products

What are the products formed and how can the equation be balanced?





3 ways of writing the chemical reaction for a double displacement reaction:

a) Molecular equation; This is an equation showing the overall reaction stoichiometry. The chemicals in the reaction are all shown in their neutral form.

b) Complete ionic equation; This is an equation shows ions that are strong electrolytes. The chemicals are shown as they would exist in aqueous medium. The ions are shown as ions and precipitates, or weak electrolytes shown as neutral formulas.

c) Net ionic equation; This is an equation shows only substances undergoing chemical changes. The ions involved in the formation of product are shown in this equation. Spectator ions are left out of the equation.

Summary:

a) Molecular equation:

$$Mg(NO_3)_{2(aq)} + 2KOH_{(aq)} \rightarrow 2KNO_{3(aq)} + Mg(OH)_{2\ (s)}$$

b) Complete ionic equation:

$$Mg^{2+}{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + 2\ K^+{}_{(aq)} + 2\ OH^-{}_{(aq)} \rightarrow 2\ K^+{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + Mg(OH)_{2\ (s)}$$

c) Net ionic equation:

$$Mg^{2+}{}_{(aq)} + 2\ OH^-{}_{(aq)} \rightarrow Mg(OH)_{2\ (s)}$$

Example # 4: Balancing a neutralization reaction is a form of double displacement reaction.

$$\_\_HNO_{3\ (aq)} + \_\_Ca(OH)_{2\ (aq)} \rightarrow \_\_H_2O_{\ (l)} + \_\_Ca(NO_3)_{2\ (aq)}$$

Information about reactants

Acids - provides H^+

Base - provides OH^-

acid in water; at a molecular level. - (Aqueous chemistry)

Information about products

Water (a weak electrolyte) and a salt (ionic compound) are produced in an acid-base reaction.

salt : (cation - anion)

Balanced Equation: $2\ HNO_{3\ (aq)} + 1\ Ca(OH)_{2\ (aq)} \rightarrow 2\ H_2O_{\ (l)} + 1\ Ca(NO_3)_{2\ (aq)}$

Table Solubility Rules. The table indicates the precipitate form in aqueous solution.

Soluble Substances		Insoluble Substances	
Containing-	Exceptions	Containing-	Exceptions
Nitrates (NO_3^-) Perchlorates (ClO_4^-) Acetates (CH_3CO_2-) Chlorates (ClO_3^-)	None	Carbonates (CO_3^{2-}) Chromates (CrO_4^{2-}) Phosphates (PO_4^{3-}) Sulfides (S^{2-})	Alkali and NH_4+
Halogens (X-) Cl^-, Br^-, I-	Ag, Hg & Pb.	Hydroxides (OH^-)	Ca, Ba, Sr, Alkali & NH_4^+
Sulfates (SO_4^{2-})	Ca, Ba, Hg and Pb	Soluble - dissolve, no precipitate (aq -phase) insoluble (or slightly sol.) - does not dissolve, precipitate forms. (s-phase)	
Alkali (Group1A) NH_4^+	None		

Try the following as an exercise.

#1 Sodium oxide and water forms sodium hydroxide

#2 Ferric(III) Sulfide & molecular oxygen yields ferric(III) oxide & sulfur dioxide.

#3 $C_4H_{10\,(g)}$ + $O_{2\,(g)}$ → $H_2O_{(g)}$ + $CO_{2\,(g)}$ (combustion)

In a combustion reaction, water, CO_2 and energy are always produced.

#4 H_2SO_4 (aq) + $Ca(OH)_2$ (aq) → $H_2O_{(l)}$ + $CaSO_{4\,(s)}$

Table A9.2 Classifications of Chemical Reactions

1. Combination Reaction

A + B → AB

Example:

i) __ SO_3 + __ H_2O → __ H_2SO_4

ii) __ Cu + __ O_2 → __ CuO

iii) __ CO_2 + __ H_2O → __ $C_{12}H_{22}O_{11}$

2. Decomposition Reaction

AB → A + B

Example:

i) __ H_2CO_3 → __ H_2O + __ CO_2

ii) __ $KClO_3$ → __ KCl + __ O_2

ii) __ $CaCO_3$ → __ CaO + __ CO_2

3. Single Displacement Reaction:

A + BC → AC + B

Example:

i) __ Zn + __ $Cu(NO_3)_2$ → __ $Zn(NO_3)_2$ + __ Cu

ii) __ Ca + __ H_2O → __ $Ca(OH)_2$ + __ H_2

iii) __ Mg + __ HCl → __ $MgCl_2$ + __ H_2

4a. Double Displacement Reaction:

AB + CD → AD + CB

Example:

i) __ $Ba(NO_3)_2$ + __ H_2S → __ BaS + __ HNO_3

ii) __ $MgCl_2$ + __ Na_3PO_4 → __ $Mg_3(PO_4)_2$ + __ NaCl

iii) __ $HC_2H_3O_2$ + __ $NaHCO_3$ → __ $NaC_2H_3O_2$+ __ H_2CO_3

4b. Acid Base (Double Displacement) Reaction:

HA + MOH → H_2O + MA

Example:

i) __ HNO_3 + __ $Ba(OH)_2$ → __ H_2O + __ $Ba(NO_3)_2$

ii) __ HCl + __ NH_4OH → __ H_2O + __ NH_4Cl

5. Combustion Reaction

CxHy + O_2 → CO_2 + H_2O

Example:

i) __ C_4H_{10} + __ O_2 → __ CO_2 + __ H_2O

ii) __ $C_{12}H_{22}O_{11}$ + __ O_2 → __ CO_2 + __ H_2O

iii) __ C_2H_5OH + __ O_2 → __ CO_2 + __ H_2O

WWW Links to balancing chemical reactions (Accessed Jan 2023)

1. http://www.webqc.org/balance.php
2. https://chemfiesta.org/
3. http://www.youtube.com/watch?v=RnGu3xO2h74
4. http://www.schooltube.com/video/db41eba5cdbd45fcbe75/Balancing-Chemical-Equations
5. http://www.chemtutor.com/react.htm
6. https://www.youtube.com/watch?v=MYmrWHzT1oI

Discussion on Stoichiometry: The molecular mass of a compound is the sum of the atomic masses of all the atoms present in one molecule of the compound. It represents the mass of one molecule of that compound in atomic mass units (amu). The formula mass of an ionic compound is calculated by adding up the atomic masses of all the atoms present in one formula unit of the compound.

A chemical reaction is a shorthand way of showing the changes occurring in any chemical reaction:

reactant 1 + reactant 2 + ... → product 1 + product 2 + ...

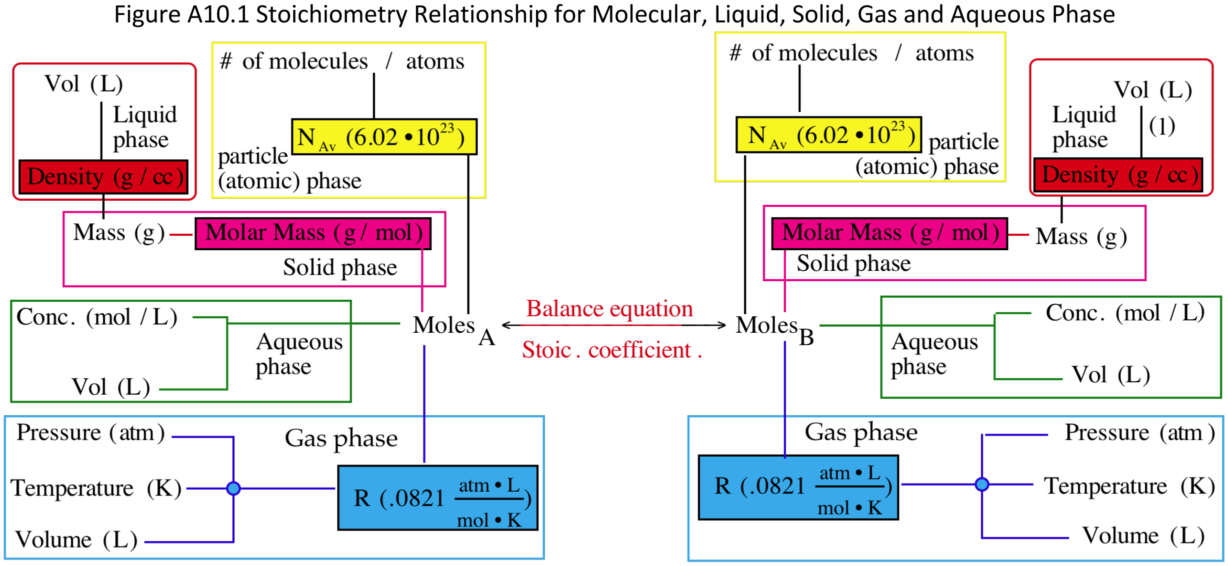
Every chemical equation must be balanced, which means that for every element shown in the equation, the number of atoms on the left must equal the number on the right:

Example: $3H_2 + N_2 \rightarrow 2\,NH_3$:
6 H atom & 2 N atoms (left) = 2 N atoms & 6 H atoms (right)
The 3 before H_2, the (implied) 1 before N_2, and the 2 before NH_3 are the coefficients of the equation. The coefficients in chemical equations represent moles as well as molecules or atoms. The equation: $3H_2 + N_2 \rightarrow 2\,NH_3$, for instance, tells us that three moles of H_2 combines with one mole of N_2 to form two moles of NH_3. Knowing the number of moles, we can calculate the amounts of reactants and products:

- Molar mass of H_2 is 2.02 g/mol; 1 mol has a mass of 2.02 g, 3 mol has a mass of 6.05 g.
- Molar mass of N_2 is 28.01 g / mol; 1 mol has a mass of 28.01 g.
- Molar mass of NH_3 is 17.04 g / mol; 1 mol has a mass of 17.04 g, 2 mol has a mass of 34.07 g.

6 grams H_2 + 28 grams N_2 → 34 grams NH_3

Figure A10.1 Stoichiometry Relationship for Molecular, Liquid, Solid, Gas and Aqueous Phase



WWW Links to stoichiometry problems (Accessed Jan 2022)

1. http://www.chemcollective.org/tutorials.php
2. http://science.widener.edu/svb/pset/stoichio.html
3. http://www.chemtutor.com/mols.htm
4. http://www.youtube.com/watch?v=EdZtSSJecJc

Figure.2 Stoichiometry Map

Stoichiometry map relating atoms within chemical compound.

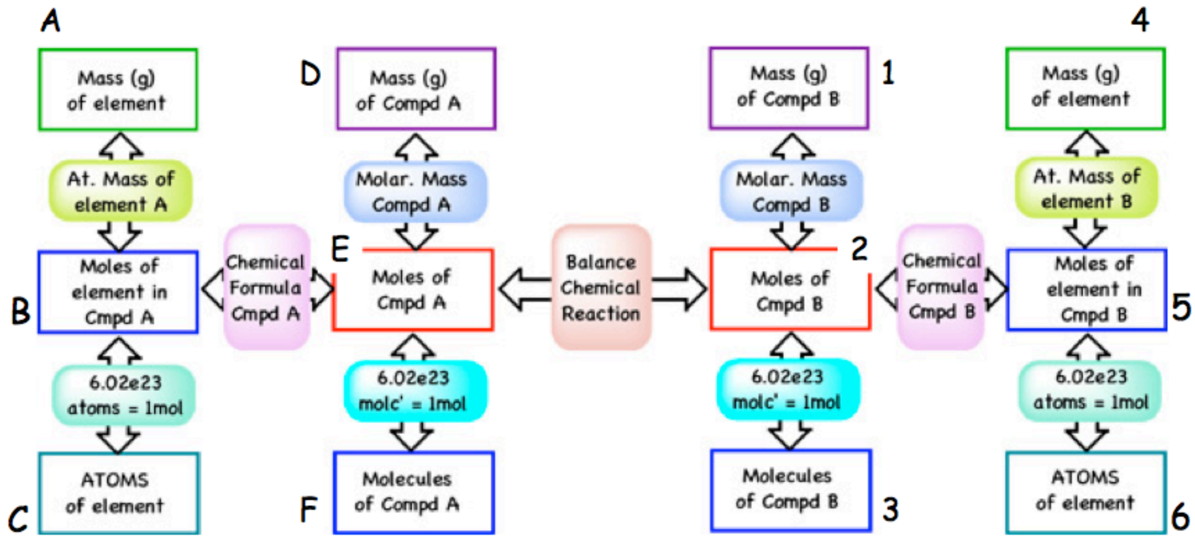
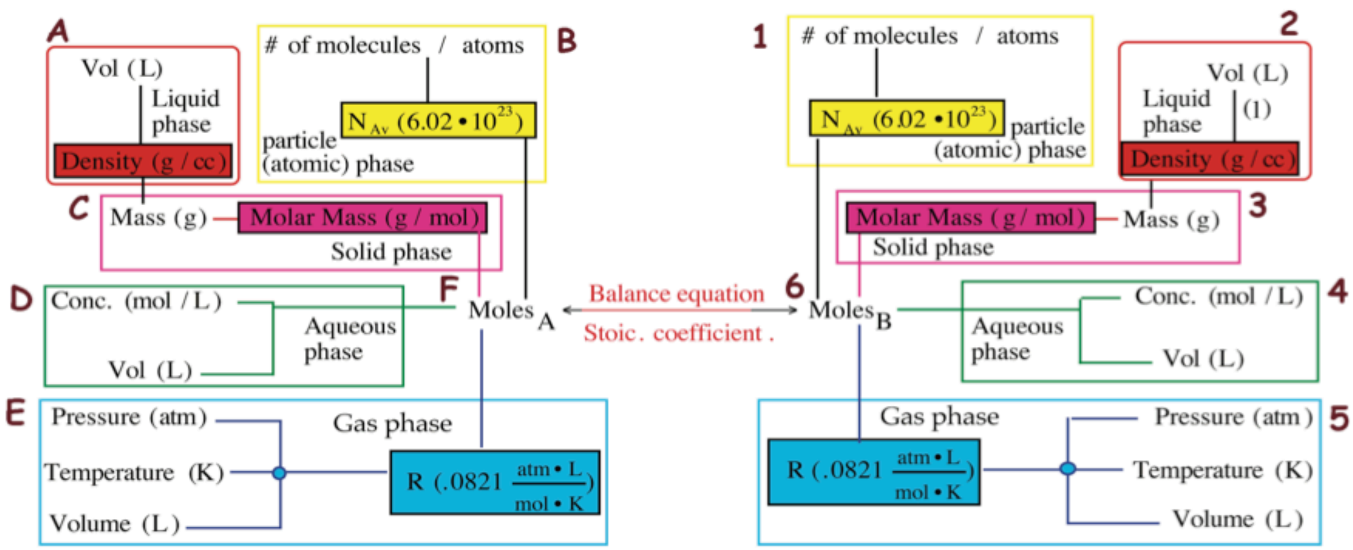


Figure 3 Overall Stoichiometry map relating different chemicals related by a chemical reaction.



08Lab | Activity 04: Balancing Equations and Stoichiometry Exercise

Last Name ________________________**First**_________________________ ____/ _____ **pts**

Required reading: Ch 7.4 "the Mole" and 7.5 "Molar Mass" in *Chemistry in our Lives* Timberlake 5th Edition.
Note that some of the numbers in this exercise may be different in Canvas.

A. Complete & balance the following double displacement reaction equations:

1)	___$NaCl$ (aq) + ___$AgNO_3$ (aq) →
2)	___$NaOH$ (aq) + ___HCl (aq) →
3)	__$BaCl_2$ (aq) + ___H_2SO_4 (aq) →

B. Complete, balance & identify the type of reaction. Product names are named in parentheses (Combination, Decomposition, Single displacement, Double displacement)

1)	___ $Zn_{(s)}$ + ___ Cl_2 (g) →	(zinc chloride)
2)	____ $H_2CO_{3(aq)}$ →	(carbon dioxide and water)
3)	___ Fe_2S_3 (aq) + ___ HCN (g) →	(Iron(III)cyanide and dihydrogen monosulfide)
4)	_____ Ni (s) + ____ HCl (aq) →	(nickel(II)chloride and hydrogen gas)
5)	___ BaO (aq) + __ CO_2 (g) →	(barium carbonate)
6)	_____ $Co(OH)_3$ (aq) + ___ Na_2CO_3 (aq) →	(cobalt(III) carbonate and sodium hydroxide)
7)	___ $ZnCl_2$ (aq) + ____ $(NH_4)_2S$ (aq) →	(zinc sulfide and ammonium chloride)

C. Beneath each word equation, write the formula equation and balance the reaction.

1) Sulfur dioxide$_{(g)}$ + Oxygen$_{(g)}$ $\xrightarrow{\Delta}$ Sulfur trioxide$_{(g)}$

2) Ammonia$_{(g)}$ + oxygen$_{(g)}$ $\xrightarrow{\Delta}$ water$_{(g)}$ + nitrogen monoxide$_{(g)}$

3) Ammonium nitrate$_{(s)}$ $\xrightarrow{\Delta}$ Nitrogen$_{(g)}$ + Oxygen$_{(g)}$ + Water$_{(g)}$

4) Sodium bicarbonate $_{(s)}$ + Acetic acid$_{(aq)}$ $\rightarrow$ sodium acetate $_{(aq)}$ + carbon dioxide$_{(g)}$ + Water$_{(g)}$

5) Sodium bicarbonate$_{(s)}$ $\xrightarrow{\Delta}$ sodium carbonate$_{(s)}$ + carbon dioxide$_{(g)}$ + Water$_{(l)}$

6) nitric acid$_{(g)}$ + nitrogen monoxide$_{(g)}$ $\rightarrow$ nitrogen dioxide$_{(g)}$ + Water$_{(l)}$

D. Find or calculate the atomic mass, molar mass, or formula mass for the following: (Include the appropriate unit and round off to the hundredth of a unit, i.e., Atomic Weight of Hydrogen is shown as 1.008 g/mol and is rounded off as 1.01 g/mol)

1) Tungsten

2) Ytterbium

3) Sulfur hexafluoride

4) Tungsten(V) oxalate tetrahydrate

E. Atom, molecules, mole, and Avogadro's Number-

1) How many atoms are in 11 molecules of sulfur hexafluoride?

2) How many moles of water are in 5 moles of Tungsten(V) oxalate tetrahydrate ?

3) What is the mass in grams (g) of a single atom of Ytterbium?
Hint: Start with the atomic weight of Ytterbium and use dimensional analysis to get grams per atom.

4) What is the molar mass of a molecule (g/mol) that weighs $2.99 \cdot 10^{-23}$ g?
What is the identity of the molecule?

5) What is the mass (grams) of 5.0 moles of Tungsten(V) oxalate tetrahydrate?

F. Balancing Equations and the Mole Concept

1) Write and balance the chemical equation when potassium chloride is combined with oxygen to produce potassium chlorate. Determine the moles of potassium chlorate ($KClO_3$) produced, if 17 moles of potassium chloride are combined with excess oxygen?

2) Write and balance the chemical equation upon combustion of sucrose.

2a) Determine the moles of H_2O produced from combustion of 5 moles of sucrose and 39 moles of oxygen? Round to the three significant figures.

2b) Which chemical is in excess and how many moles remain after the reaction is complete?

3) How many moles of S_8 are needed to produce 4.75 kg of sulfur tetrafluoride according to the reaction:

$S_8 + F_2 \rightarrow$ sulfur tetrafluoride. (Hint: First complete the equation and balance if necessary)

4) Carbon dioxide, CO_2, and ammonia, NH_3, combines to form urea, CH_4N_2O, plus water.

Write a balanced equation and calculate the mass of ammonia (in grams) that would be needed to make 2.0 moles of urea.

5) What is the percent yield for a reaction when 166.3 grams of W_2O_3 combines with excess carbon monoxide to produce 14.78 g of W ?

___W_2O_3 + ____ CO → ____ W + _____ CO_2

09Lab | Experiment 05: Observing Chemical Reactions

Objective

In this experiment, students perform a variety of chemical reactions. For each reaction, student identify the signs that a reaction has occurred, write the balanced chemical equation with appropriate phases and classify the reaction.

Material and Chemicals

KLM Equipment	(1) 18x150mm test tube w/ stopper	400mL Beaker	Thermometer	Spatula
	(2) 13x100 test tube w/ stopper	100mL Beaker	Wash bottle	Petri Dish
	Alcohol Burner/Stand	Watch glass	Test tube brush	
Miramar supply	calcium oxide (quicklime solution)	phenolphthalein	copper shots	Evaporating dish
	Ethanol (or rubbing alcohol	acetic acid (vinegar)	Straw	Berel pipet
	Magnesium metal strip	sucrose (sugar)*	Crucible Tongs	Forceps
You supply:	sodium bicarbonate (baking soda)	9-V Battery	Oven-mitts	Spoon
	NaCl (table salt)			

* Look in your lab material for this experiment and for the next experiment, Expt 6, The Mole. You should have a packet of sugar for both labs. If not, then weight this packet and the sugar content. Make a note and save that data for the next experiment. Do not burn all the sugar in this procedure so you have some for the next experiment. If you are missing a packet of sugar, contact the instructor now.

Lab Appendix: Using an alcohol Burner

Introduction

Reading: *Chemistry in our Lives* Timberlake. Chapter 7.1 *Equations for Chemical Reactions*, 7.2 *Types of Chemical Reactions,* and *9.2 Electrolytes and Non-Electrolytes.*

In this experiment, you'll be observing the signs of chemical reactions. These include the following:

- Flame
- Color Change
- Formation of a precipitate.
- A change in temperature of the reaction mixture
- Formation of Bubbles, indicates that one of the products is a gas. Ex. H_2, O_2 or H_2O vapor.

Important Notes:

Please remember that when a chemical reaction is written, the chemicals that is written in the reaction is how they are found in nature. For example, in the statement, "hydrogen and oxygen forms dihydrogen monoxide". The formula for hydrogen and oxygen would be written as H_2 and O_2 and not as H or O because H, the atom and O, the atom are not how these elements exist in their nature. Diatomic elements take on this rule when writing chemical equations. Diatomic chemicals are: H_2, O_2, N_2, F_2, Cl_2, Br_2, and I_2.

Please review 08Lab|Activity04 to see some of the reactions that you will be studying in this experiment.

Procedure –

Reaction A: Oxidation of Copper by Air (O_2)

Add copper shots to the evaporating dish. Place the evaporating dish on the alcohol burner stand. Heat the bottom of the evaporating dish slowly until the bottom gets very hot. Turn off the burner and allow the content to cool. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. Empty all chemicals in the water bottle waste container after you finish.
Photo1: Take a photo of the copper in the evaporating dish while heating.

Reaction B: Combination of CaO with CO_2

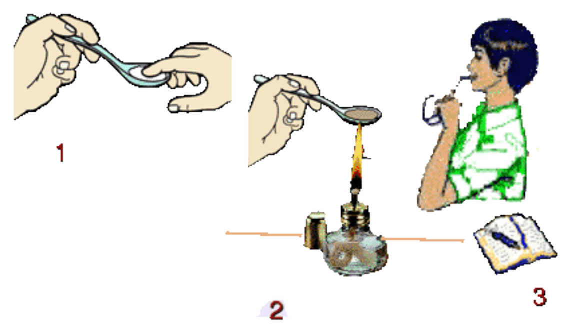
Pour quicklime solution in to a 100 mL beaker. Using a straw, blow into the solution. Observe what happens to the solution as you continue to blow bubbles. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. Empty all chemicals in the proper waste container after you finish.
Photo2: Take a photo of the quicklime solution turning murky.

Reaction C: Decomposition of H_2O

Fill the 150-mL beaker to ~ 100-mL with water then add a teaspoon full of salt. Take a 9-V battery and slowly submerge it in the water. Watch as bubbles form on the terminals. Note the rate of bubble formation on each terminal. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. When done making your observations pour the water out and dry the batter. Return all equipment clean and dry to its original storage location.
Photo3: Take a photo of the battery in the water forming bubbles.

Reaction D: Combustion of Sucrose ($C_{12}H_{22}O_{11}$)

Note that this sugar will also have to be used for the next experiment, Expt 6: The Mole, so do not use all of it.



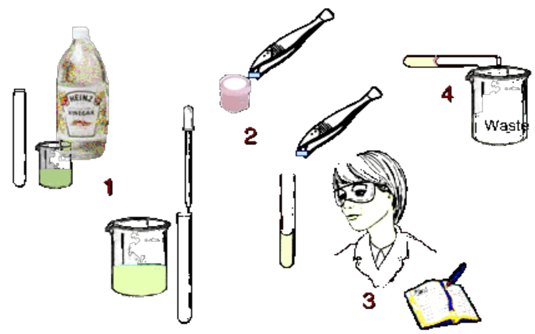
Carry out this procedure under a well, ventilated area. A spoon may be used in this procedure as shown in the figure. Place half-a-teaspoon full of sugar and then heat over the alcohol burner. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. Clean the spoon with soap and water. Empty all chemicals in the proper waste container.
Photo4: Take a photo of the sugar burning in the spoon.

Reaction E: Combustion of ethanol (C_2H_5OH) with oxygen (O_2).

As you did in the previous procedure, perform this procedure under a well, ventilated area. A teaspoon is used in this procedure as shown in the figure to the side. Add a small amount of ethanol (~0.5 ml) to a spoon. Use the alcohol burner to ignite the ethanol. Only a small amount of ethanol is necessary for safety precautions. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. Empty all chemicals in the proper waste container when you finish and return all equipment clean back to its original location.

Photo5: Take a photo of the ethanol burning in the spoon.

Reaction F: Magnesium metal with Acetic Acid, CH_3COOH



Part1: Add 2ml of Acetic Acid, (CH_3COOH) to an empty test tube. Add a 1-cm strip magnesium metal ribbon to the test tube using a forceps (tweezer). Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction.

Part 2: Fill a clean test tube with 2mL of deionized water. Heat the test tube with the water over the alcohol burner for abut 20 sec. Add two drops of phenolphthalein indicator. Phenolphthalein is an indicator that changes color (pink) in the presence of hydroxides.* (Save the rest of the phenolphthalein for expt 9. Place the phenolphthalein in the baggie, labeled Expt 9) Add a 1-cm strip of magnesium to the test tube and wait 15 minutes for the reaction to take place. After 15 minutes of observation, record in your datasheet the result of the magnesium in water. Is there the presence of hydroxide formation? Write the chemical reactions that occur in your datasheet.

Photo6: Take a photo of magnesium metal in the acid.

Reaction G: Baking soda with Vinegar (CH_3COOH).

Halfway fill an evaporating dish with vinegar. Sprinkle baking soda on to the vinegar and record your observations. Write on your datasheet the balanced chemical equation, the type of reaction and the driving force for the reaction. Empty all chemicals in the proper waste container after you finish.

Photo7: Take a photo of the baking soda bubbling in vinegar.

See 08Lab|Activity04: Balancing Equations and Stoichiometry exercise if you need help writing this equation.

Clean up.

Wash and dry all your glassware equipment.

Dispose of all used chemicals in the proper waste container.

Wipe down your work area and place your glassware and equipment back into its proper place.

Wash your hands thoroughly with soap and water before leaving your work area.

09Lab | Experiment 05: Observing Chemical Reactions, Datasheet

Last Name ________________________First________________________ ____ / _____ pts

Reaction A: Oxidation of Copper by Air (O_2) to produce copper (II) oxide.

Appearance Before	
Appearance After	
Evidence of Reaction	
Balanced Chemical Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

Reaction B: Combination of CaO with CO_2 to produce calcium carbonate.

Appearance Before	
Appearance After	
Evidence of Reaction	
Balanced Chemical Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

Reaction C: Decomposition of H_2O into hydrogen and oxygen gas

Appearance Before	
Appearance After	
Evidence of Reaction	
Balanced Chemical Equation **	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

** NaCl is used to help the battery to conduct electrons, e-, and is not part of the chemical equation.

Reaction D: Combustion of Sucrose ($C_{12}H_{22}O_{11}$)

Note that this sugar will also have to be used for the next experiment, Expt 6: The Mole, so do not use all of it.

Appearance Before	
Appearance After	
Evidence of Reaction	
Balanced Chemical Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

Reaction E: Combustion of Ethanol (C_2H_5OH) with oxygen (O_2).

Appearance Before	
Appearance After	
Evidence of Reaction	
Balanced Chemical Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

Reaction F: Magnesium Metal with Acetic Acid, CH_3COOH to produce hydrogen and magnesium acetate.

Appearance Before	
Appearance After	
Evidence of Reaction	
**Balanced Molecular Chemical Equation	
Total Ionic Equation	
Net Ionic Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

Reaction F, Part2: Write your observations when the magnesium metal was added to water that had phenolphthalein.

** The video below shows how to write a molecular, complete ionic and net ionic equation.
Reactions: https://youtu.be/pkNBXhMMrNs
Go to the 1:06:10 mark (1 hour – 6 min) to see the double displacement reaction discussion.

You can also watch this YouTube video for more information on Net Ionic Equations and Spectator ions
https://www.youtube.com/watch?v=PXRH_IrN11Y

Reaction G: Baking soda with Vinegar (CH_3COOH).

Appearance Before	
Appearance After	
Evidence of Reaction	
**Balanced Molecular Chemical Equation	
Total Ionic Equation	
Net Ionic Equation	
Reaction Type (circle one)	Combination - Decomposition - Single Displacement - Combustion - Double Displacement

** Watch this video to see how to write a molecular, complete ionic and net ionic equation:

Reactions: https://youtu.be/pkNBXhMMrNs

Go to the 1-hr mark to see the double displacement reaction discussion.

Turn in these photos in with your Data/Observation worksheet.

Photo1: Take a photo of the copper in the evaporating dish being heated.

Photo2: Take a photo of the quicklime turning murky.

Photo3: Take a photo of the battery in the water forming bubbles.

Photo4: Take a photo of the sugar burning in the spoon.

Photo5: Take a photo of the ethanol burning in the spoon.

Photo6: Take a photo of magnesium metal in the acid.

Photo7: Take a photo of the baking soda bubbling in vinegar.

At this point check to make sure you have all the chemicals and supplies for next week's experiment.

09Lab | Experiment 05: Observing Chemical Reactions, Pre Lab

Last Name __________________________First___________________________ **____ / _____ pts**

Prelab Questions

Answer these prelab questions and turn in to your instructor before the beginning of lab.

1. Explain in your own words the difference between a chemical change and a physical change.

2. In a chemical reaction, what is the solid called that forms when two solutions are mixed?

3. When two solutions are mixed, is a color change always an indication that a chemical reaction has occurred?

   Explain why.

4. Which sign of a chemical reaction is not detectable by sight? Explain.

5. Would you expect a chemical change to be always accompanied by a physical change? Explain.

6a. Write the complete ionic equation for the double displacement reaction below.

$$CuNO_{3\,(aq)} + K_2S_{\,(aq)} \rightarrow$$

6b. Name and write the formula for the spectator ions in this chemical reaction.

09Lab | Experiment 05: Observing Chemical Reactions, Post Lab

Last Name ________________________First_________________________ **____ / _____ pts**

Postlab Questions

1. Check all the reactions in this lab, which produced a precipitate.

- ☐ Oxidation of Copper
- ☐ Decomposition of H_2O
- ☐ Reaction Mg ribbon with CH_3COOH
- ☐ Reaction of Mg metal with water + phenolphthalein
- ☐ Baking soda and Vinegar
- ☐ Combination of CaO and CO_2
- ☐ Decomposition of Sugar
- ☐ Ethanol with Oxygen

2. Check all reactions in this lab that showed evidence of the release or absorption of heat. (Do not confuse the release of heat with providing an external addition of heat, i.e. Heating with a Bunsen burner)

- ☐ Oxidation of Copper
- ☐ Decomposition of H_2O
- ☐ Reaction Mg ribbon with CH_3COOH
- ☐ Reaction of Mg metal with water + phenolphthalein
- ☐ Baking soda and Vinegar
- ☐ Combination of CaO and CO_2
- ☐ Decomposition of Sugar
- ☐ Ethanol with Oxygen

3. Check all the reactions in this lab, which were accompanied by the evolution of gas.

- ☐ Oxidation of Copper
- ☐ Decomposition of H_2O
- ☐ Reaction Mg ribbon with CH_3COOH
- ☐ Reaction of Mg metal with water + phenolphthalein
- ☐ Baking soda and Vinegar
- ☐ Combination of CaO and CO_2
- ☐ Decomposition of Sugar
- ☐ Ethanol with Oxygen

4. What is the color of the sugar before and after combustion? What is the identity of the gases you observed?

5a. Both are produced in the reaction between vinegar and baking soda, and in the reaction of the combustion of ethanol.

5b. Write the molecular equation when baking soda and vinegar reacts with each other.

10Lab | Experiment 06: The Mole, Counting by Weighing

Watch the Prelab Video: https://youtu.be/isXZIglUKlw

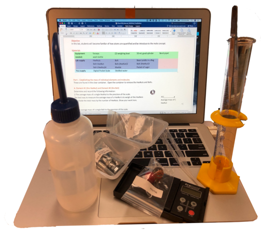
Last Name _________________________First__________________________ **____ / _____ pts**

Objective

In this lab, students will become familiar of how atoms are quantified and be introduce to the mole concept.

Material and Chemicals

KLM Equipment	50-mL grad cylinder	Spatula	Wash bottle
Miramar supply	Digital Pocket Scale	Lego Bricks	Bolt-(HexNut)2
	Forceps	Bolt	Bolt-(HexNut)3
	Berel pipet	HexNuts	Bolt-(HexNut)4
	Weighing boat	Bolt-HexNut	Packet of sugar
You supply	Distilled water		



* Look in your lab material for this experiment. You should have a packet of sugar. If not, look at Expt 5, you may have burn part of it in that experiment. If you are missing a packet of sugar, contact the instructor now.

Part I. Establishing the mass of individual elements and molecules.

These are found in the chemical kits issued by Miramar College. Open the container to remove the HexNuts and Bolts. There are 12 Hexnuts and 5 bolts. Take these apart for the following procedures.

A. Element #1 (the HexNut) and Element #2 (the Bolt)

Determine and record the following information:

i) The average mass of a single HexNut to the precision of the scale.
The best way to measure the average mass of a HexNut is to weigh the 12 HexNuts and divide this mass by the number of HexNuts (12). Show your work here.

A1)___________g
Average mass of 1 HexNut

ii) The average mass of a single Bolt to the precision of the scale.
As mentioned above, the best way to measure the average mass of a bolt is to weigh all 5 bolts and divide this mass by the number of bolts (5). Show your work.

A2)___________g
Average mass of 1 Bolt

Photo1: Take a photo of the mass of the HexNut and Bolt on the scale with the mass displayed.

B. Compounds #1 (BN), #2 (BN_2), #3 (BN_3) and #4(BN_4): Bolt – HexNut molecules

The combined Bolt (B) and HexNut (N) "elements" will represent our theoretical "compound" and will be represented by BN, BN_2, BN_3 and BN_4. As you did above, Use the hardware you have in your chemical kit and assemble as many BN, Bolt-Nut (BN). Weigh these and determine the average mass of one BN. Do a similar procedure for BN_2, BN_3 and BN_4.

Using hardware		Calculations	Average Mass
Make 5 BN and weigh			B1) __________g BN
Make 5 BN_2 and weigh			B2) __________g BN_2
Make 4 BN_3 and weigh			B3) __________g BN_3
Make 3 BN_4 and weigh			B4) __________g BN_4

Photo2: Take a photo of the mass of the BN_4 on the scale with the mass clearly displayed.

C. Lego Bricks.

The data is provided below (We forgot to pack this into your chemical list).

Watch the video for this data: https://youtu.be/isXZIgIUKIw

2. Find the Lego Bricks. The two 2x4 Bricks are labeled the E bricks (E stands for eight pegs) and the two 2x2 Bricks are your F brick (stands for four pegs). Follow the directions below so you record the mass of the brick individually as well as the whole EF_2.

Colors of the Lego bricks will vary but will not alter the mass.

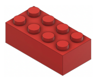
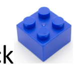
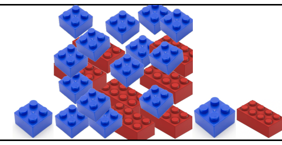
Lego Bricks E = 2x4 brick  F = 2x2 brick 	
1) Mass of E: Take the mass of two (E) 2x4 brick. Weigh and divide by 2. Watch the video and from the data, determine the average mass of one 2x4 brick (E). Do this by taking the mass of the 10 bricks and dividing by 10 to get the average.	C1A) __________g 1 x E brick. Your measurement C1B) __________g Avg mass 1 – brick (E) Video Data
2) Mass of F: Take the mass of two (F) 2x2 brick. . Weigh and divide by 2. Watch the video of 10 F bricks and write the average of one F Do this by taking the mass of the 10 bricks and dividing by 10 to get the average.	C2A) __________g 2 x F brick. Your measurement C2B) __________g Avg mass. 1- brick (F). Video Data
3) Mass of 10 EF_2: Assemble one E and 2 F bricks to make the EF_2 molecule. Write this mass on C3A.*	C3A) __________g mass EF_2 molecule Your measurement
4) Mass of EF_2 average based on Video Watch the video of the mass of 10 EF_2. From the video, determine the average mass of one EF_2.	C4A) __________g Avg mass. EF_2 molecule Video Data based on 10 EF_2
5) Percent difference between Mass of E + 2 F brick your measurement and the EF_2 Video measurement. Note that the % error here is an absolute value. $\left\lvert\frac{C3A - C4A}{C4A}\right\rvert \times 100$	C5A) _________ % Difference between measurements.

Photo3: Take a picture of the EF_2 Lego on your scale. The scale should show the mass.

From this point on, you will be using the data that is assigned in the unknown data.

Download the data for your assigned unknown by going to Canvas and clicking on the link that is titled -
C2_09Lb|Ex05 Mole: | Click here to access your Unknown **. There you will be provided data of your unknown to complete the lab.**

The table to the right is what the data will look like.

Be sure to Write your unknown number down, otherwise you will not receive credit for the analysis.

Reading your Unknown Data

1 – Your unknown number.
2 – Mass in grams of container
3 – Mass of container and item (This is gross mass)
4 – Number of "Molecules" in the container

The Mole: Counting by Weighing

Unknown # 1

	2 Mass Container (g)	3 Mass Container + Content (g)	4 No of Molecules
HexNuts:	[illegible]	[illegible]	You calculate
BN1	[illegible]	[illegible]	You calculate
BeL5	[illegible]	[illegible]	You calculate
Molecule G	[illegible]	[illegible]	5
Molecule H	[illegible]	[illegible]	4

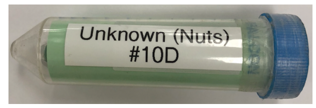
Unknown No. ______________ (You will lose 20% if you do not record your unknown number here.)

Part 2. Counting by Weighing.

In this part of this lab, you will determine the number of elements or compounds based on the data provided. You will need to use the information from part I in this experiment to calculate then number of HexNut in a sealed unknown container.

D. The number of HexNuts.

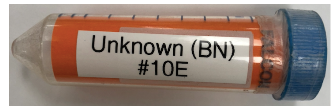
In this procedure you will determine the number of HexNut in a sealed container given the gross mass of the container and HexNuts inside.

There are HexNuts in this container. By weighing the content, the number of HexNuts will be determined.	 **Part2 D**
D1) Record the mass of the container that holds the "unknown" HexNuts, as given in the data for your unknown.	D1) ______ g Mass of Container (This is given in your unknown data that you downloaded)
D2) Record the mass of the container + HexNut as given in the data for your unknown.	D2) ______ g Mass of Container + HexNut (gross) (This is given in your unknown data that you downloaded)
D3) Calculate and record the net mass by subtracting the mass of container from container + HexNuts. (D2 - D1) This is the mass of HexNuts.	D3) ______ g Mass of HexNuts in container (net)
D4) Using the average mass of a single HexNut from Part I, calculate the number of HexNut elements in your unknown. Show your calculations below. Your answer must be a whole number	D4) _______ Number of HexNuts in container.

Show calculations for D4.

E. The number of molecules (BN_1) in a container

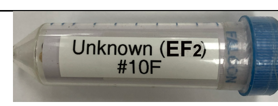
In this part of this lab, you will determine the number of BN_1 "molecule" based on the data provided. You will need to use the information from part I to calculate then number of BN_1 in a sealed unknown container.

There are BN_1 "molecules" in this container. By weighing the content, the number of BN_1 will be determined.	 **Part2 E**
E1) Record the mass of the container as given in the data for your unknown.	E 1)_______ g Mass of container (label on container)
E2) Record the mass container + BN_1 "molecule" as given in the data for your unknown.	E 2) _______g Mass of container + BN_1 (gross)
E3) Calculate and record the net mass by subtracting the mass of container from container + BN_1. (E2 - E1) This is the mass of BN_1 in the container.	E 3) ______ g Mass of BN_1 in container (net)
E4) Using the average mass of a single BN_1 compound, calculate the number of BN_1 compound in your unknown. Show your calculations below. Your answer must be a whole number.	E 4) _____ Number of BN_1 compounds in container

Calculations for E4.

F. The number of molecules (EF_2) in a container

In this part of this lab, you will determine the number of EF_2 "molecule" based on the data provided. You will need to use the information from part I to calculate then number of EF_2 in a sealed unknown container.

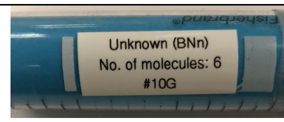
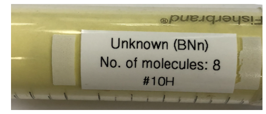
There are EF_2 "molecules" in this container. By weighing the content, the number of EF_2 will be determined.	 **Part2 F**
F1) Record the mass of the container as given in the data for your unknown.	F1) _____ Mass of container (label on container)
F2) Record the mass container + EF_2 "molecule" as given in the data for your unknown.	F2) ______ Mass of container + EF_2 (gross)
F3) Calculate and record the net mass by subtracting the mass of container from container + EF_2. (F2 - F1) This is the mass of EF_2 "molecules" in the container.	F3) ______ Mass of EF_2 in container (net)
F4) Using the average mass of a single EF_2 compound, calculate the number of EF_2 compound in your unknown and write this value. Show your calculations below. Your answer must be a whole number.	F4) ______ Number of EF_2 Lego molecules in container.

Calculations for F4.

Part 3. Identification of an Unknown based on Average Mass.

G & H: Determining the identity of the compound (BN, BN_2, BN_3 or BN_4)

In this part of this lab, you will determine the identity of a "molecule" based on the data provided in this lab. You will need to use the information from part I to calculate the BN_x formula.

	 **Part3 G**	 **Part3 H**
1) Record the number of molecules as written on the containers for this part. Write these in line G1 and H1 as given in the data for your unknown.	G1)____# of molecules	H1)____# of molecules
2) Write the mass of the container+ the Unknown molecule BN_x and record the mass in line G2 and H2.	G2) _______ g Mass of container + Unknown (gross)	H2) ________ g Mass of container + Unknown (gross)
3) Write the mass of each container as written on the label of the containers. Write the mass of each container in lines G3 and H3.	G3) _____ g Mass of container	H3) _____ g Mass container
4) Calculate the net mass of the content in each container.	G4) _______g Mass of $Unknown_1$ (net)	H4) _______ g Mass of $Unknown_2$ (net)
5) Take the net mass and divide by the total number of molecules. This is the average mass of a single molecule in the container. Show your calculations below.	G5) _______g Average mass of Unk_1	H5) ________ g Average mass of Unk_2
6) Using the data for the average mass of the BN_1, BN_2, BN_3 and BN_4 from part 1B, identify the chemical formula of your unknown in the container for this part.	G6) _________ Formula of molecule in container	H6) _________ Formula of molecule in container

Calculations to show your results.

Part 4. Measure the mass of water and sugar.

Measure the mass of water and sucrose (table sugar) as described below. You will calculate the number of moles and molecules for your post-Lab.

J The number of moles of water in 50.0 ml of water

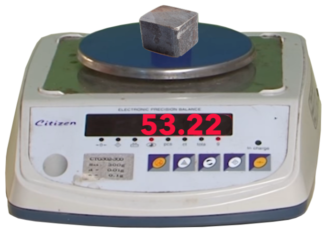
	Part4 J
J1) **An Iron Cube:** Shown is a photo of an iron cube on a scale after the scale was tared.  You must complete this section. Do not skip.	1) ___________g iron cube
J2) **50.0 mL of water:** Tare a 50mL-graduated cylinder on the scale. Add water and bring to precisely 50.0mL of water using a Berel pipet. Weigh the graduated cylinder with the water and record the mass.	2) ___________g 50.0 mL water
J3) **Packet of sucrose (sugar)**, $C_{12}H_{22}O_{11}$: Weigh a packet of sugar and record the gross mass of the sugar packet. Empty the bag to the waste bottle and weigh the bag. Subtract the mass of the bag from the original weight.	3) ___________g mass of sugar.

Photo4 & 5: Take a pic of the 50-mL water & the sugar packet on the scale with the mass showing for each.

Calculations to show your results.

Clean up. Replace all items back in the baggy. Empty the sugar in your waste plastic bottle.

Please submit the following photos with your Datasheet-

Photo1: Take a photo of the mass of the HexNut and Bolt on the scale with the mass displayed.

Photo2: Take a photo of the mass of the BN_4 on the scale with the mass clearly displayed.

Photo3: Take a photo of the mass of the EF_2 on the scale with the mass clearly displayed.

Photo4 & 5: Take a pic of the 50-mL water & the sugar packet on the scale with the mass showing for each.

Your next experiment is a gas simulation. No chemicals or equipment is needed for this experiment.

10Lab | Experiment 06: The Mole, Counting by Weighing, Prelab

Last Name ________________________**First**_________________________ ____ / _____ **pts**

Prelab Questions

Try to answer the following prelab before beginning the experiment. Use the periodic table in the appendix of this lab manual. It is important to use the periodic table atomic weigh values found in the appendix. The canvas questions were coded based on the values from this periodic table. If you use any other source, it will be mark incorrect.

1. Determine the atomic mass of the following to the **nearest hundredth** of atomic mass.

a) Phosphorus b) Fluoride c) chloride d) bromide e) iodide f) astatine

2) Calculate the molar mass of the following to **the nearest hundredth** of molar mass.

a) PF_3 b) PCl_3 c) PBr_3 d) PI_3

3) Given 100.0 g of each the following item below, calculate the number of moles. Round off based on the mass given.

a) PF_3 b) PCl_3 c) PBr_3 d) PI_3

4) Calculate the number of the molecules given 1.00 g of the following. Use three significant figures in your calculations.

a) PF_3 b) PCl_3 c) PBr_3 d) PI_3

Last Name _________________________First___________________________ **____ / _____ pts**

Postlab Questions

Part 4. Calculations, Converting from Mass to Moles for some common objects.

Using the mass of the J1) iron cube, J2) 50.0mL of water and J3) packet of sugar, determine the number of moles of metal, water, and sugar. Round of to correct number of significant figures and use scientific notation when appropriate.

J1 The number of moles and atoms in the iron cube

	Part4 J1
J1a) **Iron cube:** Write the mass of the iron cube from part j1.	J1a) ___________g iron cube
J1b) Write the atomic weight of iron.	J1b) ____________ g/mole for iron
J1c) Calculate the number of moles of iron in the cube. Show your calculations below.	J1c) ___________moles of iron
J1d) Calculate the number of iron atoms in the cube. Show your calculations below.	J1d) ___________atoms of iron

J2 The number of moles, molecules, and atoms in 50.0 ml of water

	Part4 J2
J2a) **50.0 mL of water:** Write the mass of the 50-ml water from part j.	J2a) ___________g 50.0 mL water
J2b) Write the molar mass of water.	J2b) ____________ g/mole for water
J2c) Calculate the number of moles of water in the 50-mL volume of water. Show your calculations below.	J2c) ___________moles of water
J2d) Calculate the number of water molecules in 50.0 mL. Show your calculations below.	J2d) ___________molecules of water
J2e) Calculate the number of Oxygen and H atoms in 50 mL of water. Show your calculations below.	J2e) ___________ O atoms in water J2ee) ___________H atoms in water

J3. The number of moles of sucrose in a packet of sugar

	Part4 J3
J3a) **Sucrose (sugar)**, $C_{12}H_{22}O_{11}$: Write the mass of sucrose.	J3a) __________g mass of sucrose.
J3b) Write the molar mass of sucrose.	J3b) __________g/mol for sucrose.
J3c) Calculate the number of moles of the sucrose. Show your calculation below.	J3c) ____________moles of sucrose
J3d) Calculate the number of molecules of sucrose in the packet of sugar. Show your calculations below.	J3d) _____________molecules of sugar
J3e) Calculate the number of atoms of C, H, and O in the packet of sucrose. Show your calculations below.	J3e) ___________C atoms J3ee) ____________H atoms J3eee) ____________O atoms

Last Name ________________________First_________________________

Summary of Results.

Unknown number: ____________ Write Unk No here.

Data: Mass of Hardware "Atoms and Molecules"

Average Mass of HexNut (N) ___________ g

Average Mass of Bolt (B) ___________ g

Average Mass of BN_1 ___________ g

Average Mass of BN_2 ___________ g

Average Mass of BN_3 ___________ g

Average Mass of BN_4 ___________ g

Average Mass of E ___________ g

Average Mass of F ___________ g

Average Mass of EF_2 ___________ g

% Error between EF_2 Your measurement and Video Average ___________ %

Data: Counting by Weighing

Number of HexNuts in unknown ___________

Number of BN_1 in unknown ___________

Number of EF_2 in unknown ___________

Formula of "Molecule" in Container G ___________

Formula of "Molecule" in Container H ___________

11Lab.| Experiment 07: Gas Law Simulation

Please carry out this experiment using a computer. A smart phone or tablet may have limitations.

Objective

In this experiment, you will use a gas law chamber to verify the Gas Law, determine the mole of gas each time the pump is depress and to verify the Universal Gas Constant, R.

Website

https://ch301.cm.utexas.edu/simulations/js/idealgaslaw/

Introduction

Relevant Equations

Boyle's Law	$PV = K_B$	$P_1V_1 = P_2V_2$	$\Delta T = \Delta n = 0$
Charles' Law	$\frac{V}{T} = K_C$	$V_1 / T_1 = V_2 / T_2$	$\Delta P = \Delta n = 0$
Avogadro's Law	$\frac{V}{n} = K_A$	$V_1 / n_1 = V_2 / n_2$	$\Delta T = \Delta P = 0$
Guy-Lussac's Law	$\frac{P}{T} = K_{GL}$	$P_1 / T_1 = P_2 / T_2$	$\Delta V = \Delta n = 0$

Root mean square speed: $U_{rms} = \sqrt{\frac{3RT}{M}}$ (not in your text but equation is based on the Kinetic Molecular Theory)

Ideal Gas Law: $PV = nRT$

P = Pressure in units matching R

V = Volume of the gas in liters

n = moles of gas

T = temperature of the gas in Kelvin

M = Molar mass of Gas

U_{rms} speed of particles in a gas.

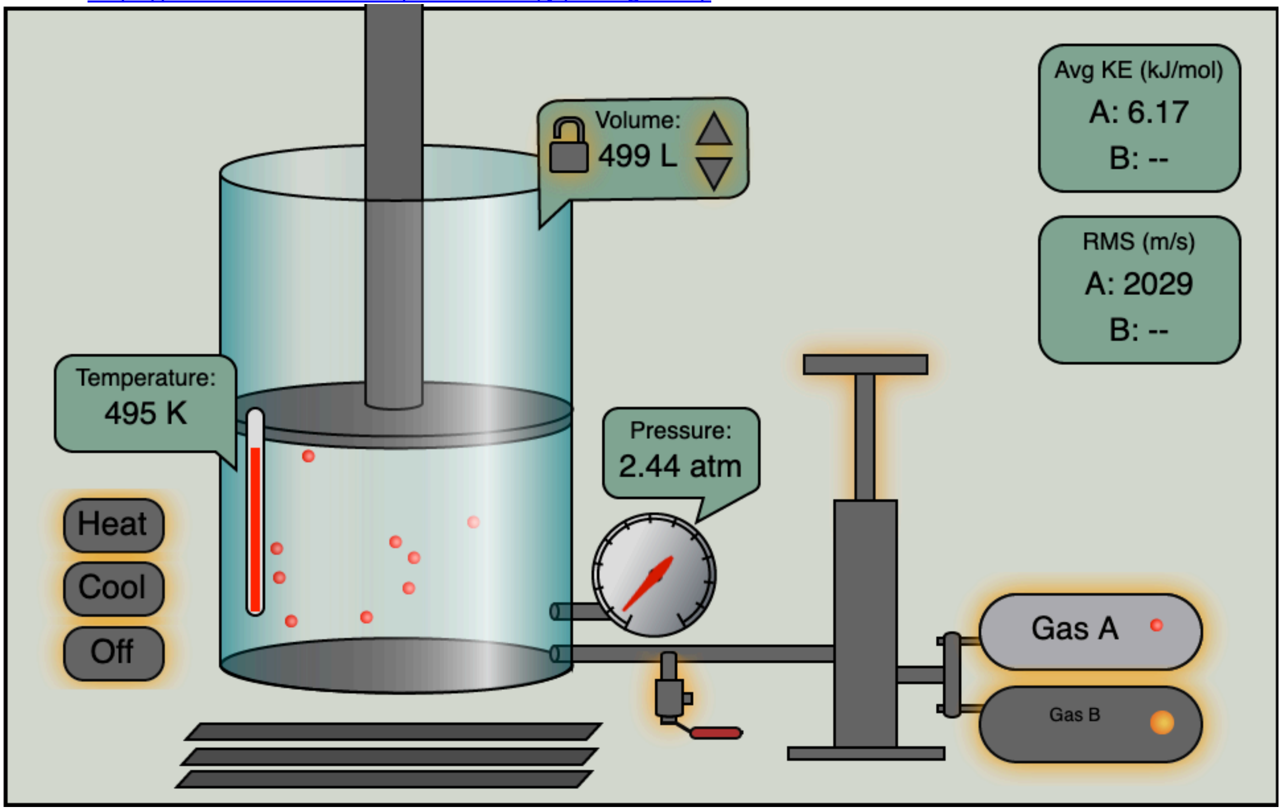
https://courses.lumenlearning.com/boundless-chemistry/chapter/kinetic-molecular-theory/

R = the ideal gas constant = 0.08206 L*atm/(mol K) = 62.4 L*mmHg/(mol K)

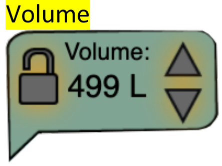
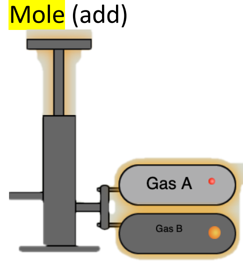
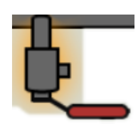
In this experiment, the gas law simulator will be used to investigate the Ideal Gas Law and properties of gases.

Note that the valve that glows in orange are the control valves. You can adjust these during the experiment.

Gas Simulator: https://ch301.cm.utexas.edu/simulations/js/idealgaslaw/



Control Valve.

Pressure	Volume	Mole (add)	Mole (release)	Temperature:
 Click on dial to adjust pressure. This cannot be lock.	 Click on triangle to increase or decrease. Click on lock to fix vol.	 Choose gas A or B and then pump handle.	 Lever to release gas in chamber.	 Click on heat to increase the temperature and click again to turn off. Do the same with cool to lower temperature.

Adjust the settings on the simulator to figure out how it works. There are a number of different controls and changing one may affect others. The pressure has no adjustment, it varies depending on the volume, moles, and temperature. The volume has a lock feature, so the volume can be adjusted to a fix setting. The number of particles (mol) in the chamber can be increase by depressing the pump, and release by turning the lever. Temperature can be controlled by the heating and cooling radio buttons. The temperature in the chamber can be temperature fixed by clicking on off. Double clicking on any control buttons turns on and off that setting quickly.

Once you understand how the gas chamber works, you can proceed according to the directions below. Note that the temperature and volume are difficult to adjust to an exact value, so the procedure below suggest a range that can be used for this experiment.

11Lab.| Experiment 07: Gas Law Simulation

Procedure –

Use the simulator found at the link above to investigate the relationships between the four gas variables: Volume (V), Pressure (P), Kelvin Temperature (T) and Number of particles, in moles (n).

There are six combinations to explore: V-T, V-P, T-P, V-n, n-P, and T-n.

For each of the combinations you MUST keep the other two variables constant (High-lighted in red in the table). Prior to each setting, empty the chamber by opening the valve and emptying the chamber. The first data point is given in each table. You will need to collect the other two data points to complete the table. Select Gas-A for parts 1-7a of the experiment. Select Gas-B for part 7b of the experiment.

1) V-P relationship (**Table 1**)

A. Empty the gas chamber before you start and then adjust the temperature to 295 K (or within 5K). Pump the plunger once then adjust the volume to a range between 300 - 400 L. The pressure will adjust itself based on the volume you select. Record the volume and pressure in the table.

B. Keep the previous temperature and number of particles the same as the last setting. Adjust the volume to a range between 500 - 600L. Record the volume and pressure in the table below.

C. Keep the previous conditions as is but adjust the volume to a range between 800 - 900 L. Read the pressure and record the volume and pressure in the table below.

D. The blank in the table below is the setting that you selected during your experiment.

Summary: Adjust temperature first, pump once and adjust volume. Read pressure and volume.

Volume (L) Adjusted range	Pressure (atm)	Temperature (K)	mole (mol) Gas-A
~ 300-400 L ____ ~ 500-600 L ____ ~ 800-900 L ____*	2.67 - 2.00 atm ____ ____ ____	295 K 295 K 295 K	1 pump

*** Photo1:** Take a photo (or screenshot) of the Gas simulator for your trial (V-P).

2) V-T relationship. (**Table 2**)

A. Empty the gas chamber before you start and then unlock the volume setting. Pump the plunger once which will adjust the pressure. Next set the temperature between 75 - 100K which will adjust the volume accordingly. Record the temperature and volume in the table below.

B. Keep the previous pressure and number of particles the same as the last setting. Adjust the temperature to a range between 125 - 150 K. Record the temperature and volume in the table below.

C. Keep the previous conditions as is but adjust the temperature to a range between 175 - 200 K. Record the temperature and volume in the table below.

D. The blanks in the table below are the setting that you selected during your experiment.

Summary: Set temperature, unlock volume, and pump once. Read volume and temperature.

Temperature (K) Adjusted range	Volume (L) - Unlock	Pressure (atm)	mole (mol) Gas-A
~75 -100 K ____ ~125 - 150 K ____ ~175 - 200 K ____	185 - 246 L ____ ____ ____	~1.00 atm	1 pump

3) <u>V-n relationship.</u> (**Table 3**)

A. Empty the gas chamber before you start and then unlock the volume setting. Adjust the temperature to 70 K or thereabouts. Pump the plunger once which will adjust the volume and pressure accordingly. Record the number of pumps and volume in the table below.

B. Start by keeping the previous pressure and the number of particles the same as the last setting. Keep the volume setting unlock. Pump the plunger the second time. Record the number of pumps and volume in the table below.

C. Start by keeping the previous conditions as before but add another pump to increase the number of particles in the chamber. Record the number of pumps and volume in the table below.

D. The blanks in the table below are the setting that you selected during your experiment.

Summary: Unlock volume, set the temperature, and pump once. Read volume and number of pumps.

mole (mol) Gas-A	Volume (L)	Temperature (K) Adjusted range	Pressure (atm)
1 pump 2 pumps 3 pumps	172 L ____ ____	70 K (or some convenient Temp)	1.00 atm

4) <u>P-T relationship</u> (**Table 4**)

A. Empty the gas chamber before you start and then add one pump. Adjust the volume to 600 L or thereabouts. You can change the volume in small increments by moving your cursor to the valve and double clicking. Lock down the volume so it is constant to your setting. Adjust the temperature to the range of 75 - 100K. The pressure will adjust accordingly. Record the temperature and pressure in the table below.

B. Start by keeping the previous volume and particles as the last setting. Adjust the temperature to the range between 200 - 250 K and the pressure will adjust accordingly. Record the temperature and pressure in the table below.

C. Start by keeping the previous conditions as before and then adjust the temperature between the range of 300 - 400K. Record the temperature and pressure in the table below.

D. The blanks in the table below are the setting that you selected during your experiment.

Summary: Pump once, set the volume and lock the volume. Read pressure and temperature.

Temperature (K) Adjusted range	Pressure (atm)	Volume (L) - Lock	mole (mol) Gas-A
75 - 100 K ____ 200 - 250 K ____ 300 - 400 K ____*	0.31-0.41 atm ____ ____	600 L	1 pump

* **Photo2:** Take a photo (or screenshot) of the Gas simulator for your last trial (P-T).

5) <u>P-n relationship.</u> (**Table 5**)

A. Empty the gas chamber before you start and adjust the temperature to 315K or thereabouts. Add one pump of gas particles in the chamber and then adjust the volume to 500 L or thereabouts. Lock down this volume setting. The pressure will adjust accordingly and so you can record the pressure and the number of pumps in the table below.

B. Start by keeping the volume and the temperature as in the last setting. Pump the plunger again to increase the number of particles in the gas chamber. Record the pressure and the number of pumps in the table below.

C. Continue to keep the previous conditions as before but add additional particles by pumping the plunger once again. Record the pressure and the number of pumps in the table.

D. The blanks in the table below are the setting that you selected during your experiment.

Summary: Set temperature, pump once, adjust volume. Read pressure and number pumps.

mole (mol) Gas-A	Pressure (atm)	Temperature (K)	Volume (L)
1 pump 2 pumps 3 pumps	1.55 atm ____ ____ ____	315 K (or some convenient Temp)	500 L (or some convenient Vol)

6) <u>T-n relationship</u> (**Table 6**)

A. Empty the gas chamber before you start. Add gas particles in the chamber by pumping once and then adjust the volume to 500 L or thereabout and lock. Adjust temperature such that the pressure changes to 1 atm. Record the temp. and the number of pumps in the table.

B. Start by keeping the previous volume. Pump the plunger a second time to increase the number of particles in the gas chamber. Adjust the temperature so the pressure changes to 1 atm. Record the temperature and the number of pumps in the table below.

C. Continue to keep the previous conditions as before but add additional particles by pumping the plunger once again. Adjust the temperature so that the pressure is 1 atm. Record the temperature and the number of pumps in the table below.

D. The blanks in the table below are the setting that you selected during your experiment.

Summary: Add particles by pumping the plunger, adjust volume and lock. Adjust temperature so pressure is 1 atm (or very near to that value). Read temperature and number of pumps.)

mole (mol) Gas-A	Temperature (K)	Pressure (atm)	Volume (L)
1 pump 2 pumps 3 pumps*	____ ____ ____	1 atm	500 L (or some convenient Vol)

*** Photo3:** Take a photo (or screenshot) of the Gas simulator for your last trial (T-n).

7a U_{rms}: Calculation of Universal Gas Constant R using root-mean-square equation. (**Table 7a**)

1) Use Gas A for this procedure. Empty the gas chamber before you start. Add gas particles in the chamber by pumping once and then adjust the temperature to 10 K. Increase the volume to 1000 L, and lock. Complete the table below by recording the number of pumps, the temperature, volume, pressure and U_{rms}.

2) Next, increase the temperature to 100K and complete the table below by recording the number of pumps, the temperature, volume, pressure and U_{rms}.

3) Continue and repeat step 2 but increase the temp. by 100K to fill the table below.

4) Adjust the number of pumps and change the temperature to some intermediate value.

mole (mol) Gas-A	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)
1 pump	10 K	____	1000 L	______
	100K	____		______
	300K	____		______
	500K	____		______
	600K	____		______
2 pumps	300 K	____	1000 L	_____
	400 K	____		_____
3 pumps*	300 K	____	1000 L	_____
	500 K	____		_____

*** Photo4:** Take a photo (or screenshot) of the Gas simulator for your last trial (U_{rms} Gas A).

7b) U_{rms}: Calc. of Universal Gas Constant R using rms equation. Use Gas B for this part. (**Table 7b**)

mole (mol) Gas-B	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)
1 pump	10 K	____	1000 L	______
	100K	____		______
	300K	____		______
*	600K	____		______

*** Photo5:** Take a photo (or screenshot) of the Gas simulator for your last trial.

Please submit the following photos with your Datasheet-

*** Photo1:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table1, V-P relationship.

*** Photo2:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table2, P-T relationship.

*** Photo3:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table6, T-n relationship.

*** Photo4:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table7a (U_{rms} Gas A).

*** Photo5:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table7b (U_{rms} Gas B).

Your ID must be shown in each screenshot. You can do this by placing your ID in front of your screen and then take a photo.

At this point check to make sure you have all the chemicals and supplies for next week's experiment.

Last Name ________________________First________________________ **____ / _____ pts**

Data Sheet

1) **Table 1:** V-P relationship Parameters in red, should be fixed and unchanged. Parameter in yellow is what is adjusted.

Volume (L) Adjusted range	Pressure (atm)	Temperature (K)	mole (mol) Gas-A
~ 300-400 L ____	2.67 - 2.00 atm __	295 K	1 pump
~ 500-600 L ____	____	295 K	
~ 800-900 L ____	____	295 K	

2) **Table 2:** V-T relationship

Temperature (K) Adjusted range	Volume (L) - Unlock	Pressure (atm)	mole (mol) Gas-A
~75 -100 K ____	185 - 246 L ___	~1.00 atm	1 pump
~125 - 150 K ___	____		
~175 - 200 K ___	____		

3) **Table 3:** V-n relationship

mole (mol)	Volume (L)	Temperature (K) Adjusted range	Pressure (atm) Gas-A
1 pump	172 L	70 K	1.00 atm
2 pumps	____	(or some convenient	
3 pumps	____	Temp)	

4) **Table 4:** P-T relationship

Temperature (K) Adjusted range	Pressure (atm)	Volume (L) - Lock	mole (mol) Gas-A
75 - 100 K _____	0.31-0.41 atm _	600 L	1 pump
200 - 250 K _____	_____		
300 - 400 K _____	_____		

5) **Table 5:** P-n relationship

mole (mol) Gas-A	Pressure (atm)	Temperature (K)	Volume (L)
1 pump	1.55 atm _____	315 K	500 L
2 pumps	_____	(or some	(or some
3 pumps	_____	convenient Temp)	convenient Vol)

6) **Table 6:** T-n relationship

mole (mol) Gas-A	Temperature (K)	Pressure (atm)	Volume (L)
1 pump	_____	1 atm	500 L
2 pumps	_____		(or some convenient Vol)
3 pumps	_____		

7a) U_{rms}: Calculation of Universal Gas Constant R using root-mean-square equation.

Use Gas A for this part.

Table 7A

mole (mol) Gas-A	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)
1 pump	10 K	____	1000 L	______
	100K	____		______
	300k	____		______
	500K	____		______
	600K	____		______
2 pumps	300 K	____	1000 L	_____
	400 K	____		_____
3 pumps	300 K	____	1000 L	_____
	500 K	____		_____

7b) U_{rms}: Calculation of Universal Gas Constant R using root-mean-square equation.

Use **Gas B** for this part.

Table 7B

mole (mol) **Gas-B**	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)
1 pump	10 K	____	1000 L	______
	100K	____		______
	300K	____		______
	600K	____		______

Calculations Analysis

A. For each data set that you collected, 1-6, determine if the variables are directly proportional (increasing one variable causes the other to increase.) or inversely proportional (increasing one causes the other to decrease.)
(Check appropriate box)

Table	Relationship	First Variable	Second Variable
Table 1	V - P	Volume: ☐Increase - ☐Decrease	Pressure: ☐Increase - ☐Decrease
Table 2	V - T	Volume: ☐Increase - ☐Decrease	Temperature: ☐Increase - ☐Decrease
Table 3	V - n	Volume: ☐Increase - ☐Decrease	mole: ☐Increase - ☐Decrease
Table 4	P - T	Pressure: ☐Increase - ☐Decrease	Temp: ☐Increase - ☐Decrease
Table 5	P - n	Pressure: ☐Increase - ☐Decrease	mole: ☐Increase - ☐Decrease
Table 6	T - n	Temperature: ☐Increase - ☐Decrease	mole: ☐Increase - ☐Decrease

Use data from table 1, 2 & 3 to complete the equations below. Equation A is done for you below.

$V \propto \frac{x \quad y}{z}$ x, y and z represent one of the gas variables.

Note that the symbol means proportional sign, $\propto$, it is not an equal sign but shows relationship between variables.

Go to the following link to learn more about the $\propto$ symbol: https://byjus.com/maths/direct-proportion/

Complete the equation with the correct variable.	$V \propto \frac{n \bullet T}{P}$	Eqn A
Continue with the following equations for P	$P \propto$ ______	Eqn B
Continue with the following equations for T	$T \propto$ ______	Eqn C
Continue with the following equations for n	$n \propto$ ______	Eqn D

B. Calculate the R value based on data from table 7 and at 300K using the equation- Root-mean-square equation. Based on the kinetic molecular theory, average speed of a gas is directly proportional to the absolute temperature and inversely proportional to its molar mass.

$$U_{rms} = \sqrt{\frac{3RT}{M}} \quad \text{rearranging to solve for R,} \quad R' = \frac{M \bullet U_{rms}{}^2}{3 \bullet T} \quad \text{(units will be } \frac{Joules}{mol \bullet K}\text{)} \qquad \text{Eqn 1}$$

To convert R to units of $\frac{L \bullet atm}{mol \bullet K}$ • Use the conversion factor, 1 L-atm = 101.3 J

$$U_{rms} = \sqrt{\frac{3RT}{M}} \quad \text{rearranging to solve for R,} \quad R'' = \frac{M \bullet U_{rms}{}^2}{3 \bullet T} \bullet \frac{1\ L \bullet atm}{101.3\ Joules} \qquad \text{Eqn 2}$$

where U_{rms} is the speed of the molecule in m/s, T is the absolute temperature in Kelvin and M is the molar mass of the gas particles. For Gas A, the molar mass is 3.0 g/mol, however you must use 3.00 x 10^{-3} kg/mol for this calculation because 1 J = $\frac{1\ Kg\ m^2}{s^2}$. The mass must be express in kilograms.

Example: Calculate value of R' and R" given the following values.

U_{rms} = 461 m/s, M = 32.0 •10^{-3} Kg/mol, and T = 0°C (273 K)

Using Eqn 1: $R = \frac{32.0 \bullet 10^{-3} \frac{Kg}{mol} \bullet (\frac{461m}{s})2}{3\ (273K)} = 8.304 \frac{Kg \bullet m^2}{mol \bullet K} = 8.304 \frac{J}{mol \bullet K}$

Using Eqn 2: R" = $8.304 \frac{J}{mol \bullet K} \bullet \frac{1\ L \bullet atm}{101.3\ J} = 0.08197 \frac{L \bullet atm}{mol \bullet K}$

Note that for the example above, 32.0•10^{-3} kg/mol is used but for your calculations you must use 3.00•10^{-3} Kg/mol. This is the molar mass of Gas – A.

Show your work in your calculation for R.

mole (mol) Gas-A	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)	R' $\frac{J}{mol \bullet K}$	R" $\frac{L \bullet atm}{mol \bullet K}$
1 pump	10 K	____	1000 L	______	______	______
	100K	____		______	______	______
	300k	____		______	______	______
	500K	____		______	______	______
	600K	____		______	______	______
2 pumps*	300 K	____	1000 L	_____	_____	_____
	400 K	____		_____	_____	_____
3 pumps	300 K	____	1000 L	_____	_____	_____
	500 K	____		_____	_____	_____
			Average R value =		Use this value in the next table	

*Show sample calculations for data high-lighted in green above.

C. **Calculate the molar mass of Gas B**, using the average R' value ($\frac{J}{mol \bullet K}$) from the previous question.

Rearranging the $U_{rms} = \sqrt{\frac{3RT}{M}}$ gives M = $\frac{3RT}{\mu^2}$, in which you use the R' value from table 7a

Use the data from table 7b. Show calculations below for the molar mass of B. Remember that the of Molar Mass of the gas when using the root-mean-square equation will be in units of kg/mol, so you will need to multiply your final answer by 1000 (1 kg = 1000 g). See sample calculations below.

Sample calculation. Given a u_{rms} =731.1 m/s at 600K, what is the molar mass of the gas? What is the identity of the gas?
M = $\frac{3RT}{\mu^2} = \frac{3*8.314*600\,K}{731.1^2}$ •1000 = 28.0 g/mol. The molar mass of a gas with 28.0 g/mol is N_2.

mole (mol) Gas-B	Temperature (K)	Pressure (atm)	Volume (L)	RMS (m/s)	R' value used	Molar mass (g/mol)
1 pump	10 K 100K 300K 600K	____ ____ ____ ____	1000 L	______ ______ ______ ______	______ This is the average for R' from previous table	______ ______ ______ ______

Show one sample calculations that is highlighted in green here.

D. Determine the number of moles in 1 pump, 2 pumps and 3 pumps. Use the R" ($\frac{L \bullet atm}{mol \bullet K}$) value you calculated above, and the data in **Table 7a** above. For this calculation, use the ideal Gas Law, PV= nRT. Solve for n, the number of moles, in this equation.

1 pump =

2 pumps =

3 pumps =

Show sample calculation here for the **2 pumps** example (in this worksheet).

Please submit the following photos with your Datasheet-
*** Photo1:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table1, V-P relationship.
*** Photo2:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table2, P-T relationship.
*** Photo3:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table6, T-n relationship.
*** Photo4:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table7a (U_{rms} Gas A).
*** Photo5:** Take a photo (or screenshot) of the Gas simulator for your last trial from Table7b (U_{rms} Gas B).
Your ID must be shown in each screenshot. You can do this by placing your ID in front of your screen and then take a photo.
At this point check to make sure you have all the chemicals and supplies for next week's experiment.

11Lab. | Experiment 7: Gas Law Simulation, Pre-Lab

Last Name ________________________First_________________________ **____ / _____ pts**

Pre-Lab Questions

1. A given amount of molecular oxygen gas is in a closed, expandable container. If the molecular oxygen acts as an ideal gas, answer the followingquestions.

a. What will happen to the volume if the temperature doubles and the pressure remains constant?

b. What will happen to the pressure if the volume is decreased by half and the temperature is doubled?

2. A sample of molecular nitrogen gas, N_2, occupies 3.0 L at a pressure of 3.0 atm. What volume will it occupy when the pressure is changed to 0.50 atm and the temperature remains constant?

3. A 325 mL sample of air at 0.95 atm and 30.0°C, occupies what volume at 1.05 atm and 75.0°C?

4. Molecular hydrogen gas was collected over water in a eudiometer at 25.0°C when the atmospheric pressure was 752 mm Hg. What was the pressure of the molecular hydrogengas in the eudiometer?
(Water vapor pressure at 25.0°C is 23.756 mmHg)

Last Name _________________________First__________________________ **____ / _____ pts**

Post-Lab Questions

Answer these post lab questions and turn in to your instructor before you leave lab unless told otherwise by instructor.

1. What happens to the pressure if the gas volume is cut in half while n and T are held constant?

2. What happens to the pressure if the gas temperature is increased while n and V are held constant?

3. Using your Volume-Temperature relationship in **Table 2** of the Data Sheet, at what temperature should the gas volume fall to zero liters?

4. Using the value of 0.0821 L• atm/mol •K for R and the Pressure (in atm) from **Table 3**, calculate the number of gas particles, n, in your **2 pumps** sample?

5. Using the value of 0.0821 L• atm/mol •K for R and the Pressure (in atm) from **Table 5**, calculate the number of gas particles, n, in your **3 pumps** sample?

12Lab | Experiment 08: Concentration of a Salt Solution

Objective

The purpose of this experiment is to determine the weight & concentration of dissolved solids in salt-tainted water solutions. Concentration by parts (%, ppm & ppb) will be determined.

Material and Chemicals

KLM Equipment	Alcohol burner with stand (or stove)	(3) 100mL Beaker or	5 mL Grad cylinder	(3) Petri dish
	Wash Bottle	(1) 400mL Beaker	Watch Glass	
Miramar supply	(3) Saltwater solutions, same concentrations (5-10 mL)		Wire gauze	Berel Pipette
	Stirring rod w/ policeman	Evaporating Dish	Spatula	1 crucible tong
You supply:	Digital Pocket Scale	Hot mitts	Hair dryer (optional)	

* As an option, you can use the burner from your stove to heat the beaker and evaporate the solutions

Introduction

Additional Reading: Ch 9.4, *Chemistry in our Lives, 5th Edition* Timberlake. "Solution Concentrations and Reactions." For this experiment, you will be determining the concentration of a saline solution of unknown concentration. Your results will be reported in a mass percent (m/m %), ppm and ppb.

Water as it occurs in nature contains various amounts of dissolved substances depending on its origin; for example, rain, lakes, rivers, wells, or oceans will contain different amounts of dissolve solids. The dissolved substances maybe gases, solids, and liquids. Undesirable gases are removed easily from the water by aeration, but dissolved solids may be difficult to remove. These dissolved substances affect the suitability of the water for drinking or other uses. Mineral water is water containing not less than 250 parts per million (ppm) total dissolved solids (TDS), coming from a source tapped at one or more bore holes or springs, originating from a geologically and physically protected underground water source. No minerals may be added to this water. If TDS content is below 500 ppm, the statement "low mineral content" must appear on the label. If TDS content is above 1500 ppm, the statement "high mineral content" must appear on the label. The standards set by the Federal Government for drinking water is no more than 500 mg of dissolved solids per liter (500 parts per million).

An example of highly mineralized water is found in certain some southern cities. The quantity of dissolved solids varies during the year (0.5-1.2 g /liter) but is almost always more than the recommended standard. The dissolved materials in the water seem to have no adverse effect on health. The water contains no transition or heavy metals because the water is slightly basic. Also, dissolved fluoride ion, which is naturally present, is thought to be beneficial in protecting the teeth of children from decay. The water is said to satisfy requirements for bacterial content even before chlorination (usually with sodium hypochlorite). On the negative side, sometimes there is a slightly unpleasant odor in the water that is caused by minute quantities of sulfur compounds originating from sulfur springs. A substantial concentration of magnesium sulfate (Epsom salts} in the water has a cathartic effect on some newly arrived visitors to the area, although the effect disappears in a day or two. Nevertheless, the principal objection to the dissolved solids is the scale deposited by the water in taps, water heaters, boilers, and plumbing fixtures, and the problems of laundering in hard water (water containing large amounts of divalent cations like Ca^{2+}, Fe^{2+}, and Mg^{2+}).

When analyzing other source of water, the source should be documented. Aside from calculating the concentration of dissolved particulates, ionic composition can also be determined.

The Environmental Protection Agency (EPA) establishes standards for drinking water that falls into two categories -- Primary Standards and Secondary Standards. The hardness of your water is usually reported in grains per gallon, milligrams per liter (mg/l) or parts per million (ppm). One grain of hardness equals 17.1 mg/l or 17.1 ppm of hardness.

Primary Standards are based on health considerations and Secondary Standards are based on taste, odor, color, corrosivity, foaming, and staining properties of water. There is no Primary or Secondary standard for water hardness. The U.S. Department of Interior and the Water Quality Association classify water hardness. The limits are as follow:

Classification	mg/l or ppm	grains/gal
Soft	0 - 17.1	0 – 1
Slightly hard	17.1 - 60	1 - 3.5
Moderately hard	60 - 120	3.5 - 7.0
Hard	120 - 180	7.0 - 10.5
Very Hard	180 & over	10.5 & over

A portion of your grade will reflect the accuracy and precision of your results based on the concentration of your unknown salt solution.

Use of Alcohol Burner (aka Alcohol lamp)

Taken from: https://www.wikiwand.com/en/Alcohol_burner

An **alcohol burner** or **spirit lamp** is a piece of laboratory equipment used to produce an open flame. It can be made from brass, glass, stainless steel or aluminum. Alcohol burners are preferred for some uses over Bunsen burners for safety purposes, and in laboratories where natural gas is not available. Their flame is limited to approximately 5 centimeters (two inches) in height, with a comparatively lower temperature than the gas flame of the Bunsen burner. While they do not produce flames as hot as other types of burners, they are sufficiently hot for performing some chemistries, standard microbiology laboratory procedures, and can be used for flame sterilization of other laboratory equipment. Typical fuel is isopropanol (or rubbing alcohol) that is available in your nearby drug store such as CVS or Walgreen. A cap is used as a snuffer for extinguishing the flame.

Fig. A

Fig B

Procedure –

Precautionary Notes:

This experiment has been modified so that you will analyze water samples that has a predetermine concentration of dissolved solid. **Do use tap water** to do a final rinse of your evaporating dish since it will contain dissolved minerals that may alter your results. It is okay to use tap water as the boiling solution in the beaker, however.

Be sure to review the use of scale and alcohol burner (lamp). Alternatively, you can use your stovetop to heat the water. Be careful so that you do not overheat the beaker which may cause the beaker to break. Always check your glassware for stress, fatigue, and stars. If you detect these, use another beaker because chances are the glassware will crack in this experiment. **After weighing each beaker in the first step, use tongs or thick gloves (oven mitts) to handle the glassware**. Do not handle glassware with your fingers. The residue from your fingers is enough to throw off the results.

For saltwater samples to be analyzed, be sure to do three trials then average the results. This experiment has been modified to take into consideration that your scale is not sensitive enough to distinguish milligram samples, you have been issued liquids with a predetermined amount of dissolved salt. You are to calculate the total dissolved solids in this solution to the hundredth of a gram, which is the sensitivity of your scale, i.e., $\pm$ 0.01.

In your chemical container kit, you will **find three vials with the same unknown letter (A, B or C)**. These are the saltwater samples that you will be analyzing. All three samples will have the same concentration because you want to carry out the procedure in triplicate and take the average for your results.

1.The baggie containing your chemicals is where you will find your unknown solution for this experiment. This unknown is the salt-tainted water sample and will be labeled Unknown A, B or C. Record the letter of your unknown in the worksheet. The letter of the unknown you analyze should all be the same. For example, you will find 3 vials of Unknown A. You are to do these in triplicate. You will do three trials then average the results in this experiment. Use the 250-mL beaker and the evaporating dish for this procedure. Thoroughly clean with soap and water the evaporating dish and be sure it is dry use a hair dryer or the microwave to dry the evaporating dish. Inspect the glassware for stress, stars, or cracks, if you suspect your beaker is stress, replace it because if it breaks, your experiment will fail.

Photo 1: **You must** take a photo of all three unknowns within the **vial showing your unknown letters, A, B or C.**

2. Pencil in "1", "2" and “3” on the label of the salt solution unknowns. You will need to do this procedure one at a time. Weigh the evaporating dish on the balance to the hundredth of a gram (0.01 g). Write the mass of each beaker in your report sheet. (An alternative procedure is to use the evaporating dish to carry out this experiment.). This is demonstrated in the video procedure.

3.Pour all the saltwater unknown sample (trial 1) into the beaker or evaporating dish. Do not worry about reading the exact volume since the amount of water will be weighed. You will need to do this same procedure for trials 2 and 3, after completing trial 1 (since you only have one evaporating dish). Weigh the evaporating dish with the saltwater solution on the balance to the nearest hundredth of a gram (0.01 g). Write this weight as the "Mass salt-solution + evaporating dish" measurement. Again, you will repeat this for the other two samples when completing a trial.

Photo 2: Take a photo of the evaporating dish containing saltwater unknown solution sitting on the scale.

4. Place the beaker / evaporating dish on the stand that came with the alcohol burner. *You can also use the method in which you place a wire gauze over your oven stove and then place the beaker on the wire gauze and then the evaporating dish over the beaker (like what you did in Expt 4)*.

Photo 3: Take a photo of the evaporating dish with the solution as it is being heated.

5. If you are using the alcohol burner, ignite the alcohol burner and allow the evaporating dish to be heated until the solution hot enough so the water in the solution begins to evaporate. Be careful not to heat too much as splashing will cause some of the salt water to splatter. *If you are using your stove, heat the beaker to a gentle boil (medium to low heat setting) so that the water in the beaker begins to boil. Be sure the beaker has ample water so that the water in the beaker does not boil to dryness. The steam from the beaker will heat the salt solution in the evaporating dish so the liquid of the salt solution begins to evaporate.* The rate of evaporation can be controlled by moving the alcohol burner in and out of the bottom of the stand. Be careful not to burn anything nearby. You should have a fire extinguisher ready. When the volume of water sample has finally boiled down to about 0.5-ml, it is advisable to cover the beaker to use low heat so that no splattering occurs. The evaporating dish should contain only salt residue, allow the remaining heat to evaporate the residual water.

6. If there is still water along the walls of the beaker or the residual salt is still wet, evaporate the small amount of water in the evaporating dish to dryness by heating the dish gently with a hair dryer or place in a microwave for 30 sec. Be careful that the hair dryer does not blow the residue out of the evaporating dish. From this point on, use tongs or hot mitts to handle the beaker so that oil from your fingers do not add to the mass of the residue. If you are to handle hot glassware, use the oven-mitts or dish towels to handle the hot evaporating dish or beaker. do not touch the heated items directly. Remember hot items look the same as cool items.

7. Note and record the color of the residue (residual salt) and describe the details in your data sheet.

8. Allow the evaporating dish / beaker to cool for an additional 10 - 15 minutes making sure that there is no residual water remaining. Pat dries the underside of the evaporating dish / beaker. Do not touch these items with your hands directly since fingerprints on the evaporating dish / beaker surface will throw off your results.

9. Weigh the evaporating dish which contains the residue and write the result in your datasheet as " Mass evaporating dish + residue ". Use the weight of "beaker", the weight of "beakers + water" and the weight of "beaker + residue" to calculate the weight of dissolved solids in the water sample and the amount of total dissolved solids (TDS) in your sample. Express the TDS in parts per hundred (% mass), parts per million (ppm) and parts per billion (ppb). Be sure to use the correct number of significant figures in your calculations.

Photo 4: Take a photo of the evaporating dish containing residual salt on the scale.

Clean up.

Wash and dry all your glassware equipment. Dispose of all used chemicals in the proper waste container. Wipe down your station and place your glassware and equipment back in its proper place. Wash your hands thoroughly with soap and water before leaving your work area.

Please submit the following photos with your Datasheet-

Photo 1: **You must** take a photo of all three unknowns within the **vial showing your unknown letters, A, B or C.**

Photo 2: Take a photo of the beaker/evaporating dish containing saltwater unknown solution sitting on the scale.

Photo 3: Take a photo of the evaporating dish with the solution as it is being heated.

Photo 4: Take a photo of the beaker/evaporating dish containing residual salt on the scale.

Each photo should show your college ID in the foreground.

12Lab | Experiment 08: Concentration of a Salt Solution, Datasheet

Last Name________________________ **First** _________________________ ____ / _____ **pts**

A. Datasheet: Show all calculations in the space. You will not receive credit for showing work if it is not show in this area.

	Sample 1	**Sample 2**	**Sample 3**
Unknown # __________ You should analyze the same unknown number (you are given 3 vials) in these 3 trials.	**Write a description of sample:**		
1. Volume of salt-tainted solution, measured from graduated cylinder. (Use the precision of the 5-mL,or 10-mL cylinder when recording your data):			
2. Mass of evaporating Dish: Write units after each measurement.			
3. Mass of solution + Evap Dish: Write units after each measurement.			
4. Mass Evap Dish + residue (salt): Write units after each measurement.			
5. Mass of residue: Write units after each measurement.			
6. Mass of solution: Write units after each measurement.			

Show one sample calculation in proper format for Mass of residue and mass of solution (Show calculation in the space below):

B. % (m/m) of Salt Solution

Unknown #. ________. (Write your unknown # or letter here again. If you forget, you will not receive points for unknown)

7. % concentration (m:m): Write units after each measurement.			
8. Average % Concentration: Write answer with correct significant figures. Write units after measurement.			

Show one sample calculation in proper format for the % concentration of your solution and the calculation of the average.
(Show calculation in the space below):

C. Parts per million (ppm) and Parts per billion (ppb)

9. ppm (m:m) Write units after each measurement.			
10. Average ppm Write answer in scientific notation with correct significant figures. Write units after measurement.			
11. ppb (m:m) Write units after each measurement.			
12. Average ppb Write answer in scientific notation with correct significant figures. Write units after measurement.			

Show one sample calculation in proper format for the ppm and ppb your solution.
(Show calculation in the space below):

Please submit the following photos with your Datasheet-

Photo 1: **You must** take a photo of all three unknowns within the **vial showing your unknown letters, A, B or C.**

Photo 2: Take a photo of the beaker/evaporating dish containing saltwater unknown solution sitting on the scale.

Photo 3: Take a photo of the evaporating dish with the solution as it is being heated.

Photo 4: Take a photo of the beaker/evaporating dish containing residual salt on the scale.

Each photo should show your college ID in the foreground.

At this point check to make sure you have all the chemicals and supplies for next week's experiment.

12Lab | Experiment 08: Concentration of a Salt Solution, PreLab

Last Name________________________ First _________________________ **____ / _____ pts**

Prelab Questions

Note that these questions may be slightly different from those found in Canvas. Numerical questions will have different data, but the concept of the question is the same and if you can answer these questions here with the given data, then you can use a similar strategy in solving the problems in Canvas using different numbers.

1. Define the unit "ppm"?

2. Define residue in the context of this experiment?

3. What common ions might be found in tap water?

4. 150 ml of water is collected from a local lake. The water is weighed and evaporated to dryness. The data is shown below. Calculate the concentration of the residue in % mass, ppm and ppb. (Show calculation for full credit)

Note that these numbers may vary in Canvas.

Mass water sample + beaker	570.055 g
Mass beaker + residue	420.143 g
Mass beaker	420.025 g

Do not forget to upload this prelab worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

12Lab | Experiment 08: Concentration of a Salt Solution, Post Lab

Last Name________________________ First _________________________ ____ / _____ **pts**

Postlab Questions

1. If the residue is not heated to dryness but is still somewhat moist, how would this change the final amount of residue calculated in the solution? Would you expect the calculated concentration of the residue to be higher or lower than the true value? (Check mark and provide explanation)

Concentration: Higher ____ Lower ____ No Change _____ Not enough information ____ than true value.

2. If a large piece of dirt, say 10 mg, falls into the beaker just after the sample is evaporated to dryness and is weighed, what effect would this have on the weight of dissolved solids found? Would you expect the calculated concentration of the residue to be higher or lower than the true value? (Check mark and provide explanation)

Concentration: Higher ____ Lower ____ No Change _____ Not enough information ____ than true value.

3. If a large amount of water splatters out of the beaker, say ~10 mL, during the evaporation process. Explain how would this affect the mass of the residue calculated in your result? Would you expect the calculated concentration of the residue to be higher or lower than the true value?

Concentration: Higher ____ Lower ____ No Change _____ Not enough information ____ than true value.

4. If you calculated a saltwater solution of about 3.5% *, what would the molarity of this solution?
Assume the density of this solution is 1.03 g/mL. (* BTW, this is the salinity of seawater).
MW_{NaCl} = 58.44 g/mol

Do not forget to upload this postlab worksheet in Canvas.
(Your college photo ID should be in the foreground when you take a pic of the completed worksheet)

13Lab | Experiment 09: Titration of Vinegar

Last Name________________________ First _________________________ ____ / _____ pts

Objective

The purpose of this experiment is to determine the molarity and weight/volume percent concentration of acetic acid in typical household vinegar by titration with sodium hydroxide to a phenolphthalein endpoint.

Material and Chemicals

KLM Equipment:	(1) 20 x 200 mm Test tube (3) test tube 18x150mm	5mL graduated cylinder 400mL beaker	Wash bottle	
Miramar supply:	(3) Unknown Vinegar Solution Phenolphthalein	~ 0.4xx M NaOH solution Hydro-ion Paper	Stirring rod w/ policeman	(6) Berel pipet
You supply:	Distill water	White printer Paper		

Introduction

Required additional reading: For a more complete description of Titrations, read *Chemistry in our Lives, 5th Edition* Timberlake. Ch11.8 *"*Acid-Base Titration."

Acetic acid (**CH_3COOH**) is the chemical compound which gives vinegar its pungent odor and sour taste. It contains one ionizable hydrogen atom (shown in bold type): CH_3COO**H**. In aqueous solution, when acetic acid reacts with a strong base like **sodium hydroxide** (**NaOH**), the hydroxide ion from the base reacts with the hydrogen ion from the acid to produce water. The remaining **sodium ion** (**Na^+**) and the polyatomic **acetate ion** (**CH_3COO^-**) form the soluble salt **sodium acetate**, **$NaCH_3COO_{(aq)}$**, which remains dissociated in solution. This acid-base reaction is called a **neutralization reaction** and has the general form:

$$\text{acid + base} \leftrightarrow \text{a salt} + \text{water}$$

For the reaction of acetic acid with sodium hydroxide, the chemical equation is written as:

$$HC_2H_3O_{2(aq)} + NaOH_{(aq)} \xrightarrow{(H_2O)} Na^+_{(aq)} + C_2H_3O_2^-{}_{(aq)} + H_2O_{(l)}$$

The progress of a neutralization reaction can be monitored by using a **pH indicator**, such as **phenolphthalein**. This type of monitoring is called **titration** and involves the incremental addition of small amounts of base to the acid in the presence of a pH indicator. An indicator is chosen which will change color at a pH very close to the **equivalence point** of the titration. Usually, an indicator undergoes a color change within 1 pH unit. The equivalence point is defined as the point at which the number of moles of base added is equal to the number of moles of acid present in the solution being titrated. When the indicator changes color, this is called the **endpoint** of the titration and indicates that the equivalence point has been reached. By accurately knowing the molarity of the base and the volume of base added to reach the endpoint, the molarity of the acid can be calculated, providing the reaction has a one to one (1:1) stoichiometry of acid to base. (It is possible to do this for other stoichiometric ratios as well.) It should be noted here that the **pH** value of an acid-base solution is a measure of the power of hydrogen. That is because the pH is calculated based on $pH = -\log[H_3O^+]$ and $[H_3O^+] = 10^{-pH}$, so the pH value is a measure of the power of hydrogen concentration. Finally, you should recall from lecture that $[H_3O^+]$ and $[H^+]$ are used interchangeably in these equations.

The method for calculating the molarity of acid in the solution is based on the definition of the equivalence point. At the equivalence point (endpoint):

moles of base added = moles of acid present

Further, it is known from solution chemistry that:

molarity * volume = number of moles

Now, in this titration we know the molarity and volume of the base added and the volume of acid titrated. Therefore, to find the molarity of the acid we use the equation:

$$\mathbf{M_{base} \bullet V_{base} = M_{acid} \bullet V_{acid}}$$

The known values are then substituted to solve for the molarity of the acid.

Example 1: A 25.00 mL sample of a monoprotic acid of unknown molarity was titrated to the equivalence point with 50.00 mL of 0.100 M sodium hydroxide. What is the molarity of this acid?

Step 1: Write the equation.

$M_{base} \bullet V_{base} = M_{acid} * V_{acid}$

Step 2: Convert mL of base to L of base.

$$50.00\ mL\ NaOH\ * \frac{1\ L\ NaOH}{1000\ mL\ NaOH} = 0.05000L\ NaOH$$

Step 3: Convert mL of acid to L of acid.

$$25.00\ mL\ acid\ * \frac{1\ L\ NaOH}{1000\ mL\ NaOH} = 0.02500L\ acid$$

Step 4. Substitute the appropriate values into the equation and solve for molarity.

$$0.100\ M * \ 0.05000L\ = M_{\ Acid} \bullet 0.02500\ L$$

Solving for Macid **M_{acid} = 0.200 M**

For acids used in the laboratory, molarity is commonly used to express concentration. However, for common household acids, such as the vinegar you will be titrating, the concentration of the acid is usually reported on the label as the percentage of acid in the solution (**weight/volume percent**). In other words, the weight of the acid in grams divided by the volume of solution in milliliters. The weight/volume percent of the acid sample titrated can be calculated from the molarity of the acid as follows:

Step 1: $M_{Acid\ \ (Calculated\ above)}\ *\ V_{Acid\ \ (titrated)}$ = # moles of acid titrated

Step 2: # moles of acid titrated • molar mass of acid = grams of acid titrated

Step 3: $\frac{grams\ of\ acid\ titrated}{volume\ of\ acid\ titrated} \bullet\ 100$ = weight / volume percent of acid

Example 2: If the acid titrated in Example 1 was HCN (hydrocyanic acid), what is the weight/volume percent of HCN in the sample?

Step 1: $0.200\ M\ *\ 0.02500\ L = 0.05000L\ HCN$

Step 2: $0.00500\ moles\ HCN\ * \frac{27.0\ g\ HCN}{1\ mol\ HCN} = 0.135\ g\ HCN$

Step 3: $\frac{0.135\ g\ HCN}{25.00\ mL\ solution} \bullet\ 100 = 0.540\ \%\ HCN$

The term **error** refers to the absolute value of the numerical difference between the known value and the experimental value. Errors are often expressed relative to the known value as a **percent error.** Percent error is given by the equation:

$$\frac{|known\ value\ -\ Experimental\ value|}{Known\ value} \bullet\ 100\ = \%\ Error$$

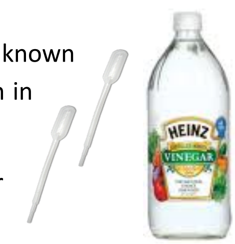
The closer the percent error is to zero, then the more accurate your experimental value (i.e., the more closely the experimental value agrees with the known value).

Example 3: If the label on the acid above indicated that the weight/volume percent was 0.600, then what was the percent error for the titration?

$$\frac{|0.600\ -\ 0.540|}{0.600} \bullet\ 100\ = 10.0\ \%\ Error$$

Procedure –

A. Setup

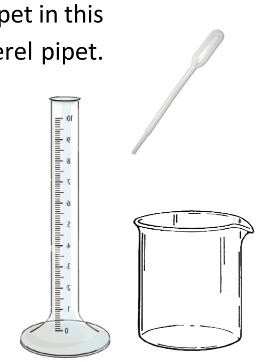


1: You are to be given an unknown vinegar solution. Write the unknown number written on the vial. If the unknown number is not given, then the lab tech provided you with Heinz white vinegar. Write this as a description in your data sheet.

2: Remove the three berel pipet from your chemical container kit and label one berel pipet "T" (titrant), another "A" (acid) and a third "W" (water).

Photo1: Take a Photo of acid (vinegar) sample you are to analyze If the sample is a household vinegar sample, show the label of the vinegar so it can be identified. If the solution in your chemical kit, take a photo of the vial.

Calibration of the berel pipet



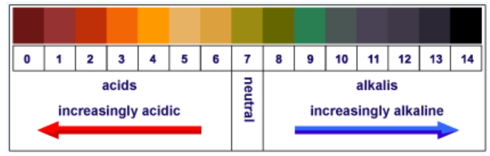
3: The berel pipet labeled with the letter "T" is your titrant pipet. You are to calibrate the drops of this berel pipet in this procedure. Pour about 20mL of deionized water into a clean glass beaker. Draw about 3.5 mL into the berel pipet. Then add the water into a clean dry 5mL graduated cylinder (or 10mL graduated cylinder, if that was what was issued to you) 1 drop at a time. Count the number of drops that is necessary to reach the 3.00mL mark. Recall that to read the volume in the cylinder correctly, you must be at eye level to the meniscus and the bottom of the meniscus must be on the 3.00mL graduated line of the cylinder. Write in your notebook the number of drops you counted to reach the 3.00 mL mark. Pour the water out of the graduated cylinder, dry the graduated cylinder and repeat the procedure two more times for a total of 3 trials. After this calibration procedure, dry the graduated cylinder. In this procedure, you will assume that the size and volume of each drop of water is equal to the size and volume of each drop of NaOH solution. This assumption is valid, since the NaOH solution is at a low concentration. At less than 2.0 M NaOH, most of the chemical is water.

Photo2: For one of the trials, take a Photo of water in the graduated cylinder clearly showing the 3.00mL volume.

4: Remember that for each calibration trial, you added drops to the 3.00 mL mark. Add the total drops for the three trials and divide by 9mL. This is the number of drops necessary for 1.00mL. Show your calculation in your notebook as well as the result of your calculation.

Recording solution information

Step 5: If you are analyzing a vinegar sample, (not an unknown) read the label and record the weight/volume concentration of acetic acid in the vinegar solution.



Step 6: You are to test the pH of the vinegar solution with Hydro-ion paper (also referred to as the test-strip). Pour about 5 mL of the vinegar into a clean dry beaker. Clean and dry your glass stirring rod, then stirring dip the rod into the vinegar solution and then transfer a drop to the Hydro-ion paper. All you need to worry about is that a small portion of the Hydro-ion paper samples the vinegar solution so that the Hydro-ion paper is wet. Record the pH of the solution in your notebook.

Photo3: Take a Photo of result of the hydro-ion paper test. Clearly show the hydro-ion paper next to the colored scale shown above.

Step 7: If you have not already done so, remove the NaOH (titrant solution) from the baggie and then record the concentration in your data sheet as written on the label for the NaOH titrant solution.

B. Titration

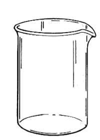
Titration of Vinegar (prepare these samples in triplicate

Step 8: Pour approximately between 1.90 mL of vinegar into the clean dry graduated cylinder from step 3. Using the berel pipet with the label "A", add more vinegar solution dropwise so the volume is precisely 2.00 mL. Pour the content of the graduated cylinder (vinegar) into a clean 18 x 150mm test tube. The test tubes you are to use should be the largest in your equipment box. The test tubes should be able to contain a volume of 15 mL or more. Rinse the inside of the graduated cylinder with 0.5mL deionized water and add this washing with the 2.00 ml vinegar solution. Set this aside. Do not use tap water in any of the procedure in this experiment.

Step 9: Repeat step 8 for the other two vinegar solution trials. Label these test tubes, 1, 2 and 3. Note that the total volume in each of the three test tubes should be approximately a quarter (or less) of the total volume capacity of that test tube. Note that if you only have one large test tube that can hold 15mL or more, then you may have to complete one trial and clean the test tube before proceeding to the 2nd and 3rd trial.

Step 10: To each of the 3 vinegar solutions in the test tube, add only one drop of phenolphthalein indicator.
This is very important. If you forget this step, your experiment will not work.

Step 11: Using the berel pipet that is labeled "T", draw about 0.5 to 0.7 mL of NaOH to rinse the inside of the pipet. Tip the pipet so that the NaOH coats the inside of the pipet stem and bulb. Dispense the NaOH in a waste container. Repeat this for a second time. This technique is called conditioning, a technique that coats the inside of glass/plastic that will be used to deliver solutions with measured concentrations. After conditioning the pipet, draw as much possible of the NaOH solution in the berel pipet. First titrate test tube 1. Counting the drops, add NaOH titrant to this test tube one drop at a time. You can go ahead and quickly add the first 35 drops and then pause to stir the vinegar solution with a clean dry glass stirring rod so that the NaOH is allowed to mix thoroughly. If there are any NaOH drops along the side of the test tube, this will be shown as a magenta color. Using your berel pipet labeled "W", draw up some deionized water and rinse the side of the test tube with this water. Remember that at this point the amount of water added to the test tube will not change the moles of acid that was originally present. Try to use a minimum amount of water when washing down the residual NaOH solution along the wall of the test tube. Continue to add NaOH solution to the test tube drop wise (counting only the drops of NaOH solution added to the vinegar). As the endpoint approaches, the pink color will persist for a longer period. Use the glass stirring rod to mix the solution. When the pink color persists for more than 1 minute then you have neutralized the acid completely (endpoint). Record the number of drops required to reach the end point.



NOTE: While adding the NaOH solution, you will see the formation of temporary pink "clouds" in the vinegar solution. As this pink coloration begins to take longer and longer to disappear, slow the rate of addition of the NaOH, adding one drop at the time so before the mixing to make sure you have not gone past the endpoint. The endpoint of the titration is reached when one drop of the NaOH solution changes the vinegar solution from colorless to a pale, pale pink that permanently remains even after mixing and swirling the solution.

Step 12: Repeat step 11 for the second and third trials. These are the vinegar solution labeled 2 and 3. Record the drops of NaOH titrant solution necessary to reach the endpoint for each trial. The results for second and third trial should be close to each other. You will convert drops to milliliter in the calculation section below.

Step 13: If you have time and enough $NaOH_{(aq)}$ titrant, repeat Steps 8 - 11 until you have three titrations that agree within 0.50 ml to each other.

Photo 4: Take a Photo of all three acid (vinegar) samples at the endpoint of the titration. The solutions should be pink or magenta to demonstrate the color has reached the endpoint in the experiment. (Once you complete the titration of one, you can pour the solution to a second test tube and save so you can take a photo of all three results)

Clean up and reflection.

Step 14: Clean your work area and pour the solutions you created in this experiment into your waste container. Pour any excess residual chemicals also in the waste plastic bottle container. Any unused chemicals should remain in their original container kit and reseal. **Be sure to turn in these chemicals to Miramar College at the end of the term for proper disposal.**

Step 15: In your lab notebook, write a detailed summary of what you did in this experiment as part of your observations and data.

Calculations of the Molarity of the Acid. See Table V below.

Show your calculations in the space provided in Table V. You will lose points if your work is not clear. Calculate average volume of NaOH used in the titration for the 3 trials and record the volume in mL. Next convert the average volume from mL to L.

Use the concentration of the NaOH, see Table III, to calculate the average number of moles of NaOH used in the titrations. Remember that the number of moles of acid is equal to the number of moles of base at the endpoint of the titration. Your answer for the number of moles of acid will be the same as the number of moles of base used.

To calculate the molarity (moles/liter) of the vinegar, divide the moles of acid by the volume (in liters) of vinegar that was titrated. This volume is found in Table III.

Please submit the following photos with your Datasheet (showing your ID in all the pages you submit)-

Photo1: Take a photo of acid (vinegar) sample you are to analyze. If the sample is a household vinegar sample, show the label of the vinegar so it can be identified. If the solution is given as part of the chemicals, you were issued and is in the vial, take a photo of the vial with the vinegar.

Photo2: For one of the trials, take a Photo of water in the graduated cylinder clearly showing the 3.00mL volume.

Photo3: Take a photo of the hydro-ion paper test after testing with vinegar. Clearly show the hydro-ion paper next to the colored scale to the hydro-legend (scale).

Photo4: Take a photo of all three acid (vinegar) samples at the endpoint of the titration. The solutions should be pink or magenta to demonstrate the color has reached the endpoint in the experiment.

Last Name________________________First_________________________ ____ / _____ **pts**

You must show calculation wherever the datasheet directs.

I Acid (Analyte) Information

Ia. Description / Brand of Vinegar	
Ib. pH of Vinegar sample	

II. Calibrate your "T" Berel pipet with water:

Using your berel pipet, count the number of drops of water necessary to fill a 5mL graduated cylinder to the **3-mL** mark.

	Titration #1	Titration #2	Titration #3
IIa. Number of drops to reach 3 mL			
IIb. Average to reach 3.00 mL. **Show calculations in box.**			
IIc. Number of drops per 1-mL **Show calculations in box.**			

III Vinegar Sample Preparation

IIIa. Weight/Volume % of Vinegar (From Label, concentration for vinegar This will either be 5% or 10% by weight)	_____ **%**
IIIb. Volume of Vinegar per trial Recommended 2-mL for each trial	
IIIc. Molarity of NaOH	

IV Titration Procedure, Volume of NaOH to reach endpoint. It is recommended that you use 2.00mL of Vinegar per trial.

	Titration #1	Titration #2	Titration #3
IVa. Initial Volume Acid (Vinegar) Analyte (mL)	**2.00 mL**	**2.00 mL**	**2.00 mL**
IVb. Drops of phenolphthalein added (1-drop is plenty)			
IVc. Drops of NaOH titrant solution to equivalent point			
IVd. Volume of NaOH to equivalent pt (mL) **Show calculations in each box**			
IVe. pH of the solution after reaching end point			

V: Calculations of the Molarity of Vinegar. **Show complete calculations in each box.**

	Calculations	**Answers**
Va. Average Volume of NaOH (mL)		
Vb. Average Volume of NaOH (L)		
Vc. Moles of NaOH		
Vd. Moles of Acetic Acid		
Ve. Molarity of Acetic Acid		

VI Calculations for Weight/Volume Percent of Acid & Percent Error (include units). **Show complete calculations!**

	Calculations	Answers
VIa. Moles of Acetic Acid **This is from Vd**	This comes from Table Vd	
VIb. Molar Mass of Acetic Acid CH_3COOH		
VIc. Grams of Acetic acid titrated		
VId. Volume of acetic acid titrated (mL)	This comes from Table IVa	
VIe. Weight/Volume %		
VIf. Percent Error *see IIIa for True Value (if given)*		

Please submit the following photos with your Datasheet-

Photo1: Take a photo of acid (vinegar) sample you are to analyze. If the sample is a household vinegar sample, show the label of the vinegar so it can be identified. If the solution is given as part of the chemicals, you were issued and is in the vial, take a photo of the vial with the vinegar.

Photo2: For one of the trials, take a Photo of water in the graduated cylinder clearly showing the 3.00mL volume.

Photo3: Take a Photo of result of the hydro-ion paper test. Clearly show the hydro-ion paper next to the colored scale to the hydro-legend (scale).

Photo4: Take a Photo of all three acid (vinegar) samples at the endpoint of the titration. The solutions should be pink or magenta to demonstrate the color has reached the endpoint in the experiment.

Please clean up chemicals and Equipment at this point.

You have reached the last experiment. Please follow the instructions below to help us recover the important supplies and so that we can dispose of waste chemicals properly. Not following these guidelines will reflect on your lab technique score.

It is important to make sure all chemicals used and unused are separated from the equipment in different plastic baggies.

1. Place all liquid chemical waste in an empty plastic bottle and secure the lid. Write your name CSID and instructor's name on the bottle or a label attached to the bottle.
2. Take the unused chemicals and place them in a clean quart-size baggie. Make sure the baggie is moisture free.
3. Clean all equipment and separate the KLM supplies from the Miramar College supplies/equipment.
4. For the Miramar College supplies, separate the plastic equipment (Berel pipet, weighing boat, straw) from the other metallic supplies and place them in a quart-size baggie.

Take the remaining supplies and ensure all metal equipment is clean and dry. If the item is damaged, indicate so with a sticky note. Next, place these items in another clean empty quart-size baggie.

5. Write your name, CSID, and instructor's name on an index card and place it in the gallon-size baggie.
6. Secure the gallon-size baggie containing the three smaller baggies and bring these to Miramar on the final exam day.
7. Drop off these items in the designated supply drop box per directions your instructor will give you on the day of the final exam.

13Lab | Experiment 09: Titration of Vinegar, PreLab

Last Name________________________First________________________ **____ / _____ pts**

Prelab Questions

Note that these questions may be slightly different from those found in Canvas assessment. Numerical questions will have different values, but the concept of the question is the same and if you can answer these questions here with the given data, then you can use a similar strategy in solving the problems in Canvas using different numbers.

1. Phenolphthalein is one of the most common chemical indicators used to test acidity or basicity. What is the color of a solution that contains two drops of phenolphthalein in acidic solutions? What is the color in basic solutions?

2. a) What does "pH" mean?
Please read the lab manual to make sure you use the right definition.

b) What is the pH of a neutral solution for water at 20°C?
Assume K_w = 1.00e-14

3. If a solution contains 0.0100 mole of HCl in 10.0 L of solution -
a) What is its molarity?

b) What is the H^+ ion concentration for this solution?

c) What is the pH for this solution?

4. a) What relationship exists between H^+ ion concentration and OH^- ion concentration?

b) What is the OH^- concentration of an aqueous solution with the H^+ concentration of $1.00 \cdot 10^{-4}$ M?

c) Calculate the pOH of the concentration in 4b.

5. How many pH units change are usually required for an indicator to undergo a color transition?

6. What are the colors and the transition pH for methyl red, bromothymol blue, and alizarin yellow? (Google "Acid-Base indicator" to find a chart of common indicators)

13Lab | Experiment 09: Titration of Vinegar, Post Lab

Last Name________________________First________________________ ____ / _____ pts

Postlab Questions

1. The equivalence point of this titration occurs between pH 8.0 and 10.0. Based on this information and the prelab question, which of the following indicator could be used for this experiment. Check all that applies.

Go to this link to see the color range for these indicators.

a) ☐ Alizarin.
b) ☐ Cresol Red
c) ☐ Bromocresol Green
d) ☐ Thymol Blue
e) ☐ Methyl Orange
f) ☐ phenolphthalein
g) ☐ No correct choice

2. Which of the following household product(s) is/are acidic? Explain why you have selected this/these product(s). (Check all that applies)

a) ☐ Soda Beverage
b) ☐ Tomato juice
c) ☐ Baking soda
d) ☐ Windex cleaner
e) ☐ Aspirin
f) ☐ Draino

3 i) What was the pH of the Vinegar (See Table 1B)

ii) Calculate the [H_3O^+] of this vinegar solution.

4. A 15.0mL volume of 0.0750M NaOH is required to reach a phenolphthalein endpoint in titrating a solution of vinegar sample. Calculate the moles (mol) of acetic acid in the vinegar sample.

5. A vinegar sample contains 2.00e-3 moles of acetic acid. If a 4.00 g sample of vinegar was used in the titration, calculate the percent mass (m/m) % of this vinegar solution. The molar mass of acetic acid is 60.05 g/mol.

6. Complete the following table. Assume that the solution is 25°C and Kw = 1.00e-14
Show calculations for your answer.

	$[H_3O^+]$	$[OH^-]$	**pH**	**Acidic Basic or Neutral**
i.e.	1.00 e-10	1.00 e-4	10.000	Basic
A				Neutral Use 3 significant figures
B			12.450	
C	1.75e-6			
D		1.38 e-10		

Appendix A

Common Conversions

Length SI Unit Meter (m)	Volume SI Unit Cubic Meter (m^3)	Mass SI Unit Kilogram (kg)
1 m = 100 cm	1 L = 1000 mL	1 kg = 1000 g
1 m = 1000 mm	1 mL = 1 cm^3	1 kg = 2.20 lb
1 cm = 10 mm	1 L = 1.06 qt	1 lb = 454 g
1 km = 0.621 mi	1 L = 0.264 gal	1 lb = 16 oz.
1 in. = 2.54 cm (exact)	1 qt = 946 mL	
1mi = 5280 ft	1 gal = 4 qt	1 mole = 6.02 x 10^{23} particles
	1 qt = 4 cups	Density of water = 1.00 g/mL @ 4°C
	1 Fl oz. = 29.57 mL	
Energy SI Unit Joule (J)	**R =** $0.08206 \frac{L-atm}{mol\ K} = 62.4 \frac{L-mmHg}{mol\ K} = 8.314 \frac{J}{mol\ K}$	
1 calorie = 4.184 J		
Specific heat water = $4.184 \frac{J}{g\ °C} = 1.00 \frac{cal}{g\ °C}$		1 Mole gas = 22.4 L at STP

Solubility Rules

Soluble	**Exceptions:**
All compounds of Li^+, Na^+, K^+, Rb^+, Cs^+, and NH_4^+	None
All compounds of NO_3^- and $C_2H_3O_2^-$	None
Compounds of Cl^-, Br^-, I^-	Ag^+, Hg_2^{2+}, Pb^{2+}
Compounds of SO_4^{2}	Sr^{2+}, Pb^{2+}, Ca^{2+}, Ba^{2+}
	These compounds generally do not dissolve in water (are insoluble):
	Compounds of OH^-, S^{2-}, CO_3^{2-} and PO_4^{3-}

Solubility Rules, General

Soluble substances with -	Exceptions	Insoluble substances with -	Exceptions
(NO_3^-), (ClO_3^-), (ClO_4^-), $(CH_3CO_2^-)$	None	(S^{2-}), (CO_3^{2-}), (CrO_4^{2-}), (PO_4^{3-})	Grp1A, NH_4^+
X^- = Cl^-, Br^-, I^-	Ag, Hg, Pb	(OH^-)	Grp1A, NH_4^+, Sr, Ba, Ca
(SO_4^{2-})	Sr, Ca, Ba, Hg, Pb	S = Soluble - dissolve, no precipitate (aq -phase)	
Alkali & NH_4^+	None	I = insoluble (or slightly soluble) - does not dissolve, precipitate forms. (s-phase)	

Solubility Table

	AsO_4^{3-}	Br^-	$C_2O_4^{2-}$	$CH_3CO_2^-$	CO_3^{2-}	Cl^-	ClO_3^-	ClO_4^-	CrO_4^{2-}	I^-	NO_3^-	O^{2-}	OH^-	PO_4^{3-}	S^{2-}	SO_4^{2-}	SO_3^{2-}
Al^{+3}	I	S	-	S	-	S	S	S	-	S	S	I	I	I	d	S	-
NH_4^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ba^{2+}	I	S	I	S	I	S	S	S	I	S	S	s	s	S	S	S	S
Bi^{3+}	s	d	I	-	I	d	d	d	-	I	d	I	I	s	I	d	-
Ca^{2+}	I	S	I	S	I	S	S	S	S	S	S	I	I	I	d	I	I
Co^{2+}	I	S	I	S	I	S	S	S	I	S	S	I	I	I	I	S	I
Cu^{2+}	I	S	I	S	I	S	S	S	I	-	S	I	I	I	I	S	-
Fe^{2+}	I	S	I	S	s	S	S	S	-	S	S	I	I	I	I	S	s
Fe^{3+}	I	S	S	I	I	S	S	S	-	-	S	I	I	I	I	S	-
Pb^{2+}	I	I	I	S	I	I	S	S	I	I	S	I	I	I	I	I	I
Mg^{2+}	d	S	I	S	I	S	S	S	S	S	S	I	I	I	d	S	s
Hg^{2+}	I	I	I	S	I	S	S	S	s	I	S	I	I	I	I	d	-
K^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ag^+	I	I	I	s	I	I	S	S	I	I	S	I	-	I	I	I	I
Li^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Na^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Zn^{2+}	I	S	I	S	I	S	S	S	I	S	S	I	I	I	I	S	I

S = Soluble in water I = Insoluble In water (less than 1 g/100 g H_2O) d = Decomposes in water

Solubility Table of Common Ions

	Group 1 Alkali Metals				Group 2 Alkaline Earth Metals			Transition Metals					Post-transition Metals	
	Ammonium NH_4^+	Lithium Li^+	Sodium Na^+	Potassium K^+	Magnesium Mg^{2+}	Calcium Ca^{2+}	Barium Ba^{2+}	Iron (II) Fe^{2+}	Iron (III) Fe^{3+}	Copper (II) Cu^{2+}	Silver Ag^+	Zinc Zn^{2+}	Lead (II) Pb^{2+}	Aluminum Al^{3+}
Fluoride F^-	Soluble	Slightly Soluble	Soluble	Soluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Soluble	Soluble	Insoluble	Slightly Soluble
Chloride Cl^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Soluble	Insoluble	Soluble
Bromide Br^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Soluble	Slightly Soluble	Soluble
Iodide I^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble			Insoluble		Insoluble	Soluble
Chlorate ClO_3^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble		Soluble		Soluble		Soluble	Soluable
Hydroxide OH^-	Soluble	Soluble	Soluble	Soluble	Insoluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble	Slightly Soluble	Insoluble	Insoluble	Insoluble
Sulfide S^{2-}	Soluble	Soluble	Soluble	Soluble		Slightly Soluble	Slightly Soluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Sulfite SO_3^{2-}	Soluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Insoluble				Insoluble	Insoluble	Insoluble	
Sulfate SO_4^{2-}	Soluble	Soluble	Soluble	Soluble	Soluble	Slightly Soluble	Insoluble	Soluble	Soluble	Soluble	Slightly Soluble	Soluble	Insoluble	Soluble
Carbonate CO_3^{2-}	Soluble	Soluble	Soluble	Soluble	Insoluble	Insoluble	Insoluble	Insoluble		Insoluble	Insoluble	Insoluble	Insoluble	
Nitrite NO_2^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble				Insoluble		Soluble	
Nitrate NO_3^-	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble
Phosphate PO_4^{3-}	Soluble	Insoluble	Soluble	Soluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Chromate CrO_4^{2-}	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	
Acetate $C_2H_3O_2^-$	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Soluble	Slightly Soluble

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Polyatomic Ions

ion name	*chemical formula*	*central atom oxidation number*		*acid name*	*acid formula*
acetate*	$C_2H_3O_2^-$	C:	+1	acetic acid	$HC_2H_3O_2$
ammonium	NH_4^+	N:	–3	ammonium ion	NH_4^+
carbonate*	CO_3^{2-}	C:	+4	carbonic acid	H_2CO_3
chlorate	ClO_3^-	Cl:	+5	chloric acid	$HClO_3$
chlorite	ClO_2^-	Cl:	+3	chlorous acid	$HClO_2$
chromate	CrO_4^{2-}	Cr:	+6	chromic acid	H_2CrO_4
cyanide*	CN^-	C:	+2	hydrocyanic acid	HCN
dichromate	$Cr_2O_7^{2-}$	Cr:	+6	dichromic acid	$H_2Cr_2O_7$
dihydrogen phosphate	$H_2PO_4^-$	P:	+5	phosphoric acid	H_3PO_4
hydrogen carbonate* (bicarbonate)	HCO_3^-	C:	+4	carbonic acid	H_2CO_3
hydrogen phosphate	HPO_4^{2-}	P:	+5	phosphoric acid	H_3PO_4
hydrogen sulfate (bisulfate)	HSO_4^-	S:	+7	sulfuric acid	H_2SO_4
hydrogen sulfite (bisulfite)	HSO_3^-	S:	+4	sulfurous acid	H_2SO_3
hydroxide	OH^-	O:	–2	water	H_2O
hypochlorite	ClO^-	Cl:	+1	hypochlorous acid	$HClO$
perchlorate	ClO_4^-	Cl:	+7	perchloric acid	$HClO_4$
permanganate	MnO_4^-	Mn:	+7	permanganic acid	$HMnO_4$
nitrite	NO_2^-	N:	+3	nitrous acid	HNO_2
nitrate	NO_3^-	N:	+5	nitric acid	HNO_3
oxalate*	$C_2O_4^{2-}$	C:	+3	oxalic acid	$H_2C_2O_4$
peroxide	O_2^{2-}	O:	–1	hydrogen peroxide	H_2O_2
phosphate	PO_4^{3-}	P:	+5	phosphoric acid	H_3PO_4
sulfate	SO_4^{2-}	S:	+6	sulfuric acid	H_2SO_4
sulfite	SO_3^{2-}	S:	+4	sulfurous acid	H_2SO_3

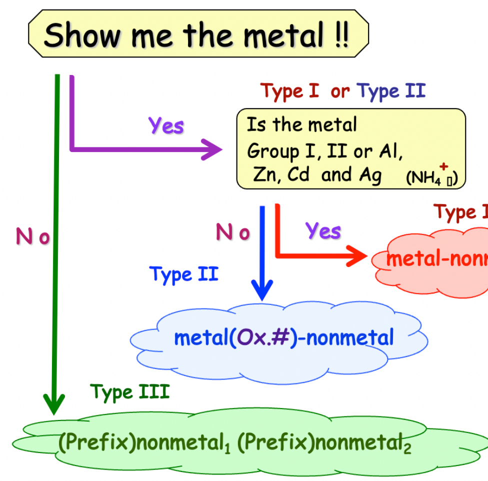
*organic compounds

Naming Compounds

... helpful hints about anions

-ide	-ate	-ite
elemental ions	oxy ions	oxy ions
X^{-m}	XO_n^{-m}	XO_{n-1}^{-m}
P^{-3} phosphide	PO_4^{-3} phosphate	PO_3^{-3} phosphite
As^{-3} arsenide	AsO_4^{-3} arsenate	AsO_3^{-3} arsenite
S^{-2} sulfide	SO_4^{-2} sulfate	SO_3^{-2} sulfite
Se^{-2} selenide	SeO_4^{-2} selenate	SeO_3^{-2} selenite
N^{-3} nitride	NO_3^- nitrate	NO_2^- nitrite
Cl^- chloride	ClO_3^- chlorate	ClO_2^- chlorite
Br^- bromide	BrO_3^- bromate	BrO_2^- bromite
I^- iodide	IO_3^- iodate	IO_2^- iodite

Determining Type (I, II, III) of Compound



Type I, II and III

Type	Elemental anion	Polyatomic anion
I (Metal - nonMetal) Cation; Rep Metal Cation - Anion	**Cation - Anion(ide)** Al_2O_3; Aluminum oxide Ag_2S; Silver sulfide	**Cation - Anion** $Cd(NO_3)_2$: cadmium nitrate $(NH_3)_2SO_4$: ammonium sulfate
II (Metal - nonMetal) (Transition) metal Cations (Oxid #) – Anion Old method (Fe^{+3} vs Fe^{+2}) higher ox.st. -ic lower ox. st. -ous	**Cation (oxidation state) Anion(ide)** $FeCl_3$; Iron(III) chloride PbS_2; Lead(IV) sulfide Cation(ic) - Anion(ide) $FeBr_3$; Ferrric bromide Iron(III) bromide Cation(ous) – Anion(ide) Fe_3N_2 ; Ferrous nitride Iron(II) nitride	**Cation (oxidation state) Anion** $Sn(C_2H_3O_2)_2$; Tin(II) acetate Au_3PO_3; Gold(I) phosphite Cation(ic) – Polyatomic anion $Fe(NO_3)_3$; Ferric nitrate Iron(III) nitrate Cation(ous) – Polyatomic anion $Fe(NO_2)_2$; Ferrous nitrite Iron(II) nitrite
III Molecular compounds- Compounds which contains nonmetal (Prefix) nonmetal $_1$ - (Prefix) nonmetal $_2$	(Prefix) nonmetal $_1$ - (Prefix) nonmetal $_2$ (ide) • Prefixes are indication of the number of atoms: mono-, di-, tri-, tetra-, penta-, hexa- • order of naming nonmetal $_1$ & nonmetal (ide)$_2$ nonmetal $_1$ is to the left and bottom of nonmetal $_2$ based on it is named first in the nomenclature scheme. Si - C - As - P - N - H - Se - S - I - Br - Cl - O - F • S & 3 O forms SO_3 ; Sulfur trioxide • 2 P & 5 O forms P_2O_2 ; Diphosphorus pentaoxide	

VSEPR Table

Lewis Structure Summary

Compounds, elements comes together:

i) electrons are shared between elements
- if there is mutually sharing, covalent compounds forms
- if there is unequal sharing, polar covalent compounds forms.

ii) electron transfer occurs, ionic compounds forms (next section).

Lewis Structure Determination:

i) Molecular Formula

ii) Atomic Sequence (H and F are terminal)

iii) Determine the # of bonds

Oe^- and TVe^-

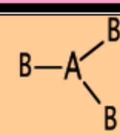
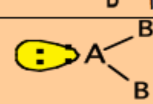
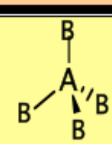
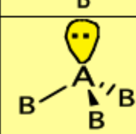
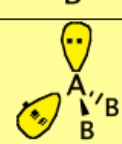
# of Bonds = $(Oe - TVe^-) / 2$

iv) Determine remaining electrons

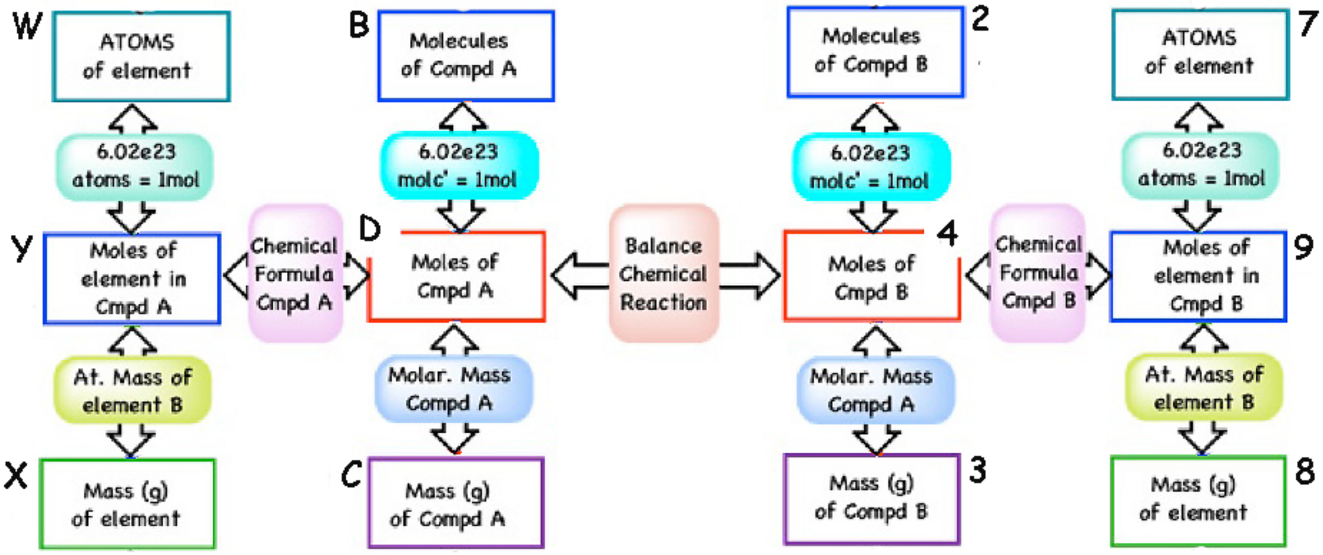
$Re = (TVe^-) - (\# e^- \text{ in bonding})$

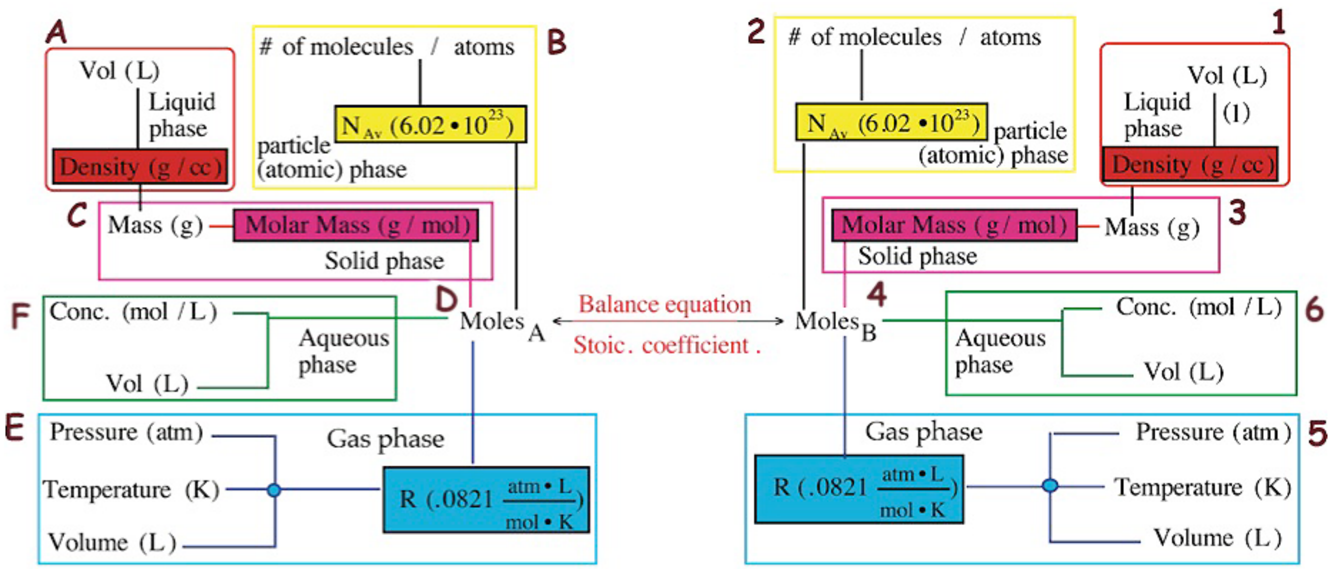
v) Make sure all atoms satisfy octet rule

(Except H which is satisfied with 2 electrons)

Electron Domains (Regions)	AE_n	Electronic Geometry	# Bonded Atoms (Coord #)	Lone pair on central atom	AB_mE_n	Molecular Geometry	Bond angle & Hybridization
2	AE_2	 Linear	2	0	AB_2	B—A—B Linear	180° sp
3	AE_3	 Trigonal	3	0	AB_3	 Trigonal	120° sp^2
			2	1	AB_2E	 Bent	< 120° sp^2
4	AE_4	 Tetrahedral	4	0	AB_4	 Tetrahedral	109.5° sp^3
			3	1	AB_3E	 Pyramidal	< 109.5° sp^3
			2	2	AB_2E_2	 Bent	< 109.5° sp^3

Stoichiometry Map





Concentrations

Concentrations and Dilutions

•Ways of expressing concentration-

-Molarity(M) - moles solute / Liter solution

-Concentration by parts

- **-Mass percent,% m (m:m)-** (grams solute/Total grams of solution) *100 → pph
- **-Mass-Vol percent, (m:v)-** (grams solute/ Total ml volume solution) *100→ pph
- **-Vol-vol percent, (v:v)-** (volume ml solute/ Total ml volume solution) *100→ pph

Note that if the multiplier is $1\cdot10^6$ instead of 100, then the unit is ppm.
ppm (m:m) = (grams solute/Total grams of solution) x $1\cdot10^6$ → ppm

If the multiplier is 109, then the unit is ppb.
ppb (m:m) = (grams solute/Total grams of solution) x $1\cdot10^9$ → ppb

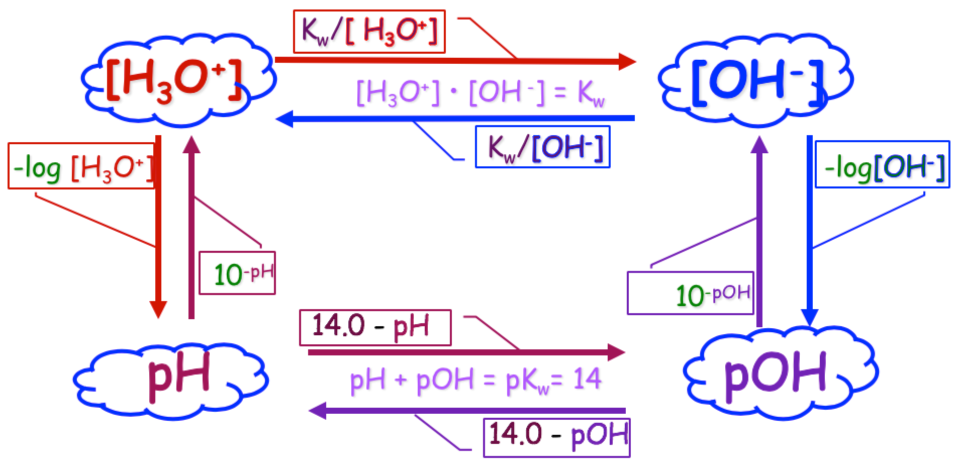
-Dilution Equation: $C_1\cdot V_1 = C_2\cdot V_2$

pH, pOH, H_3O^+, OH^- Relationship Map

Determining pH, pOH, $[OH^-]$, $[H_3O^+]$

Use this chart to determine acid and base concentration at (25° C)
$K_w = 1.00\cdot10^{-14}$ & $pK_w = 14$

$[H_3O^+]\cdot[OH^-] = K_w$ & $pH + pOH = pK_w$



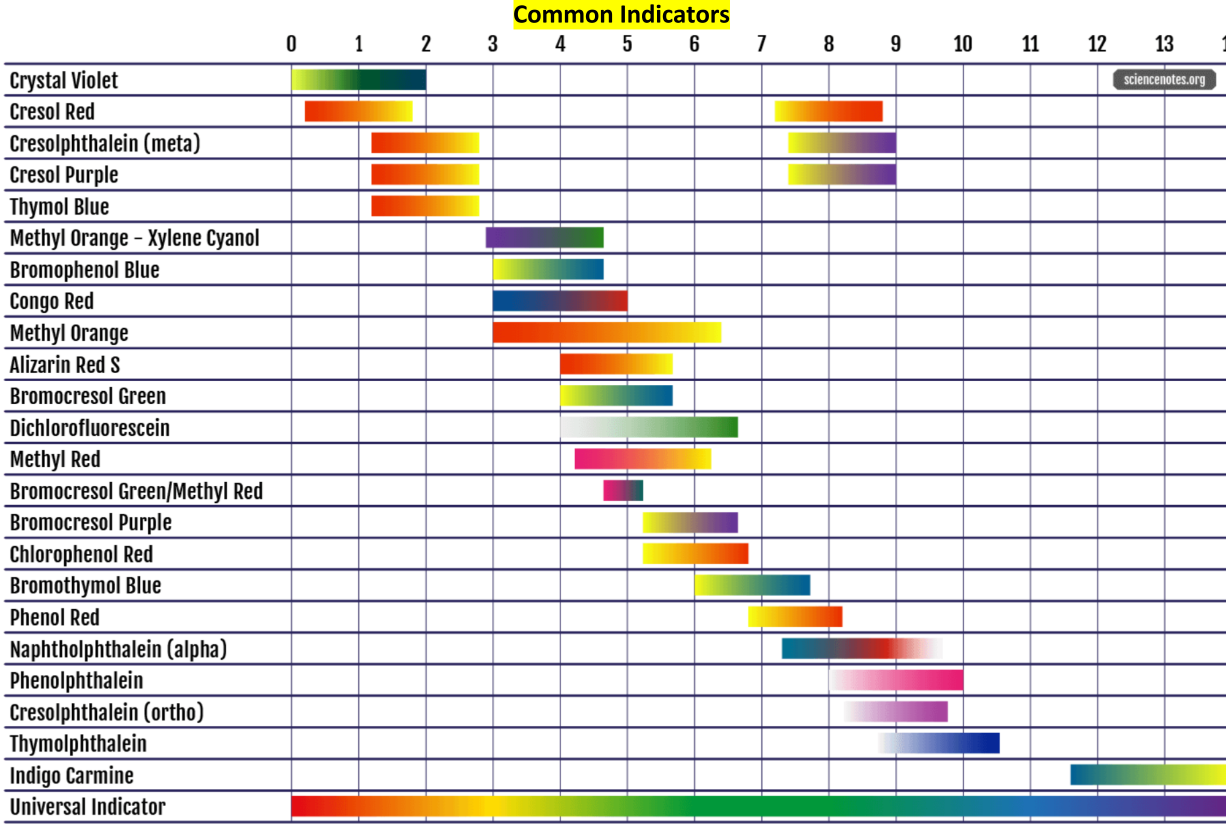
Acid-Base Indicator information: http://chemistry.about.com/library/weekly/aa112201a.htm

pH Hydro-ion paper indicator

Cabbage Indicator

Universal Indicator

Common Indicators



Periodic Table

Charge of Elemental Ions

The common charge or oxidation state of many main group and some transition metals elements can be determined by a basic knowledge of the periodic table

Common Charge for metals in Type I Ionic Compounds

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H +1																	2 He 4.0026
2	3 Li +1	4 Be 9.0122											5 B 10.811	6 C 12.0112	7 N -3	8 O -2	9 F -1	10 Ne 20.179
3	11 Na +1	12 Mg +2											13 Al +3	14 Si 28.086	15 P -3	16 S -2	17 Cl -1	18 Ar 39.948
4	19 K +1	20 Ca +2	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn +2	31 Ga 65.37	32 Ge 72.59	33 As -3	34 Se -2	35 Br -1	36 Kr 83.80
5	37 Rb +1	38 Sr +2	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc [99]	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag +1	48 Cd +2	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te -2	53 I -1	54 Xe 131.30
6	55 Cs +1	56 Ba +2	71* Lu 174.967	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 197.0	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po [210]	85 At -1	86 Rn [222]
7	87 Fr +1	88 Ra +2]	103‡ Lr [260]	104 Rf [261.11]	105 Db [262.11]	106 Sg [266.12]	107 Bh [264.12]	108 Hs [269.13]	109 Mt [268.14]	110 Ds [271]	111 Rg [272]	112 [277]		114 [289]		116 [292]		

* Lanthanide Series	57 La 138.91	58 Ce 140.115	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.368	63 Eu 151.965	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9303	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04
‡ Actinide Series	89 Ac [227.03]	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np 237.048	94 Pu [244]	95 Am [260]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

Periodic Table of the Elements

IA 1	IIA 2	3	4	5	6	7	8	9	10	11	12	IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molibdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.249
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]