CHEM 111
General Chemistry
Section 08

Dr. Bradford Gutting
Fall 2019

General Chemistry CHEM 111, Section 08
Fall 2019

Professor: Bradford Gutting
Office: Adjunct Instructor Office
Contact: bgutting@umw.edu
Lecture: T R 6:00-7:15 pm, Jepson 219
Lab: T 7:30-10:15, Jepson 214

Office Hrs: T 5:00-6:00; R 5:00-6:00 (location: adjunct office and/or Jepson 219)

Required Materials:
Principles of Chemistry: A Molecular Approach, 3rd ed., Tro
Subscription to ALEKS
Coursepack for Section 8
Lab Notebook with carbonless duplicate pages
Laboratory goggles and lab coat
Calculator with scientific notation and exponential functions; you will only be able to use non-graphing calculators on all quizzes and exams. TI-30X calculators are available in the book store.

Web Site: This course will make use of the Canvas course management system. Please check here frequently as materials posted will include course announcements, assignments, and other course materials as necessary.

General Education and Course-Specific Learning Objectives:

This course in part satisfies the Natural Science General Education requirement. After completing the course sequence, a student should

- Be able to describe the scientific methods that lead to scientific knowledge
- Be able to report and display data collected, interpret experimental observations and construct explanatory scientific hypotheses
- Be able to use theories and models as unifying principles that help us understand the natural world
- Students will be able to identify how the natural sciences are used to address real-world problems

Chemistry is everywhere, whether you realize it or not; it can be exciting, useful, or dangerous. After completing the General Chemistry I course, a student should

- Understand the basis for chemical bonding and reactivity
- Be able to solve problems related to chemical principles
- Understand the models used by scientists to explain observed phenomena
- Have gained hands-on experience in the lab and learned how to conduct scientific experiments

Grading:

	Points	Total
ALEKS Pie Completion	40	40
ALEKS Objective Completion	50	50
Quizzes (best 8 of 10)	20	160
Laboratory	250	250
In-Class Exams (4)	75	300
Final Exam	200	200
		1000

Students with a C average or lower will receive a Mid-Semester Deficiency Report.

A course grade of C- or better in CHEM 111 is required to enroll in CHEM 112.

In-Class Behavior: Please act respectfully in class of other students and myself. This includes turning your cell phone, etc. off during class time, using electronic devices only for note taking purposes, and arriving to class on time. You are expected to participate in all activities and discussions. I reserve the right to dismiss you from class if I feel you are acting disrespectfully or are disrupting the class.

Quizzes: A total of ten 15-20 minute quizzes will be given throughout the term. Quiz questions will be similar to problems in the text or come from the assigned reading or lecture material. The lowest two quiz grades will be dropped. There will be no make-up quizzes without prior arrangements with me.

Exams: There will be four in-class exams during the semester which will emphasize material introduced since the last exam. There will be no make-up exams without prior arrangements with me. The final exam will be a comprehensive, standardized final prepared by the American Chemical Society and must be taken at the time scheduled by the University: **December 12th, 7:00-9:30 pm**. According to University policy, any student who does not take the final exam will fail the course.

Exam Policies: No cell phones or other personal electronic communication devices will be permitted in the classroom during exams. You may only use approved non-graphing calculators for ALL quizzes and examinations.

If you feel a mistake has been made in the grading of your exam, you must write out what you wish to be re-graded and why (your reasoning is critical) on a separate sheet of paper. This must be turned in to me with the exam no later than one week after the graded exam is returned. Please note that the *entire* exam will be re-graded, and the new score (higher or lower) will be recorded.

If you feel there has been a numerical error in calculating your exam score, please bring this to my attention no later than one week after the graded exam is returned.

Laboratory: Detailed information regarding the laboratory component of this course can be found in the lab portion of the coursepack. It is important to note that due to the hands-on nature of the laboratory, **if a student misses three (3) lab periods, they will fail the course**.

A laboratory practical will be given the last week of lab; any student who does not take the laboratory practical will fail the course.

Group work in the laboratory may require a team effort to gather data, but all calculations and questions must be completed independently and pledged as such. You are responsible for your own lab reports. Be sure you can personally justify anything you turn in.

Attendance: Attendance in lab is mandatory. Attendance in lecture is highly recommended. Occasionally, material will be presented in lecture that is beyond the scope of your textbook or with a different emphasis than that of the text, and you will be responsible for learning this material even if you are absent.

Regardless of attendance, all assignments are due on the scheduled date. **No late assignments will be accepted without my prior consent.**

Absences: You should notify me of an expected absence as early as possible. Make-up exams will not be given except in the event of EXTREMELY extenuating circumstances.
If you must miss a quiz, see me as soon as possible *prior* to the quiz to arrange a time for a make-up quiz.
If you must miss a lab, a make-up session is usually possible if you can attend one of the other lab sections in the same week as your missed lab.

ALEKS: ALEKS (Assessment and LEarning in Knowledge Spaces) is an online, mastery-based assessment and learning system that provides an efficient, effective, and engaging learning experience. ALEKS uses artificial intelligence to determine precisely what you know, don't know, and are most ready to learn. This begins with an Initial Knowledge Check, which is a 25-30 question adaptive assessment that determines which course topics you have already mastered and which you have not. This knowledge is depicted in a pie chart divided into different areas of the course which will be filled in as you master topics.

Each week, you will be responsible for completing an objective that contains topics that have been covered in lecture. Performance on these objectives will determine your score on Objective Completion (50 total points). By the end of the semester, the goal is to have the entire pie chart filled in with topics you have mastered; performance on this will determine your score on Pie Completion (40 points).

Reading: Reading of the appropriate sections of the textbook should be done *before* coming to class. You will be responsible for this material, *even if it is not covered in lecture.*

PASS Sessions: Peer-Assisted Study Sessions (PASS) are available for this course to assist you in better understanding of the course material. The PASS program provides peer-facilitated study sessions led by qualified and trained undergraduate leaders who attend the lectures with students and encourage students to practice and discuss course concepts in sessions. Sessions are open to all students and will focus on the most recent material covered in class. These sessions are not tutoring but rather sessions to compare class notes, review and discuss important concepts, develop appropriate strategies for studying, and prepare for exams. While attendance is free and voluntary, you may earn two extra credit points a week for attending a PASS session. You must be present for the entire PASS session to get credit for that session; students who are disruptive will not earn extra credit points.

Academic Dishonesty: In accordance with the University's Honor Code, all work submitted for grading must be your own and be pledged as such by signing the complete honor pledge at the top of the assignment. Academic dishonesty in any shape or form will not be tolerated.

Suspected violations of the Honor Code will be addressed according to the policy established by the Honor Council. Please familiarize yourself with the University's policies on academic dishonesty: ignorance is not an excuse!

Disability Resources: The Office of Disability Resources has been designated by the University as the primary office to guide, counsel, and assist students with disabilities. You will need to request appropriate accommodations through this office as soon as possible, and then make an appointment with me to discuss your approved accommodation needs. I will hold any information you share with me in the strictest confidence unless you give me permission otherwise.

If you have allergies to any chemicals or other emergency medical information, please notify me as soon as possible.

How to Succeed in Chem 111:

- **DO PROBLEMS EVERYDAY!!!**
- No, seriously, do problems everyday!
- Spend about 1 hour per day on chemistry (reading, reviewing, **doing problems**)
- Attend all lectures, sit near the front, and take careful notes
- Attend all labs and complete the required lab assignments
- Attend PASS sessions regularly
- Review the appropriate sections of the text before class
- Review the appropriate sections of the text after class and organize your notes
- Do the practice problems alone and in groups
- Come to review sessions prepared with questions
- Seek the instructor's help when needed (office hours, before/after class, email)
- In the event that you require additional help beyond the instructor, you are highly advised to seek peer-tutoring through Academic Services or the ACS peer tutors

Course Schedule: The tentative schedule that follows is how I see the course arranged. It is not set in stone; if there is material that is confusing to the class, we will spend more time on it. I will strive to keep the quiz (**Q**) and exam (**Exam**) dates as scheduled. If all of the "scheduled" material has not been presented prior to the quiz/exam, the quiz/exam will include only what has been covered.

The due dates for the ALEKS Objectives will be provided in class.

Date	Topic	Chapter	Assignment
Aug. 27	Intro; Matter, Measurement, and Problem Solving	1	
Aug. 29	Matter, Measurement, and Problem Solving	1	
Sept. 3	Atoms and Elements	2	Q1 (Ch. 1)
Sept. 5	Atoms and Elements	2	
Sept. 10	Molecules, Compounds, Chemical Equations	3	Q2 (Ch. 2)
Sept. 12	Molecules, Compounds, Chemical Equations	3	
Sept. 17	Chemical Quantities and Aqueous Reactions	4	
Sept. 19	Chemical Quantities and Aqueous Reactions	4	
Sept. 24	Chemical Quantities and Aqueous Reactions	4	Q3 (Ch. 3.1-4.3)
Sept. 26	EXAM 1	1-4.3	Exam 1
Oct. 1	Thermochemistry	6	Q4 (Ch. 4.4-4.8)
Oct. 3	Thermochemistry	6	
Oct. 8	The Quantum Mechanical Model of the Atom	7	Q5 (Ch. 6)
Oct. 10	EXAM 2	4.4-4.8 & 6	Exam 2
Oct. 15	No Class- Fall break	--	
Oct. 17	The Quantum Mechanical Model of the Atom	7	
Oct. 22	Periodic Properties of the Elements	8	Q6 (Ch. 7)
Oct. 24	Periodic Properties of the Elements	8	
Oct. 29	The Lewis Model	9	Q7 (Ch. 8)
Oct. 31	The Lewis Model	9	
Nov. 5	Molecular Shapes, VBT, MO Theory	10	Q8 (Ch. 9)
Nov. 7	Molecular Shapes, VBT, MO Theory	10	
Nov. 12	Gases	5	Q9 (Ch. 10)
Nov. 14	EXAM 3	7-10	Exam 3
Nov. 19	Gases	5	
Nov. 21	Liquids, Solids, and Intermolecular Forces	11	
Nov. 26	Liquids, Solids, and Intermolecular Forces	11	Q10 (Ch. 5)
Nov. 28	No Class- Thanksgiving Break	--	
Dec. 3	Exam 4	5 & 11	Exam 4
Dec. 5	Review		Pie
Dec. 12	FINAL EXAM 7:00-9:30	1-11	Final Exam

Chem 111 Lab Schedule

	Lab	Assignments Due
8/27	Safety, Lab Check-in	Math Review
9/3	Volumetric Measurements	Volumetric Measurements Pre-Lab Notebook
9/10	Empirical Formula Determination	Volumetric Measurements Report Emp. Formula Pre-Lab Notebook
9/17	Solution Preparation	Empirical Formula Report Solution Prep Pre-Lab Notebook
9/24	Stoichiometry	Solution Prep Report Stoichiometry Pre-Lab Notebook
10/1	Thermochemistry	Stoichiometry Report Thermo Pre-Lab Notebook
10/8	Solution Calorimetry	Thermo Report Calorimetry Pre-Lab Notebook
10/15	Fall Break	--
10/22	Spectroscopy	Calorimetry Report Spectroscopy Pre-Lab Notebook
10/29	Project	Spectroscopy Report Lab Notebook Pages
11/5	Modeling: Lewis Structures and Molecular Geometry	Project Report and Evaluations Modeling Lab Report
11/12	Project	Lab Notebook Pages
11/19	H_2 Gas Generation	H_2 Gas Generation Pre-Lab Notebook
11/26	TBD	H_2 Gas Generation Report
12/3	**Laboratory Practical,** Check-out	

Lab reports are due at the beginning of lab.

Last day to drop a course: September 13

Last day to withdraw from a course or change to pass/fail grading: October 25

University Policy Statements for This Course

You can find information on the following at the web link shown below:

- Honor System Statement
- Disability Resources Statement
- Title IX Compliance Statement
- Classroom Recording Statement

https://cas.umw.edu/chemistry/university-policy-statements-for-selected-courses/

Chemistry 111
General Chemistry
Section 8

Fall 2019

Laboratory Materials

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CHEMISTRY 111: LABORATORY POLICIES

LABORATORY FORMAT

The National Science Foundation and industrial chemists from Proctor and Gamble have identified an "employable quintet" that our laboratory program strives to meet. The key points of this "quintet" are an in depth technical knowledge, problem solving ability in a laboratory setting, flexibility in learning and working, the ability to work in teams, and clarity in oral and written communication.

These abilities are developed by the combination of one week skill labs to provide technical development and the team projects, which emphasize problem solving, "thinking outside of the box," and teamwork. In the projects, you will work in a team of three or four students to develop an experimental procedure, carry out the experiments, record data and observations, and then report your results in a written communication.

LABORATORY GRADE

The laboratory grade constitutes 25% of the course grade. **Since chemistry is a laboratory-based science, students who miss 3 laboratories will fail the entire course.** One-week labs will count as 20 points each. Projects will count as 25 points each. The laboratory practical will impact the overall laboratory grade. At the end of the semester, your laboratory points will be converted to a percentage.

ATTENDANCE

Laboratory attendance is mandatory - students who miss more than 2 laboratories will automatically receive a failing grade in the course. Unexcused absences from laboratory cannot be made up and will count as a zero lab grade. Excused absences may be made-up, if possible, at the discretion of the instructor. Consult the instructor *in advance* if you expect to be absent due to an intercollegiate athletic event, etc. You are not permitted to work in the laboratory at times other than your scheduled period.

For safety reasons, it is important that you are prompt in arriving for the laboratory. Students who are late may have their laboratory grade penalized or will not be permitted to perform the experiment. At any point, a student may be removed from the lab for failure to follow proper safety rules; this will count as an unexcused absence.

LABORATORY PRACTICAL

A lab practical will be completed on the last day of lab. Performance on this 30 point practical will impact your overall laboratory grade as follows:

score on practical	impact on laboratory grade
0 – 12	-3
13 – 15	-2
16 – 18	-1
19 – 21	0
22 – 24	+1
25 – 27	+2
28 – 30	+3

For example, if your average laboratory grade is a 79%, and you score 26 points on the laboratory practical, your lab average will become an 81%. This will then be factored

into your overall course grade. If you do not take the laboratory practical, you will receive a failing grade in the course.

PRE-LAB PREPARATION

It is essential – both for your understanding of the exercises and for your safety – that you arrive for laboratory ready to perform the experiments. In addition to reading through the chapter in your textbook on the material that the laboratory will emphasize, it is expected that you will come to the laboratory prepared by closely reading and following the introductory remarks and experimental procedure in this coursepack. In many cases a PowerPoint pre-lab lecture will be posted on Canvas. For several laboratories, there are calculations in the laboratory handout that must be completed prior to coming into the laboratory. These calculations should be performed in pen in your laboratory notebook as described below. For each laboratory experiment, you will need to complete a pre-laboratory notebook entry.

Your pre-lab notebook must include

a) the title of the experiment, your name, the date, and your section number(should be included on the top of *every* page in your notebook)
b) a purpose for the experiment – briefly summarize **in your own words** the goal
c) a safety statement describing the most significant safety concern for the experiment
d) procedural summary – this should be a **one to two** paragraph a summary of the experiment to be performed. Do not rewrite the procedure from the experimental handout. This is your opportunity to think about what you will be doing and rewrite it in a way that covers the steps in a simplified manner. The procedural summary should be written in such a way that you could complete the lab without the use of the coursepack.
e) pre-laboratory calculations – these will enable you to get started measuring out reagents or preparing a solution. They must be completed in pen following your procedure and prior to your data tables.
f) OPTIONAL –you may want to prepare relevant data tables for the experiment.

The pre-laboratory notebook pages will be checked by the instructor before laboratory begins. NOTE – if you do not complete the pre-laboratory notebook assignment, you will not be allowed to complete the lab, and it will count as an unexcused absence.

An example of a pre-laboratory notebook page is shown below (page 19).

LABORATORY WORK

Laboratory data and observations are considered permanent and are recorded **in INK in the lab notebook**. Data may **NOT** be recorded directly on the data sheets during lab. There will be no scrap paper used in the laboratory.

At the conclusion of the experiment, you **must** put away your equipment in the proper place, check out using the laminated station checklist, and clean up your work area. Special equipment must also be returned. Failure to clean up after yourself will result in a penalty to your grade.

LABORATORY NOTEBOOKS

A laboratory notebook is the way in which scientists document their work. The notebook is an account of exactly what experiments or activities were performed. You will be using a carbonless duplication notebook. Each page of the notebook should have your name, an experiment title, date, and section number. Make sure every time you record in the notebook that you place a piece of cardboard between the sheets to prevent duplication on more than one copy. The white original pages should never be removed from the notebook. Never write directly on the COPY pages.

All observations (data and comments) are recorded directly in the notebook in blue or black ink as neatly as possible. If you make an error, simply cross out the mistake with a single line and rewrite the entry. **Do not** scribble out or use white out.

Use pages of the notebook chronologically and only for laboratory work, such as data collection, procedural notes, observations, and calculations. If an experiment is not completed, do not leave blank space on a page to be filled in later. Indicate that the experiment will be completed later and continue with the next set of observations and data. After the experiment is completed, indicate a page reference to the previous experiment.

REPORTS

Laboratory reports are prepared individually and the Honor Pledge is written in full on each report regardless of whether you worked alone or with others in collecting the data; this signifies that the report (the calculated results, plots, answers to questions, etc.) is entirely your own work. As indicated by the instructor, some experiments may involve working with partners to collect data. If you work with a partner in the laboratory, all calculations and answers to questions must be completed individually – you may not consult your laboratory partner for help with the laboratory report.

At the beginning of each experiment or project, the due date for the report will be announced. **A late report will not be accepted**. Please staple reports together.

Reports for Individual Experiments

As noted above, laboratory reports are prepared individually and **pledged**, indicating that all data, observations, calculations, graphs, and explanations are **entirely your own work**.

Show all work on the report in a clear manner.

For quantitative experiments, record data carefully **in ink** and show method of calculation in the space provided on the data sheets. Show units throughout, and use the appropriate number of significant figures in data and calculations. For qualitative experiments, record observations and then give concise but clear explanations to the questions, write equations, etc.

Each individual experiment report will consist of the following:

a) experimental abstract - this should be a four or five sentence summary of the purpose of the experiment, the methodology, and the major experimental findings (**i.e. – numerical results**). Do not repeat the procedure or data. An example is posted on Canvas.
b) experimental data sheets (provided in the coursepack), sample calculations, and questions from the coursepack, any necessary graphs
c) lab notebook pages including the pre-lab notebook pages, all recorded data, and observations.

Reports for Projects

Additional information about project assignments will be distributed prior to completion of these experiments/reports.

Safety Rules

UNIVERSITY of MARY WASHINGTON
DEPARTMENT OF CHEMISTRY

1. APPROVED EYE PROTECTION MUST BE WORN AT ALL TIMES WHILE CHEMICALS OR SOLUTIONS ARE BEING USED ANYWHERE IN THE LABORATORY. This means eye covering, preferably goggles, which will protect against BOTH IMPACT AND SPLASHES. If you should get a chemical in your eyes, immediately wash them with flowing water for 15-20 minutes; have someone notify the instructor who will contact campus police to arrange for transportation if emergency medical attention is necessary. The wearing of contact lenses, even under safety glasses, is discouraged because they restrict rapid cleansing of the eyes.

2. AN APPROVED LABORATORY COAT MUST BE WORN AT ALL TIMES WHILE CHEMICALS OR SOLUTIONS ARE BEING USED ANYWHERE IN THE LABORATORY. The laboratory coat must be long-sleeved and extend to the knee. CLOSED-TOE SHOES MUST ALSO BE WORN IN THE LABORATORY. Sandals are not permitted. Wear clothing appropriate for laboratory work. CONFINE LONG HAIR WHILE IN THE LABORATORY. HEAD PHONES ARE NOT PERMITTED TO BE WORN IN THE LABORATORY.

3. NO UNAUTHORIZED EXPERIMENTS MAY BE PERFORMED; NEVER WORK IN THE LABORATORY ALONE. Do not work in the laboratory at any time other than your regular laboratory period unless you have the explicit permission of the instructor.

4. IN CASE OF FIRE OR ACCIDENT, NOTIFY THE INSTRUCTOR AT ONCE. Note the location of the fire extinguishers and the safety shower. The safety equipment is for use in emergencies only.

5. FOR TREATMENT OF CUTS, BURNS, OR INHALATION OF FUMES, NOTIFY THE INSTRUCTOR IMMEDIATELY. If necessary, the instructor will arrange through the campus police for transportation for medical treatment (at the campus health center or the emergency room.)

6. DO NOT BRING FOOD OR DRINK INTO THE LABORATORY; DO NOT TASTE ANY OF THE LABORATORY CHEMICALS (INCLUDING ICE!); DO NOT EAT OR DRINK FROM LABORATORY GLASSWARE. Assume that all substances encountered in the laboratory are toxic and that all surfaces are contaminated.

7. WASH YOUR HANDS THOROUGHLY AFTER HANDLING CHEMICALS AND BEFORE TOUCHING ANY PART OF YOUR SKIN OR CLOTHING. Be especially careful about touching your face, your eyes, or your goggles. Wear gloves as appropriate when handling chemicals.

8. EXERCISE GREAT CARE IN NOTING THE ODOR OF FUMES AND AVOID BREATHING FUMES OF ANY KIND. Use the hood!

9. DO NOT USE MOUTH SUCTION TO FILL PIPETTES WITH CHEMICAL REAGENTS. Suction bulbs will be provided.

10. DO NOT FORCE GLASS TUBING OR A THERMOMETER INTO RUBBER STOPPERS. Lubricate the tubing or thermometer and protect your hands with several thicknesses of paper towels; keep your hands close together and use a twisting motion.

11. A STUDENT WITH A SPECIAL MEDICAL CONDITION (*e.g.*, SEVERE ALLERGIES, PREGNANCY, *etc.*) SHOULD CONSULT WITH HIS OR HER PERSONAL PHYSICIAN BEFORE BEGINNING LABORATORY WORK. The Chemistry Department will be happy to work with a student's physician to determine the level of risk to that particular student.

I have read and understand the above safety rules, and I will observe them in this chemistry course.
Signed

_____ Date _____

Keep the signed copy of this form in your notebook. You are required to sign the form distributed by the instructor stating you have read and understand these rules before you will be permitted to begin laboratory work.

LABORATORY SAFETY IN CHEMISTRY

I, _____, fully understand that there are hazards associated with performing new and unfamiliar procedures in a chemistry laboratory. I further understand that by signing up for CHEM _____ I must be especially careful to follow all safety rules and procedures while working in the chemistry laboratory. In addition to abiding by the Departmental safety rules, I agree that….

(1) I will receive appropriate safety training, and afterwards I will follow all proper safety guidelines for working in the chemistry laboratory.

(2) I will always have at least one other person who has had the appropriate safety training present with me in the laboratory while performing any procedures.

(3) All experimental procedures will be approved before I perform them, and the quantities of reagents used will be no greater than the amounts delineated in the approved procedure (but they may be scaled down to lesser amounts).

(4) If I take any action that puts me or anyone else at unnecessary risk of injury, I will immediately be dismissed from the laboratory and receive a failing grade for that experiment. If this happens twice, I will receive a failing grade for the course.

(5) I will not remove any chemicals or equipment from the laboratory.

(6) I will report any accidents or safety violations immediately, including those violations I have observed by others, to my instructor or, if unavailable, to another member of the Chemistry Department faculty.

(7) I will report any damaged or malfunctioning equipment to my instructor.

(8) I recognize that if I miss more than two laboratories for any reason, I will automatically receive a failing grade for this course.

Signed: _____ date: _____

LABORATORY ETIQUETTE

I Come prepared.
II Keep the balance area clean.
III Follow appropriate waste disposal guidelines carefully.
IV Do not monopolize common supplies.
V Put things back where you found them, clean.
VI Do not return excess reagents to stock bottles.
VII Use equipment only from your own station.
VIII Turn off cell phones while in lab.
IX Do not use others' lab coat or goggles.

Laboratory Stations in General Chemistry Laboratory

Each laboratory station, consisting of four drawers and one cupboard, is stocked with essential glassware and basic equipment needed for completing laboratory experiments. These stations are shared by all sections of General Chemistry. At the station, each drawer and cupboard will contain a list of the equipment kept in that particular location. Each team will be assigned to work in a particular area (4 stations) of the general chemistry laboratory. For an individually completed exercise, each student will be assigned to a single station.

So that everyone has the glassware and supplies for each experiment, it is your responsibility to keep the drawers and cabinets clean and organized with all listed equipment present. At the end of each lab, you will check out of your assigned station. If someone in the next section finds a station disorganized, dirty or missing equipment, members of the preceding section will receive a penalty of up to 5 points.

If a team or individual needs to store a solution or sample, equipment such as stoppers, additional flasks, and labels will be provided by the instructor. These labeled solutions are to be stored in the cupboard and must not be discarded by another individual or group. A little attention to keeping things organized and clean in the stations will ensure that everyone can successfully conduct their experiments.

Equipment List for Stations

Drawer A	**Drawer B**
3 beakers, 50 mL	2 crucibles with lids
3 beakers, 100 or 150 mL	1 desicooler
3 beakers, 250 mL	2 droppers
3 beakers, 400 mL	1 gas lighter (striker)
4 Erlenmeyer flasks, 125 mL	1 microwell plate
2 funnels	1 pink color card
1 graduated cylinder, 10 mL	1 ruler, 12 inch
1 graduated cylinders, 25 mL	1 ruler, 6 inch
1 graduated cylinder, 50 mL	1 spatula
1 graduated cylinder, 100 mL	4 stirring rods
1 graduated cylinder, 250 mL	1 test tube clamp
1 volumetric flask, 10 mL	1 tongs
1 volumetric flask, 25 mL	1 utility clamp
1 volumetric flask, 100 mL	1 Sharpie
Drawer	**Cupboard**
storage of goggles/lab coats	10 Florence flasks, 500 mL
	1 wash bottle
	1 Bunsen burner
Drawer	1 clay triangle
storage of goggles/lab coats	1 funnel support
	1 iron ring
	12 test tubes, 6 inch
	1 test tube rack

Use of the Balances

1. DO NOT WEIGH HOT OR WARM OBJECTS. Always cool objects to room temperature.
2. DO NOT WEIGH CHEMICAL SAMPLES DIRECTLY ON THE BALANCE.
3. DO NOT ADD CHEMICALS INTO A CONTAINER DIRECTLY ON THE BALANCE PAN. Weigh the empty container, remove it from the balance while adding chemical sample, then reweigh the container plus sample.
4. Avoid fingerprints by using tongs, forceps, etc.
5. CLEAN UP THE BALANCE AND THE AREA AROUND THE BALANCE WHEN FINISHED!

<u>Analytical Balances</u>

1. To turn the balance on, tap down once on the front bar (do not hold the bar). To turn balance off, lift up on the bar.
2. Always check the zero before weighing; check with all balance doors closed.
3. Reset zero, if necessary, by tapping once on the front bar.
4. Carefully place container or object to be weighed on the balance pan and close door.
5. Wait for the balance to reach a stable reading, displaying three decimal places.
6. Record data directly in notebook or on report sheet, in ink.
7. Remove container from balance and close doors.

Significant Figures

For a measurement, the digits recorded (with units) are those which are certain plus the first uncertain digit (the last digit recorded). These are the significant figures. The uncertainty in the last number is assumed to be ±1 unless otherwise indicated.

Significant Figures in a Recorded Number:

1. All digits are significant except leading zeros and some trailing zeros.
2. Zeros that serve only to locate the decimal are not significant. This means that leading zeros, at the beginning (or left) of number are not significant.
   Trailing zeros at the end of number are significant if after a decimal point but are not significant when there is no decimal point.
   Writing the number in scientific notation is usually helpful when there are leading or trailing zeros.

Significant Figures in Calculations:

1. ADDITION AND SUBTRACTION: The result has the same number of decimal places as the measurement with the least number of decimal places.
2. MULTIPLICATION AND DIVISION: The result has the same number of significant figures as the measurement with the least number of significant figures.

Rounding:

1. In a series of calculations, carry extra figures (in calculator) through intermediate steps and round in the final result, except when there is a parenthesis in the calculation.
2. When rounding, use only the first number to the right of the last significant figure.

Atomic Weights and Significant Figures:
Look up atomic weights (from a Periodic Table) for use in calculations to **two decimal places**, so that the atomic weight will not be limiting in significant figures.

Calculators and Significant Figures:
Calculators frequently display an incorrect number of figures. Usually the display gives too many figures. However, many calculators drop zeros at the end of a number (after a decimal) which may in fact be significant.

Interpretation of Experimental Data
The reliability and reproducibility of scientific data are usually described by the terms accuracy and precision, respectively.

Accuracy refers to how close an experimental value is to the accepted or "true" value. The experimental value may be a single result or may be an average of several results. In some cases the accepted value may be a theoretical value. Percent error is the common means of expressing accuracy.

$$\text{percent error} = \frac{\text{(experimental value - true value)}}{\text{true value}} \times 100\ \%$$

The **precision** of a set of measurements refers to how closely the individual measurements agree with each other. In order to determine the precision of a set of results, the experiment must be repeated several or multiple times.

Proper Reference Format
References in this class will be given according to the American Chemical Society *Style Guide*. Below are some examples of proper references format for some common source types.

Journal article:	Roberts, J.L.; Hollenberg, J.L.; Postuma, J.M. The Molar Mass of a Gas. *J. Chem. Ed.* **1984,** *72*, 96-100.
Edited book:	*CRC Handbook of Chemistry and Physics*, 48th ed.; Weast, Robert C., Ed., CRC Press: New York, 1967; p. 89.
Book:	Tro, N. J. *Principles of Chemistry: A Molecular Approach*, 3rd ed.; Pearson: Hoboken, NJ, 2016; pp. 47-53.
Website:	Periodic Table of Elements and Chemistry, www.chemicool.com [accessed: July 18, 2016]

Title of Experiment
Your Name
Institution
Date of Submission

Abstract

The first sentence of the abstract should introduce the problem/project that you have been working on in lab and should briefly explain why it is important for the purpose of the lab. The second sentence should focus on the general process/experimental procedure that you performed in order to obtain your results. It is important to note that this section is NOT a procedural summary. The main 2-4 sentences of the abstract focus on the results that you have obtained. This is where you include numerical results (percent yields, spectroscopic values, etc. – NOT raw data), as well as information on how these results were obtained and how confident you are in them (statistically, percent error, etc.). Your results should be clearly explained and put into context, enough so that your abstract could stand on its own as a summary of what you accomplished during the lab. The last sentence should be a brief conclusive statement.

Word count of this abstract: 153

Notes on Abstracts:

- Usually written in third person passive voice (ex: the volume of water was measured) instead of first person (ex: I measured the volume of water)
- Professional abstracts are limited to 150-250 words, max
- Any abbreviations should be defined once before their subsequent use
- Long chemical names can be given a bold number (**1**), then be referred to by that number

Volumetric Measurements

Your Name

The precision and accuracy of laboratory glassware was evaluated by determining how closely measured volumes were to the desired volume using mass measurements and the density of water at the laboratory temperature. It was determined that the 25 mL volumetric flask was the most precise and accurate piece of glassware with a calculated percent error of 0.18%. The 25 mL, 100 mL, and 250 mL graduated cylinders followed in accuracy with percent errors of 1%, 2.1%, and 8%, respectively. The 400 mL beaker was the least precise and accurate glassware investigated with a percent error of 40%.

Pre-lab notebook example.

EXP. NUMBER	EXPERIMENT/SUBJECT	DATE	99
1	Volumetric Measurements	8/25/11	
NAME	LAB PARTNER	LOCKER/DESK NO.	COURSE & SECTION NO.
Nicole Crowder			Section 1

Purpose: In this lab, the accuracy of various types of volumetric glassware will be evaluated using the mass of the water delivered and the density of the water at the specific temperatures. It will explore the precision of the different types of glassware.

Reference: The experimental procedure will be followed as given in CHEM 111 Coursepack, UMW, Dr. Nicole Crowder, Fall 2011, "Volumetric Measurements," p. 25-26.

Safety: The most significant safety concern is broken glassware.

Procedural Summary:
There are three parts to this lab, using different types of glassware: graduated cylinders, a beaker, and a volumetric flask. For parts I + II, first take the mass of a clean, dry beaker. Then use the appropriate glassware (grad cylinder or 400mL beaker) to measure 25 mL of distilled water. Deliver this to the massed small beaker and take the mass again. For part III, take the mass of the dry volumetric flask. Fill this to the calibration line with distilled water, then take the mass again. Be sure to record the ~~temperature~~ temperature and density of water. Perform the appropriate number of trials for each piece of glassware.

SIGNATURE	DATE	WITNESS/TA	DATE

THE HAYDEN-McNEIL STUDENT LAB NOTEBOOK NOTE: INSERT DIVIDER UNDER COPY SHEET BEFORE WRITING

Laboratory Glassware and Volumetric Measurements

Volumetric measurements of liquids are made with various types of glassware. In this experiment, the temperature, density, and mass of water samples will be used to verify the volume of water that various pieces of laboratory equipment will deliver or contain. The main purpose is to develop skill in using laboratory glassware and to learn the capabilities of the various types of glassware.

It is important to distinguish between glassware designed to contain a certain volume and glassware designed to deliver a certain volume. Graduated cylinders, beakers, burets and pipettes are made *to deliver*, meaning that the amount read off the glassware's markings can be accurately transferred to another container. Some liquid in the glassware will not transfer, but this is taken into account in the glassware marking. By contrast, volumetric flasks are made *to contain* a certain volume. If you need to make exactly 25.00 mL of a solution, then a 25 mL volumetric flask is the tool for you. Because no liquid is lost in transferring when using a volumetric flask, this kind of glassware can be much more accurate and precise, but only to contain, not to deliver!

It is critical, in this lab and always, that you deal with significant figures appropriately. Remember: when making a measurement it is generally advisable to record as many legitimate digits as possible. The analytical balances read to three decimal places, while the precision of the volumetric glassware depends on the calibration marks. When you use each piece of equipment to measure your 25 mL, you will notice that the task is inherently easier with some glassware than with others. If you can only confidently say that the volume was somewhere between 24 and 26 mL because the glassware is marked in 2 mL intervals, you can only report a 2 s.f. value of 25 mL. On the other hand, if you are confident that the value is between 24.35 and 24.40 mL, you can justify reporting 23.38 mL. Furthermore, the rules for retaining significant figures are different depending on what type of mathematical operation you are performing. Be sure to use the correct rule.

Volumetric Measurements

Name _____ section _____ date _____

Part I:

Fill a 250 mL beaker with deionized water. This should be enough for the whole experiment. Record the temperature of the water and the density of water at that temperature.

Water temperature _____ Water density _____

Reference _____

Part II Graduated Cylinders

Use 25 mL, 100 mL, and 250 mL graduated cylinders to measure **25 mL** of deionized water.

Obtain the mass of a clean dry 50 mL beaker. Deliver **25 mL** of water to the clean dry 50 mL beaker. Record the mass of the 50 mL beaker and water.

Use each cylinder twice. In each experiment, **only 25 mL is being delivered** regardless of the size of the graduated cylinder.

At no time do you measure the mass of the graduated cylinder.

type of cylinder	expected volume	mass of beaker	mass of beaker + water (25 ml)	mass of water	calculated volume of water delivered	% error
25 mL						
25 mL						
100 mL						
100 mL						
250 mL						
250 mL						

Part III Beaker

Use a 250 mL beaker to measure **25 mL** of deionized water.

Obtain the mass of a clean dry 50 mL beaker. Deliver **25 mL** of water to the 50 mL beaker. Record the mass of the 50 mL beaker and water. Repeat two times.

At no time do you measure the mass of the 250 mL beaker.

Expected volume of beaker _____

Trial	mass of beaker	mass of beaker + water	mass of water	calculated volume of water delivered	% error
1					
2					
3					

Part IV Volumetric Flask

Record the mass of a **dry** flask. Fill the flask to the calibration line with water and mass the flask and water. Pour out some of the water and re-fill it to the line. Then measure the mass of the flask and water.

Expected volume of flask _____25.00 mL___
Mass of dry flask _____

trial	mass of flask and water	mass of water	calculated volume of water delivered	% error
1				
2				
3				

Part V Buret

Fill the buret with water and remove any air bubbles in the tip.
Record the initial volume. (**All buret readings contain two decimal places**).
Obtain the mass of a clean dry 50 mL beaker. Deliver approximately **25 mL** of water to the clean dry 50 mL beaker. Record the mass of the 50 mL beaker and water and the final volume in the buret. **The volume delivered is the difference between the initial and final readings.** Repeat procedure twice.

Trial	mass of beaker	Initial buret reading	Final buret reading	Volume of water delivered	mass of beaker + water	mass of water	Calculated volume of water delivered	% error
1								
2								
3								

Questions

1. Consider how any individual determination of the volume varies within a given piece of equipment. What does this indicate about the value of taking multiple measurements? How many measurements do you think would be “enough”?

2. Define precision and accuracy. Based on your experimental results, which glassware is most precise? Which is most accurate?

Calculations: Show complete calculations for one trial.

25 mL graduated cylinder:

1. Mass of water

2. Volume of water

3. Percent error

100 mL graduated cylinder:

1. Mass of water

2. Volume of water

3. Percent error

250 mL graduated cylinder:

1. Mass of water

2. Volume of water

3. Percent error

Calculations: Show complete calculations for one trial.

250 mL beaker:

1. Mass of water

2. Volume of water

3. Percent error

25 mL volumetric flask:

1. Mass of water

2. Volume of water

3. Percent error

Buret

1. Mass of water

2. Volume of water delivered (using final and initial buret readings)

3. Volume of water (using mass of water and density)

4. Percent error

Formula of a Hydrate

A hydrate salt is one in which a fixed number of water molecules is crystallized with each formula unit. The number of associated water molecules is referred to as the water of hydration. For example, zinc sulfate heptahydrate, $ZnSO_4 \cdot 7H_2O$, has seven waters of hydration. When heated, a hydrate will decompose to the anhydrous salt plus steam. When calculating the molar mass of a hydrate it is necessary to include the waters of hydration. Thus the molar mass of zinc sulfate heptahydrate is 65.4 + 32.0 + 4(16.0) + 7(18.0) = 287.4 grams/mole. Of that total, 126.0 g are due to the water of hydration, so zinc sulfate heptahydrate is 43.84% water.

In this experiment you will be determining the % water in a hydrate and also the empirical formula for the hydrate, or the number of waters of hydration. This will be done by drying the hydrate. An important concept arises at this point. How does one know that the hydrate is fully dry? If you heat your hydrate for a bit, then cool it down and weigh it there is no evidence yet at hand to say that the salt is fully dry. If you re-heat the salt, cool and weigh it again, and the mass has not changed, you do have evidence that the salt is as dry as it is going to be. On the other hand, if the mass goes down after a second heating you can be sure that it was not dry after the first heating. Is it dry after the second round? There is no way to tell. You must heat it a third time. This cycle is continued until you observe a constant mass. Then you can be confident that all of the water of hydration has been removed. The cooling step must be performed in a dry environment so that atmospheric water vapor does not re-hydrate the anhydrous salt.

Procedure:

- Place a clean dry crucible and lid on a triangle and ring and heat with a Bunsen burner for 5 minutes. Let this cool in a Desicooler and record the mass.
- Place between 1.5 and 2 grams of hydrated salt in the crucible, replace the lid and record the mass.
- Heat the crucible, lid and salt for **5** minutes. Be sure not to get the crucible too hot.
- Cool in the Desicooler and record the mass. Repeat the heating (heat only 2-3 minutes for subsequent heatings) and cooling cycle until you have achieved constant mass (+/- 0.005).

Formula of a Hydrate

Name _____
section _____ date _____

DATA	
mass of empty crucible and lid	
mass of crucible, lid and hydrate (before heating)	
mass of hydrate (a calculation)	
mass of crucible, lid and anhydrous salt (1^{st} heating)	
mass of crucible, lid and anhydrous salt (2^{nd} heating)	
mass of crucible, lid and anhydrous salt (3^{rd} heating)	
mass of anhydrous salt (a calculation)	
mass of water (a calculation)	

CALCULATIONS

1. a) Calculate the moles of anhydrous salt present

   b) Calculate the moles of water lost

   c) Calculate the empirical formula for the hydrate

2. Calculate the experimental % water in the hydrate.

3. Calculate the theoretical % water in your hydrate based on your proposed formula.

4. Calculate the % error for the percent water in the hydrate.

Questions to Answer:

1. A 2.500 g sample of silver metal is heated to a high temperature in air to form 2.685 g of an oxide of silver. What is the empirical formula of the oxide?

2. Explain in your own words the principle of heating to constant mass. In this experiment, how would your experimental % water have been affected if you did NOT heat to constant mass? Would it be higher? Would it be lower?

Solution Preparation

One of the most important laboratory skills you can develop through this course is the ability to accurately prepare solutions. In your pursuit of a college degree in science, you will be required to make many solutions with a large variety of complexity. The world of scientific technology continues to advance, and computerized instruments are doing more and more of the job laboratory scientists used to do, but these instruments still need the solutions on which to perform the tests.

Although there are a variety of ways a chemist can describe a solution's concentration, we will focus only on **molarity** for this lab. Molarity is defined as moles of **solute** divided by the **solution** volume in liters. The statement that the solution is 10 molar, or 10 M, doesn't say how much stuff you have, just that it is very concentrated. It could be just 3 drops, or it could be a 55 gallon drum. It does, however, provide a very useful conversion factor.

If you have 2 L of a 0.5 M solution, you have a total of 1 mole of solute. (2 L) x (0.5 moles/L) = 1 mole. If you have 10 mL of a 0.123M solution, you have (10 mL) x (1 L / 1000 mL) x (0.123 moles/L) = 0.00123 moles. If you want to prepare 100 mL of 0.65 M solution, you would need (100 mL) x (1 L/1000 mL) x (0.65 moles/L) = 0.065 moles of solute.

During the laboratory period, you will be preparing various solutions of sucrose and determining their density. The density of aqueous sucrose varies linearly with the sucrose molarity, meaning the relationship between density (d) and molarity is of the type

$$d = a\,M + b$$

The slope of the line, a, has units of (g/mL)/M, and has a known value. For your lab report, you will graph your results and determine the slope of a best-fit line to your data. You can then check the accuracy of your solution preparation by calculating the % error in your measured slope compared to the known value.

Procedure

Working in teams of two, you will each be assigned three solutions that you must prepare. For each solution you will be given a volume and a target molarity. The solvent is DI water; the solute is sucrose ($C_{12}H_{22}O_{11}$). Determine the mass of sucrose necessary to make the solutions and check this with your instructor or lab aide before proceeding.

Measure out the calculated mass of sucrose in a 50 mL beaker. Use a graduated cylinder to measure the desired volume of solvent. Mix the solvent with the solute, using quantitative transfer to move the sucrose from the 50 mL beaker to a larger beaker or the volumetric flask, if necessary. **If your solution volume is 25 or 100 mL, you must make this solution in the appropriate volumetric flask.** Mix thoroughly, ensuring that all the sucrose is dissolved.

Once you have prepared the solution, you must measure its density. Carefully measure 15.0 mL of your solution using a graduated cylinder. Record the actual volume measured.
Obtain the mass of a clean dry 50 mL beaker. Deliver the 15.0 mL of your solution to the clean dry 50 mL beaker. Record the mass of the 50 mL beaker and water. Calculate and check this density with your instructor or lab aide before making the other two solutions.

All solutions can be poured down the drain when done. CLEAN YOUR GLASSWARE VERY WELL!!!

Pre-lab Calculation: Calculate the molecular weight of sucrose ($C_{12}H_{22}O_{11}$).

Solutions

Name _____
section _____ date _____

Solution Preparation:

Target Molarity	Target Volume	Calculated mass of sugar	Mass of beaker	Mass beaker + sugar	Actual Mass of sugar

Determination of Density:

Target Molarity	Measured Volume	Mass of beaker	Mass beaker + solution	Mass of solution	Calculated Density

Graphical Data Analysis

Prepare a graph of density versus molarity for your six solutions using Excel. Include a linear trendline and its equation. You will need at least three significant figures on the slope of your trendline. If Excel does not automatically provide that precision, double click the equation, and under the "Number" tab, select "Category" as "Number" and set it to show three decimal places.

Questions to Answer

1. The accepted value for the slope of aqueous sucrose density versus molarity is 0.127 (g/mL)/M. Calculate the % error in your experimental value (slope of your trendline).

2. If you measure25 mL using the following glassware, how many significant figures can you record?
   a) using a buret _____
   b) using a 25 mL graduated cylinder _____
   c) using a 250 mL graduated cylinder _____

Calculations: Show complete calculations for *all SIX solutions.*

1. Calculate the mass of sugar needed to make each solution at the desired volume and molarity. (These calculations should already be in your notebook for the 3 solutions that you made, so you do not need to duplicate them here.)

2. Calculate the actual mass of sugar used.

3. Calculate the mass of solution used in determining the density of the solution.

4. Calculate the density of the solution.

Mass Percent $NaHCO_3$ in Alka-Seltzer

When an Alka-Seltzer tablet is dropped into a glass of water, an acid-base reaction is initiated in which one of the products is carbon dioxide gas (hence the bubbles). When dropped into water, the citric acid in the tablet dissolves and is available to react with the sodium bicarbonate. However, citric acid is the limiting reagent. In this experiment gradually increasing amounts of acid will be added until it is safe to conclude that the sodium bicarbonate has become the limiting reagent. The pertinent reaction (minus spectator ions, i.e. Na^+, Cl^-) is

$$HCO_3^- + H^+ \rightarrow H_2O + CO_2\,(g)$$

The mass percent of sodium bicarbonate in the Alka-Seltzer tablet will be determined by measuring the mass decrease associated with the effervescence in a controlled reaction with acid. This mass decrease is attributable to the carbon dioxide lost which can be related back to the amount of sodium bicarbonate in the original tablet through stoichiometry.

Except for the need for care in handling strong acid, there are no significant safety hazards involved, and all resulting solutions can be safely poured down the drain.

Procedure:

- Prepare 1 M HCl by diluting 25 mL of the 6M desk reagent to 150 mL. Pour this into a 400 ml beaker and stir thoroughly.

** Repeat the next three steps for each solution listed in the report sheet data table

- Record the mass of a 250 mL beaker plus solution (as listed on the next page, columns 2 and 3)
- Record the mass of one tablet, then add it to the beaker solution
- Swirl gently; record the mass of the beaker plus contents one minute after the last sign of fizzing.

Mass Percent $NaHCO_3$ in Alka-Seltzer

Name _____
Section _____ Date _____

Data and Calculations

Exp.	water mL	1M acid mL	mass, tablet	mass, beaker + solution	total mass before reaction	mass, after reaction	mass CO_2	mass $NaHCO_3$ reacted	mass $NaHCO_3$ as % of tablet
1	35	0							
2	30	5							
3	25	10							
4	20	15							
5	15	20							
6	10	25							
7	5	30							
8	0	35							

Mass Percent $NaHCO_3$ in Alka-Seltzer Name _____

Calculations: Show complete calculations for *at least one experiment*.

1. Calculate the total starting mass.

2. Calculate the mass loss (this is the mass of CO_2 produced).

3. Calculate the mass of reacted $NaHCO_3$ from the mass loss (CO_2).

4. Calculate the mass of $NaHCO_3$reacted as a % of the tablet mass.

Mass Percent $NaHCO_3$ in Alka-Seltzer

Name _____

Graph

In Excel, prepare a plot of mass $NaHCO_3$ reacted vs. volume acid used.
Use appropriate scaling on axes and be sure to label appropriately. Use an appropriate trendline (DO NOT CONNECT THE DOTS).

Identify on the graph the region where acid is the limiting reagent and the region where sodium bicarbonate is the limiting reagent.

Questions to Answer

1. Based on information from the manufacturer, an Alka-Seltzer tablet should contain 59.1% by mass sodium bicarbonate. How do your data compare to this? What might be some reasons for any observed discrepancy?

2. What mass of citric acid ($H_3C_6H_5O_7$) would be required to exactly react with all of the sodium bicarbonate in one Alka-Seltzer tablet? (This equation is not balanced!)

$$H_3C_6H_5O_7 + NaHCO_3 \rightarrow CO_2 + H_2O + Na_3C_6H_5O_7$$

Thermochemistry: Energy Content in Fuels

Combustion of fuel is an exothermic process. The amount of heat liberated is not only dependent on the amount of fuel burned, but also the type of fuel that is used. Hydrocarbons are particularly energy-rich. The complete combustion process involves reaction with oxygen to form carbon dioxide and water. For instance, the combustion of propane is

$$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O + \text{energy}$$

In this experiment you will be measuring the amount of heat produced by the combustion of various fuels. Since we cannot measure heat flow as you measure mass on a balance, you will have to measure the heat flow by measuring its effect. As a measured quantity of fuel is burned, a container of water will be heated. By measuring the temperature change in the water, you will be able to calculate the heat gained. This is then attributed to the combustion of the fuel. The heat absorbed by the water is given by the formula

heat = mass of water (grams) x specific heat of water (joules/g°C) x temperature change (°C)

$$q = m\ c\ \Delta T$$

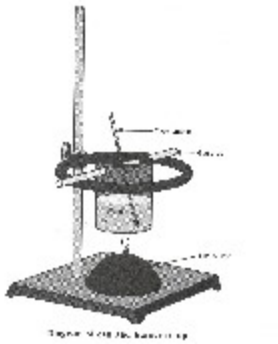
Procedure

- Assemble the apparatus shown in Figure 1
    - Record the mass of the empty can
    - Add approximately 100 mL water and record the mass of the can plus water
    - Record the temperature of the water in the can

- Obtain a fuel lamp and record the mass
- Place the burner under the can so that the bottom of the can is within an inch of the burner wick. Light the burner.
- Stir the water occasionally; continue heating until the temperature has increased at least 20 °C
- Continue stirring while you monitor the temperature. Record the highest temperature reached.
- Record the new mass of the fuel lamp.

* Repeat this procedure with fresh water. You must use each fuel at least twice.

Figure 1



Energy Content in Fuels

Name: **Section:** **Date:**

Fuel						
trial	1	2	1	2	1	2
mass of can + water (grams)						
mass of empty can (grams)						
mass of water (grams)						
final temperature (°C)						
initial temperature (°C)						
temperature change (°C)						
initial mass of burner (grams)						
final mass of burner (grams)						
mass of fuel burned (grams)						
heat absorbed by water (joules)						
heat per gram of fuel (joules/gram)						

Calculations: Show complete calculations for one trial.

1. Calculate the mass of water.

2. Calculate the change in temperature.

3. Calculate the mass of fuel burned.

4. Calculate the heat absorbed by water.

5. Calculate the heat per gram of fuel.

Name: _____ **Section:**____ **Date:**_____

1. Rank the fuels in order of heat per gram of fuel.

   Highest:

   Middle:

   Lowest:

2. Using the following heats of formation, calculate the **heat per mole of fuel** produced as a result of the **combustion reactions** for each fuel. You must have a balanced chemical equation to complete these calculations! (CO_2 = -393 kJ/mole; H_2O = -285 kJ/mole; ethanol = -278 kJ/mole; paraffin = -2230 kJ/mole; butanol = -284 kJ/mole)

3. Convert the heat per mole of fuel calculated in #2 to **heat per gram of fuel** using the molecular weight of the fuel**.**

4. Calculate the percent error between the theoretical heat per gram of fuel calculated in #3 and the experimental heat per gram of fuel for each of the three fuels. What are some sources of error in this experiment?

Solution Calorimetry

The enthalpy change associated with a reaction can be measured at constant pressure in a coffee cup calorimeter. Certain reactions are endothermic, meaning they will take in heat, and the temperature of the solution will drop. Other reactions are exothermic and release heat, causing the temperature of the solution to increase. For reactions occurring in a coffee cup calorimeter, the change in temperature of the solution can be related to the heat flow of the reaction using $q_{soln} = m_{soln}c_{soln}\Delta T_{soln}$, where m is the mass of the solution, c is the specific heat of the solution, and q is the quantity of heat gained or lost. Since it is operating at constant pressure, q is also equal to ΔH.

The heat gained or lost due to the reaction flows between the reaction and the solution such that $q_{rxn} = -q_{soln}$: the heat is equal and opposite. For instance, if the reaction is exothermic, the reaction is losing heat, and all of that heat is gained by the solution, which is what causes the temperature to rise. In this lab, you will be determining the ΔH_{rxn} values for the neutralization reaction between a strong acid and a strong base and the dissolution of a salt in water. Typically, ΔH_{rxn} values are given in kJ/mol of one of the reactants.

Unfortunately, the coffee cup calorimeter is not truly isolated from the surroundings, so there is some heat transfer between the calorimeter and the surroundings, which can be observed as a slow return to room temperature. We will try to address this issue by using graphical analysis to determine the temperature change if the reaction had happened instantaneously. The temperature will be monitored over time and graphed (temperature *vs*. time). A vertical line is drawn at the time point where mixing occurred. A linear trend line for the portion of the graph where the temperature begins to return to room temperature can then be extrapolated back to the vertical line. The difference between where the extrapolated line intersects the vertical line (T_f) and the initial temperature before mixing (T_i) will be used in the calculation of q_{soln}.

Procedure:

Part I: Neutralization Reaction

Obtain approximately 20 mL each of the NaOH and HCl solutions. Be sure to record the molarity of each solution and the actual volume that you obtained.

Assemble a coffee cup calorimeter using two nested coffee cups. Record the mass of the calorimeter empty.

Pour the NaOH solution into the calorimeter. Cover and begin recording the temperature using the LabQuest temperature probe.

After about three minutes (or when the temperature has stabilized), pour the HCl solution into the calorimeter, then quickly cover it. Be sure to note the exact time when you pour the HCl in for your graphical analysis. Swirl the calorimeter to ensure full reaction.

Continue recording the temperature until you have 3-4 data points as it begins to return to room temperature (probably 6-8 minutes).

Record the mass of the calorimeter with the mixed solution in it before pouring it out and rinsing the calorimeter.

Part II: Dissolution of a Salt

Assemble a coffee cup calorimeter using two nested coffee cups. Record the mass of the calorimeter empty.

Add 20 mL of DI water. Record the mass of the calorimeter with the water. Cover and begin recording the temperature using the LabQuest temperature probe.

Measure out 2 grams of ammonium chloride, NH_4Cl. Record actual mass.

After about three minutes (or when the temperature has stabilized), pour the NH_4Clinto the calorimeter, then quickly cover it. Be sure to note the exact time when you pour the NH_4Clin for your graphical analysis. Swirl the calorimeter to ensure full dissolution.

Continue recording the temperature until you have 5-6 data points as it begins to return to room temperature (probably 6-8 minutes).

Pour the solution out and rinse the calorimeter.

Data:

Neutralization Reaction

Time	Temperature

Dissolution of Salt

Time	Temperature

Part I:

Mass of calorimeter empty: _____

Mass of calorimeter with mixed solution: _____

Mass of solution	Initial Temp.	Final temp.	ΔT	q_{soln} (J)	q_{rxn} (J)	Mol NaOH	ΔH (kJ/mol NaOH)

Calculations:

1. Mass of solution

2. ΔT (T_i and T_f determined from graphical analysis)

3. q_{soln}(Assume the specific heat of the solution is 4.184 J/g·°C)

4. Moles of NaOH (use volume and molarity to determine moles)

5. ΔH_{rxn} in kJ/mol of NaOH

6. The true ΔH value for this reaction is -55.8 kJ/mol. Calculate the percent error in your experimental value.

Part II:

Mass of calorimeter empty: _____
Mass of calorimeter with water: _____

Mass of NH_4Cl: _____

Mass of solution	Initial Temp.	Final temp.	ΔT	q_{soln} (J)	q_{rxn} (J)	MolNH_4Cl	ΔH (kJ/mol NH_4Cl)

Calculations:

1. Mass of solution

2. ΔT (T_i and T_f determined from graphical analysis)

3. q_{soln} (Assume the specific heat of the solution is 4.184 J/g·°C)

4. Moles of NH_4Cl

5. ΔH_{rxn} in kJ/mol of NH_4Cl

6. The true ΔH value for this reaction is 14.8 kJ/mol. Calculate the percent error in your experimental value.

Spectroscopy

When light shines on or through a sample, it will interact in a very predictable manner depending on the wavelength. X-ray radiation has enough energy to eject inner shell electrons. Ultraviolet and visible radiation has energy sufficient to promote or excite valence electrons. Infrared radiation cannot push electrons around, but it can cause bonds and molecules to bend, stretch, and vibrate. Even radio waves will interact with matter, although the very small amount of energy associated with them can only manage to flip nuclei in a magnetic field.

Ultraviolet-visible spectroscopy is particularly useful to chemists as an analytical tool; particularly as the interaction of light can be directly related to the concentration of the substance. When light passes through a solution containing a species that will interact, some of the energy of light is transferred to the substance. In the case of UV-Vis light, valence electrons are excited to higher energy levels. The ratio of the power of the radiation coming out to the power of the radiation going into the sample is the transmittance, T of the sample. This number is also converted to a number between zero and one hundred and referred to as the **% Transmittance**, %T. A very important and analytically useful term is **Absorbance**, which is defined as **A = -log T**. If a solution does not interact with light at all, it would have 100% transmittance and zero absorbance. A block of wood, on the other hand, would have 0% transmittance and infinite absorbance.

Absorbance is directly related to the concentration of the absorbing species. This relationship, called Beer-Lambert Law, is A = abc, where a is the absorptivity, a factor specific to the species involved and the wavelength at which the measurement was made; b is cell length; and c is the concentration. If the absorbances of several solutions are plotted versus concentration, a Beer-Lambert plot is obtained. If the absorbance of a solution of unknown concentration is measured, the graph enables chemists to determine the concentration by visualizing where the point would fit on then graph.

In this laboratory exercise, you will analyze the spectroscopic properties of a solution of the complex ion cobalt tartrate. First you will have to determine the optimum wavelength for analysis of this rose colored ion. Then you will have to generate a Beer-Lambert plot and finally determine the concentration of an unknown solution of the complex.

Use of the LabQuest Spectrometer

Connect the spectrometer to the LabQuest using the USB cable in the spectrometer box and plugging it into the left top USB port.

Calibrate the spectrometer: Click the Play (►) button and wait for the lamp to warm up (90 seconds). Place the blank cuvette (filled with DI water) into the spectrometer with the clear, smooth sides facing the white arrow. Click “finish calibration.” When done, click OK.

To collect an absorbance spectrum: Fill the cuvette with the solution of interest and place it into the spectrometer aligned as in the calibration above. Push the Play (►) button to collect data and then Stop (■) to conclude the collection.
To find the wavelength at a particular absorbance, tap the graph at that point on the absorbance spectrum with the stylus.

To record absorbance at the lambda max: Return to the home screen. Click the mode button and change to "Selected Events." Click OK.
Click anywhere on the red box, and select "Change wavelength" from the options that pop up. Enter in the appropriate wavelength and click OK.
Absorbance at the desired wavelength can now be read directly from the home screen.

Pre-lab Calculations:

1. Calculate the mass of cobalt (II) sulfateheptahydrate ($CoSO_4 \cdot 7H_2O$) required to produce 100.mL of 0.050 M solution.
2. Calculate the mass of sodium potassium tartrate ($KNaC_4H_4O_6 \cdot 4H_2O$) required to produce 100.mL of 0.100 M solution.

Part I - Wavelength of Maximum Absorbance

1. Prepare 100.0 ml of a solution of **0.050 M**$CoSO_4 \cdot 7H_2O$ and **0.100 M** sodium potassium tartrate ($KNaC_4H_4O_6 \bullet 4H_2O$). Quantitatively transfer both salts to the same 100 mL volumetric flask. This is **one solution** containing both salts.
2. Place an appropriate amount of this solution in a cuvette and collect an absorbance spectrum. Determine and record the wavelength at which the maximum absorbance occurs.

Part II - Beer-Lambert plot

1. Calculate the volumes of your 0.050 M cobalt tartrate complex ion solution required to prepare 10.00 mL of the following concentrations: 0.0050 M, 0.010 M, 0.025 M, and 0.040 M.
   Check these volumes with your instructor **before** proceeding. Make these 4 diluted solutions in 10.00 mL volumetric flasks.
2. Measure the absorbance of each of these solutions and your stock solution at the wavelength of maximum absorbance.
3. Prepare a Beer-Lambert plot in Excel and use a linear trendline. Display the equation of the trendline on the graph.

Part III - Determining an Unknown Concentration of Cobalt Tartrate

1. Obtain a solution of unknown concentration from your instructor. Measure the absorbance at the wavelength determined in Part I.
2. Using the equation of the line from your Beer-Lambert plot from Part II, determine the concentration of the cobalt in the unknown solution.

Spectroscopy **Name** _____**section** _____ **date** _____

Part I.

Actual mass of cobalt (II) sulfateheptahydrate ($CoSO_4 \cdot 7H_2O$) _____

Actual mass of sodium potassium tartrate ($KNaC_4H_4O_6 \cdot 4H_2O$)_____

λ_{max} for cobalt tartrate: _____

Part II Dilution calculations**:**
0.0050 M

0.010 M

0.025 M

0.040 M

Concentration	Absorbance at λ_{max}
0.0050 M	
0.010 M	
0.025 M	
0.040 M	
0.050 M	

Prepare a Beer-Lambert plot: Construct a plot of absorbance *vs*. concentration. Use appropriate scaling on axes, label appropriately, and use a linear line of best fit. Display equation on graph.

Part IV
1. Unknown # Absorbance at λ_{max} _____

2. Using the trendline equation from the Beer-Lambert plot that you constructed, the concentration of cobalt in the unknown solution is _____

Questions to Answer

1. What is the stoichiometry for the cobalt (II) tartrate complex? Explain the thinking behind having the concentration of tartrate be twice the concentration of cobalt ion.

2. Why would you construct a Beer-Lambert Plot at the λ_{max}?

3. If1.277 g of cobalt (II) sulfate heptahydrate and 1.000 g sodium potassium tartratetetrahydrate in were dissolved in 50.00 mL of water, what would be the absorbance of this solution measured at the λ_{max}?

Molecular Structure and Bonding Theories

Name_____ Section _____
Partner's Name _____ Date _____

H_2O

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				H: H: O:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

H_3O^+

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				H: H: H: O:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

SF_4

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				S: F: F: F: F:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

$BrCl_3$

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				Br: Cl:
	Molecular Geometry		**Bond Angles**	Cl: Cl:
		Is there a net dipole moment?		

KrF_2

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				Kr: F:
	Molecular Geometry		**Bond Angles**	F:
		Is there a net dipole moment?		

KrF_4

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				Kr: F:
	Molecular Geometry		**Bond Angles**	F: F:
		Is there a net dipole moment?		F:

IF_5

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				I: F: F: F: F: F:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

C_2Cl_4

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: C: Cl: Cl: Cl: Cl:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

C_2H_2

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: C: H: H:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

CO_2

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: O: O:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

CO_3^{2-}

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: O: O: O:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

TeF_6

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				Te: F: F: F: F: F: F:
	Molecular Geometry		**Bond Angles**	
		Is there a net dipole moment?		

CH_2Cl_2

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: H:
	Molecular Geometry		**Bond Angles**	H: Cl:
		Is there a net dipole moment?		Cl:

$CHCl_3$

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: H:
	Molecular Geometry		**Bond Angles**	Cl: Cl:
		Is there a net dipole moment?		Cl:

CCl_4

Lewis Structure	Electron Geometry	VSEPR sketch	Hybridization of Central Atom	Formal Charges
				C: Cl:
	Molecular Geometry		**Bond Angles**	Cl: Cl:
		Is there a net dipole moment?		Cl:

This lab must be turned in before you leave.

Reaction of Metal with Acid to Form H_2

Safety: wear safety goggles, avoid contact of skin with acid

Procedure:
Using forceps to carry the Mg sample to the balance, record the mass of the sample of Mg metal (approximately between 20 and 90 mg). Mg is weighed directly on the balance. Wind or fold Mg strip into a compact bundle. Wrap the Mg in all directions with about 20 cm of fine copper wire to enclose it in a cage, leaving about 5 cm with a hook as a handle. The copper cage confines the metal particles and also speeds the reaction.

Carefully pour 20 ml of 3 M sulfuric acid into a gas measuring tube. Add room temperature water to completely fill the tube. Avoid undue mixing of acid and water by pouring down side of tube.

Insert Mg sample into the tube, hooking the copper wire over the rim. Insert stopper. Carefully tap to expel any air bubbles. If any air bubbles remain, carefully remove the stopper, add more water, and re-stopper.

Cover the hole with your finger and invert into 400 ml beaker half filled with room temperature water. While keeping the hole covered, carefully clamp the tube to a ring stand. The acid sinks and reacts with the Mg. Hydrogen gas is generated and collects at the top of the tube, pushing the acid solution out of the hole in the stopper into the beaker. Small pieces of Mg may break away and float to the surface. Make sure they react entirely by keeping them in contact with the acid solution. Record the barometric pressure while waiting for the reaction with Mg.

When the reaction is complete, tap gently to expel hydrogen trapped in copper cage or on the sides of the tube. Allow the apparatus to cool to room temperature.

When cool, record the volume of hydrogen gas, directly from the tube. Take the temperature of the gas by holding a thermometer to the outside of the gas tube. Use a metric ruler to measure the water column height, the difference in water levels inside and outside the tube, in mm. Calculate the equivalent pressure in mm Hg by using the relationship that 13.6 mm H_2O is equivalent to 1.00 mm Hg.

Carefully raise the tube out of the solution and allow the remaining acid solution to drain into the beaker. Discard the solution. Rinse out the gas measuring tube and straighten the copper wire.

Reaction of Metal with Acid

Name _____
Section _____ Date _____

Data (watch your significant figures and units!)

	Trial 1: ¼ strip	Trial 2: ½ strip	Trial 3: ¾ strip	Trial 4: Entire strip
Name of experimenter				
mass of the magnesium ribbon				
temperature of hydrogen gas				
volume of hydrogen gas				
barometric pressure				
height of water column				
vapor pressure of water at this temperature of H_2				

	Trial 1	Trial 2	Trial 3	Trial 4
pressure of the water column converted to mmHg				
corrected pressure of hydrogen gas				
temperature, absolute				
moles of hydrogen gas collected				
moles of magnesium reacted				

Calculations: Show complete calculations for your trial.

1. Convert the pressure of the water column to mmHg.

2. Calculate the pressure of H_2.

3. Convert the temperature from °C to Kelvin.

4. Calculate the moles of H_2 collected.

5. Calculate the moles of Mg reacted.

Analysis

1. Prepare a plot of volume of H_2 gas produced versus the mass of Mg used. Use appropriate scaling on axes, a linear trendline, and be sure to label appropriately. D**isplay equation on chart.**
2. Prepare a plot of moles of H_2 collected versus moles of Mg used. Use appropriate scaling on axes and be sure to label appropriately. **Display equation on chart.**

Questions

1. Compare your experimental stoichiometry (slope of the line from the plot of moles H_2 versus moles Mg used) to the stoichiometry you expected based on the balanced chemical equation for the reaction of Mg with H_2. (Show the balanced equation.) Calculate the percent error in your value.

2. Under your laboratory conditions (atmospheric pressure and temperature),**calculate** what mass of magnesium would have been **too much.** (More than 100 mL of gas would have been generated, exceeding the calibration marks of the collection tube.)

3. Starting with the mass from the entire strip, calculate the theoretical yield of H_2 gas. What is the percent yield?

4. What are some sources for any discrepancy between theoretical and actual yield?