UNIVERSITY OF CALGARY
Department of Chemistry

CHEMISTRY 209:
General Chemistry for Engineers

LABORATORY MANUAL
Fall 2016

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Time	Section | Room	Check-in	Expt #1	Expt #2	Expt #3	Expt #4	Expt #5
Monday **8:00 AM – 10:50 AM**	B01 | EEEL 225 B03 | EEEL 231	Sept 12	Sept 26	***Oct 13 (Thurs) 7-9 PM***	Oct 24	Nov 14	Nov 28
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	B14 | EEEL 225 B16 | EEEL 221	Sept 22	Oct 6	Oct 20	Nov 3	Nov 24	Dec 8
Friday **12:00 PM – 2:50 PM**	B17 | EEEL 225 B19 | EEEL 231 B23 | EEEL 221	Sept 16	Sept 30	Oct 14	Oct 28	Nov 18	Dec 2
	B18 | EEEL 225 B20 | EEEL 231 B24 | EEEL 221	Sept 23	Oct 7	Oct 21	Nov 4	Nov 25	Dec 9

Purpose of the Laboratory Experiment Component in Chem 209

This laboratory manual provides you with the information required for the laboratory component of Chemistry 209. You will find that the laboratory experiments and lecture topics are closely related. However, please note that the logistics for scheduling large numbers of students sometimes means that **you may need to read ahead in the text or to review lecture material** in order to put the laboratory exercise into context. Whether you see a concept in laboratory or lecture first, experiencing chemistry first-hand in the laboratory will help ground your understanding of each topic.

Textbook for this course: Chemistry: The Molecular Nature of Matter and Change. 2st Canadian Ed. By Silberberg M, Amateis P, Lavieri S, Venkateswaran R. McGraw-Hill Ryerson 2016.

Chemistry is an experimental science. Most chemists spend their time in laboratories mixing chemicals, analyzing samples and making observations. Although a part of chemistry involves reading chemical literature, this knowledge cannot stand apart from experimental observations. Chemists advance the field by starting with experimental or computational observations, then interpreting and explaining this data within the context of existing chemical literature.

Although practicing engineers may have a different philosophy towards handling chemical processes, your ability to understand the reports provided to you by chemists and request analyses and research from your scientist collaborators will define your success in the field. *Practice working and thinking "like a chemist"* will help you with these interactions, whatever specialty you may take.

The importance of understanding experimental techniques and concepts when studying chemistry is reflected by the **course requirement of an overall grade of 50% for the laboratory component to earn a course grade higher than D+.** If you earn a grade of C- or higher, you have a pre-requisite pass and you can register for all higher-level courses that require that course as a pre-requisite.

What should be learned from the wet experiment component of the course?

In the laboratory, you will learn the techniques and skills that chemists use in a laboratory setting. By the end of Chemistry 209, you should be familiar with and comfortable in a chemistry laboratory. You will learn how to follow procedures and how to perform those procedures quickly and efficiently. Note that there is reasoning behind each step of a procedure.

In Chemistry 209, you will not be marked on the success of your experiment. One can get a grade of excellence (A) for a laboratory write-up for an experiment that failed. Rather, Chemistry 209 aims to develop your ability to *understand why you are doing an experiment and what you are doing at every stage of that experiment*. If an experiment is not successful, you need to recognize where it went wrong and how you might modify it if asked to redo it. It is hoped that you will learn from your mistakes as the course progresses. Keep in mind that you should always be striving to improve your performance with each experiment you do. A good grade in any chemistry course will depend upon this.

You must record information about all steps performed in the laboratory. With these notes, you can then leave the laboratory, formulate ideas about the experiment, and then summarize all work in a written report. By the end of Chemistry 209, you should be able to do this for any experiment. The worksheets, pre-lab exercises and laboratory questions are designed to help you develop these skills.

Lab Safety Regulations

Safety is of the utmost concern in every chemical laboratory. The chemicals used in this laboratory may pose a variety of hazards, and it is your responsibility to ensure you have familiarized yourself with the general safety procedures below, and any specific safety precautions noted in each individual experiment.

To confirm that you have completed all required training and been oriented to the safety procedures in the lab, you will be required to sign a **laboratory safety form**, the "Student Safety Record", before you are allowed to begin any lab work.

Failure to comply with safety regulations will result in expulsion from the laboratory (temporarily or permanently). A grade of 0 will be assigned for experiments incomplete due to safety violations, and no make-up will be given.

Online Laboratory Safety Course

It is a Federal requirement that **all students** complete an introductory laboratory safety course before completing any experimental work. The Department of Chemistry provides an online safety course for this purpose. If you have not already done so at the University of Calgary and within the past 3 years, you are required to do so **within the first two weeks of laboratory** (i.e. before beginning Experiment 1)

You can enroll in this course or check to see if you have completed it already by logging on to https://lmprd.ucalgary.ca with your UCID. Detailed instructions are provided on the course D2L site.

Emergency Procedures

- In case of emergency, the primary respondent who in the Chem 209 laboratory is the Lab Instructor (TA), should call **Campus Security 220-5333** for assistance and then, if the situation warrants, dial **911 for ambulance**.
- In case of a major fire, pull the nearest fire alarm and evacuate from the laboratory and building.
- Learn the locations of the nearest telephone, fire extinguisher, fire alarm, eye wash station, emergency shower, and first aid kit, as well as exit routes from the laboratory and the building.

Safety: General

- Students are not allowed in the laboratory unless a laboratory instructor is present.
- No visitors are allowed in the laboratory.
- **Food and beverage** (including water bottles) are prohibited in the laboratory.
- Unauthorized and/or overnight experiments are prohibited.
- **Experiments in progress** must not be left unattended. If you must leave, have a labmate or your TA monitor your setup.
- Use of **earbuds or headphones** in the laboratory is prohibited.
- Use of **cell phones, tablets, personal computers** or other electronic devices is prohibited. Calculators are allowed.
- All backpacks, bags, etc. should be safely stowed such that all aisles are kept clear of bags and straps.
- You should know the locations of **important safety equipment**: telephone, fire extinguisher, eye wash station, emergency shower and first aid kit. Be aware of the fastest **exit routes** from the laboratory and building in case of emergency.
- **Wash your hands** before leaving laboratory. It is also good practice to do so frequently during lab.

Personal Protective Equipment (PPE) and Attire

Wearing appropriate personal protective equipment (PPE) and clothing can help minimize the risk of exposure to harmful substances in the laboratory.

- **Safety glasses** with side shields (or goggles) must be worn at all times while in the laboratory room.
- A **full length laboratory coat** must be worn at all times while in the laboratory room.
- Long pants (or ankle-length skirt) and closed toe shoes must be worn at all times in the laboratory. **No skin should be visible below the waist**.
    - Loose-fitting pants in a natural fibre and splash-resistant shoes are recommended.

- If you are wearing **gloves**, treat them as contaminated surfaces at all times – **do not touch** laboratory equipment or your skin with a gloved hand. Remove gloves before leaving the laboratory, or if anything is spilled on them.
  - Gloves provide **splash protection** only, and should be changed immediately and hands washed if any hazardous substance is spilled on them – especially acids.
  - If especially hazardous materials are in use, heavy-duty gloves will be made available for improved protection.

Chemical Hazards and Spills

Several of the compounds you will use in the laboratory are poisonous, for example: most alcohols, amines, and nitriles. Follow proper procedures to ensure exposure to harmful substances is minimized.

- **Concentrated acids** are used in this course. Students must handle them with caution.
- Any accidents or spills (even minor ones) should be reported to your TA immediately.
- In the event of accidental skin contact, ask a fellow student to **inform your TA** while you **immediately flush the area** with copious amounts of cold water from the sink, shower, or eyewash.
  - Flush any affected areas for at least 15 minutes, and remove any contaminated clothing or contact lenses *immediately* to prevent further injury.
- Certain harmful compounds can be absorbed relatively easily through the skin: for example, dimethyl sulphate (DMSO), nitrobenzene, aniline, phenol, and phenylhydrazine. You may wear latex or nitrile gloves if you wish to help minimize exposure to hazardous substances (see *PPE* above).
- Never pipet by mouth.
- Wipe up spills and 'bottle rings' immediately. For larger spills, there is a spill kit in the stock room.
- **Harmful, irritating, or flammable chemicals** are to be handled only in a fumehood.
  Generally, if you find a chemical in a fumehood, use it in the fumehood.
- Report any chemical bottles with damaged or missing labels to your TA. Do not use chemicals from unlabelled containers or ones with damaged labels.
- **Safety Data Sheets (SDS)** are good sources of information regarding the hazards of chemicals used in the laboratory. See the *WHMIS* section below for details on locating SDS.
- **Pay attention** to any hazards and warnings given in each experiment.

Fire

Fire in the laboratory may result from direct exposure to heat or flame, or from a chemical reaction. **Know the location of safety equipment**: fire extinguisher, alarms, telephone and blanket, and know the closest exit route from the laboratory.

- If the **fire alarm** sounds during laboratory, quickly secure your experiment (turn off any heaters, cap flasks as necessary) and assist your TA in evacuating to the assembly point through the safest route.
  - Wait at the assembly point for further instruction and permission to re-enter the building.
- Notify your TA immediately of any fire, flame, or smoke.
- If it is necessary to use a fire extinguisher, always take the extinguisher **to the fire** – do not attempt to move flaming objects.
  - Use fire extinguishers carefully in the lab – the propellant may knock over and break equipment.
- If **vapours from a flask** ignite, turn off the burner/heater and place a notebook or wire gauze over the flask opening to smother the flame. Larger fires may require a fire extinguisher.
- If **solvent spilled on the bench top** ignites, move any bottles and flasks containing flammable solvent away from the area (if possible) and use the fire extinguisher.
- If **your clothing or hair** is set on fire, move to the nearest safety shower and pull the chain.

Assembly points for chemistry laboratory locations:

EEEL: ICT food court
Science A: Social Science food court
Science B: ICT food court

Mixing Chemicals

Caution must be used whenever mixing chemicals, even those that have been tested as part of a laboratory procedure.

- Mixing reagents in too great a quantity or too quickly can result in unexpected, difficult to control reactions.
- Use especial caution when dealing with waste – certain types of waste are incompatible. Putting waste in the wrong container could result in an explosion or injury. See the *Waste Disposal* section below.
- Carefully observe warnings about mixing water with certain reagents, especially:
  - Water should not be poured into concentrated acids.
  - Sodium and other alkali metals must be kept away from water.

Burns

Keep your work area organized and tidy to avoid accidental burns from touching hot equipment.

- Remember, items such as hot plates, iron rings, and glassware may be hot enough to cause serious injury without *appearing* to be hot.
  - Especially – a thermometer bulb is as hot as the temperature it is recording! Handle thermometers carefully when removing from a melting point apparatus or other setup.
- Do not leave burners, hotplates, or heating mantles unattended.
- If you are burned, run the affected area under cool water, and seek assistance from your TA.

Explosions

Explosions are rapid exothermic reactions, usually occurring with substances that can undergo internal redox reactions or those that decompose.

- You will be warned if a significant explosion risk exists in a laboratory procedure.
- In a distillation, heating it to dryness can leave behind trace explosive residues (such as peroxides). **Never "boil dry" a distillation** – stop while there is still some liquid in the flask.
- Substances you may encounter that need special handling due to risk of explosion: polynitro compounds such as T.N.T. (trinitrotoluene), picric acid (trinitrophenol) or nitroglycerin, (all can undergo internal redox reaction) peroxides, azides, fulminates and diazo compounds (all can decompose violently).

Fumehood Use

Fumehoods are specifically designed to prevent vapours entering the general atmosphere of the laboratory by drawing air into the fumehood from the laboratory. They can also provide a safety screen for more hazardous experiments.

- **Keep the sash window below the mark** indicated on the side of the fumehood at all times, to ensure sufficient air flow. For maximum protection and efficiency, keep the sash as low as possible at all times.
  - If no one is working in the fume hood, the sash should be closed.
- Any noxious or harmful substances should be handled entirely inside the fumehood (including weighing, if applicable).
- Any equipment or glassware contaminated with noxious substances should be kept in the fume hood until it is cleaned. In some cases, equipment may need to be cleaned inside the fumehood.
  - This includes disposable materials such as pipettes and pipette tips, which must be cleaned before disposal.
- Place any equipment at least 10 cm inside the front edge so that airflow is not blocked.
- Before using a fumehood, check that it is working (e.g. by using a strip of paper to ensure that air is being drawn into the fumehood through the sash opening – the paper should flutter or be drawn in to the opening).

Waste Disposal

Proper disposal of waste is a very important issue, for your safety and to protect your environment. Failure to comply with the waste rules could lead to you being suspended from the laboratory sessions and the loss of laboratory marks.

Some guidelines to follow:

- Follow any instructions for waste disposal given in your lab manual and by your TA.
- Make sure waste is put in the correct container. Typically, there are separate waste streams for:
    - Chemically-contaminated solid waste (filter paper, excess solid chemicals, etc)
    - Glass waste (glass waste should be **cleaned** whenever possible)
    - Aqueous waste
    - Halogenated organic waste (chloroform, dichloromethane, etc)
    - Non-halogenated organic waste (methanol, pentane, etc.)
    - Non-contaminated waste (garbage – wrappers, packaging, etc.)
- **Do not overfill containers** (there must be at least 5 cm air space at the top). If a container is full, ask for a replacement.
- **Never pour waste chemicals down the sink** other than very dilute aqueous, non-toxic solutions.
- Any **broken glassware** should be collected into a beaker and rinsed (if possible) before taking it to the technician for replacement, when it is thrown away in the blue pails provided.
- Other **sharp objects** (needles, scalpel blades) should be disposed of in the designated container
- **Sample vials** should be discarded to designated areas, if applicable.
- Consult your laboratory instructor if you break a mercury thermometer (special precautions are required for disposing of mercury spills)

Appropriate waste disposal is important, for example, chemically contaminated glass (such as Pasteur pipettes) costs ~$1100 per m^3 for disposal, and is buried whereas clean glass costs ~$30 per m^3 and is recycled. So, please make sure the waste is going into the appropriate container. If in doubt, check your laboratory manual, and if you are still unclear, then ask your laboratory instructor.

Workplace Hazardous Materials Information System (WHMIS)

WHMIS provides that, by federal law, students are entitled to information concerning any materials used in the laboratory. This information is available on a Safety Data Sheet (SDS). These are available in the laboratory (ask your TA), and online through the Chematix system. To access Chematix, log into my.ucalgary.ca, and from the *Around Campus* menu, select *Stay Safe* → *Chematix*.

Best Practices and Appropriate Behaviour

While some behaviours are not strictly safety-related, they ensure that laboratory experiments are carried out in a professional manner, and that all equipment and reagents remain undamaged and un-contaminated. You are expected to follow these guidelines as strictly as the safety procedures in lab.

General

- At the end of the laboratory period, **leave your work area clean and tidy**. Leave no chemicals or pools of liquid (even water) on the bench top, and wipe it down with a damp paper towel. Return all glassware to your locker.
- The laboratory will close promptly at the end of the lab period. **No extra time will be allowed.** Try to finish your work ~10 minutes early to allow time for clean-up. This includes labs with a worksheet write-up. **All work must be completed and handed in before the end of the scheduled laboratory time**.
- Walk, do not run, in lab. Avoid walking backwards, especially when carrying equipment.

Handling Reagents

Maintaining the purity of stock reagents is essential for the success of your experiments as well as all that use the reagents after you.

- **Replace bottle tops immediately** when you have finished dispensing reagents. Many compounds react with the oxygen, carbon dioxide, or water in the air. Others are volatile and will evaporate.
- **Do not mix the tops** of reagent bottles (put the cap back on the bottle it came from).
- Rather than removing a stock bottle from its place on the cupboard, pour a small amount into a clean beaker and take that to your bench to work with.
- **Keep all pipettes and spatulas "dedicated" to one substance only.** Never cross-contaminate reagents by taking a pipette used for (and contaminated with) one substance and putting it into another reagent's bottle.

	If you see this symbol, you must talk to your laboratory instructor before you continue. There may be significant hazards that your laboratory instructor needs to check before you continue with your experiment.
	If you see this symbol, you should proceed with extra care after checking your safety precautions. Check with your laboratory instructor if in any doubt.

Overview of Laboratory Reports

There are five experiments, each worth 20 marks. The entire laboratory component is worth 20% of the final course grade. You must achieve an overall laboratory grade of at least 50% and must have completed a minimum of 3 experiments to gain a grade of C- (pre-requisite pass) in Chemistry 209.

Each laboratory cycle, you will need to prepare by completing the pre-lab quiz and assignments. After completing the experiment, you will hand in a write-up for marks.

Pre-Lab Quizzes (4 marks each)

Pre-lab quizzes are to be completed on D2L **at least one hour before the start of lab**. Questions relate to the laboratory procedure, safety precautions, and any theory or calculations that must be understood before performing the experiment. These quizzes are intended to ensure you are adequately prepared for lab, and as such, you **must score 50% or higher in order to be allowed in lab**. You will have **two attempts** in which to achieve this score. If, after two attempts, you have not scored over 50%, contact the lab coordinator *immediately*. The quizzes are designed to take ~30 min to complete, but if you are unfamiliar with the material, you should leave yourself extra time. Making your first attempt at least a day in advance is recommended, in case you need extra time.

Pre-Lab Assignments (Flowcharts)

In addition to the quiz, you must fill in a procedure flow chart (framework provided in each experimental chapter). In Lab 5, you will also prepare some calculations to save you time during lab. These assignments are not worth marks directly, however if your TA determines they are incomplete or missing, a **deduction of up to two marks** may be applied to your overall report grade. The flowcharts are designed to encourage you to think critically about the procedure and extract the most important information from the steps given in the manual.

Laboratory Write-Ups (16 marks each)

For each experiment, you will complete the associated write-up, handed in for grades. There are two general formats: worksheets and "formal" reports. The format requirements vary slightly for each type, but these guidelines apply to both:

- Lab reports and observations must be **handwritten in non-erasable ink**. Graphs may be done in pencil (or by computer).
- Show at least one sample calculation of each type. Include **formulas and units** for each, and label what calculation you are doing.
- Most labs are done with partners, but you will always hand in an **individually written** lab report. Plagiarism (of your lab partner, reports from another student – past or present, or reference sources) has serious repercussions – see the relevant section below.

Handing in Lab Reports

Experiments 1-4 will be handed in **one week after your lab period**, to the dropboxes located outside SA 116. Labs are due at the end of your scheduled lab time (i.e. 11 AM or 3 PM). Each lab section has a designated dropbox – *be sure you use the right one* or your TA will not receive your report, and you will be assessed late marks based on when your report is discovered.

Late lab reports should be handed in to the designated *late lab report dropbox* (not your regular one!). Late marks will be deducted from your overall lab grade: 1 mark per half-day and 2 marks per weekend. The report box is checked at 11 AM and 4 PM weekdays, but please **email your TA** when you hand in a late report to ensure it does not get lost. Again, make sure you use the correct dropbox, as you are assessed late marks based on when your report is actually found – which may take up to a week if you put it in the wrong box.

Experiment 5 (a worksheet report) is completed in-lab, and must be handed in before leaving the lab room. Note that no extra time is given: you need to finish experiment and report before the end of your scheduled lab time.

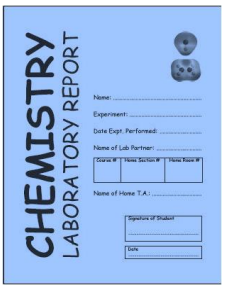
Worksheet Reports (Experiments 1 and 5)

For these reports, you will answer questions and show calculations on the pages included in the experiment chapter. Print these pages and bring them to lab with you. It may be possible to answer some of the questions before lab starts, to save yourself time.

The structure of these worksheets is modelled after the structure of an 'ideal' formal report, and is designed to give you practice identifying the key characteristics of good lab report writing. Though these reports are less formal than the

Formal Reports (Experiments 2-4)

These reports will be completed in the blue laboratory notebooks (pictured on the right and available from the bookstore or from the Engineering Student Society in SB 149). The requirements vary slightly for each report, as they are designed to walk you through developing the skills to communicate effectively in a scientific writing style.



Formal lab reports should not take more than 4-5 hours to complete. If you are taking much longer, seek help! Your TA or instructor can provide guidance – start writing early enough (even in lab if there is time) so that you have time to ask questions when needed.

A formal lab report should describe the experiment clearly and concisely – **length does not necessarily equal quality**. In CHEM 209, your reports are graded on the quality of communication, not the accuracy of your results – it is possible to achieve an *A* grade for a "failed" experiment, if the results are analyzed and discussed appropriately.

General Instructions for Formal Lab Reports

The specific requirements for each report may very slightly – **follow any specific guidelines within each experiment** as well as these general guidelines.

Format for Formal Lab Reports

- Reports must be **handwritten in non-erasable ink**. This includes observations taken in lab. Graphs may be in pencil (more on that below).
- If you make a mistake, **do not use white out or obliterate your mistake**. Draw a single line through the error (~~like this~~), leaving it legible.
- Prepare raw data tables on the **last two pages** of the blue book, and record all data and observations directly into these tables. Your TA will initial these pages. *Do not record anything on scraps of paper in the lab.*
- The entire report should fit within **one** 'blue book'. The guidelines of each section enable this length. If for some reason you require extra space, you may staple a looseleaf page into your book – but be aware that exceeding the maximum length for the written sections will result in a grade penalty. If you attach pages, make sure they are labeled and numbered clearly.
- Your report doesn't have to be painstakingly neat, but it should be legible and coherent. Spelling, grammar, and logical sentence structure will be considered (again, this doesn't have to be perfect, but if your grammar interferes with your TAs ability to understand your writing, you may be penalized). Writing in the *third person and past tense* is usually appropriate.
- The following sections should be included in a formal report (in the order presented), and are discussed more thoroughly below.
    - Introduction
    - Procedure
    - Results
    - Discussion
    - Conclusions
    - References

Introduction Section

All formal lab reports should include an Introduction section. It should be a brief paragraph (no more than 1 page) that states:

- The objective(s) of the experiment
- Why these objective(s) are relevant outside this experiment
- The chemical reaction being studied
- Brief highlights of the technique(s) used – Keep this to the most important parts. *Why* you performed the experiment (or a certain step) is more important in the Introduction than *how* it was performed.

Once written, the introduction should provide a clear overview of the experiment itself and the concepts behind it.

Procedure Section

In CHEM 209 you are not expected to write the full procedure for each experiment. However, you should use a sentence or two to:

- Make reference to the lab manual procedure that you used (including an in-text citation – see the Appendix on referencing)
- Comment on whether or not any modifications were made to the procedure as written in the manual (and if modifications were made, what they were).

Results Section

A CHEM 209 Results section should include a neatly copied re-print of *all* of your experimental data, as well as values calculated during your analysis. It should also include any graphs, as well as sample calculations. Numerical results, whenever possible, should be presented in **tabular format**, with each table labelled with a descriptive title.

If you have produced any tables or graphs on the computer, **attach printouts of computer-generated results**, either within the 'results' section or on the inside cover of your blue book. Wherever you attach them, be sure each is labelled so that it is clear what is contained on each page. Follow all guidelines for plots in each experiment, and make sure all fonts are easily readable at the size printed. Refer within your report to the location of any attached printouts.

If you have **literature/reference values** that you use in your analysis, include them here, along with citations to their sources.

Discussion Section

The discussion section is one of the most crucial sections of your report, as it highlights the findings from the results section and then analyzes all aspects of the experiment. This is a crucial place to convey your findings clearly and show your understanding of the experiment overall. It is generally **less than two pages long** and should:

- State the major findings of the experiment.
    - Recap what was done and why (briefly, no need to repeat the Introduction).
    - State the final value(s) determined in the experiment, including units.
- Place the significance of your results into context.
    - How do your results address the key issues raised in the Introduction?
- Comment on the accuracy and precision (reproducibility) of your results.
    - Compare your experimental values to literature values, if available, using % error and absolute difference.
    - Describe how reproducible your results are (using standard deviation, if possible).
- Describe any sources of uncertainty in your results, and how they have affected (or would affect) your results.
    - Avoid mentioning generic errors such as dirty glassware or misreading instruments. Focus instead on specific, identifiable errors or assumptions that were made in the procedure that may not necessarily be true.

- Sources of uncertainty (continued):
    - Make sure that the errors you propose agree with your observations. For example: if an error should cause your result to be "too low", but your actual value was higher than the literature value, the error you are considering was probably not significant.
    - Also consider the magnitude of the uncertainty. If you find your result has a 50% error, a temperature fluctuation of 0.5 degree is probably not the most important source of error in your experiment.
    - Even if you believe you performed the procedure flawlessly and your % error is small, there are always some sources of uncertainty. Examine the procedure for areas where the accuracy or precision could be improved, and suggest ways to do so, if you cannot directly identify any errors.

Conclusion

In one or two sentences, summarize the main findings of your experiment, and indicate whether the experiment was successful overall. No new information should be introduced in this section – it is merely a brief summary.

References

Provide a list of any sources you drew information from while completing this experiment and write-up. You should cite all sources for anything you did not do personally, or anything stated that was not your own original thought. All references listed in this section should have a corresponding *in-text citation* at the point(s) in your report where the information was used.

There is no standard format for references in chemistry – it varies widely depending on the publisher and publication type. In Appendix 12 of this manual, we recommend a slightly modified version of the American Chemical Society format, since it is relatively straightforward to use. As long as you use consistent formatting throughout, and your references include sufficient information to find each source, that is sufficient.

Plagiarism

A properly written laboratory report will, in most cases, include work that is not completely original from the author. While you are expected to submit your own work for laboratory reports, having a small amount of 'borrowed' material is acceptable *as long as credit is given to the source of this material*. This includes literature references as well as the work of other students.

Generally accepted principles, equations, etc. (e.g. the Henderson Hasselbalch equation, or a chemical reaction) may be used without acknowledgement, or with a general reference to a book chapter or similar source. Direct quotations, *including numerical values*, must be specifically identified and acknowledged. Appendix 12 outlines one acceptable format for providing such references to works cited.

Working with classmates can complicate the determination of whether a work is 'original' or not. Be careful when working with your lab partner that you do not accidentally plagiarize each other. If one Partner A gathered part of the data and Partner B copied the values at the end of lab, Partner B should reference Partner A as the source of this data. Introduction and Discussion sections especially should be different enough that when viewed side by side, it is clear that you and your partner's reports are two distinct creations.

Laboratory reports are subject to the academic regulations in the University Calendar outlined in the "Student Misconduct" section, including the guidelines in the "Statement of Intellectual Honesty" and "Plagiarism/Cheating/Other Academic Misconduct" sub-sections (http://www.ucalgary.ca/pubs/calendar/current/k.html). If you are struggling to determine if you have followed the principles of conduct as outlined in the University Calendar, ask your course or laboratory instructor to clarify these points before submitting work you are unsure of. **Plagiarism is dealt with strictly in CHEM 209**, with penalties ranging from a grade of '0' on the assignment to expulsion, a mark your permanent academic record, or even criminal charges.

Formal Lab Report Formatting Checklist

Refer to the instructions on the previous pages and to any specific instructions for *content* of your report. This checklist will help make sure you've met the *format* requirements for your report.

General Appearance:

- ◯ All identifying information is filled in on front cover (name, lab section, etc)
- ◯ Report is written by hand, in the same blue book as the data recorded in lab
- ◯ Report is written in non-erasable ink, with no whiteout, and any errors crossed out ~~with a single line~~
- ◯ Writing is legible, and spelling and grammar have been checked
- ◯ Writing is generally in past tense and third person
- ◯ All required sections appear and are in order, with references to any stapled-in printouts

Written sections

- ◯ Introduction is one page (single spaced) or less
- ◯ Discussion is two pages (single spaced) or less
- ◯ Conclusion is 2-3 sentences (a short paragraph) only
- ◯ In-text citations provided for all information taken from works cited in the References section
- ◯ Citations and References section have consistent formatting through report
- ◯ Writing has a clear flow and progression of ideas through each section
- ◯ All sample calculations are labelled with formulas, and units shown at each step
- ◯ Tables have been copied neatly in to Results section, including calculated values
- ◯ Tables have a descriptive title and include units (in headers or with each data entry)
- ◯ Graphs have descriptive titles and units, include appropriate gridlines, and take up most of a page

Frequently Asked Questions

How can I prepare for an experiment?

Before your scheduled lab day:

- Read through lab safety information.
- Read the appropriate pages of the lab manual for the experiment. Seek further information (from your textbook, instructor, or laboratory instructor) to clarify anything you are unsure of.
- Print the appropriate pages of the lab manual for the experiment (e.g. procedure and worksheet pages where applicable). You will not be able to do the experiment without these pages!
- Complete the pre-lab assignment and quiz. You can leave the quiz and return later if needed.

On your scheduled lab day:

- Wear appropriate lab attire (see section on Laboratory Safety – *Dress Appropriately*).
- Bring a lab coat and safety glasses (and lab locker combination for experiments 3, 4 and 5).
- Bring a printout of the procedure and relevant Appendices. (including worksheet pages for Expts 1 & 5)
- Bring a blue lab book for experiments 2, 3 and 4.
- Bring a pen (non-erasable) and scientific calculator.

What if I can't make my scheduled laboratory experiment?

If you have missed your scheduled lab section, or know you will in the future, fill out the **make-up lab request form**, available as in "quiz" format on the course D2L site. When requesting a make-up lab, please note:

- *Absences due to illness* require a doctor's note, and must be requested within 48 hours of the missed lab or due date. If you need more than 48 hours for recovery, advise the lab coordinator at the time of request.
  - If you have a medical condition that may require recurrent absences, please contact the laboratory or course coordinator as early as possible to ensure a contingency plan exists.
- *Absences due to sports, religious observance, or 'protected grounds'* under the Alberta Human Rights Act generally require confirmatory documentation (e.g. note from coach) and must be requested at minimum 2 weeks before the planned absence.
- *Absences for any other reason* or illnesses not confirmed by a doctor's note are not guaranteed accommodation, and may result in a grade of '0' for that experiment. Requests for a make-up are still encouraged through the online form, but must be filed within 48 hours of the missed lab to be considered. Advance notice, if possible, increases the coordinator's ability to accommodate such requests.

Accommodations for handing in lab reports and/or missed tutorials follow the same guidelines as for laboratories.

If you have questions about lab scheduling or want to discuss options for accommodation in the laboratory, please contact the lab coordinator, Dr. Roxanne Jackson, at rjjackso@ucalgary.ca or through the make-up lab request form.

What if I withdraw from the course?

If you withdraw from the course at any time after check-in week, it is your responsibility to contact the lab coordinator or laboratory technician to check out of your lab drawer **before the last day of classes**.

Any student who fails to sign out of lab will be assessed the "Failure to Check-out" fee of $30.00 plus any accumulated replacement cost of equipment that the student may have damaged or lost.

If this fee is not paid by the last day of the final examination period of the term, an additional $10.00 administrative fee will be charged and university services (registration, transcripts, etc.) may be withheld.