CHEMISTRY 1210

PREFACE

SAFETY IN THE LABORATORY

I. INTRODUCTION TO LABORATORY SAFETY

For some students, the General Chemistry lab is their first experience working with chemicals and glassware in a laboratory setting. In an effort to create and maintain a safe learning environment, students will learn to handle and dispose of chemicals in a manner that minimizes risk to themselves, others, and the environment. The experiments contained in this laboratory manual were developed to protect students by minimizing hazards, but it is still vital to gain a solid understanding of how to work safely in the lab. Completing each experiment safely is the first priority of the lab staff and should be yours as well. By working safely, practicing good techniques, and listening to your lab instructor, you will be able to protect yourself and your classmates from the hazards present in the General Chemistry laboratory.

II. LABORATORY SAFETY EQUIPMENT

SAFETY SHOWER AND EYEWASH

The safety shower and eyewash are found in the front of the laboratory. In the event of concentrated acid or other corrosive chemicals being spilled on a large portion of the body, stand directly under the shower head and pull the lever. It is often necessary to remove contaminated clothing to sufficiently wash the affected area. Flip down eyewashes, shown in **Figure FM.2,** are available at each sink. These units activate automatically when the spray heads are pulled down over the sink. For smaller spills, and if

FIGURE FM.1

Safety shower.

time allows, move to the bathroom where a pull-out hose can assist in flushing the spill over a drain. Skin contaminated by chemical spills should be rinsed with cool running water for a minimum of fifteen minutes.

The use of safety goggles is the best way to protect your eyes in the lab. The eyewash should be used to rinse off chemicals splashed on any part of the face. A minimum of fifteen minutes of rinsing with eyes open is required for a thorough washing. **Notify your lab instructor immediately in the event of a chemical spill or splash.**

FIGURE FM.2

From left to right: distilled water faucet, tap water faucet, and flip down eyewash.

FIRE EXTINGUISHER

Many laboratory fires occur in beakers or flasks and can be extinguished by placing a watch glass over the container. Every lab has a fire extinguisher at the front of the room for larger fires. **Your lab instructor should be alerted immediately in the event of a fire.** More serious fires require evacuation of the laboratory room and notification of the fire department.

Laboratory evacuation maps are posted at each exit. These maps show you the quickest route(s) to the nearest stairwell and exit. After evacuating the building, everyone should proceed to the pre-determined meeting point. **For Celeste Lab, the pre-determined meeting point is Hansford Quadrangle, the green space in front of 18th Ave. Library.**

FIGURE FM.3

Fire extinguisher and lab evacuation map.

III. PERSONAL PROTECTIVE EQUIPMENT (PPE) AND LABORATORY ATTIRE

Personal protective equipment, commonly referred to as PPE, is used to minimize or eliminate exposure to hazards when working in the chemistry lab. PPE is chosen to protect specific areas of the body, such as hands and eyes. You will be wearing goggles and lab coats at all times in the General Chemistry laboratory. There are also several experiments in which glove use is strongly recommended. It is important to understand why your laboratory instructor requires the proper use of PPE.

EYE PROTECTION

You must guard against the possibility of eye injury or blindness in case chemicals come in contact with your eyes. The Department of Chemistry and Biochemistry has set policies to minimize the risk of injury to your eyes. In addition, the state of Ohio requires, by law, that industrial-quality, eye-protective devices be worn at all times in the laboratory. Our laboratory instructors **must** enforce the use of safety goggles. Approved ANSI Z87.1 goggles shall be put on **before** entering the lab and are to be worn whenever in the lab. Nobody should remove their goggles until they are in the hallway. **All goggle adjustment, cleaning, and anti-fog procedures must be performed in the hallway.** Your goggles should seal around your face with no gaps. Please speak with your lab instructor if your goggles do not properly fit.

LAB COATS

Lab coats provide an extra layer of skin protection from chemicals. Our laboratory instructors will strictly enforce the use of lab coats in the General Chemistry laboratory. Lab coats shall be put on before entering the lab and must be worn whenever in the lab. Do not wear your lab coat in the restroom, when using the drinking fountain, or when sitting in the hallway. You may wear your lab coat when obtaining items from the lab support window (231/331 CE) or when getting ice. Your lab coat should always be completely buttoned closed.

GLOVES

Gloves provide protection to the hands. Glove use is strongly recommended for many of the experiments in this lab manual. It is important to always check gloves for holes or cracks before use. Gloves should never be reused or worn in the hallways. **Gloves should be removed before touching doorknobs, cell phones, bookbags, and other items you wouldn't want to risk contaminating.** Gloves should be removed when they become contaminated. Hands should be thoroughly washed with soap and water before leaving the lab.

LABORATORY ATTIRE

Clothing worn in the lab should provide skin protection from chemical spills and splashes should your lab coat fail or become saturated. Appropriate clothing includes long pants or skirts that go to the ankle. If a vessel containing chemicals falls to the floor, it is vital to make sure no exposure to the lower leg/ankle occurs. At a minimum, all of the dark areas shown in **Figure FM.4** should be completely covered before entering the lab.

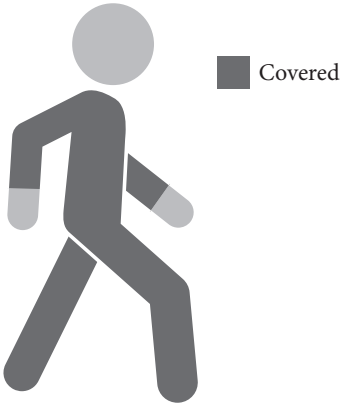


FIGURE FM.4

Regions of the body that should be covered before entering the lab are shown.

Shorts (including those worn with long socks), pants made of spandex, or other thin and/or skin-tight materials, and clothing with holes are not acceptable, even if your lab coat covers

the holes. Shoes should cover the entire foot (closed-toe and closed-back) and not have any large holes. Ankles should be completely covered. Loose or bulky clothing is also not appropriate for the lab. Baggy sleeves may be a fire hazard or may knock over lab supplies. The best materials to wear in the lab are natural fibers, such as cotton. It is acceptable to wear scrub pants or sweatpants over leggings or shorts. Long hair must be tied back, as it can catch fire if it gets too close to an open flame.

IV. LABORATORY SAFETY REQUIREMENTS

Students are required to read, understand, and implement the safety precautions indicated in the laboratory manual and laboratory handouts. The precautions are summarized below. All students must digitally sign the Lab Safety Statement on Carmen by the end of the first laboratory period.

1. You must wear Department-authorized ANSI Z87.1 code chemical splash goggles in the laboratory. Violations of this policy will result in the loss of Lab Performance points from the experiment for the day. Continued violations will result in dismissal from the course. The wearing of contact lenses is not recommended.
2. You must wear a Department-approved lab coat in the laboratory. Violations of this policy will result in the loss of Lab Performance points from the experiment for the day. Continued violations will result in dismissal from the course.
3. Each student must wear closed-toe and closed-back shoes (not sandals) that cover the whole foot and adequate clothing to reduce the possibility of injury from chemicals or broken glass. Adequate clothing includes long pants or skirts that go all the way to the ankle, shirts that cover the midriff and shoulders, and shoes that cover the whole foot. Clothing such as tank tops, pants made from thin and/or skin-tight materials (such as spandex), and loose sleeves are not allowed. Confine long hair.
4. Familiarize yourself with the location of the fire extinguisher, eyewashes, and safety shower in the laboratory.
5. Promptly report all accidents, no matter how small, to your lab instructor. Incident report forms will be required for all incidents and near misses.
6. Your work area should be cleaned before you leave lab. After putting your equipment away, wipe down your work area. This ensures that you and other students who use the space will not be harmed by chemicals left on the benchtop. Also, clean spilled solids in the balance areas by brushing chemicals into a weighing dish and disposing of them in the class Chemical Waste beaker. Failure to clean your work area may result in the loss of Lab Performance points from the experiment for the day.
7. No unauthorized experiments are allowed. No chemicals may be removed from the lab. Anyone observed performing unauthorized experiments will be dismissed for the day; no makeup time will be given, and a score of zero (0) will be given for all assignments related to the experiment for the day.

UNDERSTANDING REAGENT LABELS

Every reagent in a chemistry lab must be properly labeled. It's critical that everyone working in the lab understands each component of a reagent label. Minimally, each label has the name of the reagent(s), Chemical Abstracts Service Registry Number (abbreviated CAS #), appropriate GHS (Globally Harmonized System) pictograms, GHS signal word, and applicable hazard statements.

CHEMICAL ABSTRACTS SERVICE REGISTRY NUMBER (CAS #)

A CAS Registry Number is a unique and unambiguous identifier for a specific substance that allows clear communication and, with the help of CAS scientists, links together all available data and research about that substance. It is often easiest to find the SDS (Safety Data Sheet) for a substance by searching by its CAS number.

GLOBALLY HARMONIZED SYSTEM (GHS) PICTOGRAMS

GHS stands for the Globally Harmonized System of Classification and Labelling of Chemicals. It is a system of hazard communication for chemical hazards that can be adopted by countries around the world. GHS was developed by a United Nations (UN) international team of hazard communication experts. They established the following two major standardized elements:

1. Rules for classifying the hazards of chemical products (i.e., substances, materials, or mixtures).
2. Hazard communication tools such as format for safety data sheets (SDSs), content of label and SDSs—with hazard and precautionary statements, symbols (pictograms), and signal word.

Pictograms are graphic symbols used to communicate specific information about the hazards of a chemical. GHS pictograms consist of a red square frame set at a point with a black hazard symbol on a white background, sufficiently wide to be clearly visible. The pictograms OSHA has adopted improve worker safety and health, conform with the GHS, and are used worldwide.

On the next page are the symbols for each pictogram, the written name for each pictogram, and the hazards associated with each of the pictograms. Most of the symbols are already used for transportation and many chemical users may be familiar with them.

Health Hazard  • Carcinogen • Mutagenicity • Reproductive Toxicity • Respiratory Sensitizer • Target Organ Toxicity • Aspiration Toxicity	**Flame**  • Flammables • Pyrophorics • Self-Heating • Emits Flammable Gas • Self-Reactive • Organic Peroxides	**Exclamation Mark**  • Irritant (skin and eye) • Skin Sensitizer • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer
Gas Cylinder  • Gases Under Pressure	**Corrosion**  • Skin Corrosion/Burns • Eye Damage • Corrosive to Metals	**Exploding Bomb**  • Explosives • Self-Reactives • Organic Peroxides
Flame Over Circle  • Oxidizers	**Environment**  • Aquatic Toxicity	**Skull and Crossbones**  • Acute Toxicity (fatal or toxic)

GLOBALLY HARMONIZED SYSTEM (GHS) SIGNAL WORDS

Signal Words are used to indicate the relative level of severity of the hazard and alert the reader to a potential hazard on the label. There are only two words used as signal words, "Danger" and "Warning." Within a specific hazard class, **"Danger" is used for the more severe hazards and "Warning" is used for the less severe hazards.** There will only be one signal word on the label no matter how many hazards a chemical may have. If one of the hazards warrants a "Danger" signal word and another warrants the signal word "Warning," then only "Danger" will appear on the label.

HAZARD STATEMENTS

Hazard Statements describe the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard. For example: "Causes damage to kidneys through prolonged or repeated exposure when absorbed through the skin." All the applicable hazard statements appear on a reagent label. The hazard statements are specific to the hazard classification categories, and chemical users should always see the same statement for the same hazards no matter what the chemical is or who produces it.

Many hazard statements are too long to include on a reagent bottle label. Labels that are made specifically for use in the General Chemistry labs display the hazard statement code on the label. The statement can be looked up in the list provided on the side of Hood A in each lab room. Alternately, the statement(s) can be looked up at *go.osu.edu/GHS*.

WASTE DISPOSAL

I. CHEMISTRY STUDENTS AND HAZARDOUS WASTE

WHAT IS HAZARDOUS WASTE?

There are many forms of waste: solid or household waste, radioactive, chemical, biohazardous, and others such as asbestos. In General Chemistry, the term "hazardous waste" generally refers to chemical substances which may be ignitable, corrosive, and/or toxic.

REGULATIONS GOVERNING HAZARDOUS WASTE

Since 1986, liquid hazardous wastes have been banned from entering landfills, and disposal is governed by strict treatment standards. Comprehensive regulations enforced by the Environmental Protection Agency (EPA) restrict generators of waste (this includes students in chemistry laboratories), transporters of waste, and treatment, storage, and disposal facilities. For major violations, the EPA can fine an institution or company up to $70,000 per day per violation. The EPA has also imposed civil and criminal penalties against individuals.

WHY DO CHEMISTRY STUDENTS NEED TO SEGREGATE THEIR WASTE, AND WHY ARE THE LAB INSTRUCTORS SO PICKY ABOUT WHICH WASTE GOES WHERE?

Different types of waste have different treatment standards. Organic solvent waste is incinerated, while wastes containing heavy metals are treated and solidified before being buried in a secure landfill. Generators of hazardous wastes, industrial plants and chemistry students alike, need to follow not only the strict EPA regulations but also rules set forth by individual transporters and treatment, storage, and disposal facilities.

Students and lab instructors are required to segregate and keep accurate records of the waste they generate as part of the laboratory experiments. When waste is taken to an incinerator, regular tests are performed to ensure that the composition and quantity of waste match the list of chemicals on the waste container. Too many inconsistencies may result in termination of the waste disposal service.

WHAT CAN A LAB STUDENT DO TO HELP?

The lab instructors have a tough job. Not only do they have to instruct students, but they are also responsible for the safety of the students and the accuracy of the waste disposal. This is a formidable task and requires the full cooperation of all the lab students.

A lab student needs to understand their responsibility as a generator of hazardous waste. This includes knowing exactly what waste is being produced and where it goes for disposal. Although these regulations can be burdensome at times, they are necessary in order to effectively prevent the mismanagement of hazardous waste. In this era of heightened environmentalism, we can all do something, however small, to prevent the tragedies of the past.

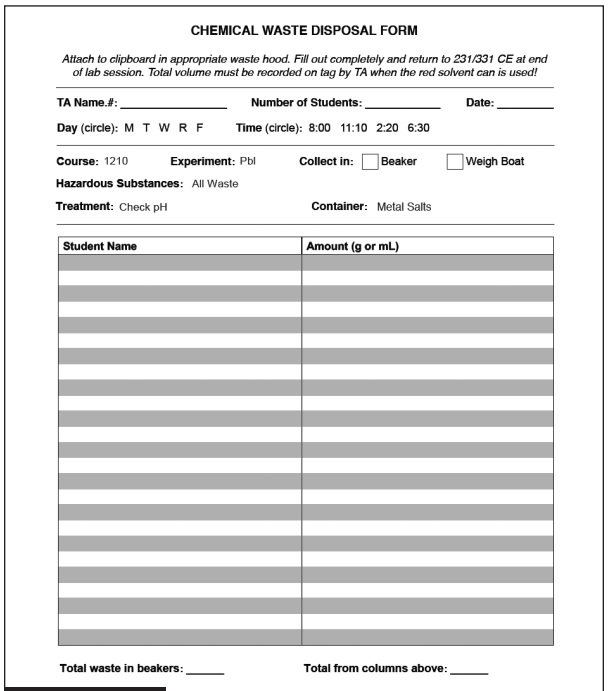
II. SPECIFIC GUIDELINES FOR WASTE DISPOSAL

All General Chemistry courses require you to perform laboratory experiments which may involve the production of hazardous chemical waste. Universities are now recognized as major producers of chemical waste and are, therefore, responsible for its disposal. To properly dispose of chemical waste, it is essential to know the identity of all hazardous materials.

For every experiment, you will receive instructions from the lab manual and your lab instructor on proper waste disposal. Waste is disposed of by these methods:

1. *Chemical waste:* Collected in a personal waste beaker by each student, then transferred to a plastic beaker provided in Hood B. This is the large fume hood with the white container labeled **Chemical Waste.** Solutions and/or solids containing heavy metals—including but not limited to Ag, Ba, Co, Cr, Mn, Mo, Ni, Pb, Sb, Sn, and all sulfides—should be disposed of in the Chemical Waste. Lab instructors will check the pH of the waste to assure it is neutral before disposal into the appropriate container.

2. *Dry solids:* Emptied plastic centrifuge tubes or paper contaminated with a reagent should be disposed of by placing them in the blue bucket under the reagent cart. Glass should never be placed in the blue bucket. Centrifuge tubes must be emptied of their contents before they can be discarded in the blue bucket.
3. *Certain acids, bases, and aqueous solutions:* When devoid of heavy metals and organics, these solutions may be washed down the sink drain with a large amount of running water. See the individual requirements for treatment within each experiment.
4. *Glass:* Used disposable glassware—including 4-mL test tubes and glass unknown vials—should be rinsed with water, then disposed of by placing them into the **Orange Glass Waste** bucket. If glassware that is found in the equipment drawers cannot be cleaned and reused or breaks, dispose of it appropriately in the **Orange Glass Waste** bucket.



CHEMICAL WASTE DISPOSAL FORM

Attach to clipboard in appropriate waste hood. Fill out completely and return to 231/331 CE at end of lab session. Total volume must be recorded on tag by TA when the red solvent can is used!

TA Name.#: _____ **Number of Students:** _____ **Date:** _____

Day (circle): M T W R F **Time** (circle): 8:00 11:10 2:20 6:30

Course: 1210 **Experiment:** Pbl **Collect in:** ☐ Beaker ☐ Weigh Boat

Hazardous Substances: All Waste

Treatment: Check pH **Container:** Metal Salts

Student Name	Amount (g or mL)

Total waste in beakers: _____ **Total from columns above:** _____

FIGURE FM.5

A typical Chemical Waste Disposal Form.

The Chemical Waste Disposal Form, shown in **Figure FM.5,** will be provided by your lab instructor for each type of waste generated. It is your responsibility to sign the sheet and record the approximate amount of waste you are disposing of. Liquid waste is always collected in plastic beakers at the waste hood before it is put into a container by the lab instructor. If the plastic waste beaker is ½ to ¾ full (or above the taped fill line), **alert your lab instructor immediately** so they can properly dispose of the waste before it overflows. **Never** add more waste to the beaker if above this threshold. The back of the Chemical Waste Disposal Form contains detailed instructions for your reference. Pouring waste in the wrong container could result in an unexpected reaction. If waste is ever placed in the incorrect container, alert your lab instructor immediately.

III. USING ELECTRONIC DEVICES IN THE LAB

Students are permitted to use an electronic device for creating and keeping their laboratory notebook. It is also common to occasionally need an electronic device to interact with a simulation or look up/view reference materials for an in-lab activity.

To protect your electronic device from chemical contamination, you should place your device in a sealed plastic bag during lab. You will be provided with one bag at the beginning of the semester. Please do not discard this bag since a replacement bag will not be provided. If chemicals are not out, and your work area has been sufficiently cleaned, you may use your electronic device outside of a bag. We still recommend placing it on a piece of paper towel to isolate it from the lab bench top.

You may choose to use an electronic writing utensil such as an Apple Pencil or stylus in lab at your own risk. Please note that we will not provide a protective barrier for them as we do for your iPads/tablets. If your electronic writing utensil should become chemically contaminated, it must be disposed of as hazardous waste and will not be replaced.

In either case, the risk of using an electronic device in the lab is solely on the student. The Department of Chemistry and Biochemistry, College of Arts and Sciences, and The Ohio State University are not liable for any damages that may occur to such devices.

SAFETY IN CHEMISTRY LABORATORY COURSES

THE OHIO STATE UNIVERSITY DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY

To the student: You are required to read, understand, and implement the safety precautions indicated for each experiment and those listed below. ***Your signature on Carmen indicates your absolute willingness to abide by these precautions while you are in the laboratory.*** *Your lab instructor may deduct points if you fail to comply with any precaution listed. You will not be permitted to participate in subsequent lab sessions until you digitally sign the safety statement.*

1. Work in the laboratory only while your instructor is present; you are not permitted to be in the lab without a lab instructor. Do not perform unauthorized experiments.
2. You are required to wear splash goggles which meet current ANSI Z87.1 code in chemistry laboratories. It is recommended that contact lenses not be worn.
3. You are required to wear a lab coat in chemistry laboratories. The lab coat must be fully buttoned closed.
4. Learn emergency procedures and know the locations of the nearest eyewashes, safety shower, and fire extinguisher.
5. All chemicals, especially concentrated acids and bases, spilled on the body should be immediately washed with cool running water **only** *for at least 15 minutes.* Contaminated clothing should be removed.
6. If you are injured or if any type of accident or fire occurs, **immediately** alert your lab instructor for assistance.
7. Carefully read all instructions and thoroughly plan your work. Proceeding with protocols you have not read and understood can be a safety hazard.
8. Wear appropriate clothing and shoes in the lab. Adequate clothing includes long pants or skirts that go all the way to the ankle, shirts that cover the midriff and shoulders, and closed-toe and closed-back shoes that cover the whole foot. Pants made of spandex—or other thin and/or skin-tight materials—and clothing with holes are not permitted. Confine long hair. Lab coats and goggles can be purchased at the Chemistry store in CE 180.

9. Carefully read all labels on chemical bottles. Never return excess chemicals to the stock bottles. Do not put a pipet or a dropper directly into a reagent bottle. Instead, pour a small amount of the reagent from the stock bottle into a beaker.
10. Do not eat, drink, or smoke in the lab. Never taste chemicals. Smell chemicals cautiously by wafting the vapors towards you.
11. When mixing or heating chemicals in a test tube, point the test tube away from yourself and others.
12. Do not use Bunsen burners or other sources of spark or flame in the vicinity of flammable liquids. Note that most organic solvents are flammable. Never leave an open flame unattended. Matches must be doused with water before being discarded in the trash.
13. Do not force glass or plastic tubing into a rubber stopper. Lubricate the hole and protect your hands with a towel while you insert the tubing into the stopper.
14. While mixing aqueous solutions of strong acids and water, always add the acid to the water, not vice versa.
15. Fill a pipet using **only** a pipet pump or pipet bulb; never pipet by mouth.
16. In the case of a spill, notify your instructor immediately. Spills should be immediately cleaned up by covering the spill with universal sorbent, contained in the Chemical Spill Kit. The spill kit is located in the back of the lab, near Hood A.
17. Prior to leaving lab, wipe down your work area with 70% ethanol spray and a paper towel. This ensures that you and other students who use the space will not be harmed by chemicals left on the desktop. Also clean up spills in the balance areas by brushing chemicals into a weighing dish and disposing of them in the appropriate waste container. Failure to properly clean up after yourself may result in the loss of points.
18. Dispose of chemicals as directed by your instructor and in a manner consistent with federal, state, and local hazardous waste disposal regulations.
19. Dispose of broken glassware in the appropriate container (NEVER IN THE TRASH CAN).
20. Inform your instructor of any broken or malfunctioning equipment or utilities.

Recommendation: **Enrollment in courses, including laboratory courses, at the Ohio State University does not automatically entitle you to medical coverage. Due to the potentially dangerous nature of laboratory work, you are strongly encouraged to obtain medical insurance coverage through OSU health service or a private agency when enrolling in chemistry laboratory courses.**

If you are pregnant or have hyper- or hypoglycemia, diabetes, narcolepsy, heart ailments, chemical sensitivity, epilepsy, or seizure disorders; or have another medical condition that may result in sudden and unexpected loss of consciousness, participation in this lab may raise specific safety concerns for you and others in the lab. If you fall within one of these categories, please inform your instructor. We will be happy to discuss the issues involved on a confidential basis and to work with you, your physician, and/or Student Life Disability Services to provide you with any needed and appropriate accommodations. If you prefer, you may contact your physician and/or Student Life Disability Services directly, and we will provide them with any information they may need to assist you.

On Carmen, you will sign the Lab Safety Statement, certifying the following:

- I realize that all chemicals are potentially dangerous; therefore, I will exercise care in handling them. If I am unsure of the potential hazards of any chemical, I will discuss this with my lab instructor prior to using the chemical in question.
- I have read the statements on Safety in the Laboratory and Hazardous Waste. I also understand that I am required by Ohio law to wear ANSI Z87.1 approved chemical splash goggles and a lab coat **at all times** while I am in the laboratory. I also understand the dangers involved in wearing all types of contact lenses in the chemical lab. If I elect to wear contact lenses in the laboratory, I will inform my instructor, and I will assume all responsibility for damages caused by wearing them in the lab.
- **I UNDERSTAND THAT I AM PERMITTED TO WORK IN THE LABORATORY ONLY WHEN IT IS UNDER THE SUPERVISION OF A LABORATORY INSTRUCTOR.**
- **I have read carefully and understand all of the safety rules contained on these pages and in the laboratory manual required for this course. I recognize that it is my responsibility to obey them faithfully.**

GUIDE FOR SUCCESS IN THE GENERAL CHEMISTRY LABORATORY

In this laboratory manual, you will find Expected Learning Outcomes (ELOs) listed for all of our individual experiments. In addition to these, the laboratory course itself has some overarching outcomes:

- Qualitatively and quantitatively examine curriculum presented in lecture, such as atomic and molecular structure, chemical reactivity, thermochemistry, and chemical calculations in an active laboratory setting.
- Practice laboratory methods applicable to chemists of all levels.
- Create, and demonstrate the proper use of, a well-prepared laboratory notebook and evaluate the importance of organized scientific data collection and data integrity.
- Demonstrate the ability to interpret data, evaluate conclusions supported and not supported by experimental results, and compare and contrast chemical methods, as communicated through Post-Labs.
- Demonstrate the safe handling and proper disposal techniques for all materials used in the lab.

As you can see, mastering the use of a laboratory notebook and analyzing experimental results are important course goals, but we know they can be intimidating. Even with experience in chemistry labs, our guidelines may not be exactly what you've seen before. It is important to try your best to meet these requirements, but equally important to learn from your mistakes. Use the feedback from your lab instructor to improve future work, both in the laboratory and in your Post-Labs.

In this guide, we will explore these components of the General Chemistry lab in the context of an experiment titled "Cake Chemistry." Baking a cake is something most people are familiar with. However, many of us have never considered the chemistry that gives us the delicious desserts that we enjoy. This experiment aims to determine what happens to the physical properties of a cake when certain ingredients are omitted from the recipe. In the following sections, you will find the following:

1. The lab manual pages for the Cake Chemistry experiment (pages XIX–XXVI)
2. A guide for preparing a Laboratory Notebook for this experiment (pages XXVII–XXXI)
3. A copy of our prepared notebook for Cake Chemistry, including the data collected (pages XXXIII–XXXVI)
4. A guide for completing Post-Labs (pages XXXVII–XLIII)