REED COLLEGE
CHEMISTRY
LABORATORY SAFETY
MANUAL

Twenty Second Edition, July 2023

Prepared by the faculty and staff of the Reed College Chemistry Department,
In conjunction with the Environmental Health & Safety Office

Reed College
3203 SE Woodstock Blvd
Portland, OR 97202

Emergency Information

Fire, Ambulance/Rescue, Police...911
Community Safety...503-788-6666
Poison Control Center (OHSU)..800-222-1222
Reed Health Services (M-F 9 am - 5 pm)...503-777-7281
Reed Environmental Health and Safety 503-777-7788
Providence Hospital Emergency Room...503-215-6000
Reed Physical Plant Maintenance...503-777-7283
Reed Public Affairs...503-777-7289
Radiation Safety Officer..503-777-7788
Chemical Hygiene Officer...503-777-7788

Please note the location of your nearest:

Fire Alarm Pull Station: ____________________

Fire Extinguishers – 2 of them: ____________________

Emergency Shower/Eyewash: ____________________

First Aid Kit: ____________________

Spill Kit: ____________________

Automated External Defibrillator: ____________________

Outside Assembly Point Location: ____________________

Shelter-in-Place Location: ____________________

SDS Location: ____________________

Chemistry Laboratory Safety Manual

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1 INTRODUCTION

1.1 Purpose

Chemistry is an experimental science, an exploration of the unknown. Chemists work with a wide assortment of materials, combining them in a multitude of ways. Experimental outcomes are often unpredictable, making lab work both exciting and potentially dangerous.

The dangers posed by hazardous reagents are easily identified. However, most compounds have not been investigated for potential hazards. Therefore, a precautionary approach is recommended. The chemist's personal safety, and the safety of the world "downstream," depends on their *willingness* and *ability* to *anticipate*, and deal with, potential hazards.

Anticipating a hazardous situation means thinking about safety *before* you even enter a lab. In planning an experiment, even an experiment that has been performed many times, you should always take time to identify potential hazards, procedures for dealing with these hazards, and safe, legal procedures for disposing of all materials after the experiment.

Training in emergency procedures is also required, and this training must occur before actual lab work begins. Accidents are inevitable, and when they do occur, the chemist must be ready to respond.

Reed College chemistry students encounter the same safety problems faced by professional chemists. Students are expected to learn about possible hazard and disposal problems *before* each experiment. In the lab, students are expected to follow safe procedures, safely deal with hazardous materials remaining after an experiment, and be ready to handle accidents. This manual has been written to acquaint you with safety problems that you might face and your responsibilities for dealing with them.

1.2 Organization

The first few chapters of this manual describe hazards that are *commonly* encountered in Reed laboratories. They tell you how to protect yourself from hazards, how to deal with accidents, and how to dispose of leftover materials.

The initial chapters are organized by lab course. Students enrolled in different courses are to read different chapters, but *all* students must complete their required reading *before beginning work in any new laboratory course*.

To underline the seriousness of this requirement, **all students must sign the *legally binding* statement that appears at the end of this manual.** This states that the signer has completed the required reading and understands its contents**. The statement must be signed either via moodle/online or paper copy depending on instructions given to you by your lab instructor.** Failure to do this can lead to dismissal from the course.

The remaining chapters contain reference material. This information is intended for students and faculty engaged in research and/or planning new experiments. Students enrolled in lab courses do not need to read the reference material before signing the safety statement, but they should scan the chapter and subchapter headings to learn what kind of information is provided.

1.3 Course-specific safety information

Naturally, this manual cannot anticipate every hazard that might be found in a Reed laboratory. Therefore, your lab instructor will provide additional safety information about particular experiments. This information supplements the information provided here: your lab instructor will assume that you have read this manual and are familiar with its contents. Make it a habit to consult both this manual *and* your course manual whenever you plan a new experiment.

If your instructor's safety instructions conflict with those provided here, please follow your instructor's instructions. Do us a favor, though, and let your instructor and the Environmental Health and Safety Office know about these conflicts. The same goes for missing information.

1.4 Environmental Health and Safety Office and the CHO

The Environmental Health and Safety (EHS) Office is responsible for providing the Reed community with the information and training necessary to handle the various hazards that can be found in the classroom, lab, and campus in general. EHS promotes a culture of safety, health, and environmental consciousness in all aspects of campus, while upholding state and federal regulatory requirements.

The Chemical Hygiene Officer or CHO is a designated employee who is qualified by training or experience, and is responsible for the overall health and safety on campus. The CHO duties/responsibilities include, but are not limited to, the following:

- Administer the Chemical Hygiene Plan (CHP).
- Work with the laboratory community, administrators, and other employees to provide adequate facilities and to develop and implement appropriate policies and practices.
- Monitor procurement, use, and disposal of chemicals in laboratories.
- Maintain appropriate audits of laboratories, stockrooms, and storage spaces.
- Provide technical assistance for complying with the CHP and answer chemical safety questions for employees.
- Know the current legal requirements concerning regulated substances.
- Seek ways to improve the chemical hygiene program.

- Review and update the CHP annually and as needed with departmental members and Environmental Health and Safety.

Please let the Environmental Health and Safety office, located at Facilities Services- Physical Plant, know of any missing information in this manual. If you have any questions, you can contact the EHS office at 503-777-7788 or go to http://www.reed.edu/ehs/.

2 Chemistry Department Policies and Regulations

2.1 Normal Building Hours and Rules

- The chemistry building is normally unlocked from:

  7 a.m. through 11 p.m. Monday-Friday,

  7 a.m. through 7 p.m. Saturday,

  Noon to 11 p.m. Sunday.

  Different hours may apply during reading week, finals week, academic holidays, and the summer.

- Smoking is prohibited everywhere in the building.

- Unless part of an officially sanctioned college event, consumption of alcoholic beverages within the building is prohibited.

- No one may ever engage in lab work after taking medication or substances known to impair judgment, motor skills, memory, alertness, or other mental faculties critical for safe lab work. Students found working under the influence of these substances risk loss of lab privileges and dismissal from lab courses.

- In general, no pets may be brought into the building. Exceptions may be made for pets that are kept confined in an office (approval must be obtained from appropriate faculty before keeping a pet in an office). *Pets must never be brought into labs*. If students or workers encounter stray dogs inside the building, they should attempt to remove them or obtain assistance to that end.

- Students may store bicycles on the 2nd floor under the stairway. Students may not store a bicycle in any lab or office. Bicycle and skateboard riding are prohibited in the building at all times.

- Department faculty and staff may remove students or other individuals from laboratory spaces due to unsafe work practices or failure to follow directions. Return to lab timeline is contingent on departmental review.

2.2 Work After Normal Hours

Lab courses. Students enrolled in lab courses may engage in lab work *only* during the normal scheduled lab hours, and *only* when an instructor or other lab supervisor is present.

Instructors may permit work beyond normal hours subject to the following conditions:

- Permission for working beyond normal scheduled lab hours must be obtained in writing from the instructor *before* beginning any work. Instructors may decline to issue permission for such work at their discretion. (**Instructors**: safety is of paramount importance in granting permission for work beyond normal hours; permission should only be granted for activities that involve minimal hazard).

- Work must be limited to the experiments and/or procedures specified by the instructor.

- Work must be performed in the location specified by the instructor.

- Work must be performed during the hours specified by the instructor and subject to whatever supervision is specified by the instructor. In most cases, permission will only be granted for work that will be done while the instructor or other lab supervisor is in the chemistry building. (**Instructors:** No student should ever work alone unless the activities are reliably hazard-free.)

Other lab work. Thesis and independent study students should discuss work hours and work activities with their research instructors before beginning work. As a rule, limit work to experiments and/or procedures specified by the instructor, and be sure to perform them in the location specified by the instructor. If a research student needs to work beyond an instructor's normal working hours, then the student should find another student who can act as a "lab buddy"— who can be in the same lab with the student and monitor the student's safety.

2.3 Special Pass for Work Outside Normal Hours

SAMPLE OF AFTER-HOURS PASS SHOWN BELOW

DEPARTMENT OF CHEMISTRY— REED COLLEGE

After-Hours Pass

________________________and ________________________* may work in the

chemistry laboratory on __________________ until _________a.m./p.m.

Nature of laboratory work authorized:

____

____

Signed________________________ (chemistry faculty member)

For after-hours work (after-hours work includes Saturdays) at least two students must be working together at **all** times in the same laboratory or within earshot.

2.4 Emergency Procedures

Write these emergency telephone numbers on the first page of your laboratory notebook:

Fire, Ambulance & Rescue, Police	**911**
Reed Community Safety Office	**503-788-6666; Ext. 6666**
Providence Hospital Emergency	**503-215-6000**
Reed Health Services (M–F 9 A.M.–5 P.M.)	**503-777-7281; Ext. 7281**
Reed Environmental Health and Safety	**503-777-7788; Ext. 7788**
Poison Control Center	**1-800-222-1222**

In any lab emergency, immediately notify the instructor or another member of the chemistry faculty. If it is after hours, or an instructor is not in the building, use the following procedures (see also the following pages).

<u>MEDICAL EMERGENCIES REQUIRING AN AMBULANCE: CALL THE FIRST TWO NUMBERS IN THE ORDER GIVEN:</u>

- **Immediately call 911**. The dispatch operator will ask you whether you need fire, police, or ambulance, and the location of the emergency. Respond "ambulance," and the location as "Reed College chemistry department, which is located at the back of the east parking lot across the street from 3626 SE Woodstock Blvd." Other useful directions: the main campus entrance is opposite 3424 SE Woodstock. The east delivery entrance is opposite 3626 SE Woodstock.

- **Then notify the Reed community safety office at 503-788-6666; ext. 6666;** inform them of the incident and that you have already summoned medical assistance. If possible, send someone to direct the ambulance personnel.

- **Do NOT move the injured person unless the victim is in a life-threatening location, such as in a fire.** Attend to the victim's immediate needs. Keep any victim of shock (electrical, chemical, or physical) warm with a blanket or warm clothing. In general, stop bleeding, monitor the victim's breathing and general status, and reassure the victim.

<u>MEDICAL EMERGENCIES NOT REQUIRING AN AMBULANCE:</u>

The injured should go to the Providence Hospital emergency room. (See below for directions). **NEVER MOVE A VICTIM WITH BACK, NECK, OR HEAD INJURIES!** If the victim is unable to transport himself or herself to the hospital, call an ambulance (911) or the Reed Community Safety Office (503-788-6666; ext. 6666). Reed Community Safety Officers (503-788-6666; ext. 6666) can arrange for transport. Notify the emergency room at Providence Hospital (503-215-6000) of an incoming accident victim. Give them all available information about the emergency. If the victim has a chemical exposure, send the appropriate Safety Data Sheet (SDS) with the person.

- **DIRECTIONS:** Emergency patients should be taken to the Providence Hospital emergency room, which is at 4805 N.E. Glisan. (Go north on César E Chávez Blvd. Cross Powell, Division, and Burnside to Glisan (5 blocks north of Burnside). Make a RIGHT turn onto Glisan, and continue east to 47th Avenue. Make a LEFT turn at this light. On the immediate RIGHT is the emergency room entrance.)

- For **CHEMICAL BURNS** such as from an acid or base splash, immediately flush the area with water for at least 15 minutes, before departure to seek medical attention. If the eyes are affected, hold the eyes open to the water in the eyewash and rotate the eyeballs to clear the material from all areas. Be gentle and do not rub your eyes. For skin contact, use an emergency shower station. Remove affected clothing and flush for at least 15 minutes. Keep flushing the affected area while making telephone calls for help. This continuous flushing could save your eyes! **Note:** For some chemicals, water flushing is contraindicated. Your instructor will inform you when you work with one of these chemicals.

- **FIRST AID:** Report all lab injuries to the instructor in charge of the course. All lab injuries require some degree of first-aid attention. Therefore, you must immediately inform your instructor if you have received any injury in the lab, no matter how slight the injury may seem to you, and no matter how embarrassed you may feel about the conditions causing the injury. Mistakes and accidents happen.

- **ACCIDENT/INCIDENT/NEAR MISS REPORTING:** All near miss/accidents/injuries should be reported to your lab instructor. If you break glassware, spill inert chemicals, or need to utilize first aid for any reason, this is considered a near miss and should be reported so that we can utilize these learning experiences to improve safety systems.

The first-aid cabinets contain materials for treating minor cuts and burns only. First aid kits are located within each teaching lab. Use first aid materials for immediate, temporary care until the victim can seek professional medical help, either from the Reed health services (M–F 9 a.m. to 5 p.m.) or hospital emergency room. All students with minor injuries must immediately go to the Reed health center.

FIRE: DO NOT ATTEMPT TO FIGHT AN UNCONTAINED FIRE. NOTIFY AND EVACUATE THE BUILDING OCCUPANTS IMMEDIATELY.

The person discovering a fire shall go to the nearest pull alarm (small red boxes on the walls) and pull it to alert the building occupants of fire. Write the location of the closest fire alarm to your lab desk on the first page of your lab notebook.

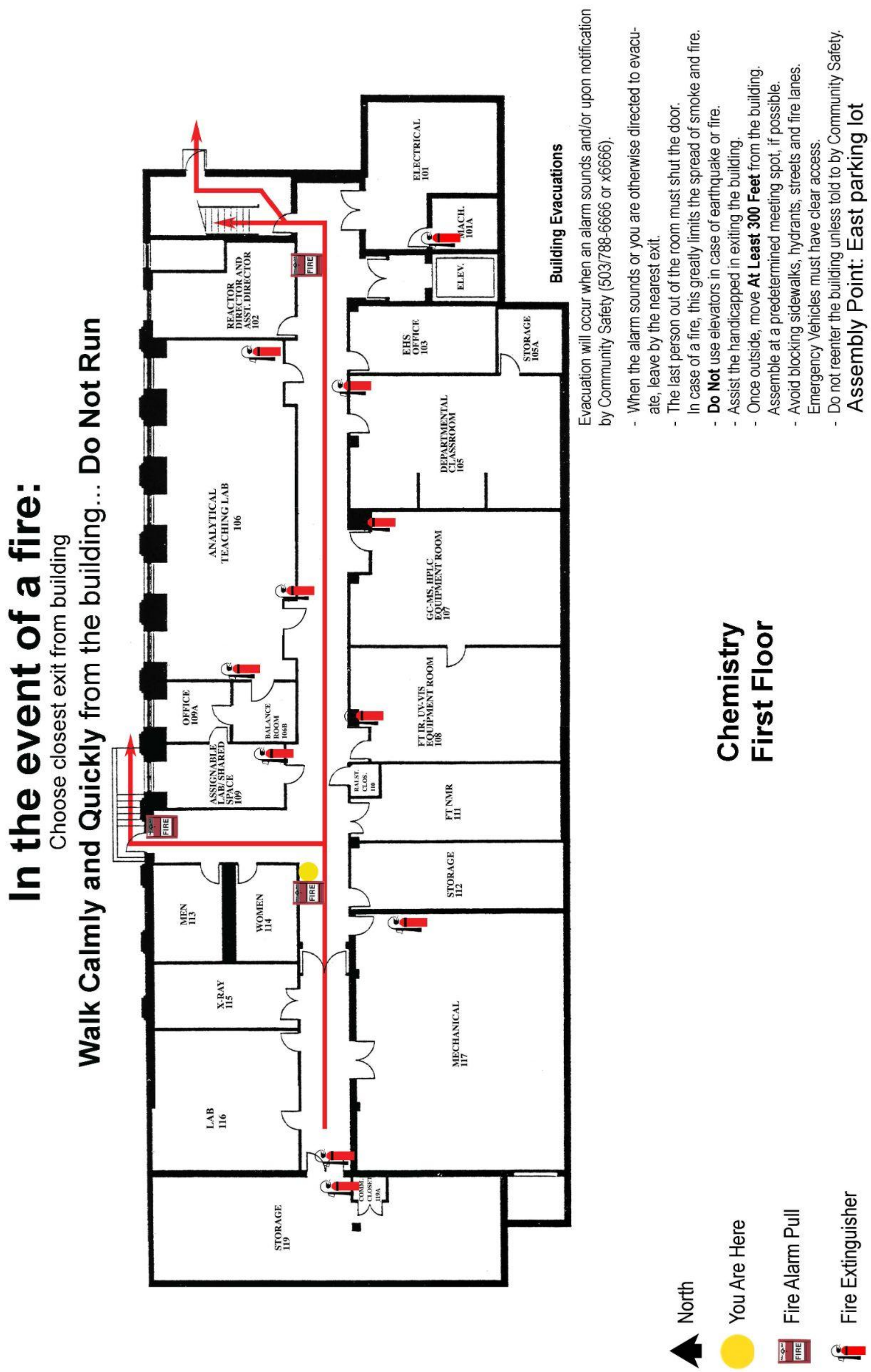
- The loud buzzer-like or bell-like sound originating from various alarms in the building is the signal for everyone to evacuate immediately the building by way of the nearest exit. Remain calm and leave through the closest safe exit.

- The chemistry building is equipped with an automatic fire and smoke sensing system. The Reed community safety office is automatically notified when an alarm in the chemistry building is activated. However, it is important to call community safety from a safe location, to ensure that emergency responders are on their way.

- **ONLY** if the fire is small and contained, such as paper towels in a waste can, should you attempt to fight it. You can put out very small fires by "starving" them (example: putting a watch glass on top of an Erlenmeyer flask will cut off the oxygen supply to a fire inside the flask). If the fire cannot be starved, use your lab's fire extinguisher to put out the fire. If a fire is *either* large, not contained, or threatens your escape from the lab, do not attempt to fight it.

- There will be periodic testing of the alarm by community safety officers. All occupants in the building will be forewarned. Whenever you hear the alarms, assume that it is a fire or other emergency, and evacuate the building in an orderly fashion. Go to the chemistry building assembly point, which is the east parking lot.

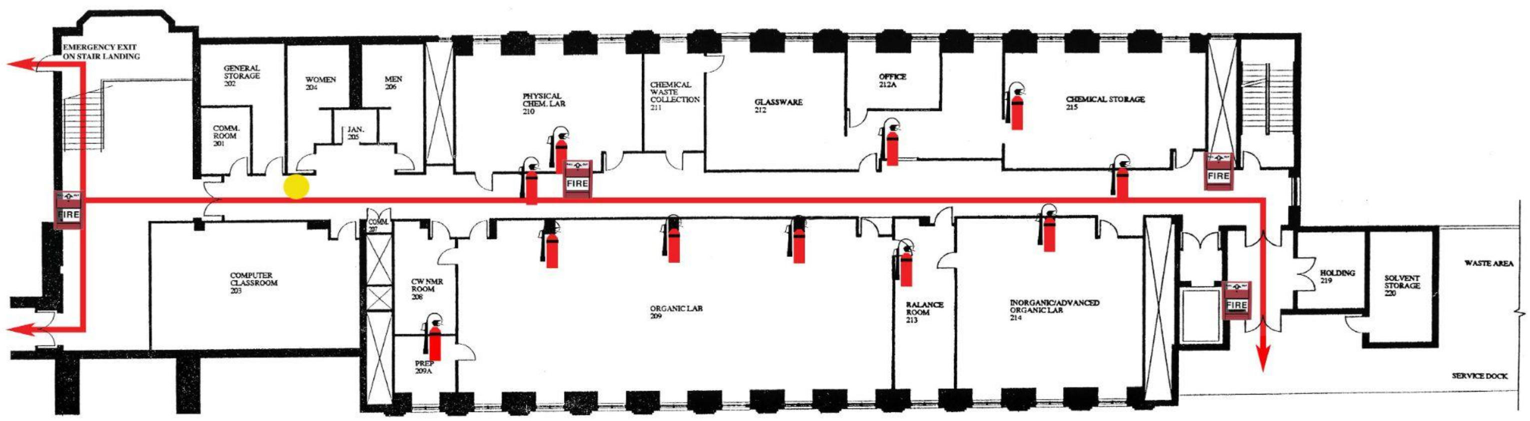
2.5 Chemistry Building Maps



In the event of a fire:

Choose closest exit from building

Walk Calmly and Quickly from the building... **Do Not Run**



North

You Are Here

Fire Alarm Pull

Fire Extinguisher

Chemistry
Second Floor

Building Evacuations

Evacuation will occur when an alarm sounds and/or upon notification by Community Safety (503/788-6666 or x6666).

- When the alarm sounds or you are otherwise directed to evacuate, leave by the nearest exit.
- The last person out of the room must shut the door. In case of a fire, this greatly limits the spread of smoke and fire.
- **Do Not** use elevators in case of earthquake or fire.
- Assist the handicapped in exiting the building.
- Once outside, move **At Least 300 Feet** from the building. Assemble at a predetermined meeting spot, if possible.
- Avoid blocking sidewalks, hydrants, streets and fire lanes. Emergency Vehicles must have clear access.
- Do not reenter the building unless told to by Community Safety.

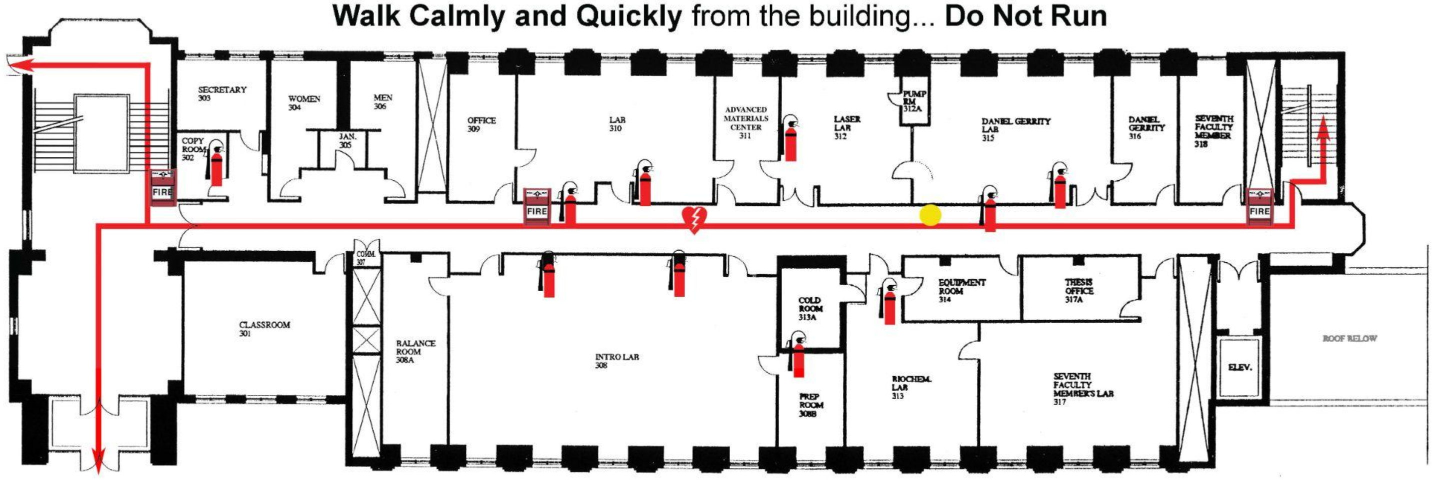
Assembly Point: East parking lot

*f*assem

In the event of a fire:

Choose closest exit from building

Walk Calmly and Quickly from the building... **Do Not Run**



North

You Are Here

Fire Alarm Pull

Fire Extinguisher

AED

Chemistry
Third Floor

Building Evacuations

Evacuation will occur when an alarm sounds and/or upon notification by Community Safety (503/788-6666 or x6666).

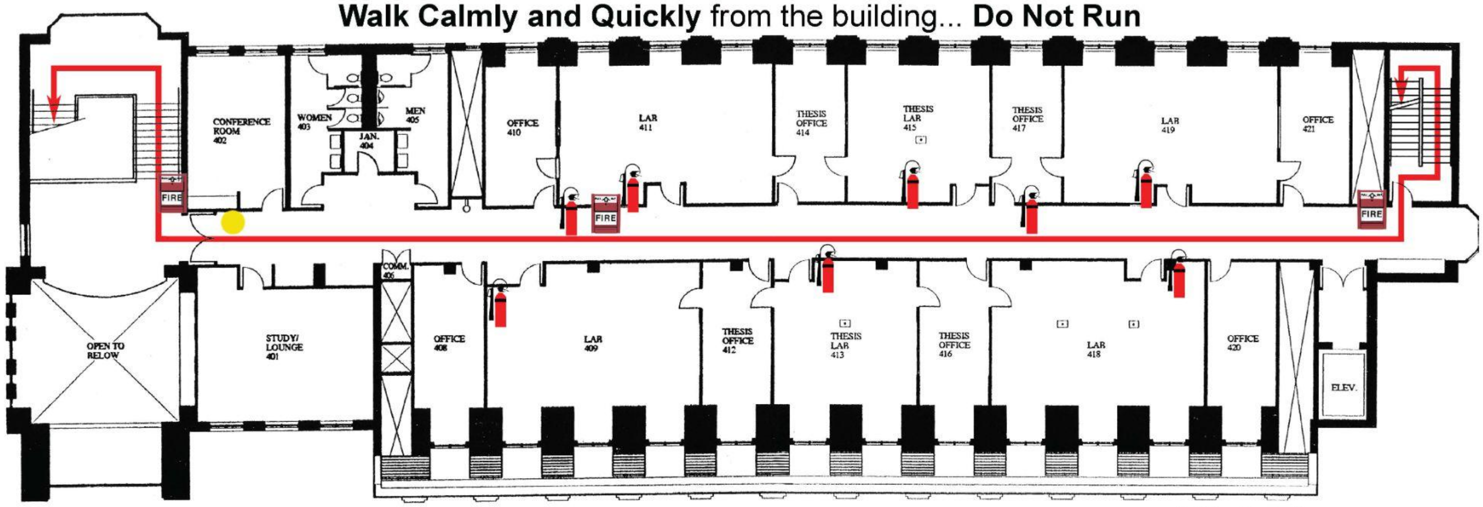
- When the alarm sounds or you are otherwise directed to evacuate, leave by the nearest exit.
- The last person out of the room must shut the door. In case of a fire, this greatly limits the spread of smoke and fire.
- **Do Not** use elevators in case of earthquake or fire.
- Assist the handicapped in exiting the building.
- Once outside, move **At Least 300 Feet** from the building. Assemble at a predetermined meeting spot, if possible.
- Avoid blocking sidewalks, hydrants, streets and fire lanes. Emergency Vehicles must have clear access.
- Do not reenter the building unless told to by Community Safety.

Assembly Point: East parking lot

In the event of a fire:

Choose closest exit from building

Walk Calmly and Quickly from the building... **Do Not Run**



North

You Are Here

Fire Alarm Pull

Fire Extinguisher

Chemistry
Fourth Floor

Building Evacuations

Evacuation will occur when an alarm sounds and/or upon notification by Community Safety (503/788-6666 or x6666).

- When the alarm sounds or you are otherwise directed to evacuate, leave by the nearest exit.
- The last person out of the room must shut the door. In case of a fire, this greatly limits the spread of smoke and fire.
- **Do Not** use elevators in case of earthquake or fire.
- Assist the handicapped in exiting the building.
- Once outside, move **At Least 300 Feet** from the building. Assemble at a predetermined meeting spot, if possible.
- Avoid blocking sidewalks, hydrants, streets and fire lanes. Emergency Vehicles must have clear access.
- Do not reenter the building unless told to by Community Safety.

Assembly Point: East parking lot

3 Things Every Chemistry Student Should Know

This section contains information that ***all*** chemistry students need to know, whether they are beginning lab work for the first time or working on a senior thesis. It is required reading for ***all*** students. If you have any questions about any of this material, ask your instructor.

3.1 Basic Building and Safety Info

Before you begin lab work, visit the chemistry building and your lab. Familiarize yourself with the following:

- The location of all building exits and routes from your lab to the *two* closest exits. There are five exits in all: three at the west end of floors 2 and 3 (floor 2 exits to the biology and physics buildings), one at the east end of floor 2 (exits to the loading dock), and two leading to the canyon, one in the middle of the hallway on floor 1 and one at the bottom of the east stairwell. (fire exit only, exits to the canyon).

- The location of your outside assembly point (East Parking Lot)

- The location of the *two* fire extinguishers closest to your workspace.

- The location of the first-aid kit closest to your workspace. Independent study and thesis students should also open a kit and familiarize themselves with its contents.

- The location and use of the emergency shower and eyewash station in your lab.

- The location of the telephone closest to your workspace.

- The location (3rd floor middle of hallway) of the automated external defibrillator (AED)

- The location of your inside shelter-in-place area.

Also, before you begin lab work, obtain the following safety information:

- Emergency phone numbers (these numbers should be written on the cover or inside cover of your lab notebook, see Section 2.4):

  - Fire, ambulance, police
  - Reed Community Safety Office
  - Providence Hospital Emergency Room
  - Reed Health Center
  - Reed Environmental Health & Safety Office

Poison Center

3.2 Self-Protection in the Lab

The first principle of lab safety is to *protect yourself* from potential hazards. Some of these hazards exist apart from any action by the chemist. For example:

- Toxic or irritating vapors emitted by volatile compounds.
- Toxic or irritating droplets given off by poured, stirred, or boiling liquids.
- Toxic or irritating chemical residues on tabletops or glassware.
- Potential implosion of vacuum glassware, like a thermos or Dewar.

The best way to protect yourself from these hazards is, first, to recognize that they exist (and, unless you know the lab extremely well, you should assume they exist in *every* lab), and second, to use equipment and protective clothing that will minimize your exposure to unpleasant compounds and flying shards of glass.

Accidents represent a more dramatic, but less frequent, hazard. As a rule, accident frequency and severity are inversely related. Minor accidents, like spills, dropped glassware, and such, happen every day. Major accidents, like fires and explosions, are much less common.

The first step in protecting yourself from accidents is to do everything you can to *prevent* them from occurring in the first place. This means avoiding behavior that might cause an accident. It also means using appropriate equipment in appropriate ways, and paying attention to the properties of the substances with which you work. Always ask if the material is, for example, flammable, corrosive (base or acid), reactive, an oxidizer, a mutagen, a poison, a biohazard, water reactive, or radioactive.

One resource for chemical hazard information is the Safety Data Sheet (SDS). SDSs, which were called Material Safety Data Sheets (MSDSs) before 2013, state the type of hazard(s) posed by the chemical, exposure limits, exposure routes, affected body systems, and suggested protective equipment for safe handling. Many SDSs have signal words, which indicate the severity of the chemical hazard, and pictograms associated with particular hazards (refer to Chapter 8 for details). For more on reading SDSs and the information they contain, check out Chapter 8 or the EHS webpage: reed.edu/ehs/index.html. Regardless of which resource you choose, it is your responsibility to learn about the chemicals you use.

Once an accident occurs, you must hope that your protective clothing and equipment will work as advertised. You also need to know and follow emergency procedures and the instructions for dealing with accidents that will limit injuries and damage (these are covered in the next section).

One especially common, and potentially tragic, student mistake is to assume that "self-protection" means protecting yourself from your own experiments *only*. This approach is flawed because it fails to recognize dangers created by other students. You should view *all* laboratories as potentially hazardous workplaces and protect yourself accordingly. This rule applies even when no one else is present and/or you are not performing an experiment.

The following basic self-protection rules apply *at all times* and *in all labs*.

> Most of the material in this manual addresses a somewhat remote incident, like spilling acid on yourself or ingesting mercury. However, eyes are the most likely organ to be damaged and the easiest to protect. Instructors have noticed a good number of people being lax. Please,
>
> **WEAR YOUR GOGGLES.**

Eye Protection - Goggles: **Goggles, or other approved protective eyewear, must be worn at all times. Normal eyeglasses do not count as safety goggles.** If you do not like the goggles provided, you can pick up a pair from Randy in the chemistry stockroom.

Skin Protection - Shoes: **Closed-toe shoes that are fastened to your feet must be worn at all times**. Sandals and flip-flops are not allowed (these shoes provide poor protection). If you forget to wear suitable shoes, your lab instructor may allow you to wear "Booties of Shame" (obtained from Randy in the chemistry stockroom).

Skin Protection - Gloves: Your instructor may require you to wear gloves when you handle dangerous compounds or dangerously hot or cold objects (consult the manual for your lab course). Otherwise, gloves are not required, but strongly recommended. Consider this: lab surfaces are often coated with residues from chemical spills.

It is important to select gloves carefully and inspect them. Different glove materials offer different types of chemical and temperature protection. Chapter 7 has more information about glove compatibility. When using gloves, follow these rules:

- Wear the correct gloves for the task.
- Check gloves for small holes or tears before donning them.
- Remove gloves and wash your hands before touching phones, computers, pens, your skin, or other personal items.
- Do not contaminate doorknobs and other surfaces *outside* the lab. If you need gloves to transport anything, wear one glove to handle the transported item. Use your other/glove-free hand to touch doorknobs, elevator buttons, etc.
- Always remove your gloves and wash your hands *before* leaving the lab.

Skin Protection & Accident Prevention - Clothes and Hair: Safe, protective clothing is required. Wear clothing that will cover everything from the tops of your shoulders to your knees. A short-sleeved T-shirt is acceptable, but a tank top (bare shoulders) and shirts that leave your mid-section exposed are unacceptable. Since spilled chemicals and broken glass naturally seek their lowest level, we strongly recommend that you cover your legs by wearing long pants.

Long hair must be tied back securely. Do not wear loose-fitting items, such as baggy clothing or dangling jewelry. Loose, dangling items are dangerous because they can get caught on an apparatus, knock over containers, and so on.

If your instructor decides that your clothing is unsafe, you will be asked to put on a lab coat or apron, or you could be sent home for clothing that is more lab appropriate. The instructor's opinion is final, so plan ahead on lab days (especially during the warm days of September and April) and wear or bring safe clothing.

Internal organ protection - Food and Drink: Do not bring food or drink into any lab. Do not store food in a lab or use lab equipment to prepare food. Never eat or taste a laboratory reagent, or even a compound that you have made (many seemingly safe compounds contain dangerous impurities).

General protection - Fume Hoods: Fume hoods prevent toxic and flammable vapors from entering the lab. In addition, their windows (or "sashes") block splashes and flying debris. Any experiment that involves a volatile toxic compound, a flammable compound, or a potentially exothermic reaction, or that requires heating via open flame, should be performed in a fume hood with the window positioned as low as possible.

3.3 Dealing with Accidents

Example accidents below are listed by their frequency, most frequent first. The accidents near the end of the list are relatively rare, but it is still important to know how to deal with them, so please review this information from time to time throughout the semester.

Acid Spill: First, rinse off any acid that spills on you (see section 2.4). Second, deal with any acid that spills on the floor or other lab surface by **neutralizing the spill with baking soda** and notifying your lab instructor. Pour baking soda directly on the spill. Once the bubbling and fizzing stop, wipe up the spill with a sponge (wear gloves!) and wash all of the material down the sink. If you need to leave the immediate area of the spill to get baking soda, make sure someone stays with the spill to keep people from walking through it or accidentally spreading it around.

Base Spill: First, rinse off any base that spills on you (see section 2.4). Second, deal with any base that spills on the floor or other lab surface, **neutralizing the spill with a *dilute* acid (such as vinegar or 3M HCl)** and notifying your lab instructor or TA. Periodically test the pH of the spill with pH paper (a pH between 5-9 can be considered "neutral"). Once the spill has been neutralized, wipe up the spill with a sponge (wear gloves!) and wash all of the material down the sink. As with an acid spill, if you need to leave the spill zone, make sure someone stays with the spill to keep other people away from it.

Other chemical spills: As with acid and base spills, first deal with material that lands on you (see section 2.4). Then, notify your instructor to get information on how to clean up the spilled material. As with acid and base spills, if you need to leave the spill zone, make sure someone stays with the spill to keep people away from it.

<u>Injury (example: cut, burn, etc.):</u> Begin first-aid treatment and immediately tell your lab instructor (see section 2.4).

<u>Mercury Spill (example: broken thermometer):</u> This is one spill that you cannot clean up yourself. Mercury is a toxic liquid. Mercury spills generate an enormous number of tiny droplets that are easily dispersed, and special vacuum equipment must be used to clean up these spills.

Do not touch or attempt to wipe up spilled mercury. Make sure someone stays near (but not in) the spill zone to keep people away. Notify your lab instructor immediately and notify the stockroom manager (Randy). Depending on the circumstances, they may clean up the spill for you, or they will provide you with the special clean-up equipment that is needed.

<u>Fires:</u> The appropriate response to a fire depends on the size, type, and location of the fire (see section 2.4).

3.4 Waste Disposal

All compounds left over after an experiment must be disposed of in a safe and legal manner in order to protect the "downstream" community (other lab workers, housekeeping staff, EHS staff, wildlife, and so on). Before you begin any experiment, you should identify the type of waste compounds that will be generated and write appropriate disposal procedures for each compound in your lab notebook.

<u>Hazardous Waste:</u> All waste that is listed as hazardous waste or characteristically hazardous must be properly disposed of. It is considered hazardous and *may not* be disposed of down the sink if it exhibits any one of the following characteristics- ignitibility, corrosivity, reactivity, or toxicity.

<u>Organic Waste:</u> All organic wastes, liquid and solid, go in the organic waste container in the fume hood of the lab, and <u>never</u> down the sink. Organic waste includes both routinely encountered compounds, like alcohol and acetone, and organic solid or liquid that you prepare during an experiment and wish to discard.

<u>Acid or Base Waste:</u> Inorganic acids and bases should be "neutralized" to bring their pH between 5-9 (check with pH paper). As with acid and base spills, neutralize acid with baking soda, and base with dilute acid. If the neutralized material does not contain one of the metals listed in the next section, rinse the material down the drain. Otherwise, treat the material as a "listed metal waste."

<u>Listed Metal Wastes:</u> Solutions containing the following metals cannot go down the sink under any circumstances: **arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), and zinc (Zn).** Special waste containers will be placed in the lab to collect each type of metal for subsequent disposal by environmental health and safety personnel.

<u>Special Waste:</u> Some compounds, whether solid or liquid, need to be placed in a special waste container in the fume hood. Your instructor will let you know specifically which ones.

Glass Disposal: In every lab there is a roughly waist-high cardboard box that says **Glass Waste.** All broken glassware, including disposable pipettes, should go in this glass waste box.

No Kidding. First-Hand Experience! In an upper level chem class at another university, incompatible nitric acid and halogenated organic solvents wastes were accidentally mixed resulting in a fire and explosion. Miraculously, no one had serious injuries from the accident. The student who last used the waste bottle reported that he saw some brown fumes coming from the waste bottle when he added his methylene chloride. He capped the bottle and walked away. A minute or two later it exploded. Glass shrapnel blew across the laboratory and hit students on the other side of the lab. At least one reported that the glass bounced off his safety goggles. Thankfully, this student was following the rule you must wear your safety glasses at all times in the laboratory even if you aren't "doing anything." Flames engulfed the hood the lab quickly filled with smoke so black, thick, and acrid that one could not see across the lab. Explosions of this nature can have an induction period ranging from one second to one hour or more. The last student to use this waste bottle was incredibly lucky. The pictures below show the charring of the cabinets and the shrapnel damage three benches away. Some fragments travelled 10 meters from the hood.

How would you avoid or minimize the damage? Some ideas should include:

Pay attention; if you see unusual fog/vapors/etc. coming from a bottle don't cap it.

Always double-check the label.

Properly label all your containers.

Don't use hoods for chemical storage unless for waste.

Use the fume hood correctly; keep the sash closed.

Can you think of others ways to prevent mistakes like this?

Find more information about chemical accidents in the lab here (https://www.acs.org/acs-webinars/program-in-a-box/pib-on-demand/lab-safety.html).

3.5 What Should You Read Next?

Chem 101/102 students can stop reading this manual at this point and may sign the safety statement in Chapter 10. After doing that, students should consult their lab course manual for additional safety instructions. We also encourage students to become familiar with the Chapter 8 Appendix on SDSs and to *scan* quickly Chapters 6 and 7 in this manual just to get acquainted with the rest of the contents of this manual.

Students in Chem 201/202/212 must also read Chapter 4.

All other chemistry students must also read Chapter 5 (they may skip Chapter 4).

4 Things Every Chem 201/202/212 Student Should Know

4.1 Self-Protection in the Lab

Fume Hoods: Virtually all of the experiments in Chem 201/202 involve volatile organic compounds and must be performed in a fume hood. Use the fume hood closest to your lab drawer to minimize foot traffic or collisions in the lab. Remember to keep the fume hood window positioned as low as possible.

4.2 Avoiding Accidents

The experimental procedures in Chem 201/202/212 tend to be more complicated than those in Chem 101/102. Most accidents can be prevented by following instructions and by paying attention to the hazardous properties of each substance and procedure.

Pay particular attention to procedures that require heating or generate their own heat (exothermic reactions). These procedures are the ones that might lead to a sudden and dangerous splash, fire, or explosion.

Never Create an Open Flame: Open flames can set off fires, and even explosions, when they come into contact with the vapors from volatile organic compounds (fuel). Most of these vapors are heavier than air, so they tend to stay close to bench tops and travel large distances horizontally.

Don't follow in the footsteps of Union Carbide: DuPont chemists developed a process that uses methyl isocyanate (MIC) as an intermediate for developing pesticides. Probably the most notorious chemical disaster in the 20th century involved the tragic death of thousands of people when MIC was accidentally released into the air at the Union Carbide facility in Bhopal, India.

A safer production process that DuPont developed uses a catalytic approach that allows the generation of just the right amount of MIC, at just the right time, needed for conversion to product. Consequently, MIC does not need to be stored for the process and potentially lethal spills or leaks are avoided. The process itself is safer and more efficient, and the "in situ" approach reduced storage and liability costs for DuPont.

Never Heat a Closed System: Heated gases expand rapidly and can "explode" a closed system. Before heating any apparatus **(especially reflux and distillation apparatus)**, check it to make sure there is an opening for expanding gases to escape.

Use Boiling Chips or a Stirrer: Liquids do not boil smoothly unless a source of nuclei is present on which the bubbles of vapor may readily form. Otherwise, a liquid will become superheated and vaporize suddenly with almost explosive force ("bump"). **Most bumping problems can be overcome by very good stirring or by adding one or two boiling chips to a solution before it is heated.**

Exothermic, Out of Control Reactions: You can control most exothermic reactions by either conducting the reaction at reduced temperature (use a cooling bath), combining reagents more slowly, or working on smaller scales. Some additional tips:

- Keep additional ice (or an ice bath) on hand to cool a reaction that might become uncontrolled

- Never use your heat source to support your reaction flask. Instead, put your heat source on top of a "lab jack" and clamp your reaction flask to a metal support rod so that the clamp+rod supports your flask. Then, if the reaction starts to go out of control, you can lower (or remove) the lab jack and quickly separate your heat source from your reaction flask.

If a reaction does go out of control, **close the fume hood entirely, remove all external sources of energy (example: lower and unplug a ceramic heater or hot plate).** Finally, notify your lab instructor.

4.3 What Should You Read Next?

Chem 201/202/212 students can stop reading this manual at this point and may sign the safety statement in Chapter 10. After doing that, students should consult their lab course manual for additional safety instructions. We also encourage students to *become familiar* with the Chapter 8 Appendix on SDSs and to *scan* quickly Chapters 6 and 7 in this manual just to get acquainted with the rest of the contents of this manual.

5 Things to Know for Upper-Class Chemistry Students

5.1 Self-Protection:

<u>Safety Goggles and Shoes:</u> As always, safety goggles and closed-toe shoes must always be worn in the lab. Remember to tie back long hair.

Elemental Tidbit: Didymium glass, which contains dissolved neodymium, samarium, and praseodymium, absorbs a portion of the orange region of the light spectrum. The extinction coefficient is highest between 580 nm and 590 nm, conveniently absorbing the bright sodium emission at 589 nm and a good deal of the blackbody radiation coming off the heated glass. It is named for the supposed element isolated by C. G. Mosander from cerite in 1840 (really a combination of neodymium and praseodymium).

<u>Other eye protection:</u>

- **For Lasers:** Special precautions are necessary, and special goggles are available for use. Consult your instructor.
- **Impact Shields**: Certain experiments may require increased eye and face protection due to the possibility of impact. Safety glasses and face shields should meet ANSI Z87.1v-2020 standards. Consult with lab supervisors about appropriate PPE.

<u>Cryogenics:</u> Cryogenic gloves when working with cryogenics. Face shields and cryo aprons are recommended.

<u>Fume Hoods:</u> All work that involves organic compounds, toxic materials, or malodorous compounds should be carried out in the fume hood. The Environmental Health and Safety staff analyzes hoods for performance in terms of air velocity at the mouth or intake point, and exhaust volume of air in cubic feet per minute. **Do not override or disable mechanical stops on the sash. Do not push the sash above the lock position nor place items in the front six inches of the hood**, as this diminishes exhaust capabilities. **Never place your head inside the hood.**

Be sure to turn on the fan any time you use a hood. If a hood is not working properly (for example, if the door does not close in position or if the fan motor is not operational), **students should tell their instructor AT ONCE.** Proper ventilation can make the difference between a safe working environment and a dangerous or toxic one.

A Question of Solubility: Materials of low aqueous solubility are sometimes categorized as being a lower environmental risk than their more soluble counterparts. However, this is not always the case. Trichloroethylene is a good example. At normal environmental temperatures (say 25°C), it has a solubility of about 0.1% (mass) and a specific gravity of 1.46. If a pint (a mole or so) were to spill into, say, a body of water, one might think it would just sink to the bottom and might not contaminate too much water because of its low solubility. However, a small concentration of trichloroethylene is sufficient to make drinking water non-potable. The pint spilled would be enough to contaminate 25 million gallons of water. This is bad enough, but trichloroethylene undergoes natural reactions (biodegradation and abiotic elimination) that transform the trichloroethylene into trans-1,2-dichloroethane and then into vinyl chloride, a potent carcinogen.

5.2 Waste Disposal

Waste Minimization Methods:

- Minimize mixing hazardous waste with non-hazardous waste, such as water. **Do not dilute hazardous waste.** This not only increases the volume necessary for disposal, but may also affect any reusable properties of the waste, such as British Thermal Unit (BTU)/heat value. The only exception is adding water to explosive chemicals to keep them wet.

- Segregate your waste according to waste streams, such as organic solvent waste (no water), photo fixer waste, aqueous waste with organic solvents, aqueous waste with toxic heavy metals, aqueous acidic waste, aqueous basic waste, metallic mercury waste, lubricating oil, formalin, or ethidium bromide.

- Use only compatible containers for collecting waste.

- Label all containers to prevent the generation of "unknowns." Label all stock, transfer, and waste containers appropriately. **All** containers must show:

    - ✔ The **chemical name** in English. It may never be abbreviated.

    - ✔ **Approximate concentrations** for each component in a mixture

    - ✔ The **hazards** associated with the chemical

    - ✔ **Generator information** that includes your name, phone number, the date, and your department

  Failure to label the contents of containers can result in very expensive disposal costs since unlabeled containers require special analytical or "fingerprinting" procedures to determine appropriate classification and disposal methods.

- Ensure that containers are in good condition, closed at all times, stored in bins or trays, adequately segregated, and inspected regularly.

- Avoid contamination of stock chemicals.

- Keep in mind that Reed College retains permanent liability for the management and appropriate disposal of your waste. As a means of ensuring compliance with the law, the DEQ and EPA may perform unannounced inspections at any time. Operations that do not meet regulatory requirements can result in substantial penalties, including fines of up to $25,000, per day, per violation. Over the past few years, numerous universities and colleges have been fined millions of dollars for violating hazardous waste requirements.

Sharps: Sometimes you will use hypodermic needles and syringes during chemical analysis or other work. Place disposable needles in red plastic "biohazard" containers, never in the trash. Consult the stockroom manager for the location of these containers.

Listed Toxic Wastes (among others): The following, among others, cannot go down the sink: **cyanides, sulfides, azides, and atrazine. Your lab instructor will provide a container in which to dump these wastes, and the Environmental Health and Safety personnel will take care of their disposal.**

5.3 Radiation Safety

Chemistry often makes use of methods involving radiation or radioactivity. Reed has facilities for X-ray diffraction (inorganic chemistry), X-ray fluorescence, gamma-ray spectrometry (analytical), and liquid scintillation counting. Radioactive materials may be prepared using the Reed reactor facility or purchased from commercial suppliers following approval by the radiation safety officer.

Always adhere to established safety procedures in all experiments involving radiation-emitting equipment or radioactive materials (see instructor[s] in charge of such equipment). All work involving radioactivity or radiation comes under Reed College's license from the State of Oregon Department of Health, radiation control section. At Reed, the radiation safety officer (RSO) and the radioactive materials committee (RAM), reporting to the president of the college, administer this license. Because one license covers all activities at Reed (except for the nuclear reactor, which has a Nuclear Regulatory Commission license), all uses involving radiation or radioactive materials must have prior authorization from the RAM committee.

Any student using radioactive materials, or radiation-emitting equipment, must receive training and pass an examination in radiation safety procedures from the RSO, before commencing experimentation. The RSO reviews all proposed purchases of radioactive materials, ascertains that the experimenters are qualified for safety, and ensures that the purchase is permitted under the radioactivity license granted to Reed by the State of Oregon. Address any questions concerning work with radioisotopes or radiation-emitting equipment to the RAM, RSO, or the faculty member authorized to use the equipment. You can reach the RAM or the RSO through the office of the Reactor Director or the Environmental Health and Safety office.

5.4 Laser Safety: Class IV-High Power Laser

Invisible Laser Radiation: Because the 1064 nm output of a Nd:YAG laser is invisible, it is extremely dangerous. Infrared radiation passes easily through the cornea, which focuses it on the retina, where it can cause instantaneous permanent damage. **Some precautions for the operation of Class IV-high power lasers:**

> **High Voltages Can Kill You:** In addition to beam-related hazards, lasers have non-beam hazards. Power supplies for lasers often double or even triple line voltages before feeding them to the laser head. Capacitors can still have a large voltage even if unplugged.
>
> In a near-fatal example, a researcher noticed condensation on the contacts of the power supply. While wiping away the moisture, he touched the anode and received a shock. He staggered into the hall, his heart stopped, and emergency responders used a defibrillator to restore his heartbeat.

- Keep the protective cover on the laser head at all times.
- Avoid looking at the output beam: even diffuse reflections are hazardous.
- Avoid wearing reflective jewelry while using the laser.
- Use protective eyewear at all times; selection depends on the wavelength and intensity of the radiation, the conditions of use, and the visual function required. For UV light, basic plastic safety goggles are sufficient.
- Expand the beam wherever possible to reduce beam intensity.
- Avoid blocking the output beam or its reflection with any part of the body.
- Establish a controlled access area for laser operation. Limit access to those trained in the principles of laser safety.
- Maintain a high ambient light level in the laser operation area so the pupils of the eyes remain constricted, reducing the possibility of damage.
- Post prominent warning signs near the laser operation area.
- Set up experiments so the laser beam is either above or below eye level.
- Provide enclosures for beam paths whenever possible.
- Set up shields to prevent unnecessary specular reflections.
- Set up an energy-absorbing target to capture the laser beam, preventing unnecessary reflections or scattering.

5.5 Dealing with Tanks of Compressed or Liquefied Gas

When dealing with tanks of compressed or liquefied gas, remember to:

- **Securely fasten all gas tanks, functioning at floor level, in position with a strap and a device anchored to the edge of the bench.** The pressure inside the most commonly used gas tanks (oxygen, nitrogen) is so high (about 200 atmospheres) that enormous damage can be done if they are knocked over and cracked (they will become random rockets). **Only those people who are experienced in moving gas cylinders may transport a gas cylinder from one location to another, and then, only with the use of a special cradle and straps.** The gas tanks are usually heavy, large, and very unwieldy. The uninitiated can easily be surprised and maneuvered into a dangerous situation. Before moving a tank, remove the regulator and replace the protective cap.

- Refer to the manufacturer's catalog (usually the Matheson Co.) to **determine the appropriate type of regulator for a particular gas tank.** Some regulators (such as those for hydrogen) are made with left-handed screw threads. Some regulators are made of special corrosion-resisting alloys (for example, HCl, HBr, Chlorine, NO_2), and others are fitted with dials. Simple ones are not. **Never** try to fit a regulator to a tank without first checking with your instructor or with the stockroom manager. **Never** use any lubricant on a high-pressure oxygen regulator; it will explode. Use a paintbrush to easily check seals. Dip the paintbrush in mildly soapy water. "Paint" onto areas where leak is suspected or likely. Check for bubbles.

- Always use a well-ventilated hood if your gas tank contains toxic or corrosive gases.

5.6 Low Pressure—Vacuum Systems

The main concern of low-pressure work is that certain vessels may implode and shatter when evacuated. Although spherical flasks resist external pressure changes best because the stress is equally applied, the same does not apply to Erlenmeyer flasks, which implode when evacuated. Always inspect your glassware for small cracks and etched lines before using it in the laboratory.

Considerable risk is associated with the evacuation of large vessels. Round-bottom flasks larger than one liter should not be evacuated (they are not thick enough). Desiccators that are evacuable ("vacuum desiccators") are made of especially thick glass, including flanges that must be well greased and/or fitted with O-rings.

Exercise great care in handling Dewar flasks and other evacuated vessels. These are normally taped to provide protection in case of implosion. You should wear eye protection when handling Dewars.

5.7 Peroxide Issues

Since ethers and alcohols are among the most commonly used organic solvents, their reaction with oxygen in the air deserves special attention.

Ethers and alcohols containing hydrogen bonded in the alpha position react with oxygen of the air in an autocatalytic process. This means the rate of absorption of oxygen is slow at first but rapidly accelerates to **produce dangerously explosive**

hydroperoxides and peroxides. Generally, these peroxides are soluble in the ether or alcohol so that they are not visible. Because their boiling points are higher than the ether, they become concentrated and leave an extremely dangerous residue from any distillation of the ether or alcohol.

Diethyl ether, the most commonly used ether, is supplied in two major grades.

- Commercial, which contains water and ethanol, is the grade used for most extractions.

- Anhydrous diethyl ether is supplied in sealed cans and contains a small amount of "stabilizing" agent—that is, a compound that reacts rapidly with the initial free radicals formed by reaction with oxygen and hence eliminates the autocatalytic effect. Because this stabilizer is present in a very small amount, it does not provide long-term protection against peroxide formation once someone opens the can.

In addition to diethyl ether, other commonly used ethers and alcohols are dioxane, tetrahydrofuran, di-isopropyl ether, glyme (the dimethyl ether of ethylene glycol), diglyme, triglyme, 2-butanol, 2-octanol, and cyclohexanol. All of these ethers form peroxides and should be used with the following precautions:

> **Chicago, Illinois:** In the mid-nineties a company delivered over 30 boxes of bottles containing old laboratory chemicals (over 1000 containers) from one of their facilities to another, located several miles away. Inside one of the boxes were two 12-year-old, one-gallon bottles of 1,4-dioxane. While the bottles were being prepared for shipment, someone discovered the dioxane had peroxidized. The bottles were clear, and several *inches* of peroxide crystals were plainly visible in the bottom of both bottles. The fire department's bomb squad was called. They carefully removed the material from the building and safely detonated it on site.

- All containers for these ethers and alcohols should remain well sealed when not in use. Particularly in the case of the more volatile ether or alcohol, a loose stopper allows both a slow evaporation and reaction with oxygen. Consequently, the peroxides gradually accumulate in the residue as the volume declines.

- Do not return unused chemicals to the container.

- Keep containers away from all ignition sources such as direct light, hot surfaces, flames, sparks, and other heat-producers.

- Record on each container the date received, the expiration date, and the date the container is opened (see following sample).

WARNING: MAY FORM EXPLOSIVE PEROXIDES			
Date received:	Date opened:	Testing interval: **3 or 12 months** (circle one)	
Date:	Result: (in ppm)	Date:	Result: (in ppm)
Date:	Result: (in ppm)	Date:	Result: (in ppm)

- Monitor container volume for evaporative loss and test for the presence of peroxides before each use. Assume peroxide forming chemicals contain peroxides unless they have been recently tested. Record on the container the test data for the next user.

- Store the substance in an airtight amber glass bottle that protects the chemical from light while allowing you to see the chemical without opening the container. Store under inert gas when possible.

- To minimize the rate of decomposition, store peroxides at the lowest possible temperature consistent with their solubility or freezing point. Do not store liquid peroxides or solutions at or lower than the temperature at which the peroxide freezes or precipitates because peroxides in these forms are extremely sensitive to shock and heat.

- Do not use metal spatulas to handle peroxides. Contamination by metals can lead to explosive decomposition. Magnetic stirring bars can unintentionally introduce iron, which can initiate an explosive reaction of peroxides. Use ceramic, Teflon, or wooden spatulas and stirring blades if you know that the material is not shock sensitive.

- Never scrape or scrub glassware and containers that have been used with peroxide-forming compounds if you see an oily or crusty residue. Avoid friction, grinding, and all forms of impact near peroxides, especially solid peroxides.

- Test and properly dispose of chemicals past their expiration date.

- Whenever possible, consider process modification and material substitution.

- Open containers will be tested for peroxides (every 3 or 12 months) once opened and discarded as necessary.

<u>Tests for peroxides and their removal</u>

EHS will not accept peroxide forming chemicals that have exceeded their retention times unless they

You be the judge: An anonymous research university. Sometime in the early seventies, a researcher did behavioral studies of small rodents. After the rodents were put through their paces and the data were evaluated, the rodents were killed and preserved for future tissue analysis using diethyl ether. After a while, the refrigerator was full of preserved specimens. One day the refrigerator's compressor kicked in, sparked, and ignited the ether fumes in the refrigerator. The resulting explosion blew the refrigerator's door off its hinges, and small flaming rodents were scattered across the room, torching it in seconds. Fortunately, the lab door was closed, so the fire did not spread.

have been tested and the peroxide concentration has been reduced to < 0.001 % (< 10 ppm).

Peroxides can be detected by in one of two ways --using peroxide test paper available in the stockroom (see the stockroom manager for more information) or conducting an iodide test with a freshly prepared solution of KI that has been acidified with glacial acetic acid. **Before** taking these steps, you **must talk with your instructor.**

A note about **biological extractions**: Those who use ether or alcohol for the extraction of biological materials must be particularly careful. There is danger that nothing was extracted and that only the peroxide remains to explode on evaporation. Generally, if other organic material is present, the peroxide will not explode—it will simply destroy some of this material rather than detonate.

<u>A List of Some Peroxidizable Compounds</u>

acetal
acetophenone
amyl acetate
butadiene
chloroethyl ether
chloroprene
cyclohexane
cyclohexanol
cyclohexanone
cyclohexene
cyclopentene
cyclopropylmethyl ketone
dicyclopentadiene
diisopropyl ether (isopropyl ether, DIPE)
1,1-dichloroethylene
dimethoxymethane
dimethoxypropane
2,4-dimethyl-3-pentanol
dioxane
ethylene glycol dimethyl ether
ethyl ether
furan
hexachlorobutadiene
3-hexanone
hexyne
isobutyl alcohol
isobutyraldehyde
isopropyl alcohol
isopropyl ether
methyl crotonate
methyl cyclohexane
methyl cyclohexene
methyl hexyl ketone
methyl isobutyl ketone
methyl methoxyacetate
1,5-pentanediol
2-pentanol
3-pentanone
potassium amide
potassium metal
1,3-propanediol
sec-butyl alcohol
sodium amide (sodamide)
tetrahydrofuran
tetrafluoroethylene
vinylidene chloride

5.8 Flammability

Information about the fire hazards of various chemicals may be found in *The Chemists' Companion,* A.J. Gordon and R.A. Ford (John Wiley & Sons, New York, 1972), pages 510–513, on reserve for Chemistry 210. The "Flash Point" is the minimum temperature at which the vapors ignite and initiate continuous burning of the liquid or solid when in contact with sparks, flames, or other ignition sources. The "Ignition Temperature" is the temperature (in °F) at which the material will spontaneously inflame in air. Give special attention to those compounds with ignition temperatures less than 500°F. Their vapors will readily ignite on contact with any moderately hot surface, such as that of a hot plate, or by allowing air into any distillation system which has been heated to 200° to 250°C (a not uncommon temperature). In addition, some cases call for special attention: CS_2 will ignite at

212°F or 100°C, and its vapor may ignite at a warm room temperature, 86°F. Hence, keep it under water. Notice also the low flash points for commonly used solvents such as acetone, 0°F; dioxane, 54°F; diethyl ether, -49°F; ethyl alcohol, 55°F; n-hexane, -7°F (typical of gasoline); toluene, 40°F. This means that the slightest spark from a stirring motor or hot plate control switch is sufficient to initiate a fire at room temperature for such solvents.

Another property related to fire and explosion hazards in the handling of chemicals is the percent by volume, which is flammable in a vapor/air mixture. This information is also in the *Chemists' Companion* reference. You will notice that even very low percent of vapor in the air supports burning or explosive combustion. Many substances will support combustion in as little as 1 to 5% concentrations in air. Additional information in this property is to be found in the "CRC Handbook of Chemistry and Physics," Section D, under the heading "Limits of Inflammability." Note in particular the wide ranges for hydrogen, acetylene, ethylene oxide, carbon monoxide, acetaldehyde, and carbon disulfide.

In summary, since the majority of organic liquids have flash points at or below room temperature and are flammable at a very low concentration in air, the safest procedures are those that avoid contact between organic vapor and **any** sources of sparks or flame. In order to minimize flammability hazards you must observe the following precautions:

- Before pouring any volatile liquid (b.p. less than 150°C), inspect the bench area for flames or for hot plates turned on, even if only for stirring. The more volatile the liquid, the farther away the "foreign" hot plate must be. Large-scale transfers involving hundreds of milliliters should occur only in a hood and with no flames or hot plate turned on in the hood area.

- Your lab is equipped with steam baths, silicone oil baths for use on hot plates, and heating mantles to use as heating sources. Do not use Bunsen burners, except in unusual circumstances.

- Before opening any system containing hot organic vapors, **turn off** the hot plate that has supplied the heat. Also, because of the spontaneous ignition problem cited above, never allow air into a system containing organic vapors above 150°C. For example, mixtures of air with dioxane and ethyl ether will ignite explosively above 185°C. Normally such compounds will not be present at this temperature; however, serious explosions have been reported in systems that were at 200°C in a vacuum and were generating dioxane by a decomposition process.

King County, Washington. One day a carpenter was working in the chemistry building. At one point, he needed to drill a hole in a four-by-eight-foot sheet of plywood. He began to drill when suddenly the entire board burst into flames. Fortunately, he escaped with only superficial burns. The fire was put out fairly quickly, and damage was not significant. During the investigation, inspectors determined that a lab had a perchloric acid hood that was vented up a pipe that ran adjacent to the exploding board. A poor seal between two sections of the vent pipes allowed perchloric acid fumes to impregnate the wood.

5.9 Detonation

Detonation may occur whenever an exothermic reaction with low activation energy generates gaseous products. In some cases, such as with acetylene, azides, and diazomethane, unstable molecules rearrange to give more stable molecules, such as graphite, H_2, and N_2. In a large number of examples, detonation is the consequence of a redox reaction occurring between molecules such as $H_2 + O_2$, or $Cl_2 + CH_4$; or, as in the case of explosives such as nitroglycerine and other organic nitrates, by "internal" redox reactions. The following compounds are representative of those for which special precautions are necessary:

- Compounds containing several nitrogen atoms linked, especially by multiple bonds, such as azo compounds (except azobenzene and related aromatics), diazonium salts, azides, triazenes, and tetrazenes.

- Diazomethane is a particularly dangerous substance since it is both very toxic and unpredictably and violently explosive.

- All organic derivatives of hydrogen peroxide, such as peroxides (ROOR), hydroperoxides (ROOH), peracids [RCO (OOH)], and diacyl or diaryl peroxides (R-CO-O)2.

- Fulminates (salts of HONC) and heavy metal salts of acetylene.

- Any organic ester of a strongly oxidizing acid such as nitric, chromic, perchloric, and permanganic.

Hence, use a dilute aqueous solution to prevent danger of violent detonation when anticipating the use of mixtures of organic materials with any of these acids. Unfortunately, the literature is full of descriptions of the use of these reagents without appropriate warnings and precautions. Nitrates are familiar as the explosive nitroglycerine. Organic oxidations use chromic acid and potassium permanganate in a variety of solvent mixtures. Perchlorate salts are used as drying agents. Used in an appropriate manner, and with a clear understanding of their dangers, these reagents are quite useful. However, the literature records many instances of the abrupt and unfortunate consequences for a failure to recognize the inherent dangers of contact between nitric acid, chromic, perchloric, or permanganic acid and any organic material. **DO NOT pour chromic acid or permanganic acid in the sink AT ALL!** (Any questions, please consult your lab instructor.)

5.10 Skin Contamination; Protective Clothing

The skin is a very sensitive organ that can be adversely affected and permanently damaged by some chemicals. Inform your instructor and your dermatologist immediately in case of injury. The most common injuries to the skin include:

- **Cuts:** from broken glass (tubing, broken thermometers, damaged glass vessels), from the edges of paper sheets, from sharp metal edges and points, and from abrasions. First aid: wash wound with water and stop bleeding, if any. Tell the lab instructor.

- **Chemical Hazards**: The following compounds are the ones you will most likely encounter in ordinary laboratory work. They also represent members of larger classes of compounds with similar properties. As you become more familiar with chemicals, you need to develop an understanding of those chemical and physical properties that create hazard. In this way, you can anticipate potential hazards when you encounter chemicals not specifically listed here.

- **Thermal burns:** burns from hot objects.

- **Corrosive burns:** from acids, alkalis, some salts, compounds that react rapidly with water (such as acid halides, anhydrides such as phosphorus pentoxide), some oxidizing agents (hydrogen peroxide).

- **Attack by vesicants** (blistering agents) such as bromoketones, mustard gas $(ClCH_2CH_2)2S$, and analogous chemicals.

- **Frostbite:** from handling dry ice (-80°C) or cryogenic liquids.

- **Allergic reactions:** such as rashes resulting from contact with certain phenols (poison oak or poison ivy constituents) and other types of chemicals for which students may have individual susceptibility.

In general, you can do a great deal to minimize these dangers. Gloves provide good protection for most problems associated with hands. Students should take care to select the proper protective gloves that are appropriate to the hazard. You can get assistance in glove selection from the class instructor or the Environmental Health and Safety office (503-777-7788; ext. 7788). No single type of glove will protect you from all hazards. Thin gloves, such as the blue nitrile gloves used in most labs, provide protection from many common chemicals and give the best tactile sensation, but are easily punctured. Thick rubber gloves afford good protection from the more corrosive and penetrating chemicals like acids, but give poor tactile sensation and can be slippery. Make sure that you examine gloves for holes or discoloration before use. It is urged that you wash your hands, with the gloves on, before removing them. This will decrease the likelihood of contaminating yourself or others while your gloves are being removed and disposed of.

You can find more information on the resistance of some common glove materials to various chemical classes in section 7.2.

6 General Hazards

6.1 Floods

At a minimum, floods are a nuisance. If however, water enters a hot oil bath, or leaks into electrical equipment or onto the floor, the resulting damage can be considerable, and potentially dangerous. Common flooding sources include condenser hose, steam baths, ice baths, hoses from steam lines, stopped-up sinks, drains too full (inside bench in organic lab), and excessive delivery rate of water.

A common cause of floods is improperly attaching a rubber hose to a condenser. The hose diameter must match the diameter of the glass tubing (see your instructor), and two hands must be used when attaching the hose to the condenser. In cases of difficulty when attempting to attach the tubing, moisten the glass with water but do not use oil or grease (because the hose will eventually slide off and cause a flood). However, in other cases where tubing must be quickly removed from glass, use a drop of silicone oil for lubrication so that the connection remains flexible and the tubing can be removed at any time. In special cases (for instance, if a condenser must operate overnight or otherwise left unattended) secure the tubing with special clamps; see your instructor. Inspect tubing periodically for pinhole leaks, cracking due to rubber tears, and other damage (such as from very hot equipment). Rubber tubing used in steam lines deteriorates over relatively short periods and should therefore be inspected frequently and replaced, when indicated.

Water flow rates that are too high will cause rubber hoses to swell up ("balloon") and burst. The result will be wasteful splashing, which can cause floors to become dangerously slippery.

In cases in which it is more imperative to monitor the flow rate, use a special "flow watchman," in which a red ball is impelled around a circle by the moving water. Check with your instructor. When you connect steam baths, make sure that the steam enters the top tube and condensed water emerges at the bottom tube. Steam baths will collect undrained water and cause a flood if:

- the draining hose is blocked (not at all uncommon, see above),
- the draining hose rises at some point to a level higher than the bottom of the bath, or the draining hose is kinked, such that bubbles of air are trapped, preventing smooth drainage.

All steam lines must remain connected to a drain, since all of them leak, even when not in use. **ALWAYS** replace your steam bath, after you have finished using it, with a direct hose from steam valve to drain.

When operating the steam valve, do not run steam at any more than a low flow rate: once a bath gets to 100°C, it will not get hotter from a faster steam flow. The idea that it might is a very common misconception. Excessive steam can contaminate your experiment as well as others' experiments.

Floods from ice baths are not very common, but will occur when large vessels are set into a rather full bath. If a large amount of ice is piled up in the bath, and subsequently left unattended for a long period, flooding can also occur.

All sinks are fitted with a strainer to remove large particles and help prevent the drains from becoming blocked. **Do not** put corks, tubing, glassware, labels, and similar items into **any** sink. These items can cause the strainer to become blocked. If you find a sink containing these items, carefully remove and discard them using gloved hands. Pay close attention for the possible presence of small shards of broken glass that may accumulate near the drain.

Finally, use reasonable flow rates of water in condensers and in sinks. If a faucet handle is stiff, obtain assistance: sudden spurts of water might result if you turn it on suddenly. **Always observe the exit hose** on a condenser when you are adjusting the flow rate; a continuous, strong trickle is satisfactory, since increasing the rate of water does not improve condensation rates. Monitor the flow rates during the first few minutes of operation. Do not turn the water on, inspect the outflow, and then assume that the flow rate will be constant. The washer in the faucet may swell in the initial stages, reduce the flow rate, and require an adjustment.

6.2 Electrical Hazards — 110 v 60 Hz AC; Grounding, D.C., High Voltage

Every piece of electrical equipment used by laboratory workers and operated on 110 volts AC from the laboratory supply must be grounded (and therefore have a three-wire cord terminating in a three-pin plug). Bring to the attention of the instructor any piece of such equipment that is not properly connected. Equipment that has only a two-wire cord may give rise to electrical shocks under certain conditions, especially if:

- The floor is wet. Never step on a damp floor when handling live apparatus.

- If the AC voltage is higher than 110 volts, special plugs are usually necessary. Check to see that the case of this equipment (certain heavy-duty furnaces and large electric motors) is grounded. In general, all DC and high-voltage circuits should have ground wires.

Do not use any piece of electrical equipment where inspection shows a break in the insulation of power cord wires. Report such breaks immediately to your instructor so that the equipment can be sent for repair.

It is also important to place electrical equipment in an area that will minimize the possibility of spills onto the equipment or the presence of flammable vapors around it.

6.3 Stoppers—Swelling in Solvents

Rubber stoppers will swell when exposed to the vapors of many organic solvents. In some cases, the action is extreme, and the stopper will be forced out of the flask. The action can occur at room temperature or when hot. If it is important that samples are tightly sealed, use glass or some other kind of stopper. Consult your instructor.

6.4 High Temperatures—Hot Plates, Heating Mantles, and Furnaces

Unsafe operation at high temperatures can cause burns, explosions (from trapped steam or gases, for example), detonations (from pyrolysis of unstable compounds or mixtures or other causes), and fires.

Use only hot plates that are fitted with a light that indicates that they are working. When you switch off a hot plate, do not forget that while it is still hot, it is a hazard to others. Label it appropriately so that the next person who tries to pick it up does not suffer an accident. Do not return hot plates to the side shelves while they are still hot. Similarly, if a dish of hot oil resides on this hot plate, either leave a thermometer in it (so that the next person can judge how hot the oil is) or attach a note. **Do not move hot oil baths**; consult the instructor if it is necessary to do so. **Never** connect heating mantles directly to the 110-volt VC supply. Use a voltage control device.

6.5 Superheated Liquids

Liquids will not boil smoothly unless a source of nuclei is present on which the bubbles of vapor may readily form. Boiling liquids that suddenly vaporize can lurch out of vessels with almost explosive force and scatter hot liquid over innocent bystanders. This problem is especially troublesome in vacuum distillations and in systems containing precipitates.

For work at atmospheric pressure, you can overcome most problems by very good stirring. A magnetic stirrer will provide enough nuclei if the liquid is devoid of precipitates. If dense precipitates are present, use a paddle stirrer.

> **Not just hot liquids: a California biotech firm.** A lab worker was removing a small Eppendorf tube out of liquid nitrogen. He was not sure it was the correct one and was examining the small lettering very closely. Apparently, some liquid nitrogen had seeped into the tube over time and was now approaching room temperature. It expanded, though the tube did not. The tube shattered, and plastic shrapnel struck his eye. He was rushed to hospital for emergency surgery. He had his protective eyewear in his lab coat pocket…

Boiling chips are either porous, solid lumps that contain trapped air that is released on heating, thus providing a stream of nuclei for even boiling, or they have sharp edges such as carborundum chips. It is important to realize that boiling chips have several limitations:

- They will not prevent "bumping" or lurching (see above) in systems that contain precipitates.
- They will not work if they are used in a hot system that is later cooled and then reheated. A new chip must be added, since the pores of the used boiling chips will be clogged by liquid.
- They are useless in vacuum; after about five seconds, all the air is sucked out.

In a vacuum distillation, the easiest way for providing nuclei is to stir the solution in a magnetic stirrer. **Caution**: Never add a boiling chip or initiate stirring when the liquid is hot. An eruption will result.

6.6 Heating Closed Systems—Unintentional and Intentional

The unintentional assembly of a sealed system (no opportunity for the escape of expanding gases upon heating) and consequent rise in internal pressure is much more common than one usually realizes. There are special adapters for use in distillations (the most common example of this danger) that allow the escape of air through side-arm **S**.

Sometimes students express concern that when heating a liquid under reflux, vapors might escape from the top of the condenser and material might be lost. Many students suppose the remedy is to insert a stopper. This is dangerous. Since there is no way for heated air to escape, the stopper will blow out, and could potentially poke your eye out (or cause some other painful or embarrassing experience). If indeed vapors are expected to issue from the top of the condenser (for example, if the water temperature in the cooling jacket is not much lower than that of the boiling liquid, as may be the case with ether or pentane) the remedy options are:

- Use a more efficient condenser (consult the instructor).
- Lower the temperature of the cooling water (circulating pump, ice water).
- Use a special condenser that employs dry ice.
- Use the fume hood.

Another unintentional construction of a sealed system is by the use of drying tubes (such as those on condensers) that contain drying agent that has become clogged (because of overexposure to atmospheric moisture, for example). Store anhydrous calcium chloride, commonly used in drying tubes, in a sealed condition. For example, you can use a rubber stopper in the wide end, and with rubber tubing and a screw clamp over the narrow end to prevent it from becoming fused into a block.

Examples of intentional use of sealed systems are:

- Urea tubes and Carius tubes
- Medium pressure catalytic hydrogenation equipment
- High-pressure "bomb" or autoclave equipment

Before using any of these different types of equipment, the student must consult a faculty member, preferably the faculty member in charge of the equipment.

You will use a specific construction for the successful resistance to the mechanical deformations expected. In the case of high-pressure autoclaves, the equipment is impressively sturdy, with thick steel walls and special heads that must be screwed down in a definite sequence. Inspect the special seals frequently.

6.7 Toxicity

Since so many commonly used reagents and solvents are toxic in some way, it is not possible to avoid entirely the use of toxic materials. For this reason, students must become familiar with the safe techniques appropriate for the use of each substance.

Toxicity data alone are not sufficient to indicate the degree of hazard involved in the use of these reagents. For example, note that carbon monoxide is not as toxic as many of the compounds listed; however, it is actually more dangerous than many of the others since it is odorless, colorless, and tasteless, and there is no obvious indication of a build-up of its concentration to a lethal level. Phosgene is doubly dangerous, in that it is lethal at low levels, and it is not as irritating as substances such as chlorine or bromine. An individual exposed to phosgene may show no sign of its effects until 8–12 hours after exposure, at which time pulmonary edema (respiratory failure) may have become fatal. Hydrogen cyanide has a characteristic odor, but it is not as unpleasant as hydrogen sulfide, which is detectable by odor in very low concentrations. On the other hand, hydrogen sulfide produces fatigue in the olfactory sensory apparatus. A person who has been exposed to very high concentrations cannot detect the difference between sub-lethal and lethal levels.

Note that some of the common solvents, such as chloroform, carbon tetrachloride, and benzene, are not very toxic on immediate and one-time exposures; however, their toxicity is far more insidious. In the case of CCl_4, two large exposures on consecutive days produce a cumulative effect on the liver (hepatotoxicity) and other organs that may not be fatal until hours after the second exposure. Benzene, which has been commonly used in large amounts as a solvent and reagent, is a known human carcinogen that causes aplastic anemia (bone marrow failure). Similarly, hydrazine and HMPA (hexamethylphosphoramide) have only recently been clearly identified as potent carcinogens. Therefore, treat all chemicals with caution as if they were potentially toxic.

Methyl bromide and dimethyl sulfate represent a class of compounds that become toxic as a result of their "methylating" effect in biological systems. You may not encounter other members of this class as frequently, such as CH_3Cl, methyl chloride, and $F\text{-}SO_2\text{-}OCH_3$ methyl fluorosulfonate (magic methyl), but always recognize the danger of any structure that shares the ability to methylate susceptible functional groups.

Diazomethane, CH_2N_2, is not only a powerful methylating agent, but as noted above it is also extremely sensitive to spontaneous detonation. If you have an occasion to use CH_2N_2, consult an instructor before proceeding.

6.8 Vesicants, Sternutators, Lachrymators, Allergens, and Burning Agents

While many compounds with these properties are fatal if an overexposure occurs, in general, they are so unpleasant they provide ample warning of their presence. Use these in fume hoods and with suitable trapping arrangements.

With many of these reagents, it is not sufficient to aspirate their vapors into the sink, since they will escape and create a very unpleasant atmosphere for everyone in the building. Use trap systems that are appropriate for the compound with which you are working.

These compounds produce particularly unpleasant reactions if carried from your hands to sensitive areas of the skin, such as mouth, nose, and eyes. Frequent hand washing is essential in order to avoid such contamination.

Based on the compounds listed below, you can begin to predict candidates for an adverse unpleasant reaction:

- **Haloethers**, ROCH2X (note that ClCH2OCH2Cl is also a particularly potent carcinogen)
- **Alpha halo carbonyls**, R-CO-CH2X
- **Benzyl and allyl halides**, ArCH2X, H2C=CH-CH2X (mace and other "tear gases" are in these categories)
- **Acyl halides**
- **Sulfur and nitrogen mustards** and related structures, S(CH2CH2X)2, RN(CH2CH2X)2 (also extremely toxic)
- **Acrolein**, CH2=CH-CHO (burning cooking grease)
- **Quinones** (sternutators)
- **Alkyl substituted phenols** (active ingredients in poison ivy and poison oak)
- **HF and other hydrolyzable fluorine compounds** (not only toxic in a most unpleasant manner, but also produce burns that heal very slowly).

6.9 Stinkies (a.k.a. unpleasantly odoriferous)

While many of the toxic and vesicant compounds also have unpleasant odors, many compounds that may not be particularly harmful may have odors that cause nausea, or at least create a very unpleasant work area.

The spreading of such substances from your own work area into areas used by others is inconsiderate. You must avoid this by every means possible. Certainly, use a fume hood. Other preventative measures include:

- Using a "quenching" material into which all of the apparatus goes (so as to remove the odor before contamination of the lab space)
- The use of paper laid down over the work area and removed later so as not to leave a permanent odor on the lab bench
- Caution about moving containers and apparatus around in such a way as to leave a trail of unpleasant stench.

Compounds of this type—almost all low molecular weight aliphatic acids up to about C_{10}—include:

- **Butyric acid**—rancid butter, stale perspiration
- **Valeric acid**—unpleasantly strong cheese, old tennis shoes
- **Caproic, caprylic, capric**—note the Latin root, "Capr" for goat
- **Phenylacetic acid**—sweaty horse

- **Cyclohexanecarboxylic acid**—canine fecal matter
- **Thioacetone**—"Stinken ahnlich dem Geruch von Katzepisse!" (ref. By A.F. Scott)
- **3-Methylindole**—feces
- **Thiols** (**mercaptans**) and **sulfides**—lower members like H_2S (rotten eggs), 4 carbon saturated and unsaturated—used by the skunk, the "odor" of natural gas is that of t-butyl mercaptan (put in to make the odorless CH_4 detectable)
- **Pyridine**—persistently acrid taste (from vapor only)
- **Lower amines**—ammonia-like, longer chains—rotten fish
- **Isocyanides**, CS_2—bad or rotten drain.

7 References:

7.1 Chemical Hazards and Toxicity:

Registry of Toxic Effects of Chemical Substances: http://search.proquest.com

NIOSH Pocket Guide to Chemical Hazards: http://www.cdc.gov/niosh/npg/npg.html

Occupational Safety and Health Administration [Federal]: http://www.osha.gov

Oregon Occupational Safety and Health Administration:
http://www.cbs.state.or.us/osha/

7.2 Chemical Resistance Guide

When choosing gloves or other protective equipment, consult a manufacturer's compatibility chart. Include the following criteria when choosing gloves:

- Make sure to pick one that is thick enough to protect against chemical and physical damage, but still provides the dexterity needed to handle and feel the work.
- Consider the type of work you will do. For example, a nylon cryogenic glove will be damaged if a hot item is handled, whereas a “hot mitt” will not protect the wearer when liquid nitrogen is used, as it may be too porous.
- Determine how long the glove needs to be. Is wrist length adequate, or do you need one that extends further up your arm.

The selected links below to glove manufacturers provide compatibility information. To find others, look at a specific manufacturer’s website or check out the NIOSH webpage at http://www.cdc.gov/niosh/ppe/.

Ansell	http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf
Aurelia	http://www.aureliagloves.com/industry/laboratory/#all.html

Best	www.chemrest.com
Kimberly-Clark	http://www.uic.edu/depts/envh/HSS/Documents/Resistance Guide for Kimberly Clark Nitrile Gloves.pdf
Microflex	http://www.microflex.com/Products/~/media/Files/Literature/Domestic Reference Materials/DOM_Reference_Chemical Resistance.ashx
North	http://webfiles.ehs.ufl.edu/North.pdf
VWR	http://eta-safety.lbl.gov/sites/all/files/vwr%20chemical%20resistance%20gloves%20chart.pdf

Manufacturers use different rating systems. Some use a color code, such as red = bad, yellow = not recommended, green = good. Others use a letter code, such as E = excellent, G = Good, P = poor, NR = Not Recommended, or a combination of these.

Compatibility charts also use a number of terms:

- Permeation: the ability of a chemical to diffuse through the glove on a molecular basis.
- Breakthrough time: time it takes for the chemical to travel through the glove material. This is only recorded at the detectable level on the inside surface of the glove.
- Degradation: the physical change that happens to the glove material as it is affected by the chemical. This includes swelling, shrinking, hardening, cracking, discoloring, etc. of the glove material.

Remember, when you select gloves for use in the laboratory, one type/brand may not be suitable for every situation. If you have any questions about the glove you should be using, contact your instructor or EHS for assistance.

8 Appendix: Communicating Chemical Hazards

In 2012, the Occupational Safety and Health Administration (OSHA) updated the Hazard Communication Rule, 29 CRF 1910.1200. The changes standardize the content of safety data sheets (SDSs) and require the use of pictograms, signal words, and statements that identify hazards and precautions.

8.1 The SDS 16-Section Format

- Section 1, Identification includes product identifiers; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
- Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.
- Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.
- Section 4, First-aid measures includes important symptoms/effects, acute, delayed; required treatment.
- Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.
- Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.
- Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities
- Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
- Section 9, Physical and chemical properties lists the chemical's characteristics.
- Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.
- Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
- Section 12, Ecological information
- Section 13, Disposal considerations
- Section 14, Transport information
- Section 15, Regulatory information
- Section 16, Other information, includes the date of preparation or last revision preparation or last revision.

8.2 The Pictograms and Hazard Classes

<u>Flame Over Circle</u>  Oxidizers	<u>Flame</u>  Flammables Self Reactives Pyrophorics Self-Heating Emits Flammable Gas Organic Peroxides	<u>Exploding Bomb</u>  Explosives Self Reactives Organic Peroxides
<u>Skull and Crossbones</u>  Acute toxicity (severe)	<u>Corrosion</u>  Corrosive to Metal Skin Corrosion Serious Eye Damage	<u>Gas Cylinder</u>  Gases Under Pressure Liquefied Gas
<u>Health</u>  Carcinogen Respiratory Sensitizer Reproductive Toxicity Target Organ Toxicity Germ Cell Mutagen Aspiration Toxicity	<u>Environment</u>  Environmental Toxicity	<u>Exclamation Mark</u>  Skin Irritant Dermal Sensitizer Acute Toxicity (harmful) Narcotic Effects Respiratory Irritation Eye Irritation

8.3 Labels

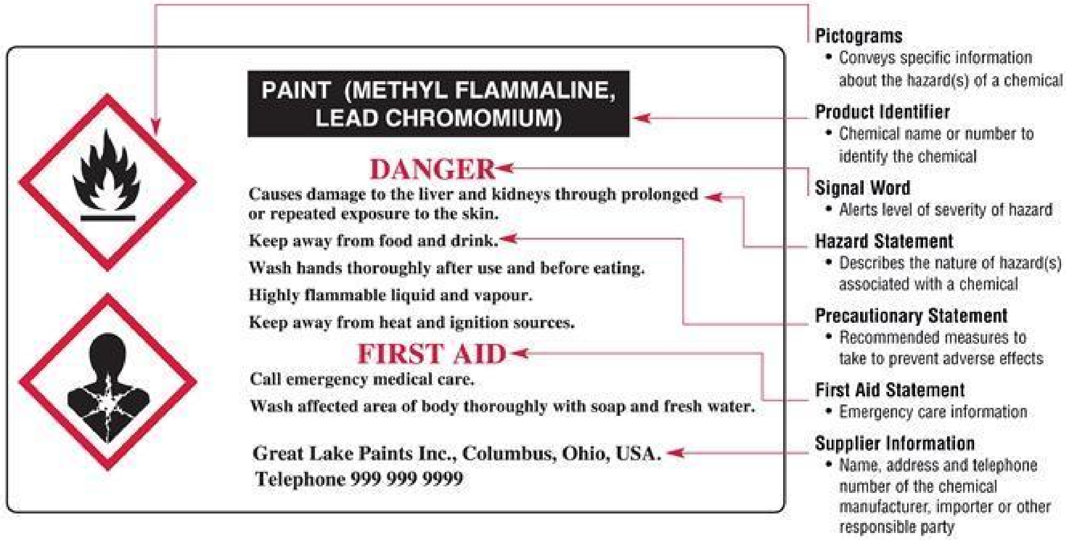
All labels from manufacturers must have the following information:

- pictograms
- a signal word: "danger" or "warning" or "caution"
- hazard statements that describe the physical, health, and/or environmental hazards
- precautionary statements that describe measures to minimize or prevent adverse effects. There are four types – "prevention," "response," "storage," and "disposal." For example, for a product identified as acutely toxic – oral, we would see the following:

Prevention	Response	Storage	Disposal
Wash ...thoroughly after handling. ... Chemical manufacturer, importer, or distributor to specify parts of the body to be washed after handling. **Do not eat, drink, or smoke when using this product.**	**If swallowed: Immediately call a poison center/doctor/...** ... Chemical manufacturer, importer, or distributor to specify the appropriate source of emergency medical advice. **Specific treatment (see ... on this label)** ... Reference to supplemental first aid instruction. - if immediate administration of antidote is required. **Rinse mouth.**	**Store locked up.**	**Dispose of contents/container to...** ... in accordance with local/regional/national/international regulations (to be specified).

- the product identifier
- supplier identification

A sample label, identifying the required label elements, is shown below. Supplemental information can also be provided on the label as needed.


PAINT (METHYL FLAMMALINE, LEAD CHROMOMIUM)
DANGER
Causes damage to the liver and kidneys through prolonged or repeated exposure to the skin.
Keep away from food and drink.
Wash hands thoroughly after use and before eating.
Highly flammable liquid and vapour.
Keep away from heat and ignition sources.
FIRST AID
Call emergency medical care.
Wash affected area of body thoroughly with soap and fresh water.
Great Lake Paints Inc., Columbus, Ohio, USA.
Telephone 999 999 9999
Pictograms
• Conveys specific information about the hazard(s) of a chemical
Product Identifier
• Chemical name or number to identify the chemical
Signal Word
• Alerts level of severity of hazard
Hazard Statement
• Describes the nature of hazard(s) associated with a chemical
Precautionary Statement
• Recommended measures to take to prevent adverse effects
First Aid Statement
• Emergency care information
Supplier Information
• Name, address and telephone number of the chemical manufacturer, importer or other responsible party

9 Notes

10 STATEMENT

I, the undersigned

____

(print student's name)

hereby declare that I have read the Reed College chemistry department's 2022 edition of *Chemistry Laboratory Safety Manual* and that I have understood its contents. I hereby undertake not to engage in any laboratory work whatsoever except that covered by the statement in Chapter 2 titled "Normal Building Hours and Rules" of work in the chemistry department on page 6 of the above manual.

In particular, I agree never to undertake experimental work, or to remove chemicals or equipment from the chemistry building, without written prior approval of my instructor.

I understand that any chemistry building activity on my part that is counter to the regulations in this booklet (Chapters 2 and 3) may result in disciplinary action by the chemistry department or by the college. In the case of persistent and/or severe infringement of the regulations, I may expect to be denied registration in the college.

Name of Student (print) ____

Signature of Student____________________________________

Date __________________

Name of Instructor (print)____________________________________

Signature of Instructor ____________________________________

Date __________________

PLEASE RETURN THIS PAGE, FILLED OUT IN ITS ENTIRETY, TO THE DEPARTMENT ADMINISTRATOR IN ROOM 303.

11 ACCIDENT/INCIDENT REPORT

SECTION I: TO BE COMPLETED BY INJURED PERSON:

FACULTY ☐ STAFF ☐ STUDENT WORKER ☐ STUDENT ☐ VOLUNTEER ☐ VISITOR ☐

IS THIS A JOB-RELATED INJURY? YES ☐ NO ☐ UNKNOWN ☐ WHAT SHIFT WERE YOU WORKING? _____________

1. NAME OF INJURED______________________TELEPHONE NUMBER __________________

ADDRESS ____

2. DEPARTMENT_______________ IMMEDIATE SUPERVISOR_______________EXT._________

3. DATE AND TIME EVENT OCCURRED____

DATE AND TIME EVENT REPORTED____

TO WHOM REPORTED?____

4. LOCATION (ROOM, BLDG, DOCK, ETC)____

5. DESCRIBE ACCIDENT/INCIDENT FULLY. ATTACH SEPARATE SHEET IF NECESSARY.

____

____

____

____

6. LIST WITNESSES. INCLUDE TELEPHONE NUMBER AND ADDRESS, IF POSSIBLE.

____

PLEASE ATTACH WITNESS STATEMENTS, IF APPLICABLE.

7. WAS EQUIPMENT INVOLVED? YES ☐ NO ☐ IF YES, IDENTIFY. ________________________

8. DID ANOTHER PERSON NOT EMPLOYED BY REED COLLEGE CAUSE ACCIDENT/INCIDENT? YES ☐ NO ☐

Name______________________ Address____

9. Describe injury (part of body, type of injury).

____

____

10. Describe first aid/medical treatment (when administered and by whom; for example, self care, occupational health clinic, ER).

____

11. List personal protective equipment worn at the time of the incident, for example, gloves, safety glasses, etc.

____

12. Were you doing your usual job duties at the time of this incident? Yes ☐ No ☐

13. Employed in current position since (M/Y)___________ Job Title_____________

14. If there was a delay in seeking treatment or in notifying your employer of this injury, please explain the circumstances: ____

15. Have you injured or had treatment in the past to this body part? If yes, please explain in detail how you were injured and who treated you for your injury.

____

This information is accurate to the best of my knowledge and understanding.

Signature of employee: __________________________Date:________________________

Section II: FINDINGS/RECOMMENDATIONS:

To be completed by the SUPERVISOR: (Attach separate page if necessary.)

1. Has there been an accident scene investigation? Yes ☐ No ☐ and/or witness interview? Yes ☐ No ☐

2. What were the conditions and/or work practices that may have contributed to this injury/accident?:

3. What actions may have contributed to this injury/accident? (by employee, witnesses, or others):

4. To the best of your knowledge, has this situation caused accidents/incidents in the past?

Yes ☐ No ☐ Unknown ☐ If "Yes," please describe:

5. Describe possible causes that may have contributed to this injury/accident (i.e. policies, procedures, supervision, training, decision-making, and other factors):

6. Describe the immediate corrective actions that have been taken to reduce or eliminate unsafe conditions and/or work practices:

7. Describe long-term corrections that can be made to ensure unsafe conditions and/or practices do not recur (such as policies, procedures, training) and provide an implementation schedule for these actions:

Supervisor signature:__________________ Date:_____________________

12 Near Miss Report Form

Department______________________________ Date_____________________________

Name of Employee/Volunteer/Student____

Name of Supervisor/Instructor____

Nature of Incident:

____

____

____

____

____

Why was this incident considered a "near miss"?

____

____

____

____

____

Remedial activities or training recommendations

____

____

____

____

____