NIPISSING
UNIVERSITY

LABORATORY

SAFETY MANUAL

Revised June 2018

Emergency Contact Information

In case of emergency:	911
Security Services: (daytime)	705-474-7600 ext. 5555
(cell phone)	705-498-7244
Laboratory Safety Coordinator:	474-3450 ext. 4180

Emergency Procedures**

Chemical Spill

On Body

- Rinse affected area immediately for 15 minutes using emergency shower, if required.
- Care must be taken to avoid contamination with face and eye(s).

In Eye(s)

- Immediately flush eye(s) using emergency eyewash station for a minimum of 15 minutes.

In Laboratory

- Assess the scene. If the situation is beyond your capabilities, contact your supervisor.
- If safe to do so, turn off any ignition sources if flammable material is present.
- Use spill kits to assist in spill containment.
- Dispose of waste material with other hazardous waste.

Fire

- If you hear the Fire Alarm ring continuously evacuate the building immediately.
- If you hear the Fire Alarm ring intermittently be alert however evacuation is not necessary.
- If Fire Alarm changes from intermittent to continuous evacuate immediately
- If you detect a fire, do not attempt to extinguish it yourself unless you are capable and it is safe to do so.

Report the injury/incident to your supervisor as soon as possible.

** This is to be used as a quick reference only. For more detailed information, please refer to section 8.0 Emergency Procedures.

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Acknowledgements

Portions of this manual are based on Wilfred Laurier University and the University of Guelph’s Laboratory Safety Manual. Their assistance in shaping Nipissing University’s manual is greatly appreciated.

Nipissing University Health & Safety Policy Statement

Nipissing University recognizes the legal, social and moral responsibility to safeguard the health and safety of University staff, students and visitors by maintaining a safe, healthy environment.

In recognition of the importance of the preceding statement, a university-wide health and safety program shall be maintained on a continuing basis and reviewed annually to ensure that it meets the needs of the University.

This program shall be aimed at:

i) Minimizing the risk of health hazards and personal injury hazards through maintaining a functional Joint Health & Safety Committee, and designating the as a Co-Chair. The Committee will have a representative from each employee constituent group. These committee members will then elect the other Co-Chair from its membership.

ii) Encouraging in all University staff and students positive attitudes and behaviour regarding health and safety issues.

iii) Establishing and practicing safe procedures throughout the University.

All Employees must be dedicated to the continuing objective of reducing risk of injury at Nipissing University. Ultimately, everyone at Nipissing is responsible for their own health and safety and the safety of their fellow employees by working in compliance with the law, and with the safe work practices and procedures established by the University.

Supervisors must also take responsibility for the health and safety of employees and students under their supervision. Supervisors are responsible for ensuring that equipment used by employees and students are in safe working order, that employees and students receive adequate training in their specific work tasks, and that employees and students work in compliance with established health and safety procedures.

Commitment to health and safety is in the best interest of all and must form an integral part of the culture of Nipissing University, from the president to every staff member and student.

Original signed by: President & Vice-Chancellor
Nipissing University

1.0 Introduction

This manual has been developed by Nipissing University based in part on the Government of Canada's Canadian Biosafety Standards 2nd edition and Canadian Biosafety Handbook 2nd edition, the Ontario Ministry of Labour Occupation Health and Safety Act and its regulations, plus current industry standards and best practices. The manual has been developed to help reduce the risks involved with activities that are undertaken in a laboratory setting and the possible consequences for the University while still recognizing the value and importance of research work. It should be noted that those working in these areas play an important role and must always keep safety in mind, not only for themselves, but for all others.

Although many safe operating procedures have been included in this manual, it shouldn't be assumed that it covers all hazards that may be present in a laboratory and any omission is not an excuse for unsafe work practices. Furthermore, your supervisor may require you to follow additional safety procedures. It is expected that workers will follow all applicable procedures contained in this manual. Failing this, the supervisor has the authority to remove laboratory privileges until these requirements are complied with. Supervisors are responsible for ensuring that safe work procedures are followed. If at any time you feel as though your health or safety is at risk, you should discuss the issue with your supervisor to address the concern.

It is mandatory for any person working or intending to work in a laboratory to take all relevant training courses and programs and to review this document prior to commencing work in a laboratory.

2.0 Definitions

Competent person – means a person who:

- is qualified because of knowledge, training and experience to organize the work and its performance,
- is familiar with the Occupational Health and Safety Act (OSHSA) and the regulations that apply to the work and
- has knowledge of any potential or actual danger to health or safety in the workplace

Critical injury – means an injury of a serious nature that:

- places life in jeopardy;
- produces unconsciousness;
- results in substantial loss of blood;
- involves the fracture of a leg or arm but not a finger or toe;

- involves the amputation of a leg, arm, hand or foot but not a finger or toe;
- consists of burns to a major portion of the body; or
- causes the loss of sight in an eye.

Laboratory personnel – any individual who performs procedures in a laboratory, including supervisors.

Non-Worker – means a person who is a volunteer who works for no monetary payment of any kind.

SDS – a Safety Data Sheet is a document which contains detailed information about a particular WHMIS controlled product.

Supervisor – means a person who has charge of a workplace or authority over a worker.

Worker – means a person who performs work or supplies services for:

- monetary compensation;
- no monetary compensation under a program approved by a college of applied arts and technology, university or other post secondary institution;
- no monetary compensation under a work experience program authorized by the school board that operates the school in which the student is enrolled.

3.0 Duties and Rights

All workplace parties have rights as well as duties under the Occupational Health and Safety Act (OHSA). According to this act, employers, supervisors and workers all have a role to play in ensuring a safe and healthy workplace.

3.1 Employers

Employers have a number of responsibilities under the OHSA. They must:

- Develop a health and safety policy.
- Develop programs to support this policy.
- Ensure that supervisors are competent.
- Ensure that equipment and materials provided are in good condition.
- Take every reasonable precaution.

3.2 Supervisors

Supervisors also have major responsibilities under the OHSA. They have overall responsibility for safety in the lab and therefore must ensure that laboratory personnel:

- Follow safe operating procedures.
- Use or wear all required personal protective equipment.
- Are aware of hazards.

- Know and understand emergency procedures.
- Are provided with written instructions where required.

Supervisors must also:

- Ensure that an injury/incident report is completed for every injury or incident which occurs in his or her lab. Examples include: injuries requiring first aid, spills, fires, explosions, and near misses.
    - Ensure that this manual is reviewed with all individuals under their authority and that a record of the review is kept on file.
- Ensure that all hazardous materials in the workplace are labelled in accordance with WHMIS 2015 regulations.
- Maintain a current electronic file of SDS's for all controlled substances used in the workplace. All SDS's must be current to within three years and be readily accessible by workers.
- Ensure that adequate emergency response equipment (e.g. first aid kit, emergency eye wash station, fire extinguisher) is available and in proper working order.

Supervisors have the responsibility of ensuring that all persons under their authority are following the procedures and must enforce these to meet the intent of the legislation. They will use this manual as a minimum standard for activities that take place inside the laboratories. It is strongly recommended that regular, formal health & safety and housekeeping inspections be conducted by the supervisor with records of these inspections kept on file. All injuries/incidents will need to be reported to Human Resources.

3.3 Workers

The OHSA states that workers must:

- Work in compliance with the OHSA and its associated regulations.
- Use or wear all required personal protective equipment.
- Report to the supervisor any contravention of the OHSA and regulations.
- Report to the supervisor any health and safety hazard.

Workers shall not:

- Remove or make ineffective any protective device.
- Use or operate any equipment, machine or device in a manner that endangers themselves or other workers.
- Engage in horseplay or pranks.

In addition, Workers shall:

- Follow all applicable safety procedures as outlined in the OHSA, this manual and by the supervisor.
- Attend and complete all applicable health and safety training courses as required by the supervisor and/or Nipissing University.
- Wear any equipment, protective devices or clothing that the University requires.
- Immediately report any injuries and/or incidents to the laboratory supervisor.
- Report all unsafe acts and conditions to the laboratory supervisor.
- Not remove or alter any protective device.
- Not operate or use any equipment in such a manner as to endanger him/herself or someone else.
- Determine, in consultation with their supervisor, the potential hazards, appropriate safety precautions and proper waste disposal techniques before beginning any new project or experiment.

3.4 Rights of Workers

The OHSA gives workers in Ontario three rights. They are:

- Right to know – about workplace hazards (e.g. WHMIS)
- Right to participate – in health and safety matters (e.g. JHSC)
- Right to refuse – work they deem to be unsafe

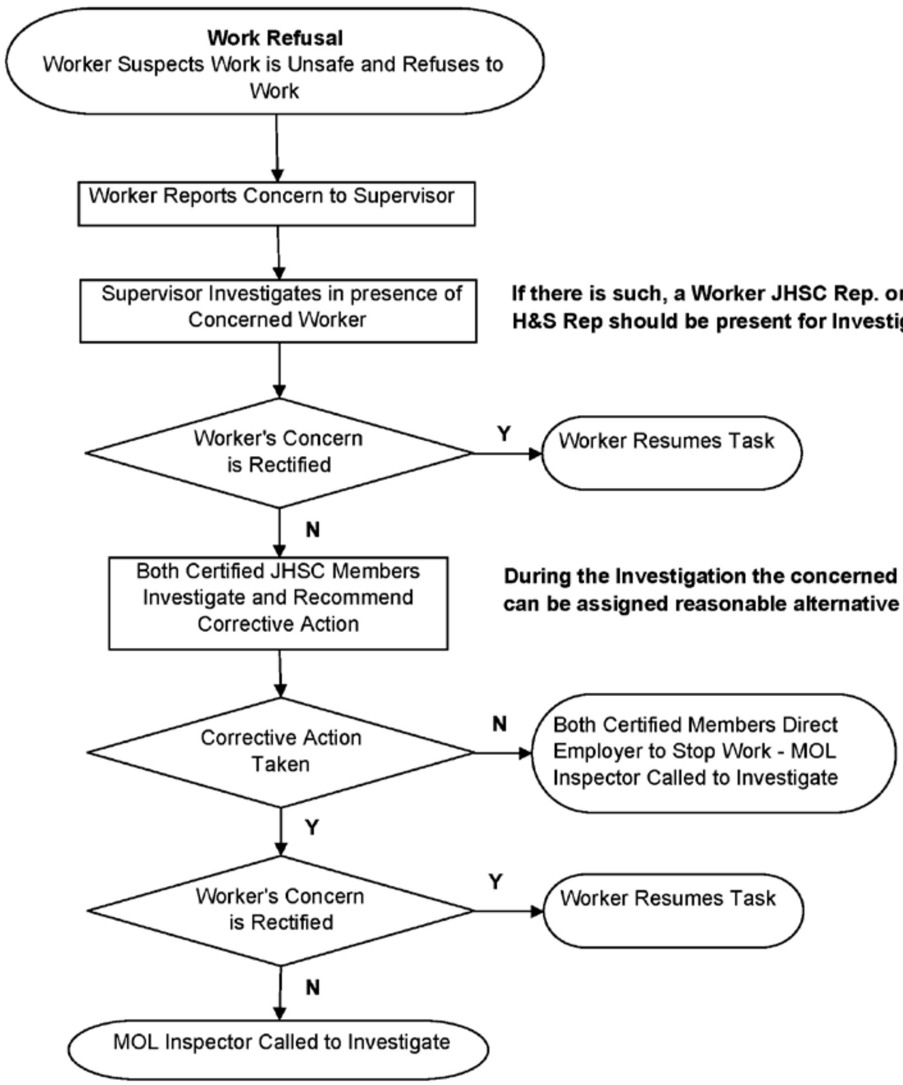
3.5 Work Refusal

The OHSA gives workers the right to refuse unsafe work. The legislation is quite clear on the steps to follow in a work refusal process. Section 43 of the Act explains this process. A flow-chart is included in Figure 1 however it is recommended that the OHSA be referenced for greater detail.

NIPISSING UNIVERSITY

WORK REFUSAL FLOWCHART

Figure 1



If there is such, a Worker JHSC Rep. or a H&S Rep should be present for Investigation

During the Investigation the concerned Worker can be assigned reasonable alternative work

During the Investigation(s) a second Worker can be assigned the task in question if:
1) Both Certified JHSC did not Stop Work
2)They are made aware of the concern in the presence of the Worker JHSC rep or H&S Rep.

3.6 Non-Workers

Non-workers (e.g. volunteers) also have a role to play in laboratory safety. They must:

- Follow all applicable safety procedures as outlined in the OHSA, this manual and by the supervisor.
- Attend and complete all applicable health and safety training courses as required by the supervisor and/or Nipissing University.
- Wear any equipment, protective devices or clothing that the University requires.
- Immediately report any injuries and/or incidents to the laboratory supervisor.
- Report all unsafe acts and conditions to the laboratory supervisor.
- Not remove or alter any protective device.
- Not operate or use any equipment in such a manner as to endanger him/herself or someone else.
- Determine, in consultation with their supervisor, the potential hazards, appropriate safety precautions and proper waste disposal techniques before beginning any new project or experiment.

4.0 Reporting

4.1 Hazard Reporting

Workers are strongly encouraged to report any health and safety concern first to their supervisor if they believe that a hazard exists. If no or inadequate action is taken by the supervisor, it can then be reported to a worker representative of the Joint Health and Safety Committee (JHSC) or the Laboratory Safety Coordinator, however it should have first been reported to the supervisor.

Remember that reporting a hazard to your supervisor should not be considered a work refusal. There is a difference between hazard reporting and a work refusal.

4.2 Injury/Incident Reporting

All injuries/incidents, including those requiring first-aid treatments only, must be reported to your supervisor immediately. It will then be the supervisor's responsibility to contact the Human Resources Generalist – Health, Safety & Wellness. The purpose of reporting all injuries and incidents is so that they can be investigated and measures implemented to prevent them from reoccurring.

Additional information can be found on the "Injury, Incident Reporting and Investigation" page of the Health and Safety web-site.

5.0 WHMIS 2015

In addition to reviewing this manual, anyone working with a product that is classified as a WHMIS controlled product must first have received WHMIS 2015 training. An on-line training course is available to students, staff and faculty at Nipissing University at no cost. It is your responsibility to provide your supervisor or laboratory technologist with a valid certificate. Also, the product's Safety Data Sheet (SDS), which contains important information such as personal protective equipment to be worn, first-aid measures and spill clean-up procedures should always be reviewed before first usage. These are available for online viewing on Nipissing University's intranet at: https://msds.nipissingu.ca.

6.0 Training

In addition to Basic Laboratory Safety Training, this Manual and WHMIS 2015, the supervisor will need to ensure that any person working in a laboratory is trained in the use of specific equipment and in the use of materials and procedures which they will be working with.

The location of fire alarms, fire extinguishers, emergency routes and exits, first aid kits, spill kits and emergency blankets must be shared with laboratory personnel. They must also be familiar with the location and proper use of emergency eye wash stations and showers.

7.0 Laboratory Safety Procedures

7.1 Personal Protective Equipment (PPE)

- Eye/face protection – CSA approved safety glasses must be worn when there is a risk of eye injury while working in a laboratory. Since safety glasses may not provide adequate splash resistance, goggles will also need to be worn where a risk exists. Goggles should have an anti-fogging agent on the lenses and indirect ventilation ports. Depending on the hazard, a full face shield, in addition to the eye protection/goggles, may also be required. Prescription glasses that do not include the CSA marking and that do not have permanently installed side shields do not meet the CSA standard.
- Foot protection – Open-toed shoes and sandals are strictly forbidden inside the laboratory. Footwear must cover the entire foot.
- Hand protection – Where required, hand protection will need to be worn. Refer to the SDS and/or glove manufacturer web-site to ensure that the proper type of glove is being used. Disposable gloves are to be removed, by pulling inside out to prevent exposure, prior to leaving the laboratory. They must also be disposed of properly if they have come into contact with chemicals. Wash hands thoroughly after removing gloves.

- Hearing protection – Where average noise levels exceed 85 dB over an eight-hour period, appropriate hearing protection will need to be worn.
- Respiratory protection – In general, the proper use of fume hoods will negate the need for respiratory protection. However, it is possible that your supervisor will require you to wear respiratory protective equipment.

7.2 General

- The wearing of contact lenses is permitted. However, they are not to be inserted or removed while in the laboratory environment.
- Lab coats are to be worn at all times while inside the laboratory and removed prior to exiting the lab.
- Protective laboratory clothing must not be worn in non-laboratory areas; laboratory clothing must not be stored in contact with street clothing.
- Personal lab coats used in multiple teaching labs should be sealed in a zip-lock style plastic bag prior to leaving the laboratory to prevent contamination of personal items.
- All bags, coats and other materials not related to work being done in the laboratory are to be left outside of the laboratory.
- Food or beverages are strictly forbidden inside any laboratory. Furthermore, these items are not to be placed inside any refrigerator in a laboratory unless used as part of an experiment and they are properly identified with markings such as “For experimental use only” and “Do not consume”.
- Where instructed to do so by the supervisor, all work areas are to be decontaminated with appropriate disinfectants provided prior to performing any procedures and before leaving the laboratory.
- Wash hands upon completion of laboratory procedures and immediately prior to leaving the lab.
- Chemicals from unlabelled containers are not to be used and their presence shall be reported to the supervisor.
- All bottles, flasks and vials containing chemicals must be labelled with a WHMIS 2015 compliant workplace label (see *Appendix I*).
- Access to emergency equipment and exits must never be blocked.
- Do not store large, awkward or heavy objects on top shelves.
- All laboratory personnel and others whose work requires them to enter the laboratory must understand the chemical and biological hazards with which they will come in contact with during their normal work in the laboratory and be trained in appropriate safety procedures.

- Horseplay and pranks are expressly forbidden.
- All mechanical equipment must be guarded to prevent access to pinch points or moving parts. If you notice a guarding hazard, please notify your supervisor immediately.
- For safety reasons, working alone should be avoided whenever possible. For work with hazardous materials or procedures, the supervisor has the right to require at least one other person be present.
- Store flammables in approved flammable storage safety cabinets.
- Eating, drinking, smoking, storing of food, personal belongings, or utensils, and applying cosmetics is not permitted while inside of a laboratory.
- Wearing jewellery is not recommended in the laboratory.
- Oral pipetting of any substance is prohibited in any laboratory.
- Long hair is to be tied back or restrained so that it cannot come into contact with gloved hands, specimens, containers or equipment.
- Access to laboratory and support areas is limited to authorized personnel only.
- Doors to laboratories must not be left open (this does not apply to an open area within a laboratory).
- Open wounds, cuts, scratches and grazes should be covered with waterproof dressings.
- Leak-proof containers are to be used for the transport of infectious materials within facilities (e.g., between laboratories).

7.3 Housekeeping

- Work areas must be kept clean and free of obstructions.
- Walkways and aisles in laboratories must be kept clear.
- Access to emergency equipment and exits must never be blocked.
- Equipment and chemicals must be stored properly.
- Spilled chemicals must be dealt with immediately and if safe, cleaned up by the chemical user. Spills must be reported to the supervisor.
- Wastes must be placed in appropriate, labelled containers and stored appropriately.
- Materials no longer used must not be allowed to accumulate and must be disposed of following proper procedures. Old or unlabelled materials must be disposed of immediately upon identification.

7.4 Working Alone

Working alone should be avoided whenever possible and *in the case where hazardous substances or procedures are being employed, working alone is strictly prohibited*. If working alone is required, then someone in the general vicinity of the work area should be informed that you are working alone. For evening and weekend work, it is advisable to inform a friend or family member of where and how long you will be working. Security Services may also be contacted and informed of where you are working and how long you expect to be at that location. When you are finished your task or work, if Security Services was contacted, they must be notified before you leave the campus. The contact information for Security Services is at the front of this manual.

8.0 Emergency Procedures

8.1 Medical Emergency

The first priority in a medical emergency is to ensure that the area is safe for you. Once this has been confirmed, it is important to provide first aid to the victim(s) as soon as possible. Someone who has this training must be contacted immediately; a list of first aiders is posted next to all first aid kits. If an ambulance is required, someone should be designated to meet the emergency response personnel to ensure a quick response time.

If the injury is classified as a critical injury as per the OHSA, the site must be secured. Unless done to save a life or prevent further suffering, the site is not to be disturbed, altered or any evidence destroyed until released by the Ministry of Labour.

All injuries and incidents must be reported to your supervisor as soon as possible. If future medical attention is sought your supervisor must be notified immediately.

8.2 Fire

For the purposes of notice of fire (fire alarms) and evacuation procedures, the Education Centre is divided into three zones. Zone One is Hewgill Hall (Block D); Zone 2 is the remainder of the Education Centre (blocks A, B, C, F, G, H and R); Zone 3 is the Student Centre. When the source of the alarm is in one zone, the fire bells will ring continuously in that zone and only intermittently in the other zones. In the area where the bell is ringing continuously, occupants are to evacuate that building. In the area where the bells are ringing intermittently, occupants should standby, not evacuate and be alert. If the intermittent ringing changes to a continuous ring, then this area shall also be evacuated. Please become familiar with fire exit locations and alternate routes of exit from your area of occupancy. Do not use elevators when exiting the building.

If you detect a fire, do not attempt to extinguish it yourself unless you are capable (i.e. you have been trained) and it is safe to do so. Do not put your own safety or the safety of others at risk. If you are not capable of extinguishing the fire or it is out of control, leave the area immediately, closing any doors and, if possible, windows. Next, proceed to the nearest fire alarm and activate it. Finally, call Security Services and advise them of the situation from a safe location.

When fighting a fire, the following points will need to be followed:

- Do not attempt to extinguish a fire unless you are properly trained and it safe to do so. Reading this manual is not considered adequate training.
- Ensure the fire extinguisher class is appropriate for the type of fire.
- Position yourself between the fire and the exit door(s) so that you have a clear escape route.
- **P**ull the pin.
- **A**im the extinguisher nozzle or hose at the base of the flame.
- **S**queeze the trigger.
- **S**weep. Using a sweeping motion, extinguish the fire.

All laboratories should be equipped with ABC rated fire extinguishers (coloured red). If a laboratory contains combustible metals, (see Appendix V) class D rated fire extinguishing material will also need to be available. This extinguishing material uses a special dry powder to put out the fire. *Using a Class A, B or C extinguisher on a Class D fire may dramatically increase the fire, introducing the possibility of an explosion.*

In addition to a fire extinguisher, many laboratories have a fire blanket. The fire blanket is used to extinguish small fires or helps smother flames from burning clothing. To use a fire blanket, the following instructions should be followed:

- When a fire starts remain calm
- Pull tapes to release blanket
- Protect your hands & body by holding the straps and keeping the blanket between you and the fire in a shield position and place over the fire – DO NOT THROW
- Unplug the hotplate if in use and it is safe to do so.
- Smoke will come through the blanket indicating that the fire is been extinguished.
- Leave covered until cool – minimum time 20 minutes.

8.2.2 Clothing on Fire

In the event that someone’s clothing catches fire, you should:

- Completely douse the person with the emergency shower, if available; or

- Force the person to the floor and smother the flames using an emergency fire blanket or other non-flammable material, if available; or

- Encourage the person to stop, drop and roll to smother the flames.

In all cases, medical attention should be sought for the person who has caught fire.

8.3 Chemical Spill

8.3.1 Chemical Spill Prevention

The first step in chemical spill response is to prevent the spill from happening in the first place. The laboratory or working environment should be examined to identify measures that can be taken to minimize the risk of a spill occurring. Chemical spills occur during five types of activities: (1) transport, (2) decanting, (3) storage, (4), handing, and (5) disposal.

8.3.1.1 Transportation

- When transporting large, heavy or a multitude of containers, use a cart suitable for the load with high edges or spill trays that will contain any spills or leaks. Two people should be involved when transporting large amounts of chemicals.

- Carry glass containers in bottle carriers or another leak resistant, unbreakable secondary container.

- Appropriate personal protective equipment shall be worn while transporting chemicals, such as safety glasses, appropriate gloves and/or a lab coat.

8.3.1.2 Decanting

- When transferring chemicals between containers, pay careful attention to the size of the receiving vessel to prevent overfilling it.

- When transferring liquids from large containers, use pumps (including pipette pumps), siphoning (not initiated by mouth), or other mechanical means instead of pouring.

- Use spill containment trays to catch leaks and spills when transferring liquids.

- When transferring flammable liquid from drums, ensure that both the drum and receptacle are grounded and bonded together to avoid an explosion initiated by a static electric spark.

- Ensure proper container labelling as per the WHMIS 2015 legislation.

- When transferring hazardous liquid chemicals, perform the transfer in a fume hood if possible.

8.3.1.3 Storage

- Ensure shelving units are sturdy. Shelves used for chemical storage should be securely fastened to the wall or floor to provide additional stability. Shelving should be compatible with the stored chemical and not overcrowded with containers.
- Ensure chemicals are stored within easy reach of everyone in the laboratory. Large bottles and containers should be stored as close to the floor as possible.
- Do not store chemical containers directly on the floor where they may be knocked over or broken, unless they are in ULC approved safety cans or still in their original shipping carton and packaging.
- Do not store chemical containers on top of flammable storage or acid storage cabinets, unless they are empty.
- Minimize the number of chemicals and size of containers stored in the lab. For commonly used chemicals (i.e. acids, solvents, etc.), keep quantities in the lab to a one-month supply, if practical.
- Ensure that lighting and ventilation is adequate in chemical storage areas.
- Regularly inspect chemicals in storage to ensure there are no leaking or deteriorating containers, including:
    - Keep the outside of the containers clean and free of spills and stains.
    - Check that caps and closures are secure and free of deformation. Use only screw caps on chemical containers in storage.
    - Ensure that metal containers are free of rust, bulges or signs of pressure build up.
- Do not store chemicals in unsuitable containers or containers made of incompatible material (e.g. nitric acid stored in metal containers).
- Do not store incompatible chemicals together (e.g. acids with bases). Chemicals must be stored by hazard group and not alphabetically (except within hazard group).
- Purchase solvents and acids in containers with a plastic safety coating, where possible or recommended.

- Ensure organic peroxides are checked for explosive peroxide formation at recommended intervals (see **Section 14.5.3** Peroxidizable Organic Chemicals for instructions).

8.3.1.4 Handling

- In laboratories, work in a fume hood whenever possible.
- When setting up and working with laboratory apparatus:
    - Inspect laboratory glassware for cracks and defects before using.
    - Do not stage experiments below heavy objects which might fall on them. Ensure the work area is free of unnecessary clutter.
    - Select equipment that has a reduced potential for breakage.
    - Use non-mercury filled thermometers or alternate types of temperature measuring devices to avoid mercury spills from broken thermometers.
- When planning experiments, anticipate possible accidents and provide controls to deal with problems that may occur.
- If you must work alone after hours, it is recommended that you let someone (friend or family member) know where and how long you will be working. In addition, you should contact Security Services at extension 5555 or (705) 498-7244 and inform them that you are working alone and specify the duration. Security Services, if previously contacted, must be notified when you leave the campus.
- Check gas cylinder valves and gas tubing before using.
- If possible keep cylinders of highly toxic, corrosive or flammable gasses in a ventilated enclosure.
- Ensure you have access to and know how to use a chemical spill kit before working with chemicals.

8.3.1.5 Disposal

- Do not mix incompatible wastes together to avoid uncontrolled chemical reactions.
- Properly identify the contents of all waste containers to avoid inappropriate disposal – use a yellow waste tag (Appendix IV).

- Leave at least 25% air space in bottle of liquid waste to allow for liquid expansion and to reduce the potential for spills.

- When not in use, keep waste containers securely closed or capped. Do not leave funnels in waste containers.

- Hazardous waste must not be kept on site for longer than 3 months (Ontario Ministry of Environment regulations).

8.3.2 On Body

- Rinse affected area immediately for a minimum of 15 minutes (or as specified in the SDS) using emergency shower if required.

- Care must be taken to avoid contamination with face and eye(s).

- Seek medical attention if required.

8.3.3 In Eye(s)

- Immediately flush eye(s) using emergency eyewash station for a minimum of 15 minutes (or as specified in the SDS).
    - If wearing contact lenses, **do not** try to remove prior to flushing.
- Hold your eyelid(s) open with your fingers.
- Roll your eye(s) to ensure that water can flow over the entire surface of the eye(s).
- Seek medical attention.

8.3.4 In Laboratory

- Assess the scene. If the situation is beyond your capabilities, contact your supervisor.

- Review the SDS.

- Don required PPE.

- If safe to do so, turn off any ignition sources if flammable material is present.

- Notify others in the immediate area and restrict access.

- Use spill kits to assist in spill containment:
    - Absorb the spilled liquid with a spill control pillow, sock or other absorbent material.
    - Place the used material into suitable bag or container and package it for disposal.

- Dispose of waste material with other hazardous waste.

9.0 Unattended Work

Unattended work is, for these purposes, defined as a procedure or a piece of equipment that is in operation while no one is in the laboratory. Only procedures that are deemed safe if left unattended may continue without personnel present in the laboratory. Unattended work should be kept to a minimum.

10.0 Laboratory Equipment

10.1 Emergency Eyewash Stations and Showers

Emergency eyewash stations and showers are to be used when a hazardous substance comes into contact with an individual's eye(s) and/or skin. For more information, please contact the Laboratory Safety Coordinator for a copy of the "Guidelines for Emergency Eyewash Stations and Safety Showers". The following are to be followed with regard to emergency eyewash and/or shower stations:

10.1.1 Installation / Location Requirements

- Where a worker is exposed to a potential hazard of injury to the eye and the skin due to a contact with a biological or chemical substance, an eye wash and a quick-acting deluge shower shall be provided **(Ont. Reg. 851, s. 124, 125)**. If required, a job hazard analysis shall be conducted to determine if potential for an injury exists.
- Installation of such equipment must be as specified in ANSI Z358.1-2014. Only equipment that is certified by the manufacturer as meeting the performance specifications contained in ANSI Z358.1-2014 should be placed in new facilities.
- Existing university facilities must be equipped as necessary to include emergency drenching and/or flushing equipment that is readily accessible and can be reached within 10 seconds from the area(s) (approximate distance of 16-17meters or 55ft) where there is a reasonable potential for injury due to contact with a hazardous material. Equipment performance specifications, height, and clearance distances should be as stated in ANSI Z358.1-2014.
- Off-site/remote locations must have drenching/flushing equipment available whenever work involves the use of hazardous materials and where there is a reasonable potential for injury due to contact.
- Plumbed units that are maintained by the owner/controller of an off-site facility may be used or self-contained units can be purchased. A water hose supplying potable water and equipped with a proper face and body wash nozzle can be used at off-site locations where the possibility of exposure to injurious hazardous materials is very low and when proper personal protective equipment is used.

- The temperature of the flushing fluid for emergency drenching and flushing equipment should be tepid (lukewarm). A means of controlling the temperature to more than 16 C and less than 38 C must be included in tempered flushing fluid systems.
- Flushing fluid shut off valves located within branch lines serving emergency eyewash and safety shower equipment should be tagged to indicate that turning off the valve would turn off the supply to the emergency equipment.
- Emergency drenching and flushing equipment must be identified by highly visible signage.

10.1.2 Use

Immediate and proper use of emergency eyewash and safety showers is essential to minimizing injury upon injurious hazardous material contact. The following guidelines should aid in minimizing injury due to contact with hazardous materials:

- Flush eyes and/or skin for at least 15 minutes. Never use home-made neutralizing solutions to flush chemicals off the body.
- Immediately remove contaminated clothing. Do this while under the shower when cross contamination has occurred.
- Have someone assist with clothing removal when possible.
- Hold eyelids open with fingers so flushing fluid can fully irrigate the eyes.
    - **Note:** People may not always be able to flush their eyes on their own because of intense pain. Nearby helpers should be prepared to assist with holding the eyelids open. Other helpers may need to assist with keeping the person under the flushing fluid for at least 15 minutes.
- Seek medical attention after flushing the areas of contact for at least 15 minutes.
- Notify supervisor as soon as the emergency has subsided.
- An assistant may use a fire blanket or uncontaminated article of clothing as a shield to provide privacy for someone who needs to remove their clothes while under an emergency shower, and for body coverage while seeking medical attention.

10.1.3 Flushing and Inspection

- The area immediately adjacent and surrounding the emergency shower and/or eyewash station must be kept clear of any equipment, utensils, boxes, etc. to ensure unimpeded access for the user.

- Emergency eyewash and eyewash/shower combination units in laboratories should be activated **monthly** to ensure flushing fluid is available as well as to clear the supply line of sediments and minimize microbial contamination caused by “still” or sitting water.

- Emergency showers in laboratories should be activated **quarterly** to ensure flushing fluid is available as well as clear the supply line of sediments.

- Flush for at least three minutes. Inspect eyewash and eye/face wash stations while flushing to make sure that water rises to approximately equal heights, and that fluid flow is sufficient to flush both eyes simultaneously while at a velocity low enough to be non-injurious to the user (an eyewash gauge is available from EHS if required).

- Water in self-contained eyewash and eye/face wash stations must be replaced with fresh potable water regularly (weekly if no preservative). Follow the manufacturer's recommendations for functionality tests and solution replacement when a preserved solution is used in these units.

- Each personal eyewash station/unit must be reviewed regularly to make sure components are in place, the station/unit is readily accessible, and that flushing solution has not passed its expiration date. Also verify that bottles with seals/tamper indicators are sealed, replacing those that are not.

- **The designated person** (person responsible for conducting the inspection) should keep a signed, dated record of the flushing/inspection. The record (tag) should be attached to the eye wash/shower unit or posted by the unit. Record of Inspection Tags can be obtained from the Laboratory Safety Coordinator.

- **Annual flushing/inspections** should be conducted on emergency eyewash stations and safety showers on campus to ensure that they are in proper working condition, are in compliance with current ANSI standards and to identify areas for improvement. The annual inspection includes but is not limited to measuring the fluid (water) flow rate, checking the operation of the valve. Refer to the ANSI Standard for details on this inspection.

- Because of the technical aspect, the annual flushing and inspections are conducted by **Facilities Services.**

10.1.4 Repairs

- Whenever an eyewash station is non-functional, a portable eyewash station or equivalent must be available if work with injurious hazardous materials cannot be delayed.
- The area/lab supervisor is responsible for ensuring that eyewash and safety shower equipment not passing inspection is repaired in a priority manner.
- When emergency eyewash and safety shower equipment is non-functional, it must be clearly tagged/signed as being out-of-service.
- Anyone removing emergency eyewash and safety shower equipment from service must notify the Laboratory Safety Coordinator and the affected department beforehand.
- New eyewash stations and showers shall be installed in accordance with ANSI standard Z358.1-2014 “Emergency Eyewash and Shower Equipment”.
- The ANSI standard recommends that the affected body part be flushed with a constant supply of clean water for a minimum of 15 minutes.
- Penetrating corrosives may require a longer flushing period, possibly up to one hour.
- Emergency eyewashes and showers are not substitutes for primary protective devices and equipment. Eye and face protection and clothing appropriate for the chemical or biological hazard must be worn.
- The area surrounding emergency eye wash stations and showers must not be cluttered.
- The laboratory supervisor will be responsible for performing monthly tests of the eye wash stations to verify that they are operating properly and to flush the pipes. A tag is to be used to document this process. Alternatively, this job may be delegated to a competent person.

10.2 Lockout

Anytime work needs to be completed on energized equipment or machinery, proper lockout procedures must be followed. Only qualified individuals can lockout equipment or machinery. Remember, lockout must be observed prior to commencing this type of work.

Interlocks are safety devices that are intended to stop a machine (e.g. when a door is opened, a gate is lifted, etc.) to prevent an individual from coming into contact with a moving part. Some machinery found in laboratories are equipped with interlocks.

Centrifuges must be fitted with an interlock so that they cannot be accessed while moving or started while open.

10.3 Equipment Maintenance

Laboratory equipment, including autoclaves, fume hoods and biological safety cabinets, must be inspected and maintained by a competent person. The frequency of these inspections depends on the hazard(s) posed by the equipment, the manufacturer's instructions and as required by legislation. Maintenance records must be provided to the Laboratory Safety Coordinator so that they can be kept on file.

10.4 Biological Safety Cabinet (BSC)

Before a person is allowed to use the Biological Safety Cabinet (BSC), he/she will need to receive documented training as specified in the Nipissing University Biosafety Manual. Please contact the Laboratory Safety Coordinator for more information.

10.5 Fume Hood

The fume hood is the primary protective device in most laboratories for protecting workers from exposure to hazardous chemicals. It is designed to contain, dilute and disperse gases, vapours and aerosols to the external environment. It is also an integral part of the building air handling system. It is imperative that the fume hood be functioning properly at all times.

Fume hoods that are in good condition, properly functioning and used as intended are vital to everyone's safety. The following list contains procedures that must be followed.

- Fume hoods must to be tested annually by a qualified individual and records of these inspections are to be kept on file by the Laboratory Safety Coordinator.
- Any work that involves hazardous or odorous chemicals should be completed in a fume hood.
- During experiments, equipment and chemicals should be kept a minimum of six inches away from the sash.
- When working with environmentally hazardous materials, it is imperative that the fume hood sink be protected with a barrier that will stop any spilled material from entering the sink drain. The use of a chemically compatible absorbent mat or sock should be used to protect the drain.
- Equipment and materials should not be stored in a fume hood for extended periods of time; the fume hood should not be considered a storage facility.
- Never place your head inside the fume hood when chemicals are present.
- Fume hoods must not be considered a substitute for PPE.
- Electrical devices should be connected outside the fume hood to avoid sparks and possible ignition.

- Equipment in the fume hood should be solidly positioned a few inches above the working surface to maximize air flow.
- Ideally, the fume hood will be situated away from heavily used walkways since foot traffic (air currents) can disrupt the proper operation of this device causing gases and vapours to escape.
- Keep the interior of the fume hood clean and tidy.
- Completely close the sash when the fume hood is on and left unattended.
- A label has been placed on fume hoods indicating optimal sash height. Do not raise sash higher than this marking when fume hood is in use.
- In emergency situations such as fires, gaseous emissions, or spills in a fume hood, always pull the sash down completely and assure hood fans are turned on.
- If you are unsure of the proper operation of the fume hood, contact your supervisor for directions.
- **Do not conduct work in a malfunctioning fume hood.**

In case of fume hood malfunction, do the following:

- Discontinue use of fume hood immediately and post a sign on the front sash indicating that the fume hood is out of service.
- Inform your supervisor or Biology laboratory technologist.
- Inform any other affected person until fume hood is locked-out.

10.6 Autoclave

The autoclave, which uses saturated steam under pressure, is one of the most dependable methods available in the laboratory for the inactivation of all forms of microbial life. To ensure safety and quality control, all biohazardous materials and items contaminated with potentially infectious agents must be decontaminated before use or disposal. Such items include, but are not limited to: culture media, surgical instruments, laboratory equipment, glassware, and biomedical waste including sharps. Steam sterilization is not recommended for anhydrous substances, flammable materials, electrical equipment or any item that may be damaged in the autoclaving process.

The following is a list of general safety rules that must be adhered to:

- Only those who have received documented training from a competent person (e.g. Laboratory Safety Coordinator) can use the autoclave.
- If steam is leaking around the door during the sterilization process, the door has not been sealed properly. Advise your supervisor and the Laboratory Safety Coordinator immediately.

- All potentially infectious materials must be autoclaved before being washed, stored, or disposed as waste.
- Never leave un-sterilized material inside the autoclave or sitting in the autoclave room overnight.
- Never autoclave materials that contain toxic agents or volatile chemicals.
- Do not stack or store combustible materials such as cardboard and plastic containers or flammable liquids next to the autoclave.
- All biohazardous waste that is to be autoclaved must first be placed in an approved and labelled autoclave bag.
- Do not double bag waste. Autoclave bags are designed to be permeable to steam but a double bag will hinder the flow of the steam through the bag.
- Do not overfill bags as this may interfere with the sterilization process due to poor steam circulation.
- Do not place sharps such as broken glass, needles or scalpel blades in a bag. These items must be placed in an approved, labelled, and rigid sharps container. These will be disposed of using a commercial waste disposal company.
- Be sure to loosen the caps on the vessels to allow for pressure build up during the process and to avoid the vessel exploding when being removed from the autoclave chamber.
- Efficacy monitoring of autoclaves used for decontamination with biological indicators must be done regularly (i.e., consider weekly, depending on the frequency of use of the autoclave), and the records of these results and cycle logs (i.e., time, temperature and pressure) must also be kept on file.

10.7 Centrifuges

Safe use of centrifuges requires proper maintenance and operation. Failed mechanical parts or improper operation can result in release of projectiles, hazardous chemicals and biohazardous aerosols. Maintenance and repairs are only to be performed by trained, qualified personnel. All maintenance work conducted by contractors is to be documented. To preserve your safety, sample integrity and equipment:

- Ensure that centrifuges have an interlocking device that will prevent both the lid from being opened when the rotor is in motion or the centrifuge from starting when the lid is open.
- Ensure that centrifuge tubes are free of hairline cracks, stress lines and chipped rims prior to use.
- Ensure that tube materials are chosen such that they provide the necessary chemical resistance and speed rating.

- Avoid over-filling tubes.
- Cap or stopper centrifuge tubes.
- Use sealed centrifuge buckets (safety cups) or rotors that can be loaded and unloaded in a biological safety cabinet or chemical fume hood as appropriate.
- Decontaminate the outside of the cups/buckets and rotors before and after centrifugation.
- Inspect O-rings regularly and replace if cracked or dry.
- Ensure that the centrifuge is properly balanced. Load the rotor with samples arranged symmetrically. Opposing tubes must be of equal weight. If necessary, use “water blank” tubes to balance sample tubes of unequal weight. Do no use sight or volume to conclude that tubes are balanced. Use an electronic balance to balance the tubes before using in an ultracentrifuge.
- Ensure that the prescribed speed limitations of the rotor or centrifuge are never exceeded.
- Unless fitted with a suitable exhaust system, do not centrifuge materials capable of creating flammable or explosive vapours.
- Remain with the centrifuge until it has reached its programming speed.
- Abort the run immediately if you hear abnormal vibration, whining or grinding noises. Check the rotor lid and balance.
- At the end of the run, ensure that the rotor and centrifuge are cleaned according to the manufacturer’s instructions. Never use abrasive cleaners.
- Rotors are easily damaged. Never use metal tools to remove tubes or to clean these.
- For each rotor, record speed and run time in a logbook for each run so that rotors can be downgraded and discarded as appropriate.
- If centrifuge is connected to a vacuum pump, ensure that the pump exhaust is connected to a trap.
- If biohazardous materials are being centrifuged and the centrifuge is connected to a vacuum pump, ensure that a HEPA filter is installed between the centrifuge and the vacuum pump.

10.8 Open Flames

There are two types of equipment that utilize open flames: Bunsen burners and alcohol burners. Bunsen burners use natural gas and alcohol burners utilize a fuel such as methanol, ethanol or isopropanol. When using either of these types of equipment it is important to ensure that you:

- Remove all flammable or combustible items (papers, notebooks, etc.) and chemicals from the immediate vicinity of the flame;
- Place the burner at least 12 inches (30 cm) from overhead shelving, equipment or light fixtures.
- Know the location of the fire blanket, fire extinguisher and/or safety shower;
- Know the location of the fire alarm pull-station;
- Tie-back any long hair, dangling jewelry, or loose clothing. Secure sleeve cuffs with long gauntleted gloves or tape;
- Wear fire-resistant clothing, if possible;
- Wear safety glasses, goggles and/or face shield, depending on the local risk assessment of the task being undertaken;
- **Do not wear nitrile gloves around open flames**. Only wear Neoprene™ or chloroprene gloves which are fire-resistant.
- Do not use open flames in a Biological Safety Cabinet. Use a bead bath or Bacticinerator loop sterilizer instead.

Additional precautions

- For small fires, attempt to extinguish the fire only if you have been trained in fire extinguisher use.
- For large fires (spreading beyond initial starting point), activate the fire alarm and begin evacuating the building. Call 911.

10.8.1 Bunsen Burners

The following steps must be followed when using a Bunsen burner:

- Ensure that all bench-top gas valves are closed and then turn on the main gas supply.
- Inspect the hose for cracks, holes, pinched points, or any other defect and replace if found to be defective;
- Make sure the hose fits securely on the gas supply valve and the Bunsen burner;
- Notify others in the laboratory that the burner will be in use;
- Use a sparker to ignite the Bunsen burner. Make sure the flint is able to spark;
- Have the sparker ready before turning on the gas supply;

- Adjust the flame by turning the collar to regulate air flow and produce an appropriate flame for the experiment;
- Do not leave open flames unattended and never leave the laboratory while the burner is on;
- When finished, turn of the bench-top gas supply and remove the Bunsen burner from the gas supply valve and return it to its storage location;
- Turn off the main gas supply before leaving the laboratory.

10.8.2 Alcohol Burners

The following steps must be followed when using an alcohol burner:

- Fill the burner in a fume hood taking care not to spill or overfill;
- Transfer the burner to the location where it is to be used;
- Ensure no flammable or combustible material is in the vicinity;
- Never light a burner with another burner;
- Never refill a lit burner. Let the burner cool completely before refilling;
- Take care not to come into contact with the invisible flame;
- When finished, cap the flame, let the burner cool down and then place the burner back into storage.

10.9 Heating Baths

Heating baths are designed to heat materials to a constant temperature. They may be filled with a variety of materials including water, mineral oil, sand, glycerine, paraffin or silicone oils, depending on the bath temperature required. Bath temperatures may attain temperatures of up to 300˚C. The following are precautions for heating baths:

- Locate on a stable surface, away from flammable and combustible materials including wood and paper.
- Ensure liquid has cooled before relocation.
- Ensure baths are equipped with controls that will turn off the power if the temperature exceeds a pre-set limit.
- Ensure thermostat is set well below the flash point of the heating liquid in use.
- Equip with a non-mercury thermometer to allow a visual check of the bath temperature.
- Do not fill over ⅔ full.

- Take care not to allow water to get into oil baths as violent splattering may result.

Steams baths are often a safe alternative for heating because they provide a consistent temperature that will not exceed 100˚C. However, care must be taken to prevent scalding due to dermal exposure to the steam or steam lines. When opening the cover, stand slightly off to the side and do not place face or arms directly over steam bath. Slowly open the cover to allow steam to dissipate.

Water baths are the most common bath found in the laboratory. When using a water bath:

- Clean it regularly; a disinfectant, such as phenolic detergent, can be added to the water.
- Avoid using sodium azide to prevent growth of microorganisms; sodium azide forms explosive compounds with some metals.
- Decontamination can be performed by raising the temperature to 90˚C or higher for 30 minutes once a week.
- Unplug the unit before filling or emptying.

10.10 Acid/Base Baths

Acid and base baths, often used to clean glassware, are very corrosive and can cause significant injury. Consideration should be given to substituting an acid/base bath with a bath prepared with a laboratory grade detergent.

The following precautions should be observed when setting up and using an acid bath (base bath is similar):

- Wear appropriate PPE (i.e. lab coat, lab apron, safety goggles, face shield, and heavy long-gauntleted gloves appropriate for the acid being handled);
- Always dispense acid in a fume hood;
- Always set up and use an acid bath in a fume hood;
- Always add distilled water to the acid bath first, followed by the appropriate amount of acid. Use the following formula to determine the appropriate amount of acid to add to the distilled water: $C1 \cdot V1 = C2 \cdot V2$. For example to make a 10 L 10% nitric acid bath using concentrated nitric acid (68% v/v) you would need 1.5 L of nitric acid into 8.5 L distilled water:

$$68\% \times xL = 10\% \times 10L$$

$$xL = \frac{10\% \times 10L}{68\%}$$

$$xL = 1.47\mathrm{L}$$

- Slowly pour the acid into the water so that splashing is eliminated or minimized. This process gives off a large amount of heat, so pour slowly;
- Mix the water/acid solution thoroughly using a stir rod and place a lid on the bath if it is not being used immediately;
- When placing glassware into the bath, ensure that all items are fully immersed;
- When removing glassware from the bath, drain all bath solution back into the acid bath and place the glassware into a transport tub – use a cart to transport glassware from the acid bath location to the rinsing location;

If the laboratory drains are connected to an acid-neutralizing pit (all A-Wing, H-Wing and R-Wing laboratories are connected to an acid-neutralizing pit), the spent solution can be poured down the laboratory drains. If the laboratory is not connected to an acid-neutralizing pit, the following protocol for the clean-up and disposal of the spent acid bath solution is as follows:

- Don PPE
- Carefully neutralize the acid bath solution with sodium bicarbonate or sodium hydroxide to a pH of 5 – 8.
- If there is no sink in the laboratory, place a lid on the acid bath and place the bath on a cart an transport to a laboratory sink. Do not hand carry.
- Pour the contents of the neutralized bath down the laboratory drain. Run water while pouring.
- Make sure the bath container is completely clean and free of particulate.

10.11 Ovens, Hot Plates and Heating Mantles

Ovens are commonly used in the lab to evaporate water from samples, provide a stable elevated environment and dry glassware. Hot plates are used to heat various general laboratory solutions while heating mantles are used to heat reaction or sample solutions in round bottom flasks or reaction vessels. Bunsen burners are not to be used to heat reaction, sample or general laboratory solutions. The following precautions should be followed to ensure their safe use:

- Familiarize yourself with location of Fire Extinguishers and Pull Stations.
- Ensure that laboratory ovens and hot plates are designed such that they prevent contact between flammable vapours and heating elements/spark-producing components.
- Avoid heating toxic, even mildly volatile materials in an oven unless it is continuously vented outdoors.

- Glassware that has been rinsed with an organic solvent is to be rinsed with distilled water or equivalent before being placed in an oven for drying.
- Hot plates or ovens whose thermostat fails are to be removed from service until repaired. Heating devices whose temperature unknowingly rises above that required could create significant fire hazards.
- Heating mantles are to be used in conjunction with a variable autotransformer and care is to be taken not to surpass the maximum voltage of the mantle as recommended by the manufacturer.
- Discontinue use of any heating mantle whose heating elements have become exposed.

10.12 Ultraviolet Lamps

Exposure to ultraviolet light (UV) may result in serious and painful injury to the eyes or skin depending on the specific wavelength of the light to which the individual is exposed, the intensity of the light and the duration of exposure.

- Conspicuously label all UV light sources with the following warning (or equivalent) “Warning – this device produces potentially harmful UV light. Protect eyes and skin from exposure.”
- Ensure that the UV light source is shielded.

Ensure that appropriate PPE is worn and is sufficient to protect the eyes and skin. PPE should include at least UV resistant face shield, gloves and lab coat.

10.13 Glassware

- Dispose of any damaged glassware. Damaged glassware must be disposed of in the proper glassware disposal receptacle. If one is not present in your lab, advise your supervisor or contact the Biology laboratory technologist.
- Ensure appropriate hand protection is used when working with glass tubing.
- Tape permanent vacuum glassware which presents an implosion risk with either electrical or duct tape, or use appropriate shielding.
- Wear suitable hand protection when picking up broken glass.
- Specific procedures may apply to contaminated glassware. Refer to section **15.6.1 Broken Laboratory Glassware** or seek advice from your supervisor or the Biology laboratory technologist.

10.13.1 Inserting/Removing Glass Tube from Stopper

When inserting or removing a glass tube from a rubber stopper, the following procedures will be used:

- Fire polish the rough ends of the glass tubing before attempting to insert it through a stopper.
- Wet both the tubing and the stopper with glycerine or water.
- Wear a protective glove and wrap glass tubing in a wad of paper towel to prevent injury.
- Slowly insert the tubing into the stopper with a slight twisting motion.
- Hold the tubing close to the robber stopper. Do not apply too much force or torque.
- If it does not go after applying gentle force, make the hole in the stopper larger.
- When it is very difficult to remove a thermometer from a rubber stopper, it is best to cut away the stopper rather than to risk breaking the thermometer.

Another method of inserting a glass tube into a rubber stopper is to use stoppers that have been specially cut on one side (side-split rubber stoppers) so that they can be opened easily and the glass rod placed into the stopper. The stopper is then closed up and inserted into the neck of the apparatus, with friction and pressure keeping the contents from escaping.

10.13.2 Freeing Seized Ground Glass Joints

Ground glass joints have a high likelihood of seizing due to their nature. To prevent seizing of ground glass joints, the joints may be coated with a laboratory grade grease before being joined. If potential contamination from grease is an issue, it may be possible to seal the joint with Teflon tape for those operations that require vacuum.

When attempting to free a seized ground glass joint the following precautions must always be taken: a) wear eye/face protection; b) use heavy, cut resistant gloves (e.g. “Chem Master” neoprene-over-rubber or leather) when manipulating the ground glass joint; c) always wrap a laboratory cloth or towel around the joint before attempting to loosen the joint before separation in order to prevent flying glass particles if the joint suddenly breaks.

The following procedures will generally free a seized ground glass joint:

1. Gently rock the joint back and forth to try and loosen the joint before separation. If rocking the joint doesn’t work, then try to gently twist the joint. Do not force the joint if it remains seized.

2. Immerse the joint in a glass container of freshly poured carbonated soda. You will be able to see the liquid penetrate the between the ground surfaces. When the surfaces are wet (allow 5 to 10 minutes submersion), remove the joint and rinse with tap water. Wipe away excess water.

3. Wearing heat-resistant gloves to avoid burns and a full face shield to protect against glass breakage, gently warm the wall of the outer joint by rotating it for 15 to 20 seconds over a low Bunsen burner flame. Be sure that 50% of the inner surface is wet before inserting the joint in the flame. Remove from the flame and gently twist the two members apart. If they do not come apart, repeat the procedure. Never use force when separating joints by this method.

If all the above procedures fail and it is necessary to remove the contents of the vessel that has been stoppered by a ground glass joint, the vessel wall below the ground glass joint can be scored and broken. This should be done in a fume hood and by placing a laboratory cloth over the scored area when breaking the vessel. Be sure to use cut resistant gloves and eye/face protection while performing this action.

10.14 Shielding

Appropriate shielding must be used whenever an operation involves working with chemicals that have the potential of exploding or severely splashing. Examples include:

- When a reaction is attempted for the first time.
- When a familiar reaction is carried out on a larger scale than usual.
- Whenever operations are carried out under non-ambient conditions.
- Whenever a severe splashing potential exists for corrosive materials.

Shielding or equivalent precautions are to be used when working with non-ionizing radiation sources, magnetic or other fields. Examples include:

- Lasers
- Infrared radiation
- Ultraviolet radiation
- Microwave radiation

Appropriate shielding is also required when using equipment with thermal hazards.

11.0 Flammable and Combustible Material Hazards

The following points must be followed when working with flammable and combustible material:

- Use an open flame only as long as necessary and extinguish it when done.
- Do not use an open flame to heat combustible or flammable materials.
- Remove all flammable and combustible materials from the work area prior to lighting a flame.

- When transporting flammable solvents and/or highly corrosive acids and bases, a safety bottle carrier must be used. These safety bottle carriers are located in rooms H206, H211 and H220.
- Eliminate all ignition sources prior to dispensing flammable or combustible liquids.
- All dispensing and collection of flammable and combustible liquids in a laboratory must be conducted in a functioning fume hood.

11.1 Flammable and Combustible Liquid Storage Regulations

- Only immediate use quantities of flammable and combustible liquids shall be stored outside of an approved flammable liquid storage cabinet.
- Glass containers are only acceptable in a laboratory where the use of metal cans would create purity problems or the liquid will cause excessive corrosion of the metal container. Glass and plastic container sizes must comply with the following table. To determine flashpoint, consult the chemical's SDS.

Classification	Flash Point °C	Container Size
Class I (flammable)	≥22.8 °C and <37.8 °C	1 litre maximum
Class II (combustible)	≥ 37.8 °C and 60 °C	5 litres maximum
Class IIIA (combustible)	≥60 °C and < 93.3 °C	5 litres maximum

- Provided the laboratory is separated from other parts of the building by a *fire separation having a rating of not less than 1 hour*[1] and the containers conform to section 4.2.3.1. (1) of the Ontario Fire Code, the maximum quantity of flammable and combustible liquids (including waste) permitted to be kept in the open area of a laboratory must comply with the following table. ***Note: Labs that do not have a 1 hour fire separation will not be able to store the maximum quantities of flammable and combustible liquids and should contact the Laboratory Safety Coordinator.***

Location	Flammable Classification	Combustible Classification	Maximum Quantity	Container Size
Laboratory	X	—	50 litres	5 litres maximum
Laboratory	—	X	250 litres	5 litres maximum
Total Combined	X	X	300 litres	5 litres maximum

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[1] The following laboratories do not conform to the Fire Code with regard to a 1-hour fire rating: all H-Wing and A-Wing Laboratories.

Note: 1. Combustible liquid quantity may increase as the quantity of flammable liquid is reduced.

2. These regulation apply to laboratories ONLY. More stringent requirements are enforced for non-lab occupancies.

- Quantities in excess of 300L must be stored within approved metal flammable liquids storage cabinets.
- Flammable storage cabinets may contain up to 500L of flammable AND combustible liquids, of which 250 mL may be Class I (flammable).
- A maximum of 1500 litres of flammable and combustible liquids (of which a maximum 750 litres may be Class I flammable) can be stored in (the TOTAL of all) flammable storage cabinets within a fire separation.
- There is no limit on the number of flammable storage cabinets per fire separation as long as the 1500 litre limit is not exceeded.
- To be approved for storage of flammables, cabinets must conform to at least one of the following standards:
  - ULC-C1275, “Storage Cabinets for Flammable Liquid Containers”;
  - ULI 1275, “Flammable Liquid Storage Cabinets”;
  - Factory Mutual Research Approved; or
  - Meet NFPA 30.

12.0 Chemical Storage Guidelines

- All chemicals must be labelled properly and shall be stored according to their hazard class and compatibility group. At Nipissing University, the system utilized is the “Fisher Scientific” system of chemical compatibility (see *Appendix III*). Chemicals within each compatibility group must be stored separately from each other and away from general chemical storage.
  - All chemical containers shall be colour coded with tape if they have not already been appropriately colour coded from the factory. A supply of the appropriate coloured tape is available from the Biology technologist.
- Laboratories are encouraged to purchase limited quantities of chemicals they need for immediate use. Long term storage of chemicals is not advised.
- An up to date inventory of all chemicals must be maintained and an inventory of laboratory chemicals must be performed at least annually. Any changes in the inventory must be reflected in the Nipissing University Material Safety Data Sheet (SDS) Chemical Inventory database. Those chemicals that are no longer needed should be disposed of as soon as possible following proper waste disposal procedures.

- Chemical storage shelves must be designed for the anticipated load and should be made of materials resistant to the chemicals stored.
- Chemicals should not be stored in direct sunlight or near heat sources.
- Flammable chemicals or materials should not be stored in regular refrigerators, but must be stored in refrigerators that have been specially designed or modified to exclude ignition sources inside the storage compartment.
- Store large containers on lower shelves.
- Avoid storing containers above eye level.
- Window sills, heaters and ledges may not be used as storage areas.
- Inspect chemicals in storage regularly to ensure that:
    - There are no leaks.
    - Caps and containers are in good condition. Look for signs of discolouration, bulging and pressure build-up.
    - Containers' exteriors are free of spills and stains.

12.1 Essentials of Chemical Compatibility for Storage and Segregation

All chemicals must be stored according to the information contained on the SDS and segregated according to the information contained in *Appendix III*. There are five colour storage codes as follows:

- Red (R): Flammable and Combustible. Store in area segregated for flammable reagents.
- Blue (B): Health hazard. Toxic if inhaled, ingested or absorbed through the skin. Store in a secure area.
- Yellow (Y): Reactive and oxidizing reagents. May react violently with air, water or other substances. Store away from flammable and combustible materials.
- White (W): Corrosive. May harm skin, eyes, and mucous membranes. Store away from red, yellow and blue-coded reagents.
- Gray (G): General storage. Presents no more than moderate hazard in any of the categories above.

12.1.1 Combustible or Water Reactive Metals (Storage Code Red)

- Combustible metals or combustible metal compounds (see Appendix V for a listing of these materials) must be stored in a flammable storage cabinet reserved exclusively for these materials and must not be stored with other flammable materials.

12.1.2 Organic Acids (Storage Code Red)

- Organic acids such as acetic, butyric, formic acids and any other organic acid are considered combustible materials and should be stored in a flammable storage cabinet with flammable solvents.

12.1.3 Health Hazard – Poisons, Carcinogens and Habit Formers (Storage Code Blue)

- These should be stored in a locked cabinet away from other chemicals and the cabinet should be clearly labelled with the appropriate hazard signage.

12.1.4 Inorganic Oxidizers (Storage Code Yellow)

- Inorganic oxidizers such as nitrates, nitrites, chlorates, perchlorates, periodates, permanganates and persulfates must be stored on a non-combustible shelf or on a combustible shelf lined with a non-combustible material in such a way as to not allow any of the chemical to come in contact with the combustible shelving.

12.1.5 Mineral Acids (Storage Code White)

- Mineral acids are classified into to 2 groups, non-oxidizing acids and oxidizing acids. Oxidizing acids are incompatible with non-oxidizing acids and must be stored in a separate cabinet. When oxidizing acids are mixed with non-oxidizing acids, the:
- Reaction products may be highly corrosive;
- Reaction products may be explosive or sensitive to shock or friction;
- Reaction products may be flammable;
- Reaction may liberate gaseous products and may cause pressurization;
- Reaction may be exothermic at ambient temperatures;
- Reaction products may be toxic;
- May produce the following gases: chlorine; hydrogen chloride; hydrogen halide; nitrogen; nitrogen oxides; halogen gas; halogen oxides.

12.1.5.1 Non-oxidizing mineral acids

Non-oxidizing mineral acid examples include: hydrobromic acid; hydrochloric acid; hydrofluoric acid; phosphoric acid and; *weak* sulphuric acid. Please note that this list is not exhaustive and care must be taken to carefully read the manufacturer supplied SDS before determining storage requirements.

12.1.5.2 Oxidizing mineral acids

Oxidizing mineral acid examples include: *strong* sulphuric acid; nitric acid; perchloric acid; chlorosulfonic acid; chloric acid; nitrosulfuric acid and; selenic acid. Please note that this list is not exhaustive and care must be taken to carefully read the manufacturer supplied SDS before determining storage requirements.

Perchloric acid must be used in a special fume hood if used in quantities greater than 10 mL. **Note:** Nipissing University does not have any fume hoods certified for perchloric acid use.

12.1.6 Inorganic Bases (Alkaline Materials) (Storage Code White)

- Alkaline materials such as sodium hydroxide, potassium hydroxide, ammonium hydroxide, and organic amines must not be stored with mineral acids. These chemicals may be stored in shelving under benches, but should be stored in HDPE tubs. The only exception is ammonium hydroxide, which must be stored in a ventilated chemical storage cabinet or room due to the presence of ammonia fumes.

12.2 Chemical Storage When Storage Space is Limiting

12.2.1 Stanford University Compatible Storage Group Classification System

It is prudent practice to store containers of chemicals based on compatibility groups and ensure that incompatible groups are stored separately from each other. Separation of the incompatibles will reduce the risk of mixing in case of accidental breakage, fire, earthquake or response to a laboratory emergency. However, when space is limited, it is permissible to use the ‘Stanford University Compatible Storage Group Classification System”. ***Each group should be separated by secondary containment (e.g. plastic trays) or, ideally, stored in its own storage cabinet.***

In addition to the storage groups listed in Table 1, reproductive toxins, select carcinogens and substances with a high degree of toxicity should be stored separately according to the information contained within their respective SDS’s.

Table 1. Stanford chemical storage group classification system compatibility guidelines.

A: Compatible Organic Bases

Diethylamine

Piperidine

Triethanolamine

Benzylamine

Benzyltrimethylammonium hydroxide

B: Compatible Pyrophoric & Water-Reactive Materials

Sodium borohydride

Benzoyl chloride

Zinc dust

Alkyl lithium solutions such as methyl lithium in tetrahydrofuran

Methanesulfonyl chloride

Lithium aluminum hydride

C: Compatible Inorganic Bases

Sodium hydroxide

Ammonium hydroxide

Lithium hydroxide

Cesium hydroxide

D: Compatible Organic Acids

Acetic acid

Citric acid

Maleic acid

Propionic acid

Benzoic acid

E: Compatible Oxidizers Including Peroxides

Nitric acid

F: Compatible Inorganic Acids not Including Oxidizers or Combustibles

Hydrochloric acid

Sulfuric acid (weak)

Phosphoric acid

Hydrogen fluoride solution

J: Poison Compressed Gases

Sulfur dioxide

Hexafluoropropylene

K: Compatible Explosive or Other Highly Unstable Materials

Picric acid dry(<10% H_2O)

Nitroguanidine

Tetrazole

Urea nitrate

L: Nonreactive Flammables and Combustibles, Including Solvents

Benzene

Methanol

Toluene

Tetrahydrofuran

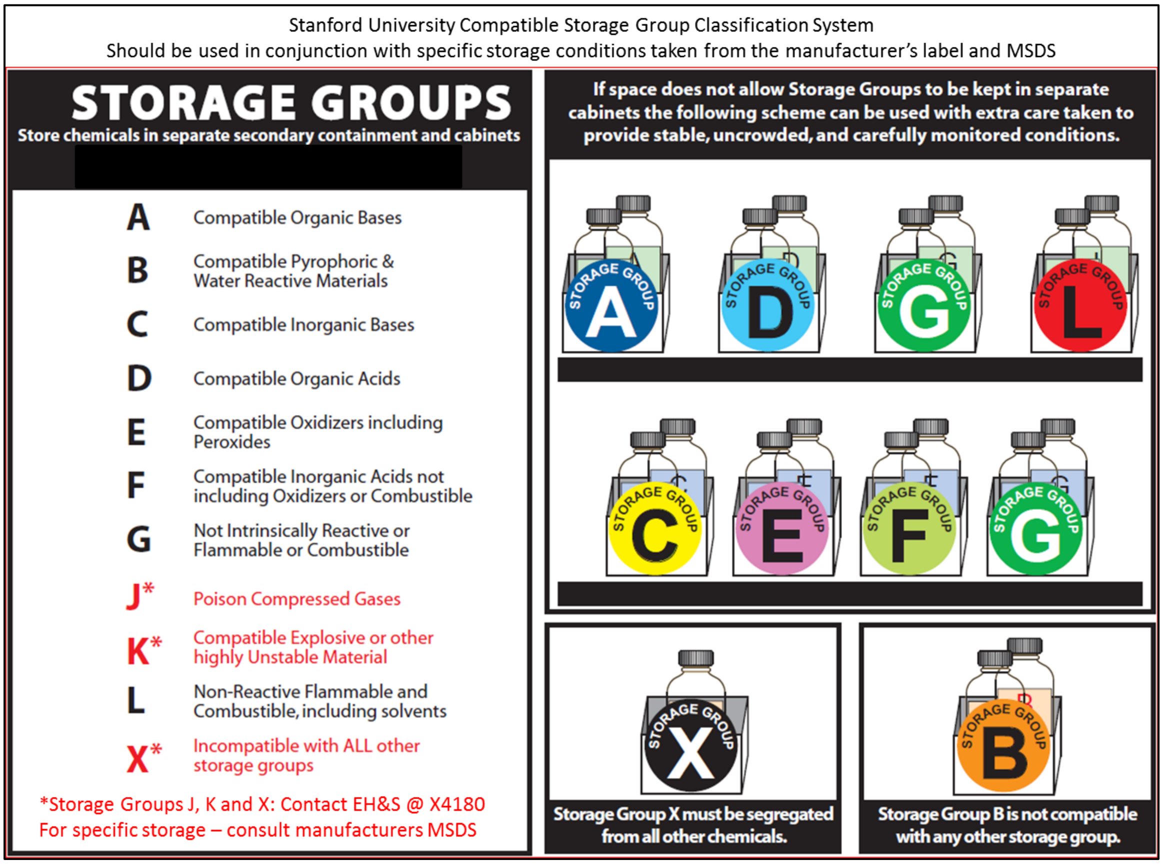
X: Incompatible with ALL Other Storage Groups

Picric acid moist (10-40% H_2O)

Perchloric acid	Phosphorus
Sodium hypochlorite	Benzyl azide
Hydrogen peroxide	Sodium hydrogen sulfide
3-Chloroperoxybenzoic acid	

Please Note: This list is not exhaustive. Please check the SDS and/or the *Wiley Guide to Chemical Incompatibilities 3rd ed.*, which is available online through the Nipissing University Libraries catalogue to ensure the compatibility of the chemical being stored.

Source: Prudent Practices in the Laboratory Handling and Management of Chemical Hazards, National Academy of Sciences.



Stanford University Compatible Storage Group Classification System
Should be used in conjunction with specific storage conditions taken from the manufacturer's label and MSDS

STORAGE GROUPS
Store chemicals in separate secondary containment and cabinets

[redacted]

A	Compatible Organic Bases
B	Compatible Pyrophoric & Water Reactive Materials
C	Compatible Inorganic Bases
D	Compatible Organic Acids
E	Compatible Oxidizers including Peroxides
F	Compatible Inorganic Acids not including Oxidizers or Combustible
G	Not Intrinsically Reactive or Flammable or Combustible
J*	Poison Compressed Gases
K*	Compatible Explosive or other highly Unstable Material
L	Non-Reactive Flammable and Combustible, including solvents
X*	Incompatible with ALL other storage groups

*Storage Groups J, K and X: Contact EH&S @ X4180
For specific storage – consult manufacturers MSDS

If space does not allow Storage Groups to be kept in separate cabinets the following scheme can be used with extra care taken to provide stable, uncrowded, and carefully monitored conditions.

Storage Group X must be segregated from all other chemicals.

Storage Group B is not compatible with any other storage group.

Figure 2. Stanford University Compatible Storage Group Classification System. Source: Prudent Practices in the Laboratory Handling and Management of Chemical Hazards, National Academy of Sciences.

13.0 Compressed Gases

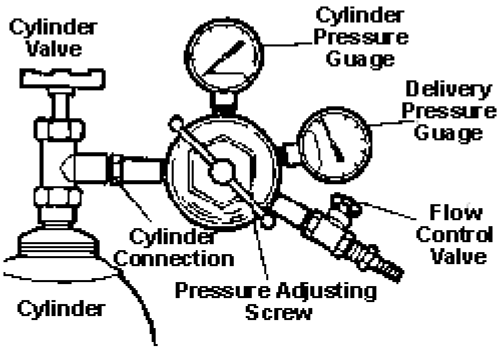
Compressed gases are inherently hazardous due to the high pressure inside the cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve and result in a rapid escape of high-pressure gas that can transform a cylinder into an uncontrollable rocket or pinwheel, causing serious injury and damage.

Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated or restricted areas and cause asphyxiation.

13.1 Handling and Transporting Compressed Gas Cylinders

The following guidelines should be used for the safe handling and transport of gas cylinders:

- All cylinders must be secured upright to a wall, bench or fixed support using a chain or strap when stored or in use.
- When cylinders are being transported, regulators must be removed and the protective cap must be attached.
- An appropriate cylinder cart must be used for transporting cylinders. Cylinders must be chained or strapped to the cart.
- When the cylinder must be transported from one floor to another floor the following protocol must be followed:
    - Two (or more) people must work as a team. If additional personnel are not available, then security must be called to help facilitate the move.
    - On each floor, each team member must ensure the elevator is unoccupied and then guard the elevator entrances on the entrance and exit floors, and all floors in between (if transporting between more than two floors).
    - Have one team member wheel the cart and secured cylinder in the elevator and push the button for the appropriate floor and exit the elevator immediately, ensuring that the elevator doors close. Do not ride the elevator with the cylinder.
    - When the elevator moves to the exit floor, the second team member will remove the cart and secured cylinder from the elevator.
- Never bleed a cylinder completely empty; leave a residual pressure of at least 25 psi to prevent contamination or “suck back”.
- Do not lubricate regulators. The mixture of lubricant and oxidizing gases could be explosive.
- Do not force, lubricate or modify cylinder valves in any way.
- Cylinders containing flammable gases must be grounded to prevent accumulation of electrostatic charge.
- Never expose skin or clothing to compressed gas flow as high velocity gas could penetrate the skin and cause serious injury.



- To use a cylinder:
    - Ensure the pressure regulating valve (adjusting screw) is closed (counter clockwise).
    - Open the cylinder valve slowly.
    - Open the pressure regulating valve to the desired pressure.
- To shut off the gas:
    - Close the cylinder valve.
    - Open the pressure regulating valve to relieve the pressure.

13.1.1 Handling Acetylene

Unskilled, improper, or careless use of acetylene can create explosion hazards and fire hazards which can result in death, severe personal injury or burns.

Use acetylene at pressures lower than 105 kPa (15 psig). At pressures above this level, acetylene can explode spontaneously. Atomic absorption equipment is designed to operate at fuel supply pressures between 65 and 100 kPa (9.5-14.5 psig). Refer to Specifications or the rear of the instrument for the exact range and recommended pressure.

Do not use any tubing or connector that will react chemically with acetylene. Never pass acetylene through copper tubing, or brass tubing or fittings containing more than 65% copper, since this may provoke an explosion. Never bring acetylene into direct contact with copper, silver, liquid mercury, gaseous chlorine or grease, as an explosion could result.

Use only acetylene that is packed in acetone with the Spectra AA system. Some gas suppliers offer acetylene packed in material other than acetone. While these alternatives may overcome some of the disadvantages of acetone, they may also introduce the more serious problem of corrosion in the gas control module and must not be used with atomic absorption spectrometers.

If the pressure in the acetylene cylinder is allowed to fall below 700 kPa (100 psig), or the consumption is greater than 1/7 of the cylinder contents per hour, acetone may be carried over from the cylinder and into an instrument. Acetone in an instrument can damage seals, ‘O’ rings and hoses, degrade analytical performance and precipitate flashbacks.

13.2 Valves and Regulators

- Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Regulators are not universal and have to be chosen based on the gas and the cylinder in use. Compressed Gas Association (CGA) connector numbers must be the same on the regulator and cylinder valve.
- Label all regulators appropriately and do not use regulators interchangeably with different gases.
- Do not rely on the pressure gauge to indicate maximum pressure ratings; check the regulator's specifications.
- Do not use adaptors or Teflon tape to attach regulators to gas cylinders. Regulator inlet connections are designed to fit the outlet connection of the cylinder valve of a particular gas. Gas tight connections are made using metal-to-metal seals and can be weakened or the lines plugged through the use of Teflon tape.
- Cylinder valve connections on regulators are designed to minimize the chances of using the wrong regulator.
- When tightening the regulator nut and hose connections, always use a cylinder wrench or other tightly fitting wrench. **Do not use an oversized wrench, adjustable wrench, pliers or pipe wrench.** These tools may damage the fittings and make it impossible to tighten them properly.
- After tightening be sure to perform a leak check with an approved leak testing liquid such as Prostar leak detector compound from Praxair.

13.3 Leaks

A leak from a cylinder in an enclosed space could displace air and lead to suffocation. Some compressed gases (e.g. acetylene, propane and hydrogen) are flammable. An air-gas mixture leak of this nature can be dangerously explosive. If leak is detected DO NOT use any equipment that could create a source of ignition (i.e. phone, lights, equipment).

Most leaks occur at the valve in the top of the cylinder and may involve the valve threads, valve stem, valve outlet, or pressure relief devices. Lab personnel should not attempt to repair leaking cylinders.

Where action can be taken without serious exposure to lab personnel:

- Move the cylinder to an isolated, well-ventilated area (away from combustible materials if the cylinder contains a flammable or oxidizing gas). Call Security Services at ext. 5555 from a telephone not in the vicinity of the leak.
- Do not use a cellular telephone in the vicinity of the leak to avoid igniting any flammable gases that may be present.
- Whenever a large or uncontrollable leak occurs, evacuate the area immediately and call 911 and ext. 5555.

13.4 Storage of Compressed Gas Cylinders

Storage of gas cylinders is regulated through the Ontario Fire Code. Only cylinders in use may be located in research or teaching labs.

- All cylinders must be secured upright to a wall, bench or fixed support using a chain or strap. Cylinder stands may be used as an alternative to straps.
- If there are no cylinder stands or straps, multiple cylinders may be nested (contact the Laboratory Safety Coordinator for instructions).
- Do not store full and empty cylinders together; they must be segregated.
- Oxidizers and flammable gases should be stored in areas separated by at least 20 feet or by a non-combustible wall.
- Cylinders should not be stored near radiators or other heat sources.
- Cylinders containing compressed gas can only be stored in areas where the ambient air temperature does not exceed 52°C.
- A flame should never be permitted to come in contact with any part of a compressed gas cylinder.
- Do not place cylinders where they may become part of an electric circuit.
- Ensure that each cylinder is properly and prominently labelled as to its contents.
- Using a chalk or masking tape, label empty cylinders clearly with either “EMPTY” or “MT” as well as the date and store separately from full ones.

14.0 Specific Chemical Hazards

All chemicals used in the laboratories at Nipissing University should be handled with the utmost caution, in keeping with good laboratory practices. Certain chemicals or classes of chemicals require specific handling precautions, described briefly in the following sections. It is beyond the scope of this manual to address the hazards associated with all of the chemicals that may be found in the university’s laboratories and the precautions required in working with them.

For more information about the toxicity, safe handling and use of specific chemicals, the appropriate SDS and/or reference such as the one listed below should be consulted:

- NIOSH Pocket Guide to Chemical Hazards, September 2007 NIOSH Publication No. 2005-149 (https://www.cdc.gov/niosh/npg/).

14.1 Flammables

Flammable materials present a serious hazard to laboratory personnel. Steps must be taken to ensure their appropriate use, handling and storage.

- Ensure containers are appropriately grounded when transferring liquid from one container to another.
- Ensure that potential ignition sources are identified and removed from the area surrounding the flammable material.

14.2 Oxidizers

Oxidizers are capable of igniting flammable and combustible material even in oxygen-deficient atmospheres. They can increase the intensity of a fire by adding to the oxygen supply and causing ignition and rapid burning of normally non-flammable materials.

Oxidizers can also:

- React with other chemicals, causing a release of toxic gases.
- Decompose and liberate toxic gases when heated.
- Burn or irritate skin, eyes, breathing passages and other tissues.

14.2.1 Solid oxidizers

Solid oxidizing agents have the ability to form explosive mixtures with common materials such as sugar, charcoal, starch, sawdust and sulphuric acid. Examples of solid oxidizers include:

- Chlorates
- Perchlorates (these are especially dangerous and their use should be avoided)
- Nitrates
- Chromates
- Permanganates

14.2.2 Liquid oxidizers

Liquid oxidizers are often strong acids as well, making them powerful corrosives. Examples include:

- Perchloric acid (use of perchloric acid is prohibited at Nipissing University as it requires the use of a special fume hood)

- Nitric acid
- Chromic acid
- Strong sulphuric acid

Personal protective equipment when working with these compounds should include a face shield, goggles, synthetic rubber apron, lab coat and synthetic rubber gloves.

14.3 Corrosives

Corrosive chemicals are commonly found in laboratories as solids, liquids and gases. These materials have the ability to damage tissue at the site of contact.

14.3.1 Corrosive Liquids

Corrosive liquids can be particularly hazardous as they act rapidly upon contact. Examples of common corrosive liquids are:

- Strong acids (chromic acid, hydrochloric acid, nitric acid, etc.) Hydrofluoric acid may be fatal through inhalation, absorption or ingestion and causes extensive, deep and painful burns. Avoid use if possible.
- Strong bases (aqueous sodium hydroxide, potassium hydroxide, ammonia, etc.)
- Strong oxidizing agents (peroxides, etc.)

14.3.2 Corrosive Solids

Inhalation of corrosive dusts presents a particular hazard as the point of contact and the injured tissue, which may belong to the lungs, is internal, creating significant damage that may be difficult to treat and heal. Examples of corrosive solids include lithium oxide, sodium sulphide and phenol, phosphorus pentoxide, calcium oxide, etc.

14.3.3 Use and Handling of Corrosives

Specific precautions to take when using or handling corrosive materials include the following:

- Ensure that acids are always added to water and not vice versa.
- Be prepared for heat generation when diluting or dissolving in water.
- Ensure all work is completed in a chemical fume hood with adequate ventilation.
- Wear appropriate personal protective equipment.

14.4 Hydrofluoric Acid

Hydrofluoric acid (HF), a clear and colourless liquid, is extremely corrosive and can release toxic fumes, which are capable of damaging the lungs. HF is significantly more hazardous than many other acids since it can cause deep tissue and bone damage. It can also cause systemic toxicity.

Honeywell International Inc. states the following:

"WARNING: Burns with concentrated HF are usually very serious, with the potential for significant complications due to fluoride toxicity. Concentrated HF, liquid or vapour, may cause severe burns, metabolic imbalances, pulmonary edema and life threatening cardiac arrhythmias. Even moderate exposures to concentrated HF may rapidly progress to fatality if left untreated."

14.4.1 Health Effects

Eye exposure – If HF contacts the eye(s), severe damage is possible, including loss of sight.

Skin contact – Due to its highly corrosive nature, HF can cause severe tissue and bone damage. Exposure to low concentrations of hydrofluoric acid can still cause impairment, even if the victim feels no pain. All skin and eye contact with HF must receive medical attention.

Inhalation – Inhalation of HF can cause lung damage, including fatal pulmonary edema.

14.4.2 Requirements for Usage

As with any hazard, prevention is paramount. Wherever possible, hydrofluoric acid should not be used. If substitution is not possible or practical, all of the following points must be adhered to prior to usage:

- The entire "Laboratory Safety Manual" has been reviewed;
- The SDS has been reviewed and a hard copy is available in the immediate area where the HF is being used;
- Review or create a Safe Operating Procedure (SOP) for the process in which HF is used, incorporating information contained in this section, and post it;
- The HF is only used in labs where both an emergency eye wash station AND shower are available;
- Working alone is not permitted when using hydrofluoric acid;
- The first aid kit in the lab where HF is used must contain an unexpired tube of calcium gluconate gel 2.5%;
- All required PPE, as outlined by the SDS, the laboratory supervisor and/or SOP must be worn;
- HF must be handled inside a fume hood;
- Know the first aid procedures related to HF exposure and/or contact;

- Know the spill response procedures.

14.4.3 First Aid

Often, symptoms of HF exposure are delayed for several hours following incidental contact. If you suspect that you may have been exposed to HF, seek first aid and medical attention immediately even if no signs or symptoms of exposure are present. A quick response can substantially reduce injury.

The person who treats a HF exposure victim must first and foremost ensure that he or she does not become a victim. Appropriate PPE must be worn at all times when providing first aid treatment.

Eye exposure

1) Immediately begin flushing the eye(s) for a minimum of 15 minutes. Encourage victim to gently hold the eyelids away from the eye(s) to maximize irrigation.
2) Have someone call 911.
3) Prepare a copy of the SDS and provide to first aid responders (e.g. paramedics)

Skin contact

1) Proceed to the emergency shower and immediately begin rinsing affected area.

2) Remove all contaminated clothing while rinsing.

3) While rinsing, have someone call 911.

4) Rinse for 5 minutes.

5) Immediately begin massaging affected area with calcium gluconate gel. Apply frequently until pain and redness disappears or until first aid responders arrive.

6) The person applying the gel must wear appropriate hand protection.

7) Provide a copy of SDS to first aid responders.

Inhalation

1) Immediately move victim to fresh air.

2) Have someone call 911.

3) Provide a copy of SDS to first aid responders.

Ingestion

1) Have the victim drink several large glasses of milk or water.

2) Do not induce vomiting.

3) Have someone call 911.

4) Provide a copy of SDS to first aid responders.

14.4.4 Transporting HF

If hydrofluoric acid must be transported from one laboratory to another, you must:

- Ensure that the container is in good condition, chemically compatible and the lid is tightly closed. Use a bottle carrier or cart to move the chemical.
- Don a single, clean glove with which to carry the container, leaving an ungloved hand to open doors and handle objects. This will limit the possibility of contamination.
- Alternatively, wear gloves and ask someone to open doors and move objects for you.

14.4.5 Storage

Store HF according to SDS requirements.

14.5 Highly Reactive Materials

Reactive materials are used for various purposes in the lab, often because of their reactive properties. Particular care must be taken to ensure safe handling, use and storage of these sensitive chemicals.

14.5.1 Water Reactives

The following situations may occur with water reactive chemicals on contact with water:

- Liberation of heat (causing potential ignition of the chemical itself or nearby flammable material).
- Release of flammable, toxic, or oxidizing gas.
- Release of metal oxide fumes (applicable to water reactive metals).
- Formation of corrosive acids.

Care must be taken to ensure that water reactive chemicals are handled and stored away from sinks, water baths or other sources of moisture.

14.5.2 Pyrophorics

Pyrophoric chemicals ignite spontaneously on contact with air. An example would be sodium metal. Pyrophorics must be handled and stored in such a way as to prevent exposure to air (e.g. storage under an inert gas or under kerosene).

14.5.3 Peroxidizable Organic Chemicals

Organic peroxides are carbon based chemicals that contain the characteristic peroxide O-O bond. Peroxide forming compounds are ones that typically react with air, moisture or impurities and produce a change in their chemical composition in normal storage. Many peroxides are shock, heat, or friction sensitive. The inadvertent production of organic peroxides, or their concentration through evaporation or distillation, or when combined with other compounds or metals, either deliberately or accidentally, can create an extreme detonation hazard. These compounds can, when disturbed by unusual heat, shock or friction can detonate with extreme violence. Chemicals that are sensitive to peroxide formation are classified into three main categories (*Richard J. Kelly of the U.S. Department of Energy by the Lawrence Livermore National Laboratory 1999*):

A. **Chemicals that form potentially explosive peroxides without concentration**. These materials may spontaneously form peroxides that will make the material shock- or heat-sensitive without any further concentration through evaporation or distillation.

B. **Chemicals that form potentially explosive peroxides when concentrated**. These materials form peroxides that will make the material shock- or heat-sensitive only when the parent liquid is evaporated, which effectively concentrates the peroxides. This class of peroxidized chemicals has a propensity for exploding when used experimentally in operations such as distillations. Very volatile materials, such as diethyl ether, may evaporate if stored without a cap, and the resulting concentrated, peroxidized material may be shock-sensitive.

C. **Chemicals that autopolymerize** and thus explode when relatively small quantities of peroxides are formed.

Susceptible chemicals should be purchased at planned intervals to ensure that they are completely used before they can become peroxidized. Note that anhydrous alcohols are subject to peroxidation. Solutions with water are not subject to peroxidation and do not need to be labelled or tested for peroxides.

Table 2. Common chemicals that form explosive levels of peroxides and their storage limits[a,b]. Please note: this list is not exhaustive. Please refer to SDS for further information.

A. Chemicals that form potentially explosive peroxides without concentration (3-month storage)[c]	**B. Chemicals that form potentially explosive peroxides when concentrated**[d,e] (12-month storage)	**C. Chemicals that autopolymerize** (24-hour to 12-month storage)[f]
Butadiene[g]	Acetal	Acrylic acid
Chloroprene[h]	Acetaldehyde*	Acrylonitrile*
Divinyl acetylene	Benzyl alcohol*	Butadiene[i]
Isopropyl ether	2-Butanol	Chloroprene
Tetrafluoroethylene[g]	Cyclohexanol*	Chlorotrifluoroethylene
Vinylidene chloride	2-Cyclohexen-1-ol	Methyl methacrylate
	Cumene	Styrene
	Decahydronaphthalene	Tetrafluoroethylene
	Diacetylene	Vinyl acetate*
	Dicyclopentadiene*	Vinyl acetylene
	Diethyl ether (stabilized)*	Vinyl pyridine
	Diethylene glycol	
	Dioxanes*	
	Ethylene glycol*	
	4-Heptanol	
	Methyl acetylene	
	Methyl isobutyl ketone	
	3-Methyl-1 butanol	
	Methyl cyclopentane	
	2-Pentanol	
	4-Pentene-1-ol	
	1-Phenylethanol	
	2-Phenylethanol	
	2-Propanol* (isopropanol)	

	Tetrahydrofuran*	
	Tetrahydronaphthalene	
	Vinyl ethers* (ethyl vinyl ether)	
	Other secondary alcohols	

* Indicates materials that are currently in Nipissing University inventory. Note, this may change over time.

[a] Materials other than those listed may form peroxides. Contact the Laboratory Safety Coordinator for more information. Applies only to pure materials.

[b] Contact the Laboratory Safety Coordinator for advice about mixtures.

[c] Store under nitrogen, if practical.

[d] **WARNING!** *May become unstable if concentrated intentionally or accidentally by the user.*

[e] Test chemicals in Groups 1 through 7 on Table 3 within 12 months of receipt, and discard or deperoxidize if necessary. Test chemicals in Groups 8 through 14 on Table 3 within 12 months of opening and discard if necessary.

[f] Chemicals to be stored for ≤5 days if uninhibited or 12 months if inhibited (stabilized). Avoid storing inhibited materials under inert gas because some inhibitors require a small amount of oxygen to work.

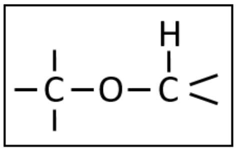
[g] When stored as an inhibited liquid monomer.

[h] When stored as a liquid monomer.

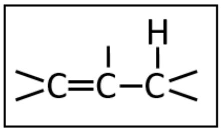
[i] When stored as a gas.

Table 3. Chemical moieties that can form organic peroxides. The moities are listed numbered 1 - 14 based on those most likely to form peroxides to those least likely to form peroxides.

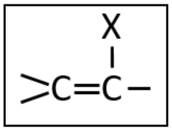
1. Ethers and acetals with α-hydrogen



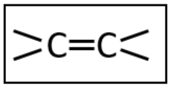
2. Alkenes with alyllic hydrogen



3. Chloroalkenes, fluoroalkenes

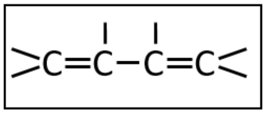


4. Vinyl halides, esters, ethers

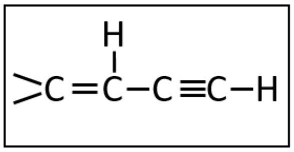


$>C=C<$

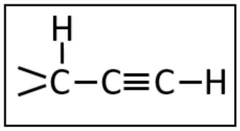
5. Dienes



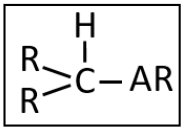
6. Vinylalkynes with α-hydrogen



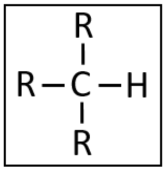
7. Alkylalkynes with α-hydrogen



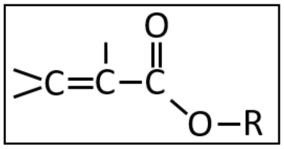
8. Alkylalkynes with tertiary α-hydrogen



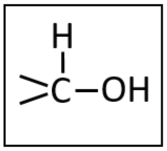
9. Alkanes and cycloalkanes with tertiary hydrogen



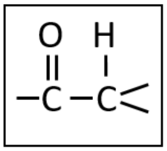
10. Acrylates, methacrylates



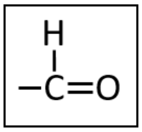
11. Secondary alcohols



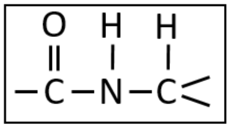
12. Ketones with α-hydrogen



13. Aldehydes



14. Ureas, amides, and lactans with α-hydrogen atom on a carbon attached to nitrogen

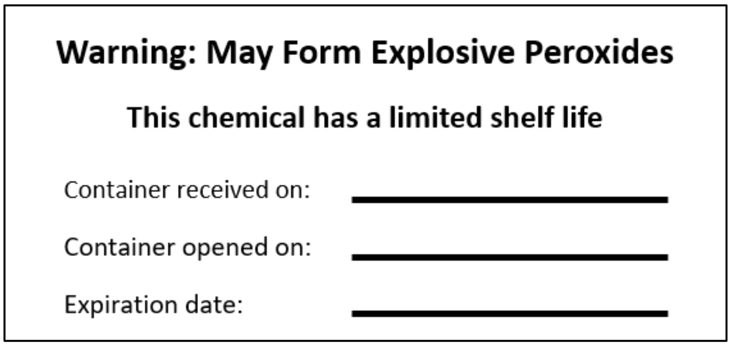


1.4.5.3.1 Handling precautions

Peroxidizable chemicals must be stored in sealed, air-impermeable, light resistant containers and stored in a cool locations or explosion-proof refrigerators or freezers (check the chemical's SDS for storage instructions). Peroxidizable chemicals should be stored and used under an inert atmosphere (e.g. argon, nitrogen, etc.) when practical.

The following handling precautions should be taken with all peroxide forming compounds:

- **Any peroxidizable chemical with visible discolouration, crystallization, or liquid stratification should be treated as potentially explosive**.
- All peroxide forming substances are to be labelled (see Figure 3 below) with:
  - Date received;
  - Date opened;
  - Expiration date (see above table or manufacturers label for expiration date).



Warning: May Form Explosive Peroxides

This chemical has a limited shelf life

Container received on: ______

Container opened on: ______

Expiration date: ______

Figure 3. Peroxide Warning Label.

- Peroxide forming chemicals must be disposed of within 6 months of container being opened *unless testing indicates no peroxides present*.
- All unopened containers to be disposed of within 12 months of the date received or the manufacturer's expiry date, whichever is later.
- **Never** purchase peroxide forming chemicals in quantities that exceed actual needs.
- **Never** attempt to open a container of peroxide forming chemicals when a cap is rusted, stuck or encrusted with scale.
- **Never** use metal spatulas to handle peroxides because contamination by metals can lead to explosive decomposition. Magnetic stir bars can unintentionally introduce iron, which can initiate an explosive reaction. Ceramic, Teflon or

wooden spatulas and stirring blades may be used if it is known that the material is not shock sensitive.

- Avoid friction, grinding and all forms of impact near peroxides, especially solid peroxides. **Glass containers that have screw-cap lids or glass stoppers should not be used**. Polyethylene bottles that have screw-cap lids may be used.
- To minimize the rate of decomposition, store peroxides at the lowest possible temperature consistent with their solubility or freezing point (consult the SDS).
- **Never** scrape or scrub glassware or containers that have been used with peroxide-forming compounds if there are oily or crusty residues present.

14.5.3.2 Testing for Explosive Peroxides in Chemicals

There are two methods widely used to test for peroxides in chemicals, the dip strip method and the iodide method. Be sure to follow all precautions above before starting the testing method. Regardless of which test is used, if a test indicates the presence of peroxides in greater than 100 ppm, do not use that chemical, but arrange for disposal. Be sure to notify the Laboratory Safety Coordinator of the presence of the peroxide containing chemical, plus the concentrations of the peroxides in the chemical so that arrangements can be made to have it disposed of safely. Be sure to record the test results on the container along with the date of testing.

Method A. Dip Strips

Sigma Aldrich markets dip strips from several manufacturers for the semi-quantitative detection of peroxides in organic and inorganic solutions. The strip incorporates the enzyme peroxidase, which transfers oxygen from peroxide to an incorporated organic redox indicator. The indicator turns blue in the presence of peroxides. The range for organic chemicals varies, depending on the manufacturer, with most manufacturers providing strips in ranges from 05 – 25 mg/L to 1 – 100 mg/L and higher. Higher ranges can be accommodated by dilution of the suspect chemical with a miscible, non-peroxidised chemical.

For volatile organic chemicals, the test strip is immersed in the chemical for 1 second; then the tester breathes slowly on the test strip for 15–30 seconds, or until the colour stabilizes. Vapour in the breath provides water for the reaction to proceed. Alternately, the test strip is immersed in the chemical for 1 second and then allowed to dry. Once dry, on drop of water is placed on the test zone. The colour is then compared with the scale provided on the test strip bottle.

For non-volatile organic chemicals, the test strip is immersed in the chemical for 1 second. After 5 seconds, the colour of the test strip is compared to scale on the test strip bottle.

These strips have a limited shelf life. Unopened packs should be stored in a refrigerator, while opened packs should be stored in a cool dry place (i.e. refrigerated desiccator).

Method B. Iodide Test

The iodide test is suitable for any peroxide forming chemical. To perform the test, use the following protocol:

1. Make up a 10% (w/v) test solution of potassium iodide (KI) dissolved in glacial acetic acid. Note; the test solution has a very limited shelf life and will naturally result in high blank readings if stored for any length of time.
2. To 1 ml of the KI solution, add 1 ml of the chemical to be tested. Use a 10 ml graduated cylinder. Be sure to run a blank at the same time.
3. Determine the colour of the resulting mixture by looking through the side of the cylinder with a piece of white paper behind the cylinder and refer to the table below to determine the indicated peroxide concentration.

Mixture Colour	Indicated peroxide concentration
Pale or barely discernable yellow colour	10 – 50 ppm (mg/L)
Bright yellow	~ 100 ppm (mg/L)
Brown	> 100 ppm (mg/L)

4. If the peroxide concentration is greater than 100 ppm, do not use the chemical and arrange for disposal. Be sure to label the container with the date and peroxide concentration.

14.6 Highly Reactive Acid Mixtures

14.6.1 Aqua Regia

14.6.1.1 Overview

Aqua regia (Latin for "Royal Water") is a solution of nitrohydrochloric acid. The traditional solution is comprised of a 3:1 mixture of concentrated hydrochloric acid and concentrated nitric acid, respectively. It is commonly used to remove noble metals such as gold, platinum and palladium from substrates, particularly in micro-fabrications and micro-electronics labs. Glassware may also be washed with aqua regia to remove organic compounds, but only in trace amounts. *Aqua regia solutions are extremely corrosive and may result in explosion or skin burns if not handled with extreme caution*.

14.6.1.2 Emergency Procedures

In case of skin contact: May cause skin burns. Flush the skin with copious amounts of water for at least 15 minutes. Seek medical attention immediately.

In case of eye contact: Aqua regia is corrosive and irritating to the eyes. Flush contaminated eye(s) immediately with copious quantities of water for at least 15 minutes. Seek medical attention immediately.

In case of inhalation: May irritate the respiratory tract. Conscious persons should be assisted to an area with fresh, uncontaminated air. Seek medical attention in the event of respiratory irritation, cough, or tightness in the chest. Symptoms may be delayed.

In case of ingestion: Not a likely route of exposure.

14.6.1.3 Handling

- **Never work with or handle aqua regia by yourself**. Aqua regia solutions, as well as any corrosive or hazardous substances, requires at all time the presence of a second knowledgeable user (buddy system).
- Always work in a clean, uncluttered fume hood. There should be no flammables in the fume hood. Keep the fume hoods' sash down at working height (usually 11 inches) when reactions are in progress. Leave the sash closed if the fume hood is unattended. It is essential that anyone working with aqua regia has unimpeded access to an emergency eyewash and safety shower. These must be within 30 meters (100 feet) of the work area.
- Wear chemical splash goggles (not glasses), face shield, lab coat, acid apron and heavy duty rubber gloves (nitrile gloves will not provide sufficient protection).
- Always use glass (preferably Pyrex) containers. aqua regia will melt some plastics and corrode most metals.
- Never store aqua regia solutions. Prepare only the amount needed for immediate use, and then destroy after each use.
- When preparing the aqua regia solution, always add the nitric acid to the hydrochloric acid slowly. Mix the solution in a hood with the sash between you and the solution.
- Dissolving metals in aqua regia releases toxic gases, always work with aqua regia in a fume hood.
- Aqua regia solution is very energetic and potentially explosive. It is very likely to become hot, more than 100 degrees C. Handle with care.
- Adding any acids or bases to aqua regia or spraying it with water will accelerate the exothermic reaction.
- Leave the hot aqua regia solution in an open container until cool.

- **Never store aqua regia in a closed container**. It will oxidize over time to form toxic nitrosyl chloride, nitrogen dioxide and chlorine gases. This will pressurize the container, likely causing an explosion.

- *Caution* - Mixing aqua regia with organic compounds may cause an explosion.

14.6.1.4 Storage

Do not store aqua regia. Aqua regia quickly loses its effectiveness due to the oxidation of its reactive components. Mix a fresh solution for each use. Excess solutions should be neutralized with sodium bicarbonate and disposed via the drain, followed by flushing with copious amounts of water.

14.6.1.5 Disposal

After the material has cooled, the spent solution should be neutralized with sodium bicarbonate and disposed via the drain, followed by flushing with copious amounts of water. The neutralized solution should be collected as hazardous waste if it is contaminated with heavy metals (i.e. silver, chromium).

14.6.2 Piranha Solution

14.6.2.1 General

"Piranha" is used to remove organic residues from substrates. Two different solutions are used. The most common is the acid piranha: a 3:1 mixture of concentrated sulfuric acid (H2SO4) with hydrogen peroxide (H2O2). Also used is the base piranha: a 3:1 mixture of ammonium hydroxide (NH4OH) with hydrogen peroxide (H2O2). Both are equally dangerous when hot, although the reaction in the acid piranha is self-starting whereas the base piranha must be heated to 60 degrees before the reaction takes off.

There are many things which will cause the reaction to accelerate out of control. "Out of control" can mean anything from the piranha foaming out of its bin and onto the deck; to an explosion with a huge shock wave including glove and acid-gown shredding glass sharps. Piranha solutions burn organic compound, therefore if you provide sufficient fuel for them (i.e. photoresist, IPA), these solutions will generate enormous quantities of heat and gas. *Piranha solutions are extremely corrosive and may result in explosion or skin burns if not handled with extreme caution*.

14.6.2.2 Emergency Procedures

In case of skin contact: May cause skin burns. Flush the skin with copious amounts of water for at least 15 minutes. Seek medical attention immediately.

In case of eye contact: Piranha solution is corrosive and irritating to the eyes. Flush contaminated eye(s) immediately with copious quantities of water for at least 15 minutes. Seek medical attention immediately.

In case of inhalation: May irritate the respiratory tract. Conscious persons should be assisted to an area with fresh, uncontaminated air. Seek medical attention in the event of respiratory irritation, cough, or tightness in the chest. Symptoms may be delayed.

In case of ingestion: Not a likely route of exposure.

14.6.2.3 Handling

- **Never work with or handle Piranha solutions by yourself**. Piranha solutions, as well as any corrosive or hazardous substances, requires at all time the presence of a second knowledgeable user (buddy system).

- Always work in a clean, uncluttered fume hood. There should be no flammables or organic compounds in the fume hood. Keep the fume hood sash down at working height (usually 11 inches) when reactions are in progress. Leave the sash closed if the fume hood is unattended. It is essential that anyone working with Piranha solution has unimpeded access to an emergency eyewash and safety shower. These must be within 30 meters (100 feet) of the work area.

- Wear chemical splash goggles (not glasses), face shield, lab coat, acid apron and heavy duty rubber gloves (nitrile gloves will not provide sufficient protection).

- Always use glass (preferably Pyrex) containers. Piranha solutions will melt some plastics and corrode most metals. Containers used during the experiment must be very clearly labeled and a warning sign, visible by any user working under the flow hood, must be posted at all time to indicate that the solutions contains Piranha mixture.

- Never store Piranha solutions. Prepare only the amount needed for immediate use, and then destroy after each use. Piranha stored in a closed container will likely explode.

- When preparing the Piranha solution, always add the peroxide to the acid very slowly. The H2O2 is added immediately before the etching process because it immediately produces an exothermic reaction with gas (pressure) release. If the H2O2 concentration is at 50% or greater, an explosion could occur.

- Piranha solution is very energetic and potentially explosive. It is very likely to become hot, more than 100 degrees C. Handle with care. Picking up a beaker that is this hot will be very painful, might melt your gloves, and may cause you to spill it!

- Substrates should be rinsed and dried before placing them in a piranha bath. Piranhas are used to remove photoresist and acetone residue, not the compounds themselves

- Leave the hot Piranha solution in an open container until cool.

- Adding any acids or bases to piranha or spraying it with water will accelerate the reaction.

- Mixing hot Piranha with organic compounds may cause an explosion. This includes acetone, photoresist, isopropyl alcohol, and nylon.

14.6.2.4 Storage

Do not store Piranha solutions. Mix a fresh solution for each use. Excess solutions should be disposed as explained below.

14.6.2.5 Disposal

The primary hazard from storage of Piranha etch waste is the potential for gas generation and over pressurization of the container when the solution is still hot. If you store a hot solution in an air tight container, it will explode!

- Therefore prior to store the Piranha solution, it must be left in an open container in order to cool down for several hours (overnight). It is your responsibility to make sure that the open container is very clearly labeled and left in a safe area for overnight cool down.

- Once cooled down, the solution can be transferred into a closed glass container for waste storage. The container must be very clearly labeled with the solution name and composition and must include VERY VISIBLE warning signs not to add any other types of chemicals.

- Collect it as hazardous waste in your satellite accumulation area.

14.7 Cryogenic Materials

Cryogenics are very low temperature materials such as dry ice (CO_2), liquefied air, nitrogen, helium, oxygen, argon and neon. The following hazards are associated with the use of cryogenics:

- Asphyxiation due to displacement of oxygen (for materials other than liquefied air and oxygen).
- Freezing and brittling of materials from extreme cold.
- Frostbite.
- Explosion due to pressure build-up.
- Condensation of oxygen and fuel such as hydrogen or hydrocarbons resulting in explosive mixtures.

The following are precautions that must be used when handling cryogenics:

- Always handle these liquids carefully to avoid skin burns and frostbite. Exposure that may be too brief to affect the skin of the face or hands may damage delicate tissues, such as the eyes.
- Protect skin and eyes from contact; wear eye protection and insulated gloves.
- Wear safety goggles when breaking large pieces of dry ice or using mixtures of dry ice and solvent.
- Wear a face shield when removing samples from storage dewars due to the possibility of rupture from pressure build-up.
- Use and store in well-ventilated areas.
- Keep away from sparks or flames.
- Use materials resistant to embrittlement (e.g. rubber tubing).
- Watches, rings, bracelets or other jewellery that could trap fluids against flesh should not be worn when handling cryogenic liquids.
- Never store dry ice in a refrigerator/freezer (especially deep chest freezers). Dry ice will sublimate at -78°C and could asphyxiate the person opening the equipment.
- Boiling and splashing always occur when charging or filling a warm container with cryogenic liquid or when inserting objects into these liquids. Perform these tasks slowly to minimize boiling and splashing. Use tongs to withdraw objects immersed in a cryogenic liquid.
- Cylinders and dewars should not be filled to more than 80% of capacity, since expansion of gases during warming may cause excessive pressure build-up.
- When transporting liquid nitrogen or frozen carbon dioxide, never use an elevator. Always use the stairs to transport liquid nitrogen and frozen carbon dioxide from one level to another.

14.8 Designated Substances

There are eleven “designated substances” regulated by Ontario’s Occupational Health and Safety Act because of their potential serious health implications. Use of designated substances in research or teaching should be avoided. However, because suitable substitution may not be possible, some of these substances may be found in university laboratories. Designated substances are listed below:

- acrylonitrile
- arsenic
- asbestos
- benzene

- coke oven emissions
- ethylene oxide
- isocyanates
- lead
- mercury
- silica
- vinyl chloride

Designated substance regulations apply to all workers at workplaces where the substance is present and is likely to be inhaled, ingested or absorbed by the worker. The regulations require that the time weighted average exposure of the worker to the substance is less than limits prescribed in the regulations themselves. Generally, designated substance regulations contain three key components:

- Assessment – the employer is required to consider the worker exposure or likelihood of exposure to the substance.
- Control program – a formal documented program is required if the assessment discloses that a worker is likely to be exposed to the substance. The program must include engineering controls, hygiene practices, work practices and facilities to ensure that the worker exposure to the substance is controlled.
- Monitoring – air emissions monitoring and medical surveillance are required to determine actual exposure to the substance.

It is the responsibility of the laboratory supervisor to ensure that such a program exists in their area.

15.0 Hazardous Waste Disposal

Disposal of hazardous waste is regulated through the Ministry of the Environment (MOE). The MOE stipulates that hazardous wastes are never to be poured down the drain or left to evaporate in a fume hood.

15.1 Minimizing Hazardous Waste

In keeping with environmental responsibility, it is important to minimize waste generation. The following points may be of assistance:

- Purchase only what you need.
- Where possible and practical, miniaturize experiments.
- Choose non-hazardous substances over hazardous substances (e.g. use digital or ethanol-based thermometers over mercury-based thermometers).
- Return unused material to the supplier if possible (e.g. gas cylinders).

- Donate chemicals to fellow researchers if located on-site. If not on-site, this may require a special transport permit.
- Recycle/recover materials when this can be accomplished efficiently, effectively and safely.

15.2 Packaging and Labelling Requirements

The generator of waste is responsible for providing appropriate waste containers and for ensuring that all hazardous waste is packaged and labelled appropriately. The following guidelines should be followed:

- Incompatible materials may not be combined in a single waste container.
- Chemical liquid waste containers may not to be filled beyond approximately 75% of their capacity to allow for vapour expansion.
- Container materials must be compatible with the contained wastes (e.g. hydrofluoric acid cannot be stored in glass containers; corrosives may not be stored in metal containers, etc.).
- Containers must be in good condition.
- Wastes must be identified appropriately (e.g. biohazard bags may not be used for chemical wastes if no biohazard exists).
- Non-hazardous wastes must be segregated from hazardous waste streams to avoid unnecessary expenses.

15.3 Chemical Waste

Hazardous chemical waste is picked up regularly by a hazardous waste contractor. If you have waste for disposal:

- Complete a hazardous waste disposal label and attach it to all waste containers. See *Appendix IV* for a sample label.
- Provide a list of all hazardous waste that needs to be disposed of to the Laboratory Safety Coordinator.

15.4 Unknown Waste

Waste of unknown composition will not be picked up by the hazardous waste contractor. It is the responsibility of the laboratory supervisor to ensure that laboratory personnel correctly identify or categorize the “unknown”.

15.5 Biohazardous Waste

See Biosafety Laboratory Manual for details.

15.6 Sharps Waste

Sharps must be separated from regular waste streams to prevent unnecessary needle stick injuries and/or lacerations.

15.6.1 Broken Laboratory Glassware

15.6.1.1 Clean Broken Glassware

Clean broken glassware, including Pasteur pipettes and broken laboratory glassware, must be separated into the proper glassware disposal container. Plant & Property will remove glass waste once the containers are full.

15.6.1.2 Contaminated Broken Glassware

Contaminated broken glassware must be treated like hazardous sharps. It will be disposed of using our hazardous waste contractor.

15.6.2 Syringes, Needles, Scalpels and Blades

- Dispose of syringes, needles, scalpels and blades in standard “Sharps” containers.
- When a container is full, autoclave according to industry practices for biomedical waste. If autoclaving is not possible, the container will be disposed of through the hazardous waste contractor.

15.7 Batteries

Batteries are to be disposed of as follows:

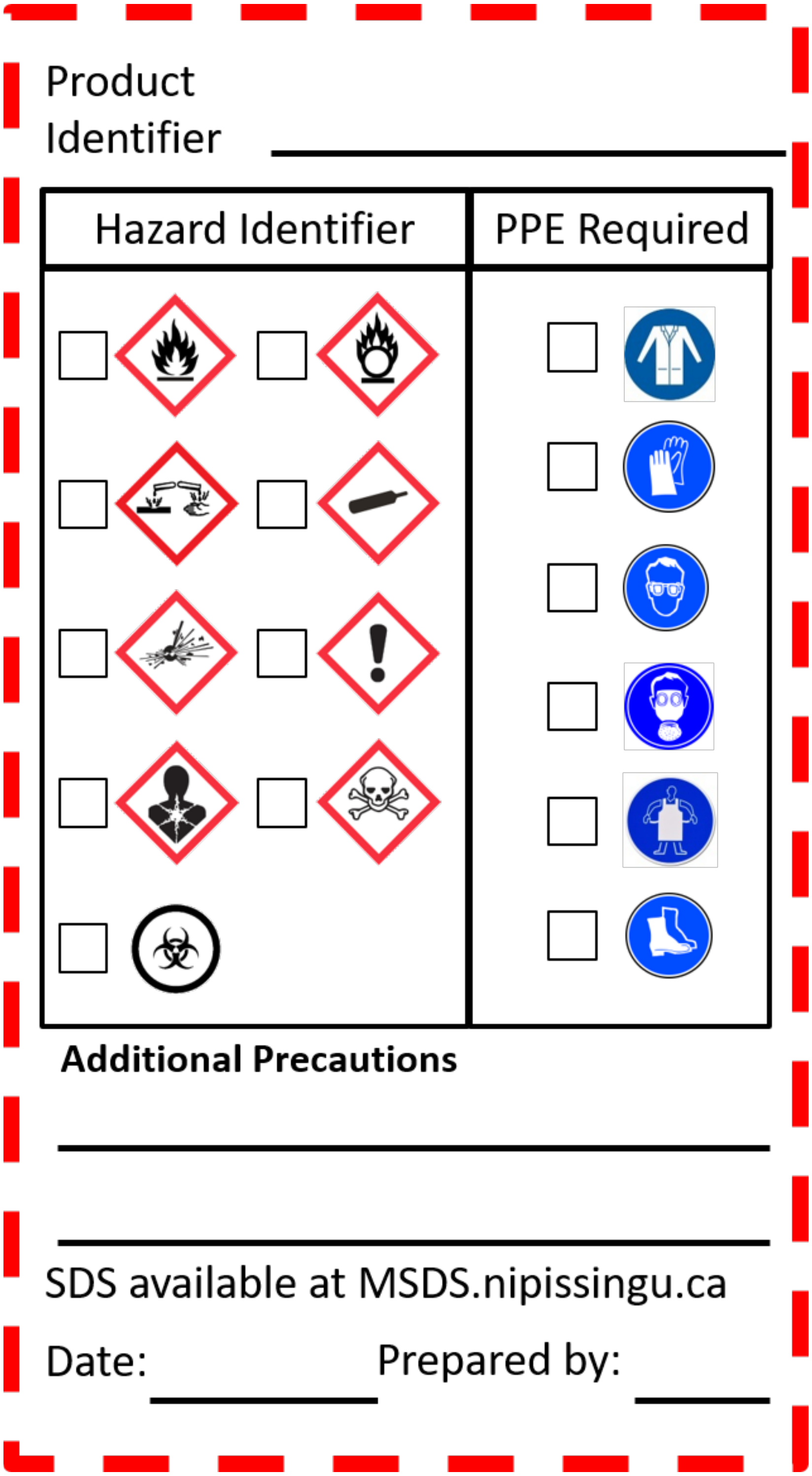
- Alkaline batteries are to be collected at a designated waste storage site (to be determined by each department) and disposed of through the normal hazardous waste stream procedures**.**
- Batteries may also be collected for donation to local schools.

15.8 Animal Carcasses

Animal carcasses that have been preserved in formalin or other preserving agent are disposed of using a hazardous waste contractor. Carcasses are to be bagged and placed in a freezer until they are ready for disposal, at which point they will be transferred to a sealed drum.

Animal carcasses that have not been preserved are to be bagged and placed in a freezer until they are ready for disposal, at which point they can be transferred to the North Bay land fill and disposed of according to the requirements of the City of North Bay.

Appendix I – WHMIS 2015 Workplace Label



Product Identifier ____________________

Hazard Identifier	PPE Required
☐ ☐	☐
☐ ☐	☐
☐ ☐	☐
☐ ☐	☐
☐	☐
	☐

Additional Precautions

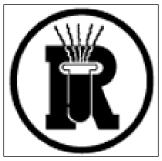
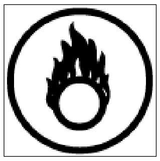
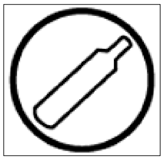
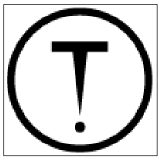
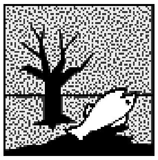
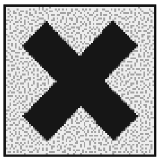
____

____

SDS available at MSDS.nipissingu.ca

Date: __________ Prepared by: ______

Appendix II – WHMIS 1998 vs. WHMIS 2015 Hazard Symbols

WHMIS 1998 Symbol (old)	WHMIS 2015 Symbol (new)	Hazard Explanation	WHMIS 1998 Symbol (old)	WHMIS 2015 Symbol (new)	Hazard Explanation
		**Exploding bomb** (for explosion or reactivity hazards)			**Flame** (for fire hazards)
		**Exploding bomb** (for explosion or reactivity hazards)			**Flame over circle** (for oxidizing hazards)
		**Gas cylinder** (for gases under pressure)			**Corrosion** (corrosive damage to metals, as well as skin, eyes)
		**Health hazard** (may cause or suspected of causing serious heath effects)			**Biohazardous infectious materials** (for organisms or toxins that can cause diseases in people or animals)
		**Skull and Crossbones** (can cause death or toxicity with short exposure to small amounts)			**Environment*** (may cause damage to the aquatic environment)
		**Exclamation mark** (may cause less serious health effects or damage the ozone layer)			

*The GHS (Global Harmonized System) system defines an Environmental hazards group. This group (and its classes) was not adopted in WHMIS 2015. However, including information about environmental hazards is allowed by WHMIS 2015.

Adapted from https://www.ccohs.ca/oshanswers/chemicals/whmis_ghs/pictograms.html

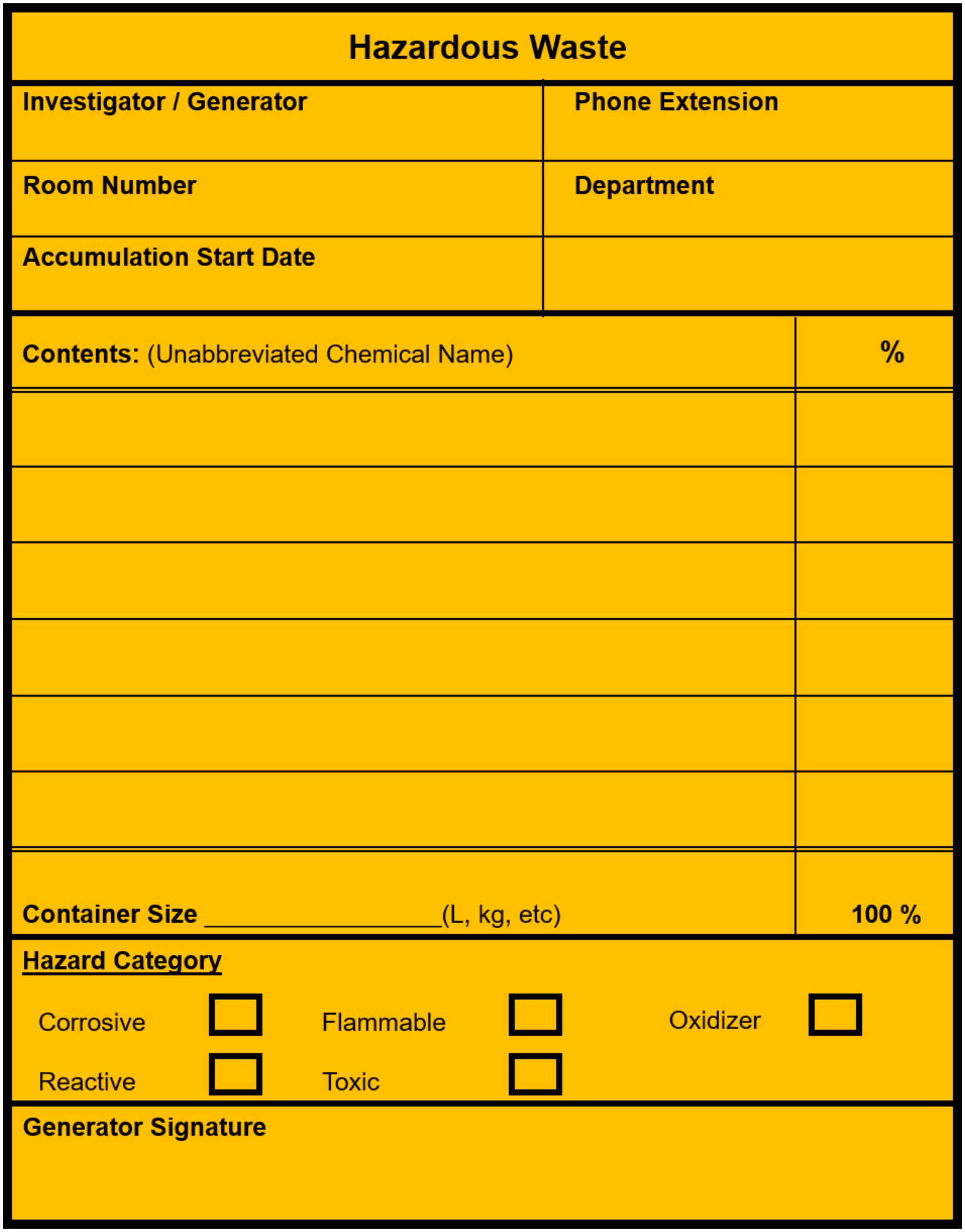
Appendix III – Chemical Compatibility Guide

The Fisher chemical classification system uses colours to broadly classify chemicals based on four basic characteristics, flammability/combustibility, health hazard, reactive or oxidizing potential, and corrosive potential. Chemicals within each broad group can be further classified based on compatibilities with other chemicals within the group.

Please note: some chemicals in the same broad compatibility group may not be compatible with others in the same group. For example, oxidizing acids should not be stored with non-oxidizing acids or inorganic bases. Inorganic bases should not be stored with oxidizing acids or with non-oxidizing acids. *See Section 14.0 for more detailed requirements for chemical storage.*

🟥 RED: Flammable. Store in area segregated for flammable reagents	**Examples of Flammables** *Organic acids* (acetic acid, formic acid, etc.) *Alcohols* (methanol, ethanol, isopropanol) *Solvents* (acetone, xylene, toluene, ethyl ether, benzene, acetonitrile, hexane, etc.)
🟦 BLUE: Health Hazard. Toxic if inhaled, ingested or absorbed through skin. Store in secure area.	**Examples of Health Hazard Material** *Poisons* (methyl viologen) *Carcinogens* (methylene chloride) *Habit-formers* (caffeine)
🟨 YELLOW: Reactive and oxidizing materials. May react violently with air, water or other substances. Store away from flammable and combustible materials.	**Examples of Reactive and Oxidizing Materials** *Inorganic oxidizers* (nitrates, nitrites, permanganates, chlorates, etc.) *Water reactives* (alkali metals, metal powders, metal hydrides, metal phosphides) *Pyrophorics* (metal alkyls and aryls, non-metal alkyls, phosphorus)
⬜ WHITE: Corrosive.. May harm skin, eyes, mucous membranes. Store away from red-yellow- and –blue coded reagents above.	**Examples of Corrosive Materials** *Non-oxidizing acids* (hydrochloric acid, sulfuric acid, phosphoric acid, bromic acid) *Oxidizing acids* (nitric acid, hydrogen peroxide, chromic acid) *Inorganic bases* (metal hydroxides, ammonium hydroxide)

Appendix IV – Hazardous Waste Disposal Label



Hazardous Waste

Investigator / Generator	**Phone Extension**
Room Number	**Department**
Accumulation Start Date	

Contents: (Unabbreviated Chemical Name)	**%**
Container Size ________________(L, kg, etc)	**100 %**

Hazard Category

Corrosive ☐ Flammable ☐ Oxidizer ☐

Reactive ☐ Toxic ☐

Generator Signature

Appendix V – Class D Combustible Materials

If your laboratory contains combustible metals or combustible metal compounds, you will need to have a type D fire extinguisher. In the event of a fire, an ABC fire extinguisher will react with combustible metals. Therefore a fire extinguisher containing agents such as sodium chloride or potassium chloride is used to extinguish combustible metal fires. Class D fire extinguishers are yellow and have a five-pointed star on them. The following is a list* of combustible metals that require a class D fire extinguisher:

Aluminum phosphide
Aluminum (powder)
Beryllium (powder)
Calcium
Calcium carbide
Cerium
Cesium
Gallium arsenide
Gallium phosphide
Lithium
Lithium aluminum deuteride
Lithium aluminum hydride
Lithium aluminum hydride bis(tetrahydrofuran
Lithium amide
Lithium borohydride
Lithium-6-deuteride
Lithium hydride
Lithium tetraphylborate tris (1,2-dimethoxyethane)
Lithium tri-tert-butoxyaluminohydride
Lutetium
Magnesium hydride
Magnesium and magnesium alloys
Neodymium
Nickel catalyst (Raney)
Phosphorous
Phosphorous pentasulfide
Potassium
Potassium hydride
Potassium-sodium alloys
Red-Al
Rubidium
Sodium
Sodium aluminum hydride
Sodium bis (2-methoxyethoxy) aluminum hydride in toluene
Sodium borohydride
Sodium borohydride cobalt-doped
Sodium borohydride on alumina
Sodium hydride
Strontium
Titanium (powder)
Zinc phosphide
Zinc (powder)
Zirconium (powder)

*** Please note**: This may not be an exhaustive list. Please consult the SDS for the material to ensure your laboratory has the correct fire extinguisher for the material you are using.

Document Revision History

Date	Author	Revision
2011-03-10	Dave Vadnais	Revised table of contents to be clickable.
2011-03-10	Dave Vadnais	Added section 14.5.3 Peroxidizable Organic Chemicals
2011-03-18	Dave Vadnais	Section 10.1 Updated to reflect new ANSI standard Z358.1-2009 and more information regarding use, maintenance and repairs
2011-05-26	Dave Vadnais	Added Appendix V – list of combustible metals
2011-05-26	Dave Vadnais	Added Section 7.4 Working Alone
2011-06-02	Dave Vadnais	Added Fire Blanket use instructions to Section 8.2
2013-08-16	Dave Vadnais	Whole document – minor revisions. Removed Lab Safety Manual Sign-off sheet. Removed Unattended Work Form (Appendix II) – Renumbered Appendixes.
2013-08-16	Dave Vadnais	Revised Introduction to better reflect sources of information used in the manual and the requirements for working in the lab.
2014-03-17	Dave Vadnais	Added new section 12.2, Chemical Storage When Storage Space is Limiting outlining the Stanford Chemical Segregation System.
2015-10-06	Dave Vadnais	Changed all references from MSDS to SDS. Changed WHMIS to read WHMIS 2015 to reflect new legislation.
2017-12-09	Dave Vadnais	Whole Document – minor revisions. Removed Lab Manual quiz. Updated workplace label image to reflect WHMIS 2015 changes. Made changes to acid storage requirements to reflect newly obtained information regarding chemical compatibility requirements for oxidizing acids. Updated all references to ANSI Standard Z358.1-2009 to read ANSI Standard Z358.1-2014 Removed Appendix II and added new Appendix II and Appendix III and renumbered Appendix III and IV to Appendix IV and V, respectively.

2017-06-20	Dave Vadnais	Updated peroxide chemical section based on new information. Added section on Bunsen burner use (10.8.1). Updated section on alcohol burners (10.8.2). Expanded section on acid bath use (10.10).