

RHODES UNIVERSITY

CHEMISTRY DEPARTMENT

LABORATORY SAFETY HANDBOOK

Authors

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1. FOREWORD

This Laboratory Safety Handbook emphasizes the importance of safety awareness in and around the research and teaching laboratories of the Chemical and Pharmaceutical Sciences building. This manual is also an attempt towards compliance with, not only national regulations, but also international standards of chemical hygiene and laboratory safety practices.

As professional chemists, we must continually be safety vigilant and safety aware. At all times we must understand and deal proactively with the risks associated with handling potentially hazardous chemicals. Safety and risk management in all the laboratories of the Chemical and Pharmaceutical Sciences building is not “someone else’s responsibility” but rather the responsibility of **everyone** who enters our laboratories.

This Laboratory Safety Handbook has been compiled with great care and attention to detail. I hope that you will refer to it regularly and continually seek improved ways to help reduce risk and maintain a safe and healthy environment for all who work in this building.

For a comprehensive overview of safety on campus please find a working draft of Rhodes University’s **Emergency Management Plan** which is now available from the Estates Division web pages, at: <http://www.ru.ac.za/estates/safety>.

2. ACCESS

Access to the laboratories is restricted to students and research assistants involved with research and practical sessions in the lab, lecturers/supervisors of such students, and the technical officers/cleaners. In addition, students and research assistants are required to pass the safety knowledge test based on this document before occupying the laboratories. No other persons will be allowed without proper arrangements in advance. Visitors must be supervised at all times.

Access to authorized persons is further strictly conditional to wearing a lab coat, safety goggles and closed shoes at all times.

Please note that these restrictions are for everybody's protection and will be strictly monitored.

3. RESPONSIBILITIES

The laboratory worker using chemicals is responsible for:

- Obeying lawful instruction by her/his supervisor;
- Being aware of hazards associated with the chemicals used in the laboratory;
- Handling and storing chemicals in a safe manner;
- Following Standard Operating Procedures (SOPs) developed for the laboratory;
- Developing good chemical hygiene work habits (i.e. working in the fume hood when necessary, taking gloves off when handling doors, etc.)
- Good Laboratory Practice (GLP) (i.e. placing chemicals back in their storage places after use, cleaning up the work bench following an experiment).
- Reporting unsafe conditions, injuries and illnesses to the supervisor.

The chemical safety officer and the supervisor(s) have the primary responsibility for overall chemical safety and health in the laboratories, including:

- Acquiring the knowledge and information needed to recognize and control hazards;
- Provide access to relevant Material Safety Data Sheets (MSDS) when needed;
- Selecting and implementing laboratory practices and engineering controls to minimize potential for exposure to hazardous chemicals;
- Training students in the potential hazards associated with chemicals used in the laboratory, laboratory practices, use of engineering controls and emergency procedures;

- Insuring that all waste disposal from the building is in accordance with the waste disposal protocol for the Chemistry and Pharmaceutical Sciences Building (see appendix D).
- Ensuring that equipment and protective devices are maintained in good working order, in conjunction with the relevant technical officer;
- Obtaining prior approval, when required, for work with particularly hazardous substances;
- Developing an understanding of the legal regulations for use of hazardous substances in the laboratory;
- Supervisors must report all work-related injuries or illnesses to the Chemical Safety Officer;
- Monitoring laboratory chemical inventory lists to make sure they are updated.

The Chemical Safety Officer shall be responsible for:

- Development and maintenance of the Laboratory Safety Handbook for the department.
- Implementation of the regulations as specified in the Laboratory Safety handbook;
- Put into place mechanisms that will provide evidence that those working in laboratories have read and understood the contents of this laboratory Safety handbook;
- Monitor procurement, use and disposal of chemicals;
- Assist laboratory supervisors in the selection of appropriate safety practices and engineering controls for present and future projects;
- Report all accidents which result in exposure of persons or the environment to harmful chemicals effects to HOD;
- Supervise or assist in cleanup and/or decontamination in the event of accidental release of chemical substances;
- Carry out monthly inspections in laboratories as required by regulations (see Appendix A for the inspection sheet).

It is the responsibility of the supervisor to assure that her/his students, be they full-time, part-time, in-service training, visiting students, are familiar with the general standards of chemical hygiene practices in the lab as outlined in this manual. Any disregard for these practices may be addressed by the Chemical Safety Officer and the Supervisor or HOD.

4. GENERAL LABORATORY RULES

4.1 Personal Behaviour

Professional standards of personal behaviour are required at all times.

- No food, drinks, cigarettes or cosmetics will be stored in an area which contains chemicals.

- No eating, drinking, smoking, or application of cosmetics may occur in the laboratory areas where chemicals are being used. Additionally, be aware that tobacco products in opened packages can absorb chemical vapours.
- Never wear or bring lab coats into areas where food is consumed (this includes the tea room). You are also not allowed to eat anywhere while wearing a lab coat.
- All persons handling chemicals shall wash hands and other exposed areas of body after handling chemicals and before leaving the laboratory.
- Gloves should be removed before handling doors and computers, phones, etc.
- Do not use solvents or laboratory detergent for washing skin. Hand soap is available.
- Do not take anything off someone else's bench or from someone else's locker without asking first.
- Avoid distracting or startling other workers.
- Use laboratory equipment only for its designated purpose.
- Do not allow unauthorized persons, including children under 12 year and pets, in laboratories where hazardous substances are stored or are in use or hazardous activities are in progress.
- Confine long hair and loose clothing in the laboratory. Wear closed shoes at all times. Open-toed shoes or sandals are not allowed.
- Keep work areas clean and free from obstruction. Clean up spills immediately.
- Do not block access to exits, emergency equipment, electrical panels, etc.

4.2 Handling of Chemicals and Laboratory Glassware and Research Equipment

- Always be aware of the hazards associated with the chemicals you are working with. Consult the relevant Material Safety Data Sheets (MSDS) as well as the Merck Risk and Safety (R&S) numbers during your work session. It is the responsibility of everyone who is working with chemicals to be aware of the hazards and the disposal procedures for all the chemicals they are handling. This responsibility is not transferable. See Safety and Hazards section.
- Skin contact with chemicals should be avoided. Nitrile and latex gloves are available at the stores. The former are available for those who are allergic to latex and when necessary to use latex gloves for everybody else.
- Do not handle instruments, PCs, mice, door handles, telephones, cellphones, etc. without first removing your gloves. Gloves are for use at your workbench only.
- Any direct contact with chemicals should be avoided. Do not smell, taste or inhale any chemical.
- Under no circumstances should mouth suction be used to pipette chemicals to start a siphon. Use a pipette bulb or a mechanical pipetting device to provide a vacuum.
- Inspect equipment and apparatus before use with a hazardous chemical. Do not use damaged or questionable equipment/apparatus. Do not attempt to repair cracks in glassware with Parafilm.

- All glassware should be handled and stored with care to minimize breakage. Broken glassware should be immediately disposed of in a broken glass container, and Mr B. Kalipa must be notified when it is full. Consult the Chemical Safety Officer if the broken glassware is contaminated.
- Needles and other sharp objects must be disposed in a sharps container (available in the Chemical stores), and Mr Kalipa must be notified when it is full.
- Round bottom flasks and other evacuated glass apparatus shall ideally be shielded to contain chemicals and glass fragments should implosion occur.
- Workbenches should be kept clear of clutter (papers, glassware, reaction vials, etc). No storage is allowed at the top of the workbench – keep this area completely clear of obstruction.
- All apparatus shall be thoroughly cleaned and returned to storage upon completion of usage.
- Chemical containers shall be cleaned (on the outside), properly labelled and returned to storage upon completion of usage.
- Solvents which are not being used must be returned to the main chemical stores for storage in the solvent room.
- Compounds that may be capable of developing explosive peroxides, such as ether, must be dated upon receipt, and be consumed or disposed of within six months. See section on Peroxide Forming Compounds under Safety and Hazards in this manual.
- Aisles and hallways should be kept clear – this includes obstruction by abandoned trolleys.
- Emergency equipment such as showers, eye washes, fire extinguishers, fire blankets, first aid boxes, and fire alarms should never be blocked and should always have a clear path to them.
- If work produces hazardous waste (e.g. on filter paper or cotton wool) this should not be thrown in with regular waste. Special arrangements need to be made with the Safety Officer regarding disposal of this type of waste. See the section on Waste Collection.
- Never carry a container by the lid. A lid may break under the weight of the bottle. Carry the container with both hands, using one to support it from the bottom. Never carry more than what you can handle.
- When moving in the laboratory, anticipate sudden backing up or changes in direction by others. If you should stumble or fall while carrying glassware or chemicals, try to project them away from yourself and others.
- Only carry a maximum of two Winchester bottles from chemical stores, distillation room, or other laboratories using a metal carrier.
- Volumetric flasks should preferably not be used as storage containers. Reasons for this include:
 - certain chemicals (e.g. NaOH, fluorides) etch the glass;
 - liquid weight alters the shape and volume of the flask;

Solvents, acids, alkalis, & flammables should always be stored in fire resistant cabinets. However, beware **NOT TO** place flammables (ethers, acetone, etc) with oxidising chemicals (potassium permanganate, chlorates, etc) and strong acids with alkalis.

4.3 Personal Protective Equipment

- Lab coats and closed shoes must be worn at all times inside the laboratory. Lab coats are available at the Chemical store. Lab coats will be collected at regular intervals by Mr B. Kalipa for washing. Do not wear a badly soiled lab coat. You are putting your health at risk.
- Safety goggles must be worn when you are working with chemical substances.
- Gloves must be worn when working with hazardous chemical substances or substances of unknown toxicity. Gloves must also be worn when washing glassware that was in contact with such chemicals. Nitrile and latex gloves are available at the stores.
- Always wash your hands with soap and water after removing your gloves.
- Respiratory protection (dust masks, etc.) is available at the stores.
- There are filter gas masks located at corridors for emergency when there is spillage of compounds with toxic vapours.
- Always use the fumehood when handling chemicals with odorous/harmful vapours

4.4 Planning

Every laboratory worker should observe the following guidelines:

- Plan and conduct operations as outlined in this manual and as well as in accordance with requirements as specified by the supervisor
- Know the potential hazards and appropriate safety precautions associated with the chemicals to be used before beginning work.
- Know the appropriate actions to be taken in case of an accident.
- Ask and be able to answer the following questions:
 - What are the hazards?
 - What are the worst things that could happen and are you prepared for such things?
 - What work practices, facilities or personal protective equipment are needed to minimize the risk and are these available?
- Material Safety Data Sheets (MSDS) can be downloaded from the sites on the Rhodes Chemistry webpage: <http://www.chem.ru.ac.za/chemlink.html> . Consult your supervisor or Chemical Safety Officer if you are concerned about the hazards associated with chemicals you are working with.
- Know the location and how to use emergency equipment, including safety showers and eyewash stations.
- Familiarize yourself with the Emergency Response Procedures, facility alarms and building evacuation routes.
- Know the types of personal protective equipment available and how to use them for each procedure.

- Be alert to unsafe conditions and actions and bring them to the attention of your supervisor or safety officer immediately so that corrections can be made as soon as possible.
- Prevent pollution by following waste collection procedures. See section on Waste Collection. Chemical reactions may also require traps or scrubbing devices to prevent the release of toxic substances to the laboratory or to the environment.
- Sand is the recommended first option to contain a chemical spill or fire. Make sure that you know where sand buckets are situated.
- Position and clamp reaction apparatus thoughtfully in order to permit manipulation without the need to move the apparatus until the entire reaction is completed. Combine reagents in the appropriate order and avoid adding solids to hot liquids.

4.5 Scaled-up Reactions

Scale-up of reactions from those producing a few milligrams or grams to those producing more than 100 g of a product may represent several orders of magnitude of added risk. The procedures and controls applicable to large-scale laboratory reactions are fundamentally the same as those for smaller-scale procedures. However, differences in heat transfer, stirring effects, times for dissolution, and effects of concentration and the fact that substantial amounts of materials are being used introduce the need for special vigilance for scaled-up work. Careful planning and consultation with experienced workers to prepare for any eventuality are essential for large-scale laboratory work.

Although it is not always possible to predict whether a scaled-up reaction has increased risk, hazards should be evaluated if the following conditions exist:

- The starting material and/or intermediates contain functional groups that have a history of being explosive (e.g. N–N, N–O, N–halogen, O–O, and O–halogen bonds) or that could explode to give a large increase in pressure.
- A reactant or product is unstable near the reaction or work-up temperature. A preliminary test consists of heating a small sample in a melting point tube.
- A reaction is delayed; that is, an induction period is required.
- Gaseous by-products are formed.
- A reaction is exothermic. Consider what can be done to provide cooling if the reaction begins to run away.
- A reaction requires a long reflux period. Consider what could happen if solvent is lost owing to poor condenser cooling.
- A reaction requires temperatures below 0°C. Consider what could happen if the reaction warms to room temperature.

In addition, thermal phenomena that produce significant effects on a larger scale may not have been detected in smaller-scale reactions and therefore could be less obvious than toxic and/or

environmental hazards. Thermal analytical techniques should be used to determine whether any process modifications are necessary.

4.6 Overnight Experiments

Unattended laboratory operations are sometimes carried out continuously or overnight with no one present. These operations should ideally be carried out in the overnight room but the department currently does not have a room dedicated for this purpose. A temporary way forward is as follows:

- Anyone performing an overnight reaction should fill out the Emergency Information Sheet (Appendix E); outlining the nature of the experiment and the form should be placed next to the location of the reaction.
- Make sure your mobile phone is always on in case of emergency.
- Carefully examine how the chemicals and apparatus are positioned considering the possibility of a fire, explosion or unintended reactions.
- No heating of reactions on the bench overnight, only stirring is allowed.

4.7 Solvent Distillation

The Department has a special room for this purpose, room F21, which is equipped with a fume hood, heating mantles, condensers, N₂ gas line, and controlled power supply (15 minute cycle). Distillation of the organic solvents must be carried out in this room. Consult with Dr R. Klein with regards to training on how to use this facility.

A logbook must be completed identifying the solvent under distillation. The columns also include the responsible individual in the event of an emergency as well as the duration of the distillation.

NB: Make sure that the gas tube is opened to allow drying of the solvents being distilled, failure to this may result in an EXPLOSION! When distillation is complete, allow the mantle and the flask to cool down before you break up the set-up to minimize chances of hot solvents dripping on the side of the flask and coming into contact with the hot mantle and resulting in fires. **NEVER** seal a crack in the distillation glassware with parafilm.

4.8 Working Alone

NEVER work alone without consulting your supervisor first especially when working with hazardous chemicals or dangerous reactions. The supervisor is responsible for determining

whether the work requires special precautions, such as having two people in the same room for particular operations. If working with hazardous chemicals, always make sure there is an individual who can come to the aid of the worker.

4.9 Reporting of Incidents

Any incident should be reported to the supervisor immediately. For minor injuries there is a first aid box in each lab. In the undergraduate laboratory, the first aid box is kept by the technical officer, and should be put out at the front bench during practical sessions. In case of major injuries the safety officer must be informed immediately and should attend to the injured person or contact a first aider on campus (see list in appendix G). The department will train more first aiders as there are currently none. An incident report must be completed for major injuries and submitted to the safety officer/head of department (see Appendix B for the template of an incident report).

Should the safety officer not be available contact in case of emergencies (for example fire, medical emergency and chemical exposure) contact Campus Protection Unit (CPU) at 8146.

4.10 First-Aid boxes

As specified above, each lab has a first aid box which should be checked by the lab managers against the inventory below (of which there should be a copy in the first aid box). The safety officer will circulate once a month to check general safety in the lab and also check whether the first aid boxes have all the required items. At other times the lab managers should notify the safety officer when they have ran out of supplies. The location of the first aid box should be clearly marked and all laboratory occupants should familiarise themselves with it.

Below is the list of the minimum requirements of a first aid box:

- Item 1: Wound cleaner/antiseptic (100 ml)
- Item 2: Swabs for cleaning wounds
- Item 3: Cotton wool for padding (100 g)
- Item 4: Sterile gauze (minimum quantity 10)
- Item 5: 1 Pair of forceps (for splinters)
- Item 6: 1 Pair of scissors (minimum size 100mm)
- Item 7: 1 Set of safety pins
- Item 8: 4 Triangular bandages
- Item 9: 4 Roller bandages (75mm x 5m)
- Item 10: 4 Roller bandages (100mm x 5m)
- Item 11: 1 Roll of elastic adhesive (25mm x 3m)
- Item 12: 1 Non-allergenic adhesive strip (25mm x 3m)
- Item 13: 1 Packet of adhesive dressing strips (minimum quantity 10)
- Item 14: 4 First-aid dressings (75mm x 100mm)
- Item 15: 4 First-aid dressings (150mm x 200mm)
- Item 16: 2 Straight splints
- Item 17: 2 Pairs large and 2 pairs medium disposable gloves
- Item 18: 2 CPR mouth pieces or similar devices.

4.11 Lab

Request to the safety officer for the first aid box should be directed to the supervisor. ALL requisition papers, should be directed to the supervisor. ALL requisition papers,

individuals are requested to complete all the columns in the file. This file is divided into laboratory room numbers in order to monitor chemical/consumable usage by each laboratory.

4.12 Evacuation Procedure

This procedure will be used for both fire drills and legitimate emergency evacuation of the Chemical and Pharmaceutical Sciences Building during working hours.

Procedure for occupants of the building

When the fire alarm siren is initiated **ALL** occupants of the building must leave the building **immediately** via the nearest available clear exit. Do not use the lifts, linger in the building or block exit routes. Once you have left the building please congregate across the road from the front of the Chemistry and Pharmaceutical Sciences building and await further instruction. Do not obstruct or interfere with emergency services.

Procedure for Heads of Department, Chemical Safety Officer and all Technical officers and emergency floor monitors (Find list of monitors in appendix G).

When the fire alarm siren is initiated make your way as quickly as possible to the fire alarm control panel on the ground floor.

1. The Chemical Safety officer or designated senior authority will note in which zone the emergency has occurred, open the glass box next to the fire control panel and be prepared to issue reflective vests and earplugs. The time the alarm was initiated will be noted on the clipboard in the glass box.
2. The floor emergency monitors will be issued with reflective vests and earplugs by the Chemical Safety Officer or senior designated authority as they arrive at the board.
3. The floor emergency monitors will be despatched to their designated floors to establish as best as they can that the floor has been cleared of its occupants. The time that the floor monitors are despatched will be recorded by the Chemical Safety Officer or senior designated authority.
4. If the emergency situation is deemed sufficiently serious the Chemical Safety Officer or senior designated authority may co-opt a second person to accompany the floor emergency monitors. The names of the co-opted accompanying person must be written down by the Chemical Safety Officer or senior designated authority.
5. The emergency floor monitors (and accompanying persons if applicable) must return to the fire control panel immediately they have cleared their floors and report to the Chemical Safety Officer or senior designated authority who will note the time they returned and any observations they have made.

6. Once the cause of the emergency evacuation has been established the Chemical Safety Officer in consultation with the Heads of Department and other senior staff members will establish whether emergency services need to be called through Campus Security.
 7. The time when the call is made to Campus Security will be recorded.
 8. The Chemical Safety Officer or senior designated authority will inform the occupants outside the building what is happening using the loud hailer kept in the Chemistry store.
 9. Chemical Safety Officer or senior designated authority will record the time the emergency services arrive at the building.
 10. After the emergency services have completed their task and/or once the fire drill is completed the Chemical Safety Officer or senior designated authority will give the all clear for the occupants to return to the building using the loud hailer kept by the safety officer.
- The Chemical Safety Officer will record all the necessary times using the Emergency Evacuation Record Sheet (see appendix E for the template).

4.13 X-ray room

The department has a powder X-ray diffractometer system in room F25, which makes use of the Cs-137 X-ray source. You may not enter the room without prior permission from Prof G. Watkins who is in charge of the equipment.

5. MATERIAL SAFETY DATA SHEETS (MSDS)

MSDSs are detailed fact sheets about chemical substances that may be a primary source of information. Certain specific information must be included on each MSDS as summarized below:

Section I: Identifies the manufacturer, name of the product, synonyms, trade names, chemical family, formula, CAS number.

Section II: Identifies the hazardous ingredients, percentages and exposure limits when known.

Section III: Describes physical properties of the material, including boiling point, vapour pressure, vapour density, solubility, specific gravity, percent volatile, evaporation rate, appearance and odour.

Section IV: Fire and explosion hazards. Upper and lower explosive limits, flash point, extinguishing agents, etc.

Section V: Known health hazards, symptoms, effects of over-exposure, special health hazards, emergency and first aid procedures.

Section VI: Reactivity and stability information, incompatibility, conditions to avoid.

Section VII: Procedures for accidental spill or release.

Section VIII: Protective equipment required such as respiratory protection, gloves, clothing, ventilation, etc.

Section IX: Handling and storage procedures.

Section X: Special precautions and miscellaneous information.

MSDSs are available from the Chemical Safety Officer or from various sources on the internet such as <http://www.sigma-aldrich.com/new>. These are also easily accessible on the Chemistry Department Web page (<http://www.chem.ru.ac.za/chemlink.html>). There are also two volumes entitled Sigma Aldrich Chemical Safety Data on the bookshelves in the reading room. Please use them but don't remove them. Another alternative would be to use google (enter the name of the chemical followed by MSDS). Where information is not available, treat the materials as hazardous.

The supplier of a chemical is also required to supply you with the MSDS data of a purchased chemical. These can be obtained from the supplier's web page.

Some laboratories may synthesize or develop new chemical compounds in the course of their research. If the composition of the substance is known, and will be used exclusively in the laboratory, it must be labelled, and to the best of the researcher's ability, the hazardous properties (corrosive, flammable, toxic, reactive, etc.) must be estimated. This can often be done by comparing the structure of the new substance with the structure of similar materials with known hazardous properties. If the chemical produced is of unknown properties, it must be assumed to be hazardous, and appropriate precautions should be taken.

If a chemical substance is produced for another user outside of the Institution, an adequate Material Safety Data Sheet must be created to accompany the substance.

6. SAFETY AND HAZARDS

6.1 Containers/Container Labels

Never carry Winchester bottles containing chemicals by their necks. Winchester bottles must always be transported in the specially designed carriers allocated to each research laboratory.

Great care is required when freeing stoppers from flasks or bottles, particularly if the contents are hazardous. If a bottle has been heated by sunlight or has been left near a hotplate or oven the bottle and contents should be cooled before opening, this is particularly important in the case of strong

ammonia solutions. If the stopper on a bottle has become frozen see the glassblower (Mr A. Adriaan).

For secondary containment for liquids choose a container that will not be weakened by the material it holds. For example, acids cannot be stored in metal containers and HF cannot be stored in a glass container. All containers must be labelled, and use labels with good adhesive. The label must be legible and durable. Chemical names should be used, rather than formulas or code names, *e.g.* "Acetone," not CH_3COCH_3 .

The labels on purchased chemicals should include:

- The common name of the chemical;
- The name, address and emergency telephone number of the company responsible for the product;
- Appropriate hazard warning (shown on the table), represented by the following symbols:

Danger	Caution	Toxic	Reactive	Flammable
Explosive	Corrosive	Irritant	Oxidizing	Harmful

The diagram shows some of the common hazard symbols used in chemistry, and their meanings. These symbols may be in a triangle or a square, and a chemical container might be labelled with more than one hazard symbol.

	Corrosive Attacks and destroys living tissues, such as skin and eyes.		Irritant Not corrosive but will make the skin red or blister.
	Toxic Can cause death, <i>e.g.</i> if swallowed, breathed in or absorbed by skin.		Harmful Similar to toxic substances but not as dangerous.
	Highly Flammable Catches fire easily		Oxidising Provides oxygen to make other substances burn more fiercely.



Explosive



Environmental hazard



Radioactive

Some common hazard symbols for containers.

Corrosive - concentrated solutions of strong acids such as **sulphuric acid** would be labelled with the corrosive symbol. Concentrated solutions of strong alkalis such as **sodium hydroxide** would also be labelled this way. Anyone using a corrosive substance should wear gloves and eye protection such as goggles.

Irritant - the dilute solutions of acids and alkalis that you normally use in the lab would be labelled with the irritant symbol. Anyone using an irritant substance should wear eye protection such as goggles, and they should take care to wash any spills off their skin immediately.

Toxic - **lead oxide** and **chromium oxide** would be labelled with the toxic symbol. Anyone using a toxic chemical would need to take great care. They should wear gloves and eye protection, and they may wear a mask over their mouth and nose or handle the chemical in a fume cupboard.

Harmful - **copper(II) sulphate** would be labelled with the harmful symbol. Anyone using a harmful substance should wear eye protection such as goggles, and they should take care to wash any spills off their skin immediately.

Highly flammable – **ethanol** and **propanone** would be labelled with the highly flammable symbol. In addition to the normal precautions of wearing eye protection, anyone using a highly flammable substance should take care to keep it away from flames and sparks, and also from oxidising substances.

Oxidising - **potassium manganate(VII)** would be labelled with the oxidising symbol. Oxidising substances do not burn themselves but they provide oxygen for flammable substances to burn. In addition to the normal precautions of wearing eye protection, anyone using an oxidising substance should take care to keep it away from flammable substances, including clothing.

Explosive - used in the transport of explosive materials.

Environmental hazard - relatively rare with laboratory chemicals (most of which pose some environmental hazard if not got rid of correctly), these require *particular* care to be taken on disposal.

Radioactive - this symbol indicates a radiation hazard.

Labels may not be removed from the container. When a chemical is transferred to another container for storage, the new containers should be labelled with the name of the product, the chemical

constituents and hazard warnings. The date of transfer must be included in the label. Labels from reliable suppliers will provide additional information such as protective clothing required, first aid information, storage recommendations, emergency procedures, target organs for health effects and other safety information. Read the label on each new shipment of chemicals. Formulations may change or new information may be available on physical or health hazards.

The Safety Officer should be notified when suppliers are not providing adequate information on the labels.

6.2 Chemical Toxicity

Chemicals may harm you in several ways. Skin contact, inhalation and indigestion are the main routes of entry. The exact hazard is, however, dependant on the chemical characteristics of the compound in question. Always review MSDS data and R&S phrases of the chemicals you use. As mentioned above, MSDS can be found at <http://www.sigma-aldrich.com/new> or from the Chemical Safety Officer. R&S phrases can be found in catalogues of the major chemicals producers e.g. Fluka, Sigma-Aldrich, Merck, Lancaster, Alfa Aesar. R&S phrases can also be obtained by searching for 'risk and safety phrases' on Google. Always establish the toxicity of a compound before using it.

6.3 Chemical Exposure Checklist

It is the responsibility of every student, lecturer and researcher that is exposed to various chemicals on a daily basis, to keep track of their exposure level. These include toxic or corrosive gases, common organic liquids used for cleaning (acetone) or analytical base liquids (methanol and ethanol). Exposure to and handling of solids which release dust must be noted.

Consider jotting down the chemicals you are exposed to in the back of your results book or pad.

6.4 Flammable Material

Properties of Flammable and Combustible Liquids

Flammable and combustible liquids vaporize and form flammable mixtures with air when in open containers, when leaks occur, or when heated. To control these potential hazards, several properties of these materials, such as volatility, flashpoint, flammable range and auto-ignition temperatures must be understood. Information on the properties of a specific liquid can be found in that liquid's Material Safety Data Sheet (MSDS) or R&S phrases.

Flammable and Combustible Liquids on Molecular Sieves

Solvents on molecular sieves, usually in glass stoppered bottles, should be stored in the extracted cupboard below your fume hood.

Reactivation of molecular sieves:

- Used molecular sieves must be thoroughly rinsed with an appropriate volatile solvent such as acetone.
- Do preliminary drying in a fume hood before putting the sieves in the oven for re-activation.
- Sieves in the oven must be clearly marked with researcher's name and pore size of sieves.
- Solvents wetted sieves must under no circumstances be placed in an oven as there is a serious risk of explosion.

Storage of Flammable and Combustible Liquids

Flammable and combustible liquids should be stored in approved containers. Containers used by the manufacturers of flammable and combustible liquids generally meet these specifications.

Storage Considerations:

- Quantities should be limited to the amount necessary for the work in progress.
- No more than 30 litres of flammable and combustible liquids, combined should be stored outside of a flammable storage cabinet. Storage of flammable liquids must not obstruct any exit.
- Flammable liquids should be stored separately from strong oxidizers, shielded from direct sunlight, and away from heat sources.

Flammable Liquid Storage Cabinets

A flammable liquid storage cabinet is an approved cabinet that has been designed and constructed to protect the contents from external fires. There is at least one such storage cabinet in each laboratory. These cabinets must be locked to be effective.

Refrigerators

Standard household refrigerators are used in most laboratories mainly for storage of organic compounds, and to some extent crystallization experiments.

- Tightly closed containers containing organic compounds can be stored readily.
- Highly volatile flammable solvents must not be used in these units for crystallization experiments as internal parts (thermostats) could spark and ignite vapours – especially after a lengthy power outage.
- All vessels must be sealed – either by tight fitting lid or Parafilm. There should be no evaporation of solvents into the refrigerator chamber.

- Refrigerator contents should be marked clearly with researcher's name, date and substance. Contents will be monitored regularly and ALL unmarked vessels removed for disposal.

Handling Precautions

The main objective in working safely with flammable liquids is to avoid accumulation of vapours and to control sources of ignition. Besides the more obvious sources such as open flames from Bunsen burners, matches and cigarette smoking, less obvious sources, such as electrical equipment, static electricity and gas-fired heating devices should be considered.

Some electrical equipment including switches, stirrers, motors, and relays can produce sparks that can ignite vapours. Although some newer equipment have a spark-free induction motors, the on-off switches and speed controls may be able to produce a spark when they are adjusted because they have exposed contacts. One solution is to remove any switches located on the device and insert a switch on the cord near the plug end.

Pouring flammable liquids can generate static electricity. The development of static electricity is related to the humidity levels in the area. Cold, dry atmospheres are more likely to facilitate static electricity. Bonding or using ground straps for metallic or non-metallic containers (e.g. to metal water tap) can prevent static generation.

- Control all ignition sources in areas where flammable liquids are used.
- Smoking, open flames and spark producing equipment should not be used.
- Whenever possible use plastic or metal containers or safety cans if available.
- When working with open containers, use a laboratory fume hood to control the accumulation of flammable vapour.
- Use a bottle carrier or trolley for transporting glass containers.
- Use equipment with spark-free, intrinsically safe induction motors or air motors to avoid producing sparks. Many stirrers, outlet strip, ovens, heat tape, hot plates and heat guns do not conform to these code requirements.
- Avoid using equipment with series-wound motors, since they are likely to produce sparks.
- Do not heat flammable liquids with an open flame. Steam baths, salt and sand baths, oil and wax baths, heating mantles and hot air or nitrogen baths are preferable.
- Minimize the production of vapours and the associated risk of ignition by flashback. Vapours from flammable liquids are denser than air and tend to sink to the floor level where they can spread over a large area.
- Electrically bond metal containers when transferring flammable liquids from one to another. Bonding can be direct, as a wire attached to both containers, or indirect, as through a common ground system.
- When grounding non-metallic containers, contact must be made directly to the liquid, rather than to the container.

- In the rare circumstance that static cannot be avoided, proceed slowly to give the charge time to disperse or conduct the procedure in an inert atmosphere.

Flammable and Combustible Solids

Flammable solids often encountered in the laboratory include alkali metals, magnesium metal, metallic hydrides, some organometallic compounds, and sulphur. Many flammable solids react with water and cannot be extinguished with conventional dry chemical or carbon dioxide extinguishers.

- The main chemical store has two Class D fire extinguisher and one carbon dioxide extinguisher available for fire involving flammable solids in that area. Each of the laboratories has a carbon dioxide extinguisher. For more information about fires and fire extinguishers see appendix C.
- Sand buckets are kept in other laboratories so as to smother a fire involving flammable solids.
- If a flammable, water-reactive solid is spilled onto skin, brush off as much as possible, then flush with copious amounts of water.
- Never use a carbon dioxide fire extinguisher for fires involving lithium aluminium hydride (LAH). LAH reacts explosively with carbon dioxide.

Catalyst Ignition

Some hydrogenated catalysts, such as palladium, platinum oxide and Raney nickel, when recovered from hydrogenation reactions, may become saturated with hydrogen and present a fire or explosion hazard.

- Carefully filter the catalyst.
- Do not allow the filter cake to become dry.
- Place the funnel containing moist catalyst into a water bath immediately.
- Do not put used metal catalysts such as palladium, platinum, etc, in a waste bin with paper.
THERE WILL BE A FIRE.

Pure gases, such as nitrogen or argon, may be used so that the catalyst can be filtered and handled in an inert atmosphere.

6.5 Other Hazards you should be aware of:

- Perchlorates + wood (Perchloric acid vapours can settle on ductwork, resulting in the deposition of perchlorate crystals. Perchlorates can accumulate on surfaces and have been known to detonate on contact, causing serious injury to researchers and maintenance personnel).

- Beware of the danger of chromium(VI) salts which can be absorbed through the skin.
- Chemical compatibility problems, e.g. storing concentrated acids and bases together, must be checked (see page 26).

6.6 Peroxide Forming Compounds

Certain chemicals can form dangerous peroxides on exposure to air and light. Since they are sometimes packaged in an atmosphere of air, peroxides can form even though the containers have not been opened. Peroxides may detonate with extreme violence when concentrated by evaporation or distillation, when combined with other compounds, or when disturbed by unusual heat, shock or friction. Formation of peroxides in ethers is accelerated in opened and partially emptied containers. Refrigeration will not prevent peroxide formation and stabilizers will only retard formation. Expect ALL ethers, for example, diethylether, tetrahydrofuran, etc, to contain peroxides.

Recommend Practices

The following recommendations should be followed to control the hazards of peroxides.

- Know the properties and hazards of all chemicals you are using through adequate research and study, including reading the label and MSDS.
- Inventory all chemical storage at least twice a year to detect forgotten items, leaking containers, and those that need to be discarded.
- Identify chemicals that form peroxides or otherwise deteriorate or become more hazardous with age or exposure to air. Label containers with the date received, the date first opened and the date for disposal are recommended by the supplier.
- Minimize peroxide formation in ethers by storing in tightly sealed containers placed in a cool place in the absence of light. Do not store ethers at or below the temperature at which the peroxide freezes or the solution precipitates.
- Choose the size container that will ensure use of the entire contents within a short period of time.
- Visually or chemically check for peroxides of any opened containers before use.
- Clean up spills immediately. The safest method is to absorb the material onto vermiculite or a similar loose absorbent.
- When working with peroxide compounds wear impact-resistant safety eyewear and face shields. Safety goggles are intended only for slight and brief exposure, and should not be used when working with peroxidizable compounds.
- Do not use solutions of peroxides in volatile solvents under conditions in which the solvent might be vaporized. This could increase the concentration of peroxide in the solution.

- Do not use metal spatulas or magnetic stirring bars (which may leach out iron) with peroxide forming compounds, since contamination with metals can lead to explosive decomposition. Ceramic, polyamide or Teflon spatulas and stirring blades are usually safe to use.
- Do not use glass containers with screw-top lids or glass stoppers.
- Polyethylene bottles with screw-top lids may be used.

Peroxide formation may be detected by visual inspection for crystalline solids or viscous liquids, or by using chemical methods. **The use of peroxide test kit from Merck is encouraged as a semi-quantitative analysis method (S3 lab has the kit, but other labs can buy for themselves).** The procedure for the test is provided by Merck. If you suspect that peroxides have formed, do not open the container to test since peroxides deposited on the threads of the cap could detonate.

Procedure for removing peroxides from ether

Vogel's textbook of practical organic chemistry under the heading "solvents and reagents" provides for a way of removing peroxides. S3 lab has the procedure and can provide you with the relevant textbook.

6.7 Corrosive Materials

Many chemicals commonly used in the laboratory are corrosive or irritating to body tissue. They present a hazard to the eyes and skin by direct contact, to the respiratory tract by inhalation or to the gastrointestinal system by ingestion.

Corrosive Liquids

Corrosive liquids (e.g. mineral acids, alkali solutions and some oxidizers) represent a very significant hazard because skin or eye contact can readily occur from splashes and their effect on human tissue generally takes place very rapidly. Bromine, sodium hydroxide, *aqua regia*, sulphuric acid and hydrogen peroxide are examples of highly corrosive liquids. Make sure you review the relevant MSDS data and R&S phrases.

The following should be considered:

- The eyes are particularly vulnerable. It is therefore essential that approved eye and face protection be worn in all laboratories where corrosive chemicals are handled.
- Gloves and other chemically resistant protective clothing should be worn to protect against skin contact.
- To avoid a flash steam explosion due to the large amount of heat evolved, always add acids or bases to water (and not the reverse).
- Acids and bases should be segregated for storage.
- Liquid corrosives should be stored below eye level.

- Adequate quantities of spill control materials should be readily available.

Corrosive Gases and Vapours

Corrosive gases and vapours are hazardous to all parts of the body; certain organs (e.g. the eyes and the respiratory tract) are particularly sensitive. The magnitude of the effect is related to the solubility of the material in the body fluids. Highly soluble gases (e.g. chlorine from *aqua regia*, ammonia, hydrogen chloride) can penetrate deep into the lungs.

- Warning properties such as odour or eye, nose or respiratory tract irritation may be inadequate with some substances. Therefore, they should not be relied upon as a warning of overexposure.
- Perform manipulations of materials that pose an inhalation hazard in a chemical fume hood to control exposure or wear appropriate respiratory protection.
- Protect all exposed skin surfaces from contact with corrosive or irritating gases and vapours.
- Regulators and valves should be closed when the cylinder is not in use and flushed with dry air or nitrogen after use.
- When corrosive gases are to be discharged into a liquid, a trap, check valve or vacuum break device should be employed to prevent dangerous reverse flow.













Corrosive Solids

Corrosive solids, such as hydroxides and phenol, can cause burns to the skin and eyes. Dust from corrosive solids can be inhaled and cause irritation or burns to the respiratory tract. Many corrosive solids, such as potassium hydroxide and sodium hydroxide, can produce considerable heat when dissolved in water.

- Wear gloves and eye protection when handling corrosive solids.
- When mixing with water, always slowly add the corrosive solid to water, stirring continuously. Cooling may be necessary.
- If there is a possibility of generating a significant amount of dust, conduct work in a fume hood and wear a mask.

6.8 Compressed Gases

Compressed gases can be toxic, flammable, oxidizing, corrosive, inert or a combination of hazards. In addition to the chemical hazards, compressed gases may be under a great deal of pressure. The amount of energy in a compressed gas cylinder makes it a potential rocket. Appropriate care in the handling and storage of compressed gas cylinders is essential. Familiarize yourself with the colour codes for common gas cylinders in the department.

Industrial Gases Nywerheidsgasse						Specialty Gases Spesialiteitsgasse					
											
Oxygen (O ₂) Suurstof (O ₂)	Nitrogen (N ₂) Stikstof (N ₂)	Argon (Ar)	Carbon Dioxide (CO ₂) Koolstofdioxide (CO ₂)	Carbon Dioxide D/T (CO ₂) Koolstofdioxide D/T (CO ₂)	Air Lug	High Purity Hydrogen (H ₂) Hoësuiverheidswaterstof (H ₂)	Helium (He)	Chlorine (Cl ₂) Chloor (Cl ₂)	Sulphur Dioxide (SO ₂) Swaeltdioksied (SO ₂)	Ammonia (NH ₃) Ammoniak (NH ₃)	Sulphur Hexafluoride (SF ₆) Swaeltheksafluoried (SF ₆)

Hazards

The following is an overview of the hazards to be avoided when handling and storing compressed gases:

Lack of Oxygen (Asphyxiation): Simple asphyxiation is the primary hazard associated with inert gases. Because inert gases are colourless and odourless, they can escape into the atmosphere undetected and quickly reduce the concentration of oxygen below the level necessary to support life. The use of oxygen monitoring equipment is strongly recommended for enclosed areas where inert gases are being used. Never transport liquid nitrogen in the personnel lift as spillage would cause asphyxiation.

Fire and Explosion: Fire and explosion are the primary hazards associated with flammable gases, oxygen and other oxidizing gases. Flammable gases can be ignited by static electricity or by a heat source, such as a flame or a hot object. Oxygen and other oxidizing gases do not burn, but will support combustion of organic materials. Increasing the concentration of an oxidizer accelerates the rate of combustion. Materials that are non-flammable under normal conditions may burn in an oxygen-enriched atmosphere.

Chemical Burns: Corrosive gases can chemically attack various materials including fire resistant clothing. Some gases are not corrosive in their pure form, but can become extremely destructive if a small amount of moisture is added. Corrosive gases can cause rapid destruction of skin and eye tissue.

Chemical Poisoning: Chemical poisoning is the primary hazard of toxic gases. Even in very small concentrations, brief exposure to these gases can result in serious poisoning injuries. Symptoms of exposure may be delayed.

High-pressure: All compressed gases are potentially hazardous because of the high pressure stored inside the cylinder. A sudden release of pressure can cause injuries by propelling a cylinder or whipping a line.

Cylinder Weight: A full size cylinder may weigh more than 60 kg. Moving a cylinder manually may lead to back or muscle injury. Dropping or dragging a cylinder could cause serious injury. Always use a cylinder trolley for transport. Ask Vuyisile Dondashe (Don) to help transport the gas cylinders from stores to the labs.

Stand-alone Gas Cylinders: All cylinders must be secured to a wall, bench or other support structure using a chain or strap. Ensure that cylinders are removed from heat sources and extreme weather conditions. Do not attempt to connect or alter a compressed gas cylinder yourself without help, ask Don for help.

6.9 Highly Toxic Gases

Highly toxic gases, such as arsine, diborane, fluorine, hydrogen cyanide, phosgene and silane, can pose a significant health risk in the event of a leak. Use of these materials requires written approval by the supervisor.

The following additional precautions must be taken:

- Use and store in a specially ventilated gas cabinet or fume hood.
- Use coaxial (double walled) tubing with nitrogen between the walls for feed lines operating above atmospheric pressure.
- Regulators should be equipped with an automatic shut-off to turn off gas supply in the event of sudden loss of pressure in the supply line.
- An alarm system should be installed to check for leaks in routinely used gases with poor warning properties. The alarm level must be set at or lower than the permissible exposure limit of the substance.
- Self-contained breathing apparatus (SCBA) may be appropriate for changing cylinders of highly toxic gases. Use of an SCBA requires enrolment in the Respiratory Protection Program and annual training and fit-testing.
- Ensure storage and use areas are posted with Designated Area signage.

Gases Requiring Special Handling

The following gases present special hazards either due to their toxicity or physical properties. Review this information before using these gases.

Acetylene
Arsine
Diborane
Fluorine
Hydrogen Cyanide
Germane
Oxygen
Phosgene
Silane
Sulfur dioxide

A face mask with appropriate filter cartridges (NOT a dust particle mask) must be used when necessary, for example when using SO_2 . Never use this gas when by yourself –always alert someone nearby of your intention to use it.

6.10 Compatibility problems when storing chemicals

The alphabet was one of the first things that you learned. However, when it comes to chemical storage, it can be dangerous to store chemicals alphabetically. Examples of compatibility problems arising from storing chemicals alphabetically include:

- Alkanes and Ammonium Nitrate
- Hydrogen Peroxide and Hydrazine
- Ammonia and Bromine
- Nitric Acid and Phenol
- Aldehydes and Amines
- Sodium Cyanide and Sulfuric Acid
- Calcium Hypochlorite and Carbon

Even apparently safe storage can be a potential problem. The following materials are often stored together even though there are hazards should the materials mix:

- Acetic Acid and Nitric Acid
- Perchloric Acid and Sulfuric Acid
- Concentrated Acids and Bases

Therefore separate the chemicals according to their compatibility. Compatibility is synonymous with chemical functionality.

The compatible families suggested are:

Inorganic

Metals, hydrides

Halides, sulfates, sulfites, thiosulfates

Amides, nitrates** (except ammonium nitrate), nitrites**, azides**, nitric acid

Ethers**, ketones, ketenes, halogenated carbon

Sulfides, selenides, phosphides, carbides, nitrides

Chlorates, perchlorates**, perchloric acid**, chlorites, hypochlorites, peroxides**, hydrogen peroxide

Arsenates, cyanides, cyanates

Borates, chromates, manganates, permanganates

Acids (except nitric)

Sulfur, phosphorus**, arsenic, phosphorus pentoxide**

Organic

Acids, anhydrides, peracids

Alcohols, glycols, amines, amides, imines, phosphates, halogens, imides

Hydrocarbons, esters, aldehydes

Hydroxides, oxides, silicates, carbonates, hydrocarbons, ethylene oxide

Epoxy compounds, isocyanates

Peroxides, hydroperoxides, azides**

Sulfides, polysulfides, sulfoxides, nitriles

Phenols, cresols

** potentially unstable

When sorting out the chemicals in the lab you must be aware that a compound can have many different names

e.g. PHENOL is also known as:

- carbolic acid
- hydroxy benzene
- oxybenzene
- phenic acid
- phenyl hydroxide
- phenylic acid or phenylic alcohol.

The Merck Index (copies in the reading room) can be a useful reference for checking confusing or equivalent names.

6.11 Cryogenics

Cryogenic liquids have boiling points less than -73°C . Liquid nitrogen, liquid oxygen and carbon dioxide are the most common cryogenic materials used in the laboratory. Hazards may include fire, explosion, embrittlement, pressure build-up, frostbite and asphyxiation.

Many of the safety precautions observed for compressed gases also apply to cryogenic liquids. Two additional hazards are created from the unique properties of cryogenic liquids:

- **Extremely Low Temperatures** – The cold boil-off vapour of cryogenic liquids rapidly freezes human tissue. Most metals become stronger upon exposure to cold temperatures, but materials such as carbon, steel, plastics and rubber become brittle or even fracture under stress at these temperatures. Proper material selection is important. Cold burns and frostbite caused by cryogenic liquids can result in extensive tissue damage.
- **Vaporization** – All cryogenic liquids produce large volumes of gas when they vaporize. Liquid nitrogen will expand 696 times as it vaporizes. The expansion ratio of argon is 847:1, hydrogen is 851:1 and oxygen is 862:1. If these liquids vaporize in a sealed container, they can produce enormous pressures that could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple pressure relief devices.

Vaporization of cryogenic liquids (except oxygen) in an enclosed area can cause asphyxiation. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere, which will support and accelerate the combustion of other materials. Vaporization of liquid hydrogen can form an extremely flammable, even explosive, mixture with air.

Handling Cryogenic Liquids

Most cryogenic liquids are odourless, colourless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, the cold boil-off gases condense the moisture in the air, creating a highly visible fog.

- 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, but may damage delicate tissues, such as the eyes.
- 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.
- Never touch non-insulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. Even non-metallic materials are dangerous to touch at low temperatures.
- 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.
- Check cold baths frequently to ensure they are not plugged with frozen material.

Protective Clothing

Face shields worn with safety glasses or chemical splash goggles are recommended during transfer and handling of cryogenic liquids.

Wear loose fitting, dry insulated or leather gloves when handling objects that come into contact with cryogenic liquids and vapour. Trousers should be worn on the outside of boots or work shoes.

Cooling Baths and Dry Ice

Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air, because oxygen can condense from the air, leading to an explosion hazard.

Wear insulated, dry gloves and a face shield when handling dry ice. Add dry ice slowly to the liquid portion of the cooling bath to avoid foaming over. Do not lower your head into a dry ice chest, since suffocation can result from carbon dioxide build-up.

Liquid Nitrogen Cooled Traps

Traps that open to the atmosphere condense liquid air rapidly. If you close the system, pressure builds up with enough force to shatter glass equipment. Therefore, only sealed or evacuated equipment should use liquid nitrogen cooled traps.

6.12 Chemicals/Cylinders in Transit

The lift near the chemical stores is designated for staff use only. Any heavy goods are transported via this lift to the upper floors.

When a sign is chained inside with the note “hazardous substances in transit” do not remove it and enter the lift. The person transporting hazardous goods may put the chain on and press the button for the floor of choice and run up the stairs to collect the goods.

6.13 Electrical Safety

Electrically powered equipment, such as hot plates, stirrers, vacuum pumps, heating mantles, ultrasonicators, power supplies, and microwave digesters are essential elements of many laboratories. These devices can pose a significant hazard to laboratory workers, particularly when mishandled or not maintained. Many laboratory electrical devices have high voltage or high power requirements, carrying even more risk. Large capacitors found in many laser flash lamps and other systems are capable of storing lethal amounts of electrical energy and pose a serious danger even if the power source has been disconnected. Also remember that the electrical wire coating of such devices will melt and cause a hazard when in contact with the heating element.

Electrical Hazards

The major hazards associated with electricity are electrical shock and fire. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin. The effect of the shock may range from a slight tingle to severe burns to cardiac arrest. The chart below shows the general relationship between the degree of injury and amount of current for a 60-cycle hand-to-foot path of one second duration of shock. While reading this chart, keep in mind that most electrical circuits can provide, under normal conditions, up to 20000 milliampere (mA) of current flow.

CURRENT	REACTION
1 mA	Perception Level
5 mA	Slight Shock felt; not painful but disturbing
6-30 mA	Painful shock; “let-go” range
50-150 mA	Extreme pain, respiratory arrest, severe muscular contraction.
1000-4300 mA	Ventricular fibrillation
10000+ mA	Cardiac arrest, severe burns and probable death

In addition to the electrical shocks, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapours or combustible materials.

Power Loss

Loss of electrical power can create hazardous situations. Flammable or toxic vapours may be released as a chemical warms when a refrigerator or freezer fails. Fume hoods may cease to operate, allowing vapours to be released into the laboratory. If magnetic or mechanical stirrers fail to operate, safe mixing of reagents may be compromised.

In the event of a power outage:

- Ensure that reaction vessels and chemical containers in fume hoods are closed.
- Ensure that reaction setups can be left unattended without risk (e.g. turn off all heating).
- Vacate the laboratory.

Preventing Electrical Hazards

There are various ways of protecting people from the hazards caused by electricity, including insulation, guarding, grounding, and electrical protective devices. Laboratory workers can significantly reduce electrical hazards by following some basic precautions:

- Inspect wiring of equipment before each use. Report damaged or frayed electrical cords immediately to the technician for replacement.
- Use safe work practices every time electrical equipment is used.
- Know the location and how to operate shut-off switches. Use these devices to shut off equipment in the event of a fire or electrocution.
- Limit the use of extension cords. Use only for temporary operations and then only for short periods of time. In all other cases, request installation of a new electrical outlet.
- Multi-plug adapters must have circuit breakers or fuses.
- Place exposed electrical conductors (such as those sometimes used with electrophoresis devices) behind shields.
- Minimize the potential for water, heat exchange oil or chemical spills on or near electrical equipment.

Safe Work Practices

The following practices may reduce risk of injury or fire when working with electrical equipment:

- Avoid contact with energized electrical circuits.
- Disconnect the power source before servicing or repairing electrical equipment.
- When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves and shoes with insulated soles.
- If it is safe to do so, work with only one hand, keeping the other hand at your side or in your pocket, away from all conductive material. This precaution reduces the likelihood of accidents that result in current passing through the chest cavity.
- Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.

- If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment.
- If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt or non-conducting strap.
- If power should trip at your workbench, switch off the main switch or circuit breaker until the power is back on.

6.14 Pressure and Vacuum Systems

Working with hazardous chemicals at high or low pressures requires planning and special precautions. Procedures should be implemented to protect against explosion or implosion through appropriate equipment selection and the use of safety shields. Care should be taken to select glass apparatus that can safely withstand designated pressure extremes. All such glassware should be carefully examined for structural integrity and should be absolutely intact.

High Pressure Vessels

- High-pressure operations should be performed only in pressure vessels appropriately selected for the operation, properly labelled and installed, and protected by pressure-relief and necessary control devices.
- Vessels must be strong enough to withstand the stresses encountered at the intended operating temperatures and pressures must not corrode or otherwise react when in contact with the materials it contains.
- Systems designed for use at elevated temperatures should be equipped with a positive temperature controller.
- All pressure equipment should be inspected and tested at intervals determined by the severity of the equipment's usage. Visual inspections should be accomplished before each use.
- Hydrostatic testing should be accomplished before equipment is placed in initial service. Hydrostatic testing should be re-accomplished every ten years thereafter, after significant repair or modification, or if the vessel experiences over-pressure or over-temperature.

Vacuum Apparatus

Vacuum work, such as rotary evaporation, can result in an implosion and the possible hazards of flying glass, splattering chemicals and fire. All vacuum operations must be set up and operated with careful consideration of the potential risks. Equipment at reduced pressure is especially prone to rapid pressure (bumping). Such conditions can force liquids through an apparatus, sometimes with undesirable consequences.

- Personal protective equipment, such as safety goggles, face shields, and/or an explosion shield should be used to protect against the hazards of vacuum procedures, and the procedure should be carried out inside a hood.
- Do not allow water, solvents and corrosive gases to be drawn into vacuum systems. Protect pumps with cold traps and vent their exhaust into an exhaust hold.
- Assemble vacuum apparatus in a manner that avoids strain, particularly to the neck of the flask.
- Avoid putting pressure on a vacuum line to prevent stopcocks from popping out or glass apparatus from exploding.
- Place vacuum apparatus in such a way that the possibility of being accidentally hit is minimized. If necessary, place transparent plastic around it or wrap in an appropriate cloth to prevent injury from flying glass in case of an explosion.
- When possible, avoid using mechanical vacuum pumps for distillation or concentration operations using large quantities of volatile materials. A water aspirator or steam aspirator is preferred. This is particularly important when large quantities of volatile materials are involved.
- Use friction tape to limit flying glass on implosion.

Glass Vessels

Although glass vessels are frequently used in pressure and vacuum systems, they can explode or implode violently, either spontaneously from stress failure or from an accidental blow.

- Conduct pressure and vacuum operations in glass vessels behind adequate shielding.
- Ensure the glass vessel is designed for the intended operation.
- Carefully check glass vessels for star cracks, scratches or etching marks before each use. Cracks can increase the likelihood of breakage or may allow chemicals to leak into/out of the vessel.
- Seal glass centrifuge tubes with rubber stoppers clamped in place. Wrap the vessel with friction tape and shield with a metal screen. Alternatively, wrap with friction tape and surround the vessel with multiple layers of loose cloth, then clamp behind a safety shield.
- Glass tubes with high-pressure sealers should be no more than $\frac{3}{4}$ full.
- Sealed bottles and tubes of flammable materials should be wrapped in cloth, placed behind a safety shield, then cooled slowly, first with an ice bath, then with dry ice.
- Never rely on corks, rubber stoppers or plastic tubing as pressure-relief devices.
- Glass vacuum desiccators should be made of Pyrex or similar glass and wrapped partially with friction tape to guard against flying glass. Plastic desiccators are a good alternative to glass, but still require shielding.
- Never carry or move an evacuated desiccator.

7. WASTE COLLECTION

The waste bottles are provided by the stores. In the HPLC room, there is a 25 L plastic drum for organic waste. Research labs have their own waste bottles. Please ensure that you notify the safety officer/stores administrator when these are full and need to be discarded. The classes of waste are given below under *Labelling of Waste Bottles*. A complete procedure for the disposal of hazardous waste for the chemical and pharmaceutical sciences building is as shown in **appendix D** (please read it carefully); and includes the responsibilities of researchers and the chemical safety officer as well as the record sheet.

In general:

- Don't make a lot of waste in the first place.
- Make it as benign as possible.
- Reduce the volume as much as possible.
- Non-hazardous solid waste can go into an ordinary waste bin.
- Hazardous solid waste must go into a solid waste container.
- Empty plastic containers of non-hazardous substances should be thoroughly rinsed before disposed of without a lid.
- Empty glass containers of non-hazardous substances should be thoroughly rinsed before being returned to stores.
- Empty containers of hazardous substances should be thoroughly rinsed into the appropriate waste bottle. Alert the safety officer for removal.
- No sharp items (i.e. used syringe needles and scalpel blades) are to be disposed of in the general garbage. A dedicated sharps container is available in each lab.
- Strong inorganic acids and bases must be diluted and can then be poured into the drain.
- Non-hazardous liquid waste that is soluble in water may also be poured down the drain.
- Any other wastes must be put in the appropriate waste bottle.
- Oxidizing agents should be reduced and reducing agents be oxidized before disposal (these reactions are usually exothermic – consult your supervisor and be careful).
- Toxic heavy metals should be converted to a more benign form and kept in a separate waste bottle.

7.1 Labelling of Waste Bottles

All waste bottles must be labelled with chemical names using the proper waste labels available from the stores. If it is a mixture the approximate amounts and percent solutions need to be recorded. Waste bottles will be monitored on a regular basis. Each lab will be held responsible for the proper labelling of their waste, **red label** for **chlorinated** waste and a **green label** for **non-chlorinated** solvent waste.

Examples of waste classes:

- Chlorinated Waste (Waste containing halogenated material must be clearly marked as Chlorinated Solvent Waste, and must have a **red label**). Chlorinated waste refers to any waste with >1% halogen content).
- Fluoride waste
- Arsenic waste
- Organic waste
- Selenium waste
- Inorganic waste
- Inorganic chromate waste
- Heavy metal waste (specifically labelled and restricted to one of cerium, mercury, osmium, lead, etc.)
- PGM waste (specifically labelled and restricted to one of platinum, palladium, rhodium, etc.)
- Oil waste (specifically labelled and restricted to one of silicone, vacuum, heat exchange, etc.)

7.2 Liquid Waste Disposal Procedure

- Use the same waste bottle for one project only.
- No mixing of waste. Waste must be separated according to waste classes as explained above.
- Be on the look out for incompatible chemicals. Do not mix non-compatible waste, especially if the reactivity of the chemicals is not known. There are several resources available for determining chemical compatibility (e.g.CRC Handbook, and the information herein).
- For primary storage use clean 2 or 2.5 litre Winchester bottles available from stores.
- Do not use a waste bottle before attaching a label – available from the safety officer/stores administrator. Complete all fields on the label.
- Keep underneath a fume hood until the bottle has been filled. Contact the Chemical Safety Officer for removal of full waste bottles.
- To avoid possible pressure build-up due to unforeseen gas evolution, lids must not be screwed on tightly.
- Always handle one waste bottle at a time. Use one hand to hold the neck right under the lid and the other hand supporting the weight of the bottle underneath.

8. CHEMICAL SPILLS

8.1 Spill Response and Clean-up Procedures

In the event of a chemical spill, the individual(s) who cause the spill is responsible for prompt and proper clean-up. It is also their responsibility to have spill control and personal protective

equipment appropriate for the chemicals being handled readily available. Paper towels, sand, or other absorbent materials may be used for this purpose. Spill absorbents are available in each laboratory.

The following guidelines to be followed in the event of a chemical spill:

- Clearly mark the affected area.
- Review Material Safety Data Sheets (MSDS) or other references for recommended spill cleanup methods and materials, and the need for personal protective equipment (e.g. respirator, gloves, protective clothing, etc.)
- Immediately alert area occupants and the supervisor. Evacuate the area if necessary. If there is a fire or medical attention is needed, contact Campus Protection Unit (CPU) at 8146 and the Safety Officer.
- Attend to any people who may be contaminated. Contaminated clothing must be removed immediately and the skin flushed with water for no less than fifteen minutes. Clothing must be laundered before reuse.
- If a volatile, flammable material is spilled, immediately warn everyone, control sources of ignition. This includes appliances, burners, ovens, etc.
- Fume hood ventilation should be maintained so that the vapours may be removed and/or diluted.
- Wear personal protective equipment appropriate to the hazards. Consider the need for respiratory protection. The use of a respirator or self-contained breathing apparatus requires specialized training and medical surveillance. Never enter a contaminated atmosphere without protection or use a respirator without training. If respiratory protection is needed and no trained personnel are available, call the Safety Officer at 8267 or Campus Protection Unit at 8146. If respiratory protection is used, be sure there is another person outside the spill area in communication, in case of an emergency. If no one is available, contact Campus Protection Unit.
- Using the chart below, determine the extent and type of spill. If the spill is large, if there has been a release to the environment or if there is no one knowledgeable about spill clean-up available, contact the safety officer at 8267 or Campus Protection Unit at 8146.

Category	Size	Response	Treatment Materials
Small	up to 300 mL	chemical treatment absorption	neutralization or absorption spill kit
Medium	300 mL – 5 litres	absorption	absorption spill kit

Large	more than 5 litres	call Campus Protection at 8146	outside help
--------------	--------------------	-----------------------------------	--------------

- Protect floor drains or other means for environmental release. Spill socks and absorbents may be placed around drains, as needed.
- Contain and clean-up the spill according to the table above.
- Loose spill control materials should be distributed over the entire spill area, working from the outside, circling to the inside. This reduces the chance of splash or spread of the spilled chemical.
- Many neutralizers for acids or bases have a colour change indicator to show when neutralization is complete.
- When spilled materials have been absorbed, use brush and scoop to place materials in an appropriate container. Polyethylene bags may be used for small spills. 20 litre pails may be appropriate for larger quantities.
- Complete a hazardous waste label, identifying the material as Spill Debris involving XYZ Chemical, and affix onto the container. Spill control materials will probably need to be disposed of as hazardous waste. Decontaminate the surface where the spill occurred using a mild detergent and water, when appropriate.
- Report all spills to your supervisor or the safety officer.

9. EXCESSIVE CHEMICAL EXPOSURE

The following procedures should be followed in the event of chemical exposure. In all cases, the incident should be reported to the supervisor or the safety officer, regardless of severity. Consult the safety officer to determine whether or not a First Report of Accidental Injury or Occupational Illness forms should be completed (make a copy of the form in appendix B, fill in and submit to the head of department) . Always take the appropriate MSDS with to Campus Health, physician or hospital.

Chemicals on Skin or Clothing

- Immediately flush with water for no less than 15 minutes, then get immediate medical attention (Sanatorium or other medical centre).
- For larger spills, the safety shower should be used.
- While rinsing, quickly remove all contaminated clothing or jewellery. Seconds count. Do not waste time because of modesty. Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes.

- Check the Material Safety Data Sheet (MSDS) to determine if any delayed effects should be expected. Discard contaminated clothing or launder them separately from other clothing. Leather garments or accessories cannot be decontaminated and should be discarded.
- Do not use solvents or laboratory detergent to wash skin. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, washing with a solvent may facilitate absorption of a toxic chemical.
- For flammable solids on skin, first brush off as much of the solid as possible, then proceed as described above.

Chemicals in Eyes

- Immediately flush eye(s) with water for at least fifteen minutes. The eyes must be forcibly held open to wash, and the eyeballs must be rotated so all surface area is rinsed. The use of an eye wash is desirable so hands are free to hold the eyes open. If an eyewash is not available, pour water on the eye, rinsing from the nose outward to avoid contamination of the unaffected eye.
- Remove contact lenses while rinsing. Do not lose time removing contact lenses before rinsing. Do not attempt to rinse and reinsert contact lenses.
- Seek medical attention regardless of the severity of apparent lack of severity. If an ambulance or transportation to the sanatorium is needed, contact the Safety Officer at 8267 or Campus Protection Unit at 8146.
- Explain carefully what chemicals were involved.

Chemical Inhalation

- Close containers, open windows or otherwise increase ventilation, and move to fresh air.
- If symptoms, such as headaches, nose or throat irritation, dizziness, or drowsiness persist, seek medical attention by calling the Safety Officer at 8267 or Campus Protection Unit at 8146 or by going to Sanatorium if possible.
- Explain carefully what chemicals were involved, presenting the appropriate MSDS.
- Review the MSDS to determine what health effects are expected, including delayed effects.

Accidental Ingestion of Chemicals

- Immediately go to Sanatorium or other medical centre, presenting the appropriate MSDS.
- Do not induce vomiting unless directed to do so by a health care provider.

Accidental Injection of Chemicals

- Wash the area with soap and water and seek medical attention.

10. FUME HOODS

A fume hood is a ventilated enclosure in which gases, vapours and fumes are contained. An exhaust fan pulls air and airborne contaminants in the hood through ductwork connected to the hood, and exhaust them on the roof to the atmosphere.

The typical fume hood found in the Department of Chemistry laboratories is equipped with a movable slide doors and an on/off switch. The doors move sideways and provide some protection to the hood user, especially if the user opens one side and works from that one corner.

In most hood installations, the exhaust flow rate or quantity of air pulled through the hood is constant. Therefore, when the doors are closed and the hood opening decreases, the velocity of airflow (face velocity) through the hood increases proportionally. Thus, higher face velocities can be obtained by closing the windows.

10.1 Using Chemical Fume Hoods

A fume hood is used to control exposure of the hood user and laboratory occupants to hazardous or odorous chemicals and prevent their release into the laboratory. A secondary purpose is to limit the effects of a spill by partially enclosing the work area and drawing air into the enclosure by means of an exhaust fan. This inward flow of air creates a dynamic barrier that minimizes the movement of material out of the hood and into the laboratory.

In a well-designed, properly functioning fume hood, only about 0.0001% to 0.001% of the material released into the air within the hood actually escapes from the hood and enters the laboratory.

The determination that a fume hood is necessary for a particular experiment should be based on a hazard analysis on the planned work. Such an analysis should include:

- A review of the physical characteristics, quantity and toxicity of the materials to be used;
- The experimental procedure;
- The volatility of the materials present during the experiment;
- The probability of their release;
- The number and sophistication of manipulations;
- The skill and expertise of the individual performing the work.

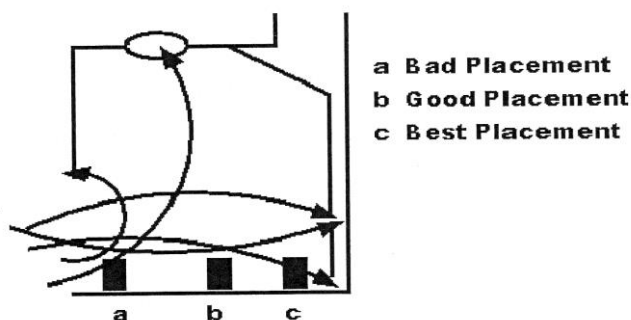
10.2 Good Work Practices

The level of protection provided by a fume hood is affected by the manner in which the fume hood is used. No fume hood, however well designed, can provide adequate containment unless good laboratory practices are used. Adequate planning and preparation are crucial.

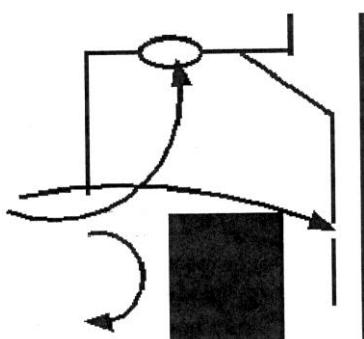
Items contaminated with odorous or hazardous materials should be removed from the hood only after decontamination or if placed in a closed outer container to avoid releasing contaminants into the laboratory air.

To optimize the performance of the fume hood, follow the practices listed below:

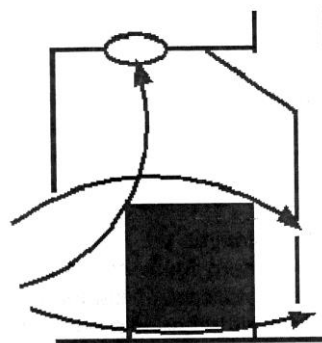
- Keep all chemicals and equipment as far back as possible during experiments. This will help to keep materials from escaping the hood when disturbances such as air currents from people walking past the hood, interfere with airflow at the face of the hood (b and c below are recommended).



- Provide catch basins for containers that could break or spill, to minimize the spread of spilled liquids.
- Keep the doors completely closed any time an experiment is in progress and the hood is unattended.
- Never use a hood to control exposure to hazardous substances without first verifying that it is operating properly.
- Do not block slots. If large equipment must be placed in the hood, put it on blocks to raise it approximately 6 cm above the surface so that air may pass beneath it. See figure below.



Poor placement of large equipment



Best placement for large equipment

- Place large or bulky equipment near the rear of the fume hood. Large items near the face of the hood may cause excessive air turbulence and variations in face velocity.
- Ideally fume hoods should not be used as a storage device. Keep only the materials necessary for the experiment inside of the hood. If chemicals must be stored in the hood for a period of time, install shelves on the sides of the hood.
- Keep the hood doors clean and clear.
- Check area around the hood for sources of cross drafts, such as open windows, supply air grilles, fans and doors. Cross drafts may cause turbulence that can allow leaks from the hood into the laboratory.
- Extend only hands and arms into the hood and avoid leaning against it. If the hood user stands up against the face of the hood, air currents produced by turbulent airflow may transport contaminants into the experimenter's breathing zone.
- Clean all chemical residues from the hood chamber after each use.
- All electrical devices should be connected outside the hood to avoid electrical arcing that can ignite a flammable or reactive chemical.

10.3 Common Misuses and Limitations

Used appropriately, a fume hood can be a very effective device for containing hazardous materials, as well as providing some protection from splashes and minor explosions. Even so, the average fume hood does have several limitations.

Particulates

A fume hood is not designed to contain high velocity releases of particulate contaminants unless the doors are fully closed.

Pressurized Systems

Gases or vapours escaping from pressurized systems may move at sufficient velocity to escape from the fume hood.

Explosions

The hood is not capable of containing explosions, even when the doors are fully closed. If an explosion hazard exists, the user should provide anchored barriers, shields or enclosures of sufficient strength to deflect or contain it. Such barriers can significantly affect the airflow in the hood.

Perchloric Acid

A conventional fume hood must not be used for perchloric acid. Perchloric acid vapours can settle on ductwork, resulting in the deposition of perchlorate crystals. Perchlorates can accumulate on

surfaces and have been known to detonate on contact, causing serious injury to researchers and maintenance personnel.

Spill Containment Lips

Fume hoods have recessed work surfaces or spill containment lips to help contain minor liquid spills. Containers of liquids should not be placed on the hood lip.

Tubing for Exhaust

Tubing is frequently used to channel exhaust to the hood from equipment located some distance away. This is not an effective control method.

Connections to the Exhaust System

Occasionally, a researcher may need local exhaust ventilation other than that provided by an existing fume hood. A new device may not be connected to an existing fume hood without the explicit approval of the Head of Department. Adding devices to even the simplest exhaust system without adequate evaluation and adjustment will usually result in decreased performance of the existing hood and/or inadequate performance of the additional device.

Highly Hazardous Substances

A well designed fume hood will contain 99.9 – 99.99% of the contaminants released within it when used properly. When working with highly dangerous substances needing more containment than a fume hood offers, consider using a glove box.

Pollution Control

An unfiltered fume hood is not a pollution control device. All contaminants that are removed by the ventilating system are released directly into the atmosphere. Apparatus used in hoods should be fitted with condensers, traps or scrubbers to contain and collect waste solvents or toxic vapours or dusts.

Waste Disposal

A fume hood should not be used for waste disposal. It is a violation of environmental regulations to intentionally send waste up the hood stack. As described above, the hood is not a pollution control device.

10.4 The Fume Hood as a Storage Device

Fume hoods are designed specifically to provide ventilation for the protection of laboratory occupants during chemical manipulations. The airflow they provide is greatly in excess of that needed for storage of closed containers of even the most toxic or volatile materials. Storing materials in this way is, therefore, a misuse of an expensive piece of equipment. In general, the storage of chemicals in fume hoods is strongly discouraged.

The extracted space below your fume hood can be used for storage of chemicals. Using this space for storage of glassware is a misuse of a useful storage resource.

The realities of available space and equipment in some laboratories may make it difficult or impossible to completely prohibit the use of hood workspaces for storage. In such a case, the following general policy is recommended:

Hoods Actively In Use for Experimentation

Storage of materials should be minimized or eliminated altogether. Materials stored in the hood can adversely affect the containment provided. In addition, the hood is frequently the focus of the most hazardous activities conducted in the laboratory. The presence of stored flammable or volatile, highly toxic materials can only exacerbate the problems resulting from an explosion or fire in the hood. Even if they are not directly involved in such an event, attempts to control or extinguish a fire may result in the spilling of stored materials.

Hoods Not In Active Use

Materials requiring ventilated storage (e.g. volatile and highly toxic, or odorous substances) may be stored in a hood if they are properly segregated and the hood is posted to prohibit its use of experimental work.

APPENDIX A **MONTHLY SAFETY INSPECTION FORM**

Inspected by:.....

Date:.....

Room number:.....

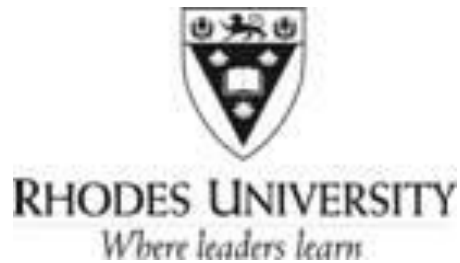
✓ = Compliance	X=Non-compliance	N/A=Not applicable
CHECK LIST	Observation	Comments
General lab organisation and physical condition		
1. Uncluttered, clean work surfaces including waste storage areas		
2. Entrance door and walkways are unobstructed		
3. Room ventilation operational		
4. Heavy objects confined to lower shelves		
5. Required PPE is being worn		
6. No evidence of food or drinks in the laboratory		
7. Equipment and electrical cords are in good condition		
Emergency equipment		
1. Safety shower and eyewash station accessible and in good working condition		
2. First aid supplies readily available and clearly visible		
3. Fire extinguishers inspected and seal intact		
4. Sand bucket available and filled		
Fume hoods		
1. Uncluttered, work surface is clean		
2. Not improperly used for storage		
3. Works properly, hood slashes open/close properly and glass intact		
4. Random question to lab user: Fire extinguisher location and first aid kit		
Miscellaneous		
1. Gas cylinders properly secured in chains		
2. Chemical inventory up-to-date		
3. Chemicals properly stored in solvents cabinets; warning signs and labels present		
4. All chemical containers capped, labelled and in good condition		
5. Waste containers properly labelled and kept to minimum in laboratory		
6. Fridge labelled "CHEMICAL USE ONLY" and interior is free of spills		

Additional comments:

.....

Discussed with lab supervisor: Yes / No Name: Date:.....

APPENDIX B
INCIDENT REPORT FORM



Student/Laboratory Worker:_____

Supervisor:_____

Date:_____ **Time:**_____

Location (Lab No):_____

Description:_____

Signature:_____

APPENDIX C

FIRES IN THE LABORATORY

Introduction

Fire is the most common serious hazard that one faces in a typical chemistry laboratory. While proper procedure and training can minimize the chances of an accidental fire, you must still be prepared to deal with a fire emergency should it occur. This document teaches you the basics about fire extinguishers -- proper types, how to use them, when and when not to use them as well as the proper procedures to follow should a fire occur. It is not a comprehensive guide and is designed to increase your general fire awareness.

Help I'm on fire!

If your clothing is on fire (and the floor is not), STOP, DROP and ROLL on the ground to extinguish the flames. If you are within a few feet of a safety shower or fire blanket, you can use these instead, but do not try to make it "just down the corridor" if you are on fire. If one of your coworkers catches fire and runs down the corridor in panic, tackle them and extinguish their clothing.

Help the lab bench is on fire!

There are different types of fire extinguishers for different fires.

The two most common types of extinguishers in the chemistry laboratory are carbon dioxide and pressurized dry chemical extinguishers. At the moment in the Chemistry Department we only have CO₂ extinguishers.

In addition, you may also need a specialized Class D dry powder extinguisher for use on flammable metal fires (without a Class D dry powder extinguisher a bucket of dry sand will do, but you really should have a Class D unit if you work with flammable metals - ask your supervisor if you are not sure if you need one in your lab).

Do not use the water hoses in the corridor for chemical fires in the laboratory.

If you are not familiar with fire extinguishers you will be shown how to use them.

Which kind of extinguisher should I use?

First recognize that there are four different kinds of fires:

- Class A fires are ordinary materials like burning paper, lumber, cardboard, plastics etc.
- Class B fires involve flammable or combustible liquids such as gasoline, kerosene, and common organic solvents used in the laboratory.
- Class C fires involve energized electrical equipment, such as appliances, switches, panel boxes, power tools, hot plates and stirrers. Water is a particularly dangerous extinguishing medium for class C fires because of the risk of electrical shock.
- Class D fires involve combustible metals, such as magnesium, titanium, potassium and sodium as well as organometallic reagents such as alkyllithiums, Grignards and diethylzinc. These materials burn at high temperatures and will react violently with water or other chemicals. Handle with care!!

Some fires may be a combination of these! Your fire extinguishers should have ABC ratings on them. You will see small pictures at the top of the CO₂ extinguishers labeled A, B and C. The pictures A, B and C represent the different types of fire. You will note that A is crossed out on the CO₂ extinguishers (see below for the reasons).

Here are typical uses for common extinguishers:

- Water extinguishers are suitable for class A (paper etc.) fires, but not for class B, C and D such as burning liquids, electrical fires or reactive metal fires. In these cases, the flames will be spread or the hazard made greater!
- Dry chemical extinguishers are useful for class ABC fires and are your best all around choice. They have an advantage over CO₂ extinguishers in that they leave a blanket of non-flammable material on the extinguished material which reduces the likelihood of reignition. They also make a terrible mess but if the choice is a fire or a mess, take the mess! Note that there are two kinds of dry chemical extinguishers! A bucket of sand will do the same job as a dry chemical extinguisher.
- Type BC dry chemical fire extinguishers contain sodium or potassium bicarbonate.
- Type ABC dry chemical fire extinguishers contain ammonium phosphate.
- CO₂ extinguishers are for class B and C fires. They don't work very well on class A fires because the material usually reignites. CO₂ extinguishers have an advantage over dry chemical in that they leave behind no harmful residue a good choice for an electrical fire on a computer or other delicate instrument. Note that CO₂ is a bad choice for flammable metal fires such as Grignard reagents, alkyllithiums and sodium metal because CO₂ reacts with these materials. CO₂ extinguishers are not approved for class D fires!
- Sand buckets or class D dry powder extinguishers are for flammable metals (class D fires)

and work by simply smothering the fire. You should have an approved class D unit if you are working with flammable metals.

Check out the potential fire hazards in your area. Is there an extinguisher available? Do you know how to operate it? Are your extinguishers suitable for the fires you may encounter?

Typical small lab fires (in a hood or on a bench) can easily be controlled by a dry chemical (ABC) or CO₂ extinguisher.

Using Extinguishers

You are not required to fight a fire. Ever. If you have the slightest doubt about your control of the situation **DO NOT FIGHT THE FIRE.**

1. Use a mental checklist to make a Fight-or-Flight Decision. Attempt to use an extinguisher only if ALL of the following apply:

The building is being evacuated (fire alarm has gone off)

The fire is small, contained and not spreading beyond its starting point.

The exit is clear, there is no imminent peril and you can fight the fire with your back to the exit.

You can stay low and avoid smoke.

The proper extinguisher is immediately at hand.

You have read the instructions and know how to use the extinguisher.

If any of these conditions have not been met, don't fight the fire yourself. Call for help, press the fire alarm button (they are strategically placed around the building find out where they are on your floor) and leave the area.

2. Whenever possible, use the "Buddy System" to have someone back you up when using a fire extinguisher. If you have any doubt about your personal safety, or if you can not extinguish a fire, leave immediately and close off the area (close the doors, but **DO NOT** lock them). Leave the building but contact a firefighter to relay whatever information you have about the fire.

3. Pull the pin on the fire extinguisher.

4. Stand several feet from the fire, depress the handle and sweep back and forth towards the fire. Do not walk on an area that you have "extinguished" in case the fire reignites or the extinguisher

runs out! The metal parts of CO2 extinguishers tend to get dangerously cold -- practice using one beforehand or have someone show you the proper way to hold one.

5. Direct the extinguisher at the base of the flames until the fire is completely out.

6. Recharge any discharged extinguisher immediately after use. If you discharge an extinguisher (even just a tiny bit) or pull the pin for any reason, inform Mr A. Adriaan.

APPENDIX D
PROTOCOL FOR THE DISPOSAL OF HAZARDOUS WASTE
(CHEMICAL AND PHARMACEUTICAL SCIENCES BUILDING)

Waste disposal responsibilities of the Researcher/Laboratory Technical Officer

Where should the waste be taken?

1. ALL chemical waste will be disposed of through the Chemistry Department Store during work hours (8.30-4.30 pm Monday to Friday).
2. Leaving hazardous waste outside the Chemistry store for any reason will be deemed a serious breach of health and safety regulations and the perpetrators will be dealt with accordingly.

What waste will be accepted?

- 1 NO individual container/item of chemical waste will be accepted for disposal if not accompanied by a Chemical Waste Disposal Sheet (page 50).
3. NO open containers of waste will be accepted.
4. NO “winchester” 2.5L glass bottles of general laboratory solvent waste will be accepted. Organic solvent waste must be disposed of in the relevant 20L plastic containers supplied by the Chemical Safety Officer.
5. “Sharps” e.g. disposable needles will only be accepted in a plastic sharps container (available from the Chemical Stores).

Separation of chlorinated solvent waste in the laboratory prior to disposal

General organic solvent waste containing ANY chlorinated solvents e.g. chloroform and dichloromethane must be placed in a solvent waste drum (available from the Chemistry Stores) labelled “chlorinated solvent waste” with a **red label**. Other non-chlorinated solvents e.g. hexane, ethyl acetate, ethanol, methanol etc must be placed in a solvent drum labelled “non-chlorinated solvent waste” with a **green label**. The disposal of chlorinated solvent is expensive and all efforts must be made to minimize the volumes of these solvents disposed of.

Waste disposal responsibilities of the Chemistry Stores

The disposal of hazardous waste is a priority and must not be left unattended in the stores.

Solvent waste:

The stores assistant will ensure that:

1. The drum is correctly labelled with either “chlorinated waste” or “non-chlorinated waste” before receiving the drum.

2. The drum is sealed.
3. The Chemical Waste Disposal Sheet has been completed for each drum.
4. The drum is placed immediately in the chemical waste storage room
5. The chemical waste disposal sheet is filed.

The Chemical Safety Officer will ensure that ALL the above are complied with and will monitor the levels of solvent waste and the state of the chemical waste storage room. The Chemistry Safety Officer will inform the waste removal company that there is waste for collection when the volume of solvent waste exceeds 400L (i.e. 20 drums). The storage of waste solvent in the Chemistry Department will be deemed critical when the volume exceeds 800L. At this stage the Head of Department and/or the Chief Technical Officer must be informed.

Chemical waste:

The stores assistant will ensure that:

1. The container containing the hazardous waste is sealed.
2. The Chemical Waste Disposal Sheet has been completed for EACH container checking the following:
 - a. The Name, Date and Department has been recorded
 - b. The type of waste i.e. either “ORGANIC”, “INORGANIC” or “UNKNOWN” is clearly indicated.
 - c. Chemical name if known is indicated (No chemical formulas)
 - d. Approximate weight or volume is clearly indicated.
 - e. The presence of free cyanide/chromium salts has been indicated.
3. The waste is IMMEDIATELY packed into the appropriate “wheelie bin” in the Chemistry Store which has been labelled either “ORGANIC”, “INORGANIC” or “UNKNOWN” depending on what is recorded on the Chemical Waste Disposal Sheet. The waste must be covered immediately with vermiculite. If large amounts of waste are delivered at one time the stores assistant can ask the deliverer of the waste to assist with the packing of the waste.
APPROPRIATE SAFETY PROTECTION (LAB COAT, GLOVES AND SAFETY GOGGLES) MUST BE WORN AT ALL TIMES WHEN HANDLING HAZARDOUS WASTE.
4. The chemical waste disposal sheet is filed in the appropriate “ORGANIC”, “INORGANIC” or “UNKNOWN” waste files. If the waste contains free cyanide or chromium (VI) salts the stores assistant will bring this to the Chemical Safety officer’s attention. These solutions will be stored in a separate wheelie bin kept in the chemical waste storage room labelled cyanide and chromium residues.
5. Inform the Chemical Safety officer that the wheelie bin is full.

6. Move the full wheelie bin to the chemical waste storage room once the list of contents has been completed by the Chemical Safety Officer and taped to the outside of the wheelie bin lid.
7. Inform the Chemical safety Officer when only FOUR bags of vermiculite and THREE empty wheelie bins remain.

The Chemical Safety Officer will ensure that ALL the above are complied with and will ensure that wheelie bins and vermiculite are available at all times. The Chemical Safety Officer will be responsible for initially labelling the wheelie bins with the labels EITHER“ORGANIC”, “INORGANIC” or “UNKNOWN” and for compiling an Excel list of the contents of each wheelie bin when it is full (note a copy of the Excel list must be retained and filed by the Chemistry Safety Officer. The Chemical Safety Officer will inform the waste removal company when three wheelie bins are full. In the event of a collection being made before a wheelie bin is full a wheelie bin can be removed by the disposal company if it is half full.

APPENDIX E
CHEMICAL WASTE DISPOSAL – RECORD SHEET

NAME.....

DATE.....

DEPARTMENT / FACULTY.....

SIGNATURE..... TEL #.....

FILL IN A SEPARATE SHEET FOR EACH CONTAINER/ITEM OF WASTE

EITHER.....BULK LABORATORY ORGANIC SOLVENT WASTE

PLEASE TICK THE APPROPRIATE BOX AND RECORD THE APPROXIMATE VOLUME.

☐☐

HALOGENATED SOLVENT

**NON-HALOGENATED
SOLV ENT**

VOLUME

OR.....OTHER LABORATORY CHEMICAL WASTE

PLEASE TICK THE APPROPRIATE BOX

☐☐☐

INORGANIC

ORGANIC

UNKNOWN

CHEMICAL NAME (NOT FORMULA)

APPROXIMATE WEIGHT OR VOLUME

DOES THE WASTE CONTAIN FREE CYANIDE? YES/NO

☐

DOES THE WASTE CONTAIN CHROMIUM SALTS? YES/NO

☐

APPENDIX F
EMERGENCY EVACUATION RECORD SHEET

Date:

Time Alarm initiated:

Time Floor monitors dispatched to clear floors:

Name and Floor	Time dispatched	Time Returned	Observations made
Lower Ground			
Ground Floor			
First Floor			
Second Floor			
Third Floor			
Fourth Floor			

Time Campus Security alerted and Emergency Services called:.....

Time Emergency Services arrived at front of building:.....

Time of all clear for emergency/fire drill:

APPENDIX G

CHEMISTRY BUILDING FIRST AIDERS

- PHARMACY DEPT: MR COLLIN NONTYI, C.NONTYI@RU.AC.ZA, 046-603.8546, FIRST AID L1 (VALID TO).
- PHARMACY DEPT: MS THEMBISA MZANGWA, T.MZANGWA@RU.AC.ZA, C/O COLLIN 046-603.8546, FIRST AID L1 (VALID TO).
- CHEMISTRYDEPT: MR VUYISILE DONDASHE, V.DONDASHE@RU.AC.ZA, 046-603.8257, 082-709.2179, FIRST AID L1 (VALID TO).
- CENTRAL CLEANING SERVICES: MR MELIKHAYA MATTHEWS NZUZO [C/O SUPERVISOR E.DEBEER@RU.AC.ZA, 046-603.8139 SPEED-DIAL 5041], FIRST AID L1 (VALID TO).

Building Emergency Coordinator:			
Building floor / area:	Assistant Emergency Coordinator / Floor Marshal:	Deputies:	Assembly Point for this floor / area (1. Primary, 2. Secondary):
Lower Ground Floor	Vuyisile Dondashe - RU ext. 8257	André Adriaan - RU ext. 8265	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department
Ground Floor	Collin Nontyi - RU ext. 8546	Dave Morley - RU ext. 8497	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department
First Floor	Dr David Khanye - RU ext. 8717	Gail Cobus- RU ext.8801 or cell 082 868 7710	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department
Second Floor	Prof Gary Watkins - RU ext. 8923	Tich Samkange - RU ext. 8412 or cell 073 235 0435	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department
Third Floor	Mr Leon Purdon - RU ext. 8397	Prof Rod Walker RU ext. 8381 or cell 072 225 6365	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department

Fourth Floor	Ms Linda Emslie - RU ext. 8381	Dr Mike Skinner - RU ext. 8189 or cell 082 802 8110	1. Paved area between Physics & Geology bldgs (Artillery Road) 2. Lawn in Anthropology department
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APPENDIX H

EMERGENCY FLOOR COORDINATORS

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