

QUEEN'S UNIVERSITY
DEPARTMENT OF CHEMISTRY

SAFETY MANUAL

IN CASE OF EMERGENCY

FROM WITHIN THE UNIVERSITY 36111

FROM OUTSIDE THE UNIVERSITY 533-6111

September 2011

Safety in the Chemical Laboratory

- ALWAYS WEAR PROPER EYE PROTECTION FOR THE TASK YOU ARE CARRYING OUT (e.g. SAFETY GLASSES, PRESCRIPTION GLASSES WITH SIDE SHIELDS, LASER GOGGLES)
- ALWAYS WEAR APPROPRIATE PROTECTIVE CLOTHING
- ALWAYS KNOW THE HAZARDOUS PROPERTIES OF MATERIALS BEING USED
- ALWAYS WASH HANDS THOROUGHLY BEFORE LEAVING THE LABORATORY
- NEVER WEAR OPEN-TOED SHOES, HIGH-HEELED SHOES OR SANDALS
- NEVER SMOKE IN THE BUILDING
- NEVER EAT, DRINK OR APPLY COSMETICS IN LABORATORIES
- NEVER PERFORM UNAUTHORIZED EXPERIMENTS
- NEVER ENGAGE IN PRANKS, PRACTICAL JOKES OR OTHER ACTS OF MISCHIEF
- DO NOT BLOCK ACCESS TO EMERGENCY EXITS AND EMERGENCY EQUIPMENT
- ANY WOMAN WHO WORKS IN A LABORATORY WHERE HAZARDOUS SUBSTANCES ARE IN USE AND WHO IS, OR BELIEVES THAT SHE MAY BE, PREGNANT MUST INFORM HER SUPERVISOR

SAFETY OFFICERS

DEPARTMENT OF ENVIRONMENTAL HEALTH AND SAFETY 32999

Mr. Dan Langham Director 74980

DEPARTMENT OF CHEMISTRY

Dr. Michael Baird Acting Head 32614

Mrs. Johann Jardine Department Manager
and
Departmental Safety Officer 36662

Dr. Ralph Whitney Chair, Departmental Safety
Committee 32641

INTRODUCTION

Safety is the responsibility of everyone who works in the Department of Chemistry. This includes all faculty, staff, graduate students, researchers and visitors to the Department. This manual is intended to cover many of the common or general hazards associated with work in the Department and must be read and adhered to by everyone working in the Department. It cannot be assumed that the warnings or rules laid out in this manual are necessarily complete for dealing with specific chemical hazards; additional information or measures may be required and the appropriate information sources should be consulted.

It is the responsibility of individual supervisors to ensure that the necessary procedures and protocols are both established and followed in their respective work areas.

It is the responsibility of workers to follow proscribed procedures and protocols when dealing with hazards in the laboratory.

Personal safety depends upon a positive attitude towards safety as well as good, informed judgment on the part of each individual working in the Department. Most health and safety problems in the laboratory can be avoided by practicing good housekeeping and common sense based upon informed knowledge of the hazards.

A safe working environment is achieved through responsible, self-motivated activity.

**QUEEN'S UNIVERSITY
DEPARTMENT OF CHEMISTRY
ACKNOWLEDGMENT OF RESPONSIBILITY**

Under the Occupational Health and Safety Act, **everyone** has both rights and responsibilities in providing a safe work environment.

The **Department** has responsibility and authority for maintaining appropriate standards for health and safety within the Department. To this end the Department sets out the appropriate standards and procedures in the Department Safety Manual, provides basic training in safety for the chemical laboratory and performs inspections of the workplace.

Supervisors are responsible for ensuring that individuals under their supervision have a safe environment in which to work, know and follow the Department safety rules, are made aware of the specific hazards associated with their work, and have available the appropriate procedures and safety equipment for dealing with these hazards.

Individuals must work safely according to the procedures outlined by the Department and the individual's supervisor, must maintain a safe working environment through good laboratory practice and good housekeeping, and must notify their supervisor or the Department of any defects in equipment or protective devices, or of the existence of hazards in the workplace.

The rights and responsibilities of supervisors and workers, as defined by the **Occupational Health and Safety Act**, are described in **Appendix 0**.

INDEX

Introduction

General Department Safety

Working Alone, Reporting of Accidents

Chemical Laboratory Safety

Material Safety Data Sheets

1. General Chemical Hazards

1.1 Corrosivity

1.2 Flammability

1.3 Noxious Chemicals

1.4 Reactive Chemicals

Air/Water Reactive

Self-Reactive

Lachrymators

Incompatible Chemicals

1.5 Toxicity

1.6 Designated Substances

2. Safe Laboratory Procedures and Techniques

2.1 Glassware

2.2 Electrical Equipment

2.3 Static Electricity and Spark Hazards

2.4 UV Lamps

2.5 Lasers

2.6 Radiation Safety and X-ray Generators

2.7 Magnetic Fields

2.8 Compressed Gases

2.9 Cryogenics and Cold Traps

2.10 Reduced Pressure Operations and Vacuum Pumps

2.11 Distillation and Reflux Operations

2.12 Biohazard Safety

2.13 Microwaves

3. Safety Equipment and Emergency Procedures

3.1 Fumehoods

3.2 Local Ventilation

- 3.3 Personal Protective Equipment
 - Eye and Face Protection
 - Clothing
 - Gloves
 - Hearing
 - Respirators
- 3.4 Emergency Equipment
 - Eyewash Fountains and Showers
 - Fire Extinguishers
- 3.5 Emergency Procedures
 - Medical Emergency
 - Fire Emergency
 - Chemical Spills

4. Waste Disposal

5. Equipment Disposal

6. Undergraduate Laboratories

7. Off-Campus Activities

Appendix 0 – Occupational Health and Safety Act

Appendix I - Waste Chemical Disposal

Appendix II - Handling, Storage and Disposal of Organic Peroxides

Appendix III - Incompatible Chemicals

Appendix IV - Handling, Storage and Disposal of Flammable Solvents

Appendix V - Distillation and Reflux of Flammable Liquids

Appendix VI – Disposal Procedures, Hazardous Chemicals

Appendix VII – Sharps Disposal

Appendix VIII – Off-Campus Activity Flow Chart

In addition to the health and safety standards set by the Department of Chemistry, the **Department of Environmental Health and Safety**, Queen's University, has established a set of policy statements and standard operating procedures for the University. As of **June 2006**, the documents listed on the following two pages have been implemented.



Queen's University Environmental Health & Safety

Date Issued: June 2006	Page No.: 1	Document No.: EHS-Admin-02A
Revision: 1.0	Subject: Table of Contents (Technical Departments)	

Table of Contents

Tab 1	<p>Policies and Terms of Reference Health and Safety Management System Policy Statement on Health and Safety Policy Statement on Environmental Management Policy and Procedures for Reporting and Managing Infectious Diseases Off Campus Safety Activity Policy Smoking in the Workplace</p> <p>Environmental Health and Safety Policies and Procedures</p>
Tab 2	<p>Chemical Procedures Spill Response Procedure (SOP-Hazmat-01) Hazardous Waste Disposal Procedures (SOP-Chem-01) Transportation of Dangerous Goods Procedures (SOP-Chem-02) WHMIS Training Program (SOP-Chem-03)</p>
Tab 3	<p>Radiation Procedures Laser Safety (SOP-Radiation-02) X-Ray Safety (SOP-Radiation-03) GammaCell 20 Irradiator (SOP-Radiation-05)</p>
Tab 4	<p>BioSafety Procedures Vacuum & Aspiration Equipment (SOP-Biosafety-01) Biohazard Permit Application Process (SOP-Biosafety-04)</p>
Tab 5	<p>Lab Safety Procedures Fume Hoods – Procedures for Installation, Maintenance and Use (SOP-Lab-01) Emergency Eyewash Stations and Safety Showers (SOP-Lab-03) Laboratory Decommissioning (SOP-Lab-04)</p>
Tab 6	<p>Fire Safety Procedures Storage in Building Corridors and Egress Routes (SOP-Fire-01)</p>
Tab 7	<p>General Safety Procedures Working in Hot Environments (SOP-Safety-01) JHSC Workplace Inspections (SOP-Safety-02) Health and Safety Roles and Responsibilities (SOP-Safety-03)</p>

Queen's University Environmental Health & Safety



Date Issued: June 2006	Page No.: 2	Document No.: EHS-Admin-02A
Revision: 1.0	Subject: Table of Contents (Technical Departments)	

Hoists and Cranes (SOP-Safety-04)
Departmental Safety Bulletin Boards (SOP-Safety-07)
Electrical Equipment Certification (SOP-Safety-08)
Unpaid Student Placements (SOP-Incidents/WSIB-01)

Tab 8

Information Bulletins

Amendments to the Criminal Code
Laser Pointer – Safety Fact Sheet
Health Concerns: Roofing Projects
SARS – Employee Information Bulletin
SARS – Students and Visitors
SARS – Planning for an Event
MOL Announces Ticketing for Industrial Safety Violations
West Nile Virus
Work Refusal Process

GENERAL DEPARTMENT SAFETY

- Know and follow safety rules, procedures and protocols
- Be aware of hazards, and the procedures for dealing with those hazards, before you start your work
- Fire doors must be kept closed at all times; automatic (self-closing) fire doors must not be blocked
- Familiarize yourself with all safety equipment and procedures in your work area (telephone, exits, fire extinguishers, fire alarms, safety shower, eyewash fountain, first aid kit, evacuation routes)
- Never block emergency exits, emergency equipment or electrical panels
- Post suitable warning signs if a specific hazardous situation exists; include the name and phone number of individual(s) responsible
- Maintain a tidy workplace
- Research labs must keep lab doors closed to effect proper ventilation of the lab
- Keep your work area locked when unoccupied to avoid unauthorized entry
- No bicycles, rollerblades or pets in the building
- WHMIS training is mandatory for anyone working in a research lab
- Anyone working in a laboratory who becomes pregnant should inform his/her supervisor so that an assessment of potential risks may be carried out

Working Alone

Undergraduate students must not work alone in a laboratory at any time. A second person must be present and must assume responsibility for supervision of the undergraduate. The work carried out must be authorized by a faculty member.

For other members of the Department, working alone is usually defined as working in a laboratory outside of normal working hours (8 a.m. to 6 p.m., Monday through Friday) in the absence of any other co-workers. Individuals may work alone if their laboratory work is of a non-hazardous nature and if there is someone else working on the same floor of the building.

If, for some reason, hazardous work must be performed outside normal working hours then the following procedure must be followed:

1. The work must have your supervisor's approval,
2. A second co-worker must be available in case of emergency, or
3. The Emergency Report Centre (36111) and/or Campus Security (36733) must be contacted to set up a check-in routine with you; they must be contacted once your work is completed.

If you are working late at night, both the Campus Security Escort Service (36080) and the A.M.S. Walk-home Service (39255) are available.

REPORTING OF ACCIDENTS

Minor accidents involving hazardous chemicals or the malfunction and/or breakdown of equipment must be reported to your supervisor. More serious accidents must be reported to the Head of the Department and/or the Department Safety Officer as well as to your supervisor.

All accidents involving personal injury must be reported promptly to your supervisor who is responsible for ensuring that the procedures below are followed. If your supervisor is not immediately available, contact the Department Safety Officer or the Head of the Department.

- Apply first aid (first aid kits should be available in all labs); first aid should be given by someone who has had appropriate training
- In the case of minor injuries that cannot be satisfactorily treated by first aid alone, or if there is any doubt, the injured person shall be sent or taken to the hospital emergency room, or doctor of his/her choice. Queen's employee's should take along a completed copy of the relevant Workplace Safety & Insurance Board (WSIB) form(s) available from the Department Administrative Assistant. If this form(s) does not accompany the injured employee to the treatment centre then it must be filled out and sent to the treatment centre as soon as possible. *See Appendix for sample copies of WSIB forms.*
- In the case of injuries that are more severe, or there is doubt about the severity of the injury, and emergency assistance is required, call **36111** from an internal phone (or 911 from an external phone). A SEVERELY INJURED PERSON MUST NOT BE MOVED without the advice of medical or ambulance personnel.
- If it is necessary to call an ambulance, indicate the location of the injured person and the location of the nearest appropriate entrance to the building. If possible send someone to that entrance to lead the ambulance personnel to the injured person.

For all accidents involving critical injury or death:

- Immediately call 36111 for assistance
- As soon as possible, notify your supervisor, the Head of the Department (or Safety Officer), and the Department of Environmental Health and Safety. The latter will notify the appropriate government agencies.
- Do not touch anything associated with the accident, except for the purpose of saving life, relieving suffering or preventing unnecessary damage to equipment or property. The scene of an accident must be examined by the appropriate authorities

CHEMICAL LABORATORY SAFETY

There are over 10 million known chemical substances with more being continually discovered; the hazardous properties of most of these substances have not been investigated. There are however many classes of compounds that are known to present certain hazards such as

- oxidizing agents and reducing agents
- corrosives such as acids and bases
- water reactive chemicals
- air reactive chemicals
- self-reactive chemicals
- highly toxic chemicals

This manual will describe general procedures and protocols for dealing with common hazards in the chemical laboratory. For detailed information on the handling and disposal of specific chemical substances, the following references, available through Queen's University Libraries, should be consulted:

“Hazardous Chemicals Handbook”, P. A. Carson & M. J. Mumford (electronic access)

“Hazardous Chemicals: Information and Disposal Guide”, M. A. Armour, L. M. Browne and G. L. Weir, University of Alberta.

“Handbook of Reactive Chemical Hazards”, L. Bretherick, Butterworths.

“Sax's Dangerous Properties of Industrial Materials”, R. J. Lewis, Sr., editor, Van Nostrand Reinhold.

“Hazardous Chemicals: Desk Reference”, R. J. Lewis, Sr., Van Nostrand Reinhold.

“The Sigma-Aldrich Library of Chemical Safety Data”, R. E. Lenga, editor, Sigma-Aldrich Co.

“Prudent Practices in the Laboratory: Handling and Disposal of Chemicals”, National Research Council, National Academy of Sciences, Washington, 1995.

Material Safety Data Sheets

The provision by chemical manufacturers of material safety data sheets (MSDSs) for hazardous materials is one means of communicating information on chemical hazards; chemicals purchased directly from a chemical supplier will be accompanied by an MSDS. In addition, various electronic MSDS databases are available at Queen's University through links on the Department of Environmental Health and Safety Website.

1. General Chemical Hazards

1.1 Corrosivity

Corrosive chemicals cause visible destruction or irreversible alteration to living tissue. Common acids and bases are the most common corrosives encountered, but other chemicals such as Br₂ are also extremely corrosive.

- concentrated acids and bases should always be diluted by addition to water due to the large heat of solution for these compounds
- **use appropriate personal protective equipment and fumehood ventilation when working with strong acids and bases, and other corrosive substances**
- safety glasses do not provide complete eye protection from chemical splashes; wear appropriate safety goggles or splash shields when working with corrosive substances

NOTE: some specific acids such as HF (extremely toxic) and HClO₄ (powerful oxidizer of organics) require special handling procedures. Consult the appropriate references and your supervisor before working with these chemicals.

1.2 Flammability

The risk of fire in the chemical laboratory is most often associated with two classes of compounds - common organic solvents, and certain metals, metal hydrides and organometallics. For common organic solvents the following should be noted:

- the minimum temperature at which vapours from a substance will ignite in air when exposed to an ignition source (flame, spark, static discharge, etc.) is called the flash point
- a flammable substance has a flash point below 37.8°C
- a combustible substance must be heated at or above 37.8°C to ignite
- bottles of flammable liquids up to 1L in size can be stored anywhere in laboratories; larger quantities must be stored in flammable storage cabinets (e.g. 4L bottles) or in approved safety containers
- the maximum volume of (flammable + combustible) liquids that may be stored in the open lab is 300 litres; the maximum allowable amount of flammable solvents is 50 of the 300 litres
- flammable waste solvents cannot be collected in the open lab in containers larger than 1 litre capacity
- always use ventilation (e.g. fumehoods) which is adequate for the quantity of flammable liquid in use
- always connect (or bond) containers when transferring flammable liquids from metal containers
- **only refrigerators/freezers that are approved for flammable storage can be used in laboratories**

See Appendix IV - **Handling, Storage and Disposal of Flammable Solvents**

The Department of Chemistry also has standard operating procedures for operations involving the distillation and reflux of flammable liquids at atmospheric pressure in

fumehoods. These procedures are described in Appendix V - **Distillation and Reflux of Flammable Liquids**.

Alkali and alkaline earth metals, certain other metals such as **aluminum**, metals in a finely divided form, **metal hydrides** and many **organometallic compounds** can ignite on exposure to air and/or water. The following should be noted when working with this class of compounds:

- store these chemicals in a location separate from other chemicals in the laboratory and in containers appropriate for the purpose
- use equipment appropriate for the hazards associated with these substances including inert atmosphere techniques
- class “D” fire extinguishers (metal fires) must be present in laboratories where these substances are in use; do not use “C” class fire extinguishers (CO₂) on metal fires

1.3 Noxious Chemicals

Certain classes of compounds such as **thiols (mercaptans)** and related sulfur-containing compounds are characterized by a particularly noxious odour

- these compounds must be used with adequate ventilation (fumehoods)
- whenever compounds of this type are used they will be released through the ventilation system into the local atmosphere, consequently both the Department Safety Officer and the Emergency Report Centre must be notified in advance of the use of these chemicals

1.4 Reactive Chemicals

Air/Water Reactive

- chemicals which can ignite on exposure to air or water, e.g. certain metallic and organometallic substances, phosphorous
- special handling, storage and disposal procedures must be established in laboratories where these substances are in use (see section on **Flammability** and Appendix IV - **Incompatible Chemicals**)

Self-Reactive Chemicals

- may be heat, shock or friction sensitive and can react violently as a consequence, e.g. acetylene and acetylides, azides, diazonium salts, nitro compounds, chlorates and perchlorates, peroxides
- special handling, storage and disposal procedures must be established in laboratories where these substances are in use (see Appendix III - **Handling, Storage and Disposal of Organic Peroxides**)

Lachrymators

- substances which react with moisture in the eyes and mucous membranes to cause tear formation, e.g. halogenated aldehydes, ketones and esters
- must be used with adequate ventilation (fumehood) and stored in well sealed containers

Incompatible Chemicals

Accidental contact of incompatible chemicals can lead to fire, explosion and/or the release of highly toxic substances. The magnitude of the problem usually increases with the quantity of chemicals being stored. Prudent practice requires that incompatible chemicals be stored in separate locations to minimize the risk of accidental mixing. Appendix III **Classes of Incompatible Chemicals** lists some general groups of incompatible chemicals; further information on specific chemicals may be obtained from references such as *Hazards in the Chemical Laboratory*, by L. Bretherick or *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council, National Academy Press, 1995.

Oxidizers (e.g. chromates, halogens, peroxides) and **reducers** (e.g. metals, metal hydrides, phosphorous, sulfur) are incompatible with each other and should be stored in separate cabinets or on separate shelves. Strong oxidizers should also be separated from flammable liquids

1.5 Toxicity

A wide range of substances are present in the chemical laboratory which present a risk due to either chronic or acute toxicity; this includes the presence of carcinogens, mutagens and teratogens.

- toxic substances may enter the body by inhalation, absorption, ingestion and/or injection
- appropriate protective measures must be taken to prevent exposure and which are consistent with permissible exposure limits for a specific substance
- where available, antidotes for poisons must be present during usage of these poisons

NO FOOD OR DRINKS ARE TO BE CONSUMED IN LABORATORIES UNDER ANY CIRCUMSTANCES

CONTAINERS/UTENSILS USED FOR THE PREPARATION OR CONSUMPTION OF FOOD OR BEVERAGES MUST NOT BE STORED IN THE OPEN IN LABORATORIES

ANY WOMAN WHO WORKS IN A LABORATORY WHERE HAZARDOUS SUBSTANCES ARE IN USE AND WHO IS, OR BELIEVES THAT SHE MAY BE, PREGNANT MUST INFORM HER SUPERVISOR

1.6 Designated Substances

The Occupational Health and Safety Act allows a biological, chemical or physical agent, or combination thereof, to be “designated” and its use in the workplace may be either prohibited or strictly regulated. Regular reporting on inventories of these substances may be required. The following are designated substances:

ACRYLONITRILE
ARSENIC
ASBESTOS
BENZENE
CARBON DISULFIDE
CARBON TETRACHLORIDE
COKE OVEN EMISSIONS
ETHYLENE OXIDE
ISOCYANATES
LEAD
MERCURY
SILICA POWDER
STYRENE
VINYL CHLORIDE MONOMER

Acrylonitrile, benzene, carbon disulfide, carbon tetrachloride, isocyanates, styrene, and vinyl chloride monomer are all volatile organic materials and must be used with adequate ventilation (fume hood) to prevent exposure through inhalation and with appropriate protective equipment to prevent exposure through skin absorption. These materials can be disposed of in the normal liquid organic waste stream (halogenated or nonhalogenated as appropriate).

Substances containing **arsenic, lead or mercury** must be handled in an appropriate manner to prevent exposure through inhalation or absorption. All chemical waste containing arsenic, lead or mercury must be collected and properly labeled for disposal by the Department of Environmental Health and Safety.

Elemental mercury is used in many types of apparatus, in particular mercury-filled thermometers. Mercury spills from broken equipment should be cleaned up immediately (mercury spill kits are available from the Department of Environmental Health and Safety). Broken thermometers are collected by lab technicians, who will recover the mercury from the thermometers before disposal.

Silica powder, including chromatography grade silica, is a respiratory hazard and should be handled in a fume hood when dry. Used silica should be stored in sealed and labeled containers then sent for disposal by the Department of Environmental Health and Safety.

2. Safe Laboratory Procedures and Techniques

2.1 Glassware

In general glassware used for standard laboratory procedures is made of borosilicate glass. Prior to carrying out an experiment the following should be done:

- check glassware for cracks, chips and other flaws; these flaws should be repaired before the glassware is used
- select the right glassware for the job: vacuum applications required thick-walled glass while operations carried out under pressure require specially designed glassware
- glassware under pressure or vacuum should be shielded
- if it is necessary to apply pressure to glassware, wear thick leather gloves
- never heat or apply pressure/vacuum to a chemical in a stock bottle; these bottles are made of a soft glass which breaks readily

2.1.1 Cleaning Laboratory Glassware

For most cleaning applications, laboratory glassware is soaked in an aqueous detergent solution (e.g. Sparkleen®, Alconox®) followed by rinsing with de-ionised water and drying. In some situations, more chemically aggressive cleaning solutions are employed; listed below are some of the more commonly encountered cleaning solutions, with the associated hazards:

- Alcohol/base baths: typically 50% aqueous base in an alcohol solution. Removes silicone grease as well as many organic residues. Highly corrosive to skin and eyes, therefore requires appropriate personal protection. Prolonged exposure of glassware to strong base leads to etching, particularly to ground glass joints, and readily destroys scintered glass funnels.
- Acid/Oxidizer baths: historically, **chromic acid** has been used as an oxidizing cleaner however disposal of chromium waste is now problematic; this cleaning solution is no longer recommended for use. **Ammonium persulfate/sulfuric acid** has been used as a metal-free cleaning solution, as has **nitric acid** either alone, or in conjunction with other acids (hydrochloric or sulfuric acid). **Piranha solution** (hydrogen peroxide and sulfuric acid) has been used in the semi-conductor industry however it, like many other acid/oxidizers, is known to react violently if mixed with significant quantities of organic solvents (e.g. acetone). As a consequence of the hazards associated with the use of acid/oxidizer baths, **they can only be used with approval of your supervisor.**

2.2 Electrical Equipment

In addition to the hazards posed by electrical shock, electrical equipment also presents a source of fire hazard when used in conjunction with flammable substances (see section on **Flammability**). Electrical hazards can be minimized by the following:

- only trained or qualified individuals should repair or modify electrical equipment
- electric wires should never be used as supports
- unplug equipment by pulling on the plug not the cord
- equipment should be regularly inspected and frayed cords or broken plugs should be repaired
- any equipment failure or overheating should be remedied immediately
- use “C” class fire extinguishers for electrical fires

2.3 Static Electricity and Spark Hazards

Protection from static discharge must be addressed in particular when handling flammable solvents; this risk is increased during periods of low humidity. Proper grounding of containers and equipment will significantly reduce this risk. Common potential sources of sparks and static discharges are:

- ungrounded metal tanks and containers
- clothing or containers made of plastic or synthetic materials
- high pressure gas cylinders upon discharge
- control systems on hotplates
- brush motors and forced air dryers

2.4 UV Lamps

Radiation of wavelengths below 250 nm poses a considerable risk to both eyes and exposed skin. Wear UV-absorbing safety glasses and avoid direct eye contact with the UV source; wear protective clothing to prevent burns from UV exposure. Work involving UV irradiation should be carried out in an enclosed work area to prevent exposure of workers to the UV source.

Mercury arc lamps should be cleaned thoroughly before use. Handling with bare hands leaves oil deposits on the surface of the outer glass which form residues that will burn into the glass causing buildup of heat during the operation of the lamp. The lamp may overheat and crack, releasing mercury vapour as a consequence.

2.5 Lasers

The Department of Environmental Health and Safety runs a “Laser Safety Program”. All personnel working in proximity to Class 3b or Class 4 lasers must complete this program before starting work with lasers.

The type and intensity of radiation available from a laser varies greatly from one instrument to another. The following general rules should be followed:

- always wear goggles that offer protection against the specific wavelength(s) of the laser in use; no available goggles protect against all laser wavelengths
- never look directly at the beam or pump source
- never view the beam pattern directly; use an image converter or other safe, indirect means
- do not allow objects that cause reflections to be present in or along the beam
- keep a high general illumination level in areas where lasers are in operation; low levels of light cause dilation of the pupils, thereby increasing the danger to the eyes
- display warning signs

2.6 Radiation Safety and X-ray Generators

The Principal of Queen's University has appointed the University Radiation Safety Committee to carry the advisory responsibility for the overall operation of the University Radiation Safety Program. The details are included in the Terms of Reference of the Committee. It is the policy of Queen's University that all activities involving ionizing radiation or radiation emitting devices be conducted so as to keep hazards from radiation to a minimum. Persons involved in these activities are expected to comply fully with the Atomic Energy Control Act and all its regulations, with the Occupational Health and Safety Act and its regulations regarding X-ray sources, lasers and sound. Radiation Safety Policy and Procedures are available through the Department of Environmental Health and Safety.

X-rays are a hazardous physical agent under the Occupational Health and Safety Act. Any equipment generating X-rays must be operated in accordance with government regulations and appropriate warning signs must be posted.

2.7 Magnetic Fields

NMR spectrometers have superconducting magnets which generate static magnetic fields with high flux densities. Hazards exist from the mechanical forces exerted by these magnetic fields on ferromagnetic tools and equipment and on medical implant devices. Individuals with implanted cardiac pacemakers and similar medical devices should not be exposed to these magnetic fields. Other implanted medical devices such as suture staples, aneurysm clips, prostheses, etc. may also be subjected to adverse effects.

2.8 Compressed Gases

Gases used in laboratories are supplied in cylinders at high pressure; lecture bottles are not permitted. In addition to any potential chemical hazards, compressed gases are a high-energy source and therefore hazardous. The following rules must be followed:

- cylinders of all sizes must be restrained from falling by restraining devices
- during storage or transport, the cylinder cap must be in place
- cylinders must only be transported when strapped to a wheeled cart
- no lubricant shall be used when connecting the regulator to the cylinder

- new connections shall be checked for gas leakage
- the cylinder delivery pressure shall be set to zero after the main cylinder valve is closed to prevent a rapid release of compressed gas the next time the cylinder is opened
- empty cylinders shall have the regulators removed, be marked MT, the shipping cap replaced and returned to Chemistry Stores
- unused or partially used cylinders that are of no further use shall be returned to Chemistry Stores
- in the event of a fire, the supply of a combustible gas shall be shut off before any attempt is made to extinguish the flame
- a trap shall be used to prevent the back siphoning of solution when a soluble gas is being employed
- do not expose cylinders to temperatures higher than 50°C
- use toxic, flammable or reactive gases in a fumehood
- use the appropriate regulator for the type of gas
- be aware that special handling procedures are required for certain gases, e.g. acetylene

2.9 Cryogenics and Cold Traps

Liquid nitrogen is the most common cryogenic coolant and must be handled with caution. The following points must be taken into account when using liquid nitrogen

- use only a properly vented container
- extreme cold can rapidly cause tissue damage; use appropriate protective equipment
- spills in confined spaces can cause asphyxiation due to rapid evaporation of the nitrogen
- glass Dewars used as cold traps should be encased to contain glass fragments in the event of implosion
- do not leave liquid nitrogen cold traps open to the air; oxygen may condense from the air and can react explosively with combustible materials

Dry ice is frequently used in conjunction with a cooling liquid. These cooling systems can also cause tissue damage due to extreme cold. The proper choice of a cooling liquid presents problems since a nontoxic, nonflammable, low viscosity, low volatility liquid does not exist. In general isopropanol (flash point 11°C) is preferable to acetone (flash point -18°C) due to a higher flash point but still represents a fire hazard. A 3:2 mixture of ethylene glycol to water which is thinned with isopropanol is an alternative cooling liquid with reduced flammability.

2.10 Reduced Pressure Operations and Vacuum Pumps

- vacuum desiccators should be taped or encased due to the risk of implosion
- glass vacuum lines should be shielded when in use
- cold traps should be placed between apparatus and vacuum pumps to prevent volatiles from entering the pump oil; traps should be cleaned after use
- exhaust from pumps should be vented into a ventilation control system, not into the open lab; this includes venting of PIAB compressed air vacuum apparatus
- pump belt drives must have a guard over the belt to prevent anything from getting caught in the belt

2.11 Distillations and Reflux Operations

Distillations and reflux operations are common laboratory procedures which present several potential dangers: pressure buildup leading to explosions if closed systems are used, and fire hazards associated with heating flammable substances are two of the most common. A variety of apparatus designs are available to accomplish reflux/distillation operations at atmospheric pressure, under inert atmospheres, under reduced pressure and by the addition of steam. The following general points should be noted when carrying out these operations:

- check the integrity of the system; leaks of flammable materials can lead to fires
- ensure smooth boiling through stirring or the addition of boiling stones (do not add boiling stones to hot liquid)
- choose an appropriate heat source - electric heating mantle, ceramic cavity heater, steam bath or silicone oil bath
- do not heat the heat source above the autoignition temperature of the liquid being distilled/refluxed
- do not distill organic liquids to dryness

NOTE: the Department has standard operating procedures for the distillation and reflux of flammable liquids at atmospheric pressure in fumehoods; see Appendix V - **Distillation and Reflux of Flammable Liquids**.

2.12 Biohazard Safety

The University Biohazards Committee, on behalf of the University, will determine the nature of biohazardous work in progress or proposed, accredit the facilities on an ongoing basis, assist the design of appropriate laboratories and training of personnel, and serve as an educational resource to members of the University community. The University has adopted the Laboratory Biosafety Guidelines, whether or not the work is externally funded and whether or not the sponsoring agency requires such certification.

Members of the University community who are contemplating, or who are presently engaged in work which might fall within these Guidelines are required to contact the Chair or Secretary of the Committee if they have not already done so.

2.13 Microwaves

Microwave radiation is a potentially harmful physical agent. The following general points should be noted when using microwave sources:

- do not attempt to use microwave ovens with the door open
- do not use metal containers in microwave oven
- ensure that seals around doors are clean and undamaged
- microwave equipment should only be modified or repaired by qualified personnel

3. Safety Equipment and Emergency Procedures

A variety of protective measures are available for dealing with the hazards present in the chemical laboratory. One of the simplest measures to reduce or eliminate a hazard is to substitute a less hazardous or non-hazardous material for one which presents a high level of risk. For example many older literature procedures may use solvents such as benzene or carbon tetrachloride for routine applications; it is now known that benzene is a potent carcinogen and that carbon tetrachloride can cause serious liver damage. Substitution of these solvents with toluene or dichloromethane may pose less risk if compatible with the procedure.

A second measure is to reduce the scale of an operation to reduce the level of risk. Smaller reactions are less likely to cause serious accidents if something goes wrong; they also produce less waste.

3.1 Fumehoods

The most common method to prevent exposure to hazardous chemicals by inhalation is to work in a ventilated work space provided in a fumehood. Protection is provided by air flow through the fumehood. Annual inspection and servicing is carried out on fumehoods to ensure proper operation however it is important to note that the protection offered by a fumehood can be compromised if the sash is opened too high or if the airflow is obstructed by equipment or chemicals stored in the fumehood. Keep the following points in mind when using a fumehood:

- keep all apparatus at least six inches from the front of the hood; airflow is less likely to be impeded and vapours are less likely to escape
- don't use the hood to store chemicals and equipment; they restrict airflow
- make sure that the airflow monitor/alarm is functioning properly
- proper fumehood ventilation of labs requires that doors to the lab be kept closed
- sash should be kept at a safe operating height

NOTE: it is an offence under the *Occupational Health and Safety Act* to disable any protective device such as the airflow monitor/alarms on fumehoods. Any fumehood without a properly functioning airflow monitor/alarm must not be used.

3.2 Local Ventilation

Flexible ventilation ducts with flared openings can also be used to provide ventilation in local areas, particularly with equipment which, because of size or function, cannot be placed in a fumehood. Any equipment which releases hazardous fumes during operation must have local ventilation.

3.3 Personal Protective Equipment

Eye and Face Protection

The minimum requirement for eye protection is that safety glasses (or prescription glasses) fitted with side shields must be worn in labs when hazardous chemicals are in use. Safety glasses do not provide complete protection to the eyes from spills and splashes. Where more protection is required, such as when working with corrosive substances, either safety goggles or a full face shield may be recommended.

Clothing

Appropriate clothing and shoes are part of your protective equipment. Short pants and open-toed shoes or sandals offer no protection from spills of hazardous chemicals. Shoes that cover the feet completely and long pants or a lab coat must be worn.

Gloves

Gloves are available in a variety of materials including natural rubber, neoprene, nitrile and vinyl. Each type of material is resistant to only a limited range of chemicals therefore no single type of glove is suitable for all situations. Wearing the wrong type of glove can cause more damage by keeping chemicals in contact with your skin. Consult manufacturers data before selecting the appropriate type of gloves.

NOTE: Disposable **latex rubber gloves** are permeable or reactive to a variety of common chemicals including benzene, carbon tetrachloride, chloroform, chromic acid, ethyl ether, hexane, methylene chloride, naphtha, nitric acid, styrene, sulphuric acid, tetrahydrofuran, toluene, and xylene. They are **not recommended for use with these chemicals**.

Respirators

Respirators are designed to protect the wearer from hazardous vapours or dust. A wide variety of respirators are available and are designed to deal with different substances in various situations. The use of respirators requires proper selection, fitting and training which must be arranged through the Department of Environmental Health and Safety

Hearing Protection

Routine exposure to noise in excess of 90dB requires the use of hearing protection (i.e. ear plugs, ear muffs); for extended exposure to noise in excess of 80 dB, hearing protection is advised.

3.4 Emergency Equipment

Eyewash Fountains and Showers

Eyewash fountains and showers are located in the corridors outside research labs, and have instructions for their use posted. Access to this equipment must not be obstructed in any way. Additional safety showers are located in the washrooms at the end of each research corridor.

If it is necessary to use an eyewash fountain, hold your eyelids open with your fingers and roll your eyes back and forth while washing them. Flush your eyes for at least 15 minutes to ensure removal of the chemical.

If it is necessary to use an emergency shower, activate the shower for preliminary decontamination, then proceed to a shower located in a washroom to remove contaminated clothing as rapidly as possible.

Fire extinguishers

All laboratories are equipped with “ABC” class fire extinguishers (Dry Chemical) which are suitable for most fires except metal fires; those labs with significant quantities of pyrophoric metals are also equipped with “D” class extinguishers. These extinguishers are only designed to fight small local fires. Do not attempt to fight large fires; evacuate the building and call for professional fire fighters (telephone 36111 - Emergency Report Center). All use of fire extinguishers must be reported to the Department Safety Officer.

3.5 Emergency Procedures

Medical Emergency

Minor accidents involving hazardous chemicals or the malfunction and/or breakdown of equipment must be reported to your supervisor. More serious accidents must be reported to the Head of the Department and/or the Department Safety Officer as well as to your supervisor.

All accidents involving personal injury must be reported promptly to your supervisor who is responsible for ensuring that the procedures below are followed. If your supervisor is not immediately available, contact the Department Safety Officer or the Head of the Department.

- Apply first aid (first aid kits should be available in all labs); first aid should be given by someone who has had appropriate training
- In the case of minor injuries that cannot be satisfactorily treated by first aid alone, or if there is any doubt, the injured person shall be sent or taken to the hospital emergency room, or doctor of his/her choice. Queen’s employee’s should take along a completed copy of the Worker’s Compensation Board “Treatment Memorandum” available from the Department Administrative Assistant. If this form does not accompany the injured employee to the treatment centre then it must be filled out and sent to the treatment centre as soon as possible.

- In the case of injuries that are more severe, or there is doubt about the severity of the injury, and emergency assistance is required, call **36111** from an internal phone (or 911 from an external phone). A SEVERELY INJURED PERSON MUST NOT BE MOVED without the advice of medical or ambulance personnel.
- If it is necessary to call an ambulance, indicate the location of the injured person and the location of the nearest appropriate entrance to the building. If possible send someone to that entrance to lead the ambulance personnel to the injured person.

For all accidents involving critical injury or death:

- Immediately call 36111 for assistance
- As soon as possible, notify your supervisor, the Head of the Department (or Safety Officer), and the Department of Environmental Health and Safety. The latter will notify the appropriate government agencies.
- Do not touch anything associated with the accident, except for the purpose of saving life, relieving suffering or preventing unnecessary damage to equipment or property. The scene of an accident must be examined by the appropriate authorities

Fire Emergency

You must be aware of the location and/or use of all fire extinguishers, fire alarm switches and fire exits in your area. If the fire cannot safely be controlled with a fire extinguisher, then the following actions should be taken:

- alert all persons in the area of the fire emergency
- leave the area while closing doors and windows (where this can be done safely)
- activate the nearest fire alarm
- check to ensure that the area has been evacuated then leave the building to the nearest safe location
- phone the Emergency Report Centre (36111)
- be available to guide the Fire Department to the location of the fire

Chemical Spills

All spills should be cleaned up promptly, efficiently and properly. All individuals at risk due to the spill should be warned immediately.

If the spill involves nonvolatile, nonflammable and nontoxic material then it should be cleaned up as directed by your supervisor. Most cleanups of liquid spills are facilitated by the use of an absorbent material that will neutralize the liquid where appropriate (spill kits are located in the safety locker found in each research lab). Cleanup can then be carried out using a dustpan, brush and appropriate protective equipment. The spill area should be washed following the cleanup.

If a hazardous chemical such as a flammable, toxic or highly reactive substance is spilled, immediately warn everyone in the area. Shut down all equipment and leave the area. Your supervisor should be notified immediately and will be responsible for the proper cleanup of the contaminated area. Any clothing that has been contaminated should be removed as quickly as possible and decontaminated where possible. Consult the appropriate MSDS for spill clean up procedures.

Waste from chemical spills must be disposed of in an appropriate manner.

4. Waste Disposal

All chemical waste disposal is carried out by the Department of Environmental Health and Safety; sinks and garbage cans are not to be used for chemical waste disposal. All chemical waste must be segregated according to the procedures outlined in Appendix I - **Waste Chemical Disposal**. The general procedure for disposing of waste chemicals is outlined in Appendix VI - **Disposal Procedures Hazardous Chemicals**. Solid and liquid chemicals boxed for disposal are collected on Thursdays. Detailed instructions on chemical waste disposal can be found on the EH&S website: (<http://www.safety.queensu.ca/chemical.htm>).

Flammable liquids such as common organic solvents must be placed in solvent disposal cans (red with wide mouths and flame arrestor) which are identified as to point of origin. This waste should be collected in separate containers for **Halogenated** and **Non-halogenated** waste (<3% halogen content). **Do not fill containers to more than 90% of capacity**. Flammable liquids in solvent disposal cans are collected on Tuesdays.

Containers which have been used to store chemicals, such as stock bottles, but which are empty may be disposed of with the normal garbage; these **bottles must be washed and the labels defaced** before they are placed in the garbage.

Sharp objects such as syringe needles cannot be disposed of in conventional waste containers. They must be collected in an appropriately labeled (“SHARPS”) metal or plastic container for disposal. Separate waste containers are provided for broken glass.

5. Equipment Disposal

Equipment that is sent out to be disposed of either by destruction or by recycling must be accompanied by a form certifying that the equipment has had all hazardous materials removed (e.g. mercury-filled thermometers, PCB-filled transformers, radioactive sources). These forms are available from the Department of Environmental Health and Safety, who will arrange for inspection of equipment prior to disposal.

6. Undergraduate Laboratories

The responsibility for safety is shared by all staff and students working in undergraduate laboratories. These laboratories must be operated in a manner that is consistent with the safety procedures of the Department. The following points should be noted:

- safety goggles must be worn in the laboratories while labs are in progress
- open-toed shoes or sandals must not be worn
- long pants and a lab coat must be worn to protect exposed skin
- long hair must be tied back or contained by a net, cap or other device
- TAs and staff must be familiar with the experiments being carried out, must be aware of the correct procedures and must be aware of the hazards associated with those experiments
- undergraduates must not work alone in a laboratory
- TAs must ensure that all students under their supervision know where emergency equipment is located, and what the procedures are for dealing with medical and fire emergencies
- chemicals from unlabelled containers are not to be used; unlabelled chemicals should be reported to a TA, lab technician or lab coordinator
- all work areas must be kept clean and tidy
- all accidents must be reported promptly

7. Excessive Heat

The Environmental Health and Safety (EH&S) document, *Working in Hot Environments* (SOP-Safety-01), shall be the policy of the Department of Chemistry and its procedures will be followed in the event of extreme high temperatures. This policy is most likely to come into effect in the event of a failure of the air conditioning system in Chernoff Hall. The EH&S SOP does not explicitly address hazards posed by extreme high temperature in the laboratory setting and leaves it up to individual departments to establish operational protocols.

In the event of extreme high temperatures (~30C), personnel in the Department of Chemistry will be required to do the following:

1. Remove from the open lab all solvents with low flash points (Class 1A) and store in solvent cabinets.
2. All experiments or reactions using solvents that have low flash points should be shut down, and not resumed until safe to do so.
3. All other temperature and moisture sensitive materials should be safely stored.
4. All non-essential heat producing equipment should be turned off, if safe to do so.
5. Any individuals affected by heat stress should be treated in accordance with other Medical Emergencies (**section 3.5**).

8. Off-Campus Activities

Queen's University has an Off-Campus Activity Safety policy that is designed to assess risk associated with various off-campus activities such as field work, trips associated with courses, international travel and many other situations. A schematic chart for this risk assessment can be found in Appendix VIII – Off-Campus Activity Flowchart. The full policy document is available through the Environmental Health & Safety website. Note that in many instances this risk assessment is **mandatory** before an off-campus activity can be carried out.

Appendix 0 - OCCUPATIONAL HEALTH AND SAFETY ACT

The *Occupational Health and Safety Act* came into effect in Ontario in 1979. The purpose of this Act is to protect workers from health and safety hazards on the job. Both workers and supervisors have responsibilities under the terms of the Act.

SUPERVISORS AND THEIR DUTIES

Definition of a Supervisor

A “supervisor” is defined in the Act as *a person who has charge of a workplace or authority over a worker. A supervisor: is qualified because of knowledge, training, and experience to organize work and its performance, is familiar with the Act and the regulations that apply to the work, and has knowledge of any potential or actual danger to health or safety in the workplace.*

A worker is an employee of the supervisor or their institution or firm. A professor who directs the research of a graduate student, postdoctoral fellow or other research associate is the direct supervisor of that individual if that individual is paid a salary for the research. A graduate student, postdoctoral fellow, or other research associate who does not receive a salary, being supported through other funds, is considered to be under the supervision of the professor who directs the individual’s research.

Duties of a Supervisor

(1) A supervisor shall ensure that a worker,

- (a) works in a manner and with the protective devices, measures and procedures required by this Act and the regulations; and*
- (b) uses or wears the equipment, protective devices or clothing that their employer requires to be used or worn*

(2) Without limiting the duty imposed by subsection (1), a supervisor shall

- (a) advise a worker of the existence of any potential or actual danger to the health or safety of the worker of which the supervisor is aware;*
- (b) where so prescribed, provide a worker with written instructions as to the measures and procedures to be taken for protection of the worker; and*
- (c) take every precaution reasonable in the circumstances for the protection of a worker.*

A supervisor also has special responsibilities in dealing with accidents involving personal injury or death; see REPORTING OF ACCIDENTS.

WORKERS AND THEIR DUTIES

Definition of a Worker

A “worker” means *a person who performs work or supplies services for monetary compensation*, which includes faculty, staff, teaching assistants, lab demonstrators, post-doctoral fellows, research associates, technicians, technologists, graduate students but NOT undergraduate students taking courses or visitors to the Department.

Duties of a Worker

The duties of a worker are:

(1) A worker shall,

- (a) work in compliance with provisions of this Act and the regulations,*
- (b) use or wear the equipment, protective devices or clothing that their employer requires to be used or worn;*
- (c) report to their employer or supervisor the absence of or defect in any equipment or protective device of which they are aware and which may endanger themselves or another worker; and*
- (d) report to their employer or supervisor any contravention of this Act or the regulations or the existence of any hazard of which they know.*

(2) No worker shall,

- (a) remove or make ineffective any protective device required by the regulations or by their employer, without providing an adequate temporary protective device and when the need for removing or making ineffective the protective device has ceased, the protective device shall be replaced immediately;*
- (b) use or operate any equipment, machine, device or thing or work in a manner that may endanger himself/herself or any other worker; or*
- (c) engage in any prank, contest, feat of strength, unnecessary running or rough or boisterous conduct.*

Students

Undergraduate students taking courses and unpaid graduate students are not employees (workers) under the Act. It is however the policy of the Department of Chemistry that the lab coordinators in undergraduate courses and research directors of graduate students shall act as the direct supervisors of these students, and shall assume the same responsibilities towards the students doing laboratory work under their direction as if the students were employees, AND the students shall act as workers and follow the duties of a worker.

Right to Refuse or to Stop Work Where Health or Safety are in Danger:

(1) A worker may refuse to work or do particular work where he or she has reason to believe that,

(a) any equipment, machine, device, or thing the worker is to use or operate is likely to endanger himself, herself or another worker;

(b) the physical condition of the workplace or the part thereof in which he or she works or is to work is likely to endanger himself, or herself; or

(c) any equipment, machine, device or thing he or she is to use or operate or the physical condition of the workplace or the part thereof in which he or she works or is to work is in contravention of this Act or the regulations and such contravention is likely to endanger himself, herself or another worker.

(2) Upon refusing to work or do particular work, the worker shall promptly report the circumstances of the refusal to the worker's employer or supervisor who shall forthwith investigate the report in the presence of the worker and, if there is such, in the presence of one of;

(a) a committee member who represents workers, if any;

(b) a health and safety representative, if any; or

(c) a worker who because of knowledge, experience and training is selected by a trade union that represents the worker, or if there is no trade union, is selected by the workers to represent them, who shall be made available and who shall attend without delay.

The *Occupational Health and Safety Act* can be found at the following Web address:

http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o01_e.htm

Appendix I - Waste Chemical Disposal

The purpose of the following instructions is to prevent dangerous chemical reactions if there is an accident during transit.

1. All chemicals must be packed by the user Department in sturdy containers, using an inert packing material such as vermiculite.
2. Chemicals must be taken from the laboratory by the user to the pick-up point. Disposal companies require that chemical wastes be identified as members of one of the following categories:

Chemical Code Groups

Group A

- 1 Inorganic Acids
- 2 Elements and inorganic salts that do not liberate gaseous products when acidified.

Group B

- 1 Inorganic alkaline chemicals
- 2 Organic bases
- 3 Elements and inorganic salts which liberate gaseous products when acidified.

Group C

- 1 Solid organic compounds (excluding bases)

Group D

- 1 Organic liquids (excluding organic bases)
NOTE: Separate containers must be used for halogenated and non-halogenated Group D liquids.

Group E

- 1 Inorganic oxidizing agents
NOTE: Group E chemicals cannot be stored or transported with any other chemicals in a common container.

Group F

- 1 Pesticides

Group G

- 1 Shock sensitive materials
- 2 Organic oxidizing agents
- 3 Pressurized containers, gas cylinders
- 4 Materials that react violently with water

Appendix II - **Handling Storage and Disposal of Organic Peroxides**

Organic peroxides are a special class of compounds which pose unusual stability problems. These peroxides are among the most hazardous chemicals normally handled in chemical laboratories and in manufacturing. As a class, organic peroxides are low-power explosives and may be sensitive to shock. Peroxides have a specific half-life, or rate of decomposition, under a given set of conditions. A low rate of decomposition may autoaccelerate into a violent explosion, especially in bulk quantities of peroxides. They are sensitive to heat, friction, impact and light as well as to strong oxidizing and reducing agents. All organic peroxides are extremely flammable and fires involving bulk quantities of peroxides should be approached with extreme caution.

The following precautions should be followed when handling organic peroxides and hydrperoxides:

- study and follow all precautions specified by the manufacturer
- store the peroxides at the minimum safe temperatures to minimize the rate of decomposition; do not refrigerate or store liquid or solutions of peroxides at or below the temperature at which the peroxide freezes or precipitates - peroxides in the solid state have increased sensitivity to shock and heat
- limit the quantity of peroxide handled to the minimum amount required; do not return unused peroxide to the stock container
- clean up all spills immediately by recommended procedures
- the sensitivity of most peroxides can be reduced by dilution with inert solvents such as aliphatic hydrocarbons (e.g. mineral oil) but never with acetone or other ketones
- avoid using peroxides in volatile solvents when it is possible that the solvent will vapourize and thereby increase the concentration of the peroxide
- never use a metal spatula with organic peroxides; contamination by metals can cause explosive decomposition - use plastic or ceramic spatulas
- avoid friction, grinding and impact; never use glass containers with screw cap lids or glass stoppers, instead use plastic bottles and sealers
- do not use open flames, sparking equipment or intense heat sources near peroxides
- avoid ingestion, inhalation and skin contact since many peroxides are irritants

A common method of disposal of liquid organic peroxides is dilution to <10% by weight in a suitable nonvolatile hydrocarbon solvent (often mineral spirits or mineral oil) prior to sending out the material (through Environmental Health and Safety) for disposal by incineration. Check the manufacturer's recommendations prior to disposal of any specific peroxide.

Appendix III - Classes of Incompatible Chemicals

Class of Chemicals	Incompatible with
Alkali and alkaline earth carbides, hydrides, hydroxides, metals, oxides and peroxides	Water, acids, halogenated organic compounds, halogenating agents, oxidizing agents
Azides, inorganic	Acids, heavy metals and their salts, oxidizing agents
Cyanides, inorganic	Acids, strong bases
Nitrates, inorganic	Acids, reducing agents
Nitrites, inorganic	Acids, oxidizing agents
Organic acyl halides, anhydrides	Bases, organic hydroxy and amino compounds
Organic halogen compounds	Group IA and IIA metals, aluminum
Organic nitro compounds	Strong bases
Oxidizing agents (chlorates, chromates, chromium trioxide, dichromates, halogens, halogenating agents, hydrogen peroxide, nitric acid, nitrates, perchlorates, peroxides, permanganates, persulfates)	Reducing agents, ammonia, carbon, metals, metal hydrides, nitrites, organic compounds, phosphorous, silicon, sulfur
Reducing agents	Oxidizing agents, arsenates, arsenites, phosphorous, selenites, selenates, tellurium salts and oxides
Sulfides, inorganic	Acids

Source: "Prudent Practices in the Laboratory: Handling and Disposal of Chemicals", National Research Council, National Academy of Sciences, Washington, 1995.

Appendix IV - Handling, Storage and Disposal of Flammable Solvents

The quantities of flammable solvents (flash point $\leq 37.8^{\circ}\text{C}$) and combustible solvents (flash point $> 37.8^{\circ}\text{C}$, $\leq 93.3^{\circ}\text{C}$) that may be stored in laboratories are governed by the Ontario Fire Code. It is the responsibility of every research supervisor to ensure that flammable and combustible solvents present in their labs are handled, stored and disposed of in accordance with this Code. Classification of flammable solvents can be found in the OFC section **4.1.2.1.(1)**.

The main points to be noted are:

1. Containers for storing solvents cannot exceed 5 litres capacity; exceptions are waste solvent (20 litres) containers with flame arrestors, and stainless steel cylinders (e.g. Aldrich Pure-Pac®, 18 litres) used in solvent purification systems in accordance with the manufacturer's specifications. (OFC pt 4 sec. 4.12.3.1(1))
2. A total of 300 litres of (flammable + combustible) solvents may be stored in the open lab; of this total, the maximum allowable amount of flammable solvents is 50 litres; flammable solvents stored in the open lab cannot be in containers > 1 litre capacity [i.e. 50 one-litre containers are the maximum that can be stored in any research lab] (OFC pt 4 sec. 4.12.3.1(2))
3. Flammable waste solvents cannot be collected in the open lab in containers greater than 1 litre capacity, and are part of the capacity listed in sentence (2)
4. Quantities in excess of sentence (2) **MUST** be stored in an approved flammable storage cabinet; all flammable solvents in containers greater than 1 litre must be stored in a flammable storage cabinet, except where noted in sentence (1)
5. Quantities described in sentence (4) cannot exceed the storage capacity of the approved flammable storage cabinets in the lab
6. All containers for storing flammable + combustible liquids must be kept closed when not in use.

The following solvents carried by Chemistry Stores are the main flammable solvents covered by this Code; individual research groups may have other flammable solvents brought in by special order which are also covered by the Code.

	Hlth	Flam	React
ACETONE	2	3	1
ACETONITRILE	2	3	1
BENZENE	3	3	1
DIOXANE	2	3	1
ETHANOL	2	3	0
ETHER	2	4	1
ETHYL ACETATE	2	3	0
HEXANES	2	3	0
ISOPROPANOL	2	3	0
LIGROIN	2	3	1
METHANOL	2	3	0
TETRAHYDROFURAN	2	3	1
TOLUENE	2	3	0
XYLENES	2	3	0

For Clarification of any of the above, please visit: <http://www.gov.on.ca/OFM/legreg/part4.htm>

This is the website for the Office of the Ontario Fire Marshal and gives much greater detail with respect to pt. IV of the Ontario Fire Code and your obligations. Questions pertaining to interpretation of the act should be addressed to Environmental Health and Safety.

Appendix V - **Distillation and Reflux of Flammable Liquids**

1. The following items must be checked prior to carrying out a distillation or reflux operation:
 - a) all heating mantles must be inspected for defects; discard any defective equipment
 - b) all power cords must be inspected for defects; defects must be repaired prior to use
 - c) all glassware must be inspected for integrity, securely assemble and properly clamped
 - d) all water hoses must be securely attached with the approved clamps obtainable from Chemistry Stores; all water leads to drains must be secured; water flow must be confirmed
 - e) any possibility of pressure build up in the glassware must be avoided; do not heat a closed system
 - f) appropriate measures (boiling chips or stirring) must be taken to avoid bumping
 - g) all reflux operations must have written identification if they are to be left unattended
 - h) electrical devices that have the potential to generate arcs or sparks, other than stirrers required to prevent bumping, shall not be operated in the fumehood during reflux/distillation operations
 - e) no flammable liquids or flammable compressed gases shall be stored in fumehoods during a reflux/distillation operation
2. Written identification must include the following:
 - a) identification of the flammable solvent
 - b) relevant physical properties including melting point, boiling point, autoignition point and flash point
 - c) operator's name and contact number
 - d) supervisor's name and contact number
 - e) any additional relevant information
3. General procedural guideline:
 - a) the maximum total volume of flammable liquids that may be distilled/refluxed in an individual fumehood at one time will be 6 litres
 - b) distillations shall not be left unattended; reflux operations may be left unattended/overnight with the appropriate identification
 - c) hood sashes shall always be lowered when manipulations are not in progress and shall be used as shields when manipulations are carried out
 - d) the temperature of the heating mantle must be well below the autoignition temperature of the solvent being distilled/refluxed; a recommended limit is 80% of the autoignition temperature.
4. Authorization for the use of procedures which deviate from the above rules must be obtained from the Department Safety Officer.

DISPOSAL PROCEDURES HAZARDOUS CHEMICALS

DEFACE

- all containers that have hazardous material warnings **if** they no longer contain hazardous materials

SEGREGATE

- incompatible materials (see back of pink form)

SEPARATE

- unopened, unused chemicals from other material to be disposed

LABEL

must of transport

be attached to **external** are provided for your convenience)

- the **chemical name**, contaminants (including levels when known), concentration (molarity, dilution factor, etc.), appear **on each individual bottle**, bag, box or container chemicals or by-product. To comply with regulations, an **inventory** must packaging (pink forms

COMPLETE and ACCURATE IDENTIFICATION of all materials is the single most important factor in providing safe, environmentally sound and cost-effective hazardous waste management.

UNKNOWN can not be transported

Individual departments must bear all costs for analysis/identification when the identity of a material can not be determined (with certainty) by the originating department.

PACKAGING

1. Solid Chemicals must be packed in cardboard boxes with an acceptable absorbent material such as vermiculite surrounding the individual containers (styrofoam chips are not acceptable as they are reactive and non-absorbent).
2. Liquid Chemicals must be packaged as above, in their original shipping containers, or (if they are non-corrosive) in suitable non-breakable containers approved by E.H.& S.
3. Flammable Liquids must be placed in Solvent Disposal cans (the red ones with the wide mouth). Cans must be clean, with an intact flame arrestor and labelled according to point of pickup. Non-flammable, non-corrosive liquid material may be mixed with flammable material provided that the materials are compatible.

Appendix VII – Incoming Member Worksheet

Incoming Member Worksheet

The personal information collected on this form is collected under the legal authority of the Royal Charter of 1841, as amended. The information collected will be used to complete your registration in the department. This information will form part of your departmental record. The forms are kept for historical purposes. If you have any questions or concerns about the information collected or how it will be used, please contact adm@chem.queensu.ca.



General Information				
Last Name:		First Name:		
Position:		Supervisor:		
Staff/Student Number:		WHMIS Certification Date:		
If Visitor/Volunteer : (please check) <input type="checkbox"/> Enrolled in a medical insurance plan <input type="checkbox"/> Copy of work assignment letter		Photograph: (please check one of the following) *For security purposes the department keeps a photograph of each incoming member on file Authorize use of Picture on website: <input type="checkbox"/> Yes <input type="checkbox"/> No		
Contact Email: (Queen's email if you are a queen's student)				
Access (Supervisor Use ONLY)				
Card Access: (Check each access group your member will need) *subject to approval				
<input type="checkbox"/> Lab Wing	<input type="checkbox"/> Seminar Rooms	<input type="checkbox"/> Front Doors (after hours)	<input type="checkbox"/> Cylinder Room	<input type="checkbox"/> Mass Spec
<input type="checkbox"/> X-Ray*	<input type="checkbox"/> Undergrad Instrument Room (CHE120)*		<input type="checkbox"/> Surface Analysis*	<input type="checkbox"/> NMR*
Key Access				
List of rooms member needs keys to:				
Keys (Office Use ONLY)				
<input type="checkbox"/> \$20 Deposit Received _____ Initial		Contract End Date: _____		
Keys Issued		Card Issued		
*Deposit will NOT be returned unless you return your key(s) and card in usable condition				
Room#			Card#	
Key#			Access (M&S)	&
Chemistry Email (Office Use ONLY)				
User ID:		Password:		Email:
Photocopiers (Office Use ONLY)			Computer (Office Use Only)	
Five digit code for use on Chemistry copiers: _____			<input type="checkbox"/> IP Address Assigned	
Note: All charges for this code will be applied to your Supervisor's account			# of IP Addresses Assigned: _____	
Signatures				
By signing this document, you agree to the following rules:				
1. Report immediately if the key is lost. You may be assessed a charge for changing the locks and replacing corresponding keys.				
2. The keys/access card are the property of the Department of Chemistry. They are not to be loaned to others nor used to admit others to the building.				
3. You may not duplicate keys.				
4. You have read the Department of Chemistry Safety Handout.				
5. You have read the Queen's University Computing Code of Ethics.				
6. You understand that any privileges can be revoked as penalty for infractions in the department.				
7. You also agree that at the time of termination, e-mail accounts, computer accounts & photocopier accounts will be removed.				
Signature: _____			Date: _____	
Supervisor's Signature: _____			Date: _____	
Exit Signatures				
Supplies Returned (Stores)	Keys/Card Returned (Office)	Deposit Refunded (Member)	Photocopier Removed (Office)	Computer Removed (Office)
Forward E-mail Address:		Forward Mailing Address (Faculty/Staff):		

Appendix VIII – Off-Campus Activity Flowchart

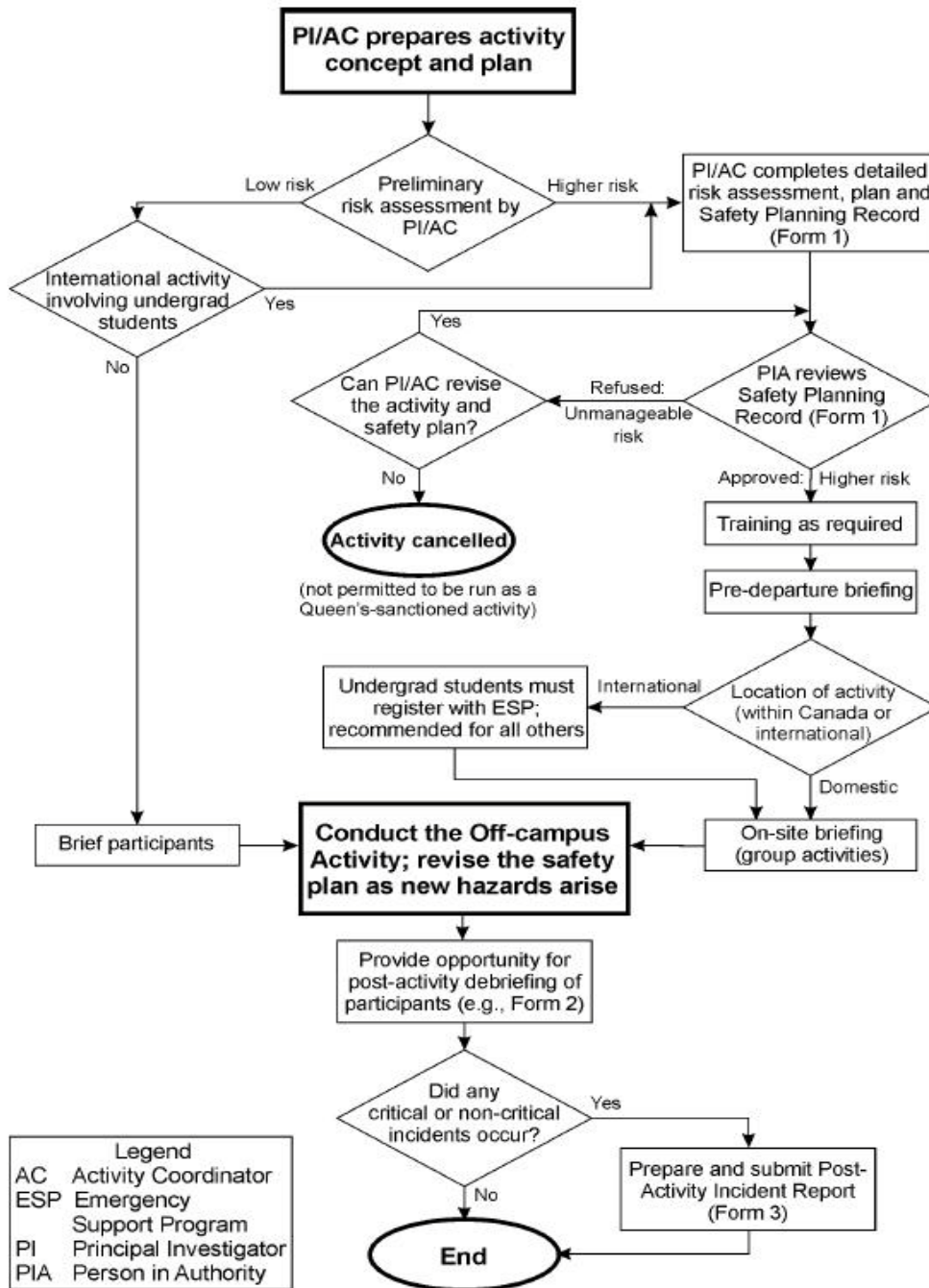


Figure 1. Flow chart showing principal planning stages and decision points defined in the Policy.