UNIVERSITY OF MAINE

Department of Chemistry

CHEMICAL HYGIENE PLAN

October, 2001

Contents

I. Laboratory Clothing and Personal Protective Equipment

A. Dressing for safety in the laboratory

Individuals should prepare for a safe laboratory experience by dressing appropriately for laboratory work. Appropriate clothing includes the following:

- Shoes should fully cover the feet to protect against spills; no open-toed shoes or sandals are permitted, and shoes with mesh inserts (such as athletic shoes) are not recommended. One may choose to keep a pair of sturdy leather shoes in the laboratory to change into upon arrival.

- Trousers or skirts falling below the knee are preferred; if shorter garments are worn, a lab coat or apron of below knee length is **required**. Preferred materials are resistant polyester, cotton or wool, since ordinary polyester and acrylics may be dissolved by common laboratory solvents.

- Neckties, if worn, should be firmly clipped to the shirt or confined inside a lab coat or apron.

- Loose, flowing garments and scarves should be avoided; they may easily pick up spills or trail through a burner flame.

- In a laboratory where open flames may be used, long hair should be confined.

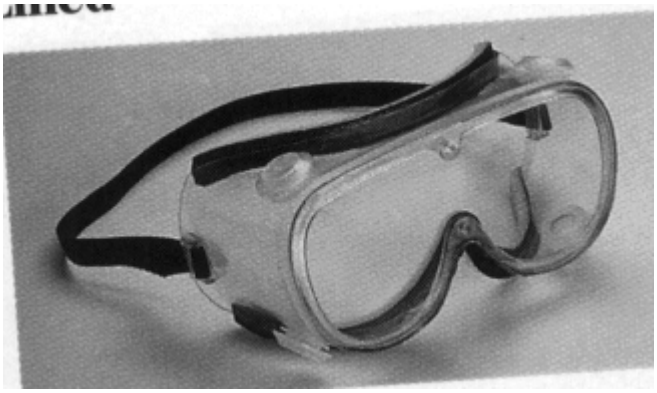
- Loose jewelry should be avoided, since it may catch on equipment. Also avoid ornate rings that can damage protective gloves or make wearing or removing gloves difficult

B. Protective Equipment

Every laboratory must have available, and workers must be trained in the use of, safety goggles, face masks, lab coats or aprons, gloves, and reaction shields.

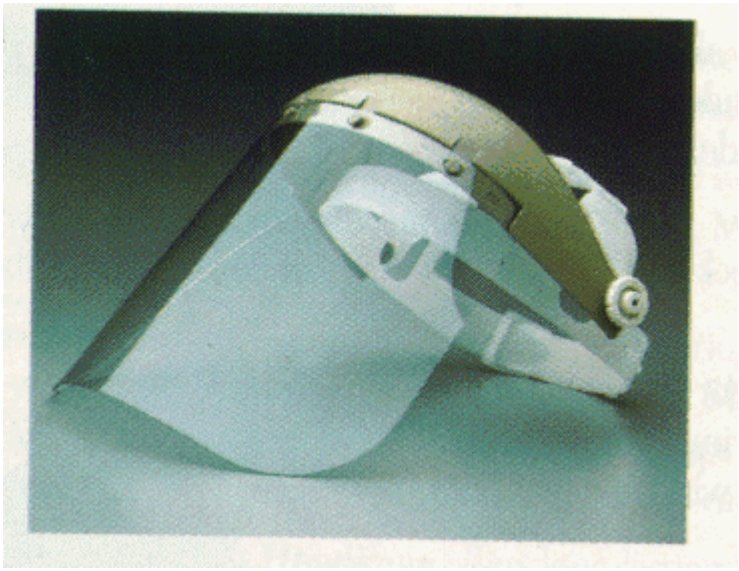
(1) Goggles that completely enclose the area of the eyes are *required*, rather than spectacles, to avoid the possibility of splashes running down the forehead into the eyes. They **must** be worn at all times when *anyone* in the laboratory is working with chemicals, as well as when an experiment is running unattended. The choice of specific type of goggle is left to the individual, except that goggles chosen must conform to ANSI standards for splash and impact resistance.

Several spare pairs should be available for visitors.



(A satisfactory type of protective goggle)

(2) For work that poses a greater than ordinary danger of splashing or violent reaction, a hard face shield that protects the entire face as well as the eyes should be worn. Each laboratory must have at least one face shield available at all times. It is the responsibility of the laboratory workers and their supervisor to determine when this protection is needed.



(A polycarbonate face shield)

(3) After the face and eyes, the hands are the most vulnerable part of the body. Their protection should be routine. Disposable gloves may be used for ordinary laboratory operations such as recrystallizations, setting up equipment, and the like. Sturdier, less permeable gloves should be selected when working with strong acids or bases or other particularly hazardous materials. Nitrile gloves, such as those stocked by Central Supply, are preferred.

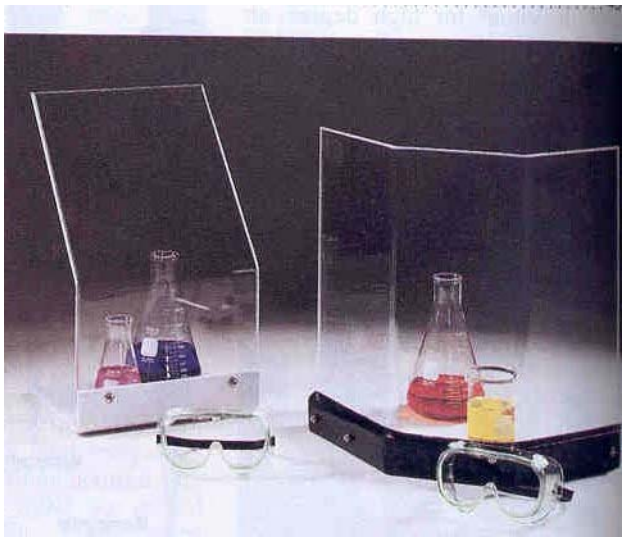
In addition to disposable gloves, each laboratory should have available at least one pair of natural rubber gloves and one pair of Viton (or similar heavy, impermeable) gloves. Our stockroom will make these types available; individuals may special order other kinds as desired. Consult your MSDS or your glove safety chart (attached at the end of this document) to select the appropriate pair for the materials with which you are working.

(a) Do *not* leave the laboratory while wearing protective gloves. Contaminants on the gloves can easily be transferred to doorknobs and other common objects. Remove and discard disposable gloves, and select a fresh pair upon returning to the lab.

In the newly renovated area, lab suites are closed off from general public areas. Unless gloves are obviously wet or otherwise contaminated, they need not be removed while moving within the suite.

(b) Note that gloves that are not disposable should be washed *before they are removed!!* These gloves also should be left in the laboratory.

(c) Insulated gloves (cryoscopic gloves) should be worn when handling liquefied gases or Dry Ice. A research group that makes extensive use of these materials should purchase a pair for the group, rather than constantly borrowing them from the stockroom.



(Two types of reaction shields)

(4) Lab coats or aprons are worn to absorb or deflect spills and prevent corrosive or toxic substances from reaching the skin. Which garment is used is largely a matter of personal preference, but one or the other should be available to every individual working in a laboratory. The stockroom provides a basic cotton blend coat; however, individuals may choose to order coats of Tyvek, a spun, bonded polyester material made by DuPont, which is the best (most impermeable) material for these garments.

Because coats and aprons are uncomfortable in hot weather, individuals often avoid their use. Although the best policy is to wear such protection at all times, its use may be limited to particularly hazardous operations such as use of strong acids, waste disposal, or accident cleanup.

Like gloves, laboratory coats or aprons should remain in the laboratory. Because they are worn for protection, they are assumed to be "contaminated", and to be capable of transferring their contamination to other objects and persons. Again, within the new lab suites, coats need not be removed.

(5) Reaction shields are curved sheets of polycarbonate resin with lead bases, of such a size that they may be set up in front of a reaction to deflect violent splashes or glass fragments. They should be used whenever a potentially explosive reaction (such as one involving peroxides) or one involving especially corrosive materials (such as fluorosulfonic acid) is being conducted.

Every laboratory should have at least one such shield of medium size.

C. Use of Hoods

Hoods, while typically classified as "engineering controls" for air quality, also are a form of personal protective equipment. Making proper decisions about when hoods should be used, and then using them safely, should be part of the planning for every experiment.

(a) In research laboratories, almost all processes, save for recrystallizations from innocuous solvents, should be conducted in hoods.

(b) Hoods must be kept uncluttered. Remove the equipment from one experiment before setting up another.

(c) No part of the body save the hands and forearms should ever be inside a hood; leaning into the hood to place one's face in closer proximity to the experiment is particularly dangerous.

(d) Keep the hood sash pulled down to the marked safe operating level at all times when not actually installing or removing equipment.

II. Storage of Chemicals in Laboratories

A. Introduction.

Two major groups of regulations issued by Federal and State agencies affect the disposal and storage of chemicals by academic laboratories. OSHA, in both Federal and State incarnations, propounds regulations intended to ensure worker safety in laboratories. The US EPA and Maine DEP regulate laboratory practices that have the potential for harm to the environment. These two sets of agencies, with two different purposes, sometimes generate regulations that seem to conflict. However, both sets of rules specify the conditions under which chemicals can be kept, the information that must be available to users of the chemicals, and what chemicals can be disposed of in what ways.

Without spelling out the rules in detail, we will try here to provide some general information about what one can and can't do, including good practice for the storage of chemicals. The information here is directed specifically to chemistry programs, and does not include janitorial, secretarial, and other areas.

B. Keeping Chemicals in the Laboratory and Stockroom.

1. The Department of Labor (OSHA), requires you to have a Material Safety Data Sheet (MSDS) for every substance you keep or use in a laboratory. The MSDS provides information on any known toxic properties of the substance, its corrosiveness or flammability, and how to deal with spills, accidental exposure, and fires involving the substance. The MSDS is the key to safe laboratory practice.

The law does not care how or where you get the MSDS, just that you either have it immediately available in the laboratory, or know how to obtain it rapidly when it is needed. If an MSDS was not provided with a chemical purchased for use in your lab, the easiest way to get one is to use the Internet. A collection of Web links to MSDS is available on the Department Web page: http://chemistry.umeche.maine.edu/Safety.html). OSHA now requires *hard copies* to be kept in each research laboratory, stored in such a way that a needed MSDS can be found quickly. The Department Safety Committee therefore suggests a loose-leaf notebook, with the MSDS in **alphabetical order!**

The law also provides that any employee who works with these chemicals be trained specifically in the safe handling of each chemical. The training

can be very basic, such as a discussion of general safe laboratory practice, and the specific safety procedures indicated in the MSDS. Training must be provided for new employees as part of their entrance procedure, and must be repeated annually. A description of the plan for providing this training must be put in writing. This handbook, and others the Committee will provide on other subjects, will become part of notebooks kept in each laboratory to record the training, and to serve as a memory aid.

C. Storage Facilities and Practices.

Modern safe practice and OSHA regulations require the storage of like classes of compounds together, away from other compounds with which they might react if their containers leaked or were broken. Color coding of containers for various storage classes is now common practice among chemical manufacturers. The scheme is described below, and on the posters in each of our laboratories. Consider the following classes:

(1) *Solvents and other flammables*. There are two major aspects of safe practice in the storage of solvents: (a) limit the quantity to be stored, and (b) use proper storage equipment.

We all have the habit of buying large quantities of goods and storing the excess until it is needed. With chemicals, this practice is deceptively cost-saving. The cost of storage and potential disposal must be factored in. Therefore, **BUY THE SMALLEST QUANTITY OF SOLVENT THAT WILL SERVE THE PURPOSE!** This is a good rule for any chemical purchase, not just flammables.

The proper equipment for storing solvents includes metal safety cans for quantities larger than one quart, or double-walled metal cabinets approved by the National Fire Prevention Association, in which the bottles should be kept when not in use. (Such cabinets are available from all major laboratory supply and laboratory furniture houses.) Local fire code requires that vents in the cabinets should be connected into a fume hood that runs continuously, or into a ventilation system designed specifically for the purpose, or should be kept plugged.

Common solvents that require this treatment include: methyl, ethyl, and isopropyl alcohols; acetone and methyl ethyl ketone; methyl, ethyl, and butyl acetates; all ethers; pentane, hexane, heptane, octane, and "light petroleum" or "petroleum ether"; benzene, toluene, and xylene; and carbon disulfide. The last substance has a flash point of 30 degrees below zero Celsius, and <u>its use in teaching laboratories is strongly discouraged</u>. Likewise the use of the chlorinated solvents carbon tetrachloride, chloroform, and methylene chloride (dichloromethane) is discouraged because of their toxicity.

(2) *Peroxidizable substances*. Particular attention must be given to substances that form explosive peroxides on prolonged contact with air. All chemicals should be dated when they arrive at the laboratory or stockroom (a Chart outlining a standard arrival procedure for new chemicals is available for posting in laboratories); this is especially critical for peroxidizables.

(a) The following are especially hazardous and should be disposed of after three months:

isopropyl ether
divinyl acetylene
vinylidene chloride
potassium metal
sodium amide

These materials should be distinguished by placing a red band or dot on the label.

(b) The following should be discarded after one year:

diethyl ether
dioxane
methyl acetylene
methyl isobutyl ketone
ethylene glycol dimethyl ether (glyme)
tetralin
cyclohexene, cyclopentene
methylcycloalkanes
tetrahydrofuran
diacetylene
cumene

These materials also are distinguished by a red band or dot on the label.

Since most peroxidizable materials are solvents and are flammable, they must be kept in a flammables cabinet; a separate one for peroxidizables as opposed to merely flammables is a good idea, but separation by shelf is acceptable..

(3) *Oxidizing Agents* should be stored away from substances that they may oxidize vigorously. Oxidants include: perchloric acid and perchlorate salts; chlorate salts, hypochlorites such as bleaching powders and "liquid bleach"; liquid bromine; perbromate and bromate salts; chromic acid and its salts; hydrogen peroxide; and potassium permanganate. Concentrated nitric and sulfuric acids also are oxidants; they must be stored together, and away from all other substances. A fire has occurred in Aubert Hall when bottles of nitric and formic acids, carelessly stored together, leaked.

Oxidizing agents are color coded yellow.

NOTE: perchloric acid may be used *only* in a specially designed hood, intended to prevent its coming in contact with oxidizable organics or metals with which it forms explosive salts. We have no such hoods in Aubert Hall. Hence, perchloric acid may not be used without explicit permission from the Department Chair.

Reducing agents are substances that are especially easily oxidized. Particular care should be taken to keep them separate from oxidizing agents, both in storage and when placed out in the laboratory for student use. The accidental combining of oxidizing and reducing agents by confused students represents a significant fire and explosion hazard. Such materials include: elemental sulfur in any allotropic form; powdered carbon (carbon black, activated carbon, powdered charcoal, graphite powder); sodium and potassium metals; most aldehydes; and all hydrocarbons and most solvents. Paper, sawdust, and wood shavings also are reducing agents.

(4) *Acids and Bases* are of concern for two reasons: they are generally corrosive, and their reactions with each other are usually highly exothermic. Hence acids and bases should be stored apart from each other.

(Improper storage)

Acids commonly encountered in the general chemistry laboratory include: hydrochloric, nitric, sulfuric, and acetic acids. Hydrofluoric acid is so

corrosive, and produces such vicious burns, that its use is not recommended in any teaching laboratory. Storage problems are minimized if acids are purchased in the smallest practicable containers, rather than in the common 1-gal jugs.

The most common bases are ammonium hydroxide (aqueous ammonia), sodium and potassium hydroxides (typically in pellet form), calcium hydroxide (slaked lime), and sodium carbonate (washing soda). A familiar sight in many stockrooms where acids and bases are not segregated is the white crust of ammonium salts formed by fumes from ammonium hydroxide combining with acid fumes. This crust is mildly acidic, and over time can degrade labels and both wood and metal storage shelves.

Acids and bases, and other corrosive materials, should be distinguished by a white dot or band on the label.

(5) *Health Hazards* are substances that pose a health hazard through either acute (immediate) or chronic (long-term) toxicity. Examples of substances that are acutely toxic are sodium cyanide and ammonium molybdate; chronic toxicity is displayed by many organics such as aniline derivatives, chlorinated hydrocarbons, and thiocyanates.

These substances should be stored together, away from materials of other classes. Labels should be marked with a blue dot or band.

(6) *Nonhazardous materials* are those **known** to pose no health risks. Examples are simple salts such as calcium chloride, buffer solutions, indicators, copper metal, and so on. The materials can be kept in a general chemical storage area. Their labels should bear green or gray dots or bands.

What all of this boils down to is that a laboratory needs **five** chemical storage areas:

1. Sulfuric and nitric acids; perchloric acid would be kept with these, but since we have no perchloric acid hoods in Aubert, no one should be using perchloric acid. Chromic acid solutions belong here also.
2. Other corrosive acids: HCl, HBr, acetic acid, formic acid.
3. Corrosive bases: NH_4OH, NaOH, KOH.
4. Flammables, in an approved cabinet.
5. General storage, permitting separation at least onto separate shelves, of the various hazard categories.

Within these areas, liquid containers of more than 250 mL require secondary storage; that is, they must be placed in a chemical-resistant (polypropylene or polyethylene) tub or tray. Note that approved flammables cabinets have secondary containment built in.

E. Compressed Gases.

Storage of compressed gases in the laboratory requires precautions unique to the unusual containers in which these materials are kept, and the high pressures to which they are subject.

(1) Full size cylinders

- must be fastened to a laboratory bench or other stable, immovable object using a heavy canvas strap or a chain; the fastening should be placed about one-third of the way down from the top of the cylinder.

- must have either the appropriate type of pressure regulator or the protective cap screwed in place at all times.

- Must be located away from sources of significant heat, such as radiators.

(2) Lecture bottles

- must be placed in a rack designed for the purpose (resembling an oversize test-tube rack) or be firmly clamped to a ring stand with a heavy base, in an upright position.

- may not be used or stored lying on their sides.

These precautions are designed to avoid the cylinder cap being broken off through a fall or a sudden increase in pressure. In such events explosions may result, and the gas cylinder may become a dangerous projectile.

(Improper storage)

F. Summary of Storage Recommendations**.**

Segregation of chemicals by class within appropriate cabinets is the key idea. One ***may not*** merely arrange substances on a shelf alphabetically without regard to their chemical characteristics. Solvents must have their own special fire-resistant cabinets; oxidants are stored away from reductants; acids are stored away from bases; and peroxidizables are monitored and discarded at regular intervals. A good idea is color coding the edges of the shelves to match the category of substance stored there. Within, each category, materials can be arranged alphabetically.

It is **strongly recommended** that chemical storage within research and teaching laboratories be minimized. Again, buy the minimum practical quantity, use it promptly after purchase, and dispose of any excess.

Rooms chosen for chemical storage should be well-ventilated and preferably equipped with an exhaust fan that will accomplish six air changes per hour.

Significant quantities of chemicals should not be stored in a room that is regularly occupied by students or faculty who are not conducting experiments. *Furthermore, consumption or storage of food or beverages*

*of ANY kind is **strictly forbidden** in rooms where chemicals are stored or used!*

The best shelving is steel with acid-resistant paint; next best is wood with acid-resistant paint. Shelving should be labeled clearly to indicate what kinds of chemicals may be stored there. As noted above, an easy way to do this is to color-code the edges of shelves with paint or tape to match the color-coding of labels; materials then can be returned to proper storage at a glance.

Storage areas should be equipped with fire extinguishers, eyewash fountains, and materials for cleaning up spills. Kitty litter is excellent for this latter purpose, being both adsorbent and inert. It can be spread over the spill, and then swept up with implements kept specifically for that purpose. Contaminated litter then is placed into a plastic bucket, and arrangements made for its pickup by EH&S, as described below.

Fume hoods normally **should not** be used for storage of chemicals. When such storage cannot be avoided, because properly ventilated cabinets are not available, or because the compounds are particularly odiferous (*e.g.,* thiols), the bottles must be placed in a plastic tub or tray to contain any leakage or spill. Hoods being used for storage may **not** be used for experimentation, and should be labeled clearly as storage hoods.

G. Labels.

Labels on commercially available chemicals now must conform with both federal and state law. These laws mandate the appearance of the name of the substance and any common synonyms, as well as information on the toxicity and other hazards associated with the substance. Labels of most substances carry the colorations noted above.

(1) *Additional Information*. For your own benefit, and that of anyone else who may use the chemical storage area in future, you should add to all labels the date on which the material was acquired and the storage location.

Adding the date will allow easy culling of overage substances. Furthermore, as manufacturing and purification processes generally improve with time, the date of purchase is an indication of quality.

Storage location should indicate storage room, the cabinet or set of shelves, and the individual shelf. Thus, a label might bear the notation: 223-C-5, meaning room 223, cabinet C, shelf 5.

(2) *Label Materials.* The best way to add additional information is with a small label of your own, stuck over a corner of the manufacturers' label, or just above it.

If the original label has disintegrated or otherwise been lost, you should make a new one, containing as much of the necessary information as possible. Use good quality paper or polyethylene labels and India ink.

Labels, both your own and the manufacturers', should be protected against spills and fading. Lab supply houses sell label lacquers that are chemical-resistant; an easy-to-use option is a clear polyester tape that is water-resistant and also will stand up to casual exposure to acids, bases, and organic solvents. It is available from Aldrich Chemical Company in 36-yd rolls ranging in price from $7 to $15, depending on width. The Department provides adhesive dots for color coding chemicals acquired prior to the introduction of such coding by manufacturers.

(3) **All** chemicals, whether commercial materials or samples prepared in the laboratory, **must** be labeled. Absence of identification is a violation of the law.

H. Containers**.**

Except for flammable solvents, which should be transferred to safety cans if proper cabinets are unavailable, the containers, usually of glass, in which chemicals are received from the supply house are appropriate for storage for reasonable periods of time. Materials received in sealed glass ampoules should be used completely or the excess should be disposed of. Only a professional should attempt to reseal an ampoule.

In the past, however, chemicals often were received in inappropriate containers or were transferred locally into inappropriate containers. The best method of dealing with these materials is to dispose of them, especially if the cap is corroded. If you must keep the material, transfer it carefully to a new container purchased for the purpose from a lab supply house. Label it clearly, including the information that it has been repackaged and both the date of acquisition (if known) and the date of repackaging. Supply houses also sell Teflon cap liners, which can be used to protect older containers not yet deteriorated.

The law requires that damaged containers be disposed of immediately. “Damaged” includes: cracked or broken caps; chipped threads on bottle necks; and corrosion of metal containers, even if an interior glass container is intact.

I. Maintenance.

At monthly intervals, inspect the storage area. Make sure that all chemicals are in their proper locations. Remove for disposal any substances

with leaking containers, and repackage or dispose of any with caps that show signs of corrosion. Unless you are certain that you will use them in the near future, remove for disposal bottles with only small amounts of material remaining in them, and anything more than two years old.

If you store volatiles that represent long-term health hazards, such as benzene and chlorinated solvents, regular air-sampling is a good idea. Lab supply houses sell sampling kits, the core of which is a cartridge that is exposed for a period of time and then mailed in for analysis. The price of the kit includes the analysis. If you find that you are unable to store such materials without exceeding safe limits, then perhaps you should rethink your need for them.

J. Additional Information.

More detailed information about the storage of chemicals may be found in the book, Safe Storage of Laboratory Chemicals, by D. A. Pipitone, John Wiley and Sons, New York, 1984, available from the publisher for $68 plus postage. Improving Safety in the Chemical Laboratory, by J. A. Young, also from Wiley ($45) is likewise helpful.

III. Disposing of Chemicals

The disposal of chemicals is now heavily regulated. However useless we may consider some of these regulations, it is our responsibility as citizens and especially as chemists, to dispose of the materials with which we work safely and in accordance with the law. Laws regarding the disposal of chemicals are enforced by federal and state Environmental Protection Agencies (EPA).

An important point to remember here is that *nothing is waste until you say it is.* As long as you have an MSDS, and follow safe practice in storage, you may keep chemicals forever if you wish. No law requires you to throw out anything. But once you decide to get rid of something, the law regulates how you may do so.

A. Legal Disposal into Sewer Systems**.**

The large majority of chemical substances must be disposed of by transmitting them to a company licensed to operate a disposal facility (see below). Others may be treated by a trained individual to reduce the quantity of material that may be disposed of. A few substances can be treated and flushed down the drain by any reasonably careful person.

(1) *Acids and Bases*. Mineral acids and bases may be neutralized and the resulting salt solutions flushed down the drain. Follow the following steps:

(a) Prepare a dilute aqueous solution of the acid or base to be destroyed in a beaker or wide-mouth flask. **Always add acid or base to an excess of water**. Never add the water to the acid or base, because the heat generated may be enough to boil the water, and expel the substance violently from the container. Set the container in a plastic tub containing ice-water while preparing the solution.

(b) Similarly, prepare a dilute solution of sodium hydroxide if you wish to neutralize an acid, or hydrochloric acid if you are neutralizing a base. Cool this solution in ice-water also.

(c) Using pH paper or a pH meter, and keeping the receiving flask in the ice-bath, neutralize to pH 6.6-7.4. Stir well while mixing the solutions.

(d) Turn on the cold water in the sink to a vigorous stream, and wash the neutralized solution down the drain.

(2) *Other Inorganic Compounds* also may be dissolved in water and flushed down the drain with much cold water, ***provided they do not contain any heavy metals or toxic anions!*** Thus, lithium, sodium, potassium, magnesium, and calcium salts may be disposed of in this way, but copper, tin, lead, silver, iron, cobalt, nickel, chromium, zinc, manganese, and mercury salts may not be. Chlorides, bromides, carbonates and bicarbonates, sulfates, and nitrates may go down the drain, but fluorides, sulfides, bisulfides, and cyanides may not. Many states and towns have ordinances against phosphates in detergents; hence, phosphate salts generally should not go down the drain.

B. Illegal Disposal into Sewer Systems

With the exception of the inorganic compounds noted under (A), most states and the federal government prohibit the disposal, except by a licensed contractor, of:

- All heavy metals and their salts;
- All sulfides, bisulfides, and cyanides;
- All other toxic or corrosive inorganics;
- All organic compounds except ethanol;
- All gases not normally constituents of the earth's atmosphere.

Federal law prohibits the interstate shipment of such chemicals for disposal or the disposal of chemicals that have been previously shipped in interstate commerce, except under license, and many municipalities have enacted even more stringent regulations. The language of the laws varies considerably from the plain English used above; often, if applied literally, the laws would prohibit the disposal, not only of laboratory chemicals, but of almost all everyday substances. Often, no one in community government can tell you whether disposal of a particular substance is legal under local laws.

C. Satellite Hazardous Waste Accumulation Sites

Other than the limited number of substances described above, all laboratory wastes, unused chemicals, and research samples must be disposed of by having them collected by the University Environmental Health and Safety staff.

The EPA now defines the places within our laboratories where we store temporarily the wastes generated in our teaching and research as "Satellite Hazardous Waste Accumulation Areas". These areas, usually consisting of a few glass containers in the back of a hood, must be managed in accordance with the following rules.

(1) You must keep separate containers for incompatible kinds of waste. *Incompatible* here means exactly what it did when we discussed storage. Thus, for example, acidic and basic wastes should not be added to the same container.

(2) A record must be kept of the nature and approximate quantity of each addition to a waste container. The record must be attached to the container, or kept immediately adjacent.

(3) The container must be labeled as "Hazardous Waste" (even if it isn't hazardous); bright yellow labels are available in the stockroom. Sub-labeling, such as "Chlorinated Solvents" is useful in keeping wastes properly segregated.

(4) Containers must be kept closed, unless there is potential danger of gas formation.

(5) Each site **must** be inspected each working day by a responsible individual, usually a graduate student designated by his or her advisor as in charge of a particular laboratory. A form confirming the inspection **must** be signed, and kept adjacent to the storage area. Weekends and legal holidays are excluded from this requirement.

(6) A hood that is used for waste storage may not be used for experimentation! EPA and OSHA differ, in fact, on just where waste containers may be stored; OSHA prefers otherwise unused hoods, but EPA prefers any storage location where a spill will not reach a floor or sink drain. Consult with your advisor to establish the best location for your laboratory.

The University EH&S makes regular pickups in Aubert. Simply make a notation on the form in the mailroom that you have waste to be picked up. The easiest way of all to deal with waste regulation is to get it out of the laboratory as quickly as possible.

D. Unknowns.

(1) Unidentified substances present a major problem for both storage and disposal. A substance may not be kept in the stockroom or laboratory without an MSDS being available (unless it is a substance for which no MSDS exists - a research sample).

(2) Unknowns can be removed by the EH&S staff, but their disposal by the firm with which the University contracts is much more expensive than disposing of known hazardous materials. Hence, the best policy is:

(a) Do a thorough cleanup of your laboratory, and dispose of all unknowns at one time.

(b) Subsequently follow the storage and labeling practices described above to ensure that no unknowns are generated in future.

E. Summary of Disposal Recommendations

To maintain a safe stockroom and laboratory, one must:

(1) Regularly inspect the chemical and waste storage areas, removing outdated and leaking chemicals.

(2) Collect safely and dispose of promptly all mixed experimental wastes.

(3) Have wastes collected frequently. No quantity of waste is small enough to be kept past a scheduled pickup date.

IV. Obtaining and Reading MSDS

A. As noted above, the easiest way to obtain MSDS is to use the online resources linked to the Department's Safety Web page,

http://chemistry.umeche.maine.edu/Safety.html. However, OSHA now requires us to have MSDS actually in our laboratories, so MSDS located from these sources should be printed out and stored in the laboratory.

We strongly recommend that you establish a notebook for the MSDS rather than simply tossing them in a desk drawer or file folder. Clear plastic page protectors will increase the life span of the sheets.

B. The following is the MSDS for dichloromethane, obtained from the Aldrich Chemical Web site. We will look at it section by section. Some parts of the sheet have been excised to save space.

SECTION 1. - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - -
CATALOG #: 34908
NAME: DICHLOROMETHANE (SPECTRANAL) 99.8% MIN. STABILIZED WITH AMYLENE (CA. 25MG/L)

The first section gives the Aldrich catalog number, and the name and grade (spectroscopy quality), and notes that it has been stabilized against photodissociation by the addition of a trace of amylene.

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -
CAS #: 75-09-2
EC NO: 200-838-9
SYNONYMS
AEROTHENE MM * CHLORURE DE METHYLENE (FRENCH) * DICHLOROMETHANE (DOT: OSHA) * METHANE DICHLORIDE * METHYLENE BICHLORIDE * METHYLENE CHLORIDE (ACGIH:OSHA) * METHYLENE DICHLORIDE * METYLENU CHLOREK (POLISH) * NARKOTIL * NCI-C50102 * R 30 * R30 (REFRIGERANT) * RCRA WASTE NUMBER U080 * SOLAESTHIN * SOLMETHINE *

Section 2 give the Chemical Abstracts Registry number (CAS #). The EC number is the European Community registry number. Following are a variety of synonyms and trade names under which the substance is sold

SECTION 3. - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -
LABEL PRECAUTIONARY STATEMENTS
TOXIC
MAY CAUSE CANCER.
POSSIBLE RISK OF HARM TO THE UNBORN CHILD.
HARMFUL IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
READILY ABSORBED THROUGH SKIN.
TARGET ORGAN: HEART BECAUSE METHYLENE CHLORIDE IS CONVERTED TO CARBON MONOXIDE IN THE BODY.
TARGET ORGAN: CENTRAL NERVOUS SYSTEM BECAUSE OF POSSIBLE DIZZINESS, HEADACHE, LOSS OF CONSCIOUSNESS AND DEATH AT HIGH CONCENTRATIONS.
AVOID EXPOSURE - OBTAIN SPECIAL INSTRUCTIONS BEFORE USE.

IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION. DO NOT BREATHE VAPOR.

This section presents potential hazards of exposure to the substance, and indicates appropriate personal protective equipment. Like almost all halogenated organics, dichloromethane is a suspect carcinogen upon extended exposure, has narcotic effects if inhaled, and is irritating to mucous membrane.

SECTION 4. - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

The fourth section presents appropriate first-aid measures for overexposure.

SECTION 5. - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -
EXTINGUISHING MEDIA
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
WATER SPRAY.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS: EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

Section 5 describes precautions for fires involving dichloromethane, including appropriate types of fire extinguishers.

SECTION 6. - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -
EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

An accidental release is a spill of a quantity large enough to expose others to hazard. Except for the SCBA, the procedure recommended is our standard procedure for spills of non-corrosive materials.

SECTION 7. - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -
REFER TO SECTION 8.
ADDITIONAL INFORMATION. FOR PROTECTION AND HANDLING REQUIREMENTS CONSULT CFR TITLE 29 PART 1910.1052.

CFR is the Code of Federal Regulations; Title 29 is the section dealing with the regulations of the Occupational Safety and Health Administration.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -
POSITIVE PRESSURE RESPIRATOR SHOULD BE WORN.
MECHANICAL EXHAUST REQUIRED.
COMPATIBLE CHEMICAL-RESISTANT GLOVES.
IMPERVIOUS PROTECTIVE CLOTHING.
STORE AND USE WITH ADEQUATE VENTILATION.
DO NOT BREATHE VAPOR.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
KEEP TIGHTLY CLOSED.
STORE IN A COOL DRY PLACE.

This section repeats some of the warnings from Section 3. Generally, Section 8 will indicate any special equipment required for handling or storing the material.

SECTION 9. - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -
APPEARANCE AND ODOR: LIQUID.

SECTION 10. - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -
STABILITY: STABLE.
INCOMPATIBILITIES
ALKALI METALS
ALUMINUM
HEAT
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE
HYDROGEN CHLORIDE GAS
PHOSGENE GAS
HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

Section 10 indicates any circumstances under which unusual chemistry is to be expected, which might result in a fire, or strongly exothermic reaction. The listed incompatibilities mean that dichloromethane should not be stored on the same shelf as sodium under xylene, for example, or handled with aluminum spatulas or stirring blades.

This section also explains the statement in Section 5 that it emits toxic fumes during combustion.

SECTION 11. - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS

HARMFUL IF SWALLOWED.
MAY BE HARMFUL IF INHALED.
MAY BE HARMFUL IF ABSORBED THROUGH THE SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
HEAVY OR PROLONGED SKIN EXPOSURE MAY RESULT IN THE ABSORPTION OF HARMFUL AMOUNTS OF MATERIAL.
DICHLOROMETHANE IS METABOLIZED IN THE BODY PRODUCING CARBON MONOXIDE WHICH INCREASES AND SUSTAINS CARBOXYHEMOGLOBIN LEVELS IN THE BLOOD, REDUCING THE OXYGEN-CARRYING CAPACITY OF THE BLOOD.
PROLONGED OR REPEATED EXPOSURE TO SKIN CAUSES DEFATTING AND DERMATITIS.
A SIMPLE ASPHYXIANT. EXPOSURE CAN CAUSE ANESTHETIC ACTION, DIFFICULTY IN BREATHING, HEADACHE, AND DIZZINESS.
EXPOSURE CAN CAUSE:
CNS DEPRESSION
PARESTHESIA
SOMNOLENCE
CONVULSIONS
CONJUNCTIVITIS
PULMONARY EDEMA. EFFECTS MAY BE DELAYED.
IRREGULAR BREATHING
INGESTION CAN CAUSE GASTROINTESTINAL DISORDERS, NAUSEA AND VOMITING.
DROWSINESS
INCREASED LIVER ENZYMES
WEAKNESS

CHRONIC EFFECTS

THIS IS OR CONTAINS A COMPONENT THAT HAS BEEN REPORTED TO BE CARCINOGENIC BASED ON ITS IARC, OSHA, ACGIH, NTP OR EPA CLASSIFICATION.

Acronyms here: IARC = International Agency for Research on Cancer; OSHA = Occupational Safety and Health Administration; ACGIH = American Conference of Governmental Industrial Hygienists; NTP = National Toxicology Program; EPA = Environmental Protection Agency

EXISTING DATA SUGGESTS THAT METHYLENE CHLORIDE MAY BE A WEAK MUTAGEN IN MAMMALIAN SYSTEMS.
POSSIBLE RISK OF CONGENITAL MALFORMATION IN THE FETUS.
TARGET ORGAN: HEART BECAUSE METHYLENE CHLORIDE IS CONVERTED TO CARBON MONOXIDE IN THE BODY.
TARGET ORGAN: CENTRAL NERVOUS SYSTEM BECAUSE OF POSSIBLE DIZZINESS, HEADACHE, LOSS OF CONSCIOUSNESS AND DEATH AT HIGH CONCENTRATIONS.
TARGET ORGAN(S):
LIVER
PANCREAS
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.

RTECS #: PA8050000

METHANE, DICHLORO-

IRRITATION DATA

SKN-RBT 810 MG/24H SEV	**EJTXAZ 9,171,1976**
SKN-RBT 100 MG/24H MOD	**85JCAE -,88,1986**
EYE-RBT 162 MG MOD	**EJTXAZ 9,171,1976**
EYE-RBT 10 MG MLD	**TXCYAC 6,173,1976**
EYE-RBT 500 MG/24H MLD	**85JCAE -,88,1986**

Irritation data are for rabbit eye and skin; skn-rbt 810 mg/24h sev means that severe irritation was produced on rabbit skin by exposure to 810 mg for 24 hours. The abbreviations at right are to the journal articles.

TOXICITY DATA

ORL-HMN LDLO:357 MG/KG	**34ZIAG -,390,1969**
ORL-RAT LD50:1600 MG/KG	**FAONAU 48A,94,1970**
IHL-RAT LC50:52 GM/M3	**TPKVAL 15,64,1979**
IPR-RAT LD50:916 MG/KG	**ENVRAL 40,411,1986**
UNR-RAT LD50:5350 MG/KG	**GISAAA 53(6),78,1988**
IHL-MUS LC50:14400 PPM/7H	**NIHBAZ 191,1,1949**
IPR-MUS LD50:437 MG/KG	**AGGHAR 18,109,1960**
SCU-MUS LD50:6460 MG/KG	**TXAPA9 4,354,1962**
UNR-MUS LD50:4770 MG/KG	**ESKGA2 28,P31,1982**
UNR-RBT LD50:1225 MG/KG	**GISAAA 53(6),78,1988**

ORL = oral; HMN = human; RAT = rat; MUS = mouse; IPR = intraperitoneal; SCU = subcutaneous; IHL = inhalation; LD50 = dosage killing 50% of experimental animals; LC50 = concentration in air killing 50% of animals.

TARGET ORGAN DATA

PERIPHERAL NERVE AND SENSATION (PARESTHESIA)
BEHAVIORAL (ALTERED SLEEP TIME)
BEHAVIORAL (EUPHORIA)
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (ATAXIA)
CARDIAC (CHANGE IN RATE)
LUNGS, THORAX OR RESPIRATION (CHANGE IN TRACHEA OR BRONCHI)
LUNGS, THORAX OR RESPIRATION (ACUTE PULMONARY EDEMA)
LUNGS, THORAX OR RESPIRATION (TUMORS)
LIVER (LIVER FUNCTION TESTS IMPAIRED)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (UROGENITAL SYSTEM)
TUMORIGENIC (CARCINOGENIC BY RTECS CRITERIA)
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - -

DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND

SCRUBBER. OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

Legal disposal methods.

SECTION 14. - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - -
CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -
EUROPEAN INFORMATION
EC INDEX NO: 602-004-00-3
TOXIC
R 40
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
S 23
DO NOT BREATHE VAPOR.
S 24/25
AVOID CONTACT WITH SKIN AND EYES.
S 36/37
WEAR SUITABLE PROTECTIVE CLOTHING AND GLOVES.
TLV AND SOURCE
FOR DICHLOROMETHANE(METHYLENE CHLORIDE):
ACGIH TLV-TWA: 50 PPM (175 MG/M3).
OSHA PEL: 8H TWA 25 PPM; STEL 125 PPM

TLV = threshold limit value; TWA = time weighted average; PEL = permissible exposure limit

REVIEWS, STANDARDS, AND REGULATIONS
OEL=MAK
ACGIH TLV-ANIMAL CARCINOGEN DTLVS* TLV/BEI,1997
ACGIH TLV-TWA 174 MG/M3 (50 PPM) DTLVS* TLV/BEI,1997
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE IMEMDT 41,43,1986
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMEMDT 41,43,1986
IARC CANCER REVIEW:GROUP 2B IMSUDL 7,194,1987
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION
FEREAC 54,7740,1989
MSHA STANDARD-AIR:TWA 500 PPM (1750 MG/M3)
DTLVS* 3,171,1971

……. Lines deleted …….

NIOSH REL TO METHYLENE CHLORIDE-AIR:CA LOWEST FEASIBLE CONCENTRATION
NIOSH* DHHS #92-100,1992
NOHS 1974: HZD 47270; NIS 374; TNF 89025; NOS 192; TNE 975696
NOES 1983: HZD 47270; NIS 363; TNF 87086; NOS 212; TNE 1438196; TFE 352536
ATSDR TOXICOLOGY PROFILE (NTIS PB/89/194468/AS)**
EPA GENETOX PROGRAM 1988, POSITIVE: CELL TRANSFORM.-RLV F344 RAT EMBRYO
EPA GENETOX PROGRAM 1988, POSITIVE: HISTIDINE REVERSION-AMES TEST

EPA GENETOX PROGRAM 1988, POSITIVE: S CEREVISIAE GENE CONVERSION; S CEREVISIAE-HOMOZYGOSIS
EPA GENETOX PROGRAM 1988, POSITIVE: S CEREVISIAE-REVERSION
EPA GENETOX PROGRAM 1988, NEGATIVE: D MELANOGASTER SEX-LINKED LETHAL
EPA TSCA SECTION 8(B) CHEMICAL INVENTORY
EPA TSCA 8(A) PRELIMINARY ASSESSMENT INFORMATION, FINAL RULE FEREAC 47,26992,82
EPA TSCA SECTION 8(D) UNPUBLISHED HEALTH/SAFETY STUDIES
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, DECEMBER 1998
NIOSH CURRENT INTELLIGENCE BULLETIN 46, 1986
NIOSH ANALYTICAL METHOD, 1994: METHYLENE CHLORIDE, 1005
NIOSH ANALYTICAL METHOD, 1996: VOLATILE ORGANIC COMPOUND, 2549
NTP CARCINOGENESIS STUDIES (INHALATION);CLEAR EVIDENCE:MOUSE,RAT NTPTR* NTP-TR-306,86
NTP 8TH ANNUAL REPORT ON CARCINOGENS, 1998:REASONABLY ANTICIPATED TO BE HUMAN CARCINOGEN
OSHA ANALYTICAL METHOD #ID-59
U.S. INFORMATION
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.
CALIFORNIA PROPOSITION 65:
THIS PRODUCT IS OR CONTAINS CHEMICAL(S) KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER.
OSHA REGULATED - SEE CFR TITLE 29 PART 1910.1052.

The deleted section dealt with a number of foreign registrations. The final segment indicates the sources of some of the information on the toxicity, and labeling and reporting requirements for transportation in interstate commerce.

SECTION 16. - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -
THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

The usual "hold harmless" legal disclaimer for the MSDS.

V. Emergency Action Plan for:

Department of Chemistry - Aubert Hall

A. General

The major hazards in Aubert Hall are:

Hazard	Location
Fire	Entire Building
Chemical Spill	Entire Building

The emergency evacuation alarm consists of horns and strobe lights, and is sounded from pull stations nears the exits or automatically by heat sensors in the ceilings of each room.

In the event that:

1. You discover a fire or chemical spill emergency (defined below); or

2. You smell smoke or the odor of burning or hot material from undetermined sources; or

3. The alarm sounds.

Take such of the following steps as are appropriate to your situation:

1. Orally warn others in your vicinity of the hazard.
2. Activate the alarm system.
3. If you can do so safely: turn off equipment, close any open windows and close and lock the door behind you. Do not delay evacuation more than momentarily to take these steps.
4. Leave the building directly by the nearest stairway (see below), warning anyone you pass on the way out. Do not attempt to use the elevator.
5. If you discovered the emergency, call 911 from a safe location and inform the dispatcher of the situation (see below). Be prepared to brief Department safety personnel and the Fire Department regarding the emergency.
6. Proceed to the designated rally point (see below).
7. Remain outside the building until emergency personnel signal that you may re-enter; do not leave the rally point without informing the Department Emergency Coordinator.

B. Explanations

1. *Exit Pathways*. Recommended exit pathways for emergencies are posted in each laboratory and at several points in each hallway. In general, use the nearest pathway that leads directly outside the building.

2. *Rally Point*. A "rally point" is designated so that the Emergency Coordinator may determine if everyone has safely evacuated the building.

The rally point for Chemistry personnel is the lawn across Munson Road next to Wingate Hall in good weather.

3. *Emergency or Evacuation Coordinator*. The Evacuation Coordinator is Ray Fort, Chair of the Chemistry Safety Committee and Building Manager. In his absence responsibility passes to the Department Chairperson, Barbara Cole, the most senior faculty member present, or Cindy Commeau, Department Safety Officer, in that order.

At the rally point, the Coordinator will attempt to account for personnel who are known to have been in the building; if individuals cannot be accounted for, the Coordinator shall inform the emergency personnel.

4. *Fire Emergencies*. The basic policy in case of a fire is that the individual discovering the fire shall proceed as described above to report the emergency and evacuate the building. You should NOT choose to fight the fire unless:

- You have had hands-on training in the use of a fire extinguisher within the past year;
- You are able to maintain an open path of escape at all times;
- You are confident that the fire can be rapidly and completely extinguished without endangering others.

Clearly this response requires quick and accurate judgement on the part of the individual discovering the emergency. Anyone who is at all uncomfortable about making such judgements should simply follow the basic policy.

5. *Personal Injury Emergencies*. Three situations are possible:

- You are injured;
- You discover or respond to a call from an injured person;
- You discover what appears to be blood or other body fluids, but no accident victim is present.

In situation (a), if the injury is serious enough that you cannot deal with it yourself, call 911 if you are able, or shout for assistance from lab mates.

In situation (b), call 911 and describe the emergency to the dispatcher. Administer first aid ONLY if you have current Red Cross first aid training and have available personal protective equipment to prevent coming in

contact with blood or other body fluids (minimum: goggles and disposable gloves; lab coat preferred).

In situation (c), call 911 and inform the dispatcher of your discovery. *Do not attempt to clean up the fluids yourself,* to avoid possible infection.

Once the personal injury emergency situation has been resolved, the injury must be reported by the individual injured (if possible) or the discoverer to the Chemistry Safety Committee, so that an investigation can be conducted and measures implemented to prevent a recurrence of the problem. Unless the injury is severe, requiring hospitalization, the form on our Safety Web page may be used for reporting. The Safety Committee will notify the University Environmental Health and Safety Office if necessary, as well as the Human Resources Office.

6. *Chemical Spills*.

All workers in a laboratory must be aware of the location of, and know how to use, the following equipment which may be needed in a chemical emergency:

- Emergency eyewash
- Emergency shower
- Spill kit
- Fire alarm system

Chemical spills may or may not be emergencies, depending upon a variety of factors that are discussed below in more detail. Emergency spills must be reported by calling 911, and no clean-up should be attempted. Non-emergency spills can be cleaned up by laboratory workers, provided that proper procedures are followed.

(a) Whether an emergency exists is a judgement call on the part of the person who creates or discovers the spill. In general, the spill IS an emergency under any of the following circumstances:

- Someone received more than a minor injury from the spill.
- The spill involves more of the building than just the room in which it occurred.
- The spill is in a public area, such as a hallway or stairwell, and a knowledgeable person is not available.
- An appropriate spill kit and personal protective equipment (PPE) are not available.
- The individual involved doesn't know what was spilled or what PPE is required for cleanup.

- The spill is too large for the available spill kit; typically this means more than about 4 L.
- The individual involved is frightened or uncertain about the hazards involved.

(b) If you determine that the situation is an emergency, you should take the following steps:

(i) If you have been splashed by the spill, take immediate first aid action:

- Use the eyewash station or emergency shower; rinsing the affected area thoroughly; usually this means for a minimum of 15 minutes.

- Shout for help and to alert others of the spill.

- Once help has arrived, seek immediate medical attention.

(ii) If another person is the victim, administer first aid only if you have recent first aid training and the proper personal protective equipment.

- At the first opportunity, call 911 or shout for someone else to do so.

(iii) If no personal injury is involved, leave the room, close the door, and warn others to stay away.

(iv) Activate the emergency alarm, and evacuate the building.

(v) After evacuation, call 911 and explain to the dispatcher the nature of the emergency, including the following information:

- The location of the spill: building, room number, location within the room;
- The identity of the material spilled, if known;
- Your name and where you can be reached.

(vi) Meet the emergency response personnel and identify yourself as the person who reported the spill; remain available until the commander of the emergency response team tells you your help is no longer needed.

(vii) Do not re-enter the building until the emergency personnel have indicated that it is safe to do so.

(c) Each laboratory should develop its own procedures for cleaning up non-emergency spills of the materials most frequently used in that laboratory. Factors that should be considered in developing such procedures include:

- The location of the spill; a spill in a hood, for example, poses little inhalation hazard, whereas the same material on the floor may be more hazardous.
- The toxicity of the material, and the PPE required to ensure the safety of the workers.
- Can the spill simply be absorbed or should it be neutralized first?
- Any special precautions, such as might be needed to prevent ignition of a flammable material.

An example of a protocol, which should be written down and placed in the notebook containing other local safety materials:

(i) Determine what was spilled.

(ii) Determine if an emergency exists (see above).

(iii) If the substance is flammable, turn off potential ignition sources, such as Bunsen burners and hot plates.

(iv) Warn others in the area and request assistance if needed.

(v) Equip yourself with appropriate PPE.

(vi) Surround a liquid spill with absorbent to limit its spread.

(vii) Neutralize if appropriate; for example, by adding sodium bicarbonate to an acid spill.

(viii) Cover the spill with absorbent.

(ix) Use a scoop and scraper or brush to gather waste into a suitable container.

(x) Notify the Chemistry Safety Committee of the spill and request an inspection; the form on the Safety Web page may be used.

(xi) Notify the University Environmental Health and Safety Office of the spill and request pickup of the waste; EH&S will notify the EPA, if necessary.

7. *Spill Kits.* Each laboratory must have a spill kit, which can either be purchased from a laboratory supply house or assembled in the laboratory. A spill kit should include the following parts:

- A five-gallon plastic pail with a tight fitting lid, to hold absorbent material and waste;
- Absorbent, such as kitty litter or Speedi-Dri (available from Central Supply); enough to nearly fill the pail
- A plastic scoop and scraper or brush for dispensing and picking up the absorbent;
- A heavy-duty plastic bag to contain any additional waste generated by cleanup;
- Neutralization materials, such as sodium bicarbonate for acid spills and citric acid for bases (many times these are not necessary);
- Decontamination supplies - usually, detergent and water.
- A brightly colored label, carrying the legend:

SPILL KIT Useful for spills of up to 4 L of any substance except hydrofluoric acid

Appropriate labels are available from the stockroom.

Personal protective equipment also is required, to include goggles, gloves, and an apron or lab coat. These items should always be available in the laboratory in the normal course of events.

C**. Once the emergency has been declared by calling 911, or by pulling a building alarm, and the emergency response team (firefighters, police, University EH&S) has arrived, the Incident Commander is in charge of the building, and is required by law to follow specific procedures for ensuring the safety of the building.** Accurate and timely information from the persons involved in the incident can greatly facilitate this process.

VI. STANDARD OPERATING GUIDELINES

A. Standard operating guidelines (SOG) are intended to provide guidance on working safely with specific classes of chemicals or other laboratory hazards. In some instances, multiple SOGs may be applicable for a specific substance. For example, SOGs for flammable liquids and for carcinogens would both apply to benzene. SOGs include the following categories of information:

1. Hazard Assessment. Prior to beginning work, you should determine whether the materials you will work with pose any special hazards, such as being pyrophoric (spontaneously flammable in air), and what special precautionary measures may be required to cope with these hazards.

2. Notification of the Office of Environmental Health and Safety. Some categories of hazards require that you notify the EH&S office prior to beginning work. For example, the initial use of reproductive hazards in a laboratory requires EH&S notification.

3. Personal Protective Equipment (PPE). Consult the MSDS for all substances you will work with to learn what special PPE may be necessary. In general, you should always make use of the following:

(a) *Eye Protection.* If no possibility of a splash hazard exists, safety glasses that meet the requirements of the Practice for Occupational and Educational Eye and Face Protection (ANSI Z.87.1, 1987) and are equipped with side shields may be worn. However, safety glasses do not provide protection from splashes; therefore, when working with chemicals, goggles or face shields MUST be worn. This is Department of Chemistry policy, as well as safe practice. Prescription (street) glasses are NEVER adequate for protective purposes, but may be worn *under* goggles when required for clear vision.

(b) *Gloves.* Consult the MSDS or the glove guide provided by the Department for selection of proper glove materials.

(c) *Lab Coat or Apron.* Consult the MSDS to determine if the substances you are using require coats or aprons made of special materials.

Consult Section I of this document if you are in doubt as to the appropriateness of available PPE.

4. Safety Equipment. Consult the MSDS to see if any special safety equipment is required before beginning any new type of experiment. The following should be available in every laboratory:

(a) *Eyewash.* A drench or flush type eyewash station is necessary when working with many kinds of materials. Bottle-type eyewashes generally are not acceptable.

(b) *Safety Shower.* Use the safety shower both for chemical splashes and for clothing fires.

(c) *Safety Shielding.* Safety shielding is required any time an experiment involves a risk of explosion, high exothermicity, or splash hazard. The sash of a fume hood, in the lowest feasible position, provides appropriate shielding. Portable shields are acceptable if placed so as to protect *all* laboratory occupants, and are a useful accessory in hoods as well.

5. Ventilation.

(a) *Fume Hoods.* Any process that may release noxious or flammable gases, or that involves flammable substances with high vapor pressure, must be conducted in a fume hood.

(b) *Glove (Dry) Boxes or Bags.* If inert or dry atmospheres are required in handling of chemicals, such as pyrophoric materials, glove boxes or bags flushed with dry nitrogen or argon may be employed.

6. Emergency Procedures. Consult the MSDS to determine if any special emergency procedures must be developed for the substances with which you are working. If so, put the procedures in writing, and add them to the section on emergency procedures in your Department chemical hygiene manual. Such procedures should address at least the following issues:

- Emergency telephone numbers (EH&S, University police, your advisor, the building manager)
- The locations of all safety equipment.
- How to warn others in the event of an emergency.
- Special spill control materials required.
- Any special first aid treatments

Be sure you are familiar with the Department's Emergency Action Plan (in your copy of the chemical hygiene plan).

7. Gas Cylinders. Be sure that equipment is available for securing any gas cylinders that may be needed to supply gases for your experiment. Cylinders must be firmly restrained by a clamp affixed to a bench top or hood, or confined in a restricted area by a strong chain. Lecture bottles of

gases also must be restrained, either by clamping to a ring stand with a heavy base or in a rack specially designed for the purpose.

8. Labels and Signs. All chemicals in use must be clearly labeled with a correct name or structural formula. Hand-written labels are acceptable. When especially hazardous materials or procedures are in use, the hood or other work area should carry a warning sign.

9. Designated Areas. Some procedures and chemicals may be used only in designated areas of a laboratory. For example, special areas marked with caution tape or signs must be set aside for work with reproductive hazards.

10. Special Storage. The substances used must be stored appropriately to their hazard category, as described in the storage and disposal section of the Department's chemical hygiene plan. Any special storage requirements, such as for pyrophoric materials, should be determined from the MSDS.

11. Vacuum Equipment. If the use of high vacuum is part of the experimental procedure, precautions must be taken to avoid injury should evacuated glassware implode. This may mean conducting work in a hood with the sash at the lowest feasible level or behind a portable shield.

Mechanical vacuum pumps must be protected by cold traps, so that experimental materials do not reach the pump where they might be vented into the room. For some kinds of materials, the pump must be vented into a hood.

12. Waste Disposal. Consult the MSDS to determine if any special disposal procedures are required. Otherwise, follow the standard disposal procedures in the Department's chemical hygiene plan.

B. The tables below, which also are available in poster form, are intended to provide SOGs for most general classes of laboratory operations. You should examine them carefully to determine whether your research involves procedures not adequately described in the tables.

If so, you **MUST** write your own SOGs for each non-conforming procedure used in your laboratory. These must be in writing, either in tabular or descriptive form, and **MUST** be placed with the Department's Chemical Hygiene Plan in your laboratory. You must be able to produce these guidelines upon request by any inspection team.

1. Definitions. The following definitions apply to the categories of chemicals in the following tables.

(a) *Pyrophoric substances* ignite spontaneously in air at room temperature, either by oxidation or by reaction with atmospheric moisture. Phosphorus is a pyrophoric solid, tributylaluminum is an example of a pyrophoric liquid, and phosphine is a pyrophoric gas.

(b) *Corrosive chemicals* cause visible destruction of permanent changes in human skin tissue at the site of contact. Strong acids (*e.g.*, H_2SO_4), strong bases (e.g., NaOH), and dehydrating agents such as P_2O_5 are the major corrosives.

(c) *Compressed gases* are gases or mixtures of gases having an absolute pressure exceeding 40 psi at 70 °F; or an absolute pressure exceeding 104 psi at 130 °F, regardless of the pressure at 70 °F; or liquids having a vapor pressure exceeding 40 psi at 100 °F.

(d) *Acutely toxic chemicals* are immediately dangerous to life or health at concentrations in the ppm range. Cyanide salts are an example of an acutely toxic substance.

(e) *Reproductive hazards* are substances known to affect human reproductive capabilities, including chromosomal damage (mutagens) and fetal damage (teratogens).

(f) *Water Sensitive* chemicals react vigorously with water. The most common ones are the alkali metals, metal hydrides, alkyl lithiums, and alkyl aluminums.

(g) *Flammable Liquids* are chemicals that have a flash point below 38.7 °C (100 °F), and a vapor pressure that does not exceed 40 psi at 100 °F.

(h) *Oxidizing Substances* are either substances that promote combustion, or substances that spontaneously release oxygen at room temperature or upon slight warming. They include peroxides, chlorates, perchlorates, nitrates, and permanganates. *Strong Oxidizers* are capable of forming explosive mixtures with combustible or easily oxidized compounds, including most organics. Examples of strong oxidizers: ammonium perchlorate, ammonium permanganate, barium peroxide, bromine, calcium chlorate, chlorine trifluoride, chromic anhydride, chromic acid, benzoyl peroxide, fluorine, hydrogen peroxide (> 3%), magnesium peroxide, perchloric acid, potassium bromate, potassium chlorate,

potassium peroxide, propyl nitrate, sodium perchlorate, ozone, nitric acid.

(i) *Reactive Liquids* are liquid chemicals that react vigorously with moisture or oxygen. Acetyl chloride is a reactive liquid.

(j) *Reactive Solids* are solid chemicals that react vigorously with moisture or oxygen. The alkali metals and lithium aluminum hydride are examples of reactive solids.

(k) *Carcinogens* are substances that can initiate or speed the development of malignant or potentially malignant tumors, or malignant neoplastic proliferations of cells. Aromatic amines are examples of carcinogens.

(l) *Acutely toxic gases* are substances that are immediately dangerous to life or health at concentrations in air in the low ppm (parts per million), and have an absolute pressure exceeding 40 psi at 70 °F or 104 psi at 130 °F. Liquids having vapor pressures exceeding 40 psi at 100 °F also are classified as acutely toxic gases. Examples of acutely toxic gases are hydrogen cyanide (HCN) and phosgene ($COCl_2$).

C. The two tables below provide information about the 12 categories of chemical hazards, organized as described above.

	Category of Substance					
	Pyro-phoric	**Corro-sive**	**Com-pressed Gases**	**Acutely Toxic**	**Repro-ductive Hazards**	**Water Sensitive**
Hazard Assessment	Fire safety, spill response, special fire extinguish-er	As in hygiene plan	Proper regulators, pressure shielding, secure hose connec-tions	Be aware of health risk; any special handling	Be aware of health risk; any special handling	Fire safety, spill response, special fire extinguisher
EH&S Notification	NA	NA	NA	Prior to first use, or if proced-ures or quantity change	Prior to first use, or if proced-ures or quantity change	NA
PPE	Gloves, goggles, lab coat required	Gloves, goggles, lab coat required	Thermal gloves for liquefied gases	Gloves, goggles, lab coat required	Consult MSDS; Gloves, goggles,	Gloves, goggles, lab coat required

					lab coat required	
Safety Equipment	Eyewash, safety shower, shielding, required	Eyewash, safety shower, required	Shielding required; exposure monitors for toxics	Eyewash, safety shower, shielding, required	Eyewash, safety shower, required	Eyewash, safety shower, required
Ventilation	Hood or glove box required	Hood required if vapor production is expected	Hood required if gas otherwise hazardous	Hood or glove box required; biological safety cabinet?	Hood or glove box required; biological safety cabinet?	Hood or glove box recom-mended
Emergency Procedures	Special spill controls, special first aid measures	Standard, as in hygiene plan	Special first aid for toxics	Standard; plus special first aid	Do not attempt to clean up spill; call EH&S	Standard; consult MSDS
Gas Cylinders	NA	NA	Secured by straps, etc., transport with safety cart	NA	NA	NA
Signs and Labels	Chemicals must be labeled as pyrophoric	Chemicals must be labeled as corrosive	Label full or empty, as well as chemical identity	Sign on room door noting designat-ed area for toxics	Sign on room door noting designat-ed area for repro hazards	Label with chemical identity
Designated Area	NA	NA	NA	Caution tape or signs to demarcate designat-ed area	Caution tape or signs to demarcate designat-ed area	
Special Storage	Inert atmospher e, away from flammables	As in hygiene plan	Upright, secured; cylinder cap or regulator at all time; away from heat sources	Store in area designat-ed for acutely toxic substan-ces	Store in area designat-ed for repro hazards	Store in cool, dry location
Vacuum Protection	Pump must be rated for pyrophorics	NA	NA	Shielding required if used under vacuum	Shielding required if used under vacuum	NA
Waste Disposal	EH&S must be notified	May be neutralized if	Return to supplier	Minimize waste	Minimize waste	Minimize waste when

		not otherwise toxic		when possible; dispose of as hazardous waste	when possible; dispose of as hazardous waste	possible; dispose of as hazardous waste

	Category of Substance					
	Flammable Liquids	**Oxidizing Agents**	**Reactive Liquid**	**Reactive Solid**	**Carcinogens**	**Acutely Toxic Gases**
Hazard Assessment	Fire safety measures	Fire safety assessment	Fire safety and specific reactivity assessment	Fire safety assessment; possible peroxide formation	Be aware of health risk; any special handling	Be aware of health risk; any special handling
EH&S Notification	NA	Required for $HClO_4$	NA	NA	Prior to first use, or if procedures or quantity change	Prior to first use, or if procedures or quantity change
PPE	Consult MSDS	Consult MSDS	Consult MSDS	Consult MSDS	Consult MSDS	Consult MSDS
Safety Equipment	Eyewash, safety shower, required	Eyewash, safety shower, shielding, required	Eyewash, safety shower, required	Eyewash, safety shower, shielding, required	Eyewash, safety shower, required	Eyewash, safety shower, required
Ventilation	Use hood if > 500 mL	$HClO_4$ requires hood with washdown facility	Fume hood or glove box required	Fume hood or glove box required	Fume hood or glove box required	Fume hood or glove box required
Emergency Procedures	If spilled, turn off ignition sources	Standard; possible special first aid	Standard; possible special first aid	Standard; possible special first aid	Standard	Standard; possible special first aid
Gas Cylinders	NA	NA	NA	NA	NA	Upright, secured; cylinder cap or regulator at all time; away from heat sources
Signs and Labels	Must be correctly	Must be correctly	Must be correctly	Must be correctly	Sign on room door	Sign on room door

	labeled	labeled	labeled	labeled	noting designat-ed area for carcino-gens; containers must carry carcino-gen label	noting designated area for toxics
Designated Area	NA	NA	NA	NA	Caution tape or signs to demarcate designat-ed area	Caution tape or signs to demarcate designated area
Special Storage	Flammables cabinet required for > 5 L outside safety cans	Store below 30 °C; in dry location; minimize quantity stored	Store below 30 °C; in dry location; minimize quantity stored; date containers	Store below 30 °C; in dry location; minimize quantity stored; date containers	Must be stored in designat-ed area	Must be stored in designat-ed area
Vacuum Protection	Fume hood, glove box, or otherwise isolated; use cold trap on vacuum pump	Fume hood, glove box, or otherwise isolated; use cold trap on vacuum pump	NA	NA	Cold trap on vacuum pump; filter if needed to prevent release of particles	NA
Waste Disposal	Standard for hazardous waste	Do not combine with other wastes	Do not combine with other wastes	Do not combine with other wastes	Standard for hazardous waste	Empty/par-tially filled cylinders returned to supplier

VII. General Housekeeping and Prudent Practices

A. Although the term "prudent practice" has legal meaning, as used here it means simply that individuals working in laboratories shall conduct themselves in accord with the best standards of laboratory technique and precaution.

In research laboratories, the object of a procedure often is to prepare a substance never previously characterized, termed a *research generated sample.* Unless these substances are *known* to be harmless, they should be treated as if hazardous; that is, handled with the same care and respect as a substance known to possess at least moderate toxicity. This is prudent practice.

Maintaining a laboratory in good order, clean, well organized, with easy access to protective equipment and swift exit in case of emergency, also is prudent practice. None of us would care to eat food prepared in a kitchen caked with the residue of years of cooking and served on dishes not washed since they were purchased. Doing chemistry under such conditions is even more dangerous.

(Terrible housekeeping)

Before initiating any chemical procedure the prudent investigator informs him- or herself of the potential risks and the appropriate methods and equipment for minimizing those risks, making use of MSDS and SOGs. The procedure is set up in an appropriate environment (usually a fume hood), uncluttered, with clean glassware. The investigator will be wearing appropriate gloves and goggles, and perhaps a lab coat or apron as well. If the procedure involves the potential for a violent exotherm, a face or reaction shield may be necessary. A spill kit will be at hand. Coworkers in the laboratory will have been informed of the nature of the experiment so that they may respond appropriately in the event of an emergency. If the process is to run unattended, a sign will indicate its nature.

When the process is complete, it will be "worked up" promptly, and the equipment disassembled and cleaned. Dirty equipment and glassware will not be allowed to pile up on a desktop or in a hood. Any material spilled during setup, reaction, and workup will be promptly cleaned up and disposed of

appropriately. The lab bench or fume hood thus will be left ready for the next experiment.

B. We list here some items of general housekeeping and prudent practice. Some of these points are sufficiently evident that they should not need listing; however, all reflect problems observed in our laboratories during the past few years.

(1) **Absolutely no** food or beverages of any kind may be stored or consumed in a laboratory where chemicals are manipulated or stored. This includes cans of soft drinks, tea bags, instant coffee, cereal, bottled water …. What part of NO don't you understand?

(2) **Absolutely no** smoking is permitted in any part of Aubert Hall. Furthermore, smoking materials (or snuff or chewing tobacco) may not be stored in any laboratory. Since they are for oral consumption, OSHA categorizes them as food.

(3) All spills, of whatever origin, **must** be cleaned up immediately, no matter how harmless the material spilled. Areas around balances and sinks are particularly likely to become messy, and eventually dangerous as repeated spills generate uncharacterized mixtures.

(4) Keep aisles and doorways clear of furniture, boxes, equipment carts, and other impediments. Do not allow electrical cords to trail across aisles, and do not lead tubing for gas or water flow across these areas. All occupants of a laboratory must be able to exit the lab quickly in an emergency.

(5) Avoid working alone in a laboratory. If you absolutely must do so, be sure that a friend or family member knows where you are, and when you are expected to return home. Or "buddy" with someone in another laboratory: each of you checks occasionally to make sure the other is OK.

(6) Never introduce any part of your body except hands and arms into a fume hood. Raising the sash and leaning into the hood to check a reaction is the single most dangerous action one can perform in a laboratory.