LABORATORY & CHEMICAL SAFETY MANUAL

Optical & Semiconductors Devices Group
Department of Electrical & Electronics Engineering
IMPERIAL COLLEGE

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LABORATORY & CHEMICAL SAFETY

The purpose of this guide is to promote safety awareness and encourage safe working practices in the laboratory. These guidelines should serve as a reminder of things you can do to work more safely and are applicable to all users of the laboratory.

SAFETY PHILOSOPHY

We would like to keep laboratories and clean rooms as an informal and friendly place to work and would neither like to make or enforce rules unnecessarily, nor to "baby sit" users. Guidelines on laboratory safety and chemical use are formulated on the basis of past happenings in laboratories, basic chemical knowledge, the properties of individual chemicals, and common sense. Safety guidelines were developed in many cases in response to specific incidents of laboratory and chemical misuse. In addition, Health & Safety Executive has issued guidelines under the Control of Substances Hazard to Health (COSHH) which covers all chemical handling and use in a workplace. These guidelines are mandatory and they apply to all chemical handlers and users.

In spite of guidelines and staff supervision, the primary responsibility for safety rests with the individual. A responsible, considerate worker with an understanding of the working of the laboratory, its equipment, basic chemistry, common sense, and an instinct for self-preservation will have little trouble with laboratory and chemical guidelines or chemical safety.

The staff cannot oversee or supervise operations all the time. Under these conditions, any inconsiderate user can endanger his or her own as well as other's safety. A majority of problems, incidents and violations in the laboratory are the result of haste. Haste, however, makes waste, as the old saying goes. Working under such conditions, you can waste your samples, waste time and money, get crummy results, break things, and endanger yourself and others by being careless.

If you do not have time to do things correctly and safely, with adequate time for thought, please stay away from the laboratory.

Your safety in the laboratory is determined not only by your own actions but also by the actions of those around you. Since the staff is not around most of the time, the users are often in the best position to observe the behaviour of others. You may point out about the violations of the safety guidelines to the offender and to the staff at the first available opportunity. (Please do not start an argument and if you think the reaction by the individual was inappropriate report it to the staff.) The use of laboratories and clean room facilities depend on maintaining a safe working environment. Thoughtless behaviour, violations of the laboratory or chemical guidelines would not be tolerated.

All research workers are expected to adhere to safety guidelines and maintain safety standard expected in a university facility where direct staff observation is not possible.

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If you have any suggestions, observations or concerns please e-mail them to

Dr Zahid Durrani	*(z.durrani@imperial.ac.uk)*
Dr Steve Wright	*(s.wright02@imperial.ac.uk)*
Dr Kristel Fobelets	*(k.fobelets@imperial.ac.uk)*
Dr Tom Tate	*(t.tate@imperial.ac.uk)*
Dr Munir Ahmad	*(m.m.ahmad@imperial.ac.uk)*

and /or your supervisor.

LABORATORY HAZARDS

Names and phone numbers of personnel to be contacted in an emergency are:
(Chemical Emergency & Laboratory safety)

Dr Steve Wright	*(safety committee member)*	*Ext 46206*
Dr Zahid Durrani	*(departmental chemical safety officer)*	*Ext 46232*
Dr Kristel Fobelets	*(Lab and Chemical safety)*	*Ext 46236*
Dr Tom Tate	*(laboratory & equipment safety)*	*Ext 46208*
Dr Munir Ahmad	*(chemicals & laboratory safety)*	*Ext 46260*
Mr Andy Paice	*(departmental safety officer)*	*Ext 46190*

Hazards in the laboratory fall into three general categories:

First, there are a wide variety of equipment used for different activities e.g. chemistry, material processing, device fabrication and characterisation. Most of the equipment is delicate, sensitive and expensive. Misuse of equipment can lead to injury and substantial cost in repair bill.

Second, a variety of compressed gases are used, some of which may be toxic, corrosive, flammable, or explosive. The use of these gases is thus strictly regulated. These hazards, however, have been minimised by the proper use of engineering controls, such as, use of proper equipment, proper confinement, ventilation, safety valves, etc., and by procedural controls. An accident with any of these could be catastrophic.

Third, concerns wet chemicals, i.e. the acids, bases, etching solutions and solvents commonly used in chemistry and device fabrication. These are "hands on" hazards which are hard to control by engineering controls only. These chemicals can cause severe burns, tissue damage, organ damage, asphyxiation, and genetic damage if used improperly. These chemicals can enter the body by inhalation, ingestion, or absorption (either directly through the skin or through gloves) and may have either long or short-term health consequences.

In addition, improper use of solvents can result in a major fire. These chemicals even they look ordinary, are definitely not hazard free. Users are expected to treat all chemicals with appropriate care, and to be aware of all possible reactions, which may be created, either intentionally or by accident.

Filling in COSHH form shouldn't be for the fulfilment of legal obligation only but also to learn how to handle and use chemicals safely.

General Safety Awareness

Familiarise yourself with all aspects of safety before using any equipment.
Be alert to unsafe conditions of the equipment, procedures and actions, and call attention to them so that corrections can be made as soon as possible.
Label all storage areas, refrigerators, etc., appropriately, and keep all chemicals in properly labelled containers.
Date all chemical bottles when received and when opened.
Note expiry dates on chemicals.
Note special storage conditions.
Familiarise with the appropriate protective measures to take when exposed to the following classes of hazardous materials.

Flammable	*Carcinogen*
Corrosive	*Reactive Compressed Gases*
Toxic	*Poisons*

Segregate chemicals by compatibility groups for storage.
Post warning signs for unusual hazards such as flammable materials no naked flames or other special problems.
Pour more concentrated solutions into less concentrated solutions to avoid violent reactions (i.e., add acid to water, not water to acid).
Avoid distracting other worker.
Use equipment only for its designated purpose.
Position and secure apparatus used for hazardous reactions in order to permit manipulation without moving the apparatus until the entire reaction is complete.

Personal Safety

Use fume hoods (extracted wet benches) for all chemical work whenever possible.
Splash proof safety goggles should be worn at all times in the laboratory.
Laboratory coat/apron should be worn in the laboratory.
Appropriate gloves should be worn as needed.
Appropriate shoes should be worn in the laboratory.
Wear breathing mask as appropriate.
Only trained personnel may use respirators.

Personal Hygiene

Wash hands before leaving the laboratory.
Never mouth suck anything in a pipette in the laboratory.
No food or drink is allowed in laboratories or areas where chemicals are used or stored.
No food should be stored in a laboratory refrigerator.
Never eat or drink from the laboratory glassware.
If possible avoid wearing contact lenses in the chemical laboratory.
Keep exposed skin covered in the laboratory.

Fire Prevention

Aware yourself of ignition sources in the laboratory and service areas (open flames, heat, electrical equipment).
Purchase chemicals in quantities that will be used in not distant future.
Store flammable liquids in appropriate safety cabinets.
Do not store incompatible reagents together (e.g., acids with flammables).
Do not store ethers or similar chemicals for extended periods of time as explosive peroxides could form.
Date chemicals when received and opened.
Make sure that all electrical cords are in good condition and all electrical outlets are earthed.
Remain out of the area of a fire or incident if you are not in position to help.
Familiarise yourself with siting and condition of fire extinguishers. Broken seals mean fire extinguisher has been used and need be recharged.
Do not use fire extinguishers unless you are trained and feel confident to do so.

Housekeeping

Eliminate safety hazards by maintaining the laboratory work areas in a good state of order.
Maintain clear passages to the laboratory exit.
Always keep bench tops, fume hoods, floors and aisles clear of unnecessary material.
Wipe down bench tops and other laboratory surfaces after each use.
All equipment should be inspected before use.
If experiments must be left unattended, place a note next to experimental apparatus indicating the chemicals involved and possible hazards and your name and a number where you can be reached in case of an emergency.
Keep the laboratory floor dry at all times. Attend to spills immediately and notify other lab workers of potential slipping hazards.
Only authorised personnel should do maintenance work on laboratory equipment.
Sink traps should be flushed with water on a regular basis to prevent the release of chemical odours in the laboratory.
All compressed gas cylinders should be securely chained or clamped to a rack.
Take empty cylinders to the empty cylinder bay for collection. Unnecessary delays accumulate rent that is usually much more than the price of the gas.

Emergency Procedures

Familiarise with the emergency response to any incident.

Familiarise with the location, use and limitations of the following safety devices:

Safety Shower	*Spill Cleanup Materials*
Eye Wash Station	*First Aid Kit*
Protective Respiratory Gear	*Fire Alarm*
Fume Hood	*Fire Extinguisher*

Clean up all small spills immediately. If a spill is large and is expected to poses a hazard to others in the laboratory, stop the activity or equipment if possible, and call for help.
If volatile, flammable, or toxic material spill, shut off flames and spark-producing equipment at once and evacuate and call one of the above members of staff for help to deal with the spill.
In the event of fire or explosion, call for help.
Maintain a clear path to all safety equipment at all times.

PERSONAL PROTECTIVE EQUIPMENT

Protection of health and safety of workers at work is a legal requirement for all according to Health and Safety Executive Directive. Only informed and responsible individuals can achieve personal and laboratory safety, therefore it is important for all workers to familiarise themselves with the safety guidelines and adhere to them. These guidelines provide information for the choice of suitable personal protection equipment for use in the laboratory.

Eye Protection

Splashing chemicals or flying objects are possible at any time in a laboratory environment. For this reason, eye protection should be worn in the laboratory all the time. Eye protection is available in the form of safety glasses, goggles, and safety visors. Please select the one most appropriate for your work.

For example if there is a danger of splash or explosion select safety visor or at least goggles, safety glasses are not suitable in such circumstances.

PROTECTIVE CLOTHING

Laboratory Coat

The laboratory coat is designed to protect the clothing and skin from chemicals that may be spilled or splashed. It should always be properly fitted to the wearer and is best if it is knee length.

Aprons

An apron provides an alternative to the lab coat. It is usually made of plastic or rubber to protect the wearer against corrosive or irritating chemicals. An apron should be worn over garments that cover the arms and body, such as a laboratory coat.

It is important you keep the protective clothing in good condition. Dirty and damaged clothing should be cleaned and repaired or replaced. Dirty protective clothing is a hazard in itself.

Hand Protection

Always wear protective gloves in the laboratory specially when handling chemicals. Aside from acting as a shield between hands and hazardous materials, some gloves can also absorb perspiration or protect the hands from heat.

Because certain glove types are not impervious in contact with chemicals gloves should be selected on the basis of the material being handled and particular hazards involved. Glove manufacturer /supplier and the Material Safety Data Sheets (MSDS) accompanying product in use are good sources of specific glove selection information.

Here are few suggestions for the selection of gloves.

PVC protects against mild corrosives and irritants.
Latex provides light protection against irritants and limited protection against infectious agents.
Natural Rubber protects against mild corrosive material and electric shock.
Neoprene rubber is good for working with solvents, oils, or mild corrosive material.
Cotton absorbs perspiration, keeps objects clean and provides a limited fire retardant properties.
Thermal gloves should be used when handling small hot objects.
When removing gloves, peel the glove off the hand, starting at the wrist and working toward the fingers, turning inside out. Avoid contacting the working surface area of gloves during removal. If gloves are contaminated with mutagens, tratogens or carcinogens etc., they should be packed in a plastic bag and labelled for safe disposal.
Wash hands as soon as possible after removing protective gloves.
Before use, check to make sure the gloves are in good condition and free from holes, punctures, and tears.

Foot Protection

Foot protection is designed to prevent injury from corrosive chemicals, heavy objects, electrical shock, as well as giving traction on wet floors. If a corrosive chemical or heavy object were to fall on the floor, the most vulnerable portion of the body would be the feet. For this reason, shoes that completely cover and protect the foot are recommended.

Fabric shoes, such as tennis shoes, absorb liquids readily. Similarly sandals provide no barrier at all. If chemicals happen to spill on fabric shoes, remove footwear immediately.

Please wear sturdy shoes that cover the foot completely. These will provide the best protection. Avoid shoes that expose feet in any way.

Breathing Mask and Respirator

Certain laboratory procedures can produce noxious fumes and contaminants. This usually happens when engineering controls cannot successfully minimise or eliminate the potentially harmful fumes. Also different people have different sensitivity when exposed to certain chemicals, in these circumstances one may require a respiratory protection. There are two types of protection available, a Breathing mask or Respirator.

Breathing masks are simpler in use and are available with filters for specific contaminants. In laboratory work these are most likely to be a practical choice. VWR International, Aldrich and RS catalogues provide information for the selection of suitable breathing mask and filters appropriate for certain hazardous contaminants.

Respirators are slightly more complicated kits and not easy to use in a laboratory environment. These are usually used in an emergency. Only trained persons are allowed to use them. A medical examination may be required to assure the potential respirator wearer is physically capable of respirator use.

LABORATORY SAFETY EQUIPMENT

Extracted Wet Bench (Fume Hood)

Fume hoods capture, contain, and expel emissions generated by hazardous chemicals or chemical reactions. In general, all laboratory experiments with chemicals should be done in a fume hood. While it is possible to predict the release of undesirable or hazardous effluents in most laboratory operations, surprises can always happen. Therefore, the fume hood offers an extra measure of protection.

Before use, check to see that fume hood is functioning according to specifications. An inspection certificate will tell the date of the most recent fume hood evaluation. If the fume hood does not appear to be in good working order (a tissue, held inside the fume hood, can indicate if airflow is present), or if you have any concerns, please report to

Operation & Maintenance

All users should be familiar with the operation of the fume hood.
Always maintain the sash at or below the optimum operating height as designated by the label.
Large objects used inside the fume hood like a water bath or hotplate must be raised above the wet bench floor to allow airflow beneath and on all sides of the object.
Always work back into the hood, six inches beyond the sash line, keeping the sash line between your body and your work.
Keep the inside of the fume hood clean, uncluttered and in good condition for routine use.
The user should not be able to detect strong odours released from materials in the fume hood. If odours are detected, check to make sure that the ventilation fan is turned on and or extraction is not blocked.

All protective clothing should be worn when working with chemicals in the fume hood. In addition to gloves, safety glasses, goggles or visor, and laboratory coats, a face shield or explosion shield will provide an extra measure of safety from reactive chemicals.

Fume hood should not be used for long-term chemical storage.

Chemical Storage Cabinets

Storage of flammable and corrosive chemicals in the lab should be limited to small quantities as for as possible. Flammable materials should be stored in flammable material storage cabinets.

Storage outside of the cabinet should be limited to materials used in the current process and must be returned after use to the appropriate storage cabinets. Leaving chemicals on benches or working areas is hazardous and is not acceptable.

Plastic cabinets are designed for corrosion resistance and used for storing acid and other corrosive materials.
Acids and other corrosive chemicals in the chemistry laboratory are stored under the fume hoods.

Refrigerators

Refrigerators approved for laboratory use should be selected for specific chemical storage needs. To prevent potential safety hazards, the length of storage of any material should be kept to a minimum. In addition, refrigerators should be periodically inspected.

Eyewash Stations

Eyewash stations provide an effective means of treatment when chemicals come in contact with eyes. A bowl-mounted eyewash station, which provides continuous water flow through a plumbed unit, is available in the chemistry laboratory and is accessible to all laboratory personnel. Always flush the eyewash line before use.
Eye wash solutions are also available in all laboratories.
Water or eyewash solutions should not be directly aimed onto the eyeball, but rather, aimed at the base of the nose. This increases the chance of effectively rinsing the eyes free of chemicals (harsh streams of water may drive particles further into the eyes).
Eyelids may have to be opened to attempt eye rinse.
Irrigate eyes and eyelids with water or eyewash solution for a minimum of 15 minutes.
If wearing contact lenses remove them as soon as possible to rinse eyes of any harmful chemicals.

Fire Safety Equipment

Fire Alarms are to alert all endangered laboratory personnel and building occupants by an audible warning.

Fire Extinguishers are located as required by current fire codes and standards near exits in most laboratories.

Only use a fire extinguisher if the fire is controllable and you know how to use the extinguisher safely. If you can't put out the fire, leave immediately and trigger a fire alarm.
If fire alarm is activated inform immediately to

Dr Tom Tate	*(ext 46208)*
Dr Steve Wright	*(ext 46206)*
Mr Andy Paice (Technical Services Manager)	*(ext 46190)*

LABORATORY EQUIPMENT SAFETY

Glassware

Accidents involving glassware are a leading cause of laboratory injuries. These can be avoided by following a few simple procedures. In general, be certain that you have received proper instructions before you use glass equipment designed for specialised tasks that involve unusual risks or potential injury.

Here are few safety rules.
Handle and store glassware carefully so as not to damage it or yourself.
When inserting glass tubing into rubber stoppers, corks or when placing rubber tubing on glass hose connections:
Protect hands with a heavy glove or towel.

Lubricate tubing or stopper with water or soap solution and be sure that the ends of the glass tubing are fire-polished.
Hold hands close together to limit movement of glass should fracture occur.
Substitute plastic or metal connections for glass ones whenever possible to decrease the risk of injury.
Use glassware for vacuum work that is designed for that purpose.

When dealing with broken glass wear hand protection when picking up the pieces.
Use a broom to sweep small pieces into a dustpan and store glass pieces in a designated bin for broken glass.

Heating Devices

Electrical devices that supply heat in laboratories include:

Hotplates
Hot-Tube Furnaces
Heating Mantles
Hot-Air Guns
Oil Baths

Improper use of any one of these could result in fire or burns to the user.

Before using any heating device:
Check to see if the unit has an automatic safety shutoff in case of overheating.
Note the condition of electrical cords and have them replaced as required.
Make sure the apparatus has been maintained as required by the manufacturer.
Check to see that all heating units in use without automatic shut-off have been turned off before leaving an area for any extended period of time.
Flammable or combustible solvents should not be used in a heated bath or placed near the bath. Oil baths must always be housed in a chemical fume hood.

Vacuum Systems

Familiarise yourself with the operations of the vacuum system in use.
Make sure the service cord and switch are free of observable defects and accessible in case of emergency.
Always use a trap on the suction line to prevent liquids from being drawn into the pump.
If gases or vapours are being drawn through the pump, a cold trap should be used in the suction line to prevent contamination of the pump oil.
Place a tray under the pump to catch any oil drips.

FIRST AID & EMERGENCY PROCEDURES

The first aid and emergency procedures detailed in this section could be lifesaving. Familiarise with the information described below, so that mishaps can be speedily contained. It is the responsibility of the injured person to report any injury or property damage to **Mr Andy Paice, Departmental Safety Officer.** Required forms and instructions are available with the departmental safety officer's office. It is advisable to call the College Health Centre (South Side) and let them know about your injury before visiting the centre for material help.

First Aid

Wounds

Cleanse area with water as appropriate.
Small cuts and scratches place sterile pad over wound and apply gentle pressure evenly with the opposite hand. If direct gentle pressure does not control bleeding, raise the area above the level of the heart. Apply dressing plaster as appropriate.

If there is significant bleeding apply direct pressure i.e. place sterile pad over wound and apply gentle pressure evenly with the opposite hand and call the College Health Centre (South Side) immediately for help and advice.

Thermal Burns

First degree burns are characterised by redness or discoloration of the skin, mild swelling and pain. These can be treated by rinsing or immersing in water for at least 10 minutes and applying a skin cream as appropriate, and seeking further medical treatment as needed.

Second and third degree burns are characterised by red or scared skin with blisters (second degree), white or charred skin (third degree). Immediate first aid is to clean the area if possible and keep it dry and call Health Centre for medical help immediately.

Chemical Burns

If hazardous chemicals should come into contact with skin or eyes, follow the first aid procedures below.

Skin: Remove garments as required and rinse the affected area with large quantities of water for at least 15 minutes (sink, shower, or hose).
Do not apply burn ointments/spray to affected areas.
Call the Health Centre (South Side) for medical help without delay.

Eyes: Rinse area of eyes, eyelids, and face thoroughly with lukewarm water for at least 15 minutes at the eye wash station and call the Health Centre (South Side) without delay.

CHEMICAL SAFETY

Names and phone numbers of personnel to be contacted in an emergency are:
(Chemical Emergency & Laboratory safety)

Dr Zahid Durrani	*(departmental chemicals safety officer)*	*Ext 46232*
Dr Steve Wright	*(safety committee member)*	*Ext 46206*
Dr Munir Ahmad	*(chemicals & laboratory safety)*	*Ext 46260*
Dr Tom Tate	*(laboratory & equipment safety)*	*Ext 46208*
Mr Andy Paice	*(departmental safety officer)*	*Ext 46190*

All chemicals have some degree of risk attached to their use and it is important before any work is started that a careful investigation is made into the nature and the reaction of the chemicals in use in order to determine whether a hazardous situation could develop. The aim is to protect people against the risks to their health whether immediate or delayed. If the assessment indicates a risk then the hazard must be prevented or controlled and the necessary controls must be properly used and adequately maintained.

PROPERTIES OF HAZARDOUS CHEMICALS

FLAMMABILITY

Flammability is a measure of how easily a gas, liquid, or solid will ignite and how quickly the flame, once started, will spread. The more readily ignition occurs, the more flammable the material. Flammable liquids themselves are not flammable; rather, vapours from liquids are combustible. Two physical properties of materials that indicate their flammability are flash point and volatility (boiling point).

The flash point of a material is the temperature at which a liquid (or volatile solid) gives off vapour in quantities significant enough to form an ignitable mixture with air. Given an external source of ignition (i.e., spark, flame), a material can ignite at temperatures at or above its flash point. The flash point of ethyl ether, a highly flammable solvent, is -49F. Kerosene has a flash point between 100F and 150F. Flammable gases have no flash point, since they are already in an ignitable form.

The volatility of a material is an indication of how easily a liquid or solid will pass into the vapour stage. Volatility is measured by the boiling point of the material -- the temperature at which the vapour pressure of the material is equal to the atmospheric pressure. The term volatility is often mistakenly used as a synonym for flammability. There are some materials that are volatile but not flammable such as water, chloroform and mercury.

Some materials are pyrophoric, meaning that they can ignite spontaneously in air or moisture with no external source of ignition. Potassium metal, for example, can react with the moisture in air. This reaction causes hydrogen gas to be evolved, and the heat generated by the reaction can be hot enough to ignite the hydrogen.

Examples of commonly-used flammable chemicals.

Acetone,	*Sodium*
Diethyl ether,	*Lithium*
Hydrogen,	*Ethyl alcohol*
Acetylene	*Potassium*

Labelling & Information

Product flammability may be indicated on the label by a picture of a flame, a flame in a red diamond by the word flammable or combustible.

Flammability information can be found on the MSDS under **Fire and Explosion Data**. Flash point and boiling point information can be found in the section entitled **Physical Properties**.

Storage

Flammable materials should never be stored near acids or oxidising materials.
Keep storage areas cool to decrease the possibility of formation of vapours in excess of the lower flammable limit for the material or auto-ignition in the event that vapours mix with air.
Adequate ventilation should be provided to prevent vapour build-up under normal storage conditions.

Do not store flammable materials in conventional (non-explosion proof) refrigerators. Sparks generated by internal lights or thermostats may ignite flammable material inside the refrigerator, causing an extremely dangerous explosion hazard.

Storage areas should have spill cleanup materials. In case of fire in flammables storage area do not attempt to extinguish a fire, call immediately for help and trigger fire alarm.
Storage areas should be inspected periodically for deficiencies, and storage of flammable materials should be kept to a minimum.

Handling

Use gloves and splash-proof safety goggles when handling flammable liquids.
Mixtures of flammable or combustible liquids should be treated as though the mixture had the lowest flash point represented.
Dispensing of flammable or combustible liquids should only be carried out in a fume hood.

When transferring or using a flammable liquid, all ignition sources should be eliminated from the area.
Open flames or hot plates should NOT be used to directly heat flammable liquids.
DO NOT use water to clean up flammable liquid spills.
DO NOT dispose of flammable or combustible liquids in a sink, always store in waste solvent bin for disposal.

CORROSIVITY

Gases, liquids, and solids can exhibit the hazardous property of corrosivity. Corrosive materials can burn, irritate, or destructively attack skin. When inhaled or ingested, lung and stomach tissue are affected. Corrosive gases are readily absorbed into the body through skin contact and inhalation. Corrosive liquids are frequently used in the laboratory and have a high potential to cause external injury to the body. Corrosive solids often cause delayed injury. Because corrosive solids dissolve rapidly in moisture on the skin and in the respiratory system, the effects of corrosive solids depend largely on the duration of contact.

Materials with corrosive properties can be either **acidic** (low pH) or **basic** (high pH). Examples of corrosives are listed below:

> *Acids: sulphuric acid, hydrochloric acid, nitric acid*
> *Bases: ammonium hydroxide, sodium hydroxide, chromium trioxide*

Labelling & Information

The corrosive label normally depicts the corrosion of a hand and bar of steel.
Information on corrosive properties can be found in the MSDS under **Health Effects and First Aid**.

Storage

Segregate acids from bases, and corrosive materials from both organic and flammable materials.
Store corrosive materials near the floor to minimise the danger of falling from shelves.
Store in cool, dry, well-ventilated areas and away from sunlight. The storage area should not be subject to rapid temperature changes.

Handling

Wear adequate protective equipment (lab apron, appropriate gloves and splash-proof eye protection). If splashing is a definite hazard, face shields must also be worn.
Corrosive materials should always be handled in a fume hood to protect the user from the hazardous and noxious fumes.

Add reagents slowly. Always add acids to water (**never water to acid**). During the addition of reagents, allow acid to run down the side of the container and mix slowly.
Corrosive materials should be transported in unbreakable containers.

REACTIVITY

Explosives

Explosive materials are chemicals that cause a sudden, almost instantaneous release of large or small amounts of pressure, gas and heat when subjected to sudden shock, pressure or high temperature.
Some substances, under certain conditions of shock, temperature or chemical reaction, can explode violently. Such explosions present many hazards to laboratory personnel.

flying glass can seriously lacerate skin
fires can result from burning gases
corrosive or toxic substances can be liberated

Before working with explosive materials, understand their chemical properties, know the products of side reactions, the incompatibility of certain chemicals, and monitor possible environmental catalysts (such as temperature changes).
Examples of materials that may be explosive under some conditions of use:

acetylene	*ammonia*
azides	*organic peroxides*
hydrogen	*per-chlorates*
nitro compounds	*bromates*

Information on explosives can be found on the MSDS under **Fire and Explosion Data**.

Storage & Handling

To avoid explosion hazards:

Do not mix flammable chemicals with oxidants e.g acids with organic solvents
Do not allow flammable gas leaks.
Do not allow heating compressed or liquefied gas.
Do not allow uncontrollable or fluctuating temperatures during experiments when using materials likely to expand.
Do not bringing hot liquid (e.g., oil) into sudden contact with low boiling material.
Do not allow generation of unstable products that build up in solvent containers during storage.
Avoid distilling ethers unless free from peroxides.
Minimise storage of ethers.
Determine all explosive hazards prior to experimental work, including the stability of reactants/products.
Do not mixing like nitric acid with acetone or allowing picric acid to dry out.

OXIDISING AGENT

An oxidising agent is a chemical that provide oxygen or remove electrons for chemical reactions. Oxidising agents spontaneously evolve oxygen at room or slightly elevated temperatures, and can explode violently when shocked or heated. Because they possess varying degrees of chemical instability, oxidising agents are explosively unpredictable and, therefore, represent a particularly hazardous safety threat.

Examples of oxidising agents:

peroxides
hyper-peroxides
peroxyesters

Oxidising agents can react violently when in contact with organics, for example nitric acid with acetone. For this reason, avoid interactions between oxidising agents and organic materials. Common oxidising agents include nitric acid, sulphuric acid, chromic acid, and permanganates.

Peroxides

Some organic compounds, such as ethers, can react with oxygen from the air, forming unstable peroxides. Peroxide formation can occur under conditions of normal storage. The accumulated peroxides can violently explode when exposed to shock, friction, or heat. Pure compounds will accumulate peroxides more readily than compounds containing impurities.

Examples of organic compounds that form hazardous peroxides:

aldehydes, ketones
ethers
compounds with allylene ($CH_2 = CHCH_2R$) *structure*
alkali metals, alkoxides, amines
vinyl and vinylidene compounds
compounds with benzylic hydrogen atoms

Examples of chemicals which form hazardous peroxides during exposure to air:

ethyl vinyl ether,
p-Dioxane,
decalin,
ethyl ether
tetralin,
isopropyl ether,
tetrahydrofuran (THF)

Destruction of the listed chemicals is recommended within 1 year of chemical receipt or 1 month after opening without any testing for peroxide content.

Acetal
Diethyl ether
Allyl ether
Diethyl fumarate
Allyl phenyl ether
Dioxane

Isoamyl benzyl ether	*Cyclohexene*
1,3-Dioxepane	*Vinylidene chloride*
Benzyl n-butyl ether	*Diethoxymethane*
Dibenzyl ether	*Diisopropyl ether*
Benzyl ethyl ether	*1,2-Epoxy-3-isopropoxypropane*
Isophorone	*Di-n-propoxymethane*
Benzyl 1-naphthyl ether	*2-Chlorobutadiene beta-*
Dimethoxymethane	*1,3,3-Trimethoxypropene*
p-Dibenzyloxybenzene	*Chloroacetaldehydediethylacetal*
2,2-Dimethoxypropane	*n-Propyl isopropyl ether*
Decalin	*1,2-Dibenzyloxyethane*
Tetralin	*Isopropoxyproprionitrile*
Cyclooctene	

Discard chemicals where peroxide are likely to be produced after exposure to air.

Labelling & Information

A pictorial oxidising agent label depicts a flaming letter "O" on a yellow background.
Information on oxidising agents can be found on the MSDS under the heading **Reactivity Data**.

Storage & Handling

Order reactive chemicals in small quantities and do not keep for extended period.
Include the date of purchase on containers of reactive compounds. Note the date of opening on the label.

When possible, store reactive compounds under an inert atmosphere. Keep away from heat, light, and ignition sources.
Store in a cool, dry, well-ventilated area, out of direct sunlight. Protect from extreme temperatures and rapid temperature changes. Store in amber glass or inert containers, preferably unbreakable. Containers should be tightly sealed. DO NOT use corks or rubber stoppers to cap containers.

Before opening glass bottles, look for the presence of solids (crystals) or viscous liquid at the bottom of the bottle. These are good indicators of peroxide formation. *Do not open a container that is suspect.*

Isolate reactive chemicals from incompatible materials for example
organic materials, flammable solvents from
corrosives materials (e.g acids)

Avoid friction, grinding and all forms of impact while working with oxidising agents.
Avoid mixing oxidising agents with other chemicals during disposal procedures.

Peroxide Test: To detect the presence of peroxides, the following procedure can be used. In a 25ml glass-stoppered cylinder (colourless, protected from the light), add 1 ml of freshly prepared 10% aqueous potassium iodide solution to 10 ml of organic solvent. View the cylinder transversely against a white background. If a yellow or brown colour appears, peroxide is present.

TOXICITY

The concept of toxicity is unique because it can be applicable to all chemical substances used in a laboratory. The terminology explained below can assist laboratory workers in assessing the degree of hazard and provide guidance in the selection of appropriate personal protective equipment.

***Toxicity** is defined as the ability of a substance to cause: damage to living tissue, impairment of the central nervous system, severe illness, or in extreme cases, death when ingested, inhaled, or absorbed through the skin.*

The administration of a particular dosage of a chemical, and the subsequent response by experimental animals, can help predict that chemical's toxic effect on humans. The dose-response behaviour is represented by a dose-response curve, which demonstrates that not all individuals will respond to a particular dose of a chemical in the same manner. *Some people will be more sensitive than others, and a specific dosage that may be lethal to one person may not be lethal to another.*

EXPOSURE LEVELS

TLV - Threshold limit value

Inhalation of toxic substances can cause a great deal of tissue damage. Each lung is composed of a large surface area of folded tissue, which is vulnerable to assault by toxic vapours and airborne particles.

The toxicity of a substance via **inhalation** is represented by **TLVs**,(Threshold Limit Values) or **PELs** (Permissible Exposure Limits). That is the statutory equivalent of **TLV**.

TLVs are compiled by the Governmental Industrial Hygienists based on available research, and are considered the industry standards. **PELs** are determined by the Occupational Safety and Health Administration (OSHA) and promulgated as enforceable standards. This is actually **TLV-TWA** (time weighted average) but is commonly called just TLV. It is the (averaged) level to which you can be exposed 8 hours a day, 5 days a week forever, without adverse health effects. An important point to keep in mind is that the adverse effects of over-exposure to a material can range from headache or nausea to more severe disabilities. For this reason, time-weighted averages should be considered only as a guide in controlling health hazards in the laboratory, not as definitive marks between "safe" and "dangerous" concentrations.

Both measures are expressed in parts per million (ppm) of the substance in air, or milligrams of substance per cubic meter of air.

IDLH - Immediately Dangerous to Life and Health.

This level represents the maximum value for which a 30 minute exposure will result in no irreversible or escape impairing effects, i.e. the maximum level which will not cause you to pass out or sustain irreversible organ damage. It is the value most appropriate to sudden, one time accidental exposures. For your information, a short table of values for relevant chemicals is listed below.

Immediately Dangerous to Life and Health (IDLH)

Ammonia	*500 ppm*
Carbon Monoxide	*1500 ppm*
Chlorine	*25 ppm*
Hydrogen Fluoride	*20 ppm*
Diborane	*40 ppm*
Phosphine	*200 ppm*

STEL - Short Term Exposure Limit
STEL. Maximum concentration to which you can be exposed for 15 minutes, up to 4 times a day without adverse effects.

LC_{50}
Median Lethal Concentration. The concentration of a material in air that, on the basis of laboratory tests, is expected to be lethal by inhalation to 50% of an animal population when exposed for a single period of time, usually one hour. The **LC_{50}** is expressed as parts of material per million parts of air by volume (ppm) for gases and vapours, and as micrograms of material per litre of air (mg/L), or its numerical equivalent milligrams of material per cubic meter of air (mg/m^3) for dusts and mists.

LD_{50}
Median Lethal Dosage. The point on the curve where 50% of the test animals have died as a result of a particular chemical dosage is referred to as the Lethal Dose50, or **LD_{50}**. The LD_{50} is usually indicated in terms of milligrams of substance **ingested** per kilogram of body weight (mg/kg). On the other hand, if it takes a very large dose of the substance to result in death units of grams of substance per kilogram of body weight (g/kg) may be used.
The lower the LD_{50}, the more toxic the material.

It is obvious that one cannot do well controlled experiments on human subjects. It is thus wise to be conservative in estimates using these numbers.

Ceiling
The **Ceiling** limit of a substance is the concentration that should not be exceeded during any part of the work day.

The toxicity of a substance via **skin absorption** can be determined several ways. Often, the threshold limit values of a substance will have a "skin" notation, indicating they are rapidly absorbed through the skin. Absorption can also be indicated by the solubility of the material in water. Materials that are extremely soluble in water can dissolve in skin moisture and be transported through the skin's surface. For instance, dimethyl sulfoxide (DMSO) rapidly absorbs into the skin. If any toxic materials are present in this solvent or on the surface of the skin, DMSO will transport these contaminants into the body as well.

A substance can have either **acute** or **chronic** toxicity. A substance that is acutely toxic will have immediate effects on the health of an over-exposed individual, (e.g., phosgene causes immediate throat irritation at a concentration of 3 ppm and immediate death at 50 ppm). A substance that has chronic toxicity will eventually affect the health of a person due to long-term exposure to that material (e.g., phosgene in concentrations less than 1 ppm over a long period of time are a potential trigger for emphysema).

POISONS

A poisonous compound is a substance that causes death or serious injury if relatively small amounts are inhaled, ingested or have contacted the skin. All substances can be in some quantity or condition of use.

Labelling & Information

Any substance that carries the international poison symbol (skull and crossbones) should be treated as hazardous.
Information on the poisonous nature of chemicals can be found in the MSDS section **Health Hazard Data**.

Storage & Handling

Treat poisonous compounds with extreme caution. Wear protective lab coats, gloves and safety glasses, and work in a functioning fume hood.
For specific substance information call the Occupational Health Unit (South Side).

SPECIAL CLASSES OF MATERIALS

Carcinogens

Carcinogens are substances that will cause cancer in humans or animals given appropriate exposures. Suspect carcinogens are substances that have chemical similarities with known carcinogens or have shown preliminary evidence of carcinogenic activity. Carcinogens can represent an insidious hazard in the laboratory since they can cause disease with exposures that do not produce acute toxic effects. There may be a long latency period between exposure and the appearance of cancer.

The consequence of exposure to carcinogens varies according to the species, the physiological and metabolic state of the organism, and the dosage of the carcinogen (including duration and route of exposure, concurrent exposure to other agents, and other factors). There is continuing scientific debate regarding the minimum exposure required to produce cancer, as well as the relevance of experimentally-induced animal cancers to a human situation. The complex interaction of such determinants makes risk assessment of human exposure to carcinogens exceedingly difficult. Due to these uncertainties, assurance of laboratory safety requires strict limitation of human exposure to carcinogenic substances.

Some compounds are carcinogenic only in combination with certain other compounds. It is known that particular chemicals promote the carcinogenic action of others. Since the potential for synergistic action of most chemicals is unknown, it is essential that caution be exercised with all organic compounds and metals when used in combination with carcinogens.

Labelling & Information

The following terms, defined by the International Agency for Research on Cancer (IARC), are used to describe material carcinogenicity:

Sufficient positive: Those chemicals that were found to promote and increase incidence of malignant tumours in multiple species or strains of lab animals.

Limited positive: Those chemicals found to promote either malignant tumours in a single strain, or benign tumours in single or multiple species or strains.

Inadequate: Insufficient evidence to make a decision.

Equivocal: Almost no supporting evidence.

Negative: Limited or sufficient significant negative evidence.

Examples of known or suspected carcinogens are listed below. The risk factor associated with these compounds is high, and alternative compounds should be used whenever possible.

Acrylonitrile
4-Aminodiphenyl
4-Nitrobiphenyl
Naphthylamine
Ethylenimine
Formaldehyde
Arsenic
Benizidine
Chloroform
Benzidine
Vinyl chloride
betaPropiolactone
Benzene
N-Nitrosodimethylamine
2-Acetylaminofluorene
4-Dimethylaminoazobenzene

α and β Methylchloromethyl ether
3,3'-Dichlorobenzidine bis(chloromethyl) ether
4,4'-Methylene bis(2-chloroaniline) Benzene
Methyl chloromethyl ether
bis-Chloromethyl ether
beta-Naphthylamine
Coke oven emissions
1,2-dibromo-3-chloropropane
n-Nitrosodimethylamine
3,3'-Dichlorobenzidine and its salts
beta-Propiolactone
alpha-Naphthylamine
Dimethylaminoazobenzene
1,2-dibromo-3-chloropropane

Anyone contemplating work with these carcinogens must contact make arrangements for initial environmental monitoring or engineering control evaluation. Depending on the results, laboratories may be required to meet the OSHA regulations on training, record keeping, and personal monitoring and medical surveillance.

Access Control

Entrances into areas where known carcinogens are used should be posted

appropriately, such as: *"Cancer Suspect Agent, Authorised Personnel Only"*.
Principal Investigators are required to designate locations within the lab for use of carcinogens. The designation must include consideration of necessary control measures.
Allow only authorised persons in the laboratory. Close all doors and restrict traffic in the work area when the carcinogen is being used.
Place warning labels such as *"Carcinogen" or "Cancer Suspect Agent"* on all stock, dilution, and hazardous waste disposal containers.
Visitors should be notified about carcinogen use in the laboratory work area.
Housekeeping personnel must be informed of any possible hazards or special cleaning procedures that are required.
All work with carcinogens must stop and the area and equipment decontaminated before any repair or maintenance work is permitted.

Personnel Protection

In some high-risk operations involving carcinogens, a clean room or vestibule may need to be and shower constructed and properly used when entering and exiting a work area.
Wear protective clothing, preferably disposable, such as

gloves
lab coats
respirators

when handling carcinogens. Do not wear them outside of the laboratory.
Under normal working conditions, no carcinogen should contact gloves or clothing. They are the last line of defence.
Check the manufacturer's description to be sure that the type of glove or respirator planned to be worn truly forms a barrier against the carcinogen being used. This is particularly true when using organic solvents, acids and bases.
Use mechanical pipettes only.
There should be no eating, drinking, smoking or other unnecessary hand-to-mouth contact.
Only small amounts of carcinogens should be kept in stock. Only minimal amounts should be kept at work stations.
Wash hands with soap after procedures involving a carcinogen.

Storage & Handling

Containers of carcinogens should be clearly labelled and kept in a separate (preferably locked) storage location. Designated work areas appropriate for carcinogen use should be clearly demarcated.
Conduct work practices involving volatile, aerosols or dust in a chemical fume hood exhausted to the exterior so that the possibility of entry into the supply air intake of any building is minimised.

Check fume hoods, biological safety cabinets (laminar flow hoods) and glove boxes for leaks, air-flow rate and air-flow patterns prior to using them. Follow-up with periodic checks.
All work surfaces on which carcinogens are used should be stainless steel or covered with plastic trays or dry absorbent plastic-backed paper.
Laboratory supervisors are responsible for training laboratory workers on proper carcinogen-handling techniques.

Each laboratory worker must adhere to proper operations, emergency procedures, monitoring of lab work and required medical examinations. Medical records must be accurately maintained when working with carcinogens.

Before working with suspected or known carcinogenic compounds, obtain health hazard information for each compound. In addition, compile spill cleanup emergency procedures for your laboratory.

MUTAGENS AND TERATOGENS

Mutagens

Mutagens are chemical and physical agents that induce mutations in DNA and in living cells. This affects the genetic system in such a way as to cause cancer or hereditary changes in chromosomes. Individuals exposed to chemicals with mutagenic properties may develop genetic damage to the extent that future offspring may be affected.

Two forms of somatic (body/organ) cell interference may be noted.
Leukemias: White blood cells are produced far more rapidly than they can be removed from the blood, interfering with normal body functions.
Cancers: Cells that do not normally divide during adult life begin to proliferate to the extent that such division displaces or invades normal tissues.

Examples of mutagens:

Arsenic | *Ionizing Radiation (gamma, x-rays)*
Ethidium Bromide | *Alkylating agents (i.e.,dimethyl sulfate)*

Teratogens

Teratogens are chemical and physical agents that interfere with normal embryonic development. Teratogens differ from mutagens in that there must be a developing foetus. Damage to the foetus (embryo) is most likely to occur early in pregnancy, during the first 8 - 10 weeks. Teratogens may produce congenital malformations or death of the foetus without inducing damage to the pregnant woman.

In general, carcinogenic chemicals should be considered as a hazard to reproductive health. Even though OSHA has established exposure limits for dangerous materials, a developing foetus may be adversely affected by lower doses than those considered acceptable for adult exposure. Toxicology is still not well developed to evaluate reproductive health hazards. However, as of 1985, OSHA has identified three substances as teratogens:

Dibromochloropropane | *Ethylene oxide*
Lead

Examples of several other materials that are thought to be associated with reproductive health disorders are listed below.

Antimony	*Nitrous oxide*
Carbon disulfide	*Formaldehyde*
Ethylene thiourea	*Ethylene dibromide*
Ionizing radiation	*Polychlorinated biphenols (PCBs)*

Handling & Storage

See precautions as listed under carcinogens.
Before working with suspected or known mutagenic or teratogenic compounds, obtain health hazard information for each compound. In addition, compile spill cleanup emergency procedures for your laboratory.
Exercise extreme caution, as you would with carcinogens. Wear personal protective clothing and equipment, and work in a well ventilated area.

TYPES OF EXPOSURE

Acute Exposure
Acute Exposure as used in toxicology refers to a short term exposure. It has nothing to do with either the severity of the exposure or the severity of the effect. The type of exposure occurring during an accidental chemical spill is properly described as an acute exposure.

Chronic Exposure
Chronic Exposure as used in toxicology refers to a long term exposure. Again, it has nothing to do with the severity of the exposure, the severity of the consequences, or the duration of the consequences. Chronic exposures can be the result of chemicals in the workplace, the home, or the environment. Chronic exposures are usually the result of carelessness, ignorance, or neglect, and not the result of an accident.

Local Exposure
Local Exposure refers to exposure limited to a small area of skin or mucous membrane.

Systemic Exposure
Systemic Exposure means exposure of the whole body or system, through adsorption, ingestion, or inhalation.

TYPES OF EFFECTS

Acute Effects
Acute Effects refers to the duration of the symptoms. Acute means symptoms lasting a few hours or days.
Again, it has nothing to do with the severity of the effects.

Chronic Effects
Chronic Effects are long term effects, manifested by prolonged duration and continuing injury.

Local Effects
Local Effects occur in a small area, at the place of contact.

Systemic Effects
Systemic Effects occur throughout the body, or at least away from the point of contact.

Allergies and Hypersensitivity
Allergies and Hypersensitivity are reactions by particular individuals to particular chemicals, caused by heredity or prior overexposure. Hypersensitive individuals should avoid exposure to the offending agents.

HOW CHEMICALS ENTER THE BODY

There are three main routes by which individuals can be exposed to chemicals:

Through Skin Contact
Oral Ingestion
By Inhalation

Through Skin Contact

Certain parts of the skin are more active than others, namely sweat and sebaceous glands, hair follicles, etc. and areas against which clothing rubs are particularly vulnerable. Localised irritation is most common form of complaint and is enhanced by chemicals which absorb moisture and dehydrate the skin. Corrosive chemicals cause varying degrees of injury from relatively mild attacks to severe burns. Toxic chemicals may be absorbed into the bloodstream after passage through the skin. Eyes are particularly sensitive area of the body and are irritated by the physical pressure of even the smallest object. When the material is corrosive and toxic pain and injury can be serious.

Oral Ingestion

Oral ingestion of chemicals, apart from the deliberate act, is mainly due to accidental occurrence or poor personal hygiene, and can be easily avoided.
If the victim is unconscious, turn their head or entire body onto their left side. Be prepared to start resuscitation if you are properly trained, but be cautious about exposing yourself to chemical poisoning via mouth-to-mouth resuscitation. If appropriate call for nearest trained resuscitator for immediate help or if available, use a mouth-to-mask resuscitator.
Call the Health Centre (South Side) immediately for advice on appropriate actions to be taken while awaiting emergency medical assistance. Explain the nature of chemical or chemicals and hazards as for as possible to the medical staff to get immediate assistance.

By Inhalation

Inhalation is the most common method of absorbing materials into body. A very large volume of air inhaled by an average person per day means that even the very small amounts of toxic material become important and very large surface area of the lungs increases the chances of the material being absorbed rapidly. Some even may be absorbed into the mucous lining of the air passage and be brought up in the sputum and swallowed, thereby presenting additional method of absorption.
If the victim is not breathing properly trained resuscitator should perform resuscitation until the medical help arrives. Be careful to avoid exposure to chemical poisoning via mouth-to-mouth resuscitation. If a mouth-to-mask resuscitator is available, use that instead of mouth to mouth resuscitation.
Evacuate the area and move the victim into fresh air and call the Health Centre (South Side) for advice and immediate medical assistance.

SPECIFIC CHEMICAL HAZARDS

Acetone and Flammable Solvents

Acetone is widely used throughout the facility. It is a very flammable solvent with a low flash point, (i.e. it can be ignited at a low ambient temperature). Because of this it presents a significant fire hazard. A spill of a gallon bottle of acetone could cause a catastrophic fire or explosion.

It should not be transported except in chemical buckets. Solvents should also be handled with care in the hoods and not used near hot plates. Spilled solvent can be ignited by the hot plates. The resulting fire could easily be drawn up into the exhaust ducts, again with catastrophic consequences.

Spilled solvents can react explosively with chemical oxidising agent present, e.g., peroxides, nitric acid. Spilled solvents should be contained immediately with chemical spillage absorbent. Seek help as required. If you require help please contact is *Dr Munir Ahmad (ext 46260).*

Hydrofluoric Acid

Hydrofluoric acid, HF, presents a significant hazard for personal injury. It is widely used in the semiconductor processing. It is only allowed in two designated wet benches, one in staff clean room and other in the chemistry lab. It is available in 40% concentration, diluted, and as the active component of buffered HF, Buffered Oxide Etch. It is used for etching silicon dioxide and for stripping the native oxide prior to further processing.

HF is a very hazardous chemical, much more so than any other acids we use. Its danger comes from its colourless, odourless appearance and its systemic poisoning.

At the concentrations used in the laboratory, a HF "burn" is initially painless. You may not even know that you have gotten a splatter on your hands, arms, face, or in your gloves. The acid however will silently eat away at your flesh. The fluoride ion is not consumed in this process and is soluble in tissue, so the damage penetrates deeper and deeper, until it comes to the bone. About this time the excruciating pain begins. It is too late, however, to reverse the considerable tissue damage. At some point, it enters your blood stream and goes everywhere scavenging Ca ions, totally messing up the ionic chemistry of your nervous system. At some point, if left untreated, you die.

Simple washing of HF splash is not sufficient to prevent damage. It does not wash off; it is already dissolving you and will continue to do so until you receive medical attention specific to HF burns (including deep injections to neutralise the penetrated acid). Be sure that medical personnel know that it is HF burn and know that it requires specific treatment different from a common acid burn.


HF burn (courtesy of UC Berkeley)

HF etches silicon dioxide as well as glass. It must not be kept in a glass bottle, used in a glass beaker or disposed in a glass waste bottle. Plastic laboratory ware is available for this purpose.

HF must only be used in the designated chemical hoods*. It is not acceptable to use HF or HF containing solutions in any other areas.*

Piranha mixture
Liquid piranha is a common name applied to a mixture of Hydrogen Peroxide and Sulfuric Acid (typically 1:5). It is extremely aggressive toward carbonaceous materials (e.g. flesh and photoresist residue, equally).

It also removes heavy metal contamination. It is also used for cleaning Si wafers.

We have difficulty disposing of this mixture because the waste continues to react and decompose for a long period of time. This builds up pressure in the waste bottles causing them to burst. Also if the solution is mixed very peroxide rich, one can make unstable compounds. Therefore, if you wish to use this mixture please make sure you mix only a minimum of the quantities you can live with.

Chlorinated Solvents (not in use but for information only)
Chlorinated solvents (chlorobenzene, trichloroethylene, and methylene chloride) are used in various resist processes. They are particularly bad for you, causing cancer, organ damage, etc. They should not be mixed with normal solvents in waste bottles. There are separate waste bottles for chlorinated solvents. As with most solvents, they can be readily absorbed through the skin.

Glycol Ethers
Commercial photoresists and electron beam resists are dispersed in a variety of solvents. The composition of these mixtures is generally not disclosed on the bottle; you must look on the

MSDS for it. One family of chemicals, the glycol ethers, commonly used in photoresists, masquerades under a variety of names. It is not often clear that many of these are the same chemical; oh, the wonders of organic chemistry nomenclature. In addition, the common trade name "Cellosolve" is often thrown in. Anyway,

Methyl Cellosolve
Ethylene glycol mono methyl ether
2-methoxyethanol
are all the same thing. Similarly,
Cellosolve
Ethyl Cellosolve
2-ethoxyethanol (2EE)
Ethylene glycol mono ethyl ether

are all the same solvent. To further complicate things, each solvent has an acetate relative, so we have

Cellosolve Acetate
Ethyl cellosolve acetate (ECA)
Ethylene glycol mono ethyl ether acetate
2-Ethyoxy ethyl acetate

which are again all identical. Members of this family of chemicals have been shown to be teratogens and have other effects on reproduction in laboratory animals. A number of recent studies funded by IBM and others have found evidence that these chemicals can lead to miscarriage and other reproductive effects. To quote from the MSDS for AZ 2131 Thinner (2 Ethoxyethyl Acetate and N-Butyl Acetate).

"In studies with laboratory animals, 2-ethoyxethyl acetate caused birth defects, increased foetal death, delayed foetal development, caused blood effects, testicular damage and male infertility."

The liquid and vapour are eye and respiratory tract irritants and may cause kidney damage, narcosis, and paralysis (in simple terms, it damages your kidneys, eyes, lungs and brains). Primary routes of exposure are inhalation, skin absorption, and skin and eye contact with vapours. N-butyl Acetate, the other component of this thinner, has a similar list of possible systemic effects.

As with all chemicals, these are only the effects we know about. These experimental laboratory exposures were large amounts but nonetheless it is prudent to be careful with these solvents. If after reading this section, you still do not have sufficient respect for these chemicals, please go back and read it again.

Manufacturers of resist have substituted this class of solvents with safer versions but still as a precaution please do not be sloppy with resist.

If you can smell resist in the resist room, somebody is doing something wrong!! Find out what it is and stop it. Users may have resist on their lab coats or have placed resist-contaminated trash in the waste basket. This is not acceptable.

The conclusion is that you should be careful with the use of even these seemingly innocent chemicals, wear the proper protective equipment, and work in a well ventilated area at all times.

Peroxides

All peroxides are highly oxidising materials. Considerable energy can be released in their reactions with common materials. Some peroxide compounds are unstable, and can explode. We have hydrogen peroxide in the facility. Extreme care should be used in mixing solutions containing peroxides. Peroxides are incompatible with all forms of organic solvents and flammable materials.

Chemical Spills

For small chemical spills use the chemical spillage absorbent material for cleanup. If unsure about the chemicals involved or how to handle the spill please call *Dr Steve Wright (46206) or Dr Tom Tate (46208) or Dr Munir Ahmad (ext 46260)* for help. For larger spills always call for help. Do not take unnecessary risks.
Always wear the appropriate personal protective equipment (e.g., lab coat, gloves, goggles) when cleaning up spills.

Acid Spills

Apply neutraliser (likes, calcium oxide, sodium bicarbonate) to perimeter of spill and mix thoroughly until fizzing and evolution of gas ceases. It may be necessary to add small amount of water to the mixture to complete the reaction because a neutraliser has a tendency to absorb acid before fully neutralising it. Make sure with litmus paper that the acid has been neutralised. Transfer the mixture into a plastic bag, tie shut, label, and place in a safe place.

Caustic Spills

Apply neutraliser to perimeter of spill and mix thoroughly until fizzing and evolution of gas ceases. Make sure with a litmus paper that the material has been completely neutralised. Transfer the mixture to a plastic bag, tie shut, label, and place in a safe place for disposal.

Solvent Spills

Wear face mask if appropriate and apply chemical absorbent to the perimeter of the spill and mix thoroughly until material is dry and no evidence of liquid solvent remains.
Transfer absorbed solvent to a plastic bag (if compatible), tie shut, label, and place in the fume hood as appropriate.

Mercury Spills

Using a mercury vacuum available through DES, vacuum all areas where mercury was spilled with particular attention to corners, cracks, depressions and creases in flooring or table tops.
Call DES for mercury vacuum delivery or pick-up.
To clean up small spills with a mercury spill kit, dampen the mercury sponge with water, then wipe the contaminated area.
Do this procedure slowly to allow for complete absorption of all free mercury. A silvery surface will form on the sponge.
Place the contaminated sponge in its plastic bag, tie shut, fill out and attach a waste label, and place in the fume hood. Notify supervisor or call DES for disposal.
For larger spills that cannot be cleaned up by lab occupants, call

Chemical Waste Disposal
Disposal of waste chemicals is an area of great concern and of great difficulty. Disposal of chemical waste is expensive. Generally, it costs more than the original cost of the chemical to dispose of the waste. Please buy use chemicals wisely and minimise waste.
All chemical waste is to be collected, consolidated, bottled and sent out as regulated chemical waste. Waste bottles are collected by Environmental group in Sherfield building and disposed off via a licensed waste disposal contractor. The waste is usually burned, neutralised, or buried in licensed facilities, in accordance with Health & Safety Executive rules.

Fire Safety

Familiarise locations of fire alarm pull stations and emergency phones.
All occupants must vacate the building in the event of fire or other emergencies.
Always use stairs for emergency evacuation.
Operations should be made secure before evacuation without placing personnel safety in danger.
All group members should assemble at the muster point outside the entrance of the building.

Small Laboratory Fires

Small fires should be extinguished safely by covering the fire with a fire blanket or using a fire extinguisher if the laboratory personnel is confident to do so.

DO NOT attempt to fight a fire that cannot be extinguished immediately.

If some one's attire is on fire the rescuer should instruct the victim to STOP - DROP - ROLL. Victims should also place their hands over their face.

The victim should NOT run to a fire blanket. If a fire blanket is available, it may be used by a rescuer to smother flames.

DO NOT use fire extinguishers to extinguish a person that is on fire.
DO NOT attempt to remove clothing from burned areas.
DO NOT put water on large burns.
Keep burned areas clean and dry.

Keep victim calm and call for help immediately.

First Aid Kits

There is a standard First aid kit in every laboratory. A typical first aid kit includes a variety of items specially selected to carry out emergency treatment of cuts, burns, eye injuries, or sudden illness. The first aid kit should contain individually sealed packages for each type of item. Contents of the kit should be checked periodically to ensure that expended items are replaced.

No oral medication (including aspirin) should be dispensed from the first aid kit without medical advice.

Emergency Assistance

Emergency assistance for all types of emergencies may be obtained during working hours by dialling the emergency assistance number.

COMPRESSED GASES

Compressed gases can be hazardous because each cylinder contains large amounts of energy and may have high flammability and toxicity potential.

Labelling & Information

Compressed gas containers are labelled in five ways:
Flammable gases are designated by a flame on a red label;
Non-flammable gas labels depict a gas canister on a green background
Poison gas labels depict a skull and crossbones
Oxygen-containing gases are designated by the letter "o"
Chlorine gas is distinctly labelled.

Know the contents of the cylinder and be familiar with the properties of the gas.
The contents of the cylinder or compressed gas should be clearly marked and identified with proper labels or tags on the shoulder of the cylinder.

Those cylinders or compressed gases that do not comply with identification requirements should be returned to the manufacturer.

Label all empty cylinders "EMPTY" or "MT" and date the tag. Treat an empty cylinder in the same manner that you would if it were full.

All regulators, gauges, valves, manifolds, must be designed for the particular pressures and gases involved.

Storage & Handling

All cylinders should be stored in cool, dry, well-ventilated surroundings and away from all flammable substances including oil, greases, and gasoline. DO NOT subject any part of a cylinder to high temperatures.
Cylinders should not be located where objects may strike or fall on them.
Keep a minimum number of cylinders on hand.
All cylinders and compressed gases (full or empty) should be properly fastened and supported by straps, belts, buckles or chains to prevent them from falling and causing bodily harm or becoming a projectile.
Close valves and relieve pressure on cylinder regulators when cylinders are not in use.
Valve handles must be in place when cylinders are in use.
DO NOT smoke in areas where there are flammable gases.
DO NOT extinguish a flame caused by a gas until the gas source has been shut off.
A cylinder should only be moved when the regulator is removed and strapped to a wheel cart to ensure stability. When storing or moving cylinders, always attach safety caps.
Compressed gases must be handled as high-energy sources and dangerous projectiles.

All cylinders should be checked for damage prior to use. DO NOT repair damaged cylinders yourself. Damaged or defective cylinders, valves, etc., must be taken out of use immediately and returned to the manufacturer for repair.
Each regulator valve should be inspected annually. Never force valve or regulator connections. Threads and the configuration of valve outlets are different for each family of gases to prevent mixing of incompatible gases.
When opening a cylinder, direct the cylinder opening away from personnel and open slowly.
DO NOT use lubrication on valve regulators.
Do not alter cylinder labelling.
Do not alter the cylinder pressure by use of an external heat source.
If an inert, flammable or toxic gas cylinder develops a **small** leak at the valve, carefully remove the cylinder and return it the supplier with a note about the defect.

CRYOGENIC MATERIAL

Cryogenic materials have special properties that make them particularly hazardous to use in the solid, liquid or gaseous states. They are characterised by severe low temperature (-60^{o}C to –270^{o}C). Cryogenic temperatures are achieved by liquefaction of gases, most commonly helium, hydrogen, nitrogen, argon, oxygen or methane.

Storage & Handling

The severely cold temperatures associated with cryogenic liquids (-60^{o}C to -270^{o}C) can damage living tissue on contact and embrittle structural materials.

Liquefied under pressure, cryogenic liquids must be kept in specially designed, high-pressure vessels that contain fittings to relieve overpressure. When located in moist areas, ice formation can plug pressure release devices and pose an explosion hazard. For this reason, store vessels in a dry place and periodically check for ice formation.

Cryogenic liquids present fire and explosion hazards. A flammable mixture, cooled in the presence of air with liquid nitrogen or liquid oxygen, can cause oxygen to condense and thereby present an explosion hazard. Keep away from ignition sources. Flammable liquids will support combustion in both the liquid and gaseous states. If allowed to depressurise, cryogenic liquids will rapidly and violently expand.

Store and work with cryogenic liquids in a well-ventilated area to prevent the accumulation of flammable, toxic or inert gases as evaporation and condensation occurs near the cryogenic tank. Safety glasses and face shields should be used. For handling of cryogenic liquids, use appropriate thermal gloves.

Cushion glassware in a protective covering to prevent injury caused by flying glass in the event of implosion/explosion.
Transport fragile cryogenic containers with caution.
Vent cryogenic storage containers outdoors or into a chemical fume hood system.
Cryogenic gases always pose high pressure hazard since they are stored near boiling point. Liquid to gas evaporation causes high pressures to build up.

Solo Working

Solo work is not encouraged or allowed.

INFORMATION AND TRAINING

All laboratory personnel have the right to be informed and trained on the chemical hazards present in their work area. The responsibility for apprising laboratory workers of the necessary precautions to take when using or handling hazardous materials rests with the supervisor and incharge of the laboratory. Ultimately your safety in the lab depends on you! So take the time to learn about the hazards, the precautions to be taken, and carry out your role safely. If you have questions, ask your supervisor, or Dr Tom Tate or Dr Munir Ahmad.

MATERIAL SAFETY DATA SHEETS (MSDS)

MSDS are a major product-specific information resource for chemicals purchased for use in laboratories. Health & Safety Executive requires chemical manufacturers and importers to produce MSDS for each hazardous chemical they manufacture or import. All suppliers will supply MSDS with their product. It can also be accessed via their Web-Site e.g.
www.sigma-aldrich.com ,
www.vwr.com etc.

MSDS usually have the following information:
The identity of substance designated on the container label.
Single substance: chemical and common names.
Mixtures tested as a whole: chemical and common names of all ingredients which are health hazards, in concentrations of 1% or greater.
Mixtures untested as a whole: chemical and common names of all ingredients which are health hazards and which are in concentrations of 1% or greater; carcinogens in concentration of 0.1% or greater; hazard determinations are based upon the characteristic of the individual products instead of the combined mixture.
Physical and chemical characteristics of the hazardous chemicals.
Physical hazards (potential for fire, explosion, etc.)
Known acute and chronic health effects and related health information.
Primary routes of entry into the body.
Information on exposure limits.
Whether a hazardous chemical is considered a carcinogen by OSHA, the International Agency for Research on Cancer, or the National Toxicology Program.
Precautions for safe handling.
Generally acceptable control measures (engineering controls, work practices, personal protective equipment).
Emergency and first aid procedures.
Date of MSDS preparation, or most recent change.
Name, address, and phone number of the party responsible for preparing and distributing the MSDS.

A MSDS may be used for similar mixtures with essentially the same hazards and contents.

*A selection of **Safety Data Sheets (SDS)** for chemicals or reagents commonly used in our laboratories are available asa hard copy in the Wolfson cleanroom.*

CLEAN ROOM WORKING AND SAFETY

Clean rooms are a multi-user facility and they houses expensive, delicate and fragile equipment. They also houses chemicals which pose significant hazards if handled incorrectly. This booklet attempts to document acceptable operating behaviour from all users. It is impossible, however, to define a policy for every conceivable situation. Rules and policies are no substitute for common sense. Under these conditions, anyone who fails to act in a safe and responsible manner may be banned from further use of the clean rooms.

If you have any suggestions please feel free to communicate to

Dr Zahid Durrani
Dr Steve Wright
Dr Tom Tate
Dr Munir Ahmad

All laboratories operate under COSHH regulations. The COSHH establishes the rights of laboratory workers and mandates training programs, monitoring and other actions by the laboratory. Compliance with the provisions of the COSHH Laboratory Standard are detailed below and are mandatory. Laboratory Workers are expected to have a technical level sufficient to understand everything in this guide.

Any questions regarding your rights under the COSHH Lab Standard should be directed to the above personal.

Other requirements of the Lab Standard are:

- Training for all laboratory workers in Hazard identification and safe operating practices.
- Standard Operating Procedures.
- Medical Examinations or consultations for laboratory workers under certain conditions.
- Training and availability of Personal Protective Equipment.
- Application of appropriate Engineering Controls to limit employee exposure.
- Special precautions/procedures for particularly hazardous materials.
- Exposure monitoring when appropriate.
- Record keeping.

General Procedures

User Orientation
An orientation and training process is required before any new user may work in clean rooms. An orientations sessions may be arranged with Dr Munir Ahmad or Dr John Stagg.

In general, this may involve:

> An individual is taken through the laboratory, discussing general rules, safety procedures, etc. This will follow an introduction to basics of the laboratory safety, chemistry and chemical safety. Emphasis is on safe use of chemicals and chemical safety protective equipment. This may be carried out with a small group.

Have completely read and understood this Lab Safety Manual?
Have their own clean room clothing?

In addition to the initial orientation, there will be training available as required depending on the nature of the work to be carried out by a research worker.

Clean Room Etiquette

A clean room also includes the changing room area. To enter a clean room users must be properly attired. Users must follow a proper procedure for gowning in order to avoid generating unnecessary particles in the clean room. Unnecessary items may not be taken into the clean room. Shoes should be properly clean before using shoe covers.

Clean Room Facilities

Special ventilation equipment is used and extensive housecleaning procedures are implemented to assure some level of cleanliness in clean rooms. The number of users, the informality of our operations, housekeeping inside and service areas of clean rooms limits the cleanliness level attainable in clean rooms. A design compromise is also made to reduce construction and operation costs.
The clean room is nominally Class 1000; i.e., fewer than 1000 particles larger than 0.5 micron per cubic foot of air.
Outside air intake for the clean room is taken from the corridor, between the Gets end of the chemistry laboratory. Smells from these areas are also drawn into the clean room. Because of the large air recirculation, all smells permeate the clean room quickly and can be hard to localise. In spit of this all strong new odours in the clean room should be investigated thoroughly as they may be due to a fire, chemicals or a gas leak. Each clean room has a separate ventilation air supply. The supply and return are balanced to provide proper air flow and pressure for the room. Do not block the doors of the rooms open as this disturbs the air flow balance.

Clean Room Functions

Contamination Control

The primary limitation to clean room cleanliness is the people using the clean room. Your clothes, your feet, your skin, and your hair produce particulates which may compromise your research goals. By industrial standards, we have very lax clean room procedures. However, strict adherence to rules and common sense allow us to maintain a level of cleanliness adequate for the types of work done in our group.

A few obvious rules are:

- Do not bring anything into the clean room which is not absolutely necessary for the work you are doing.
- Socks or nylons must be worn along with regular shoes. Sandals, cleated sole shoes or boots are not allowed.
- Do not use pencils or erasers in the clean room.
- Remove outside coats and place outside the changing area. Changing room area are for clean room coats only.
- Do not wear dirty clothes, particularly soiled boots or shoes into the clean room.
- Unpack cardboard boxes outside the clean room. Do not take packing material inside.
- Newspapers may not be brought into the clean room.
- Clean off equipment, parts, tools, etc. before bringing them into the lab.

Approved Users

There is a variety of equipment for processing and analytical work in clean rooms. Most are complex and delicate. Each piece of equipment is under the charge of a staff member and or a designated member usually an RA. That designated member will train users on that instrument. When he/she is satisfied, the user will be authorised to use the system without further supervision.

This hands-on access is considered as an important part of the educational process. Each instrument necessarily has rules and operational procedures that are set by the staff to assure the continued and safe operation of the equipment. Violation of these procedures or carelessness in operation can result in damage to the equipment, down-time and considerable expense.

The wet chemical hoods may be treated as any other "instrument". You must familiarise yourself with the working of wet chemical hoods before you start using them. You are required to attend these sessions on chemical safety and chemical use prior to using any chemicals in the facility.

Equipment booking

Some of the equipment requires a booking in advance and depending on the demand, there may be a limit on the length of a session and the amount of time you may book in advance. All users are expected to adhere to the booking guidelines. For efficient use of equipment please cancel unneeded reservation. All projects require a certain process flow between instruments so one problem can throw off your entire process schedule. Also, sometimes a process can take longer than anticipated therefore please be flexible and cooperative with other users in stretching, sharing, and relinquishing time slots.

Visitors and Guests

You are discouraged from taking casual visitors in the clean room. All visitors using any equipment or laboratory facility must be booked into the **visitor's book available in Wolfson Cleanroom** and escorted and coordinated by the host with other users to avoid conflict for resources. You are also responsible for the actions and safety of your visitors and guests.

Problems
Problems with equipment malfunctions, breakage, etc. should be reported to the designated member of the staff or the RA responsible for that piece of equipment. Please do not try to fix or adjust anything, you are not responsible for, as most of the equipment is very expensive and much of it is very delicate. Considerable damage can be done at a great cost of both money and downtime by careless attempts to fix things. There is no reason for any one to use a tool on anything, which he or she is not responsible.

Other House Services
Compressed air, laboratory vacuum, and house dry nitrogen gas are supplied throughout the laboratory. Compressed air is used for blow drying and actuating pneumatic valves on certain machines. House nitrogen is obtained from a nitrogen generator run in conjunction with air compressor. Currently it is only used for venting vacuum systems, for vacuum pump purges, for blowing off wafers etc in the STS ICP RIE kit. Rest of the equipment and processes use bottle nitrogen.
Vacuum cleaning is carried out by a special sealed clean room compatible vacuum cleaner. Deionised water is available in all the chemical benches in the fat grey plastic taps. Just because DI water comes from a tap does not mean it is free or inexhaustible. Please do not leave DI faucets running unnecessarily.

Chemical Bench Operation

The wet chemical benches (hoods) where chemicals are used in the facility are not like the exhaust hoods in the chemical laboratory. They are designed firstly to be clean benches, with laminar air flow, with only secondary consideration to ventilation and exhaust.

The air flow is such that when improperly used a considerable amount of fumes can be blown into the room. First, you must work well inside the hood, away from the front edge or chemical fumes will be blown into the room. You must also not unnecessarily block the array of little holes in the work surface. They are the exhaust holes. This disturbs the airflow in the entire hood. If you are using the hoods properly, you should not be able to smell chemicals outside the wet benches.

Chemical Bench Use Rules
All chemical operations are to be done in the chemical/clean benches. You are expected to clean up wet benches after use. Do not leave beakers, petri dishes, chemical or liquid residue in the wet benches. The work surface should be clean and dry when you start, and clean and dry when you leave. The next user has no idea if that puddle of clear liquid is HF or just water.

Please adhere to these rules:

- Please keep the wet chemical hoods clean, neat, and dry, before and after use.
- Chemicals must not be used until the SDS is read and understood.
- Waste containers must be overfilled. Always leave about 2 – 3 inch air space at the top. Empty it into waste solvent drum in the chemistry laboratory.
- Please use Nitrile gloves for all chemicals.
- Please wear appropriate personal protection equipment when handling chemical waste.
- All incidents must be corrected and reported on a time scale appropriate to the severity of the event.
- Thoroughly rinse empty chemical bottles before disposal.

Reminders and Final Checklist

Common sense is the most valuable aid you have in working with chemicals. If you are unsure, either don't do it or ask one of the staff. It is impossible to enumerate all the rules and cautions applicable to chemical use, but here are a few more to consider:

- Always add acid to water.
- Perform all chemical operations carefully. Moving, mixing, pouring.
- 24 hours maximum parking of "cooling" beakers in hoods. Empty them as soon as possible.
- Chemicals must remain under the hoods. Move them around inside, not outside.
- Keep your head above the bottom of the Plexiglas guard especially when mixing, pouring, and heating.
- Don't leave gloves lying around- store them or pitch them.
- Don't sit down at the hood, it puts your face directly in the fume path.
- Finish open chemical bottles before opening new ones.
- Put the correct caps on waste bottles. There are at least two different kinds, vented and unvented.
- Don't use blow guns near open chemicals.
- Don't use chemicals in shallow sloppy containers.
- Don't use plastic beakers on hot plates. (yes, people have done this!)
- Clean up after yourself and be careful.

Clean room Hot Plates

While you may think hotplates are mundane, they can in fact be very dangerous when used in chemical hoods. Fires and melt down of the plastic hoods are both significant concerns. The following rules apply to hotplate use.

- Hot plates used for heating chemicals must be attended. You must be in the clean room and near the hot plate whenever it is plugged in. All hotplates available in the facility have special plugs, which fit only in special outlets in each hood. These electrical outlets are on timers. You must reset the time every 15 minutes or the hot plate will shut off.
- The wafer baking hot plates are not to be used with chemicals.
- You may not heat solvents with flashpoints of <130 F.
- No user hot plates may be brought into the facility to defeat the imposition of timers.
- There are no Mercury thermometers in the facility, due to the hazards after breakage. Only electronic thermometers are to be used.

The Bottom Line on Safety

Safety is an overriding concern in all laboratory activities. All operations must be undertaken with the safety of both the individual user and other users as the primary consideration. While it may be difficult for some to understand, operating safely is more important than getting your experiment done, or, in fact, than getting anything done. As a general rule, anyone violating any safety rule or otherwise compromising his or her personal safety or the safety of others may be denied access to the laboratory.

Ignorance of the rules, lack of common sense, language difficulties, carelessness, and haste are not adequate excuses for unsafe behaviour. Safety violations could mean a long delay in the project.

Student Storage

A limited amount of storage space, mostly in the form of small drawers, is available in clean rooms, typically, one to three drawers are enough per researcher. These should be used for keeping only currently needed samples, masks, etc. Please do not store junk, old samples and masks, and everything you ever did since joining the group.

No chemicals of any kind may be stored in these drawers. Chemicals are to be stored only in chemical cabinets. Private stocks of glassware are not to be kept in these drawers. Please use your storage space wisely. Please label things with your own name and date. All items belonging to former students or staff must be removed from the drawers and handed over to respective member of academic staff for keeping or disposal.

Before you sign this please make sure you have understood all aspects of laboratory and chemical safety and you are confident enough to use equipment and chemicals.

Declaration:

I have read the safety manual and familiarised myself with the laboratory, equipment and chemical safety issues. I have acquired the knowhow and have all the necessary training for safe working in the laboratory and I shall adhere to all safety guideline and safe practices during my laboratory work.

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