University of
St. Andrews

Guidance on Chemical and Biological Safety

Part 1 - Chemical Safety

Environmental, Health and Safety Services (June 2011)

Contents

1.0 INTRODUCTION

1.1 Preface.

The Control of Substances Hazardous to Health (COSHH) Regulations, which were first enacted in 1988, initiated a management system to control the use of all hazardous substances at work. The revised COSHH (2002 as amended) Regulations also include biological agents and amendments to the definition and use of carcinogens.

This booklet, Part 1, provides advice and guidance on the control of substances hazardous to health and on the control of carcinogenic substances. Guidance on biological agents and genetic modification is provided in Part 2.

The key feature of the legislative management system is the requirement to formally assess the risk of the substance to the health of employees / environment and then introduce control measures to protect their health. These controls measures must include suitable information, instruction and training. Where required, the control measures should include monitoring of exposure to the hazardous substance and also health surveillance.

Safety legislation increasingly places emphasis on the assessment of risks within a workplace, not just for hazardous substances. The underlying principles of risk assessment and implementation of control measures are defined under the Management of Health and Safety at Work Regulations (1999) (MHSWR). The MHSWR has a wide ranging requirement for assessing all risks within a workplace. An assessment made under COSHH is considered to fulfill the requirements of the MHSWR, thus, with respect to the hazardous substances used, no further risk assessment need be performed. The management system for COSHH should, therefore, be integrated into the arrangements made for compliance with the MHSWR. Where there are other risks as well as chemical risks, these should be incorporated into one risk assessment (for example manual handling risks when handling large quantities of chemicals).

The arrangements for managing the use of hazardous substances within a School/Unit will be detailed in the School/Unit Safety Policy.

1.2 University Chemical and Biological Hazards Management Group.

The Chemical and Biological Hazards Management Group fulfills, for the University, all of the legal requirements pertaining to the use of hazardous substances. Membership and remit of this Group is given in the University Health and Safety Policy (2010).

1.3 Summary of the COSHH Regulations (2002 as amended)

1. The COSHH Regulations impose duties on the University to protect staff and students from the hazards of working with ‘Substances Hazardous to Health’.

2. Regulation 2 of the COSHH Regulations defines a ‘Substance Hazardous to Health’ as:

    a) a substance which is listed in Part 1 of the Approved Supply List as dangerous for supply within the meaning of the Chemicals (Hazard, Information and Packaging for Supply) Regulations

and for which an indication of danger specified for the substance is Very Toxic, Toxic, Harmful, Corrosive or irritant;

b) A substance for which the Health and Safety Commission has approved a Workplace Exposure Limit

c) A biological agent;

d) Dust of any kind, when present at a substantial concentration in air;

e) A substance, not being a substance mentioned in sub-paragraphs (a) to (d) above, which creates a risk to health.

3. The regulations include:

a) Work with biological agents. A biological agent is defined as 'any micro- organism, cell culture or human endoparasite, including any which have been genetically modified, which may cause any infection, allergy, toxicity or otherwise create a hazard to human health'.
Note: Naked DNA is **not** considered to be a biological agent;

b) Amendments to the definition of a carcinogen and to guidance on the prevention of occupational cancers;

c) The separate publication of Workplace Exposure Limits

5. The Head of the School/Unit must implement procedures are in place to ensure that no work is performed until suitable and sufficient risk assessments on 'substances hazardous to health' are completed. Each Head of School/Unit will implement this University Policy for controlling 'substances hazardous to health'.

6. The risk assessment process contains the following elements:

a) Identify substances hazardous to health;
b) Assess the risk of the 'substance hazardous to health';
c) Develop control strategies which will minimise exposure to this substance;
d) Record the findings;
e) Monitor the effectiveness of the control strategies;
f) Review the assessment at regular intervals.

More details on performing risk assessments can be obtained from the Director of Environmental, Health and Safety Services.

The University has produced a computer software package for performing COSHH risk assessments. This system called CHARM will be discussed in later sections of the guide. This programme can be accessed at the following URL:

http://charm.st-andrews.ac.uk/COSH/

7. Exposure to hazardous substances must be kept as low as is reasonably practicable. To control exposure to hazardous substances, COSHH defines a Workplace Exposure Limit (WEL) which is based on the concentration of the substance in the air.

The HSE regularly reviews WELs for substances and defines these limits in the publication entitled EH40/(Relevant Year) Occupational Exposure Limits. A School/Unit should purchase a copy of this publication if it

intends to work with substances hazardous to health. A copy of EH40 can be downloaded from:
http://books.hse.gov.uk/hse/public/saleproduct.jsf?catalogueCode=9780717629770

8. Procedures must be established at the School/Unit level to ensure that the controls measures are effective and being suitably implemented.

9. Where Personal Protective Equipment (PPE) must be issued as a requirement of a risk assessment, then written specified procedures should be implemented to ensure that the correct PPE is issued, that suitable instruction and training in the use of the PPE provided and if respiratory protective equipment (RPE) is issued, then ensure that the RPE has been suitably face fitted. Guidance on PPE is given in the University publication entitled: 'The Selection, Use and Maintenance of Personal Protective Equipment (PPE)'. A copy of this document is available at:
http://www.st-andrews.ac.uk/media/PPE-Policy-04-11-2008.pdf

or from the Director of Environmental, Health and Safety Services.

10. Information, instruction and training is necessary for all those whose work may involve exposure to substances hazardous to health. It is vital that this is given not only to regular workers but to infrequent workers e.g. maintenance staff, cleaners etc..

1.4 Summary of the Risk Assessment Process.

A risk assessment should be performed when a hazardous substance is used in the workplace. Only one risk assessment need be performed for a procedure which uses several different substances.

The University has implemented an electronic record keeping system for COSHH risk assessments entitled 'CHARM'. The first step in carrying out a risk assessment is to obtain a hazard rating for the substances to be used. A University approved list of hazard ratings is published and may be viewed on the electronic COSHH management system. Details of the rating system and the criteria used for hazard ratings is given in Section 2.2.

Having obtained the hazard ratings the electronically produced risk assessment form should be completed.

Note: Substances hazard rated 1 are deemed to be a minimal hazard to employees, thus do not require a written risk assessment to be performed.

Prior to any work with a hazardous substance, a form should be completed and electronically signed by the assessor and by those workers also named in the risk assessment. This signed form is then electronically sent to the Supervisor named in the risk assessment who can then approve the risk assessment if they deem it suitable and sufficient'. If the project requires the use of category 5 substances, then the risk assessment is automatically sent to the School/Unit/Building Safety Co-ordinator so that they can approve the project on behalf of the School/Unit. The risk assessment is only valid if it has been appropriately signed and dated. The electronic COSHH risk assessment system can be accessed via the following URL

http://charm.st-andrews.ac.uk/COSH/

Guidance on the use of the CHARM programme can be obtained at the following websites:

http://charm.st-andrews.ac.uk/COSH/docs/4CHARM_User_Notes.pdf

http://charm.st-andrews.ac.uk/COSH/docs/3aGuidanceNotesCOSHH.pdf

The procedure for performing a COSHH risk assessment on a hazardous substance is summarised as follows:

1. Gather information about the substance(s) and the procedures to be used.

    a) Decide who will carry out the assessment;
    b) What substances are present - or likely to be present;
    c) Identify the hazards of these materials.

2. Evaluate the risks to health. Find out:

    a) The chance of exposure occurring;
    b) What level of exposure could occur;
    c) How long the exposure goes on for;
    d) How often the exposure is likely to occur;
    e) Who could be exposed to these materials.
    f) What are the potential effects on workers the hazardous substance may have

3. Determine the necessary control measures required to eliminate or minimise exposure to the substance. Control measures should be prioritised as follows:

    a) Eliminate use of the substance; **if this cannot be achieved then -**
    b) Substitute the substance by a less hazardous one; **if this cannot be achieved then -**
    c) Introduce engineered controls e.g. local exhaust ventilation; **if this cannot be achieved then -**
    d) Introduce specific systems of work e.g. permits to work;
    e) Provide supervision, information, instruction and training;
    f) As a last resort, issue Personal Protective Equipment (PPE).

    NOTE: Where local exhaust ventilation is used as a control measure in COSHH (e.g. a fume cupboard), then it must be tested every 14 months under this legislation.

4. The assessment should be recorded on the University COSHH form. This form **must** be signed by all relevant people before it is valid.

5. Review the assessment at regular intervals.

Specific information which will help in producing COSHH risk assessments can be obtained from EH40, Material Safety Data Sheets (MSDS), which give details on the hazardous properties of the substance and must be supplied by the manufacturer/supplier, Advisory Committee on Dangerous Pathogens publications as well as information available from Environmental, Health and Safety Services.

More detailed information on risk assessments can be obtained from the Director of Environmental, Health and Safety Services.

1.5 Classification and Labeling of Chemicals

Under previous legislation, all hazardous chemicals were labelled with an orange label which identified the type of hazard (see Table 1).

All over the world, however, there were different laws on how to identify the hazardous properties of chemicals ('classification') and how information about these hazards is then passed to users (through labels, and safety data sheets for workers).

This has now been harmonised through the United Nations in a system called the 'Globally Harmonised System' (GHS).

The UN GHS has been implemented in Europe through a European Regulation entitled Classification, Labeling and Packaging of Substances and Mixtures (CLP) which is enacted in the UK through the Chemicals (Hazard Information and Packaging) for Supply Regulations 2009. The UK legislation will be repealed when the European CLP regulation is fully enacted in 2015.

The GHS system uses different type of hazard pictograms on bottles which is shown in Table 1:

Table 1 - Comparison of Old Chemical Label symbols and new GHS Labels

Old Pictogram		Type of Hazard	New Pictogram
	**E**	Explosive	
	**O**	Oxidiser	
	**F**	Flammable	
	**T**	Toxic	
	**Xi**	Harmful	
	**Xn**	Irritant	
	**C**	Corrosive	
	**N**	Dangerous to the Environment	
		Gas Cylinder	
		Long term health risk eg respiratory sensitiser, carcinogen, teratogen	

Manufacturers or suppliers must provide details of the risks of chemicals and actions to be taken in an emergency. These are supplied in documents called Material Safety Data Sheets (MSDS). These can be supplied as paper copies or electronic copies.

Under previous legislation, the MSDS included phrases which identified the risk of a chemical (R Phrase) and a phrase which identified actions to to take, called a Safety Phrase (S Phrase). Appendix 1 lists the R phrases.

The European CLP legislation is gradually replacing (must be completely changed by 2015) R Phrases and replaced them with Hazard Statements (H Statements). These are similar but not identical. A list of Hazard Statements can be found on the Sigma Aldrich site at the following URL:

http://www.sigmaaldrich.com/etc/medialib/docs/promo/General_Information/1/h_overview.Par.0001.File.tmp/h_overview.pdf

Similarly, the new CLP legislation is gradually replacing the Safety Phrases with Precautionary Statements. A list of Precautionary Statements can be found on the Sigma Aldrich website at the following URL:

http://www.sigmaaldrich.com/etc/medialib/docs/promo/General_Information/1/p_overview.Par.0001.File.tmp/p_overview.pdf

The MSDS will include a lot more information which should be used to determine the hazards and potential risks of the chemical.

1.6 Emergency Procedures.

1.6.1 General Fire Procedures

In the event of a fire, follow the instructions on the blue 'Fire Action' notices which are posted in your School/Unit and any special instructions issued by the School/Unit. The Material Safety Data Sheet (MSDS) will also include details of what actions to take in the event of a fire or spillage of a chemical

1.6.2 Fire in a Fume Cupboard.

In the event of a fire in a fume cupboard, close the sash of the cupboard, then switch off the extraction fan and then raise the alarm by the nearest call point. You should then comply with the normal 'Fire Action' notice (see section 1.6.1).

Note: Within certain School/Units special procedures, which differ from the above, may be in place.

1.6.3 Release of Toxic Gases or a Major Spillage of a Hazardous Substance.

i) Do not attempt a clean-up operation unless you are confident you can do this without any risk to yourself or others;
ii) Evacuate the room or, if necessary, the building;
iii) Call the Fire Brigade: **Dial 9-999**;
iv) Ensure that an appropriate person is delegated to meet the Fire Brigade and provide any additional information which they may require e.g. the exact

location of the accident and the specific hazards which Firemen may be exposed;

v) **Do not return to the room unless authorised to do so by the senior Fire Officer present.**

vi) Ensure that all relevant janitorial, trades or contract staff, particularly those who work outside of normal hours, are made aware of any restriction on the entry to the building or particular area.

1.7 Reporting Accidents and Near Misses

All accidents and near misses involving hazardous chemicals should be reported to the Director of Environmental, Health and Safety Services using the appropriate form which can be downloaded from the URL:

http://www.st-andrews.ac.uk/media/Accident-Rep-Form.doc

This report should give concise details of the incident and any injuries sustained. Severe injuries have to be reported to the Health and Safety Executive (HSE) under the Reporting Injuries, Diseases and Dangerous Occurrences Regulations 1995. It should also give details of any time off work as the University must report accidents where a worker has been injured at work and is off work for more than 3 working days. Reporting of such accidents will be done by the Director of Environmental, Health and Safety Services.

All accidents should be investigated to identify the cause(s) and put in place appropriate measures to stop such an incident occurring again. Minor incidents should be investigated by the School/Unit Safety Co-ordinator or a Depute. Serious incidents will be investigated by a nominated person from Environmental, Health and Safety Services in conjunction with the School/Unit Safety Co-ordinator.

2.0 CHEMICAL SAFETY

2.1 Organisation and Duties

The structure of the management system for Health and Safety is given in the University 'Health and Safety Policy' (2010). This can be viewed at the following website:

http://www.st-andrews.ac.uk/media/Approved HS Policy Final.pdf

The Head of the School/Unit is responsible for implementing the University Policy on controlling substances hazardous to health, and to ensure procedures are in place to monitor compliance with the University Policy. The Head may delegate specifically defined duties to other members of staff.

Specialist advice on chemical safety is available from the University Chemical Safety Adviser. Communication with the University Chemical Safety Adviser should normally be through the Director of Environmental, Health and Safety Services.

As part of their training, all postgraduate and final year undergraduate students should receive appropriate training in COSHH risk assessments from the School/Unit.

The School/Unit Safety Policy should, in compliance with sections 1.3 and 1.4, include a section on the identification and control of hazardous substances within the School/Unit. In compliance with the aforegoing sections 1.3 and 1.4, the policy should ensure:

i) implementation of the University Policy on controlling substances hazardous to health which requires that a suitable and sufficient risk assessment should be performed and signed by all relevant people before any work can be initiated;
ii) whethe systematic elimination or reduction of risks from substances hazardous to health;
iii) the control of exposure to hazardous substances by means other than Personal Protective Equipment (PPE);
iv) that substances with a WEL are controlled so as to reduce the levels of the relevant substance to below this limit;
v) that, where appropriate, a suitable maintenance regime is implemented for general and local exhaust ventilation systems (e.g. fume cupboards, microbiological safety cabinets);
vi) that, where appropriate, suitable guidance is produced for the selection, issue, use and maintenance of Personal Protective Equipment (PPE);
vii) where appropriate, that suitable health surveillance for employees is provided;
viii) that suitable and sufficient information, instruction, training and supervision in the use of hazardous substances is provided;
ix) that regular reviews of risk assessments are carried out;
x) that regular reviews of the School/Unit arrangements for the compliance are carried out.

2.2 Criteria for the University of St Andrews Hazard Rating System for Chemicals and other Substances

The University has developed a system of Hazard Assessment which is expressed as a hazard rating according to the following five point scale:

5 = highly hazardous
4 = hazardous
3 = moderate hazard
2 = low hazard
1 = no significant hazard

The nature of the hazard(s) involved will be indicated by adding letters as follows:

A = corrosive or irritant	C = carcinogenic
F = flammable	O = oxidising agent
T = toxic	X = explosive
M = mutagenic	R = radioactive

Each substance in use in the University has been assigned a hazard assessment code and this is available on the computerised Risk Assessment Management System. The hazard ratings can be accessed through the following procedure:

In the CHARM programme, go to the search mode and then begin by typing in the name of the chemical or biological organism to be used. In doing this, relegate all numbers, letters and brackets which describe isomers to the end and be careful as to what should be a separate word. In accordance with the 1990 decision of

IUPAC, sulfur, aluminium and caesium and all derived names should be spelled as such. Examples:

ethyl acetate but ethylbenzene dipropylphenol 2,4- -iso-
cytosine glucopyranoside 1-alpha-D-
ethyl chlorophenylacetate (±)- alpha-
bis(diphenylphosphino)butane 1,4-

Once the hazard rating of the substance is determined, a risk assessment of the procedure should be performed using the University electronic risk management system. Guidance on completing the COSHH forms on the CHARM programme is given at the following websites:

http://charm.st-andrews.ac.uk/COSH/docs/4CHARM_User_Notes.pdf

http://charm.st-andrews.ac.uk/COSH/docs/3aGuidanceNotesCOSHH.pdf

If after trying all possible alternative names and spellings the programme does not find a chemical, you should open the weblink entitled: 'Suggest a Chemical'. This will involve entering the name of the substance in the 'New' section of the CHARM programme so that the hazard assessment code can be confirmed or assigned by the University Chemical Safety Adviser.

One piece of information which can be used in assessing the hazard of a chemical is the Risk Phrase given to the chemical/product by the manufacturer in the Materials Safety Data Sheet (MSDS). The MSDS will include details of Hazard Phrases as set by the European Chemical Agency or older R (risk) phrases which are detailed by UK legislation which has now been repealed. Appendix 1 gives a list of R phrases and their meaning. A list of Hazard Statements under the UN GHS system can be viewed at:

http://www.sigmaaldrich.com/etc/medialib/docs/promo/General_Information/1/h_overview.Par.0001.File.tmp/h_overview.pdf

It is stressed that each substance in use in the University must be assigned an official hazard assessment code approved by the University Chemical Safety Adviser. According to local rules in various Schools and Units, work with a new substance may or may not begin while confirmation of a provisional code is awaited. However under no circumstances should any person attempt to assign their own codes and then proceed as though they were official without entering them in the "New" section of the CHARM programme.

As a rough guideline for the assignment of provisional hazard ratings the following examples may be used:

Toxic substances

5T Substances with an WEL of less than 1 ppm or mg/m^3 or EC risk phrase 'very toxic' and all ‘Controlled’ substances as defined in the Misuse of Drugs Act 1971 (and subsequent amendments);

4T Substances with an WEL of between 1 and 10 ppm or mg/m^3 or EC risk phrase 'toxic';

3T Substances with an WEL of between 10 and 100 ppm or mg/m^3 ;

2T Substances with an WEL of between 100 and 1000 ppm or mg/m^3;

Carcinogenic and mutagenic substances

5T,C Substances defined as carcinogens in the current EH40 or other proven human carcinogens;

4T,C Substances not listed in the current EH40 but which may result in the development of cancer in humans;

M Substances which have clearly demonstrated mutagenic properties likely to be a significant hazard to humans.

It should be noted that relevant legislation define three categories of carcinogens for the purposes of classification and labelling:

1. Category 1 Carcinogen**:** Substances known to cause cancer in humans (University Hazard rating of 5 C,T);

2. Category 2 Carcinogen**:** Substances which should be regarded as if they are carcinogenic to humans. There should be sufficient evidence to provide a strong presumption that human exposure to the substance may result in the development of a cancer, generally on the basis of
   a) appropriate long term animal studies
   b) other relevant information (University Hazard Rating of 4 C,T);

3. Category 3 Carcinogen**:** Substances which cause concern for humans owing to possible carcinogenic effects but that the evidence that these substances will cause cancer in humans is inconclusive.

These categories can be used to help in assessing the carcinogenic properties of substances not listed in the EH40 as a human carcinogen.

Flammability

4F Extremely flammable substances;

3F Highly flammable substances.

Explosive properties

5X Dangerously explosive substances;

4X Explosive substances.

Corrosive or Irritant properties

5A Very severely corrosive or irritant;

4A Severely corrosive or irritant;

3A Moderately corrosive or irritant;

2A Mildly corrosive or irritant

Oxidising Properties

4O Powerful oxidant;

3O Moderate oxidant;

2O Mild oxidant;

LD_{50}/LC_{50} Information

Where LD_{50}/LC_{50} information is available it should also be considered when setting the hazard rating.

Some examples of hazard ratings for chemicals:

5T All substances containing the following elements:
arsenic, barium (except sulfate), beryllium, cadmium, chromium (VI), mercury, osmium, selenium, tellurium, thallium.
Organo-aluminium, gallium, indium, lead, tin and zinc compounds.
Soluble compounds of iridium, platinum, rhodium, ruthenium and silver.
Transition metal carbonyl compounds.
All metal cyanides and hydrogen cyanide (but not ferrocyanides or ferricyanides).
Alkaloids and dangerous drugs including strychnine, brucine, morphine, codeine, atropine and many others.
All organic isocyanates

4T All substances containing the following elements:
antimony, bismuth, cobalt, indium, lead, nickel, palladium, vanadium

3T All substances containing the following elements:
aluminium, chromium (II and III), copper, gallium, iron, manganese, molybdenum, rubidium, strontium, tantalum, tin, tungsten, yttrium, zinc, zirconium

5X Organic azides, diazo compounds and diazonium salts
Perchloric acid and all perchlorates

2.3 Guidance on the Safe Use of Chemicals

2.3.1 General Laboratory Practice

Previous inspections of some Schools and Units by the Health and Safety Executive have highlighted the very poor standard of "housekeeping" and working practices in some laboratories. All work areas must be kept clean and tidy as possible. Benches and fume cupboards must be cleared and cleaned on a regular basis. In the event of an accident, the presence of large quantities of chemicals, solvents and apparatus seriously aggravates the hazard. All items should be returned to safe storage after use. Laboratory floors must be kept as clear as possible.

2.3.2 Storage and Care of Chemicals

All chemicals must be stored in an appropriate safe place. Old bottles of chemicals which have deteriorated or decomposed should be repurified or immediately disposed of (see Section 2.5). All corrosive or hazardous chemicals

must be periodically inspected for signs of leakage or deterioration. Any labels which have deteriorated or fallen off must be replaced immediately. Any unlabeled bottles must be sent for disposal immediately (never assume what might be ion a bottle).

The need to keep the quantity of chemicals held in Schools and Units, and in particular those stored in laboratories, to the minimum is emphasised. Most Schools have extensive stocks of many chemicals in various Stores and these should be used whenever possible rather than ordering up new materials. Always check whether a material you need is already available before ordering up new stocks. All excess chemicals, which will not be used for some time, should be placed in an appropriate Store.

No more than 50 litres of flammable, highly or extremely flammable materials should be stored in laboratories.

All items kept in refrigerators, freezers and cold-rooms must be labelled to indicate who is responsible for them. Where a research group or individual requires to put several items in these, it is sufficient for a compartment or shelf to be labeled rather than each item. No-one else should then put items in such a reserved space. Containers placed in these facilities should generally be closed and the facilities should be defrosted and cleaned out on a regular basis. Solvents especially flammable solvents should not be stored in fridges. Where there is a requirement for such storage, only fridges with 'Inherently Safe Electrical' systems should be used (Spark proof fridges).

2.3.3 Fume Cupboards

Fume cupboards are essential for much experimental work involving toxic or hazardous chemicals. Indeed, when space allows, it is advisable to handle all volatile chemicals in a fume cupboard. Fume cupboards which are filled with bottles of dangerous and corrosive chemicals are not suitable for experimental work. Fume cupboards used for experimental work must be cleared of all unnecessary items including bottles of dangerous chemicals. In particular the storage of highly toxic or corrosive chemicals along the back of such fume cupboards is forbidden. Where chemicals need to be stored in a fume cupboard they should be placed in one set aside for storage in which experimental work is not allowed. The vented cupboards available in some laboratories are ideal for this purpose. These vented cupboards must be kept in good order and cleaned out regularly. This valuable space should not be wasted for storage of non-volatile materials. Containers used for the collection of highly toxic waste for disposal must on no account be stored in a fume cupboard where experimental work takes place. While being filled they should be kept in a separate fume cupboard set aside for that purpose or in a closed wooden cupboard. Once full they should be disposed of immediately by arrangement with your School Safety Co-ordinator.

Experiments involving a foreseeable risk of explosion should be carried out within a fume cupboard and also surrounded by safety shields.
Experiments involving the foreseeable risk of fire should only be carried out in a laboratory with automatic fire protection or a fume cupboard which is fire resistant.

<u>Maintenance Of Fume Cupboards</u>

The performance of all fume cupboards should be tested on an annual basis and the flow rates achieved recorded on the notice on the front. Please ensure that this

notice remains legible and in place. You should report any problems with a fume cupboard performance immediately to your School Safety Co-ordinator.

Fume cupboard baffles should be removed at intervals of not more than 12 months and appropriate cleaning operations carried out. This maintenance should be carried out on all fume cupboards other than those whose physical design is such that it is not practicable to do so.

2.3.4 Personal Hygiene, Cleanliness and Good Laboratory Practice

All laboratories should have a Code of Practioce posted on the door which defines the actions that must be taken. Eating and drinking are forbidden in all laboratories where toxic chemicals are in use. In accordance with University policy, smoking is forbidden anywhere in the University.

Good practice requires that, after carrying out any experimental work, you should wash your hands thoroughly and move to a suitable clean area before eating or drinking. Storage of food and drinks is not allowed in any laboratory.
Care should be exercised in the use of gloves so that clean areas are not inadvertently contaminated. Gloves which have been in contact with toxic chemicals should be decontaminated and removed to be placed in suitable storage area or discarded as soon as possible. In particular, they should not be allowed to come into contact with taps, door handles, telephone receivers, computer keyboards or books.

All persons should adopt the correct use of laboratory coats. Laboratory coats should be worn for all work with toxic chemicals and should then be taken off before leaving the laboratory area. These coats provide a useful means of confining the dangers of toxic chemicals to certain areas within the building. The wearing of a laboratory coat which has been in any contact with chemicals, in lecture theatres, common rooms or libraries, is strictly forbidden.

2.3.5 Personal Protective Equipment

The Personal Protective Equipment at Work Regulations 1992 place a statutory requirement on the University to assess the risks of a work activity and if Personal Protective Equipment (PPE) is required to eliminate or minimise these risks then it must be supplied by the employer and worn by all persons within that work area.

<u>Eye Protection</u>
The wearing of eye protection is mandatory for all persons in any laboratory where any hazardous chemicals, vacuum systems or high pressure systems are in use and also in any laboratory marked with an eye protection sign on the door. The protection must conform to British Standard for the type of eye protection required. All workmen and visitors must be provided with suitable eye protection before entering such laboratories.

<u>Safety Shield</u>
A safety shield must be placed around any experiment involving a reasonably foreseeable risk of explosion. Safety shields are more effective when weighted at the base.

<u>Gloves</u>
Gloves should be worn when handling:

- hazardous materials;
- toxic chemicals;

- corrosive materials;
- materials with sharp or rough edges; and
- very hot or very cold materials.

The type of hand protection issued under a risk assessment will depend on the properties of the gloves and substance you are using.

Glove selection - the following properties should be taken into account when selecting the type of glove to be used:

Degradation – the change in one or more physical properties of the glove upon contact with the chemical. This is usually reported in a chemical compatibility chart as E (excellent), G (good), F (fair), P (poor), NR (not recommended) or NT (not tested).

Breakthrough time – the time between initial contact of the chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove. Given on a chemical compatibility chart in minutes.

Permeation rate – the rate at which the chemical passes through the glove once breakthrough has occurred and equilibrium is reached. This is usually reported as 0 (if there is no breakthrough), Slow, Medium or Fast.

Type of Chemical	Natural Rubber	Nitrile	Neoprene (TM)	PVC	Butyl	Viton (TM)
Water miscible substances weak acids/alkalis	X	X	X	X	------	------
Oils	------	X	------	------	------	------
Chlorinated Hydrocarbons	------	------	------	------	------	X
Aromatic Solvents	------	------	------	------	------	X
Aliphatic Solvents	------	X	------	------	------	X
Strong Acids	------	------	------	------	X	-------
Strong Alkalis	------	------	X	------	------	------
PCBs	------	------	------	------	------	X

Detailed guidance on the use of Personal Protective Equipment can be found at the University Website -

http://www.st-andrews.ac.uk/staff/policy/Healthandsafety/Publications/

Note: If any employee develops a sensitivity to gloves they should contact the Occupational Health Adviser as soon as practicable.

Respirators

Appropriate respiratory protective equipment (RPE) should be worn when handling substances which pose a risk when inhaled. If RPE is issued then it must be 'Face Fitted' by a suitably trained person to ensure that it works effectively.

2.4 Types of Hazards

2.4.1 Fire and Explosion Hazards

Many substances used in the University are highly flammable or explosive. All workers who work with potentially explosive substances must be given appropriate training and instruction on the chemical properties of the substances and the precautionary actions they must take to protect themselves and others around them. Stringent precautions are required to minimise the risk of accidents. These substances should be stored in appropriate containers and must never be disposed of to drain (see Appendix 2)

2.4.2 Poisons

Whilst all chemicals should be regarded as potentially toxic, certain substances used within the University are known to be very severe poisons. In handling these all possible precautions must be taken to completely avoid contact with the body or release to the environment.

Dangerous Poisons - Substances listed in the **Poisons Rules 1982 (as amended), Misuse of Drugs Regulations 2001 and the Drugs Act 2005,** are subject to strict legal control Where a compound is classed as a Controlled Drug under the Misuse of Drugs Regulations 2001, then a specific licence will be required from the home Office. Guidance on applying for such licences can be obtained from the Director of Environmental, Health and Safety Services. These substances **must** be stored in a LOCKED CUPBOARD and excess quantities returned to a secure store as soon as possible.

Some examples of other highly poisonous substances are given in Appendix 3.

2.4.3 Drug Precursors

Certain compounds which can act as precursors for Controlled Drugs under the Misuse of Drugs Regulations 2001 are regulated under the Controlled Drugs (Drug Precursors)(Intra-Community Trade) Regulations 2008. To be able to purchase compounds classed as Category 1 precursors will require a specific licence from the Home Office. Guidance on applying for such a licence can be obtained from the Director of Environmental Health and Safety Services.

2.4.4 Carcinogens

These substances present a very serious hazard since slight exposure, even on a single occasion, may result in serious irreversible effects producing cancer. In handling these compounds all possible steps must be taken to completely avoid contact with the body or release to the environment. The list of carcinogens, many of which are subject to statutory control under the COSHH Regulations 2002 , must not be taken as comprehensive. Appendix 5 of EH40 lists category 1 and 2 carcinogens. Most of these materials have a University classification 5T,C. examples of carcinogens can be found in Appendix 4.

2.4.5 Chemical Weapons Act 1996

Under the Chemical Weapons Act (1996) possession or production of certain chemicals is prohibited and possession or production of others must be notified to the relevant regulatory body. The materials involved are mainly sulfur and nitrogen mustards and organophosphorus nerve agents and their direct precursors.

If you propose to handle or produce such chemicals which comes within the scope of these Regulations then you must notify the Director of Environmental, Health and Safety Services **prior to any such work beginning** to ensure that it is permitted. A list of such agents can be found at the following URL:

http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/nonprolif/chemical_bio/cwc_uk_auth/chemicals/chemicals.aspx

This list does regularly change and thus you must check this list if you believe you may be working with such chemicals.

The University is required to make an annual declaration to the government if we have such chemicals on site.

2.4.6 Toxic Gases

All toxic gas should be used with great care. A suitable risk assessment must be completed before any such work which includes details of emergency actions to be taken in the event of a leak of this gas. No operation involving such gases must be carried out by anyone working in a laboratory on their own or outside normal working hours. The following are some of the most commonly used:

LTEL (or STEL*)	(ppm)	
Phosgene	0.02	(danger to life after 1/2-1 hr at 50 ppm)
Diazomethane	-	
Fluorine	0.1*	
Bromine	0.1	(danger to life after 1/2-1 hr at 10 ppm)
Ozone	0.2*	(danger to life after 1/2-1 hr at 50 ppm)
Chlorine	0.5*	(danger to life after 1/2-1 hr at 14 ppm)
Hydrogen bromide	3*	
Hydrogen fluoride	3*	
Hydrogen chloride	5*	
Hydrogen cyanide	10*	
Hydrogen sulfide	10*	(immediate danger to life at 700 ppm)
Ammonia	25	
Carbon monoxide	30	(colourless and odourless)

All toxic gas cyliders must be used with a secondary control valve. The dispensing of any toxic gas from a cylinder by means of the main cylinder valve alone is strictly forbidden.

Before using any toxic gas cylinder all persons should plan exactly what action will be taken if an uncontrolled escape of gas occurs, e.g. by the cylinder valve sticking open. In all such cases, immediately signal evacuation of the building by activating the nearest fire alarm button. Any malfunction of the valve of a toxic gas cylinder should be reported to your School Safety Co-ordinator immediately.

The direct venting of significant quantities of toxic gases to the atmosphere is not allowed. Wherever possible excess gas should be absorbed in a suitable solution.

The stock of toxic gas cylinders in Schools and Units should be kept to a minimum. Before ordering any new gases please ensure that any existing stocks are used up.

2.5 Waste Disposal

2.5.1 Waste Disposal Procedures

It is the responsibility of all research workers to ensure the safe and correct disposal of all wastes produced in the course of their work. Improper and irresponsible disposal of chemical wastes down drains, to the Local Authority refuse collection or into the atmosphere is forbidden by law and can put yourself and other workers at risk of injury.

The disposal of hazardous waste is regulated by 'The Special Waste Amendment (Scotland) Regulations 2004'. Details on the control measures required for hazardous waste are given in the document entitled: 'Hazardous Waste - Interpretation of the Definition and Classification of hazardous Waste - Technical Guidance WM2'. A copy of this document can be viewed on the SEPA page at URL:
http://www.sepa.org.uk/waste/waste_regulation/special_waste/hazardous_waste.aspx

It is vital that no waste is disposed to drain which may harm others or react with other chemicals to produce a dangerous environment. Thus consideration must be given to potential risks to plumbers. Also, many chemicals can react to produce hazardous situations for example dilute acid reacting with hypochlorite to produce chlorine gas.

Advice on the waste disposal procedures which eliminate risks to workers and to comply with current legislation can be obtained from the School Safety Co-ordinator or from the Director of Environmental, Health and Safety Services.

Questions regarding the management of domestic and recycling type wastes should be made to the Environment Manager at Estates.

2.5.2 Laboratory waste bins and controlled waste

All waste produced within the University is classified as 'controlled waste' and must be disposed of in accordance with governing legislation. Hazardous waste, as defined by the 'Special Waste Amendment (Scotland) Regulations 2004', can only be disposed of by Specialist contractors. The arranging of the disposal of such Special Waste will be carried out by Environmental, Health and Safety Services.

All waste must be put in the correct coloured bag. The relevant colour coding of bags is as follows:

- Yellow bags for clinical waste
- Blue bags or clear bags with biological hazard sign on it for biological material requiring autoclaving
- red bags for chemically contaminated waste (e.g. gloves and weighing boats)
- clear bags with a radioactive hazard sign on it for radioactive waste
- yellow bag with red stripe on it for infectious waste contaminated with cytotoxic and/or cytostatic medicinal products
- Dustbin with purple strip - for oily rags and such workshop waste
- Black or Clear (with NO symbols on the bag) for domestic waste

Non- contaminated items of paper, plastic may be put in the re-cycling containers which are not located in the laboratory (contact the Environment Manager at Estates to determine what can and cannot be put into recycling bins). Certain types of glass can be put in the glass recycling bins. Soda glass (e.g. Pyrex equipment) cannot be recycled and should be disposed of as waste.

Note - Do not put glass items or broken glass into domestic bins as these can cause cuts to cleaners. Broken glass should be kept in appropriate solid containers which will protect workers from cuts.

Domestic waste, dirty paper, plastic, rubber, wood and glass are exempt from certain requirements of the Controlled Waste Regulations and will be routinely collected by the Local Authority. These items may be placed in the bins provided for domestic waste in each laboratory and will be collected by the cleaners.

Each laboratory, however, must also have a container for items which are potentially contaminated with chemicals and thus not allowed to be put in the domestic waste bins. Such contaminated items include weighing boats, gloves and other items contaminated by trace quantities of chemicals. This waste should then be put in special containers (skips) for uplift by a special contractor. Such uplifts should be arranged through the Director of Environmental, Health and Safety Services. These items should never be put in skips uplifted by Fife Council.

Note: Sharps in the form of scalpels, syringes/needles should be put into a proper sharps container and uplifted by an appropriate contractor.

Laboratory controlled waste containers must be emptied regularly and never allowed to overflow. Under no circumstances must any item of glass, sharp metal or fine powder ever be put in a laboratory bin for domestic waste.

Where there are bottles with significant quantities of chemicals in them, these must be disposed of as 'Special waste' through a specialised contractor and arranged through the Director of Environmental, Health and Safety Services. Significant quantities of solid chemicals musty never be put to drain as a means of disposal.

Note: All empty bottles put out to recycling waste must be carefully washed to remove trace quantities of chemicals such that there is no detectable chemical smell, the label identifying any previous contents removed, tops must be removed from all bottles put out for disposal.

2.5.3 Wash down drains with excess water

Specific chemicals which are not classified as 'Special Waste' (see sections 2.5.3 and 2.5.4) maybe disposed of via the drain. These include:

- solutions with **trace** quantities of reagent (with appropriate dilution) eg from washing out bottles with minute quantities of reagent being present
- very small quantities of harmless soluble inorganic salts (including all drying agents such as $CaCl_2$, $MgSO_4$, Na_2SO_4)
- **very** dilute hypochlorite solutions

Nothing should be put to drain which may put at risk others (for example Estates plumbers, Scottish Water employees etc). If you are unsure what can be put to

drain **always ask the Director of Environmental, Health and Safety Services BEFORE disposing of it to drain**

2.4.4 Disposal of 'Special Waste'.

The Special Waste Amendment (Scotland) Regulations 2004 define certain waste as 'Hazardous Waste' and this waste can only be disposed of via special precautions burial or by incineration. A list of chemicals defined as 'Hazardous Waste' is available from the School Safety Co-ordinator or from the Director of Environmental, Health and Safety Services. The disposal of Special Waste **must** be organised via the Director of Environmental, Health and Safety Services. A form for the disposal of 'Special Waste' is available from the School Safety Co-ordinator or the Director of Environmental, Health and Safety Services. A copy of this form is given in Appendix 6

2.5.4.1 Disposal of Waste Solvents

The following examples of solvent waste should be disposed of by Specialised Contractor for appropriate disposal:

a) all organic solvents including water miscible ones
b) soluble organic waste including most organic solids
c) paraffin oil (from oil baths and pumps).

This is not a comprehensive list and if you are not sure if your waste should be incinerated, contact your School Safety Co-ordinator or the Director of Environmental, Health and Safety Services.

The materials to be disposed of in this way should be collected in containers which are labelled to indicate halogenated or non-halogenated. Waste solvent containers must be put out for collection or removed whenever they are full and never be overfilled or allowed to overflow. The waste containers will be uplifted by a specialist contractor for incineration.

2.5.4.2 'Special Waste' Disposal

Substances for 'Special Waste' disposal must be collected in a separate labelled container. On no account must different types of waste be mixed. Advice should be sought from your School Safety Co-ordinator before beginning any work which will produce waste requiring special disposal in order to ensure:

a) that the waste can be disposed of,
b) that it is collected in the most suitable form so as to minimise the cost involved, and
c) that it will be stored under suitable conditions.

Note: The hoarding up of hazardous waste in laboratories is strictly forbidden.

2.5.5 Special Waste Disposal Arrangements for Specific Substances

2.5.5.1 Disposal of Pyrophoric Reagents

The disposal of used bottles of pyrophoric organometallic reagents presents a major hazard and the procedure required in Schools and Units must be strictly followed. The School of Chemistry procedure for disposal of such substances is given in Appendix 5.

2.5.5.2 Disposal of Lithium, Sodium and Potassium

Disposal of alkali metals, which involves addition to a flammable solvent and liberation of large quantities of hydrogen, is a serious fire hazard. Always carry this out in a fume cupboard away from sources of ignition and anticipate a fire. Alkali metals are disposed of by careful addition of small pieces to an excess of an alcohol: for sodium and lithium use ethanol or methylated spirit; for potassium use isopropanol.

2.5.6 Glass Recycling

For environmental reasons the recycling of glass is encouraged, but only certain items of waste glass produced within the University are acceptable for recycling. Each laboratory should have a bin for recyclable glass. Only clean glass bottles (soda glass) such as those in which chemicals are received, and broken or waste plate glass are allowed. All broken laboratory glassware (pyrex or borosilicate glass or quartz), items significantly contaminated by chemicals, sample tubes, droppers and glass wool must be disposed of as controlled waste (see 2.5.1). The recycling service will refuse to empty a recycling container if any of these prohibited

items is discovered in it. Laboratory glass recycling bins must be emptied by research workers directly into the containers provided, with items being sorted according to colour, and never allowed to overflow.

2.5.7 Waste Paper Recycling

Most laboratories and offices should have a special separate container for the collection of waste paper for recycling which will be emptied by the cleaners. No material contaminated with chemicals and no plastic straps, acetates, used toner cartridges etc. must be put in the paper recycling containers – these should instead be put in the nearest controlled waste container.

Appendix 1

Risk Phrases

R1	Explosive when dry
R2	Risk of explosion by shock, friction, fire or other sources of ignition
R3	Extreme risk of explosion by shock, friction, fire or other sources of ignition
R4	Forms very sensitive explosive metallic compounds
R5	Heating may cause an explosion
R6	Explosive with or without contact with air
R7	May cause fire
R8	Contact with combustible material may cause fire
R9	Explosive when mixed with combustible material
R10	Flammable
R11	Highly flammable
R12	Extremely flammable
R14	Reacts violently with water
R14/15	Reacts violently with water, liberating extremely flammable gases
R15	Contact with water liberates extremely flammable gases
R15/29	Contact with water liberates toxic, extremely flammable gases
R16	Explosive when mixed with oxidising substances
R17	Spontaneously flammable in air
R18	In use, may form flammable/explosive vapour-air mixture
R19	May form explosive peroxides
R20	Harmful by inhalation
R20/21	Harmful by inhalation and in contact with skin
R20/21/22	Harmful by inhalation, in contact with skin and if swallowed
R20/22	Harmful by inhalation and if swallowed
R21	Harmful in contact with skin
R21/22	Harmful in contact with skin and if swallowed
R22	Harmful if swallowed
R23	Toxic by inhalation
R23/24	Toxic by inhalation and in contact with skin
R23/24/25	Toxic by inhalation, in contact with skin and if swallowed
R23/25	Toxic by inhalation and if swallowed
R24	Toxic in contact with skin
R24/25	Toxic in contact with skin and if swallowed
R25	Toxic if swallowed
R26	Very toxic by inhalation
R26/27	Very toxic by inhalation and in contact with skin
R26/27/28	Very toxic by inhalation, in contact with skin and if swallowed
R26/28	Very toxic by inhalation and if swallowed
R27	Very toxic in contact with skin
R27/28	Very toxic in contact with skin and if swallowed
R28	Very toxic if swallowed
R29	Contact with water liberates toxic gas
R30	Can become highly flammable in use
R31	Contact with acids liberates toxic gas
R32	Contact with acids liberates very toxic gas
R33	Danger of cumulative effects
R34	Causes burns
R35	Causes severe burns
R36	Irritating to eyes
R36/37	Irritating to eyes and respiratory system
R36/37/38	Irritating to eyes, respiratory system and skin
R36/38	Irritating to eyes and skin
R37	Irritating to respiratory system
R37/38	Irritating to respiratory system and skin
R38	Irritating to skin
R39	Danger of very serious irreversible effects

R39/23	Toxic: danger of very serious irreversible effects through inhalation
R39/23/24	Toxic: danger of very serious irreversible effects through inhalation and in conta with skin
R39/23/24/ 25	Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed
R39/23/25	Toxic: danger of very serious irreversible effects through inhalation and if swallowed
R39/24	Toxic: danger of very serious irreversible effects in contact with skin
R39/24/25	Toxic: danger of very serious irreversible effects in contact with skin and if swallowed
R39/25	Toxic: danger of very serious irreversible effects if swallowed
R39/26	Very Toxic: danger of very serious irreversible effects through inhalation
R39/26/27	Very Toxic: danger of very serious irreversible effects through inhalation and in contact with skin
R39/26/27/ 28	Very Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed
R39/26/28	Very Toxic: danger of very serious irreversible effects through inhalation and if swallowed
R39/27	Very Toxic: danger of very serious irreversible effects in contact with skin
R39/27/28	Very Toxic: danger of very serious irreversible effects in contact with skin and if swallowed
R39/28	Very Toxic: danger of very serious irreversible effects if swallowed
R40	Limited evidence of a carcinogenic effect
R41	Risk of serious damage to eyes
R42	May cause sensitisation by inhalation
R42/43	May cause sensitisation by inhalation and skin contact
R43	May cause sensitisation by skin contact
R44	Risk of explosion if heated under confinement
R45	May cause cancer
R46	May cause heritable genetic damage
R48	Danger of serious damage to health by prolonged exposure
R48/20	Harmful: danger of serious damage to health by prolonged exposure through inhalation
R48/20/21	Harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin
R48/20/21/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed
R48/20/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed

R48/21	Harmful: danger of serious damage to health by prolonged exposure in contact with skin
R48/21/22	Harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed
R48/22	Harmful: danger of serious damage to health by prolonged exposure if swallowe
R48/23	Toxic: danger of serious damage to health by prolonged exposure through inhalation
R48/23/24	Toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin
R48/23/24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed
R48/23/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed
R48/24	Toxic: danger of serious damage to health by prolonged exposure in contact with skin
R48/24/25	Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed
R48/25	Toxic: danger of serious damage to health by prolonged exposure if swallowed
R49	May cause cancer by inhalation

R50	Very toxic to aquatic organisms
R50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment
R51	Toxic to aquatic organisms
R52	Harmful to aquatic organisms
R53	May cause long-term adverse effects in the aquatic environment
R54	Toxic to flora
R55	Toxic to fauna
R56	Toxic to soil organisms
R57	Toxic to bees
R58	May cause long-term adverse effects in the environment
R59	Dangerous for the ozone layer
R60	May impair fertility
R61	May cause harm to the unborn child
R62	Possible risk of impaired fertility
R63	Possible risk of harm to the unborn child
R64	May cause harm to breast-fed babies
R65	Harmful: may cause lung damage if swallowed
R66	Repeated exposure may cause skin dryness or cracking
R67	Vapours may cause drowsiness and dizziness
R68	Possible risk of irreversible effects

Appendix 2

Fire and Explosive Hazards

Flammable Solvents

Many organic solvents are highly flammable and their vapour forms explosive mixtures with air. The following rules are to be strictly observed:

(i) Stocks of flammable solvents stored in laboratories are to be kept to a minimum. As a rough guide, the stock should never exceed one Winchester bottle of each solvent per two research workers (specially dried or purified solvents may be counted separately).

(ii) Flammable solvents must never be disposed of by pouring down drains. This includes water miscible solvents such as methanol and acetone. For the correct disposal procedure see 2.4.

(iii) Winchester bottles of flammable solvents must be kept fire-resistant storage cupboards in each laboratory at all times except when being dispensed. Winchester bottles of flammable solvents must never be left on the floor, on benches or in direct sunlight.

(iv) Wherever possible flammable solvents should be heated by steam or electrically. The use of open flames for heating flammable solvents is strongly discouraged.

(v) Wherever possible flammable solvents should be used in a fume cupboard. Before using a flammable solvent make sure there is no open flame or other source of ignition in the vicinity.

(vi) Chromatography supports (silica and alumina) covered with flammable solvents must **not** under any circumstances be placed directly in a waste bin. For correct disposal procedure see 2.4.

(vii) Where flammable solvents have to be stored below room temperature, the refrigerator must be spark-proof making it 'Intrinsically Safe'.

Other Fire Hazards

Certain substances may ignite spontaneously on contact with air or water. These must be handled and disposed of with great care.

(i) *Hydrogenation catalysts* - including palladium/charcoal and Raney nickel may ignite spontaneously in air. Under no circumstances are these to be placed in a waste bin. They should be made safe and then washed down the sink.

(ii) *Reactive metals* - Finely divided magnesium, aluminium and zinc may ignite spontaneously. These must not be placed in a waste bin but should be dissolved in dilute acid and washed down the sink.

(iii) *Organometallic reagents* - Many commonly used solutions of organolithium compounds, Grignard reagents and other organometallics in organic solvents may ignite spontaneously in moist air. These should be handled under nitrogen and disposed of as detailed in the following Section.

Explosive Hazards

All experiments involving potentially explosive substances should be carried out in a fume cupboard and behind a safety shield. Except under special circumstances, explosive substances should not be heated and must never be subjected to grinding or mechanical shock.

The following materials are explosive:

(i) All azides, organic and inorganic (except sodium azide);
(ii) Certain acetylenes including dimethyl- and diethyl acetylenedicarboxylate which explode on distillation, all metal acetylides;
(iii) All diazo compounds;
(iv) All diazonium salts - (aryl diazonium fluoroborates are marginally safer);
(v) Hydrazine;
(vi) All perchlorates, organic and inorganic
(vii) Ammonium nitrate;
(viii) All peroxides;
(ix) Many nitro compounds including polynitroalkanes and polynitro-aromatics such as trinitrobenzene, trinitrotoluene, trinitrophenol (picric acid), metal picrates, trinitrochlorobenzene (picryl chloride), all o-nitrobenzoyl chlorides and metal salts of nitrophenols;
(x) Some poly-nitrogen heterocycles such as tetrazoles and tetrazines.

Oxidising Agents

Certain strong oxidising agents are themselves stable, but react with any organic material to cause fire or explosion. These include:

(i) Fuming nitric acid and concentrated nitric acid - Operations involving these should be performed on as small a scale as possible. Special care is required when using conc. nitric acid for cleaning purposes : Nitric acid should only be used as a last resort for removal of metal residues ,not for organic dirt. The apparatus must be thoroughly washed with water before and after use of nitric acid. The mixing of nitric acid with organic solvents such as ethanol or acetone for cleaning purposes is extremely dangerous and is prohibited;
(ii) Perchloric acid - Steps should be taken to avoid accidental contact of perchloric acid with any other material. Several very serious accidents have occurred after a spillage of perchloric acid reacted with organic material (e.g. a wooden floor). There was often no immediate effect but friction or spillage of another chemical many years later resulted in explosions and fires. Any spillage of perchloric acid must be reported immediately to your School Safety Coordinator. Never mix perchloric acid with dehydrating agents such as acetic anhydride or sulfuric acid;
(iii) Hydrogen Peroxide - While normal concentrations of hydrogen peroxide up to 30% ("100 volume") do not present a serious hazard, stronger solutions may cause spontaneous ignition of any organic material. Solutions stronger than 50% and particularly 90% "anhydrous" H_2O_2 require special precautions and should not be used without the permission of your School Safety Co-ordinator;
(iv) Liquid Oxygen - Because nitrogen has a lower boiling point than oxygen, cooling any vessel in liquid nitrogen, while it is open to the air, results in the condensation of a liquid rich in liquid oxygen. This may cause a violent explosion in contact with any organic material. This situation most often arises through forgetting to remove the liquid nitrogen flask from a trap in a vacuum system after it is opened to the air. If this does occur allow the liquid oxygen to evaporate behind a safety shield in a fume cupboard.

Ether Peroxides

Many commonly used ether solvents form explosive peroxides on storage. These include: diethyl ether, tetrahydrofuran, 1,4-dioxane, all ethers of ethylene glycol and higher ether diols (including glyme, diglyme, etc), all aliphatic ethers such as di-n-butyl ether and diisopropyl ether which peroxidises particularly easily.

(i) Most of these solvents are now supplied containing an inhibitor to prevent peroxide formation. This will be removed by distillation. Do not redistill these solvents unnecessarily and if distillation is necessary the distilled solvent should be used immediately. Never store quantities of ethers which have had the inhibitor removed by distillation.

(ii) Note that the inhibitors used only prevent peroxide formation. Once peroxides have formed the inhibitor will not destroy them.

(iii) All ether peroxides are less volatile than the corresponding ethers and evaporation will concentrate them leading to a violent explosion. Never evaporate an ether solution which may contain peroxides.

(iv) All redistilled ethers and older bottles of ethers must be tested for peroxides before use and peroxides if present must be removed (test and removal procedure - P.404 Vogel's Textbook of Practical Organic Chemistry; 5th Ed'n.; B S Furniss, A J Hannaford, P W G Smith and A R Tatchell; Longmans, 1989.

(v) For disposal of ethers found to be badly peroxidised or containing crystalline deposits of peroxide consult your School Safety Coordinator.

Sodium and Potassium Metal

Because of their extreme reactivity sodium and potassium present a serious fire and explosion hazard.

(i) Sodium presses used to produce sodium wire for drying solvents should be kept clean and tidy. Excess sodium on the press and die should be destroyed with ethanol or methylated spirit immediately after use.

(ii) On no account try to dry any chlorinated solvent with sodium - a violent explosion will result.

(iii) The oxide coating on old potassium may catch fire or explode on touching (e.g. on cutting up). Potassium should always be cut up under oil. Oxidised potassium should be disposed of with great care.

(iv) Fires involving sodium or potassium should never be tackled using water or CO_2 extinguishers. Use only dry sand or a dry powder extinguisher. Small fires during disposal of these metals may be quickly extinguished by covering the vessel with a glass plate.

Carbon Disulfide

Besides being highly toxic, carbon disulfide presents a very serious fire and explosion hazard due to its extreme volatility, low flash point ($\sim$ 30 °C) and low autoignition temperature (102 °C). The latter means that its vapour can ignite spontaneously even in contact with steam-heated equipment.

Appendix 3

Highly Poisonous Substances

i) Compounds of arsenic (LTEL 0.1 mg/m^3);
ii) Alkaloids and dangerous drugs including strychnine, brucine, morphine, codeine, atropine and many others;
iii) Compounds of barium (LTEL 0.5 mg/m^3) except barium sulfate;
iv) Bismuth iodide;
v) All bis(2-chloroethyl)amines ("nitrogen mustards");
vi) Compounds of cadmium (LTEL 0.025 mg/m^3)
vii) Sodium and potassium cyanides, all other metal cyanides and hydrogen cyanide (but not ferrocyanides or ferricyanides).
viii) Fluoroacetic acid and its salts, fluoroacetamide, fluoroacetanilide and fluorocitric acid.
ix) Lead tetra-acetate and organolead compounds.
x) Methyl bromide.
xi) Compounds of mercury.
xii) All nitro- and dinitro-phenols, -naphthols, -cresols and -thymols, p-nitrobenzyl cyanide.
xiii) Osmium tetroxide (LTEL 0.0002 ppm).
xiv) Paraquat and derivatives.
xv) Fluorophosphate and fluorophosphonate nerve gases and similar compounds.
xvi) Metal phosphides.
xvii) Compounds of selenium (LTEL 0.1 mg/m^3).
xviii) Componds of tellurium (LTEL 0.1 mg/m^3).
xix) Compounds of thallium (LTEL 0.1 mg/m^3).
xx) Organo-tin compounds (LTEL 0.1 mg/m^3) (readily absorbed through the skin).

Other poisonous chemicals include the following
i) Volatile unsaturated aldehydes and ketones including acrolein (LTEL 0.1 ppm), crotonaldehyde and methyl vinyl ketone;
ii) amyl nitrite - a powerful heart stimulant;
iii) Simple aliphatic amines including methylamine; ethylamine, dimethylamine and triethylamine (all LTEL 2 ppm); diethylamine and diisopropylamine (both LTEL 5 ppm).;
iv) Aromatic amines including aniline and all substituted anilines such as anisidines, 2-aminopyridine, N-methylaniline (LTEL 0.5 ppm), o-toluidine (LTEL 0.2 ppm), p-phenylenediamine (LTEL 0.1 mg/m^3). (Highly toxic by skin absorption);
v) Volatile organic azides and sodium azide (LTEL 0.3 mg/m^3).
vi) Benzene (LTEL 1 ppm);
vii) Volatile metal carbonyls including nickel carbonyl (STEL 0.1 ppm) and iron pentacarbonyl (LTEL 0.01 ppm);
viii) Dimethyl and diethyl sulfate (LTEL 0.05 ppm) - rapidly absorbed through the skin (antidote - conc. ammonia), also carcinogenic;

ix) Halogenated solvents including carbon tetrachloride (LTEL 2 ppm) and chloroform (LTEL 2 ppm), and bromoform, carbon tetrabromide, 1,2-dichloroethane (ethylene dichloride, LTEL 5 ppm), hexachlorocyclopentadiene, iodoform (LTEL 0.6 ppm), methyl iodide (LTEL 2 ppm), 1,1,2,2-tetrachloroethane;

x) All compounds of many transition metals and heavy metals including chromium (LTEL 0.5 mg/m^3 for Cr^{II} and Cr^{III} and 0.05 mg/m^3 for Cr^{VI}), manganese (LTEL 0.5 mg/m^3), nickel (LTEL 0.1 mg/m^3), platinum (LTEL for soluble salts 0.002 mg/m^3), rhodium (LTEL for soluble salts 0.001 mg/m^3), silver (LTEL for soluble salts 0.01 mg/m^3), tin (LTEL for inorganic compounds 2 mg/m^3), molybdenum, tantalum and zirconium (all LTEL 5 mg/m^3), vanadium pentoxide (LTEL 0.05 mg/m^3);

xi) All organic isocyanates (LTEL 0.02 mg/m^3);

xii) Nitrobenzene (LTEL 0.2 ppm) and all substituted nitrobenzenes including nitrotoluenes, p-nitrochlorobenzene (LTEL 1 mg/m^3), p- nitroaniline;

xiii) Oxalic acid (LTEL 1 mg/m^3) and its salts;

xiv) Phenol (LTEL 2 ppm) and all substituted phenols including cresols and picric acid (LTEL 0.1 mg/m^3). (Highly toxic by skin absorption);

xv) Pyridine (LTEL 5 ppm) and substituted pyridines;

xvi) Thiophenol and all substituted thiophenols.

Benzene

Although commonly used for many years, benzene is now known to be so dangerous that it must not be used except when there is no possible alternative. Benzene is rapidly absorbed both by inhalation and skin contact to produce very serious irreversible effects leading to leukaemia. The LTEL has recently been reduced to 1 ppm and the level at which it can be detected by smell is already well above this. Benzene must only be handled in an efficient fume cupboard and wearing heavy gloves. For most purposes toluene is a safer substitute (LTEL 50 ppm).

Beryllium

Beryllium (LTEL 0.002 mg/m^3) and all its compounds are extremely toxic and also carcinogenic. No compound of beryllium may be used without the permission of your School Safety Co-ordinator.

Carbon tetrachloride and Chloroform

Carbon tetrachloride (LTEL 2 ppm) and chloroform (LTEL 2 ppm) are both highly toxic, accumulating in the liver and kidneys to produce very serious irreversible effects including cancer. These solvents must not be used except where there is no possible alternative (an exception is the use of deuteriochloroform as an NMR solvent, which should nevertheless be handled with adequate precautions). Work with these solvents must only be carried out in an efficient fume cupboard and wearing heavy gloves. Dichloromethane (LTEL 100 ppm) is a much safer substitute in most applications.

Chloromethyl methyl ether and bis(chloromethyl) ether

Commercial samples of chloromethyl methyl ether contain a significant impurity of bis(chloromethyl) ether (LTEL 0.001 ppm) which is an extremely powerful carcinogen. Cancer has been caused in experimental animals at concentrations as low as 0.1 ppm. Neither of these substances should be used without the

permission of your School Safety Co-ordinator. Bis(chloromethyl) ether is also formed at room temperature when formaldehyde and HCl vapours mix and in Friedel-Crafts reactions involving formaldehyde. All personnel should consider very carefully whether this compound might be formed fortuitously in the course of any operations (for example washing up) and take adequate precautions.

Chromic Acid

The mixture of sulfuric acid and chromic acid, formerly in common use for cleaning glassware, is highly dangerous. Apart from the obvious corrosive nature of the acid, solutions of Cr^{VI} are highly toxic (LTEL 0.05 mg/m^3) and there is evidence that it may also be carcinogenic. A particular danger exists in the preparation of chromic acid which involves a highly exothermic reaction and in some cases has resulted in an explosion with disastrous consequences. For these reasons chromic acid must not be used unless there is no possible alternative. In many cases modern detergents (Decon 90", "Micro", etc) are an efficient and safe alternative for cleaning. Where chromic acid must be used the following precautions should be strictly observed:

i) The preparation of chromic acid must only be carried out by experienced personnel. Thick rubber gloves and face mask must be worn.
ii) Baths of chromic acid must be covered by a glass plate at all times.
iii) Tongs and/or thick rubber gloves should be used to put items in and out of chromic acid. Skin contact must be avoided.
iv) Many nitrogen compounds react in chromic acid to release highly toxic nitrogen dioxide fumes. Where this is likely to occur the bath must be sited in a fume cupboard.
v) Chromic acid should be made up in the minimum quantity required and disposed of as soon as it is depleted or no longer required. Under no circumstances is chromic acid to be stored in closed bottles.

Cyanides

Because of the extremely rapid and potentially fatal consequences of cyanide poisoning the rules in force in your School or Unit must be strictly observed for all experiments involving inorganic cyanides or hydrogen cyanide.

These might typically be as follows:

i) All experiments involving significant quantities of cyanides must be carried out in a particular identified fume cupboard. The fume cupboard should be posted with warning notices clearly indicating that cyanide is in use. No other experiment should be performed in the same fume cupboard until the cyanide work, including disposal, is complete.
ii) Experiments using cyanides are only permitted in normal working hours. While a reaction may, for example, be left overnight, any steps involving manipulations (for example, setting up the experiment, taking it off and extracting the product) must be done during normal working hours.

N.B. In the event of cyanide poisoning, the required treatment is rapid administration of oxygen and transport to hospital. To allow this a specific First Aid Worker, who has had the necessary training, must be identified before the work begins and they must be on call. Any person using cyanides must be accompanied by another at all times who can quickly summon the First Aid Worker if required.

iii) Before any work with cyanide commences, a special form (available from your School Safety Co-ordinator) must be completed to indicate the

precise date(s) and times of the planned manipulations, who will be the other person accompanying the worker at all times and which first-aid worker will be on call. This must be signed by the School Safety Co-ordinator, together with the Risk Assessment Form before the work begins.

Note that a special form must be completed and signed each time a cyanide experiment is planned.

iv) *Disposal Procedure* . The disposal of solutions containing cyanides directly down the drain, or of solids contaminated with cyanides directly into a solid waste container, is strictly forbidden. All cyanide wastes, solid or liquid, must first be made safe by addition to a strong solution of sodium hypochlorite. After at least 24 hours, or when a Prussian Blue test shows cyanide to be absent, solids should be removed, washed with water, and placed in a controlled waste bin and the solution poured down the sink in a fume cupboard. Gloves and apparatus may be decontaminated in a similar way. Solids which have been made safe should not be sent for special disposal.

v) The solution of sodium or potassium cyanide in dimethyl sulfoxide, sometimes required in organic synthesis, is immediately fatal on contact with the skin and may not be used without the permission of your School Safety Co-ordinator.

Diazomethane

As well as being extremely toxic and a suspected carcinogen, diazomethane is dangerously explosive in contact with rough surfaces. It should only be prepared and handled in dilute ether or methanol solution behind a safety shield in an efficient fume cupboard. Apparatus with ground glass joints or other rough surfaces must on no account be used. Diazomethane is safely destroyed by addition of acetic acid.

Hexamethylphosphoric triamide (HMPA, HMPT)

Hexamethylphosphoramide has long been known to be highly toxic but it has recently been reported that it is also very strongly carcinogenic, producing cancer in experimental animals at concentrations as low as 0.4 ppm. The most stringent precautions must be taken in its handling and disposal.

Hydrofluoric acid

In contact with the skin hydrofluoric acid produces very severe burns which may take some time to become apparent. Several cases of serious HF burns have been followed by death from systemic fluoride poisoning. Anyone intending to use hydrofluoric acid must first obtain the treatment for burns, calcium gluconate jelly. Anyone suffering skin contact with HF should apply this treatment and then get immediate medical attention.

Methyl Fluorosulfonate ("Magic methyl")

Some time ago a research student in the Netherlands died after accidentally inhaling the vapour of "magic methyl". Commercial production of this compound has now been stopped and in view of its high volatility and extreme potency as an alkylating agent, its preparation or use in the University is strictly forbidden without the permission of your School Safety Co-ordinator.

Mercury

Mercury vapour is extremely toxic and stringent precautions must be taken to avoid its inhalation. Although the vapour pressure of mercury at room temperature is low, evaporation may be rapid if it is finely divided or on heating.

In the absence of ventilation the concentration may ultimately reach 20 mg/m^3 in a confined space. Even brief exposure to 1 mg/m^3 will result in serious poisoning.

i) An exposed surface of mercury must never be left open to the air in any laboratory. All mercury stored in bottles or in manometers open to the air should be covered with a layer of water. Mercury should always be handled in a fume cupboard.

ii) The exhaust from all vacuum systems containing mercury must be vented to a fume cupboard or out a window. All possible precautions must be taken to prevent mercury being sucked into oil pumps: the hot oil will cause a dangerous release of mercury vapour.

iii) The release of mercury vapour resulting from fracture of a hot mercury diffusion pump is likely to cause serious poisoning or death to all persons in the vicinity. These pumps should not be used unless absolutely essential and must be inspected periodically for cracks.

iv) Any spillage of mercury should be treated as follows:
pick up all large drops by suction using a pipette connected *via* a trap to the water pump. Cover the affected area with a paste of sulfur and lime in water (this is more effective than sulfur alone). When the mercury has been absorbed (several hours) sweep up the mixture, place it in a bottle and give it to your School Safety Co-ordinator for special disposal.

v) Items contaminated with finely divided mercury should be given to your School Safety Co-ordinator for special disposal. Apart from this and paste from spillages, all mercury must be recovered for re-use.

Appendix 4

Examples of Carcinogens

i) Certain aromatic nitrogen compounds including:
α- and ß-Naphthylamine, nitronaphthalenes.
All amino and nitrobiphenyls, including benzidines, tolidines, dianisidines, aminobiphenyls, nitrobiphenyls.
All amino and nitro stilbenes.
4,4'-Methylenedianiline (LTEL 0.01 ppm)
o-Toluidine.
3-Amino-1,2,4-triazole and related compounds.
Nitroquinoline *N*-oxides and similar compounds.

ii) Certain polycyclic aromatic hydrocarbons, notably "bay region" compounds such as benzo[*a*]pyrene, and heterocyclic analogues such as benzacridine.

iii) All *N*-nitroso compounds including:
Nitrosamines such as dimethylnitrosamine
Nitrosamides, including the diazomethane precursors N-methyl-N-nitrosourea, *N*-methyl-*N*-nitrosoguanidine and *N*-methyl-*N*-nitroso-*p* toluenesulfonamide ("Diazald").

iv) All diazo-compounds including ethyl diazoacetate and diazomethane.

v) Alkylating agents including:
All epoxides and aziridines.
Dimethyl and diethyl sulfate (LTEL 0.05 ppm).
Trimethyl- and triethyloxonium fluoroborate ("Meerwein reagents").
All alkyl halides, particularly more volatile and reactive ones such as methyl iodide (LTEL 2 ppm).
Methyl fluorosulfonate ("Magic methyl")
Acylating agents such as ß-propiolactone ß-butyrolactone and 1,3-propanesultone.

vi) All hydrazines and derivatives thereof, e.g. 1,1- or 1,2-dimethylhydrazine, methylhydrazine, hydrazine (LTEL 0.02 ppm).

vii) Vinyl halides including vinyl chloride monomer (LTEL 3 ppm), vinyl bromide and acrylonitrile (LTEL 2 ppm).

vii) Haloalkane solvents including carbon tetrachloride (LTEL 2 ppm), chloroform (LTEL 2 ppm), 1,2-dibromoethane (ethylene dibromide) (LTEL 0.5 ppm), hexachlorobutadiene.

viii) Benzene (LTEL 1 ppm).

ix) Hexamethylphosphoramide.

x) Chloromethyl methyl ether and bis(chloromethyl) ether (LTEL 0.001 ppm).

xi) Certain compounds of nickel and chromium(VI) including nickel sulfide, lead and zinc chromates, chromic acid.

xii) All compounds of arsenic

xiii) All radiochemicals

xiv) All forms of asbestos.

xv) Miscellaneous compounds including ethyl carbamate (urethane), thioacetamide, and thiourea.

Appendix 5

School of Chemistry Procedure for Disposal of Pyrophoric Substances

The following procedure, required in the School of Chemistry, applies to commercial bottles of methyllithium, butyllithium (all isomers), phenyllithium, Grignard reagents and also to stocks of such reagents prepared in house:

a) The quantities of such reagents for disposal must be minimised by keeping bottles in good order, properly sealed and not allowing moisture or oxygen to enter. If the concentration of such a solution has dropped, carry out a titration to find the current concentration and wherever possible use the remaining reagent, do not simply order up a new bottle. Once the contents of a bottle are of no further use, they must be disposed of immediately using the procedure below and on no account stored for prolonged periods.

b) The disposal of pyrophoric materials must only be carried out in the fume cupboard of a particular room identified for this purpose. This is a potentially dangerous operation:- expect a fire and plan in advance exactly what action will be taken in that event. On no account carry out this operation outside normal working hours or over lunch time (1 - 2 p.m.)

c) No other materials and, in particular, no flammable materials must be present while the fume cupboard is being used for such an operation. A dry powder fire-extinguisher should be placed in readiness beside the disposal site.

d) Carefully remove the top from the bottle and place it behind a safety shield at the back of the fume cupboard. With great care, add all at once 100 ml of isopropanol or ethyl acetate. Particularly in the case of methyllithium, ethyl acetate is recommended for this operation. While it has a lower flash point than isopropanol (–3 °C vs. 22 °C) the reaction is less exothermic, and of particular importance in the case of methyllithium, no flammable gas is evolved since an addition rather than hydrolysis reaction is involved.

e) After waiting for 30 minutes, any visible crust of solid must be carefully broken up, using a glass or metal rod, before pouring out the contents of the bottle, behind the safety shield, into a large fire-clay trough half full of water. After pouring out the contents, the bottle should be rinsed out with ethyl acetate or isopropanol first into the trough and only then with water.

Appendix 6

University of St Andrews

Hazardous Waste Uplift Request Form

Name/ Materials	Quantity	Components	Concentration (% o mg/kg)	Hazard Co	Physical Fo	Drum Number	Drum S	UN	Class	EWC Co	Unit Price	Total Price	Waste Category
				H-1									
				H-1									
				H-1									
				H-1									
				H-1									

School/Unit	
Tel:	**Fax:**
List Produced By:	

Environmental, Health & Safety Services
University of St Andrews
65 North Street
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Fife
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Tel: 01334 462750
Fax: 01334 462747
Email: ehss@st-andrews.ac.uk

For Official Use
Customer: **SA Number:** **Date of Uplift:**