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Ministry of Education

Revised 2003

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Disclaimer

The materials in this manual have been compiled from sources believed to be reliable and to represent the best current opinions on the subject, in order to provide a basic science safety manual for use in British Columbia schools. This manual is intended to serve as a starting point for good practices and does not purport to specify legal standards. No warranty, guarantee, or representation is made by the Ministry of Education as to the accuracy or sufficiency of the information contained herein. This manual is intended to provide guidelines for safe practices.

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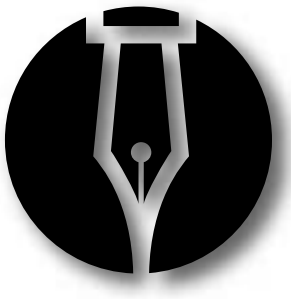

Preface

The first edition of the *Science Safety Resource Manual* was printed in 1988 and reprinted in 1990.

The first *Science Safety Resource Manual* was developed in response to safety needs as identified in the Provincial Science Assessments of 1978, 1982 and 1986, as well as concerns identified by various school districts and the British Columbia Science Teachers Association. This revised edition was developed in response to the need to update the *Science Safety Resource Manual* on recommendations from the Science Overview Team and a recommendation that came out of the Science Curriculum Review Report, March 2001.

It is intended that this manual will be used by schools and school districts to examine science safety in schools and initiate actions to improve science safety for all students and teachers.

This manual is located in PDF format at
http://www.bced.gov.bc.ca/irp/resdocs/

Acknowledgements

The Ministry of Education appreciates the contributions made in preparing the revised *Science SafetyResource Manual* by a number of individuals, committees and school districts.

Specific thanks are extended to the following contributors to this revised edition of the *Science Safety Resource Manual*

Thank you to:

Dave Berg, Associate Professor of Inorganic Chemistry, University of Victoria
Jackie Goodwin, Fire Safety Officer, Office of the Fire Commissioner
Gerrit Keizer, Port Moody Secondary School
Barbara Webster-Evans, Legal Counsel, Risk Management, Finance and Corporate Relations

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This revision was the responsibility of Darlene Monkman, Science Curriculum Coordinator.

Specific thanks are extended to the following contributors of the 1988 Edition:

THE SCIENCE SAFETY COMMITTEE MEMBERS (1980-1981)
Peter Beckett - School District No. 35 (Langley)
Doug Black - School District No. 43 (Coquitlam)
Lynne Broman - Consultant, School District No. 39 (Vancouver)
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SCHOOL DISTRICTS ASSISTING IN THE PILOT (1981)

School District No. 4 (Windermere)
School District No. 10 (Arrow Lakes)
School District No. 11 (Trail)
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Ministry of Attorney General
The Provincial Educational Media Centre
RETECH - Discovery Park, University of British Columbia
The Provincial Fire Commissioners Office
The Workers' Compensation Board
Ministry of Health
Consumer & Corporate Affairs
Electrical and Gas Safety Branch of the Ministry of Labour
B.C. Safety Council
The Red Cross
The Waste Management Branch of the Ministry of Environment
St. John Ambulance
B.C. Hydro

Acknowledgment is made to the numerous school districts and other organizations throughout North America who responded to requests for information and publications.

Finally, management of the updating, editing, and production of the 1988 document was the responsibility of Mr. David Williams of the Curriculum Development Branch of the Ministry of Education.

Teachers and school districts are not expected to guarantee 100% safety. Risk is always present.

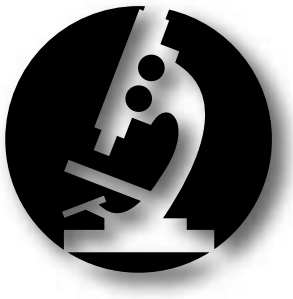
With each investigation the teacher should weigh the total benefits against potential hazards. In the final analysis it is the science teacher in the classroom who is in the best position to decide which particular activities should be

School Board/Trustees and Superintendent

The School Board and Superintendent should endeavour to:

- plan for the necessary improvements and procedures outlined in this manual;

- making provision for the safety of students with handicaps, cultural or language difficulties;
- ensuring teachers have the necessary resources to carry out their safety



Elementary

- formulate, in consultation with administration and other teachers, an action plan to deal with accidents in the classroom and also on extracurricular activities such as field trips. This plan should provide for the following:
  - removal of the source of the accident to prevent further injury to the victim and to other students. For example:
    - shut off the electrical mains for the room
    - shut off gas to the room
    - cease all class activities
  - administration of first aid, as necessary, or sending for a qualified first aid attendant
  - notification of the school administration, and, if necessary, the acquisition of medical aid
  - notification of parents or guardians.

****Caution - Do not administer medications in a first aid situation.**

Disposing of Chemicals

Every effort should be made to avoid the use of hazardous or dangerous chemicals. Please employ the following instructions for the disposing of non-toxic chemicals. For further information on the disposal of chemicals, go to “Chemical Waste Handling and Disposal” page 73 and / or consult your School District Safety Officer.

- The disposal of non-hazardous, water-soluble liquid wastes should involve diluting the liquid waste before pouring it down the drain, then running tap water down the drain to further dilute the liquid.
- Non-hazardous solid wastes should be disposed of in a waste container.
- Hazardous wastes should be disposed of in specially marked waste containers and need to be collected and disposed of by a contractor (e.g. oils, organic solvents). For detailed information, see pages 73-77.

1. Read all written instructions before doing an activity.
2. Listen to all instructions and follow them carefully.
3. Make sure you understand all the safety labels. (WHMIS symbols)
4. Always ask your teacher if you do not understand.
5. Wear proper safety protection as instructed by teacher.
6. Never remove your goggles during an activity.
7. Tie back long hair and avoid wearing loose clothing such as scarves, ties or long necklaces.
8. Know the location of safety and first aid equipment, including fire extinguisher, fire blanket, first-aid kit, and fire alarm. Never play with the safety equipment.
9. Work carefully and make sure that your work area is not cluttered.
10. Always cut away from yourself and others when using a knife or razor blade.

Elementary Equipment List

For a suggested list of science equipment for elementary classrooms, visit the following websites.

Arkansas Science Teachers' Association.
http://www.aristotle.net/~asta/equip1.htm

Utah Elementary Science Teacher Resource Book (TRB).
http://www.uen.org/utahlink/lp_res/TRB001.html

ProTeacher – Doing Science. http://www.proteacher.com/110002.shtml

Plant and Animal Care in the Classroom

(http://www.sasked.gov.sk.ca/docs/elemsci/corgesc.html)

Teachers are responsible for familiarizing themselves with any local, provincial, or federal statutes pertaining to the care of plants or animals. If in doubt, inquire. Pet shops or plant shops may have useful information. Remember that there are regulations preventing the picking of wild flowers, or the captive use of migratory birds or endangered species. The following are some guidelines for the care of plants and animals in the classroom:

- Be wary of any possible signs of allergic reactions among students to any plants or animals.
- Inform the administration before bringing any animals in to the school.
- Inquire about specific feeding and facility requirements for classroom pets.
- Be wary of possible diseases that may be spread by animals, or by people to animals.

pls.

1. Read all directions before starting an experiment.
2. Safety considerations in the science classroom demand responsible behaviour at all times.
3. Know the location of safety equipment.
4. Always alert the teacher in case of any accident.
5. If a chemical reagent comes in contact with the skin rinse off immediately with large amounts of cold water for at least 5 minutes. **Please note** that a concentrated acid spill should be wiped off first and then the area can be flushed thoroughly with water.
6. If any foreign substance enters the eye, rinse the eye immediately for 15 minutes.
7. If you wear contact lenses, notify the teacher. Some activities may require you to remove contact lenses.
8. When instructed, wear safety goggles and protective clothing.
9. Wear closed shoes during laboratory sessions.
10. Long hair should be tied back.
11. Do not use cracked or chipped laboratory glassware.
12. Chemicals are to be used in the lab only.

Sample Student Safety Contract/ Agreement

Class _____ Student's Name_____

Sample Medical Form

NAME OF STUDENT_____ DATE OF BIRTH _____

NAME OF PARENT/GUARDIAN _____

IN CASE OF EMERGENCY CONTACT: PARENTS /OR _____ PHONE _____

A. Please note any health problem, physical handicap, emotional difficulty, behavioural problem, or facts which may limit full participation in the science classroom. _____

HOME PHONE _____ FAMILY DOCTOR _____

WORK PHONE _____ OFFICE PHONE _____

Medical Insurance Plan No.: _____

B. Student's immunization shots are current , i.e. tetanus and diptheria, typhoid, smallpox and polio vaccine

❑ YES ❑ NO

C. Student is subject to:

❑ asthma	❑ sensitive skin	❑ sleepwalking	❑ nosebleed
❑ ear ache	❑ sinus trouble	❑ convulsions	❑ high blood pressure
❑ fainting	❑ frequent colds	❑ headache	❑ motion sickness
❑ tonsillitis	❑ nightmares	❑ bed wetting	❑ allergies (describe)
❑ eye infection	❑ bronchitis	❑ kidney problem	

D. Student wears contact lenses ❑

E. Medications: I would like my child to be given:

Name of Medication(s) _____

Purpose of Medication _____

* *

In case of emergency, I hereby give permission to the physician selected by the school to provide necessary treatment for my child.

Parent/Guardian signature: _____ Date: _____

Safety Equipment For Science Classrooms

Teachers and students should be familiar with the location of and use of the following equipment. The safety equipment should be located for easy access.

- Safety equipment should be checked at least twice a year.
- Frequently used safety items should be provided on a separate, centrally located cart for easy access and availability.
- It is recommended that science rooms have both windows and extractor fans.
- Science safety posters should be displayed.
- Emergency lighting should be available.
- A hand held drench hose may be installed to supplement the safety shower and eye wash units.

Equipment

Free standing clear plastic screen,
minimum size 60 cm high x 1 m wide

Safety Equipment For Science Classrooms Cont.

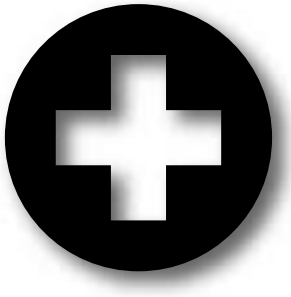
Equipment	Comments
One pair of safety glasses, goggles or face shields for each teacher/demonstrator	Teachers and students must wear eye protection whenever there is the likelihood of eye injury. It is good practice to wear eye protection in laboratories at all times. Safety eyewear must meet the requirements of *CSA Standard CAN/CSA-Z94.3-92* (8.14 OHSR)
Lab coats	Lab coats should be worn when there is a possibility of exposure to corrosive or other harmful chemicals. It is good practice to wear a lab coat in laboratories at all times.
One respirator of the dual cartridge type, fitted with a filter to provide protection from dusts/mists/fumes. Ammonia cartridges should also be available.	This is satisfactory for organic vapours, acid gas, dust and mist. Familiarity with its operation is important. Not suitable for persons with beards because of respirator leakage.
One pair of safety/beaker tongs.	If necessary, use with heat resistant gloves when handling very hot equipment. Extreme care should be taken to avoid accidents with heated material.
One fume hood with working extractor fan, sink and adequate lighting. Controls must be placed outside the hood.	Necessary in each science classroom. The fume hood must provide average air velocities over the operational face of a hood of 0.5 metres/second but not less than 0.4 meters per second at any point across the face. This
Simple handwashing facilities.	
Safety showers.	
Spill kits.	
Pails containing 12 to 15 L of kitty litter or bentonite	

Safety Equipment For Science Classrooms Cont.

Personal Protective Equipment For Students

- Educators should ensure that students are provided with personal protective equipment. If personal injuries to students result from the failure to have or use this equipment, negligence may be claimed.
- The use of laboratory coats is recommended for protection of persons and clothing when working with chemicals, and also whenever appropriate in other science activities, e.g., dissections. Sleeve protectors should be worn by students when needed.
- Eye protection must be used in all situations where there is any risk of eye injury.
- Gloves should be worn in all work involving hazardous chemicals or in any other situation when required by the teacher, e.g. dissections.
- Safety training is an integral part of learning laboratory techniques. Though infrequently put to the test, safety training is an excellent way of ensuring that safety becomes a lifelong practice.

Student Protective Equipment	Comments
Each student should have protective goggles or plastic face shields (protective equipment should be splash-proof if used for chemistry) *Note: Some facility or procedure for sterilizing goggles after use is strongly recommended. UV cabinets or disinfectant solutions are commonly used.*	As part of the risk assessment the level of eye protection must be predetermined before handling of the chemical. If there is a high or moderate risk of eye injury, then a chemical splash goggles must be worn. If not, safety spectacles fitted with side shields are recommended. If glasses are normally worn, goggles should be able to fit over them.
Laboratory coat (optional)	Laboratory coats should be made of approved laboratory material only.
Sleeve Protectors	Should be worn when required.
Gloves (plastic is preferred because it does not cause allergic reactions which are characteristic of latex gloves).	Gloves should always be worn when handling hazardous chemicals, and in biological experiments to prevent contact with dyes, formaldehyde, or possible infectious materials.
Suitable eye protection against UV radiation must be worn when UV sources are in use.	Sources include discharge tubes, mercury or ion arcs, and lamps for fluorescent “black light” experiments.



First Aid

The Workers' Compensation Board of British Columbia recommends that a Level 1 Kit be available for a classroom where there are between 11 and 50 people.

First Aid Kit Contents

Except for blankets, these items must be kept in a container that can readily be taken to the scene of an injury. The container must be weatherproof if necessary to keep the items clean and dry. Blankets must be readily available to the first aid attendant.

3	blankets
24	14 cm x 19 cm antiseptic towelettes individually packaged
60	hand cleansing towelettes, individually packaged
100	sterile adhesive dressings, assorted sizes, individually packaged
12	10 cm x 10 cm sterile gauze dressings, individually packaged
4	10 cm x 16.5 cm sterile pressure dressings with crepe ties
2	7.5 cm x 4.5 m crepe roller bandage
1	2.5 cm x 4.5 m adhesive tape
4	20 cm x 25 cm sterile abdominal dressings, individually packaged
6	cotton triangular bandages, minimum length of base 1.25 m
4	safety pins
1	14 cm stainless steel bandage scissors
1	11.5 cm stainless steel sliver forceps
12	cotton tip applicators
1	pocket mask with a one-way valve
6	pairs of latex gloves
1	first aid record book, and pencil or pen

First Aid Procedures

In the event of a serious accident involving personal injury, the teacher should:

1. Report immediately to the school office via the P.A. and calmly explain where the accident occurred, how many students were injured and how serious the injuries appear to be.
2. During the time required for emergency personnel to arrive, remove everyone from the vicinity of the accident and administer first aid.

(page 2-6 STAO, 1994)

First Aid in the Science Classroom

Injury	Response
Burns and Scalds	• If minor – immerse the wound in cold water. Where immersion is not possible, apply towels or cloths soaked in clean cool water to the affected area and change frequently. • Do NOT apply any lotions or ointments. • Do NOT remove clothing if stuck to the burned area. • Arrange for medical attention.
Bruises	• Apply cold compresses
Fainting	• Leave the person lying down • Loosen any tight clothing • Keep crowds away
Inhalation of toxic fumes or gases	• Summon trained personnel who can administer oxygen and other medical procedures.
Poisoning	• Note the suspected poisoning agent • Call Poison Control Centre – 1-800-567-8911 or 604-682-5050 • Call an ambulance. Send container and contents with casualty to hospital.

Injury	Response
Cuts	Control the bleeding by:
Severe bleeding:	• Compressing the wound with a cloth or whatever is available • Elevate the injury above the level of the heart
If blood is spurting:	• Place a pad directly on the cut • Apply firm pressure • Wrap the injured person (to avoid shock) • Get immediate medical attention.
Less severe bleeding:	• Wash the cut • Apply a pressure pad firmly on the wound • If bleeding continues or if any pieces of glass have to be removed, seek medical attention. • **Teachers must use disposable gloves when in contact with blood.**
Chemical Spills and Splashes *Chemical splash – on the skin*	• Flush the affected area with cold water for at least 5 minutes. • Wash affected area with a mild detergent, preferably soap and water. • Do NOT neutralize chemicals on the skin. • Remove any clothing contaminated with chemicals. Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes. • Depending on the nature of the chemical, seek medical help.
Chemical spills – eyes	• Check for, and remove contact lenses before irrigation. If contact lenses are difficult to remove, begin irrigation with lenses in place. • Irrigate both eyes immediately with steady gentle stream of tap water for at least 15 minutes. • Arrange for medical help and continue irrigation while victim is transported to emergency care facility. **Notes** • Alkali splash in the eyes is more dangerous than acid at the same concentration because of its rapid penetration into tissues of the skin and eye. Protective

The purpose of any action taken at an accident is to minimize the effect of the accident. If action must be taken quickly, do you know what to do? Do you, and your students, have a **Planned Accident Response?**

A Planned Accident Response means:

- a familiarity with the resources (knowledge, human resources and material) available for reducing the effects of an accident;
- maintaining the resources on a regular basis; and
- understanding the steps necessary for a rapid, organized response to an accident.

- One person must have absolute control of the actions taken by all people at the site. If necessary, send for qualified help; make sure the one who goes for help will report back to you. Parents of injured students should be contacted.
- Life threatening conditions must be recognized and reduced immediately. This may just mean clearing everyone from the area.
- Injury must be quickly assessed and appropriate action initiated. Do only the things you have been trained to do; leave extensive treatment to the medical experts.
- The accident environment must be made safe. Fire, electrical and toxic material hazards can be reduced by shutting off gas and power, ventilating, and using protective gear. A safe approach to the accident area must be well thought out.
- **An Accident Investigation report** should be completed for all minor accidents. If there is an accident with significant personal injury, it should be referred to School District and Schools Protection Program immediately. Ensure that it is reported before beginning an investigation. School District's are responsible to comply with WCA Part 3, Division 10, and OHSR 3.4 for accident reporting and investigating.
- Preliminary investigation of the accident must be assigned to one person and initial notes taken before clean up starts.
- Every accident must have a thorough investigation that results in written recommendations for the prevention of more accidents of the same type.

Format

- An objective description of the accident event.
- A description of the accident result.
- A description of the action taken at the accident.
- A description of the **root** cause(s)) of the accident.
- Recommendations for action that will prevent recurrence of the accident.

To reduce accident frequency, students as well as teachers must be aware, be alert and be willing to act. Student safety awareness and attitudes should be addressed frequently. A thorough discussion with students should be part of the follow-up action for any accident that occurs.

Eye Hazards

The eye is probably the most vulnerable portion of the body surface from an injury standpoint. It is also a most important link between the individual and the outside world. Every effort should be made to protect the eye. Protective eyewear (spectacles, goggles, or face shields), that complies with the relevant Canadian

- Dusts or chemicals can be trapped behind the lens and cause irritation or damage to the cornea or both;
- Gases and vapours can cause irritation and excessive eye watering
- Chemical splash may be more injurious when contact lenses are worn

This increased risk is related to the removal of the lenses. If removal is delayed, first aid treatment may not be as effective and, in turn, the eye's exposure time to the chemical may be increased. The opposite, however, may be true as well. Contact lenses may prevent some substances from reaching the eye, and thus minimize or even prevent an injury. Both situations have been documented. As a result, a wide range of opinions about the safety of contact lenses in the workplace has formed. More complete information is hard to find since occupational injury reporting systems do not typically include information about contact lens use.

The critical point to remember is that contact lenses are not intended to be used as protective devices. They are not a substitute for personal protective equipment (PPE) – if eye and face protection is required for certain work operations then all workers, including contact lens wearers, should wear the proper protective devices. Safe work conditions for all workers are only possible when basic occupational health and safety practices and procedures are followed.

Are there situations where it may be hazardous to wear contact lenses?

While the following conditions may be hazardous to all students, contact lens wearers should be aware that certain conditions may make it necessary to avoid wearing their lenses. Each situation should be carefully investigated. These situations may include:

- Exposure to chemical fumes and vapours
- Areas where potential for chemical splash exists
- Areas where particulate matter or dust is in the atmosphere
- Exposure to extremes of infrared rays
- Intense heat
- Dry atmosphere
- Flying particles
- Areas where caustic substances are handled, particularly those used or stored under pressure

In workplaces with ultra-violet and infrared radiation sources, users of contact lenses require protection just as non-users do. Contact lenses absorb infrared radiation. This effect is potentially more harmful to the soft lens wearer as it could alter the water balance of the contact lens.

Are some hazards specific to soft contact lens wearers?

Soft lenses are made from a type of plastic that contains a large proportion of water. The soft lens adheres more tightly to the cornea and does not have as much fluid motion as the hard contact lens. For these reasons, some researchers think

the soft lens offers some, but not total, protection against entrapment of foreign substances between the contact lens and the cornea.

The major risks for soft contact lens wearers are from chemical splashes and from hot, dry environments. Because of the high water content of the soft contact lens, some chemicals can pass through the lens and be held against the cornea by the lens itself.

Hot, dry environments can lead to problems because they can cause the tear layer (upon which the lens sits) to dehydrate. This situation results in eye discomfort.

Are some hazards specific for hard contact lens wearers?

Hard lenses are made from an impervious material. Increased risk may result if foreign substances, such as dust or small metal fragments, become trapped behind the contact lens. Since the hard contact lens floats on the tear film in front of the cornea (not in a fixed position), there may be an abrading action between the contact lens and the foreign substance that may result in injury to the cornea. Also, chemicals may become trapped behind the contact lens and held in place against the cornea. In dirty, dusty environments, the wearing of hard lenses may be more hazardous than soft contact lens.

Who has responsibility for users of contact lenses?

The school and the student have responsibilities to ensure the safe use of contact lenses. Where contact lenses are worn, the following steps should be followed:

School

- Ensure that proper health and safety practices and procedures are followed.
- Provide training and education about eye hazards – particularly those specific to contact lens use – and training on the proper use of eye wash stations and procedures for rinsing the eyes.
- It is important that students wearing contact lenses be clearly identified (especially for first aid).
- Have personnel available who are knowledgeable in the removal of contact lenses in case of an emergency.

Student

- Take special care to keep contact lenses clean.
- Make sure your teacher knows that you are wearing contact lenses.
- Be alert for changes to environmental conditions that may be hazardous to you.
- Keep eye glasses available for unforeseen circumstances.
- Wear personal protective equipment whenever required.
- Learn about eye hazards.

Updates from 1988 Science Safety Resource Manual

Chemicals that have been added to the "*should be removed list*".

**Ammonium nitrate
NH_4NO_3
**Adrenaline (Epinephrine)
$C_9H_{13}NO_3$
**Cadmium carbonate
$CdCO_3$
**Dichloro methane (Methylene chloride)
CH_2Cl_2
**Litharge (lead oxide, yellow)
PbO
**Magnesium peroxide (Magnesium dioxide)
MgO_2
**Mercurous nitrate
$Hg_2(NO_3)_2$
**Mercurous oxide
Hg_2O
**Potassium
K
**Potassium bichromate (Potassium dichromate)
$K_2Cr_2O_7$
**Potassium chromate
K_2CrO_4
**Potassium dichromate (bichromate)
$K_2Cr_2O_7$
**Prussic Acid (Hydrocyanic Acid)
HCN
**P.T.C. paper (Phenylthiocarbamide, phenylthiourea)
$C_7H_8N_2S$
**Sodium bromate
$NaBrO_3$
**Sodium chlorate
$NaClO_3$
**Sodium chromate
Na_2CrO_4
**Sodium dichromate
$Na_2Cr_2O_7$
**Strontium
Sr
**Thallium
Tl

Aniline
C_6H_7N
Cesium chloride
CsCl
Diphenylamine
$C_{12}H_{11}N$
Ethyl acetate
$C_4H_8O_2$
Ethyl butyrate
$C_6H_{12}O_2$
Ethylene diamine
$C_2H_8N_2$
Ethylene dichloride
$C_2H_4Cl_2$
Hydrogen peroxide 3%, 6% or 10%
H_2O_2
Magnesium oxide
MgO
Molybdenum
Mo
Ninhydrin
$C_9H_6O_4$
Phosphoric acid (14.6M, 85%)
H_3PO_4
Phosphoric anhydride (phophorus pentoxide)
P_2O_5
Phosphorus pentoxide (Phosphoric anhydride)
P_2O_5
Titanium dioxide
TiO_2
Tungstic acid

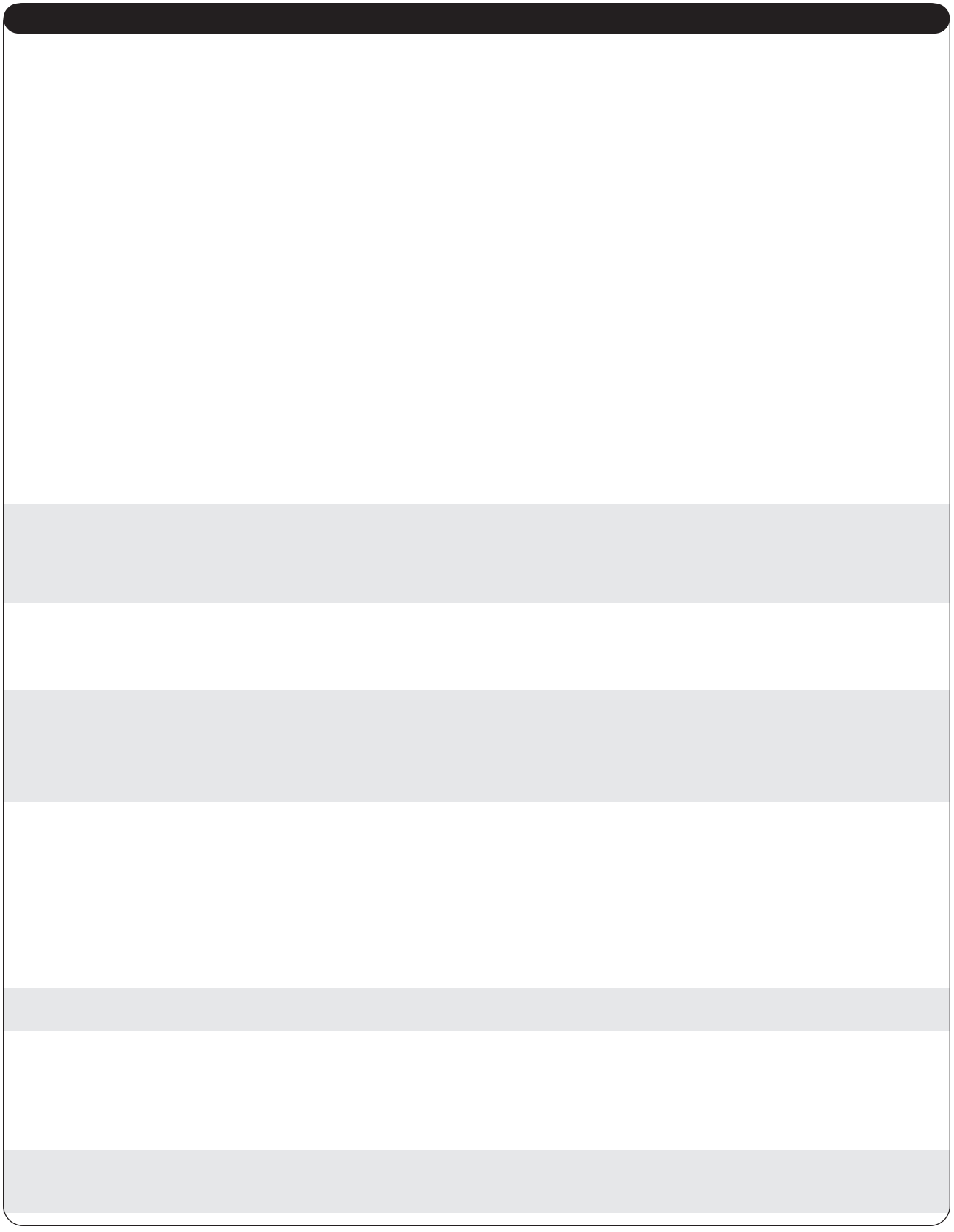
Chemical Name and Formula	H*	F*	R*	Comments
**Acetaldehyde CH_3CHO	3	4	2	Possible carcinogen; highly flammable; moderately toxic (narcotic); dangerous fire and explosion risk. May form explosive levels of peroxides on concentration.
Acetamide CH_3CONH_2				Possible carcinogen; otherwise low toxicity. Practice strict hygiene in the use of this material.
Acetic acid (7.4M, 99.8%) CH_3COOH	3	2	0	Corrosive to skin and tissue; moderate fire risk; moderately toxic by ingestion and inhalation.
**Acetic anhydride (oxide) $C_4H_6O_3$	3	2	1	Strongly irritating and corrosive; moderate fire risk; causes severe eye damage; wear eye protection; have access to eyewash. Vapours are strongly irritating; open and dispense in a hood. Reacts (sometimes delayed) violently with water. Moderately toxic by ingestion.
Acetone CH_3COCH_3	1	3	0	Dangerous fire risk; flammable ; slightly toxic by ingestion and inhalation.
Aceto-carmine stain				
Aceto-orcein,. 2% solution				Slightly corrosive to eyes and skin; moderately toxic by ingestion.
**Acetyl chloride CH_3COCl	3	3	2 W	Strong irritant; flammable, fire risk, causes burns; reacts with water and alcohol.
**Acrolein C_3H_4O	4	3	3	Strong irritant; flammable.
**Acrylic acid $C_3H_4O_2$	3	2	2	Irritant, causes eye damage, flammable
Adipic Acid $C_6H_{10}O_4$		1	0	Combustible; eye irritant.
**Adrenaline (Epinephrine) $C_9H_{13}NO_3$	2			Increases blood pressure. Toxic by ingestion.
L-alanine $C_3H_7NO_3$				
Alizarin $C_{14}H_8O_4$				Low Toxicity; combustible.
Alum (Potassium aluminum sulfate) $KAl(SO_4)_2$				Low Toxicity; combustible.
Aluminon (Aurin Tricarboxylic Acid) $C_{22}H_{23}N_3O_9$				Low acute toxicity, mutagen.
Aluminum Al	0	3	1	Fine metal powders form an explosive mixture with air.
Aluminum ammonium sulfate (Ammonium alum) $AlNH_4(SO_4)_2$				Absorbs moisture on exposure to air.
**Aluminum carbide Al_4C_3				Dangerous fire risk.
Aluminum carbonate $Al_2(CO_3)_3$				Do not store near combustible materials.
Aluminum chloride, anhydrous $AlCl_3$				Slightly toxic by ingestion; body tissue irritant.
Aluminum hydroxide $Al(OH)_3$				Non-combustible.
Aluminum nitrate $Al(NO_3)_3$				Strong oxidizer; slightly toxic by ingestion.
Aluminum oxide Al_2O_3				Body tissue irritant; avoid inhalation of dust.
Aluminum phosphate $AlPO_4$				Solutions are corrosive to tissue.
Aluminum potassium sulfate (alum) $KAl(SO_4)_2$				Low toxicity; non-combustible.

***** Should not be used in high school laboratories.***

**Barium dioxide BaO_2				
Barium hydroxide $Ba(OH)_2$				Toxic by ingestion.
Barium nitrate $Ba(NO_3)_2$	1	0	0 OX	Strong oxidizer; potentially serious fire risk; moderately toxic by ingestion.
**Barium sulfide BaS				
Benedict's qualitative solution (water solution of sodium carbonate, copper sulfate, sodium citrate)				
Benzaldehyde Green (Malachite green) $C_{23}H_{25}ClN_2$				This can make a huge mess! Carcinogen.
**Benzene C_6H_6	2	3	0	Known carcinogen; strict observance of safety precautions must be practiced, i.e., use a hood, wear gloves; use eye or face protection. Flt86 or face prr fmodt.,
**Benzene sulfonic acid $C_6H_5SO_3H$				
Benzoic acid $C_7H_6O_2$	2	1	-	
**Benzoyl peroxide $C_4H_{10}O_4$				
**Beryllium Be	3	1	0	
**Beryllium compounds (Be salts)				
Bismuth Bi				
Bismuth chloride (trichloride) $BiCl_3$				
Bismuth nitrate $Bi(NO_3)_3$				
Bismuth oxide Bi_2O_3				
Biuret (reagent) $C_2H_5N_3O_2$				
Bleach (Sodium hypochlorite) (dilute) NaOCl				
Bleaching powder (Calcium hypochlorite) $Ca(OCl)_2$				
Borax (Sodium borate, Sodium tetra borate) $Na_2B_4O_7$				
Boric acid crystal H_3BO_3				
**Boron B				
Brass (Copper-zinc alloys)				
**Bromine (reagent) Br_2				
Brom(o)cresol green $C_{21}H_{14}Br_4O_5S$				

Chemical Name and Formula	H*	F*	R*	Comments
Brom(o)cresol purple $C_{21}H_{16}Br_2O_5S$				
Bromoethane (Ethyl bromide) C_2H_5Br	2	1	0	Tumorigen, mutagen, limit exposure to vapour.
Bromophenol blue C_6H_5BrO				
Bromothymol blue $C_{27}H_{28}Br_2O_5S$				
1-Butanol (n-butyl alcohol) $C_4H_{10}O$	1	3	0	Moderate fire risk; moderately toxic by inhalation and ingestion; eye irritant; absorbed by skin.
2-Butanone (Methyl ethyl ketone) C_4H_8O	1	3	0	Flammable; dangerous fire risk; narcotic by inhalation.
iso-butyl alcohol $C_4H_{10}O$				Flammable; slighlty toxic; skin, eye and respiratory irritant.
Tert-butyl alcohol $C_4H_{10}O$ (2-methyl-2-propanol)	1	3	0	Moderate fire risk; slightly toxic by ingestion and inhalation; eye irritant; absorbed by skin.
Butyric acid $C_4H_8O_2$	3	2	0	Obnoxious odor; stench agent; strong irritant to skin and eyes; flammable liquid; moderately toxic by ingestion and skin absorption.
**Cadmium Cd				A known carcinogen; dust or fume inhalation especially toxic.
**Cadmium carbonate $CdCO_3$				All cadmium salts are highly toxic.
**Cadmium iodide CdI_2				
**Cadmium nitrate $Cd(NO_3)_2$				A known carcinogen; moderately toxic by inhalation and ingestion; strong oxidizer; fire and explosion risk.
Caffeine $C_8H_{10}N_4O_2$				Very toxic; as little as 65 mg can be life threatening.
Calcium Ca	3	1	2 ~~W~~	Contact with water or moisture evolves flammable hydrogen. Flammable in finely divided form. Avoid contact with oxidizers; skin irritant.
Calcium acetate $CaC_2H_6O_4$				
**Calcium carbide CaC_2	3	3	2 ~~W~~	Exposure to water or moisture evolves flammable acetylene gas; corrosive to eyes and skin. 500 grams of calcium carbide will yield approximately 150 liters of flammable acetylene.
Calcium carbonate (powder) $CaCO_3$				
Calcium chloride $CaCl_2$				Slightly toxic.
Calcium fluoride CaF_2				Slightly toxic; skin irritant.
**Calcium hydride CaH_2			3 W	Fire hazard. Water reactive.
Calcium hydroxide $Ca(OH)_2$				Skin irritant; avoid dust inhalation.
Calcium hypochlorite (Bleaching powder) $Ca(OCl)_2$				Moderately toxic by ingestion and inhalation; fire risk in contact with organic substances; an oxidizer. Body tissue irritant.
Calcium nitrate $Ca(NO_3)_2$				Strong oxidizer; potential fire risk in contact with organic material; may explode if shocked or heated. Slightly toxic.

***** Should not be used in high school laboratories.***



Chemical Name and Formula	H*	F*	R*	Comments
**Chloroform $CHCl_3$	2	0	0	A suspected carcinogen. Prolonged inhalation may be fatal; toxic and narcotic by inhalation; ingestion may be fatal.
**m-Chlorophenol C_6H_5ClO				Toxic by skin absorption.
**Chromic acetate $C_6H_9CrO_6$				Oxidizer.
**Chromic acid (Chromium trioxide) CrO_3	3	0	1 OX	Corrosive to skin; highly toxic; powerful oxidizing agent; avoid contact with reducing agents and organic material. A carcinogen as fume or dust. Practice strict hygiene in the use of this substance.
Chromic chloride $CrCl_3$	3	3	0	
**Chromic nitrate $Cr(NO_3)_3$				
Chromium metal Cr				Beware of chrome dust or chrome as a fume – a known carcinogen.
Chromic potassium sulfate $CrK(SO_4)_2$				Body tissue irritant.
**Chromium trioxide (Chromic acid) CrO_3				Corrosive to skin; highly toxic; powerful oxidizing agent; avoid contact with reducing agents and organic material. A carcinogen as fume or dust. Practice strict hygiene in the use of this substance.
**Chromous salts				Toxic.
Citric acid $C_6H_8O_7$				Severe eye irritant.
Cobalt Co				Possible carcinogen as fume or dust.
Cobaltous carbonate $CoCO_3$				Cobalt compounds are possible carcinogens; moderately toxic.
Cobaltous chloride $CoCl_2$				Moderately toxic by ingestion; causes blood damage; possible carcinogen as fume or dust. Practice strict hygiene in the use of this substance.
Cobaltous nitrate $Co(NO_3)_2$				Oxidizer; fire risk in contact with organic material; moderately toxic; possible carcinogen.
Cobaltous sulfate $CoSO_4$				Eye, skin and respiratory irritant; possible carcinogen; moderately toxic.
**Colchicine $C_{22}H_{25}NO_6$				Highly toxic; as little as 0.02 grams could be fatal.
**Collodion (solution of pyroxylin in alcohol and ether)				Dangerous fire risk; body tissue irritant.
Congo red $C_{32}H_{22}N_6Na_2O_6S_2$				Mutagen, moderate toxicity, negative reproductive effects.
Copper Cu				
Cream of tartar (Potassium bitartrate) $KHC_4H_4O_6$				
Crystal Violet (Gentian violet)				Moderately toxic by ingestion; body tissue irritant. Mutagen.
Cupric acetate $CuC_4H_6O_4$				Moderately toxic.
Cupric bromide $CuBr_2$				
Cupric carbonate (basic) $Cu_2(OH)_2\ CO_3$				Slightly toxic by ingestion and inhalation.
Cupric chloride $CuCl_2$				

***** Should not be used in high school laboratories.***

Chemical Name and Formula	H*	F*	R*	Comments
Ferrous sulfate $FeSO_4$				Slightly toxic by ingestion.
Ferrous sulfide (iron sulfide) FeS				Contact with acid liberates poisonous hydrogen sulfide gas.
**Fluorine F_2	4	0	3 OX, ~~W~~	Extremely corrosive gas.
Formaldehyde (37% formaldehyde, methanol free) HCHO	3	2	0	Alleged carcinogen; strong irritant; avoid breathing vapour and avoid skin contact. Use a fume hood. Highly toxic by ingestion, inhalation, and skin absorption.
Formalin (37% formaldehyde with 15% methanol) HCHO	3	2	0	Formaldehyde is an alleged carcinogen. Avoid skin contact. Provide lots of ventilation.
Formic acid HCOOH	3	2	0	Corrosive to skin and tissue; reacts violently with bases. Upon aging, decomposes to carbon monoxide and water thus creating potential explosive danger in a tightly ingestion and inhalation.
Freon (fluorcarbon products)				
Fructose $C_6H_{12}O_6$				
Fuchsin (acid) $C_{20}H_{17}N_3Na_2O_9S_3$				
Fumaric acid $C_4H_4O_4$				
Galactose $C_6H_{12}O_6$				
Gallium Ga				
Gentian violet (Methyl violet) $C_{25}H_{30}N_3Cl$				Moderately toxic by ingestion; body tissue irritant.
Germanium Ge				
Gibberellic acid $C_{19}H_{22}O_6$				
Glucose (Dextrose) $C_6H_{12}O_6$				
Glutamic acid $C_5H_9NO_4$				
Glycerol (Glycerine) $C_3H_8O_3$	1	1	0	Some people are allergic to glycerin and may experience irritation to their skin and eyes. Contact with strong oxidants (chromium trioxide, potassium chlorate, potassium permanganate) may cause an explosion.
Glycine $C_2H_5NO_2$	1	1	0	
Gold Au				
Graphite (plumbago) C				
n-Heptane C_7H_{16}	1	3	0	Dangerous fire risk; flammable liquid; slightly toxic by inhalation.
n-Hexane C_6H_{14}	1	3	0	
1,6,-hexanediamine $C_6H_{16}N_2$				

***** Should not be used in high school laboratories.***

Magnesium hydroxide $Mg(OH)_2$				
Magnesium nitrate $Mg(NO_3)_2$	1	0	0 OX	Strong oxidant; fire and explosion risk in contact with organic material. Skin, eye and respiratory tract.
Magnesium oxide MgO				
**Magnesium peroxide (Magnesium dioxide) MgO_2				
Magnesium sulfate $MgSO_4$				Irritates eyes and respiratory tract.
Malachite green (Benzaldehyde green) $C_{23}H_{25}ClN_2$				This can make a HUGE mess! Carcinogen.
Maleic acid $C_4H_4O_4$				Moderately toxic by ingestion; severe body tissue irritant.
**Maleic anhydride $C_4H_2O_3$	3	1	1	
Malic acid $C_4H_6O_5$				
Maltose $C_{12}H_{22}O_{11}$				
Manganese Mn				Irritant as a fume or dust; dust is flammable.
Manganese carbonate $MnCO_3$				
Manganese dioxide MnO_2				Strong oxidant; avoid contact with organic material; body tissue irritant.
Manganese sulfate $MnSO_4$				
D-Mannose $C_6H_{12}O_6$				Body tissue irritant.
Marble chips (Calcium carbonate) $CaCO_3$				
Menthol $C_{10}H_{20}O$				Slightly toxic by ingestion and inhal TD and in6idaltant as a fume or duNIodide Manganese
**Mercuric chloride $HgCl_2$				
**Mercuric iodide HgI_2				
**Mercuric nitrate $Hg(NO_3)_2$				
**Mercuric oxide (red, yellow) HgO				
**Mercuric sulfate $HgSO_4$				
**Mercuric sulfide (black, red) HgS				
**Mercurous chloride Hg_2Cl_2				
**Mercurous iodide Hg_2I_2				

**Mercurous nitrate $Hg_2(NO_3)_2$				
**Mercurous oxide Hg_2O				
Mercury Hg				Metallic mercury is highly toxic by skin absorption and by inhalation of vapour. Metallic mercury has a relatively low vapour pressure and vapourizes readily when heated. Continuous exposure to small concentrations of vapour is harmful. Frequent skin contact is harmful. Dispense and use mercury only under a hood or in a well-ventilated area. Dispense mercury in a plastic or glass tray so that any spillage can easily be recovered. ONLY KEEP SMALL QUANTITIES IN SCHOOLS AND STORE IN PLASTIC BOTTLES. WARNING: Students should not be permitted to amalgamate coins or jewellery witpTj-6.5NLS00bH46.5N8.71[9stic 7s tray so that any spillage can easily be recoverecoverc(19TD[(easirc6e.h(oug-0.0ae3t26zes r)18(eadily wh4D[Elly COLS AND STORE IN)]TJO
Methanol (Methyl alcohol) CH_3OH	1	3	0	
Methionine $C_5H_{11}NO_2S$				
Methyl alcohol (Methanol) CH_3OH	1	3	0	
Methyl benzene (Toluene) C_7H_8	2	3	0	
Methyl cellulose (Cellulose methyl ether)				
Methylene blue $C_{16}H_{18}ClN_3S$				
**Methylene chloride (Dichloro methane) CH_2Cl_2	2	1	0	
Methyl ethyl ketone (2-Butanone) C_4H_8O	1	3	0	
Methyl glycol (1, 2 Propylene glycol) $C_3H_8O_2$				
Methyl orange (tropaeolin D) $C_{14}H_{14}N_3NaO_3S$				
2-methyl 1-propanol (Iso butyl alcohol) $C_4H_{10}O$	1	3	0	
Methyl red $C_{15}H_{15}N_3O_2$				
Methyl salicylate (winter green oil) $C_8H_8O_3$	1	1	0	
Methyl violet (Gentian violet) $C_{25}H_{30}N_3Cl$				
Methylene blue $C_{16}H_{18}ClN_3S$				
**Million reagent (solution of Mercury - Nitric acid - water)				
Mohr's Salt (Ammonium ferrous sulfate) $FeH_8N_2O_8S_2$				
Molybdenum Mo				
Naphthalene $C_{10}H_8$	2	2	0	
Nichrome				
Nickel Ni				

Nickel acetate Ni $(CH_3CO_2)_2$		
Nickel chloride $NiCl_2$		
Nickel nitrate $Ni(NO_3)_2$		
Nickel sulfate $NiSO_4$		
Ninhydrin $C_9H_6O_4$		
Nitric acid (15.4 M, 69%) HNO_3	3	H Palmitic acij2.3811 -0.33 TD0 Tc(43 TD(8)3)Tj r8 -0.33 TD(6)Tj0.5448-8.8D-0.0113 Tc(20)Tj1.0896 0.33 oTj1.0e36 43 TD(8)3D3el m54n0l-t18t34m5t56da6aM.35 2kH.(H)Tj0.7103540 .ol8M.3540 .ol.gh6572
**Nitrobenzene $C_6H_5NO_2$	3	
Nitrogen, gas (liquified) N_2		
**Nitrogen dioxide (liquefied) NO_2		
Octyl acetate $C_{10}H_{20}O_2$		
n-Octyl alcohol (1-octanol) (Caprylic alcohol) $C_8H_{18}O$		
Oleic acid $C_{18}H_{34}O_2$		
Orange IV (Troparolin OO) $C_{18}H_{14}N_3NaO_3S$		
Oxalic acid $C_2H_2O_4$		
Oxygen, gas O_2		
Palmitic acid $C_{16}H_{32}O_2$		
Paraffin (oil, wax) (solid hydro carbons) C_nH_{2n+2}		
Paraformaldehyde		
**n-Pentane C_5H_{12}		
Pentyl alcohol (Amyl alcohol) (1-2-3 pentanol) $C_5H_{11}OH$		
**Perchloric acid $HClO_4$		
**Petroleum Ether		
**Phenol (carbolic acid) C_6H_6O		
Phenolphthalein $C_{20}H_{14}O_4$		
Phenol red (Phenolsulfonephthalein) $C_{19}H_{14}O_5S$		

Chemical Name and Formula	H*	F*	R*	Comments
Phenylalanine $C_9H_{11}NO_2$				
Phenylhydrazine $C_6H_8N_2$	3	2	0	Mutagen, negative reproductive effects. Limit exposure to vapour.
Phenyl salicylate $C_{13}H_{10}O_3$				Slightly toxic by ingestion.
**Phenylthiocarbamide (PTC paper)				Highly toxic by ingestion.
Phosphoric acid (14.6M, 85%) H_3PO_4	3	0	0	Skin and eye irritant; slightly toxic by ingestion and inhalation; corrosive; burns tissue.
Phosphoric anhydride (phophorus pentoxide) P_2O_5				Severely corrosive substance; reacts violently with water; moderately toxic.
**Phosphorus, amorphous (red) P	1	1	1	Flammable solid; yields very toxic fumes on burning. Avoid contact with potassium chlorate or potassium permanganate or other strong oxidizing agents. Explosions have been known to result. Dangerous fire risk; skin contact may cause burns. Moderately toxic.
**Phosphorus, purified (yellow) P	4	4	2	
Phosphorus pentoxide (Phosphoric anhydride) P_2O_5				Severely corrosive substance; reacts violently with water; moderately toxic.
**Phosphorus trichloride PCl_3	4	0	2 W	Reacts with water.
Phtalic acid $C_8H_6O_4$	0	1	1	
P-Hydrion paper (indicator paper)				
**Picric acid $C_6H_3N_3O_7$	3	4	4	Poison; corrosive liquid possibly absorbed through the skin; if allowed to dry, the solid is a powerful explosive. Extreme danger.
Platinum Pt				
**Potassium K	3	1	2 W	Extremely dangerous in contact with moisture and water; releases hydrogen with sufficient heat to cause ignition or explosion; may ignite spontaneously in air or oxygen; can cause severe skin or eye burns. Shipped under dry oil (no water) and that is the way it must be stored. Keep away from water and handle with dry utensils. **SPECIAL HAZARD ALERT: Peroxides have been known to develop on the exterior surface of potassium metal. These peroxides are yellow and have been known to react explosively with the light oil (kerosene) in which the product is stored when the product is cut into small pieces by the science instructor. Be sure you provide personal protection when dealing with this very reactive metal. If you have a choice as to which alkali metal you elect to buy and use, sodium metal might be your better choice since, upon aging, it does not develop peroxides. Extremely prone to formation of peroxides and will burn and melt when exposed to air. SUBSTITUTE WITH LITHIUM OR SODIUM.
Potassium acetate CH_3COOK				
Potassium bicarbonate (Potassium hydrogen carbonate) $KHCO_3$				
**Potassium bichromate (Potassium dichromate) $K_2Cr_2O_7$				Powerful oxidizing agent.
Potassium bisulfate (Potassium hydrogen sulfate) $KHSO_4$				Slightly toxic by ingestion; severe body tissue irritant.

***** Should not be used in high school laboratories.***

Salicylic acid
$C_7H_6O_3$

Sand (Silicon dioxide, silica)
SiO_2

Selenium + compounds
Se (+ Se salts)

Serine
$C_3H_7NO_3$

Silicic acid (hydrated silica)

**Sodium chlorate $NaClO_3$				Dangerous fire risk; strong oxidant; contact with organic material may cause fire; slightly toxic.
Sodium chloride NaCl				
**Sodium chromate Na_2CrO_4				Highly toxic by ingestion, inhalation, and skin absorption; known carcinogen; oxidizer.
Sodium citrate $Na_3C_6H_5O_7$				
**Sodium dichromate $Na_2Cr_2O_7$				Known carcinogen as dust; corrosive to skin; harmful to eyes and respiratory tract; highly toxic. Strong oxidizer.
Sodium fluoride NaF	3	0	0	Highly toxic by ingestion and inhalation; strong skin irritant.
Sodium hydrogen carbonate (Sodium bicarbonate - baking soda) $NaHCO_3$				
Sodium hydrogen sulfate (Sodium bisulfate) Na_2HSO_4				Body tissue irritant; moderately toxic.
Sodium hydrogen sulfite (Sodium bisulfite) $NaHSO_4$				Severe irritant to skin and tissue as an aqueous solution; slightly toxic.
Sodium hydroxide, pellets (Caustic soda) NaOH	3	0	1	Corrosive solid; skin burns are possible; much heat evolves when added to water; very dangerous to eyes; wear face and eye protection when using this substance. Wear gloves.
Sodium hypochlorite (bleach) NaOCl				Corrosive liquid; causes skin burns; reacts with acid to evolve chlorine gas; evolves chlorine when heated; moderately toxic by ingestion and inhalation; avoid contact with organic material.
Sodium iodate $NaIO_3$				Oxidant; fire risk in contact with organic material; slightly toxic by ingestion.
Sodium iodide NaI				Slightly toxic.
Sodium metabisulfite $Na_2S_2O_5$				Skin and tissue irritant; slightly toxic by ingestion.
Sodium metasilicate Na_2SiO_3				Slightly toxic by ingestion; body tissue irritant.
Sodium nitrate $NaNO_3$	1	0	0 OX	Strong oxidizer; avoid friction or shock – explosions have occurred; moderately toxic by ingestion.
Sodium nitrite $NaNO_2$				Strong oxidizer; gestion a9ysred; moderately SnC8sn.
Sodium oxalate $Na_2C_2O_4$				
**Sodium peroxide Na_2O_2	3	0	1 OX	
Sodium phosphate (mono basic) NaH_2PO_4				
Sodium phosphate (tri basic) Na_3PO_4				
Sodium propionate $C_3H_5NaO_2$				
Sodium silicate (water glass) Na_2SiO_3				
Sodium sulfate Na_2SO_4				
Sodium sulfide Na_2S	3	1	1	

Sodium sulphite

Thymol blue $C_{27}H_{30}O_5S$				Mutagen.
Thymolphthalein $C_{28}H_{30}O_4$				
Tin Sn				
Titanium Ti				
Titanium dioxide TiO_2				
**Titanium tetrachloride $TiCl_4$	3	0	2	Reacts with water.
Toluene (Methylbenzene) C_7H_8	2	3	0	Moderately toxic by ingestion, inhalation and skin absorption; flammable liquid; dangerous fire risk. Possible skin irritant.
Trichloroethane $C_2H_3Cl_3$				
Tryptophan $C_{11}H_{12}N_2O_2$				
Tungsten W				
Tungstic acid H_2WO_4				
Turpentine $C_{10}H_{16}$	1	3	0	Slightly toxic; irritating to skin and mucous membranes.
Tyrosine $C_9H_{11}NO_3$				
Universal indicator				Alcohol-based solution; flammable liquid.
**Uranium compounds (soluble and insoluble) U + U salts				Radioactive.
Urea (carbamide) CH_4N_2O				
Urethane $C_3H_7NO_2$				Slightly toxic by ingestion; combustible. Possible carcinogen.
Valine $C_5H_{11}NO_2$				
Vanadium V				
Vitamin C (Ascorbic acid) $C_6H_8O_6$				
Water glass (Sodium silicate)				Body tissue irritant.
Wintergreen oil (Methyl salicylate) $C_8H_8O_3$				Moderately toxic by ingestion; severe body tissue irritant.
Xylene C_8H_{10}	2	3	0	Flammable liquid; moderate fire risk; slightly toxic by ingestion and inhalation. Avoid skin contact.
Zinc Zn	0	1	1	
Zinc acetate $ZnC_4H_6O_4$				Possible body tissue irritant. Moderately toxic by ingestion.
Zinc carbonate $ZnCO_3$				
Zinc chloride $ZnCl_2$				Both solid and solutions are severe skin irritants; moderately toxic.

Chemical Name and Formula	H*	F*	R*	Comments
Zinc nitrate $Zn(NO_3)_2$				Slightly toxic; severe body tissue irritant; strong oxidant; fire risk.
Zinc oxide ZnO				If heated, fumes could be severely toxic; may react vigorously with some forms of rubber at elevated temperatures.
Zinc sulfate $ZnSO_4$				Skin and mucous membrane irritant; slightly toxic.
Zinc sulfide ZnS				Contact with acid liberates toxic and flammable hydrogen sulfide gas.
Zirconium Zr				

***** Should not be used in high school laboratories.***

The WHMIS symbols

	Class A - Compressed Gas	Contents under high pressure. Cylinder may explode or burst when heated, dropped or damaged.
	Class B - Flammable and Combustible Material	May catch fire when exposed to heat, spark or flame. May burst into flames.
	Class C - Oxidizing Material	May cause fire or explosion when in contact with wood, fuels or other combustible material.
	Class D, Division 1 Poisonous and Infectious Material: Immediate and serious toxic effects	Poisonous substance. A single exposure may be fatal or cause serious or permanent damage to health.
	Class D, Division 2 Poisonous and Infectious Material: Other toxic effects	Poisonous substance. May cause irritation. Repeated exposure may cause cancer, birth defects, or other permanent damage.
	Class D, Division 3 Poisonous and Infectious Material: Biohazardous infectious materials	May cause disease or serious illness. Drastic exposures may result in death.
	Class E - Corrosive Material	Can cause burns to eyes, skin or respiratory system.
	Class F - Dangerously Reactive Material	May react violently causing explosion, fire or release of toxic gases, when exposed to light, heat, vibration or extreme temperatures.

There are nine basic categories of materials that are not covered by WHMIS. When WHMIS was created it was recognized that a lot of safety information was

- hazard symbols [the pictures of the classification(s)]
- risk phrases (words that describe the main hazards of the product)
- precautionary measures (how to work with the product safely), and
- first aid measures (what to do in an emergency)
- have all text in English and French
- have the WHMIS hatched border.

Supplier labels for materials from a laboratory supply house that are intended for use in a laboratory in amounts less than 10 kg. and any controlled product sold in a container with less than 100 ml may contain less information than listed above.

If the product is always used in the container with the supplier label, no other label is required (unless the supplier label falls off or becomes unreadable). However, sometimes you will want to put some of the material into another container for use in the workplace. This new container does require a workplace WHMIS label.

A **workplace label** must:

- appear on all controlled products produced in a workplace or transferred to other containers by the employer
- may appear in placard form on controlled products received in bulk from a supplier
- have the following information:
  - product identifier (product name)
  - information for the safe handling of the product
  - statement that the MSDS is available
  - may contain the WHMIS hazard symbols or other pictograms.

These are the minimum requirements for workplace labels. The employer may wish to put more information on the labels but it is not required under the law.

Laboratory chemicals from a recognized supply house may carry less information on the label (i.e., WHMIS symbols, distinctively marked border, and the supplier identifier). For example:

2. Material Safety Data Sheets (MSDS)

A Material Safety Data Sheet (MSDS) is a document that contains information on the potential health effects of exposure and how to work safely with the chemical product. The MSDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

Employers must make sure that all controlled products have an up-to-date (less than three years old) MSDS when it enters the workplace. The MSDSs must be readily available to the workers who are exposed to the controlled product and to the health and safety committee or representative. If a controlled product is made in the workplace, the employer has a duty to make an MSDS for any of these products.

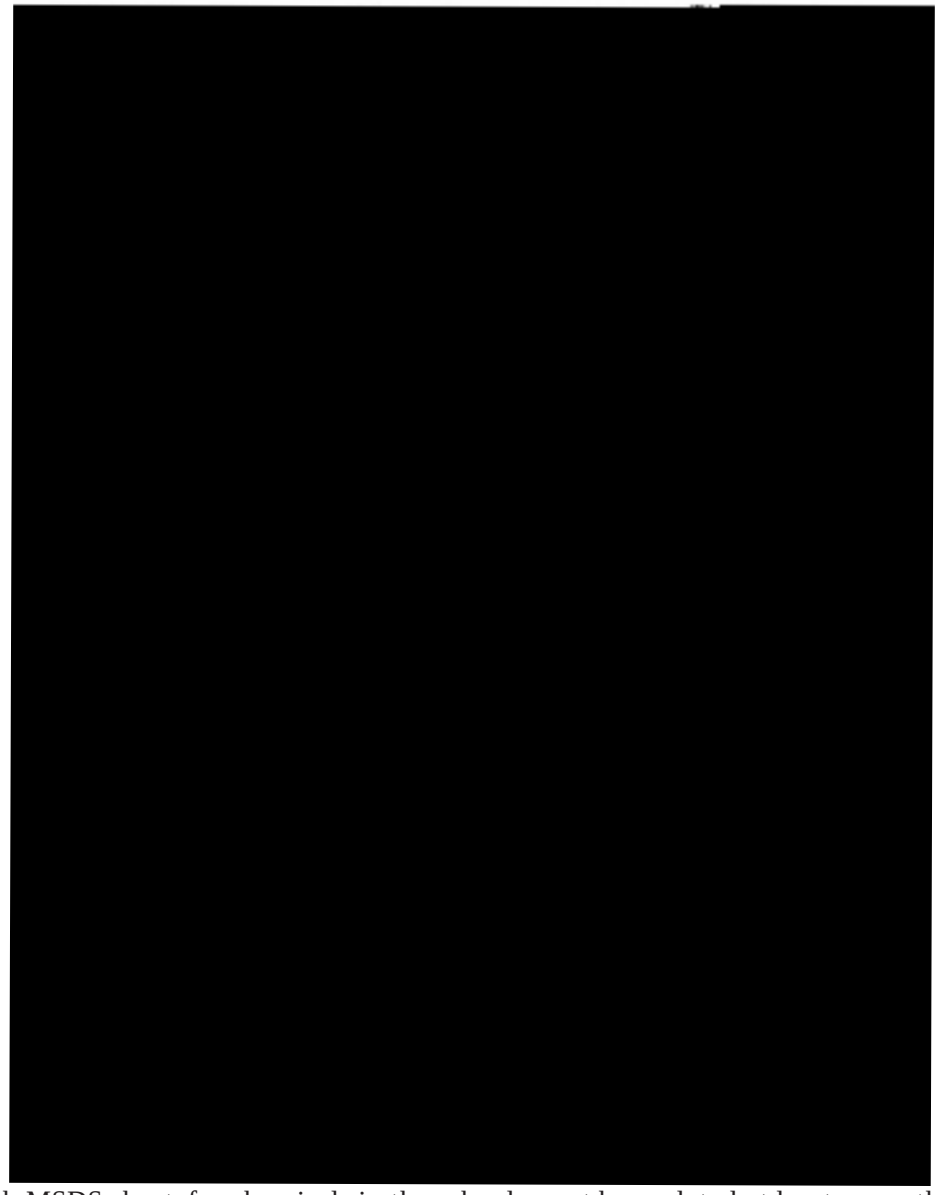
In Canada, every material that is controlled by WHMIS (Workplace Hazardous Materials Information System) must have an accompanying MSDS that is specific to each individual product or material (both the product name and supplier on the MSDS must match the material in use). Therefore, all chemicals in stock in the schools must have an MSDS sheet.

Teachers and students should be familiar with the type of information contained in a MSDS. WHMIS legislation does not require a standard format for the layout of MSDSs. MSDSs may look very different and information items may be located in different sections.

Alternative MSDSs

In certain circumstances, the employer may need to obtain an MSDS from a source other than the manufacturer or supplier. Employers can use an up-to-date MSDS from a database if the MSDS was prepared by the supplier or manufacturer

	Category	Information
I	Product Information	• name of product • intended product use • manufacturer's name and address • supplier's name and address • emergency phone numbers
II	Hazardous Ingredients	• lists the specific chemical names, percentages, and acute toxicity data for the individual components.
III	Physical Ingredients/data	• general information on physical and chemical properties such as the specific gravity, melting and boiling point, evaporation rate, colour, form, solubility, vapour pressure
IV	Fire and Explosion Hazard	• flammability • flashpoint • fire fighting procedures
V	Reactivity Data	• information on the chemical instability of a product • substances it may react with
VI	Toxicological Properties	• how the substance enters the body
VII	Preventative Measures	
VIII	First Aid Measures	
IX	Preparation Information	



Each MSDS sheet, for chemicals in the school, must be updated at least every three years and a copy must be available in the lab for use by teachers and students.

3. Education and Training

WHMIS is a system of information delivery to workers.

- Employers must ensure that their employees are informed about the hazards of any controlled products they may work with.
- The employer is responsible for worker education and training within WHMIS.
- The school is responsible for developing safe work procedures using knowledge of the job, information from the labels, and MSDS sheets.
- All science teachers should be sufficiently trained to use the information to protect themselves and their students.

- It is the responsibility of all teachers to adhere to safe working procedures and the responsibility of principals to insist that they are followed.
- Science teachers have a responsibility to educate their students in the aspects of WHMIS.
- The training programs must include all controlled products in use, including those which have been exempted from the Federal WHMIS requirements of supplier label and MSDS.

Additional Labeling Requirements

Other legislation in Canada requires precautionary labeling on containers of hazardous materials (e.g., explosives, pesticides, or radioactive substances). Specific guidelines for the transportation of dangerous goods (TDG) have been developed to handle emergency response in the event of a spill or other accident under section D12 of the Dangerous Goods Handling and Transportation Act. These are also outlined in *Prudent Practices for Handling Hazardous Chemicals in Laboratories* published by National Academy Press in 1981. Transporting vehicles require diamond-shaped hazard placards.

WHMIS is a complementary information system to the TDG regulations (consumer packaging is also regulated). In some jurisdictions, liability suits have been based on the inadequacy of a label on materials involved in an accident. Adequate labeling practices should help protect the teacher and school district from liability where labeling is the primary issue. TDG regulations do not cover the hazards of extended exposure in the workplace or the long-term effects of exposure.

U.S. System of Labelling

The National Fire Protection Association (NFPA) has developed the NFPA 704, Standard System for the Identification of the Hazards of Materials for Emergency Response. It has ecome widely accepted in both industrial and educational laboratories throughout North America. It is a simple, easily understood coding system which identifies hazards associated with health, flammability, and reactivity of any given material as well as indicating special hazards associated with a substance. The information on chemical labels varies from company to company in the United States and some chemicals come with the NFPA hazard diagram and should be understood by Canadian users. See Part F for details of the NFPA 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.

It is important to note that the health hazard designations refer only to acute effects of exposure to the chemical. The long term, chronic effects are not taken into account.

Note: *The N.F.P.A. system is provided as information only - it is not acceptable by itself (WHMIS is the Canadian standard).*

Chemical Storage

A first step towards preventing chemical accidents is the proper storage of chemicals. It is recommended that every school set up at system to properly store and maintain up-to-date inventory of chemicals. An active inventory of biological, chemical or physical agents stored and/or handled must be maintained, as well as for any tool, equipment, machine or device. Hazard information, or material safety data sheets (MSDS), must be readily available for any chemical or biological substance that could cause an adverse health effect.

- Pressurized / Compressed Gases – The number of compressed gas cylinders stored in laboratories should be restricted to those in daily use. Compressed gas cylinders of all sizes must be kept upright and fully secured against falling. Valve caps must be kept on all cylinders that are not being used. Before compressed gas cylinders are used, all fittings and regulators must be checked for defects, leaks, oil and grease. Bulk storage of cylinders should be in a well-ventilated area, segregated from flammable and corrosive materials. Flammable gases should be separated from oxidizing gases by noncombustible partitions. Cylinders should be protected from excessive variations in temperature, from sources of ignition and from direct contact with the ground. (page 5-6 in WBC Laboratory Health and Safety Handbook)
- In laboratories, chemicals other than dilute reagents should not be stored on the open working bench or the shelving above it.

Suggestions for Chemical Storage Room

- A chemical storage room must be secure. This will prevent theft and unwarranted use of chemical stock. A separate key from those used to enter classrooms or preparation areas is essential. Only authorized personnel should have access to the chemical storage room.
- An effective ventilation system is needed and the room itself must be adequately vented (5.0 L / s / m^2 floor area) with a fan that is permitted to run continuously.
- Explosion proof lights, switches, and fan motor housing must be installed in order to prevent fires from electrical shorts or sparks in faulty switches. Ground fault interrupter (GFI) circuits should be installed, especially near sinks. The fan and the light switches should be outside the door.
- The ceiling and walls should be gyproc, or some similar noncombustible material.
- Shelf assemblies should be firmly secured to walls. Avoid island shelf

Disposal of Chemicals and Biological Materials

The disposal of waste chemicals and potentially hazardous materials is by necessity a common occurrence in school science laboratories. Managing of chemical and biological wastes is everyone's responsibility. Failure to appropriately dispose of chemical and biological materials risks harm to people and the environment and could lead to prosecution if the appropriate procedures are not followed.

Disposal of these materials is subject to a number of federal, provincial and municipal regulations. The disposal of hazardous waste materials or "special wastes" in British Columbia is governed by the Waste Management Act [RSBC 1996] Chapter 482 (http://www.qp.gov.bc.ca/statreg/stat/W/96482_01.htm) and Environment Management Act [RSBC1996], Chapter 118 (http://www.qp.gov.bc.ca/statreg/stat/E/96118_01.htm)

The science teacher must be fully acquainted with the properties and method of safe handling of all substances being used in the laboratory and must have access to the appropriate Material Safety Data Sheets (MSDS). Contact the manufacturer or find it on the internet. This manual cannot provide specific detailed information for the disposal of all materials. Please consult reference books for the correct disposal practices for specific chemical and biological materials. Useful references for chemical and biological disposal are:

- *Flinn Chemical & Biological Catalogue Reference Manual* (free). E-mail: flinn@flinnsci.com
- *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals.* (1995). National Research Council. Available online at http://www.nap.edu/.

The following are some general guidelines for the handling and disposal of chemical and biological materials.

Chemical Waste Handling and Disposal

If you are cleaning out unwanted chemicals you should contact your School District Safety Officer for disposal. If a Safety Officer is not available, contact a local Disposal Service Contractor through the yellow pages.

Use the following procedure to prepare the materials for disposal.

- Place each chemical container (jar, tin, etc.) in a heavy clear plastic bag. Freezer bags work well.
- Seal the bag and label the contents.
- Pack the bag in vermiculite, Styrofoam chips, or similar material in a box.
- If the collection of disposables is large, pack chemicals from different hazard groupings in separate boxes (i.e., keep acids and reducing agents separate).
- **DO NOT** pack explosive or highly reactive (NFPA code reactivity 4) substances in this way.

School Boards licensed to transport special waste in BC (current as of June 2001)

School District	LT #	Address	City	Expiry Date	Phone	Wastes
#39 - Vancouver	LT0841	1580 West Broadway	Vancouver	24-Mar-01	713-5000	asbestos, paint, solvents, used batteries, PCB's, petroleum product
#60 - Peace River North	LT1005	10112 195 A Ave.	Fort St. John	02-Nov-01	785-1577	PCB's, asbestos
#61 - Greater Victoria	LT0242	PO Box 700	Victoria	11-Aug-01	475-3212	asbestos
#62 - Sooke	LT0867	3143 Jacklin Rd	Victoria	27-Nov-01	474-2183	asbestos
#63 - Saanich	LT0038	2125 Keating Cross Rd	Saanichton	20-Jul-01	652-7354	asbestos, paint, PCB's, solvents, contaminated soil, lab packs, petroleum products

Disposal of Biological Materials

(Animal Tissues, Tissue Culture and Microbial Waste)

These wastes may contain infectious agents and should be treated as biohazardous waste.

- **Autoclaving** potentially infectious waste is the preferred method of rendering tissue culture and microbiological waste non-infectious prior to disposal. Autoclave used petri dishes and cultures in autoclavable disposable bags before disposal in a landfill site. Autoclave liquid cultures and pour into a drain with large amounts of water.
- **Incineration** - If the waste contains dangerous materials such as phenol, formaldehyde or radio-iodine, that are likely to be evolved by heating in the autoclave, the waste must not be autoclaved. Instead, such wastes must be treated with a chemical such as bleach to render it non-infectious. Ideally much of the materials should be incinerated in an appropriate incinerator.
- **Landfill** – If autoclaving and incineration are not possible the carcasses and animal remains should be placed in heavy opaque biohazard plastic bags, well sealed, and sent to the local landfill. Dispose of syringes, needles, scalpels, and razor blades in a **labelled** metal or thick plastic container.

Spillage of

Corrosive Liquids

Spill Reporting Procedures

Spills of highly toxic substances must be reported to the Provincial Emergency Program (PEP) at 1-800-663-3456. Where it is impossible to report to PEP within a reasonable time, a spill must be reported to the local police or nearest detachment of the RCMP. You must also report to the Schools Protection Program if there is any damage to school property or if the spill causes pollution outside the school building. (http://www.bcspp.org/index.shtml). Further information can be found at http://www.qp.gov.bc.ca/statreg/reg/W/WasteMgmt/263_90.htm

Highly toxic substances that must be reported if there is a spill

Item	Column 1 - Substance spilled	Column 2 - Specified amount
1	Explosives of Class 1 as defined in section 3.9 of the Federal Regulations	any
2	Flammable gases, other than natural gas, of Division 1 of Class 2 as defined in section 3.11 (a) of the Federal Regulations	10 kg, if the spill results from equipment failure, error or deliberate action or inaction
3	Non-flammable gases of Division 2 of Class 2 as defined in section 3.11 (d) of the Federal Regulations	10 kg, where spill results from equipment failure, error or deliberate action or inaction
4	Poisonous gases of Division 3 of Class 2 as defined in section 3.11 (b) of the Federal Regulations	5 kg, where spill results from equipment failure, error or deliberate action or inaction
5	Corrosive gases of Division 4 of Class 2 as defined in section 3.11 (c) of the Federal Regulations	5 kg, where spill results from equipment failure, error or deliberate action or inaction
6	Flammable liquids of Class 3 as defined in section 3.12 of the Federal Regulations	100 L
7	Flammable solids of Class 4 as defined in section 3.15 of the Federal Regulations	25 kg
8	Products or substances that are oxidizing substances of Division 1 of Class 5 as defined in section 3.17 (a) and 3.18 (a) of the Federal Regulations	50 kg
9	Products or substances that are organic compounds that contain the bivalent "-0-0-" structure of Division 2 of Class 5 as defined in sections 3.17 (b) and 3.18 (b) of the Federal Regulations	1 kg

Item	Column 1 - Substance spilled	Column 2 - Specified amount
10	Products or substances that are poisons of Division 1 of Class 6 as defined in section 3.19 (a) to (e) and 3.20 (a) of the Federal Regulations	5 kg
11	Organisms that are infectious or that are reasonably believed to be infectious and the toxins of these organisms as defined in sections 3.19 (f) and 3.20 (b) of the Federal Regulations	any
12	Radioactive materials of Class 7 as defined by section 3.24 of the Federal Regulations	All discharges or a radiation level exceeding 10 mSv/h at the package surface and 200 µSv/h at 1 m from the package surface
13	Products or substances of Class 8 as defined by section 3.25 of the Federal Regulations	5 kg
14	Miscellaneous products or substances of Division 1 of Class 9 as defined by section 3.27 (1) and (2) (a) of the Federal Regulations	50 kg
15	Miscellaneous products or substances of Division 2 of Class 9 as defined in section 3.27 (1) and (2) (b) of the Federal Regulations	1 kg
16	Miscellaneous products or substances of Division 3 of Class 9 as defined in section 3.27 (1) and (2) (c) of the Federal Regulations	5 kg
17	Waste asbestos as defined in section 1 of the Special Waste Regulation	50 kg
18	Waste oil as defined in section 1 of the Special Waste Regulation	100 L
19	Waste containing a pest control product as defined in section 1 of the Special Waste Regulation	5 kg
20	A substance not covered by items 1 to 19 that can cause pollution	200 kg
21	Natural gas	10 kg, if there is a breakage in a pipeline or fitting operated above 100 psi that results in a sudden and uncontrolled release of natural gas

Hazards

A. Corrosive Chemicals
B. Reactive Chemicals
C. Insidious Hazards
D. Toxic Hazards
E. Biological Hazards
F. Radiation Hazards
G. Carcinogens
H. Mechanical and Electrical Hazards
I. Fires

A. Corrosive Chemicals

The most familiar corrosive chemicals encountered in laboratories are the acids and bases. Corrosive chemicals are substances that are injurious to body tissues or corrosive to metals by direct chemical contact. A corrosive injury may be just a minor irritation or actual physical destruction of body tissue. Corrosive chemicals can be of any phase (gas, liquid, or solid).

How are they hazardous?

The action of these substances on body tissues is through:

- direct contact with skin;
- contact with eyes;
- inhalation;
- ingestion.

The tissues of the body are affected by:

- direct chemical reaction;
- dissolution of essential components;
- destruction of protein;
- disruption of cell membranes.

Corrosive materials also pose a hazard via the dangerous gases produced when they react with other materials. For example, Nitric acid will react with copper to produce nitrogen dioxide.

Types of Liquid Corrosives and Their Hazards

Perhaps the most important category is the **liquid corrosive.** The most typical ones encountered in school laboratories are the acids (hydrochloric, sulphuric, nitric, and acetic) and the bases (sodium hydroxide, potassium hydroxide, ammonium hydroxide).

The acids act on body proteins causing denaturation and destruction of the protein structure. The denatured protein produces a protein barrier which will limit the activity of the acid (although this is very painful). Bases however penetrate deeply with little or no pain and no protein barrier produced.

Bases can cause greater skin or eye damage than acids because the protein barrier formed by acids is not formed by bases.

Corrosive Solids - The effects of solid corrosives is related to their solubility in skin moisture and also the duration of contact.

Some examples are:

Alkali Metal Hydroxides (e.g., NaOH)
Alkali Metal Carbonates (e.g., Na_2CO_3)
Alkali Metal Sulphides (e.g., Na_2S)
** Phosphorus
** Antimony Salts
** Arsenic Salts
Alkaline Earth Hydroxides (e.g., $Ca(OH)_2$)
Elemental Alkali Metals (e.g., Na)
Trisodium Phosphate
Chromium Salts
** Phenol†

Should not be used in high school laboratories.

† Synonyms: carbolic acid, hydroxy benzene, oxybenzene, phenic acid, phenyl hydrate, phenyl hydroxide, phenelic alcohol.

Corrosive solids pose hazards by

- being readily absorbed through the skin (solutions of corrosive solids)
- causing delayed injury (corrosive alkalies may not produce immediately painful reactions)
- being inhaled as dust
- being in a liquid and a molten solid (e.g., phenols) form that greatly increases the threat of exposure.

It is a mistake to think of corrosive solids as being relatively harmless because they can be removed more easily than liquids. Actually, solid corrosives are usually rapidly dissolved by the moisture in the skin and even more rapidly by moisture in the respiratory and alimentary systems. For example ****phenol†** is an ***extremely*** dangerous solid and should not be stored in school.

Hazards of **Phenol†

- Easily absorbed into system, can be fatal.
- Prolonged contact can produce gangrene.
- Effects:
  - local areas - burns of skin and eyes
  - gastrointestinal - burns of mouth and larynx, nausea, pain
  - respiratory - breathing difficulties, cough, cyanosis, pulmonary edema
  - central nervous system - headache, dizziness, visual impairment, convulsions, unconsciousness.

Corrosive gases - Perhaps the most serious hazard associated with corrosives is from substances in the gas phase. These corrosives enter the body via absorption through the skin and by inhalation. The corrosive gases are grouped by solubility and effect upon the respiratory system.

Group I	**Hazard**
Ammonia	Very soluble, affect upper respiratory tract.
Hydrogen Chloride	
** Hydrogen Fluoride	
Formaldehyde	
** Sulfonyl Chloride	
** Thionyl Chloride	
Group II	**Hazard**
** Arsenic Trichloride	Soluble, upper respiratory tract1 1 Tf4et.Shict.
** Bromine	
** Chlorine	
Iodine	
** Phosphorus Chloride	
** Sulphur Dioxide	
Group III	**Hazard**
** Carbonyl Chloride (phosgene)	
** Nitrogen Dioxide	
** Ozone	
Group IV	
** Acrolein	
** Dimethyl Sulphate	
** Mustard Gas	**Hazard**
** Chlorinated ethers	

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Accident Procedures

- Alert the teacher.
- In the event of contact with eyes, remove contact lenses if worn, then ***immediately flush the eyes with water and continue to flush for 15 minutes.*** Get medical attention if necessary. The first few seconds after contact are critical. Immediate flushing of the eyes may prevent permanent damage. An eyewash fountain is preferred, however, an eyewash hose or any other source of water should be used in an emergency. Remember, the one and only emergency treatment is to dilute the chemical immediately by complete flushing with water. The patient's eyelids may have to be forced open, so that the eyes may be flushed. Alkali (base) burns are usually more serious than acid burns.
- Strong chemicals burn the skin rapidly. There is no time to waste. Begin flushing the area with water immediately. Carefully remove and discard clothing including socks and shoes. Continue to flood the area, while clothing is being removed.
- The precautionary warning on the product label should be consulted for full first-aid information. Provide the label information to the attending physician.
- Neutralizers and solvents (alcohol, etc.) should not be used by the first aid attendant. The spread of a skin absorbing corrosive poison, like **phenol, can result in death.

Protection

In all cases where a procedure involves a corrosive chemical, wear protective goggles. If corrosive gases or solids are involved where dusting may occur use the fume hood.

Note: The use of contact lenses in some laboratory environments can pose a danger to the eyes and/or the lenses. Contact lenses should not be worn where water-soluble gases, vapours, dusts or other material may be released into the atmosphere.

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B. Reactive Chemicals

Frequent accidents occur in laboratories simply because the effects of a particular chemical combination have not been anticipated. This is not uncommon even among highly experienced chemists.

The mishandling of reactive chemicals has been a well known problem in all types of science laboratories. The literature contains many case histories of explosions, fires, burns and other bodily injuries which have been caused by improper and careless handling of reactive chemicals. Misuse does not necessarily refer to problems occurring while the reactive chemicals are being used. It can also consist of improper storage, record keeping and labelling.

The frequency and severity of accidents involving reactive chemicals can be minimized by using the data on chemical reactions and incompatible chemicals supplied in this manual, or by reference to specific titles listed in the bibliography.

Types of Reactive Chemicals

Reactive chemicals can be referred to as substances which will, under certain conditions, enter into violent reactions with spontaneous generation of large quantities of heat, light, gas, or toxicants. The types of reactive chemicals can be classified as follows:

Explosives are substances which will decompose with such speed to cause rapid expansion of air, sometimes accompanied by burning gases and flying objects. Some substances are time sensitive in a dangerous manner. Many substances are oxidized by atmospheric oxygen. **Ether and **dioxane may form explosive peroxides after sitting for varying periods of time (form

General Precautionary Measures

When dealing with reactive substances the following guidelines should be followed:

- Isolate reactive materials (refer to Chemical Storage, page 69).
- Have plenty of water available for flushing where water sensitive substances are not involved.
- Do not have water (extinguishers, sprinklers, etc.) in areas where water sensitive chemicals are stored.

Reactive Type	Examples
Explosives should not be stocked in schools	**Fulminates **Nitroglycerin **Peroxides (Benzoyl, Sodium) **Picric Acid **Azides **Perchlorates (Na, K) **Hydrazines **Dioxane **Ether (not Petroleum Ether)
Acid Sensitive Substances	Alkalai Metals Alkaline Hydroxides Carbonates **Carbides Nitrides Metals Sulphides **Cyanides
Water Sensitive Substances	Strong Acids and Bases Acid Anhydrides Alkalai Metal Hydrides **Carbides Aluminum Chloride (anhydrous)
Oxidation Reduction	Oxidizers Oxygen Mineral Acid **Perchlorates **Peroxides (H_2O_2 excepted) Nitrites and Nitrates
Special Organic Substances	
Pyrophors	

Perchloric Acid

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- Perchloric acid is a serious fire and explosion hazard.
- Perchloric acid is a strong acid and contact with the skin, eyes, or respiratory tract will produce severe burns. Always wear goggles or a face shield as well as a rubber apron and gloves when handling perchloric acid. Any spills or splashes on equipment and particularly on protective clothing must be washed off immediately. Contaminated clothing and protective equipment may be highly flammable.
- It is a colourless, fuming, oily liquid. When it is cold, its properties are those of a strong acid. When it is hot, the concentrated acid acts as a strong oxidizing agent. Direct flames, oil baths and electrical stirring equipment must not be used to heat perchloric acid.
- Perchloric acid must be used in a fume hood designed exclusively for its use and posted with a notice which
  (a) identifies the hood as being for perchloric acid use, and
  (b) prohibits the use or storage of combustibles in the hood.
- Exhaust ducts must be as short as possible, routed directly outdoors with no interconnections to other exhaust ducts, and provided with washdown facilities.
- Aqueous perchloric acid can cause violent explosions if misused, for example, if it contacts incompatible substances such as alcohols.
- Containers of perchloric acid must be stored in such a manner that, in the event of breakage, the spilled acid will not contact flammable materials, wood or similar combustible materials.
- No more than 6.4 kg (14 lbs) of perchloric acid may be stored in a laboratory unless the laboratory facility consists of several smaller laboratories physically separated as fire compartments meeting the requirements of the *BC Fire Code*, in which case a maximum of 6.4 kg (14 lbs) of perchloric acid may be stored in each laboratory.
- Rubber stoppers or equipment with rubber components must not be used with perchloric acid.
- Stored perchloric acid must be inspected at least monthly and if any discolouration is noted it must be disposed of immediately and in a safe manner.
- Anhydrous perchloric acid may only be used if freshly made, and any unused perchloric acid must be disposed of safely at the end of the experiment or procedure but must not be kept for more than one day.
- Spilled perchloric acid must immediately be neutralized and cleaned up using safe procedures, and waste material from the cleanup must be kept moist, sealed in plastic bags, placed in a separate covered metal waste receptacle and disposed of as soon as possible.

- Perchloric acid should not be stored with or allowed to come in contact with the chemicals listed below. The following chemicals in contact with perchloric acid have caused fires and violent explosions:

A. Examples of Chemicals Incompatible With Perchloric Acid

Acetic acid
Acetic anhydride
Alcohols
Aniline and formaldehyde mixtures
Antimony compounds (trivalent)
Bismuth
Dehydrating agents
Diethyl ether
Fluorine
Glycerine and lead oxide mixtures
Glycols
Glycol ethers
Hydriodic acid
Hydrochloric acid
Hypophosphites
Ketones
Nitrogen triiodide
Nitrosophenol
Organic matter
(e.g. paper, wood, charcoal, rags, cotton)
Sodium iodide
Sulfoxides
Sulfur trioxide

Picric acid

- Containers of picric acid should be dated and checked periodically to ensure they have a greater than 10 percent water content. Bottles of picric acid containing less than 10 percent water should be considered as shock-sensitive high explosives and should be disposed of immediately without being opened by anyone other than those instructed in the applicable hazards, precautions and safe disposal methods.
- Solutions of picric acid must not be allowed to accumulate and dry around cap threads.

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Azide Hazards

- Soluble azides (e.g. sodium azide) in contact with heavy metals (e.g. copper, lead and brass) can produce insoluble heavy metal azides which are heat and shock sensitive explosives. Sinks, drains and constant temperature baths containing heavy metals are areas where potentially explosive conditions can exist if azides are present.
- Water solutions containing azides must be neutralized before disposal in sinks and drains.
- Constant temperature baths using soluble azides must be decontaminated before heavy metal components are handled.

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Examples of Potentially Explosive Compounds

The following compounds are materials which may readily detonate or decompose or react explosively at normal temperatures and pressures. These examples also include materials which are sensitive to mechanical or localized thermal shock. All of these compounds and any other potentially explosive compounds must be treated with extreme caution and adequate safety equipment must be used:

Acetyl peroxide (25% solution in dimethyl phathalate)
Ammonium perchlorate
3-bromopopane (propargyl bromide)
tert-butyl hydroperoxide
tert-butyl perbenzoate
tert-butyl peroxyacetate (75% solution in benzene)
tert-butyl peroxypivalate (75% solution in mineral spirits)
1-chloro-2, 4 dinitrobenzene
cumene hydroperoxide
diacetyl peroxide
Dibenzoyl peroxide
Tert-dibutyl peroxide
Diethyl peroxide
Diisopropyl peroxydicarbonate
o-dinitrobenzene
ethyl methyl ketone peroxide
ethyl nitrate
nitroglycerine
nitromethane
2-nitro-p-toluidine

Peroxide-forming compounds

- Peroxide formation in laboratory solvents and reagents to explosive levels has caused many laboratory accidents. Peroxide inhibitors are usually included in compounds that readily form explosive peroxides, but may not be sufficient to control peroxide formation once the container has been opened. Peroxide-forming compounds must be inspected and tested for peroxides regularly after the container is first opened, and records of the tests must be maintained.
- Compounds contaminated with peroxide materials must be disposed of using safe work procedures or must be treated chemically to eliminate the peroxides.
- All peroxidizable compounds should be stored away from heat and light and protected from physical damage and ignition sources.
- There are several methods for the detection of peroxides. The simplest method is to dip a starch iodide paper strip into the solvent to be tested. If it turns purple, peroxides are present. If the solution to be tested has been stored past the expiry date, disposal is preferable to testing. NEVER OPEN A CONTAINER CONTAINING PEROXIDIZABLE LIQUID IF VISIBLE SOLID IS PRESENT.

Examples of Compounds that can Form Explosive Conditions Upon Peroxide Formation

Cryogenic liquids

- Containers used for storage, transport and dispensing of cryogenic liquids

- One mL, can increase the mercury level of millions of cubic metres of air to above the PC.

Control of Mercury Hazards

When mercury is spilled, clean up must be immediate and thorough.

- Store mercury in plastic bottles.
- Mercury should be stored under a layer of water or oil.
- Keep containers sealed in a cool, well-ventilated area.
- Provide catch-trays beneath set ups using mercury.
- Use care in handling mercury and instruments containing mercury.
- Use gloves when handling mercury.
- Immediately and thoroughly clean up spills.
- The proper use of a commercial spill kit for mercury is highly recommended. This includes the control of mercury vapours (aspirator, mercury absorbent, vapour absorbent).
- The use of organic-filled thermometers is recommended over mercury thermometers.

Mercury droplets (10-1000 micrometres diameter) adhere to vertical surfaces and penetrate into porous flooring. Large amounts of mercury can be left undiscovered after spills. Unless spills are promptly and thoroughly cleaned up and the area decontaminated, the contamination will continue.

Other Insidious Hazards

In the laboratory, one common source of insidious hazards is the sink drain. If aqueous solutions are disposed of by flushing down the drain, this can lead to the build up of toxic or other hazardous materials that may be released into the laboratory air upon contact with a catalyst. Some of the other insidious hazards include:

- Coal process products;
- Peroxide formed in old or improperly stored **ethers;
- Leaking toxic gas cylinders, **phosgene, **hydrogen, **cyanide, **chlorine;
- Mixed chemicals that can slowly react to form toxic products or build pressure;
- Liquid chemicals in glass containers stored above eye level;
- Explosive **perchlorate in fume hoods;
- Unlabeled chemicals;
- Reactive chemicals stored on the same shelf;
- Faulty pressure control equipment for compressed gases;
- Ignition sources in flammable solvent areas.

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Control Measures for Insidious Hazards

- Prepare a checklist of insidious hazards. Use the NFPA rating as a guide. A value of 3 indicates a serious hazard, a value of 4 is an extreme hazard;
- Provide adequate ventilation in the form of hoods and forced air (0.5 m/s);
- Do not allow stock build up of toxic, flammable, or corrosive materials;
- Have efficient and appropriate clean up agents for spills;
- Have suitable disaster equipment available (extinguishers, respirators, etc.).

D. Toxic Hazards

A toxic substance has the potential of injury by direct chemical action with body systems. Almost any substance is toxic when taken in excess of "tolerable" limits. Toxic substances include corrosive as well as poisonous materials.

Toxic materials can enter the body in four ways:

- **Inhalation** - breathing in poisonous or corrosive vapours and dust is by far the most common route by which toxic materials enter the body.
- **Ingestion** - swallowing liquid or solid toxic materials.
- **Direct Entry to the Blood Stream** - chemicals in open wounds may be rapidly distributed throughout the body. (Direct injection through punctures can occur).
- **Contact** - absorption of toxic materials through skin, mucous membrane, and eyes.

The effects of corrosive materials are usually rapid but the effects of poison may not be immediately noticed. In fact, many substances (e.g., arsenic and mercury) are cumulative and poisoning can be the result of several exposures over a period of time.

Poisoning may be suspected when any of the following are evident and access to poisons is possible:

- **strange odour on the breath;**
- **discolouration of lips and mouth;**
- **unconsciousness, confusion or sudden illness;**
- **pain or burning sensation in the throat;**
- **bottles or packages of drugs or poisonous chemicals are found open in the presence of students.**

Toxic materials damage the body by interfering with the function of cells in body tissue. The damage can occur as the destruction of tissue by direct corrosive action (e.g., NaOH contact with skin), interference with chemical reactions of the body (e.g., CO replaces O_2 in hemoglobin), disruption of biological processes (e.g., NO_2 causes pulmonary edema and allergic responses).

Toxic effects can be local or systemic as well as acute or chronic. Local effects are confined to the area of the body that has come in contact with toxic materials. Systemic effects occur throughout the body after absorption into the bloodstream.

Acute effects are more or less immediate while chronic effects may take many

Hazardous Situations

- **handling toxic materials in open containers** - vapours, dust, liquids can easily escape during normal handling.
- **heating toxic materials** - smoke and vapours may be released in much greater quantity when material is hot.
- **creating dusts of toxic materials** - crushing and grinding solids, transferring powders, may release dusts into the air.
- **use of toxic materials in areas without adequate ventilation** - toxic vapours can rapidly accumulate to dangerous levels in a room, or part of a room, that does not have a constant replacement of contaminated air. Toxic vapours can be in high concentration immediately above an open bottle even in well ventilated rooms - do not lean over the bottle.
- **storage of toxic materials without proper ventilation** - dangerous levels of toxic substances accumulate in the air and on surfaces in closed, unventilated storage areas.
- **storage of toxic materials without proper hazard identification** - the hazards must be clearly seen and understood every time a substance is used in order to avoid dangerous mistakes.
- **use of toxic materials without proper protective gear** - skin contact with hazardous materials and inhalation of toxic vapours must be prevented by the use of correct clothing, face protection, fume hoods or respirators.
- **storing or consuming food and beverages, chewing gum and smoking in an area where toxic materials are used** - food, beverages and cigarettes can readily absorb toxic vapours or become contaminated with unseen toxic dust. Poisons may be transferred from hands to food and cigarettes.

Special Note: *Odours and appearance are not reliable guides to the toxicity of substances. What looks like water could be a dangerous acid or base—or worse. Many toxic vapours have little or no odour, even in dangerous concentrations.*

Protection Guidelines

- Unless you know definitely that a substance is not toxic, treat it as though it were.
- When using poisonous or corrosive material, cover all exposed areas with chemical resistant clothing. Use appropriate protective gloves, aprons, lab coats, and face shields.
- Wash with soap and warm water after handling any chemicals. The glassware that was used and your hands should always be clean at the end of a lab period.
- Keep food, beverages and cigarettes out of all laboratory rooms.
- Don’t use lab glassware for eating or drinking.
- Work in a fume hood if using substances with toxic vapours or dusts.
- All bottles should be clearly labeled. Read the label so you know the hazard.
- Replace the bottle lid as soon as you have taken the materials you need.
- Do not store anything in unlabeled containers.

- Be informed. Know what you are working with, its hazard, and how to handle it safely. Always be sure you know what to do in the event of an accident. If you are unsure, ask your teacher to review emergency procedures.

Accident Procedures

- **Alert the teacher** - Speed is essential.
- In the case of contact with the skin or eyes, thorough washing must start immediately (within 10 seconds!) and continue for at least 15 minutes.
- If the material has been inhaled or swallowed or if a victim is unconscious, in convulsions or in pain, trained assistance is required immediately.

E. Biological Hazards

Micro organisms, like toxic chemicals, are a potential hazard to persons performing biological experiments. Working with them requires special handling, storage and disposal techniques. Teachers must be aware of the hazards presented by infectious agents and their possible sources.

Common Causes of Accidental Infection

- oral aspiration through pipettes
- accidental syringe inoculation
- animal bites, scratches, or simply contact with an animal
- spray from syringes
- centrifuge accidents
- allergic reactions to plants
- cuts or scratches from contaminated glassware
- cuts from dissecting instruments
- the spilling or dropping of cultures
- airborne contaminants entering the body through the respiratory tract.

Item	Precaution
Handling Micro-organisms	• avoid bacteria, fungi, etc. known to be pathogenic • do not encourage growth of any microorganisms other than those that occur naturally on mouldy bread, cheese, or mildewed objects • cultures should be grown at room temperature in the range of 25°C to 32°C. Incubation at 37°C encourages growth of microorganisms that are capable of living in the human body • clean and disinf1.2lt1d8 TD0o3.8wn at.61 1
Dissections	
Plants	
Food	
Animals	

Specific Laboratory Operations

A number of specific laboratory operations deserve special attention when microorganisms are involved.

Pipetting—The greatest hazards are:	• production of aerosols • accidental ingestion of fluid • contamination of the mouthpiece • the last two hazards can be eliminated by the use of a pipetting bulb.
To prevent the first hazard the following precautions are urged.	• never use a pipet to bubble air through a contaminated liquid • liquid should never be forcefully blown out of the pipet • the pipet should be discharged with the tip below the surface of the receiving liquid • Immediately after use, contaminated pipets should be immersed in a germicidal solution, and then autoclaved.
Syringes—The greatest hazards are:	• accidental inoculation • aerosol production.
Inoculating Loops	• use care, as the film held by a loop may break and cause atmospheric contamination. A hot loop may cause a liquid to spatter upon insertion into the liquid. Allow it to cool first. A contaminated loop may produce an aerosol by boiling and volatilization when it is placed into a flame for sterilization, even before all pathogenic organisms are killed. Whenever inoculating loops are used, any actions that might result in the generation of an aerosol—jerky motions, shaking the loop, agitating liquids—must be avoided • teachers/technicians should dip inoculating loops into ethanol before flaming (prevents aerosol formation) • ***note:*** *Care must be taken because of the flammability of ethanol.*
Centrifuges	• centrifuges can be cleaned with ethanol to kill any bacteria present. Use the fume hood.
Growing Your Own Bacterial Cultures	• keep in mind that there is always the possibility of a few spores of pathogenic bacteria being introduced from the atmosphere. Be sure the culture medium is properly sterilized by autoclaving. After inoculating the medium with bacteria be sure to wash hands and clean up any spills with a good disinfectant • it is recommended that disposable petri dishes be used • when finished with the bacterial cultures, the dishes should be collected in a bio-hazard plastic bag and then autoclaved before disposal.

Use of Human Tissue and Fluid

A recent review of information and concerns expressed about the potential risk of transmitting hepatitis or A.I.D.S. through activities that involve the extraction and analysis of samples of human fluid or tissue has led to the following policy statements in British Columbia:

While these activities have been considered safe, providing that rigorous procedures were followed in the handling, sterilizing and disposal of materials and equipment, there is a growing public concern that even with appropriate procedures a risk to individuals may remain. Therefore activities involving the extraction and analysis of human fluid or tissue should not be attempted in B.C. schools without the written permission of both school and district authorities. Activities such as blood typing, cheek cell scraping or urinalysis may be replaced or modified to use prepared microscope slides or audiovisual materials.

Teachers, schools, and districts wishing to conduct these activities should ensure that proper procedures are **strictly** adhered to. In the case of student blood typing; ***only serum that is certified free from AIDS and Hepatitis antibodies should be used.***

Infectious Agents

Nearly all groups of microorganisms have some effect on humans. The various groups and some of the diseases for which each group is responsible are shown below.

Microorganism
Bacteria

Each group is responsible for many more diseases than listed. There is no group of microorganisms that does not contain some pathogenic members. Consequently, experiments which may involve microorganisms either directly or indirectly must be strictly controlled.

F. Radiation Hazards

Radiation is everywhere. Today, with more electronic equipment and a greater variety of experimental procedures, including nuclear experiments, an increase in radiation sources in the school laboratory has resulted. Radiation is a hidden hazard, because its presence is not perceived by our senses. Radiation is capable of causing a variety of biological damage with results ranging from no observable effects to serious disability and death.

Radiation is the emission of energy from a substance. The energy can pass through space and be reflected or absorbed, or may pass through a receiving substance. The form that radiation takes may be particulate or electromagnetic wave (or photon). The emission of radiation can be a spontaneous event or the result of some stimulation of the source materials by its interaction with another source of energy.

In ordinary discussion, "radiation" and "radioactivity" are often used interchangeably. However, radioactivity is just one case covered by the general term "radiation", which includes the following forms, divided into two classes:

Ionizing Radiation

X-rays

Cathode rays

Radioactivity:
- alpha particles
- beta particles
- neutron (particles)
- gamma rays (electromagnetic waves or photons)

Non-Ionizing Radiation

Ultra-violet light

Visible light:
- spectroscopic sources such as mercury, hydrogen, iodine, and sodium vapour discharge tubes)
- infra-red light

Microwaves

Radio Waves

Ionizing radiation when absorbed causes atoms in the receiving materials to lose electrons—to become ionized. The result is a drastic alteration of the chemical activity of the atom and, therefore, a change in the nature of any molecule containing the ionized atom. In general, the high energy of short wavelength electromagnetic waves or high velocity particles are required to cause the ionization of most atoms, especially when they are combined in molecules. The generally lower energy, longer wavelength, non-ionizing radiation can be absorbed by molecules resulting in heat (an increase in their kinetic energy) rather than causing atoms to lose electrons. This increase in kinetic energy of the molecules sometimes results in an alteration or destruction of the molecule. Because the effect is dependent upon the energy intensity of the radiation, as well as its form (particle or wave), some overlap of the "ionizing" and "non-ionizing" classes can exist.

Where Do The Hazards Exist?

Ionizing Radiation

Radioactive Isotope Samples - Low intensity sources of radioactive isotopes that may be purchased include metal discs containing small amounts of the radioisotopes of uranium and thorium and crystalline compounds of the radioisotopes of uranium, thorium, potassium, and rubidium. Uranium and thorium emit alpha, beta, and gamma radiation; potassium and rubidium emit beta and gamma radiation. The metal discs, when unshielded, should not contact bare skin. The powders of the crystalline compounds must be well contained to prevent spilling on skin, clothing, or work surfaces and to prevent escape into the air where they can contact skin or be inhaled. Powders are most easily contained if they are kept slightly damp.

Vacuum and Discharge Tubes - Cathode Ray Tubes operating at accelerating

Disposal

Accident Procedures

- **Alert the teacher** - if you suspect that you have been exposed to radiation or

In addition to the above mentioned compounds, these compounds have been proven to be carcinogenic in humans or have induced cancer in animals under appropriate experimental conditions.

- Acrylonitrile
- Aflatoxins
- 4-aminodiphenyl
- antimony trioxide
- asbestos
- benzo a) pyrene
- beryllium
- cadmium oxide
- chloroethylene
- chloroform
- 1, 2-dibromoethane
- dimethyl carbamyl chloride
- dimethyl sulfate
- epichlorohydrin
- hexamethyl phosphoramide
- hydrazine
- lead chromate
- 4,4'-mthylene bis (2-chloroaniline)
- B-naphthylamine
- 4-nitrodiphenyl
- 2-nitropropane
- N-nitrosodimethylamine (dimethylnitrosamine)
- Particulate polycyclic aromatic hydrocarbons (as benzene solubles) (coal tar pitch volatiles)
- B-propiolactone
- Trichloromethane (chloroform)
- Vinyl chloride (chloroethylene)
- Zinc chromate

More detailed lists are available from:

- the International Agency for Research on Cancer (IARC) (an arm of the World Health Organization) that conducts literature reviews to assess the cancer causing potential of chemicals, chemical mixtures and manufacturing processes. IARC has reviewed the medical and scientific literature on hundreds of chemicals. Based upon the strength of the scientific evidence presented in these reports, IARC concludes its review by placing each studied chemical into one of several categories. IARC presents a complete list of evaluated chemicals at: http://www.iarc.fr and select "Data Bases".
- American National Toxicology Program - Report on Carcinogens http://ntp-server.niehs.nih.gov/NewHomeRoc/AboutRoC.html

H. Mechanical and Electrical Hazards

Mechanical and Electrical Hazards will seldom exist in a well maintained laboratory where commercially produced, approved equipment is in good working order. With all protective devices, and guards in place there is little opportunity for an accident to occur.

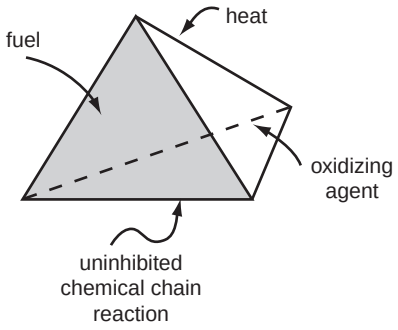
Mechanical Hazards

- **All rotating machinery** - When guards, lids and covers are not in place over exposed shafts, belts and pulleys, loose clothing, hands and long hair can quickly get caught.
- **Use of tools (including glass cutting operations)** - Carelessly used tools, and tools in poor condition are the source of many accidents resulting in crushed or cut fingers and hands, eye injuries, lesions and abrasion on arms, legs and head.

- Clearly tag all faulty equipment so it will not be used before it is repaired;
- Arrange for modification to building installations to be made by district electricians;
- Use electrical equipment at its rated capacity only;
- Be sure all equipment is shut off when not in use;
- Ensure regular safety inspection and completion of dated and signed inspection sheet;
- Store all heavy items as close to the floor as possible.

I. Fires

Burning is the rapid oxidation of a fuel by an oxidizer (usually air) with the liberation of heat and (usually) light. A fire can be started when sufficient energy is present to initiate the reaction. The process of burning involves the four interrelated components: fuel, oxidizer, an energy source and uninhibited chemical chain reaction. These four components make up the fire tetrahedron. Removal of at least one side is the basis of fire control and safety.



Sources of Fires

Fire has always been one of the attendant hazards of laboratory operation. Laboratories make use of flammable materials including solids, liquids and gases. The following are among the more common sources of fire hazards encountered in school laboratories:

- Ignition of solvent vapours;
- Ignition by reactive chemicals;
- Uncontrolled chemical reactions;
- Inadequate storage and disposal techniques;
- Heating due to electrical faults;
- Loose clothing and hair ignited by the Bunsen burner;
- Misuse of gas cylinders;
- Inadequate maintenance;
- Static electrical buildup;
- Inadequate laboratory design;
- Inadequate temperature control, especially in areas where solvents are stored.

Fire Safety

The goal of every science teacher should be to reduce the chance of fire to the lowest probability possible. Elements of a successful fire control program include:

- adequate education of students in the hazards of fire;
- the use of proper lab procedures;
- the maintenance of proper chemical storage facilities and;
- the provision and maintenance of effective fire control equipment.

Fire Safety Equipment

- **Fire Blanket** - are made of fire proofed wool/rayon material and are not to be used where spillage and fire spreading is possible.
- **Sand bucket and scoop** are useful for small fires of all kinds.
- **Fire Extinguishers** - The type of fire and extinguisher used are related. Teachers should learn the different classes of fire and the proper extinguisher to use. An extinguisher may act on any of the four sides of the fire tetrahedron, or all four of them, to extinguish the fire. Usually, however, an extinguisher either cools the area so a fire will not burn (remove energy source) or smothers the fire (removes oxidizer), or both.

Fire Classification

Dealing With a Small Fire

Field Trips

The benefits of field trips are often so significant that long after students complete a science course, the "field trip" may be the only event recalled from the course. Whether the trip involved an afternoon at the aquarium or four days on the West Coast Trail, it was special. The routine of school life was broken, and an opportunity to explore the "real world" was provided.

For the teacher, however, the field trip represents a myriad of logistical issues which must be dealt with long before the event itself. Each of these issues has at its root a potential safety problem. If not dealt with appropriately the consequences of incomplete planning could be disastrous.

The primary purpose of a field trip for a science class is to investigate applications of science or to explore some aspect of the natural environment. Field experiences may be classified in two groups: **Routine** and **Special**. Routine trips are usually of one day or less in duration and usually involve a facility such as a museum, zoo, factory, or research centre such as a university. Special field trips are usually to outdoor sites. A backpacking trip on the West Coast Trail or a day hike to investigate glacial and volcanic formations on a nearby mountain would be examples. Here the element of risk is greater, and consequently the need for thorough planning is essential.

Educators should ensure that they review School District Field Trip Policies and use the appropriate parental consent forms.

The Routine Field Trip

The major problem to be dealt with here is probably transportation. If all students travel together in a bus you should have no problem. If other methods of transportation are to be used, review District Policies and ensure that parents are given the opportunity to consent to the given method of transportation. However, if teachers, parents, or students drive other students in private cars, you must find out if this complies with school district policies.

Does the site itself pose any special hazards to students? Find out by questioning the contact person at the site before you arrive, and let your students know about the hazards before you leave. Then, remind them again upon arrival at the site.

Adequate supervision is important. The number of additional adults who should accompany your students to the site will vary according to the age group, number of planned activities and the site itself. Consultation with site staff to confirm adequate numbers is suggested. Teachers must also obtain written permission from parents before taking students on any field trip.

The Special Field Trip

The factor which makes this trip "special" is that it usually involves a more remote wilderness destination than a routine trip. As with routine field trips, discuss the trip with your adminstrator, outline the trip to your students and their parents, and obtain written parental permission. Important medical information must also be gathered. (see sample page 117).

A major concern for many educators is potential teacher and school board liability arising from outdoor field trips to remote or wilderness areas. For teachers who have some special expertise, for example training as a canoe instructor or gymnastics teacher, the teacher will be expected to exercise that skill while instructing and supervising students in activities involving those skills. If a teacher fails to exercise such skills or care, and a student is injured as a result, the teacher and the school board may be liable for the loss the student has suffered.

Mr. Justice Carrothers of the B.C. Court of Appeal, in a case involving an injury sustained in a gymnasium accident, set out the test to be applied when considering the appropriateness of an activity for a school activity as follows:

- Is the activity suitable to the age and condition (mental and physical) of the student?
- Have the students been progressively trained and coached to do the activity and avoid the foreseeable dangers?

Travelling to the U.S.A.

If your field trip will take you to the U.S.A. you will have to investigate health/safety issues. What health coverage do you and your students have should you be hospitalized while in the United States? Many students, upon checking with their parents will find they do not have an "Extended Medical Benefit" package with their health insurance. Extra medical insurance should be mandatory no matter the length of stay.

Please note: Parental consent forms and all associated documentation relating to field trips should be preserved for at least two years following the field trip or longer if any serious injuries or incidents occur.

Sample Field Trip Medical Form

To be completed by Parent or Guardian

Field Trip to:_____ Date:_____

Student's Name: _____

Medical Information

Name Of Family Doctor:_____ Phone: _____

Medical Plan No.:_____ Dependant No.: _____

Date of most recent immunization against tetanus, if known: _____

Known sensitization (allergies) if any: _____

Chronic disability or illness (past or present):_____

Does the student have any health issues we should be aware of?_____

Please describe: _____

_____

Dietary Restrictions:

Describe:_____

Medications:

I would like my child to be given the following medications:

Name of medicine:_____ What is it to be used for: _____

How is it to be given: _____

Quantity to be given: _____ Times to be given: _____

Medicine should be clearly labeled with the child's name, name of medication, what it is to be used for, quantity to be given and time to be given. In case of emergency, I hereby give permission to the physician named above, or, in his or her absence, to any other physician, to provide treatment for my child.

_____ _____
Signature of Parent/Guardian Date

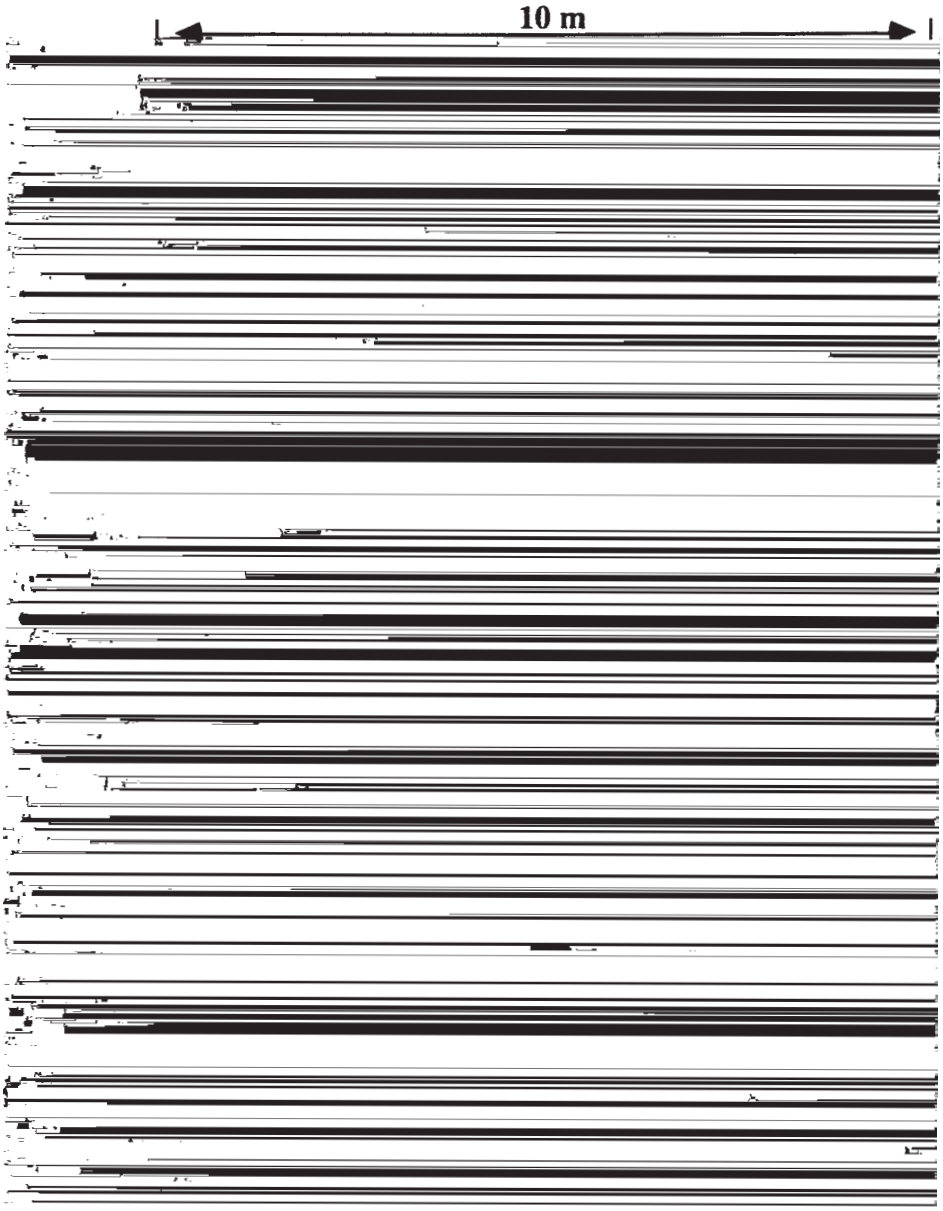
_____ _____
Parent/Guardian's Home Phone Business Phone (if applicable)

_____
Emergency number and/or contact

- The following diagram is suitable for use in the planning of possible science facilities. The space represented is 140 m2 and fixtures are approximately to scale. Photocopy the diagram and try alternative arrangements. Remember that space allocated to preparation and storage is more efficiently used if it is shared between two or more rooms.

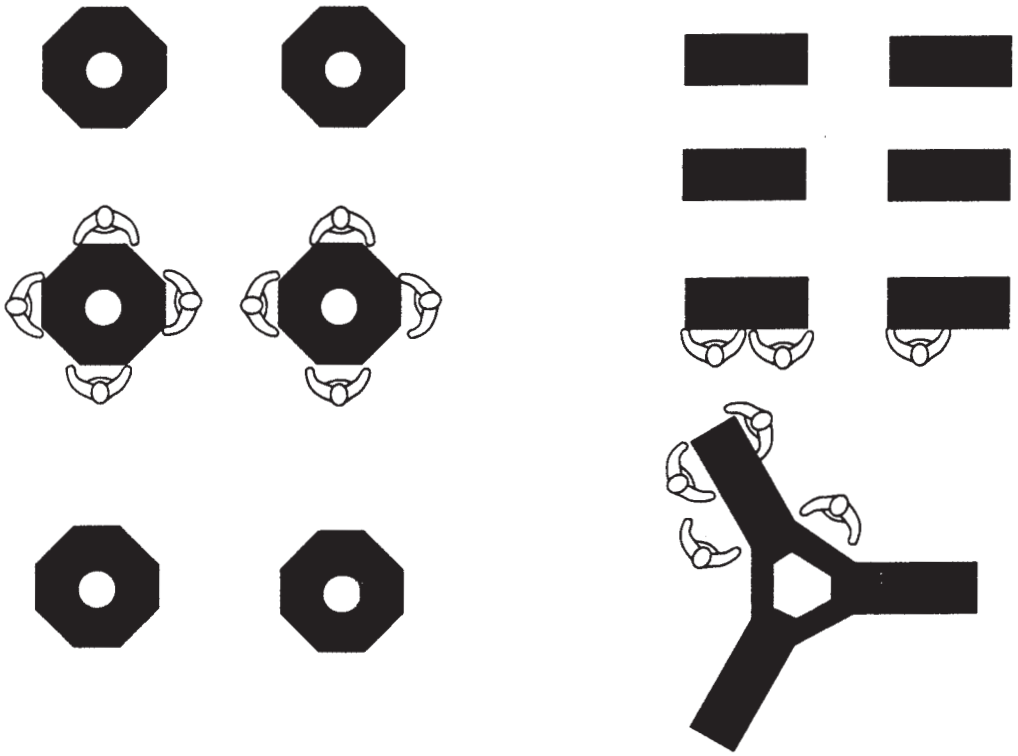
140 m2 Science Module

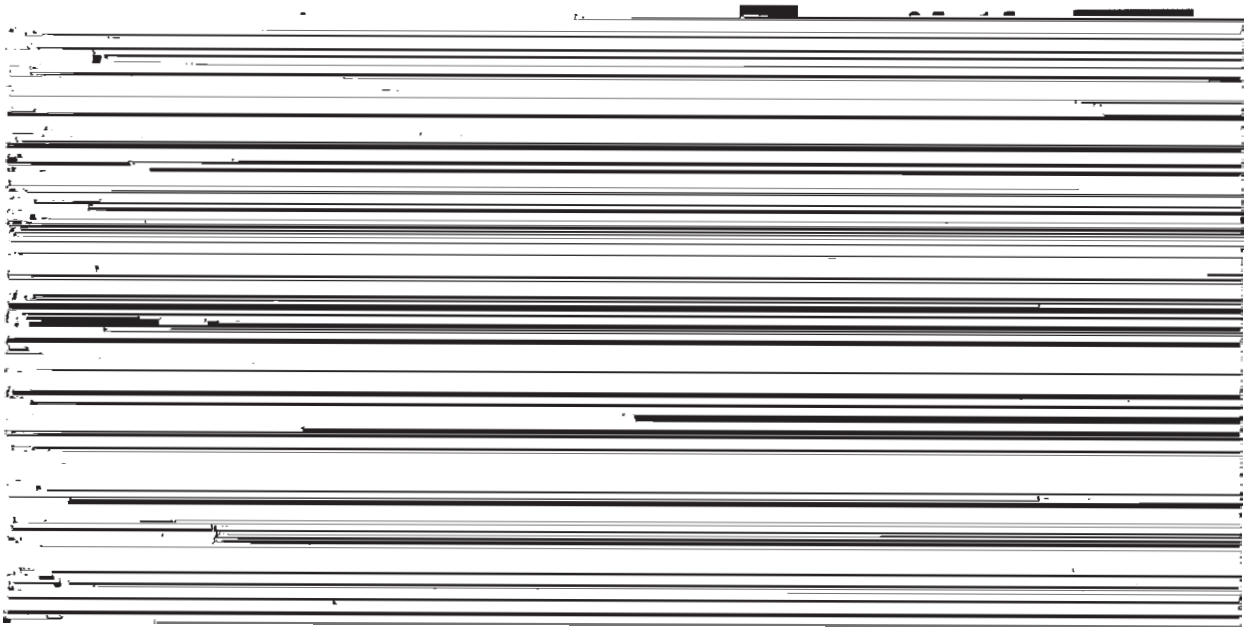
This is the standard size (area only) for a science room in B.C. Teacher, student, storage, preparation and safety facility space must all fit inside this box.



Fixtures

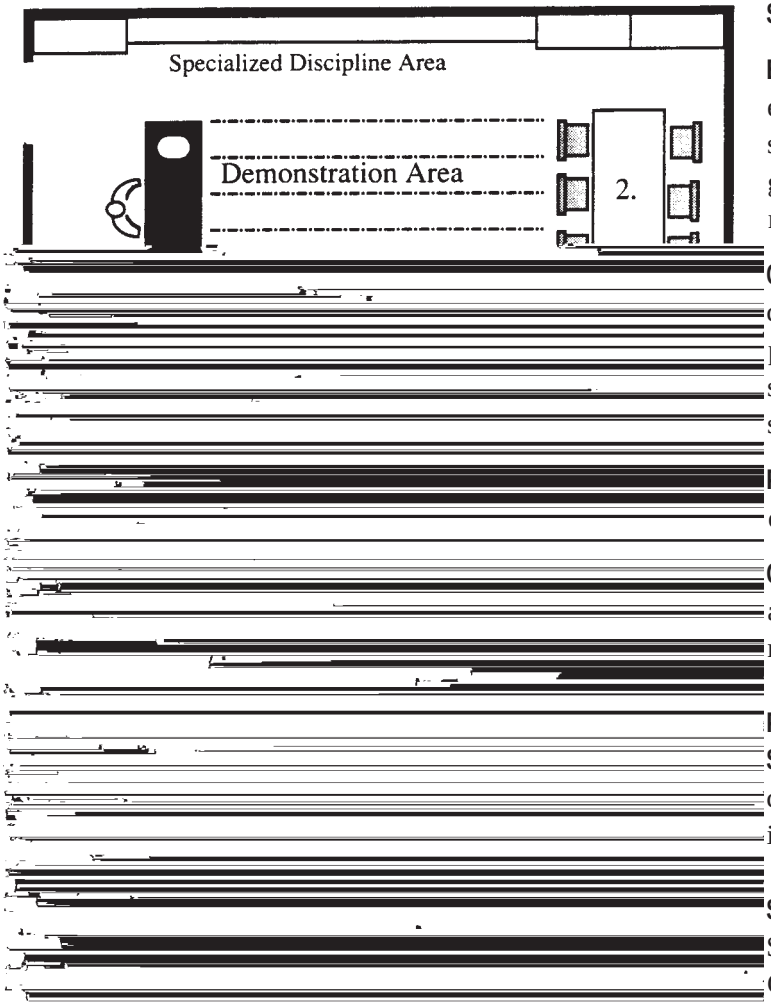
Use the fixtures shown below to assist in the design or modification of science rooms. A sample design is shown on the following page.





Sample Laboratory Layout

Note: This sample is provided as an example of the use of materials on the previous pages only. None of the objects in the diagram are to exact scale or specification. (The students shown are a bit 'bulky' for a 1:100 scale)



Specialized Discipline Area

Biology: animal study centre, controlled environment centre; growing cart, aquatic study centre, skeleton storage, herbarium, germination bed, specimen storage, microscopic storage.

Chemistry: acid and reagent dispensing centre, titration station, spectrophotometer, pH meters, electronic balances, compact storage centre, protective clothing storage, safety glass storage, general storage.

Physics: apparatus storage, tool storage, demonstration apparatus set-up.

Geology/General Science: clean-up and rinse-away sink centre, rock and mineral storage, rock saws, polishing apparatus.

Preparation & Storage Area

Suggestions: wash-up sink, disposal, under-counter dishwasher, refrigerator, freezer, instructor's work station, instructor's desk.

Storage Area

Specialized and/or general storage. See the Chemical Storage section page 69.

Student Laboratory Area

There is room for general storage in the base of the four-student lab benches. A variety of types of service islands and student benches are in use in BC.

Demonstration Area

This area could accommodate desks for lecture and demonstration. Equipment such as overhead projection screens should be oriented to this area.

Numbered Items

1. Demonstration desk 2. Reference Area or work table 3. Four student laboratory table with services (Gas, Water). 4. Safety Station containing: eye wash, overhead shower, fire blanket, sand, fire extinguishers, first-aid kit. 5. Two-sided fume hood

Potential Structural Hazards in the Laboratory and Storeroom

These hazards mainly refer to shortcomings in the accommodation. It is important that they should be recognized, not only in order to effect improvement, but also to take particular care until improvements can be carried out.

Facilities	Comments
Floors	• Should be level throughout, with no steps in the laboratory/stores area. • Should be without defects e.g., loose or broken tiles, uneven patches, cracks. • Should be without cracks which can harbour spilled chemicals. Sheet • Flooring is far preferable to tiles or carpeting. • Shemical storerooms should have an adequate drain at the lowest point to cope with flooding. • Should be capable of being washed.
Doors	• No doors should be defective or jam. • All doors should open toward the nearest safety exit without use of a key. • All doors should have a safety glass window at head height. • No doors should be situated in an obscure area, e.g. around a blind corner.
Exits	• All science classrooms should have two exits. • Exits should be clearly marked. • Exit route markers with non-slip surfaces should be painted on the floor.
Ceilings	• Should be non-flammable. Flammable ceiling materials, such as polystyrene tiles, should be removed and replaced with materials having a low flame spread rating e.g. drywall.
Plumbing	(http://www.worksafebc.com/policy/regs/bcrohs30.asp#SectionNumber:30.4) • (1) Laboratory water faucets with goosenecks must be protected by vacuum breaks meeting the requirements of ANSI Standard ANSI/ASSE 1001-1990, Pipe Applied Atmospheric Type Vacuum Breakers, or other standard acceptable to the board. • (2) A vacuum break must be maintained in a state of good repair and must be tested in accordance with the manufacturer's requirements.

Facilities	Comments
Fume hood	(http://www.worksafebc.com/policy/regs/bcrohs30.asp#SectionNumber:30.8) • (1) Controls for the operation of a fume hood and its services must be located outside the fume hood and must be immediately accessible to the laboratory worker, except that water taps may be located inside the cabinet if the main shutoff valve is in a safe location outside the cabinet. • (2) A fume hood must be connected to a local exhaust ventilation system which will provide minimum air velocities over the operational face area of the hood of
Extractor Fans	

Duties of Laboratory Technicians /Assistants

Most of the duties of the lab technician / assistant are related to safety. The lab technician / assistant should be thoroughly familiar with all other sections of this manual.

A school science inventory is likely worth $200,000.00-$400,000.00. It is susceptible to theft and vandalism. Appropriate control and maintaining of that inventory is also a prime role of a laboratory technician / assistant.

In many instances, a laboratory technician's activities in terms of preparation of equipment and materials, as well as clean up and storage, determines whether experimental science courses are offered in a school.

1. Inventory:
   - record stock
   - maintain security
   - prepare orders as needed
   - label and code chemicals
   - put away dangerous/other chemicals
2. General security:

5. B.C. Safety Council

Website: www.safetycouncil.bc.ca
Address: #2225-21331 Gordon Way, Richmond, B.C. V6W 1J9

6. Canadian Red Cross

Website: http://www.redcross.ca/
Telephone: 1-888-307-7997

Coastal Office
909 Fairfield Rd.
Victoria, BC
V8V 3A3
Phone: (250) 382-2043
Fax: (250) 382-3420
Toll Free: 1-800-661-9055

Lower Mainland Office
4750 Oak Street
Vancouver, BC
V6H 2N9
Phone: (604) 709-6600
Fax: (604) 709-6675
Toll Free: 1-800-565-8000

Kootenay Office
625 Columbia Avenue
Castlegar, BC
V1N 1G9
Phone: (250) 365-3911
Fax: (250) 365-6242
Toll Free: 1-800-761-0099

Thompson/Okanagan Office
2280 B Leckie Road
Kelowna, BC
V1X 6G6
Phone: (250) 763-1859
Fax: (250) 763-613

Northern BC/Yukon Office
1399 - 6th Avenue
Prince George, BC
V2L 5L6
Phone: (250) 564-6566
Fax: (250) 564-2688
Toll Free: 1-800-278-7177

7. Ministry of Water, Land and Air Protection

Website: http://www.gov.bc.ca/wlap/
Regional and Sub-Regional Offices :
http://wlapwww.gov.bc.ca/main/prgs/regions.htm

8. St. John Ambulance

Website: http://www.sja.ca/

9. B.C. Hydro

Website: http://www.bchydro.com/
Telephone: General Inquiries - 1-800-224-9376
School Safety Program Co-ordinator - 604-528-3054

10. Natural Gas Safety

BC Gas

Website: www.bcgas.com
Emergency Telephone: 1-800-663-9911

Centra Gas

Website: www.centragas.com
Emergency Telephone: 1-250-388-6944
1-800-667-6064

Pacific Northern Gas Ltd.

Website: www.pacificnortherngas.com
Emergency Telephone: 1-800-663-1173

11. Office of the Fire Commissioner

Website: http://www.marh.gov.bc.ca/FIRECOM/

12. WHMIS - WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM – Health Canada

Website: http://www.hc-sc.gc.ca/ehp/ehd/psb/whmis.htm

13. Canadian Centre for Occupational Health and Safety (CCOHS)

Website: www.ccohs.ca
E-mail: inquires@ccohs.ca
Telephone: Toll-free in Canada and US 1-800-263-8466

The Science Teachers' Association of Ontario (STAO). (1999). *Chemical Storage Provision for School Science Laboratories.* Ontario.

The Science Teachers' Association of Ontario (STAO). (1998). *Science Laboratory General Safety Practices.* Ontario.

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Appendix A

Laboratory Safety Checklist

The following checklist is intended to assist school and district staff to ensure a safe environment in the science areas of the school. The laboratory safety checklist could be completed by each science teacher each year as part of an overall safety program while the lists of carcinogens, mutagens and explosives should be used to identify potential hazards for immediate removal

Please note that the checklist is neither comprehensive nor prescriptive. The criteria should be reviewed and modified to suit local situations.

Please place a check mark in the appropriate column. Under the Date column, indicate the date of last maintenance if one is available. Base your answers on current practice. "No" answers suggest a potential problem.

Laboratory Safety Checklist	Yes/Date	NO	N/A
I. Space & Class Size			
A. 140 m2 floor space per laboratory (including preparation areas)			
B. 5.0 m2/ student in combined classroom/laboratory (rough guide)			
C. Class size is appropriate and safe for room design			
D. Sinks (with mats) - 1 per 4-5 students			
II. Communication System			
A. Phone			
1. Accessible phone located nearby			
2. Current emergency phone numbers posted			
B. Intercom System			
C. Cooperative plan with nearby colleague			

Laboratory Safety Checklist	Yes/Date	NO	N/A
VIII. Lighting			
A Safe light level in laboratory (500-750 lux ambient plus task lighting)			
B. Emergency light			
1. In each laboratory (possibly not necessary if adequate natural light is available			
2. Located in each storeroom/prep room			
3. Evidence of regular maintenance (Please indicate date)			
IX. Personal Protection			
A. Safety Shower			
1. One in each chemistry laboratory			
2. Functional (with water turned on) unobstructed shower and valve handle			
3. Rigidly fixed valve handle (no chains unless provided with large ring)			
4. Plainly labeled valve handle			
5. Sufficient water pressure			
6. Floor drain			
7. Large enough to accommodate more than one person			
8. Evidence of maintenance on a regular basis (Please indicate date)			
B. Eye Wash			
1. Available and visible in each laboratory			
2. Training in eye wash procedures within last year (Please indicate date)			
3. Type of eye wash (Squeeze bottles or single eye drench are not recommended)			
a) dual eye wash fixture or portable pressurized, eye wash pump			
b) one located near a safety shower			
4. Equipment to treat both eyes simultaneously with instant, gentle, tempered flow of aerated water for 10-15 minutes			
5. Evidence of maintenance of eye wash equipment (Please indicate date) Please indicate date for:			
a) change solutions(s)			
b) check for pressure			
c) check for breakage			
C. Protective Clothing			
1. Presence of aprons			
2. Presence of gloves			
a) heat resistant gloves			
b) chemical resistant gloves for student use			
3. Presence of safety goggles/eye protectors for each student when needed			
4. System for disinfecting goggles/eye protectors			
5. Presence of face shields			
6. Are standard procedures for use of protective gear enforced?			
7. Eye protectors/goggles are clean and in good condition.			
D. Carriers available for carrying chemicals and acids			
E. Belt guards on all belt driven equipment (e.g. rock saw)			
X. Storage			
A. Chemicals			
1. Regular inventory and disposal of unused hazardous chemicals			
2. Chemicals not stored in areas regularly traveled by students			

		Yes/Date	NO	N/A
3.	Correctly labeled when transferred from original container			
4.	Quantity of chemicals stored not excessive (1 or 2 semesters)			
5.	Properly and clearly labeled by WHMIS standards with			
	a) secure, water-proof labels			
	b) date of acquisition			
	c) hazard alert			

Laboratory Safety Checklist	Yes/Date	NO	N/A
XI. Animal Cages/Tanks			
A. Cleaned regularly			
B. Animals have adequate food and water			
C. Animals appear to be in healthy condition			
D. Could animals pose a threat or health hazard to people in the room?			
XII. General Storeroom or Lab Safety			
A. Centrifuges			
1. Anchored securely			
2. Instructions labeled			
3. Positive locking head			
4. Top equipped with disconnect switch that shuts off if top is inadvertently opened			
B. Electrical			
1. Outlets carry grounding connections			
2. Sufficient electrical outlets are provided so as to eliminate the use of extension cords or overlapping wires or multiple plugs			
3. No outlets close to faucets, etc.			
4. All major lines fused or on circuit breakers			
5. Location of circuit breakers is known to teachers, custodians, and administrators			
6. Date of last inspection			
7. Floor plugs securely fastened			
8. Recessed floor plugs water proof			
9. Extension cords are 18 gauge or heavier			
10. No extension cords across aisles			
11. DC and AC lines clearly labeled			
12. Sockets and switches securely screwed without cracks			
13. No loose or exposed wires.			
C. Preparation/Workroom			
1. Large sink			
2. Hot water			
3. Posted rules for safe: handling, clean-up, disposal, protective equipment, conduct			
D. Presence of			
1. Bulb (not mouth) pipets			
2. Fan guards			
3. Materials Safety Data Sheets (MSDS) for each hazardous chemical present			
4. Automatic request for MSDS on all purchase orders			
5. Aisles wide enough so teachers and students can move freely without interfering with others (no books and coats on floor)			
6. Work surfaces are made of non-porous and chemical resistant materials			
7. Non-reactive chemical waste container(s) available			
E. Clean-up materials for chemical spills			
1. Chemical spill kit available			
2. Spill pillows available			
3. Protective clothing			
4. Approved waste disposal practised			
F. Presence of laboratory chemical and biological wastes disposal system for			

Laboratory Safety Checklist	Yes/Date	NO	N/A
1. glass			
2. dry chemicals/reagents			
3. liquid chemicals/reagents			
4. biological wastes			
G. Respirator available (ensure that any respirator is appropriate for its intended use; check with WCB)			
H. No pathogenic bacteria			
I. Annual safety inspection			
J. Chemicals in original containers not available for student use			
K. Caution (Do Not Eat) sign on icemaker			
XIII. Housekeeping			
A. Labs, storage, and prep rooms are organized and clean			
B. Aisles are clear			
C. Supplies and equipment (cleaned) are returned to proper storage area			
D. Work surfaces are clear and clean			
E. Floor in safe condition			
F. Adequate number and size of garbage containers			
G. Glassware is free of cracks, chips and sharp edges			
H. Bunsen burner tubes are free from leaks			

School _____ Inspection by_____

Classroom location _____ Date _____

Actions taken and other recommendations

Teacher Signature_____ Date _____

Copies of completed survey should be given to Safety Chairperson, Science Department Head and School Administration.