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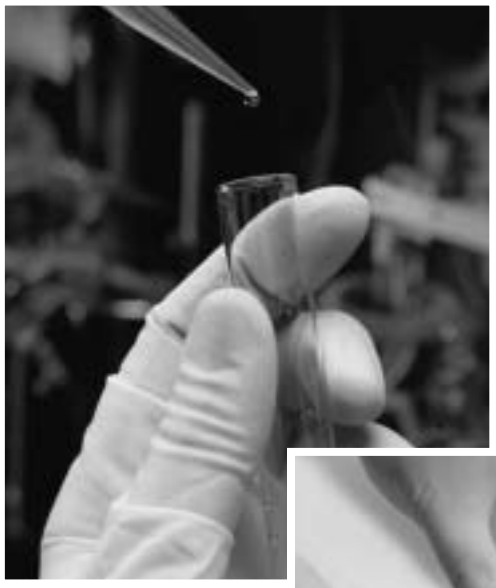

Science Safety Resource Manual

BRITISH COLUMBIA
Ministry of Education

Revised 2003

QP # 7530877090

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. Therefore, it cannot be assumed that all necessary warnings and precautionary measures are contained in this document and that other or additional measures may not be required.

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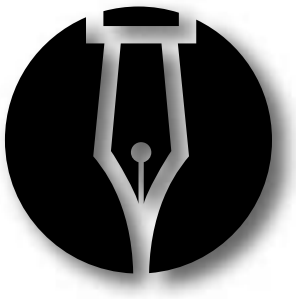


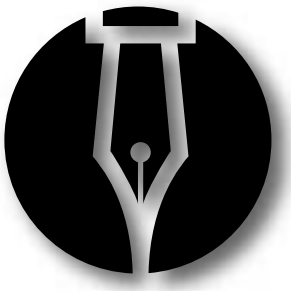
Preface

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/



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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)
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School District No. 4 (Windermere)
School District No. 10 (Arrow Lakes)
School District No. 11 (Trail)
School District No. 27 (Williams Lake)
School District No. 29 (Lillooet)
School District No. 35 (Langley)
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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.

Introduction to Science Safety

In today's world, a scientifically and technologically literate population is now more important than ever. As a global community, we are experiencing rapid and fundamental economic, environmental, social and cultural changes that affect our quality of life. Science education is a key element in developing scientific literacy among today's and tomorrow's youth. They will need to understand the major concepts and principles of Science and be able to use this knowledge. The development of scientific literacy is supported by instructional environments that engage students in active inquiry, problem solving and decision making. (Pan-Canadian Science Curriculum Framework page 8).

With active inquiry comes an element of caution and safety that must be followed. The safety consciousness of society in general and science educators in particular has been raised substantially over the past few years. As stated in the Pan-Canadian Science Curriculum Framework, "Students will be encouraged to demonstrate a concern for safety in science and technology contexts. Science education can contribute to attitudinal growth when students are encouraged to assess and manage potential dangers and apply safety procedures, thus developing a positive attitude toward safety." (page 18)

This manual has been developed and revised to address the need for an increased safety consciousness. The teaching of science requires the active involvement of students in laboratory procedures. Any safety guidelines should support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time assisting in the development of a safe teaching environment.

The information in this manual is intended to help educators provide a complete science safety program that supports an exciting and meaningful science curriculum and reduce the risk of injury to staff and students.

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 performed by the students; done as a demonstration; or omitted entirely. Please see page 8 of this manual regarding the expectations for teachers. The materials included in this manual have been compiled to assist educators, in particular, the classroom teacher, in making sound decisions regarding science safety.

Some Legal Aspects of Science Safety

A science teacher will be held to the standard of care of a reasonably prudent science teacher in the province of British Columbia. Following the suggestions in this manual will help to ensure that legal standards are met. If an accident and injury occurs during a science class, a science teacher 's legal liability for that injury will be judged by considering some of the following criteria:

1. Did he/she use appropriate activities for the grade level?
2. Did he/she give careful instruction of all aspects of the activity?
3. Did he/she teach safety rules, and satisfy himself/herself that the students understood the activity and safety requirements (safety tests are helpful)?
4. Did he/she carefully supervise the activity?
5. Did he/she strictly enforce safety rules?

Responsibilities

Responsibility for ensuring a safe environment in the science classroom is shared by five main groups:

- School Board/Trustees and Superintendent;
- School Administration;
- School Science Safety Officer/Laboratory Technician;
- Science Teacher;
- Science Student.

The co-operation of all these groups helps to develop a strong safety consciousness both inside and outside the school.

The Insurers' Advisory Organization (IAO) are contracted to perform regular safety inspections of all schools. Educators should take the time to review the IAO annual school reports and recommendations to ensure that they are followed.

School Board/Trustees and Superintendent

The School Board and Superintendent should endeavour to:

- plan for the necessary improvements and procedures outlined in this manual;
- set up a school district science safety committee with representatives from the school district administration, school administration, teachers and the public, and consult with this committee on matters of science safety;
- ensure that school administrators carry out the safety responsibilities outlined in this manual;
- provide in-service training and encouragement to ensure that the professional staff have the necessary expertise to develop and maintain a safe working/learning environment (for example, every employee should have WHMIS training);
- make provision for staffing alternatives to permit safe operation and maintenance of science facilities on a day-to-day basis;
- provide any special safety facilities/provisions needed for special needs students and students for whom English is a second language;
- establish fire drills and emergency procedures; and
- maintain school buildings, furniture and equipment in proper repair.

School Administration

The school administration should endeavour to:

- designate a school science safety officer, and support her/him in maintaining a safe working/learning environment in the school;
- ensure that safety concerns that can be dealt with at the school level are corrected;
- direct any safety concerns that cannot be corrected at the school level to the appropriate district personnel;
- ensure regular (annual, monthly & special) safety inspection of science facilities, and report findings to the school district, the district safety committee, and the school science safety officer. The checklist provided on pages 137-143 of this manual is a useful instrument for use in safety inspections;
- ensure that the school has effective policies and procedures to follow in case of accidents and emergencies;
- conduct fire drills and emergency training during the school year;
- ensure that all teachers and substitute teachers of science have the expertise to teach the science assigned to them in a safe and effective manner;
- ensure that the size of science classes allows for a safe learning environment which can be reasonably supervised (see Facilities page 119);
- support teachers in providing a safe working environment through:
  - providing necessary safety equipment;
  - enabling teachers and technicians to obtain in-service training in science safety (ex. WHMIS, First Aid, CPR);
  - providing necessary discipline to ensure safety in science classes;
  - ensuring safety procedures identified in this manual are effectively carried out;

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

- co-operate with outside personnel and agencies in encouraging science safety, e.g., Fire Commissioner's office, BC Hydro, W.C.B. (see page 127);
- ensure that teachers-on-call do not undertake activities that endanger the safety of students (i.e., ensure they have the necessary expertise to carry out the activities outlined in the lesson plans; otherwise alternative activities should be arranged);

School Science Safety Officer and/or Laboratory Technician

The school safety officer or laboratory technician (possibly the same person) should endeavour to:

- follow the suggestions of this manual;
- establish a safety awareness program in the science department;
- assist in planning and organizing emergency drills;
- maintain safety equipment and supplies;
- ensure that science equipment and facilities conform to safety standards;
- implement and maintain safe storage and waste disposal systems for potentially dangerous substances used or produced in the course of laboratory work;
- provide proper security to prevent theft;
- immediately report any recognized safety hazards to the appropriate school or district authority.

Science Teacher

Safety in the classroom is of paramount importance. Other components of education – resources, teaching strategies, and facilities are effective only in a safe classroom or lab. Safety is not just a matter of common sense.

A teacher should:

- be informed by
  - being familiar with this manual
  - reading safety articles in teachers' journals
  - attending safety sessions at in-services or conferences
  - exchanging information with colleagues
  - being aware of district and provincial policies related to laboratory activities.
- be aware by
  - having safety equipment prominently displayed
  - having safety posters on the wall
  - organizing a safety class with students at the beginning of the year and placing regular emphasis being placed on safety precautions prior to an activity.
- be proactive by
  - protecting the health, welfare and safety of the students

- providing students with the necessary personal protective equipment
- being aware of students' health or allergy problems
- planning carefully for all activities. The following questions can be used to guide planning for a particular unit or activity:
  - What are the hazards?
  - What are the "worst case" scenarios?
  - How can I prepare for and avoid the "worst case" scenarios?
  - What practices, safety equipment and protective facilities are prudent and appropriate?
- modeling safe procedures at all times
- instructing students about safe procedures regularly
- supervising students
- reporting all hazardous or potentially hazardous conditions to supervisory personnel immediately
- maintaining adequate records of all aspects of laboratory operations
- displaying commercial, teacher-made, or student-made safety posters
- taking First-aid, CPR, WHMIS courses.

Science Student

A science student should:

- give undivided attention to science activities and behave in a safe and careful manner in the science room;
- follow all safety procedures and instructions;
- not carry out any science activity without the teacher's permission and appropriate supervision;
- report any unsafe situations or accidents to the teacher immediately.

Elementary Science

Although experimentation in the elementary years may not be in as much depth as in secondary school, and the equipment and chemicals may not be as sophisticated, the attention to safety is just as important. More detailed information may be found throughout this manual.

Safety is an important concern in the elementary science classroom because students are learning new skills and working with unfamiliar equipment and materials that can pose some degree of hazard. Safety in the elementary school science classroom depends upon the wise selection of experiments, materials, resources and field experiences as well as consistent adherence to correct and safe techniques. It also requires thorough planning, careful management and constant monitoring of students' activities. Teachers should be knowledgeable of the properties, possible hazards, and proper use and disposal of all materials used in the classroom. This information can be attained through the Material Safety Data Sheets (MSDS). (page 9 Nova Scotia Science Safety Manual: Draft, October 2000)

The Safe Classroom

Some general principles of safe science classroom management may be identified:

- Prepare, maintain, and prominently display a list of emergency telephone numbers.
- Identify people within the school who are qualified to administer first aid.
- Annually review and complete the safety checklists relevant to your situation. See Pages 137-143
- In consultation with the school nurse (where available), familiarize yourself with the relevant medical histories of individual students.
- Review basic first aid procedures regularly. It is strongly recommended that teachers obtain some formal instruction in first aid. Contact The Canadian Red Cross Society or St. John Ambulance.

- 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.**

Suitable Chemicals

The following chemicals can be used safely by students (but remember that any substance, even salt, can be harmful if taken in sufficient quantity). Be aware that any substance in a fine powder or dust form can be inhaled and thus harm health.

Aluminum foil

Antacid preparations (e.g. Alka-Selzer)

Baking powder (sodium bicarbonate and tartaric acid)

Baking soda (sodium bicarbonate)

Bath salts/Epsom salts (magnesium sulfate)

Borax (sodium borate)

Carbonated (fizzy) drinks

Chalk (calcium carbonate)

Charcoal (carbon)

Citric acid crystals

Clay (moist)

Cobalt chloride paper (only the paper)

Copper foil or powder

Cream of tartar (tartaric acid and potassium hydrogen tartrate)

Detergents, hand-washing types (but not dishwashing)

Food colouring

Glycerine (glycerol)

Iron filings

Lemon juice (contains citric acid)

Marble chips (calcium carbonate)

Litmus paper or solution

Milk

Oils, vegetable and mineral (but not motor oil)

Plaster of Paris or cellulose fillers ('Polyfilla')

Salt (sodium chloride)

Sand

Soap

Starch

Steel wool

Sugar

Tea (contains tannic acid)

Universal (pH) indicator paper or solution

'Vaseline'

vinegar (dilute acetic acid)

vitamin C (ascorbic acid)

washing powder, hand-washing types

water glass (sodium silicate)

zinc foil

(from Be Safe! Canadian Edition)

Dangerous Household Chemicals

These household chemicals are dangerous and in the classroom should only be used by the teacher, if at all. Consider warning the students about the dangers in their homes. (page 12 *Be Safe! Canadian Edition*)

- Bleach
- Caustic soda (sodium hydroxide)
- Rust-removal solution (e.g. 'CLR')
- Dishwasher detergents
- Drain cleaner
- Dry cleaning fluids
- Some fertilizers
- Fine powdered substances
- Fireworks, sparklers and party poppers
- Gasoline and other fuels
- Hydrogen peroxide (more than a 3% solution)
- Laundry detergents
- Oven cleaners
- Paint strippers
- Pesticides, fungicides, and insecticides
- Some plant growth substances e.g. rooting powders
- Scale removers
- Toilet cleansers
- Weed killers

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.

Science Safety Rules and Procedures

for Elementary Science (not a conclusive list)

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.
11. Always keep the pointed end of scissors or any other sharp object facing away from yourself and others if you have to walk with it.
12. Dispose of broken glass as your teacher directs.
13. Do not smell a substance directly, fan the smell toward you with your hand.
14. Never eat or drink in the laboratory.
15. Never drink or taste any substances.
16. Never use cracked or broken glassware.
17. Make sure that your hands are dry when touching electrical cords, plugs, or sockets.
18. Handle hot objects carefully.
19. Tell your teacher immediately if an accident or spill occurs, no matter how minor.
20. Never do any experiment without the approval and direct supervision of your teacher.
21. Clean equipment before you put it away.
22. Dispose of materials as directed by your teacher.
23. Clean up your work area upon completion of your activity.
24. Wash hands carefully with soap and water after handling chemicals, after all spills and at the end of each activity.

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)

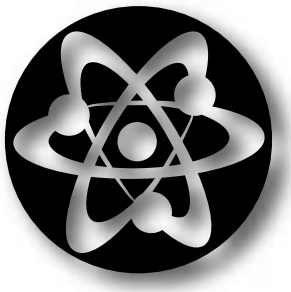
Teachers are responsible for familiarizing themselves with any local, provincial, or federal statutes pertaining to the care of plants or animals. If in doubt, inquire. Pet shops or plant shops may have useful information. Remember that there are regulations preventing the picking of wild flowers, or 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.
- Poisonous animals and plants, or other potentially dangerous animals such as venomous snakes and spiders should not be kept in the classroom.
- Wear gloves when handling animals in the classroom. Over-handling can put the animals under excessive stress.
- Involve students in helping to care for plants and animals.
- Make arrangements to have the plants and animals looked after over holidays and on weekends.

Regulations for Animal Experimentation in Science Fairs

There are strict safety requirements. Teachers are asked to ensure that students adhere to these rules at all times. Live animals are not to be displayed and procedures which could harm or distress animals are not to be used. Safety requirements are constantly being reviewed and updated. If an experiment can be performed in some other way than by using live or preserved specimens, then do so. Alternatives might include computer simulations and research projects.

For the most current information contact the Provincial Science Fair Coordinator at http://www.sciencefairs.bc.ca/ or the Youth Science Foundation Canada at http://www.ysf.ca/. This organization has established guidelines for the National Science Fair Program.



Secondary Science

No matter what age level, safety is a primary concern in the science classroom. Secondary students should already have experience handling chemicals and science equipment. As they progress through secondary school, more opportunity is given to them to work with more sophisticated apparatus and chemicals. The following are guidelines, cautions and recommendations for teaching science in a secondary classroom. (page 13, *Nova Scotia Science Safety Manual*: Draft, October 2000).

Science Safety Rules and Procedures

For Secondary Science (not a conclusive list)

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.
13. Take only as much chemical as needed and never return excess chemicals to the original container.
14. Dispose of chemicals as directed by your teacher.
15. Bottles should never be held by the neck.
16. Taste nothing unless you are instructed to do so.
17. Never eat or drink in the science classroom.
18. Never enter the chemical storeroom without permission.
19. Always clean off bench and sink after completion of an experiment.
20. At the end of the laboratory session wash your hands thoroughly with warm water and soap.

Sample Student Safety Contract/ Agreement

Class _____ Student's Name_____

Teacher's Name_____

I WILL:

1. Follow all written and oral instructions given by the teacher.
2. Ask questions, or state concerns before beginning a lab procedure.
3. Behave in a manner that will ensure the health and safety of myself and others in the laboratory or classroom at all times.
4. Use protective devices for my eyes, face, hands, body and clothing during laboratory activities.
5. Know the location and use of first aid and fire extinguishing equipment.
6. Refrain from eating, drinking, chewing gum or applying cosmetics in the laboratory.
7. Keep my work area clean and free of clutter during lab class.

I understand and realize that many accidents are caused by carelessness and being in a hurry. I will come to class prepared to be responsible so that the safety and welfare of myself and others is not jeopardized.

I have read the set of written science safety rules prepared by my teacher and agree to follow these and any other rules.

Student's signature _____ Date: _____

Parent's signature _____ Date: _____

Teacher's signature _____ Date: _____

Please list any known allergies or health problems: (If additional space is needed, please use the back of this sheet.):

_____

Do you wear contact lenses? ❑ NO ❑ YES (If yes, please complete the section below.)

Contact lenses are not recommended to be worn in the laboratory as certain chemical fumes or small particles may become lodged under the lens. Please be aware of the slight increase in the risk of eye damage for contact lens wearers as compared to students in similar situations without contact lenses. All students must wear safety goggles in certain activities, even if they wear contact lenses or prescription glasses.

Please check the appropriate choice below and sign. Whatever your decision should be, it is up to your son/daughter to follow your choice.

1. My son/daughter, will wear contact lenses under goggles during labs. _____
2. My son/daughter, will remove contact lenses prior to lab and will wear glasses under goggles _____

Parent/ Guardian Signature: _____ Date: _____

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	Comments
Free standing clear plastic screen, minimum size 60 cm high x 1 m wide	Clear P.V.C. is satisfactory. Polycarbonate is less easily scratched, and therefore preferable. Use for teacher demonstration. Screen should be securely fastened.
One pair heat resistant gloves	Gloves should be made of treated textured silica or woven fabric. Do not use asbestos gloves.
One eyewash station	A plumbed in type is preferred, provided the water supply is free of grit and contaminants. The water supply should be tempered by mixing hot and cold water. Eye wash facilities must be tested at least once every six months and be maintained in good working order. A maintenance and testing record should be kept. (WCB – page 15)
One fire blanket with wall stand mounted low on wall	The only use is to smother clothing fires. Replace any existing asbestos blankets with fire-proofed wool/rayon fabric.
One ULC listed 2A10BC type dry chemical fire extinguisher	After use, the extinguisher will require service. Demonstrations should not be carried out with this extinguisher. A spare extinguisher reserved for that purpose should be used. Fire exits and routes out of science classroom must be clearly marked and kept clear of obstructions at all times.
Sand bucket (approximately 20 L of sand)	For small fires only.

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 velocity is for substances that are not carcinogenic or radioactive. The face velocity must be measured and recorded at least once annually.
Simple handwashing facilities.	Should be in or near each science classroom.
Safety showers.	Readily accessible from each science classroom. Should be installed well away from chemicals. Safety showers must be tested at least once every six months and be maintained in good working order. A maintenance and testing record should be kept. (WCB – page 15)
Spill kits.	Spill kits absorb spills or dilute solutions of chemicals. The spill kits should be specific to the chemicals being handled.
Pails containing 12 to 15 L of kitty litter or bentonite	Containers should be clearly labelled and contents disposed of safely

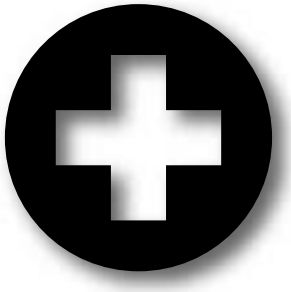
Safety Equipment For Science Classrooms Cont.

Equipment	Comments
Waste Disposal a) Glass b) Organic Solvents and Soluble Chemicals c) Biological Waste	a) Broken glass, metal or similar waste that can cut must be disposed of in separate and clearly identified waste containers. b) Organic solvents and flammable waste must be collected in separate, tightly-covered containers and disposed of according to municipal, provincial and federal regulations. c) Biological waste must be segregated and disposed of safely. (WCB – page 21)
Metal container with lid	It is preferred that materials soiled with combustible or flammable agents be disposed of in a metal container with a lid.
Weak acid solution (acetic acid). Large container of dry Na2HCO3 (baking soda)	To neutralize small alkali spills. To neutralize strong acids before disposal.
Laboratory First Aid Kit.	Refer to First Aid Kit Contents on Page 25
KIK™-type step-stool, step ladder.	To aid in reaching high storage areas safely.
One plastic hand dustpan, brush, protective gloves and a scooping device.	Used for brushing up used sand, vermiculite, broken glass, etc. As both pan and brush will be contaminated after use, wash and clean up thoroughly.
One pair 45 cm long chemically resistant rubber gloves (usually included with spill kits).	Gloves should always be worn when dealing with spills. Often broken glassware is involved, and the danger of toxic chemicals entering through open cuts is serious.
One pack heavy duty garbage bags. (Also useful for biohazard bags.)	For disposal of all solid waste, including used sand, vermiculite and chemically contaminated broken glass. Double bag if necessary. Dispose of each spill separately. Tie bags very securely and label. For disposal of specimens, cultures, etc. use designated biohazard bags or extra thick garbage bags.
Goggles sterilizing cabinet (using an ultraviolet [UV] source) with interlocking door (it is recommended for Grade 8 to 12 Science classrooms)	This cabinet is used for sterilizing goggles worn by students. The door cannot be opened when the UV light is on. One cabinet can serve a number of classrooms.

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.

First Aid in the Science Classroom Cont.

Injury	Response
Cuts *Severe bleeding:*	Control the bleeding by: • 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 goggles or preferably face shields must be worn when handling caustic solutions. • Fresh tap water is preferable to stored saline or bacteriostatically treated water which may become contaminated. DO NOT USE HOT WATER.

First Aid in the Science Classroom Cont.

Injury	Response
Chemical Spills and Splashes *Ingestion of Hazardous Chemicals*	• Encourage the victim to drink large amounts of water while en route to medical assistance. Never give anything by mouth to an unconscious person.
Electrical Accident	• Do not touch a person in contact with live electrical current. Disconnect power first. Give artificial respiration if necessary and treat burns.
Epileptic Seizure in Class *For Tonic-Clonic (Grand Mal)*	• Ease the person to the floor and stay calm • Move away any sharp objects from near them • Don't restrain • Never put anything in their mouth • Let seizure run its course • If seizure lasts more than 10 minutes or they have a second one – call an ambulance immediately. After seizure • Roll onto left side • Reassure and comfort • Call parents immediately
Absence/Petit Mal	• Reassure and explain what has happened • Call parents • Only restrain wandering by guiding away from danger or to a seat.

Accidents

"Accident" implies damage and injury or the potential for damage or injury. Accidents do not just happen – they are caused. If the potential cause can be detected and eliminated, fewer accidents should happen. Accidents can be prevented by:

- An educational safety program
- Proper supervision of students
- Instruction in appropriate laboratory techniques
- Good laboratory housekeeping

Science instructors who have been alerted to the hazards in the labs, who have provided a student educational safety program and who promote sound laboratory techniques are in a better position to ensure a safe and successful science program.

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 standard CSA Z94.3 – 99, must be worn whenever there is significant risk of damage to the eyes. Failure to do so could be regarded as negligence. It is essential that teachers and students comply with this basic requirement.

Potential Eye Injuries

Foreign bodies	• most common danger to the eye • particles can lodge on the surface of the eye where they are become very irritating • sharp objects may penetrate deeply into the eye where they may cause no pain • some chemicals have a toxic effect on eye tissue
Flying glass	• from an exploding test tube or flask
Chemical Agents	• acids – the eye will set up a protection barrier • caustic materials – readily penetrate into the eye tissue
Radiation	• ultraviolet, visible, and infrared radiation can all damage eye tissue if the intensity level is sufficiently high. • use of lasers requires special eye protection in addition to special facilities and proper techniques.

Approved eye protection must be worn at all times by everyone in a laboratory situation involving chemicals, explosive materials, compressed gases, hot liquids or solids, injurious radiation, or other identifiable hazards.

Contact lenses

(Appendix E: *Nova Scotia Science Safety Manual:* Draft, October 2000)

The wearing of contact lenses in the lab has long been an item for discussion. The following information was taken from the Canadian Centre for Occupational Health and Safety (February 16, 2000) and Flinn Scientific, Inc. (1998).

What is the controversy about wearing contact lenses at work in the Science lab? Put as simply as possible, the problem is that, according to some people, contact lenses may complicate eye safety. The arguments against wearing contact lenses while conducting experiments are based on the following:

- 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?

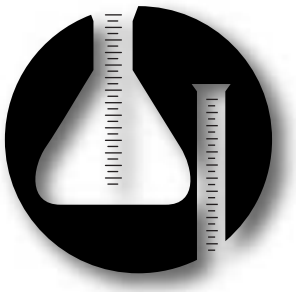
The school and the student have responsibilities to ensure the safe use of contact lenses. Where contact lenses are worn, the following steps should be followed:

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.



Chemicals

Chemicals Likely to be Found in School Science Departments

The following list gives recommendations and comments on hazardous or potentially hazardous chemicals. The information on chemicals contained on pages 36 through 58 has been compiled from sources believed to be reliable, accurate and representative of the best opinions on the subject as of 2002. While every reasonable effort has been made to provide dependable information, neither the authors nor the Ministry of Education can assume responsibility for the validity or completeness of all chemical references given or for the consequences of their use.

The purpose in listing a substance is not to discourage its proper use, but rather to make information available relative to its hazardous properties. **It should be noted that the Health, Fire, and Reactivity columns are keyed to concerns in a fire situation, they do not provide a complete picture of hazards such as carcinogeneity.** Additional hazards appear in the Hazard and Comments columns and should be carefully noted. If there is doubt as to the potential hazard of a substance then additional sources or authorities should be consulted such as the MSDS information sheets.

The decision to use certain substances in school laboratories should be based on the best available knowledge of each chemical's particular hazard and the availability of proper handling facilities. When the risk outweighs the benefits and no substitute is available, then the experiment/demonstration should not be done.

Remember for safety's sake:

- Limit the quantities of chemicals.
- Dangerous chemicals should only be used by trained educators.
- Use proper storage techniques.

NFPA Chemical Hazard Labels

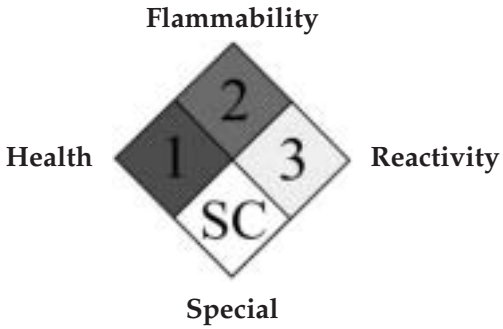
http://www.nfpa.org/

NFPA Rating (optional) - The National Fire Protection Association (NFPA) has developed a system for indicating the health, flammability and reactivity hazards of chemicals. In addition, a special precaution symbol may be used where necessary.

N.F.P.A. Hazchem Code

Sample Hazard Diagram

Note: The colour-coding is often not consistent among manufacturers. Some omit colour entirely.



Rating Summary

Health (Blue) H*

4	Danger	May be fatal on short exposure. Specialized protective equipment required
3	Warning	Corrosive or toxic. Avoid skin contact or inhalation
2	Warning	May be harmful if inhaled or absorbed
1	Caution	May be irritating
0		No unusual hazard

Flammability (Red) F*

4	Danger	Flammable gas or extremely flammable liquid
3	Warning	Flammable liquid flash point below 100° F
2	Caution	Combustible liquid flash point of 100° to 200° F
1		Combustible if heated
0		Not combustible

Reactivity (Yellow) R*

4	Danger	Explosive material at room temperature
3	Danger	May be explosive if shocked, heated under confinement or mixed with water
2	Warning	Unstable or may react violently if mixed with water
1	Caution	May react if heated or mixed with water but not violently
0	Stable	Not reactive when mixed with water

Special Notice Key (White)

	~~W~~	Water Reactive
	OX	Oxidizing Agent

For further information about common chemicals and whether skin absorption is a significant route of exposure, and toxicological designations, refer to **Table 5-4: Exposure Limits and Designations** in the Workers' Compensation Board *Occupational Health and Safety Regulation*. For any substance that bears the K1, K2, K3, R1, R2 or Z designation, it must be replaced if practicable.

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

Chemicals that have been removed from the "*should be removed list*" and can be used in schools.

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
H_2WO_4
Zirconium
Zr

NOTE: Those chemicals with asterisks (**) beside them should be removed from the school and should under no circumstances be used in school laboratories without written approval from school and district authorities.

Please note: If the boxes for H, F*, R* (See page 34) are blank, this does NOT imply that there is no hazard for these materials.*

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.***

Chemical Name and Formula	H*	F*	R*	Comments
Aluminum sodium sulfate $NaAl(SO_4)_2$				Low toxicity; non-combustible.
Aluminum sulfate $Al_2(SO_4)_3$				Low toxicity; non-combustible.
Aluminum sulfide Al_2S_3				
**Ammonia, anhydrous gas NH_3	3	1	0	Corrosive to eyes, respiratory tract, and skin; moderately toxic by inhalation and ingestion. Use only under fume hood; Stainless steel control valve required for use with Ammonia gas.
Ammonia Solution NH_4OH				Slightly toxic by ingestion and inhalation; both liquid and vapor extremely irritating, especially to the eyes.
Ammonium acetate CH_3COONH_4				
Ammonium alum (Aluminum ammonium sulfate) $AlNH_4(SO_4)_2$				
Ammonium bicarbonate NH_4HCO_3				Creates irritating fumes when heated.
Ammonium bromide NH_4Br	2	0	0	Moderately toxic by ingestion and inhalation.
**Ammonium chlorate NH_4ClO_3				Explosive. Very Dangerous.
Ammonium chloride NH_4Cl	2	0	0	
**Ammonium chromate $(NH_4)_2CrO_4$				Very strong oxidizing agent. Moderately toxic by ingestion; strong irritant.
Ammonium citrate $(NH_4)_2HC_6H_5O_7$				
**Ammonium dichromate $(NH_4)_2Cr_2O_7$	2	1	1 OX	Very strong oxidizing agent; dangerous fire risk; dusts and solutions are toxic; irritant to eyes and skin; known carcinogen.
Ammonium ferrous sulfate (Mohr's salt) $FeH_8N_2O_8S_2$				
**Ammonium fluoride NH_4F	3	0	0	Corrosive to tissue; toxic by ingestion and inhalation.
Ammonium hydroxide, (7.4M;28%) NH_4OH				Both liquid and vapor are extremely irritating – especially to eyes. Dispense in a hood and be sure an eyewash is accessible. Moderately toxic by ingestion and inhalation. Serious respiratory hazard.
Ammonium molybdate $(NH_4)_6Mo_7O_{24}$				Skin and eye irritant; moderately toxic by ingestion.
**Ammonium nitrate NH_4NO_3	0	0	3 OX	Strong oxidizer; may explode if heated under confinement; will explode at temperatures of 210 C; explodes more readily if contaminated with combustible material; slightly toxic by ingestion; body tissue irritant.
Ammonium oxalate $(NH_4)_2C_2O_4$				Moderately toxic by ingestion and inhalation; corrosive to body tissue.
Ammonium phosphate, monobasic $(NH_4)H_2PO_4$				
Ammonium phosphate, dibasic $(NH_4)_2HPO_4$				
Ammonium sulfate $(NH_4)_2SO_4$				Slightly toxic by ingestion.
Ammonium sulfide $(NH_4)_2S$				Contact with acids or acid fumes may liberate flammable and poisonous hydrogen sulfide gas. Strong skin and mucous membrane irritant; toxic by skin absorption; vapour harmful. Even low concentrations may cause headache and general discomfort.

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

Chemical Name and Formula	H*	F*	R*	Comments
Ammonium sulfite $(NH_4)_2SO_3$				
Ammonium thiocyanate NH_4SCN				Moderately toxic by ingestion.
Ammonium thiosulfate $(NH_4)_2S_2O_3$				
n-Amyl acetate $CH_3COOC_5H_{11}$	1	3	0	Dangerous fire risk.
n-Amyl alcohol (1-pentanol; Pentyl alcohol) $C_5H_{11}OH$	1	3	0	Moderate fire risk; slightly toxic by ingestion and inhalation; severe body tissue irritant.
Aniline (Amino Benzene) C_6H_7N	3	2	0	Highly toxic by ingestion, inhalation and skin absorption. Severe eye irritant and mild sensitizer. Combustible. Limited access suggested. Mutagen.
**Antimony Sb				
**Antimony pentachloride $SbCl_5$	4	0	1	
**Antimony sulfate $Sb_2(SO_4)_3$				
**Antimony trichloride $SbCl_3$				Corrosive as solid or liquid; strong skin and eye irritant; moderately toxic.
**Antimony trioxide Sb_2O_3				
**Antimony trisulfide Sb_2S_3				
L. Arabinose $C_5H_{10}O_5$				
Arginine $C_6H_{14}N_4O_2$				
Argon Ar				
**Arsenic As				
**Arsenic pentoxide As_2O_5	3	0	0	
**Arsenic (tri)chloride $AsCl_3$	3	0	0	
**Arsenic trioxide As_2O_3	3	0	0	A known carcinogen; highly toxic by ingestion and inhalation. Use only under a fume hood.
**Asbestos (Magnesium silicate minerals)				
Ascorbic Acid (Vitamin C) $C_6H_8O_6$				
Asparagin $C_4H_8O_6$				
Aspartic acid $C_4H_7NO_4$				
Baking Soda (Sodium bicarbonate) $NaHCO_3$				
**Barium Ba				
Barium carbonate $BaCO_3$				Moderately toxic by ingestion; strong body tissue irritant.
Barium chloride $BaCl_2$				Highly toxic by ingestion.

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Chemical Name and Formula	H*	F*	R*	Comments
**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. Flammable; dangerous fire risk; moderately toxic by ingestion, inhalation and skin absorption. Use Toluene as a substitute.
**Benzene sulfonic acid $C_6H_5SO_3H$				
Benzoic acid $C_7H_6O_2$	2	1	-	Slightly toxic by ingestion; body tissue irritant; combustible.
**Benzoyl peroxide $C_4H_{10}O_4$				Radical initiator. Explodes when heated.
**Beryllium Be	3	1	0	Very toxic. All Beryllium compounds should be removed.
**Beryllium compounds (Be salts)				Very toxic. All Beryllium compounds should be removed.
Bismuth Bi				Flammable in finely divided form such as dust. Slightly toxic by inhalation or ingestion.
Bismuth chloride (trichloride) $BiCl_3$				
Bismuth nitrate $Bi(NO_3)_3$				Oxidizer; fire risk near organic material; slightly toxic.
Bismuth oxide Bi_2O_3				
Biuret (reagent) $C_2H_5N_3O_2$				Corrosive liquid; corrosive to tissue; eye protection a must when working with this solution.
Bleach (Sodium hypochlorite) (dilute) NaOCl				Concentrated NaOCl is very dangerous.
Bleaching powder (Calcium hypochlorite) $Ca(OCl)_2$				
Borax (Sodium borate, Sodium tetra borate) $Na_2B_4O_7$				Slightly toxic by inhalation and ingestion.
Boric acid crystal H_3BO_3				Slightly toxic by ingestion; irritant to skin in dry form.
**Boron B				
Brass (Copper-zinc alloys)				
**Bromine (reagent) Br_2				Highly toxic by inhalation and ingestion; severe skin irritant; very strong oxidizer; reacts violently with many organic compounds; very hazardous substance even in this small ampule.
Brom(o)cresol green $C_{21}H_{14}Br_4O_5S$				

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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.

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Chemical Name and Formula	H*	F*	R*	Comments
Calcium oxide CaO	3	0	1	Corrosive; dangerous in contact with organic material; exposure to water or moisture evolves heat. A lump of calcium oxide my disintegrate violently when water is added. Wear eye protection when handling this substance.
Calcium oxalate CaC_2O_4				
Calcium phosphate (monobasic) $Ca(H_2PO_4)_2$				
Calcium phosphate (tribasic) $Ca_3(PO_4)_2$				Body tissue irritant.
Calcium propionate $C_6H_{10}CaO_4$				
Calcium sulfate $CaSO_4$				
Calcium sulfide CaS				
Camphor $C_{10}H_{16}O$	0	2	0	If heated, flammable and explosive vapours.
Caprylic alcohol (n-octanol) $C_8H_{18}O$				
Carbamide (urea) CH_4N_2O				
**Carbolic acid (phenol) C_6H_6O	4	2	0	Toxic by ingestion, inhalation and skin absorption. Strong skin irritant. **Special Hazard Alert: Phenol in contact with more than approximately 100 inches square of skin is absorbed so quickly through intact skin as to be fatal in 90 seconds – unless promptly and completely washed off by scrubbing with a cloth under a copious quantity of flowing water. Drench affected area quickly and thoroughly.
Carbon C				
Carbon dioxide (gas) CO_2				In solid form (dry ice) is very damaging to skin and eyes.
**Carbon disulfide CS_2	3	4	0	Dangerous fire and explosion risk; flash point – 30 C; can be ignited by friction; vapour heavier than air and may travel at floor level – thus distant ignition is possible; moderately toxic by ingestion and inhalation.
**Carbon tetrachloride CCl_4				Mutagen and carcinogen.
Carmine				
Carnoy's fluid (Alcohol + Acetic acid)				Flammable liquid; store in a dedicated flammables cabinet. Moderately toxic.
Caustic potash (Potassium hydroxide) KOH				Skin contact causes sever blisters; strongly corrosive as a solid and as a solution; very harmful if swallowed; extremely dangerous to eyes. Use gloves when handling.
Caustic soda (Sodium hydroxide) NaOH				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.
Cellulose Methyl ether				
**Cesium Cs				
Cesium chloride CsCl				Slightly toxic by ingestion.
Cetyl alcohol				Slightly toxic by ingestion; body tissue irritant.
Charcoal, wood (amorphous Carbon) C				Flammable solid.
**Chlorine (gas) Cl_2	4	0	0 OX	

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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 $CuCl_2$				

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Chemical Name and Formula	H*	F*	R*	Comments
Cupric nitrate $Cu(NO_3)_2$	1	0	0 OX	Oxidizing material; dangerous in contact with organic material; moderately toxic.
Cupric oxide CuO				
Cupric sulfate $CuSO_4$				
Cupric sulfide CuS				
Cuprous chloride CuCl				Toxic ; irritates eyes, skin and respiratory tract.
Cyclohexane C_6H_{12}	1	3	0	Dangerous fire risk; flammable liquid; slightly toxic by ingestion, inhalation and skin contact; store in a dedicated flammables cabinet.
Cyclohexanol $C_6H_{12}O$	1	2	0	Combustible; may form explosive peroxides, do not distill to dryness; slightly toxic by ingestion, inhalation and skin absorption.
Cyclohexene C_6H_{10}	1	3	0	Flammable liquid; dangerous fire risk; slightly toxic by ingestion and inhalation; may form explosive peroxides, do not distill to dryness. Strong, offensive odour. Store in a dedicated flammables cabinet.
Cysteine $C_3H_7NO_2S$				
Cystine $C_6H_{12}N_2O_4S_2$				
Dextrose (Glucose) $C_6H_{12}O_6$				
Diastase (amylolytic enzymes)				
p-Dibromo benzene $C_6H_4Br_2$	2	2	0	
p-Dichloro benzene $C_6H_4Cl_2$				Severe irritant to eyes, skin and respiratory tract. Possible carcinogen. Moderately toxic by ingestion.
**Dichloro methane (Methylene chloride) CH_2Cl_2				Carcinogen/mutagen. Readily absorbed through skin.
2,4 Dichloro phenoxy acetic acid (2,4D) $C_8H_6Cl_2O_3$				Toxic by ingestion; severe eye irritant.
Dichloro tetra fluoroethane $CClF_2CClF_2$				
**Diethyl ether (Ethyl ether) $C_4H_{10}O$				Severe Fire and Explosion Hazard; may form explosive peroxides; vapour harmful, use only under a good or in a well-ventilated area. A possible carcinogen; dangerous fire risk; slightly toxic by inhalation; absorbed by skin; may form explosive peroxides upon concentration.
Dimethyl glyoxime $C_4H_8N_2O_2$				
**Dimethyl sulfate $(CH_3)_2SO_4$	4	2	0	
**3, 4 Dinitrophenol $C_6H_4N_2O_5$				
**1,4 Dioxane $C_4H_8O_2$	2	3	1	A possible carcinogen; dangerous fire risk; slightly toxic by inhalation; absorbed by skin; may form explosive peroxides upon concentration.
Diphenylamine $C_{12}H_{11}N$	3	1	0	Moderately toxic by ingestion.
E.D.T.A. (ethylenedinitrilotetra acetic acid) $C_{10}H_{12}N_2Na_4O_8$ (Ethylene diamine tetra acetic acid, sodium salt)				
Eosin B $C_{20}H_6Br_2N_2Na_2O_9$				

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Please Note: for Iron II compounds: see listings under Ferrous Compounds
for Iron III compounds: see listings under Ferric Compounds

Chemical Name and Formula	H*	F*	R*	Comments
Eosin Y $C_{20}H_6Br_4Na_2O_5$				
**Epinephrine (Adrenalin) $C_9H_{13}NO_3$				Increases blood pressure. Toxic by ingestion
Eriochrome black T $C_{20}H_{12}N_3NaO_7S$				
Ethanol (ethyl alcohol) C_2H_5OH	0	3	0	Dangerous fire risk; flammable; addition of denaturant makes the product poisonous - it cannot be made non-poisonous; store in a dedicated flammables cabinet or safety cans.
Ethyl acetate $C_4H_8O_2$	1	3	0	Dangerous fire hazard and explosion risk; irritating to skin and eyes; slightly toxic by inhalation, ingestion, and skin absorption.
Ethyl alcohol (ethanol) C_2H_5OH	0	3	0	Dangerous fire risk; flammable; addition of denaturant makes the product poisonous - it cannot be made non-poisonous; store in a dedicated flammables cabinet or safety cans.
**Ethylamine C_2H_7N	3	4	0	
Ethyl bromide (Bromoethane) C_2H_5Br	2	1	0	Tumorigen, mutagen, limit exposure to vapour.
Ethyl butyrate $C_6H_{12}O_2$	0	3	0	
Ethylene diamine $C_2H_8N_2$	3	2	0	Irritant, toxic, mutagen, negative reproductive effects. Limit exposure to vapour.
Ethylene dichloride $C_2H_4Cl_2$	2	3	0	Possible carcinogen; flammable, dangerous fire risk; moderately toxic by ingestion, inhalation and skin absorption; strong skin and eye irritant.
Ethylene dinitrilotetra acetic acid (E.D.T.A.) $C_{10}H_{12}N_2Na_4O_8$ (Ethylene diamine tetra acetic acid sodium salt)				
Ethylene glycol $C_2H_6O_2$	1	1	0	Moderately toxic by ingestion, inhalation, and skin absorption, but the ingestion of even small quantities can be lethal to some people.
**Ethyl ether (Diethyl ether) $C_4H_{10}O$	1	4	1	Severe Fire and Explosion Hazard; may form explosive peroxides; vapour harmful, use only under a hood or in a wellÐventilated area. A possible carcinogen; dangerous fire risk; slightly toxic by inhalation; absorbed by skin; may form explosive peroxides upon concentration.
Ethyl iodide (Iodoethane) C_2H_5I				Mutagen.
Fehling alkaline No. 1 copper sulfate) + Fehling alkaline No. 2 alkalkine tartrate)				
Ferric ammonium citrate				
Ferric ammonium sulfate $FeNH_4(SO_4)_2$				
Ferric chloride $FeCl_3$				Skin and tissue irritant; corrosive; slightly toxic by ingestion.
Ferric nitrate $Fe(NO_3)_3$				Strong oxidizer; skin and tissue irritant.
Ferric oxide Fe_2O_3				
Ferric Sulfate $Fe_2(SO_4)_3$				
Ferrous ammonium sulfate (Mohr's salt) $FeH_8N_2O_8S_2$				
Ferrous chloride $FeCl_2$				Slightly toxic by ingestion; body tissue irritant.

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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 $C_6H_{16}N_2$				

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Chemical Name and Formula	H*	F*	R*	Comments
Histidine HCl $C_6H_9N_3O_2$				
Hydrochloric acid (11.6M, 36%) HCl				Highly toxic by ingestion or inhalation; severely corrosive to skin and eyes.
**Hydrocyanic acid (Prussic acid/or hydrogen cyanide) HCN	4	4	2	Severe poison.
**Hydrofluoric acid HF				Severe poison. Extremely corrosive to skin, eyes and all body tissue. Users must wear appropriate body, hand and face protection. THIS SUBSTANCE SHOULD NEVER BE USED BY ANYONE.
**Hydrogen gas H_2	0	4	0	Highly flammable gas ; severe fire hazard.
**Hydrogen peroxide (30%, 50% solution) H_2O_2	2	0	1 OX	Many substances will cause hydrogen peroxide to decompose into water and oxygen gas. It deserves the science teacher's special handling and storage attention. Substance is severely corrosive to skin, eyes and respiratory tract; very strong oxidant. Dangerous fire and explosion risk. Do not heat his substance. Wear appropriate protective clothing. DO NOT FREEZE.
Hydrogen peroxide 3%, 6% or 10% H_2O_2				Very weak but is still an oxidizer and skin irritant.
**Hydrogen sulfide H_2S	4	4	0	Offensive stench; solution may react with oxidants; irritates eyes and respiratory tract; use adequate ventilation. Toxic by ingestion or inhalation.
Hydroquinone $C_6H_6O_2$	2	1	0	Corrosive to skin, eyes and respiratory tract; toxic by ingestion and inhalation.
Indigo carmine $C_{16}H_8N_2Na_2O_8S_2$				Slightly toxic by ingestion; body tissue irritant.
**Indium In				Extremely toxic.
3-Indoleacetic acid $C_{10}H_9NO_2$				
Iodine I_2				Toxic by ingestion or inhalation. Reacts violently with reducing materials, sulfur, iron, alkali metals, metal powders and phosphorus. Irritates the skin; corrosive to eyes and respiratory tract. Inhalation of vapours or ingestion may be fatal
Iodoethane (Ethyl iodide) C_2H_5I				Mutagen.
Iron Fe				
Iron sulfide (Ferrous sulfide) FeS				
Iso-butyl alcohol (2 Methyl, 1 propanol) $C_4H_{10}O$	1	3	0	Flammable; slightly toxic; skin, eye and respiratory irritant.
Iso propyl alcohol (Sec. propyl alcohol) C_3H_8O	1	3	0	Moderate fire risk; flammable liquid; slightly toxic by ingestion and inhalation.
Kerosine (kerosene)	0	2	0	Moderate fire risk; moderately toxic by ingestion, inhalation, and skin absorption.
Kinetin $C_{10}H_9N_5O$				Mutagen.
Lactic acid $C_3H_6O_3$				Corrosive liquid; corrosive to eyes; irritates skin and respiratory tract.
Lactose $C_{12}H_{22}O_{11}$				
Lauric acid $C_{12}H_{24}O_2$				

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Chemical Name and Formula	H*	F*	R*	Comments
Lead Pb				Lead as a powder is extremely toxic by inhalation and ingestion. Possible carcinogen as a fume or dust. Take all precautions when working with lead powder.
**Lead acetate $Pb(CH_3COO)_2$				A possible carcinogen; eye, skin and respiratory irritant; moderately toxic.
**Lead arsenate $Pb_3(AsO_4)_2$	2	0	0	
**Lead carbonate (basic) $Pb(CO_3)_2Pb(OH)_2$				Moderately toxic by inhalation and ingestion; skin, eye and respiratory tract irritant. Possible carcinogen.
**Lead chloride $PbCl_2$				
**Lead chromate $PbCrO_4$				
**Lead dioxide PbO_2				Moderately toxic by inhalation and ingestion; severe body tissue irritant; avoid all body contact. Possible carcinogen.
Lead nitrate $Pb(NO_3)_2$				Moderately toxic by inhalation and ingestion; strong oxidant; dangerous fire risk in contact with organic material; body tissue irritant. Possible carcinogen.
**Lead oxide (red) PbO				
**Lead oxide (yellow) (Litharge) PbO				Moderately toxic by ingestion and inhalation. Possible carcinogen.
**Lead sulfide PbS				Moderately toxic by ingestion and inhalation. Possible carcinogen.
Lime water $Ca(OH)_2$				
**Litharge (lead oxide, yellow) PbO				Moderately toxic by ingestion and inhalation. Possible carcinogen.
Lithium Li	3	2	2 W	Dangerous; water-reactive; explosion risk; flammable solid. Use a Class D fire extinguisher or have a generous supply of dry sand to use as a fire extinguisher. Corrosive to skin, eyes and respiratory tract.
Lithium acetate $C_2H_3LiO_2$				
Lithium carbonate Li_2CO_3				Strong base when dissolved in water; substance is corrosive to eyes and respiratory tract. Moderately toxic.
Lithium chloride LiCl				Moderately toxic by ingestion.
Lithium fluoride LiF				
Lithium hydroxide LiOH				A strong basic substance; water solutions are strong irritants; corrosive to the eyes, skin and respiratory tract.
Lithium nitrate $LiNO_3$				Strong oxidant. Risk of explosion when shocked or heated. Do not grind pulverize. Body tissue irritant.
Litmus, granular blue				
Lycopodium powder (vegetable sulfur)				Highly flammable powder. Possible allergen.
Magnesium Mg	0	1	1 W	Flammable solid; burns with an intense flame; keep either dry sand or Class D fire extinguisher available.
Magnesium bromide $MgBr_2$				
Magnesium carbonate $MgCO_3$				
Magnesium chloride $MgCl_2$				Slightly toxic by ingestion.

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Chemical Name and Formula	H*	F*	R*	Comments
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 inhalation; body tissue irritant; severe eye irritant.
**Mercuric chloride $HgCl_2$				Highly toxic by ingestion, inhalation and skin absorption. May be fatal! Use all precautions in handling this substance.
**Mercuric iodide HgI_2				Highly toxic by ingestion, inhalation and skin absorption. May be fatal! Use all precautions in handling this substance.
**Mercuric nitrate $Hg(NO_3)_2$				Highly toxic by ingestion, inhalation and skin absorption. May be fatal. Use all precautions in handling this substance. Fire risk in contact with organic materials. Strong oxidizer.
**Mercuric oxide (red, yellow) HgO				Highly toxic; skin irritant; avoid contact with organic material.
**Mercuric sulfate $HgSO_4$				Highly toxic; skin, eye, respiratory irritant.
**Mercuric sulfide (black, red) HgS				
**Mercurous chloride Hg_2Cl_2				
**Mercurous iodide Hg_2I_2				

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

Chemical Name and Formula	H*	F*	R*	Comments
**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 with mercury.
Methanol (Methyl alcohol) CH_3OH	1	3	0	Flammable; dangerous fire risk; toxic by ingestion (ingestion may cause blindness)
Methionine $C_5H_{11}NO_2S$				
Methyl alcohol (Methanol) CH_3OH	1	3	0	Flammable; dangerous fire risk; toxic by ingestion (ingestion may cause blindness)
Methyl benzene (Toluene) C_7H_8	2	3	0	Irritant, mutagen.
Methyl cellulose (Cellulose methyl ether)				
Methylene blue $C_{16}H_{18}ClN_3S$				Slightly toxic.
**Methylene chloride (Dichloro methane) CH_2Cl_2	2	1	0	Carcinogen/mutagen. Readily absorbed through skin.
Methyl ethyl ketone (2-Butanone) C_4H_8O	1	3	0	Flammable, dangerous fire risk; narcotic by inhalation.
Methyl glycol (1, 2 Propylene glycol) $C_3H_8O_2$				
Methyl orange (tropaeolin D) $C_{14}H_{14}N_3NaO_3S$				Highly toxic by ingestion.
2-methyl 1-propanol (Iso butyl alcohol) $C_4H_{10}O$	1	3	0	Flammable; slightly toxic; skin, eye and respiratory irritant.
Methyl red $C_{15}H_{15}N_3O_2$				Mutagen.
Methyl salicylate (winter green oil) $C_8H_8O_3$	1	1	0	Moderately toxic by ingestion; severe body tissue irritant.
Methyl violet (Gentian violet) $C_{25}H_{30}N_3Cl$				Moderately toxic by ingestion; body tissue irritant.
Methylene blue $C_{16}H_{18}ClN_3S$				Slightly toxic.
**Million reagent (solution of Mercury - Nitric acid - water)				A solution of mercury (II) nitrate in concentrated nitric acid. The combination of toxic mercury (II) nitrate and a corrosive acid combined with the fact that the solution is frequently boiled makes its use extremely hazardous.
Mohr's Salt (Ammonium ferrous sulfate) $FeH_8N_2O_8S_2$				
Molybdenum Mo				
Naphthalene $C_{10}H_8$	2	2	0	Moderately toxic by ingestion, inhalation and skin contact; moderate fire hazard.
Nichrome				
Nickel Ni				

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

Chemical Name and Formula	H*	F*	R*	Comments
Nickel acetate Ni $(CH_3CO_2)_2$				
Nickel chloride $NiCl_2$				Highly toxic by ingestion and inhalation ; avoid dispersing this substance ; dispense with care. Nickel compounds are known carcinogens by inhalation of dust.
Nickel nitrate $Ni(NO_3)_2$				Slightly toxic ; avoid dispersing this substance ; dispense with care ; strong oxidant. Nickel compounds are known carcinogens by inhalation of dust.
Nickel sulfate $NiSO_4$				Moderately toxic by ingestion and inhalation ; severe body tissue irritant ;avoid dispersing this substance ; dispense with care. Nickel compounds are known carcinogens by inhalation of dust.
Ninhydrin $C_9H_6O_4$				Body tissue irritant. Common indicator.
Nitric acid (15.4 M, 69%) HNO_3	3	3	0 OX	Corrosive; strong oxidant; toxic by inhalation; avoid contact with acetic acid and readily oxidized substances.
**Nitrobenzene $C_6H_5NO_2$	3	2	1	
Nitrogen, gas (liquified) N_2				
**Nitrogen dioxide (liquefied) NO_2	3	0	0 OX	
Octyl acetate $C_{10}H_{20}O_2$	2	2	0	
n-Octyl alcohol (1-octanol) (Caprylic alcohol) $C_8H_{18}O$	1	2	0	
Oleic acid $C_{18}H_{34}O_2$	0	1	0	
Orange IV (Troparolin OO) $C_{18}H_{14}N_3NaO_3S$				
Oxalic acid $C_2H_2O_4$	3	1	0	Skin and eye irritant; moderately toxic by ingestion. Avoid condensing.
Oxygen, gas O_2				
Palmitic acid $C_{16}H_{32}O_2$				
Paraffin (oil, wax) (solid hydro carbons) C_nH_{2n+2}	0	1	0	
Paraformaldehyde	3	1	0	Severe skin and eye irritant.
**n-Pentane C_5H_{12}	1	4	0	Flammable liquid; narcotic in high concentrations. Use hexane or heptane as a substitute.
Pentyl alcohol (Amyl alcohol) (1-2-3 pentanol) $C_5H_{11}OH$				Moderate fire risk; slightly toxic by ingestion and inhalation; severe body tissue irritant.
**Perchloric acid $HClO_4$	3	0	3 OX	Extreme explosion hazard. Requires special “wash-down” hoods. Reacts with metal duct work.
**Petroleum Ether	1	4	0	Flammable liquid; dangerous fire risk.
**Phenol (carbolic acid) C_6H_6O	4	2	0	Toxic by ingestion, inhalation and skin absorption. Strong skin irritant.
Phenolphthalein $C_{20}H_{14}O_4$				
Phenol red (Phenolsulfonephthalein) $C_{19}H_{14}O_5S$				

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

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.*

Chemical Name and Formula	H*	F*	R*	Comments
Potassium bisulfide (Potassium hydrogen sulfide) KHS				
Potassium bitartrate (Potassium hydrogen tartrate) (cream of tartar) $KHC_4H_4O_6$				
Potassium binoxalate (Potassium hydrogen oxalate) KHC_2O_4				
Potassium bromate $KBrO_3$	1	0	0)X	Fire risk in contact with organic material; strong irritant; oxidizer; moderately toxic.
Potassium bromide KBr				Slightly toxic by ingestion; severe body tissue irritant.
Potassium carbonate K_2CO_3				Slightly toxic by ingestion; body tissue irritant.
**Potassium chlorate $KClO_3$	2	0	0 OX	Strong oxidizer; slightly toxic; irritant. Extremely dangerous since the substance, if only slightly contaminated, will explode when exposed to moderate shock or when heated. Because this substance is so frequently a source of accidents on school premises we have elected to list some of the incompatible substances which should be avoided: Ammonium Salts, Carbon, Combustible Material, Finely Divided Materials, Sulfur, Phosphorus, Sulfuric Acid, Metal Powders, Sugar
Potassium chloride KCl				Slightly toxic by ingestion.
**Potassium chromate K_2CrO_4				Highly toxic; harmful to skin, eyes and respiratory tract; corrosive action on skin and mucous membranes. Chromates as a chemical family deserve special safety attention from science teachers. Known carcinogen.
**Potassium dichromate (bichromate) $K_2Cr_2O_7$				Strong oxidant; fire risk in contact with organic material; toxic by ingestion and inhalation; corrosive to body tissue; known carcinogen.
Potassium ferricyanide $K_3Fe(CN)_6$				
Potassium ferrocyanide $K_4Fe(CN)_6$				Dangerous if heated or if in contact with concentrated acids since hydrogen cyanide gas may evolve. Slightly toxic by ingestion.
Potassium hydrogen carbonate (Potassium bicarbonate) $KHCO_3$				
Potassium hydrogen oxalate (Potassium binoxalate) KHC_2O_4				Moderately toxic by ingestion.
Potassium hydrogen phthalate $KH_5C_8O_4$				
Potassium hydrogen sulfide (Potassium bisulfide) KHS				
Potassium hydrogen tartrate (Potassium bitartrate, cream of tartar) $KHC_4H_4O_6$				
Potassium hydroxide, pellets (Caustic potash) KOH	3	0	1	Skin contact causes severe blisters; strongly corrosive as a solid and as a solution; very harmful if swallowed; extremely dangerous to eyes.
Potassium iodate KIO_3				Oxidizer; moderately toxic; tissue irritant.
Potassium iodide KI				
Potassium manganate $K_2M_nO_4$				
Potassium nitrate KNO_3	1	0	0 OX	Strong oxidant; fire and explosion risk when heated or in contact with organic material; skin irritant.

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

Chemical Name and Formula	H*	F*	R*	Comments
Potassium nitrite KNO_2				Strong oxidant; fire and explosion risk when heated or in contact with organic material; skin irritant; highly toxic.
Potassium oxalate $K_2C_2O_4$				
Potassium permanganate $KMnO_4$	1	0	0 OX	Powerful oxidizing agent; can explode on sudden heating; common cause of eye accidents; wear face protection. Strong skin irritant; slightly toxic by ingestion. Use extreme care and store separately from organics.
Potassium phosphate (monobasic) KH_2PO_4				
Potassium phosphate (tribasic) K_3PO_4				Slightly toxic; severe body tissue irritant.
Potassium sodium tartrate (Rochelle salt) $KNaC_4H_4O_6$				
Potassium sulfate K_2SO_4				
Potassium sulfide K_2S	2	1	0	
Potassium sulfite K_2SO_3				
Potassium thiocyanate KSCN				Moderately toxic by ingestion; emits toxic fumes of cyanide if strongly heated or in contact with concentrated acids.
Proline $C_5H_9NO_3$				
n-Propanol (n-Propyl alcohol) C_3H_8O	2	3	2	
Propionic acid $C_3H_6O_2$	3	2	0	Flammable liquid; flash point 54 C; liquid burns skin and eyes.
n-Propyl alcohol (n-Propanol) C_3H_8O	1	3	0	Flammable liquid; dangerous fire risk; harmful to eyes and respiratory tract.
Sec-propyl alcohol (Iso propyl alcohol) C_3H_8O	1	3	0	Moderate fire risk; flammable liquid; slightly toxic by ingestion and inhalation.
1,2 Propylene glycol (Methyl glycol) $C_3H_8O_2$	0	1	0	
**Prussic Acid (Hydrocyanic Acid/or Hydrogen Cyanide) HCN	4	4	2	Severe poison.
**P.T.C. paper (Phenylthiocarbamide, phenylthiourea) $C_7H_8N_2S$				
**Pyridine C_5H_5N	3	3	0	Flammable liquid (flash point 20 C); harmful to skin and eyes; avoid prolonged exposure; toxic by ingestion, inhalation, and skin absorption.
Pyrogallol $C_6H_6O_3$				Toxic; readily absorbed through the skin; harmful to eyes and lungs. Stains skin.
Quinaldine Red $C_{21}H_{23}IN_2$				Mutagen. Mild irritant.
Quinine Sulfate (Quinine acid) $C_{40}H_{50}N_4O_8S$				Skin irritant; moderately toxic by ingestion.
Resorcinol $C_6H_6O_2$	-	1	0	Toxic; readily absorbed through skin; skin and eye irritant.
Rhodanine $C_3H_3NOS_2$				Eye irritant.
Rochelle salt (Potassium sodium tartrate) $KNaC_4H_4O_6$				
Safranin				40% alcohol based solution; vapours may be flammable. Mutagen.

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

Chemical Name and Formula	H*	F*	R*	Comments
Salicylic acid $C_7H_6O_3$	0	1	0	
Sand (Silicon dioxide, silica) SiO_2				
Selenium + compounds Se (+ Se salts)				Toxic, tumorigenic.
Serine $C_3H_7NO_3$				
Silicic acid (hydrated silica) H_2SiO_3				
Silicon Si				Flammable in powder form.
Silicon dioxide (silica, quartz - amorphous, sand) SiO_2				
Silver Ag				
Silver acetate $AgC_2H_3O_2$				
Silver bromide AgBr				
Silver chloride AgCl				
Silver nitrate $AgNO_3$	1	0	0 OX	Corrosive solid; causes burns; avoid contact with eyes and skin; will stain skin and clothing; highly toxic.
Silver oxide Ag_2O				Slightly toxic; fire risk in contact with organic material or ammonia.
Silver sulfate Ag_2SO_4				
Soda lime CaO + NaOH				Soda lime is a corrosive solid – skin burns are possible; much heat is evolved when added to water; very dangerous to eyes.
Sodium Na	3	3	2 W	A flammable, corrosive solid; dangerous when exposed to heat or flame; dangerous by reactions with moist air, water or any oxidizer. Spontaneously flammable when heated in air; reacts violently with water, producing very dangerous hydrogen gas and a solution of corrosive sodium hydroxide. USE CAUTION WHEN HANDLING.
Sodium acetate $NaC_2H_3O_2$				Skin, eye and respiratory irritant.
**Sodium arsenite $NaAsO_2$				Highly toxic by ingestion and inhalation. Alleged carcinogen.
Sodium bicarbonate (Sodium hydrogen carbonate - Baking soda) $NaHCO_3$				
Sodium bisulfate $NaHSO_4$				Body tissue irritant; moderately toxic.
Sodium bisulfite $NaHSO_3$				Severe irritant to skin and tissue as an aqueous solution; slightly toxic.
Sodium borate (Borax, Sodium tetraborate) $Na_2B_4O_7$				Slightly toxic by inhalation and ingestion.
**Sodium bromate $NaBrO_3$				Powerful oxidizing agent; keep from contact with organic material; toxic by ingestion; skin irritant.
Sodium bromide NaBr				Slightly toxic by ingestion or inhalation.
Sodium carbonate Na_2CO_3				May be skin irritant.

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

Chemical Name and Formula	H*	F*	R*	Comments
**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; fire and explosion risk if heated; highly toxic by ingestion and inhalation.
Sodium oxalate $Na_2C_2O_4$				Moderately toxic by ingestion; body tissue irritant.
**Sodium peroxide Na_2O_2	3	0	1 OX	Serious explosion/fire risk. Avoid contact with water, alcohol, acids, powdered metals, and all organic materials. Strong oxidizing agent. Keep dry. Moderately toxic; corrosive to body tissue.
Sodium phosphate (mono basic) NaH_2PO_4				
Sodium phosphate (tri basic) Na_3PO_4				Slightly toxic by ingestion; severe body tissue irritant.
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	Dangerous fire and explosion risk; flammable solid; liberates toxic hydrogen sulfide on contact with acids; moderately toxic; corrosive to body tissue.

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

Chemical Name and Formula	H*	F*	R*	Comments
Sodium sulphite Na_2SO_3				Moderately toxic; possible body tissue irritant.
Sodium tetraborate (Sodium borate, borax) $Na_2B_4O_7$				Slightly toxic by inhalation and ingestion.
Sodium thiosulfate $Na_2S_2O_3$				Slightly toxic by ingestion; body tissue irritant.
Stannic chloride $SnCl_4$	3	0	1	Contact with warm, moist air produces hydrochloric acid; fumes produced are severely irritating to eyes, skin and respiratory tract; moderately toxic by inhalation.
Stannic oxide SnO_2				
Stannous chloride $SnCl_2$				Corrosive to body tissue; moderately toxic.
Stannous oxide SnO				
Stannous sulfate $SnSO_4$				
Stearic acid $C_{18}H_{36}O_2$	1	1	0	
**Strontium Sr				Extremely reactive metal.
Strontium chloride $SrCl_2$				
Strontium nitrate $Sr(NO_3)_2$				Strong oxidant; fire risk in contact with organic material; slightly toxic. Possible body tissue irritant.
Styrene C_8H_8	2	3	2	
Succinic acid $C_4H_6O_4$				Slightly toxic by ingestion.
Sucrose $C_{12}H_{22}O_{11}$				
Sudan III $C_{22}H_{16}N_4O$				
Sulfamic acid H_3NO_3S				Slightly toxic by ingestion; corrosive to body tissues. Severe eye irritant.
Sulfur S	2	1	0	This finely divide form of sulfur can be a moderate fire or explosion risk. Sulfur has low toxicity. When sulfur is burned, toxic sulfur dioxide is produced. May be skin irritant.
Sulfuric acid (17.8M:95%) H_2SO_4	3	0	2 W	Severely corrosive to eyes, skin and other tissue; considerable heat of dilution with water; mixing with water may cause spraying and spattering. Solutions might best be made by immersing the mixing vessel in an ice bath. Even very dilute solutions are harmful to eyes and skin. Always add the acid to water, never the reverse; extremely hazardous in contact with finely divided materials, carbides, chlorates, nitrates and other combustible materials.
Tannic acid $C_{76}H_{52}O_6$	0	1	0	Slightly toxic by ingestion and inhalation; possible allergen.
Tartaric acid $C_4H_6O_6$	0	1	0	
**Thallium Tl				Very poisonous metal.
Thioacetamide C_2H_5NS				Moderately toxic by ingestion and inhalation; possible carcinogen.
**Thorium Th				Radioactive.

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Chemical Name and Formula	H*	F*	R*	Comments
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.

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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.***

Labelling Requirements

WHMIS - Workplace Hazardous Materials Information System

WHMIS is a short form for Workplace Hazardous Materials Information System. It was created in response to the Canadian workers' right to know about the safety and health hazards that may be associated with the materials or chemicals they use at work. It is mandated under Federal Law, namely the Hazardous Products Act (HPA) and the associated Controlled Products Regulations (CPR). (WCB – page 22). In British Columbia the Workers' Compensation Act and Occupational Health and Safety Regulation, Part 5 apply to workers and employers.

Exposure to hazardous materials can cause or contribute to many serious health effects such as effects on the nervous system, kidney or lung damage, sterility, cancer, burns and rashes. Some hazardous materials are safety hazards and can cause fires or explosions. WHMIS was created to help stop the injuries, illnesses, deaths, medical costs, and fires caused by hazardous materials. It is a comprehensive plan for providing information on the safe use of hazardous materials used in Canadian workplaces.

Information is provided by means of:

a) bilingual product labels providing basic hazard information in a specific format,
b) materials safety data sheets (MSDS) containing more detailed technical information and
c) worker education programs.

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 already being transmitted to workers for many of these products under other laws. To prevent delay in starting WHMIS, exclusions were made.

They are:

- consumer restricted products (those products sold to people in regular stores that are already labelled following the rules of the Hazardous Products Act)
- explosives (as defined by the Explosives Act)
- cosmetics, drugs, food or devices (as defined by the Food and Drug Act)
- pest control products (pesticides, herbicides, insecticides, etc) (as defined by the Pest Control Products Act)
- radioactive materials (as defined by the Atomic Energy Control Act)
- wood and products made of wood
- a manufactured article
- tobacco or products made of tobacco
- hazardous wastes

Three major components to WHMIS:

1. Labels
2. Material Safety Data Sheets (MSDS)
3. Education and Training

1. Labels

Labels on chemicals from laboratory supply houses which are packaged in quantities less than 10 kg must disclose the following information in both English and French:

- chemical name
- where a MSDS is available, a statement to that effect
- any hazards of the chemical
- the supplier identification (including address and telephone number)
- precautionary measures to be followed for safe use
- where appropriate, first aid measures in case of exposure

If chemicals are removed and transferred to another container, the transfer container must be labeled clearly with enough information to enable the safe handling of the material. In the lab, samples less than 100 mL in volume that are used in-house only, require a product identifier only.

A **supplier label** must:

- appear on all controlled products received at workplaces in Canada
- contain the following information:
  - product identifier (name of product)
  - supplier identifier (name of company that sold it)
  - a statement that an MSDS is available

- 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.

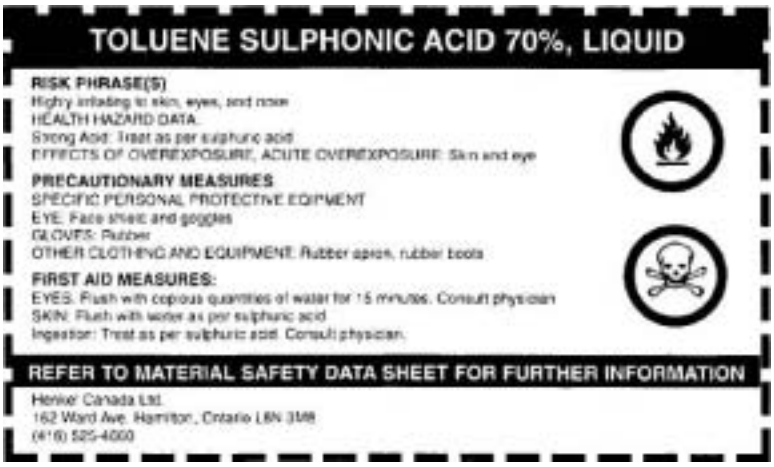
If the product is always used in the container with the supplier label, no other label is required (unless the supplier label falls off or becomes unreadable). However, sometimes you will want to put some of the material into another container for use in the workplace. This new container does require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



All chemical containers, including the original container, must be labeled in such a way as to identify the contents clearly.

Inside the laboratory, small transfer containers and reaction vessels containing mixtures, solutions or reaction products must have a clear identifier, usually the chemical name.

Outside the laboratory, transfer containers must carry a workplace label. This form of label has three components--the chemical identifier, instructions for safe use (combination of risk phrase and precautionary statement), and a reference to the MSDS.

Acceptable Format for the Workplace Label

Product Identifier Phrases for Safe Handling Information See MSDS

An example of a workplace label.

Acetone Keep away from heat, sparks, and flames. Wear saftey goggles and butyl rubber gloves. Use with local exhaust ventilation. MSDS available.

Example from http://www.worksafebc.com/pubs/brochures/howto/whmis.pdf

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 of the product they have purchased. If an employer chooses to use an MSDS prepared by someone other than the supplier or manufacturer of the purchased product, then the employer becomes responsible for all of the information on that MSDS. This includes ensuring that the information is accurate, complete, and current and is reviewed at least every 3 years.

If an MSDS is not available, request one from the manufacturer or subscribe to an online MSDS information service. For example http://www.msdsonline.com or http://www.msdssearch.com/ or http://www.ilpi.com/msds/index.html

These nine categories must be on each MSDS.

	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 • possible health effects from single or repeated exposures • identifies if the product has known long-term health effects such as liver or kidney damage, sensitization, cancer, or reproductive effects
VII	Preventative Measures	• protective clothing • protective equipment • how to safely clean up spills • how to safely use, handle, store, dispose of and transport
VIII	First Aid Measures	• instructions for the immediate treatment of a worker who has inhaled or swallowed the product or who has had skin or eye contact with the product.
IX	Preparation Information	• who is responsible for preparation and date of preparation of MSDS

Material Safety Data Sheet – Example on page 66
http://www.worksafebc.com/pubs/brochures/howto/whmis.pdf

Sample: Material Safety Data Sheet

SECTION 1 - PRODUCT IDENTIFICATION AND USE

PRODUCT IDENTIFIER ⇨ Sodium hydroxide, Caustic soda		PRODUCT IDENTIFICATION NUMBER (PIN) S-318	
PRODUCT USE ⇨			
MANUFACTURER'S NAME La Bell Industries		SUPPLIER'S NAME Omega Chemicals	
STREET ADDRESS 18 Rue LeJour		STREET ADDRESS P.O. Box 1989	
CITY Montreal	PROVINCE Quebec	CITY Sunware	PROVINCE Ont.
POSTAL CODE H6N 0C0	EMERGENCY TELEPHONE NO. (522) 555-4433	POSTAL CODE C1H 2O1	EMERGENCY TELEPHONE NO. (416) 555-4321

SECTION 2 - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS	%	CAS NUMBER	LD_{50} OF INGREDIENT (Specify species & route)	LD_{50} OF INGREDIENT (Specify species)
Sodium Hydroxide	96	1310-73-2		
Sodium Carbonate (Na_2CO_3)	0.5-2.5			
Sodium Chloride (NaCl)	0.0-2.1			
Sodium Sulphate (Na_2CO_3)	0.02-0.1			
Potassium, Calcium, and Magnesium	0.1			
Sodium Dioxide (SiO_2)	0.03			
Other Metals (total)	0.01			

SECTION 3 - PHYSICAL DATA

PHYSICAL STATE Other	ODOUR AND APPEARANCE White/off-white odourless, hygroscopic			ODOUR THRESHOLD (ppm) odourless
VAPOUR PRESSURE (mm Hg) Not appl.	VAPOUR DENSITY (AIR = 1) Not appl.	EVAPORATION RATE Non-volatile	BOILING POINT (°C) 1388°C	MELTING POINT (°C) 318°C
pH Not appl.	SPECIFIC GRAVITY 2.13	COEFF. WATER/OIL DIST. Not appl.		

SECTION 4 - FIRE AND EXPLOSION DATA

FLAMMABILITY
YES ☐ NO ☒ IF YES, UNDER WHICH CONDITIONS? ⇨

MEANS OF EXTINCTION Although it is non-combustible, it can be hazardous in a fire area. The following should be known for fire fighting: 1) it can melt and flow when heated (mp 318°) 2) Hot or molten material can react violently with water (splattering). 3) Can react with certain metals, such as aluminum to generate flammable hydrogen gas.

FLASHPOINT (°C) AND METHOD Not flammable	UPPER FLAMMABLE LIMIT (% BY VOLUME) Not flammable	LOWER FLAMMABLE LIMIT (% BY VOLUME) Not flammable
AUTOIGNITION TEMPERATURE (°C) Not flammable	HAZARDOUS COMBUSTION PRODUCTS Not flammable	
EXPLOSION DATA ⇨ SENSITIVITY TO IMPACT Not appl.	SENSITIVITY TO STATIC DISCHARGE Not appl.	

SECTION 5 - REACTIVITY DATA

CHEMICAL STABILITY
YES ☒ NO ☐ IF NO, UNDER WHICH CONDITIONS? ⇨

INCOMPATIBILITY WITH OTHER SUBSTANCES
YES ☒ NO ☐ IF SO, WHICH ONES ⇨ Strong acids, many organic compounds, leather, wool, aluminum, zinc, and tin.

REACTIVITY, AND UNDER WHAT CONDITIONS Slowly picks up moisture and CO_2 from the air to form Sodium carbonate

HAZARDOUS DECOMPOSITION PRODUCTS None

PRODUCT IDENTIFIER

SECTION 6 - TOXOLOGICAL PROPERTIES

ROUTE OF ENTRY — SKIN CONTACT X SKIN ABSORPTION X EYE CONTACT X INHALATION X INGESTION X

EFFECTS OF ACUTE EXPOSURE TO PRODUCT: Damage to any human tissue particularly skin, eyes, and respiratory tract.

EFFECTS OF CHRONIC EXPOSURE TO PRODUCT: Dust and mist can cause damage particularly to the respiratory tract.

EXPOSURE LIMITS	IRRITANCY OF PRODUCT	SENSITIZATION TO PRODUCT	CARCENOGENICITY
2 mg/m^3 Ceiling limit.	Causes burning sensation	Not known	Not listed
TERATOGENICITY	**REPRODUCTIVE TOXICITY**	**MUTAGENICITY**	**SYNERGISTIC PRODUCTS**
Not known	Not known	Not listed	Reacts violently when molten

SECTION 7 - PREVENTATIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT

GLOVES (SPECIFY)	RESPIRATOR (SPECIFY)	EYE (SPECIFY)
rubber, polyethylene	filter type	goggles, face shield
FOOTWEAR (SPECIFY) rubber boots where needed to prevent contact	CLOTHING (SPECIFY) rubber apron where needed to prevent contact	OTHER (SPECIFY) Lab coat, overalls

ENGINEERING CONTROL (SPECIFY E.G., VENTILATION, ENCLOSED PROCESS): local exhaust

LEAK AND SPILL PROCEDURE: When spilled in a dry condition, it can be promptly shovelled up for recovery or disposal. Flush surfaces with water, neutralize with diluted acid (vinegar).

WASTE DISPOSAL: Disposal must meet with local requirements. Waste must never be discharged directly into sewers or surface waters. (Neutralize and dilute with much water)

HANDLING PROCEDURES AND EQUIPMENT

STORAGE REQUIREMENTS: Store in well-sealed containers, have abundant water (running preferred) at hand.

SPECIAL SHIPPING INFORMATION: This material is classified as **Corrosive**

SECTION 8 - FIRST AID MEASURES

SPECIFIC MEASURES

Eye Contact: Wash eyes immediately with plenty of running water for no less than 15 min. (including under the eyelids). Speed is important to avoid permanent injury. If one eye is injured, keep the injured eye at a lower level to avoid contaminating the uninjured eye.

Skin Contact: Wash contact area promptly with much water. (Dilute acetic acid, vinegar, can be used to neutralize). Remove contaminated clothing under the shower. Prolong washing until medical help arrives.

Inhalation: Remove from exposure to mist or dust and get prompt medical help.

Ingestion: Immediately phone 911 and ask for poison treatment. Describe the chemical that has been swallowed, and follow the advise of emergency personnel.

SECTION 9 - PREPARATION DATE OF MSDS

PREPARED BY (GROUP, DEPARTMENT, ETC.)	PHONE NUMBER	DATE

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.

Suggestions for Chemical Storage and Organization

Many School Districts are organizing chemicals using the Flinn Scientific Inc. Chemical Storage Pattern of Inorganic and Organic Chemicals. This information is available in the Flinn Chemical and Biological Catalog Reference Manual.

- Compile an inventory list with MSDS for each chemical. The MSDS's can be no more than 3 years old.
- All containers of chemicals should bear a purchase as well as an expiry date.
- Use of a WHMIS-approved labelling system that segregates all chemicals into classes to make it easy to access and replace them in their proper storage position.
- Each chemical must be individually evaluated to determine where and how it should be stored.
- Organize chemicals into their compatible chemical families. The actual sequence of compatible families on the shelves is not critical. What is important is to keep the compatible families separate and to keep the organic and inorganic families as far apart as possible.
- As a general rule, flammable/combustible liquids, toxic chemicals, explosive chemicals, oxidizing agents, corrosives, water-sensitive chemicals and compressed gases should be segregrated.
- Avoid floor chemical storage (even temporary).
- No top shelf chemical storage as chemicals should not be stored above eye level.
- Store acids in an acid cabinet. Store nitric acid in that same cabinet ONLY if isolated from organic acids. Store 'mineral' acids (HNO_3, H_3PO_4, H_2SO_4, HCl, HBr) in the same cabinet but each acid should be placed in a plastic tub to contain the liquid in case of bottle failure. Organic acids such as acetic acid, formic acid, salicylic acid etc. can be stored together and often with other organics provided ventilation is adequate. Never store organic acids with nitric and sulphuric acids. Perchloric acid should never be used.
- Store alkaline solutions in corrosion resistant plastic trays as close to the floor as possible and away from acids.
- Store flammables in a dedicated flammables cabinet.
- Store severe poisons in a dedicated poisons cabinet.
- Explosives - *NEVER* store explosives in schools.

- 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 assemblies.
- Provide anti-roll-off lips on all shelves.
- Ideally, shelving assemblies would be of wood construction.
- Avoid metal, adjustable shelf supports and clips. Better to use fixed, wooden supports.

Alternatives to a Separate Chemical Storage Room

While a separate room is preferable for chemical storage, the principles of proper chemical storage can be maintained without a separate room. If a science preparation room is used as the chemical storage room, it is appropriate to:

- prevent the accumulation of harmful vapours by adequately and continuously venting to the exterior with an exhaust fan
- equip the room with a properly vented flammables cabinet to house all solvents and flammable materials
- store acid and basic (alkaline) solutions separately in closed and vented cabinets

- keep toxic chemicals (poisons) in a separate locked cupboard
- keep oxidizers and reducers on separate shelves as far from each other as possible
- store hydrolyzing (water reactive) solids in a separate area
- store alphabetically general miscellaneous chemicals if they are compatible

This is a challenging system to adequately maintain. Good housekeeping can be a problem when chemical storage is not housed in a separate room.

Note: *When the science preparation room is used as the chemical storage room, it must not be used as a general teacher preparation area/working station (i.e., teachers are not to be present in the room other than when dealing with chemicals).*

Chemical Stock and Minimizing Chemical Waste

A major problem is associated with the quantities of chemical stock ordered from year to year and the cost of chemical disposal. The following are suggestions to help reduce the amount of chemicals that need to be disposed.

- Do not order more chemical stock for your school than you will use in a 12-month period.
- Maintain an up-to-date inventory of your chemicals.
- Purchase chemicals carefully
  - purchase smaller size packages of chemicals, only what is needed for up to 12 months.
  - if you only need a dilute solution, buy the solution and not a large bottle of the solid.
  - buying chemicals in bulk to save a few dollars ends up costing more in disposal costs.
- Date and label your chemicals and only buy from chemical supply companies that date label their chemicals.
- Chemicals should be dated when the container is opened.
- Use older chemicals first, before they decompose.
- Provide good climate control for the chemical storeroom.
- Prepare only enough solution for immediate use and always label.
- Never store chemicals or solutions in containers not designed for chemical storage.
- Store hygroscopic and deliquescent chemicals in proper containers.
- Follow good laboratory practices.
- Never accept donations of chemicals.
- Purchase chemical demonstration kits or chemistry students kits that contain exact quantities of chemicals.
- Dispose of waste chemicals immediately after they are generated.
- Keep waste solutions separate.

Examples of Incompatible Chemicals

Chemical	Incompatible With
Acetaldehyde	Acetic anhydride, acetic acid, acetone, ethanol, sulfuric acid
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkaline metals such as powdered aluminum or magnesium, sodium, potassium	Water, carbon tetrachloride and other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury, chlorine, calcium, hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, chromic acid, hydrogen peroxide
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Diborane, fluorine
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, turpentine, all other flammable liquids
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene and finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Dimethyl sulfoxide	Perchloric acid, silver fluoride, potassium permanganate, acetylchloride, benzene sulfonyl chloride
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Isolate from everything
Hydrocarbons (butane, propane, benzene, gasoline, etc.)	Fluorine, bromine, chlorine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia, aqueous or anhydrous
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia, oxalic acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic acid	Silver, mercury
Perchloric acid	(see Perchloric acid page 87)
Phosphorus(white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals such as sodium, lithium)

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.

Cleaning Up Spills

Spills are a frequent occurrence in science classrooms/labs. The first priority of the teacher is to ensure that no students have been injured by the material spilled and then clean up the spill immediately. Students should be encouraged to report spills and breakages, so that they can be cleaned up immediately. Refer to MSDS sheets for the directions.

Spill Kits

The items listed below will enable you to deal with most common spills of acids, alkaline solutions, flammable solvents, and mercury. **However commercial spill kits are more convenient to use and are recommended.**

- Vermiculite (6 kg) and Activated Charcoal (1 kg) mixture
- Bentonite or Kitty Litter (10 kg)
- Sodium bicarbonate (baking soda) or sodium carbonate (soda ash) (3-4 kg of dry solid)
- Weak acid (boric or citric) (liquid or solid – 2 kg)
- Plastic Aspirator Bottle (250 mL cap.)
- Various size "Freezer Bags" with ties
- Dustpan and whisk broom
- Labels and tape
- Metal containers for flammable wastes
- Large plastic scoop
- Plastic buckets
- Protective gloves
- Mask with organic cartridge to cover nose and mouth
- Heavy duty apron
- Full eye protection
- Floor cloths (old rags)
- Paper towels
- Rubber boots
- Spill Control Pillows [commercially purchased Spill Control Pillows can be used to absorb spills of hazardous chemicals. Applied directly, they will absorb and contain most spills within 30 seconds. The pillows contain an inert inorganic absorbent that is safe to use on flammable liquids, concentrated acids and bases. Spill control pillows are available to handle spills of varying sizes (e.g. 250 ml; 1.0 L and 4.0L]

For all Spills:

- Advise all students to vacate the immediate area of the spill.
- Determine the degree of hazard before attempting to clean up and take necessary preventative measures (i.e. protective equipment, eye protection, gloves, etc.)

Spillage of	Procedure
Corrosive Liquids (acids and bases)	• Neutralize acids. Test with indicator paper after bubbling has stopped. • Bases should be neutralized with boric or citric acid. Test with indicator paper. • Scrape or sweep up the residue that remains after all reaction has stopped. Discard down the sink with an excess of water. • Wash the spill area with water and wipe dry with paper towels.
Flammable Liquids	• Shut off all sources of ignition. • Cover the spill with mineral absorbent (e.g. cat litter or vermiculite). • Scoop the contaminated absorbent into a heavy gauge polythene bag or plastic bucket and arrange for disposal. • Mop the area of the spill or wipe with a damp disposable cloth. • Open windows to ventilate the room.
Other liquids (except mercury)	• For water soluble liquids – dilute and mop up using paper towels or cloths. • For water immiscible liquids – cover the spill with mineral absorbent (e.g. cat litter) to prevent spreading. Then scrape and mop into a suitable container for disposal. (Only very small bench spills should be treated by swabbing into a sink, followed by flushing with large volumes of water.) • Wash down the spill area with water and wipe dry with paper towels. • Place any contaminated cloths and/or mops in a suitable container for disposal.
Large Spills	• For large spills of poisonous, corrosive, or reactive materials, evacuate the lab, notify administration and seek immediate assistance from the Provincial Emergency Program (PEP) at 1-800-663-3456.
Mercury Spills	• Immediate and thorough clean-up is imperative. • Provide maximum ventilation through doors and windows. • Never sweep with a broom nor use a vacuum. • Wear gloves and cover shoes with plastic bags. • Push pools of mercury together. • Pick up pools with a dropper pipette; transfer droplets to a seamless polyethylene or polypropylene bottle; store under a layer of water or oil and cover securely. • Good ventilation must be continued.
Solids	• Sweep up with a brush into a dustpan, taking care to avoid raising dust. If it is a highly reactive solid, such as alkali metals, are best gathered using tongs. • Wipe the area with a damp disposable cloth. • Determine appropriate disposal procedures. • Clean, broken glass should be placed in the glass disposal container.

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†

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† 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.

Categorization of Corrosive Gasses

Group I	**Hazard**
Ammonia Hydrogen Chloride ** Hydrogen Fluoride Formaldehyde ** Sulfonyl Chloride ** Thionyl Chloride	Very soluble, affect upper respiratory tract.
Group II	**Hazard**
** Arsenic Trichloride ** Bromine ** Chlorine Iodine ** Phosphorus Chloride ** Sulphur Dioxide	Soluble, upper respiratory tract and bronchi
Group III	**Hazard**
** Carbonyl Chloride (phosgene) ** Nitrogen Dioxide ** Ozone	Least soluble, minimal primary irritation,severe system .
Group IV	**Hazard**
** Acrolein ** Dimethyl Sulphate ** Mustard Gas ** Chlorinated ethers	Locus of action unknown. Toxic activity not related directly to solubility.

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The harmful effect of a corrosive gas is not directly related to the concentration and exposure duration. To make the problem worse, there are primary effects that can produce severe immediate damage, and even death without causing systemic injuries. When evaluating possible effects it is necessary to consider the concentration, solubility and duration of exposure.

Two common corrosive gases are ammonia and **phosgene. Although phosgene is less severe in local immediate effect, it has long-range system effects (pneumonitis).

Corrosive substances may react with another material to give off corrosive, toxic and flammable gases, and may react to produce other hazardous substances.

Examples:

Halogens	-	Will support combustion, may ignite powdered metals (on contact.) React violently with organic substances.
Hydrochloric Acid	-	Can liberate gases such as hydrogen, and hydrogen cyanide. With formaldehyde produces chloromethoxychloromethane, a very potent carcinogen.
Nitric Acid	-	Can oxidize cellulose material, creating a self igniting condition. Extremely exothermic when mixed with organic materials.
**Perchloric Acid	-	Strong oxidant and dehydrating agent. Explodes on contact with many organic substances. Should not be in schools.
Sulphuric Acid	-	Powerful oxidizer. Can dehydrate organic material rapidly with the production of heat.

Personal Precautionary Measures with Corrosive Chemicals

It is important to:

- use adequate protective equipment (safety screen, lab coat, safety goggles/face shield, and gloves)
- use adequate respiratory protection (fume hood, gas mask)
- have adequate exhaust ventilation where corrosive hazards are present
- have plenty of water available for flushing, including eyewash
- have plenty of sodium bicarbonate available for neutralizing liquid corrosive spills
- obtain immediate medical attention upon accidental contact
- store corrosive chemicals properly

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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 green/grey precipitates which are not always noticeable). The containers should not be moved if there is any doubt about stability. Immediately clear the area and contact the local bomb squad.

Acid Sensitive Chemicals react with acids to release heat, hydrogen, explosive gases, and toxicants.

Water Sensitive Chemicals react with water to evolve heat and/or flammable or explosive gases.

Oxidation-Reduction reactions can occur in any phase. The reactions tend to generate heat and are often explosive.

Pyrophoric Substances burn when exposed to air.

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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.
- Store in a well-ventilated, cool, dry area, and protect from sunlight.
- Label properly including the date received and opened, especially in the case of peroxidizable compounds.
- Protect from shock.
- Keep away from flammables.
- When handling, wear adequate protective equipment.
- Order only what you will use during the year. **Do not overstock.**
- Regularly discard old chemicals according to proper disposal procedures.
- Work on as small a scale as is practical (hazards are much less severe on a small scale).

Reactive Type	Examples	Specific Hazards	Precautionary Steps
Explosives should not be stocked in schools	**Fulminates **Nitroglycerin **Peroxides (Benzoyl, Sodium) **Picric Acid **Azides **Perchlorates (Na, K) **Hydrazines **Dioxane **Ether (not Petroleum Ether)	• Flying objects from explosion • Easily detonated • Can explode from shock, friction, or heat • Unstable • Can form peroxides	Protect from shock, high temperature, sudden temperature changes, other reactive substances.
Acid Sensitive Substances	Alkalai Metals Alkaline Hydroxides Carbonates **Carbides Nitrides Metals Sulphides **Cyanides	Liberation of heat, flammable gases, and toxicants.	Isolate from reactive substances, wear and use adequate protection.
Water Sensitive Substances	Strong Acids and Bases Acid Anhydrides Alkalai Metal Hydrides **Carbides Aluminum Chloride (anhydrous)	• Heat generation • Hydrogen generation • Ignite in moist air, can cause explosions • Can form Acetylene or Methane • Spontaneously decomposes on long storage and can explode on opening container	Isolate from other reactive substances. Store in cool, waterproof area. Wear protective gear.
Oxidation Reduction	Oxidizers Oxygen Mineral Acid **Perchlorates **Peroxides (H_2O_2 excepted) Nitrites and Nitrates Chromates and Dichromates Permanganates Halogens **Chlorates Reducers **Hydrogen **Phosphorous Alkalai Metals Metallic Hydrides Formaldehyde	All generate heat and can be explosive.	Isolate from each other and other potentially reactive substances. Use adequate protection.
Special Organic Substances	** Acrolein ** Benzene	• Flammable and may also polymerize violently • Explodes with many oxidants	Store in an air tight container in a cool place. Isolate from oxidants.
Pyrophors	**Phosphorous (white or yellow)	• Initiation of fire.	Protect from air.

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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
peroxyacetic acid (diluted with 60% acetic acid solution)
picric acid
trinitrotoluene
trinitrobenzene

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

The following list of compounds can form explosive peroxides during storage and should be tested for peroxide formation at least once every three months after opening and before use.

Divinyl acetylene
Isopropyl ether
Potassium metal
Sodium amide
Vinylidene chloride

The following compounds can produce explosive peroxide conditions upon concentration (e.g. during distillation or evaporation upon storage). They should be tested for peroxide formation at least once every 12 months after opening and before use.

Acetal
Cyclohexene
Diacetylene
Dicyclopentadiene
Diethylene glycol dimethyl ether (diglyme)
Diethyl ether
Dioxane
Ethylene glycol dimethyl ether (glyme)
Methyl acetylene
Tetrahydrofuran
Tetrahydronaphthalene (tetralin)
Vinyl ethers

The following compounds can initiate explosive polymerization upon peroxide formation and should be tested for peroxide formation at least once every 12 months after opening. A suitable peroxide inhibitor should be added before distillation.

Acrylic acid
Acrylonitrile
Butadiene
Chloroprene
Chlorotrifluoroethylene
Methyl methacrylate
Styrene
Tetrafluoroethylene
Vinyl acetate
Vinyl acetylene
Vinyl chloride
Vinylidene chloride
Vinyl pyridine

All of the previously named compounds and all other compounds known to form peroxides, must be properly labeled. The recommended label for such compounds is:

PEROXIDIZABLE COMPOUND

Received Opened

Date _____ _____

Discard or test within

_____ months after opening

Test Dates _____

Cryogenic liquids

- Containers used for storage, transport and dispensing of cryogenic liquids must be designed for that purpose.
- Indoor dispensing stations and storage locations for cryogenic liquids must be adequately ventilated and monitored to prevent the development of harmful atmospheres.
- Dispensing stations and freezers with automatic filling cycles for cryogenic liquids must be posted with a sign identifying the materials, the hazards and the precautions required.

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C. Insidious Hazards

Insidious hazards are conditions within the laboratory that represent potential health hazards and, because they are not usually conspicuous (seen, tasted, smelled, or felt), are easily overlooked and ignored. However, they may cause local or systemic, acute or chronic effects, depending upon the nature of the substance and duration of exposure. In addition, insidious hazards represent a type of problem that one may never be aware of until chronic, systemic poisoning has occurred. All too often insidious or hidden hazards are overlooked during routine safety inspections. Substances such as mercury, present in small droplets on a floor, can emit toxic vapour over a long period of time. Explosive perchlorates can form in fume hoods and ventilation systems. Shock sensitive azide salts form in copper drain pipes which are exposed to **sodium azide solutions. Improperly sealed containers of toxic liquids such as carbon tetrachloride and leaking cylinders of toxic gases, can poison the air. In fact, defective safety devices represent a category of insidious hazards.

The Mercury Hazard

One of the most common insidious hazards is mercury, not only in laboratories but also in homes. Mercury is widely used in such various items as electric switches, amalgams, boilers, barometers, thermometers, lamps, and cells. Mercury compounds are also common reagents found on laboratory stock shelves. Because of its widespread use the hazardous nature of mercury may be overlooked or ignored, even when its hazards are understood. It may be common practice to aspirate or sweep up any visible drops after an accident involving mercury, but many small droplets may be hidden in small cracks and crevices where they are left to evaporate into the atmosphere.

- Mercury is capable of forming explosive compounds, such as mercury fulminate.
- Its maximum permissible concentration (PC) is 0.05 mg/m3 averaged over an 8-hour exposure.
- Its accumulated effect works on the gastrointestinal and central nervous system.

- 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 years before they become evident.

Toxic materials are rated in British Columbia by ***Permissible Concentrations*** (PC). PC is the average airborne concentration of a substance to which a person can be exposed without likely adverse effect. Some people will be harmed by exposure to materials at or below the listed PC value. PC's are determined on the basis of adult body mass and metabolism thus they may be misleading when applied to small children. The following factors should be considered when using PC measures:

- the time of exposure to a substance
- concentration of airborne contaminant.

Therefore, PC's should not be applied on a 'spot check' basis. They should be used as strict guidelines when working with toxic substances. Some substances are rapidly absorbed by the skin, eyes and mucous membranes (either from the gas phase or from directly contacted solids and liquids). Substances with high rates of cutaneous absorption are labelled "SKIN". For certain substances the use of PC is not appropriate. Substances whose effects are acute and rapid are best controlled by a "ceiling limit" which should not be exceeded for even an instant.

The potential for contact with toxic materials exists in many areas of the school curriculum. Chemistry experiments are the most obvious situations with potential hazard. However, a person may be exposed to toxic substances from unsuspected sources. Toxic materials may be involved incidently as part of a laboratory or demonstration procedure. Careful consideration must be given to all materials used and produced in an activity. For example, the dust of heavy metal minerals may be inhaled during the breaking of rock samples. Inadequate clean-up can lead to exposure to toxic materials after a lab procedure is finished. Substances left on benches, beakers and bottles may be contacted by the next person working with the articles. Students may ingest toxic materials they have been in contact with if they do not wash very thoroughly before eating or smoking. Foods and beverages readily absorb many vapours and must not be brought into a lab. Chewing of gum should also not be allowed.

Toxic Materials Protection Policy

Accident prevention will depend on forethought, identification of hazards and careful instruction of the students. The onus is on the teacher to be aware of potential dangers and convey this information to students. The teacher must instruct students in proper handling procedures and must insist that they be followed.

The acquisition, use and storage of toxic materials must be related to real needs. If safe alternatives exist they should be used. Minimum quantities only should be stored. Stock bottles should not be allowed into the laboratory. Toxic materials should be used only when there is adequate protection from exposure.

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.

Biological Precautions

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 disinfect all work surfaces before and after handling micro-organisms. All apparatus used in microbiology must be autoclaved. Liquid disinfectants and germicidal agents generally have limited effectiveness and should not be relied upon for complete sterilization • do not culture anaerobic bacteria, soil bacteria or swabs from any surface which may contain micro organisms from a human source • petri dishes containing cultures should be sterilized (autoclaved) before disposal • transparent tape should be used to seal petri dishes before they are passed around the class • avoid spattering cultures to prevent aerosol formation which is a common means of infection • flame wire loops and needles before and immediately after transfer of cultures • do not move throughout the lab with a wire loop containing a culture.
Dissections	• do not dissect wild or stray animals found dead outside • any organs used should be federally and provincially inspected • use dissecting instruments with care; make sure they are rust free and clean • when making incisions, cut down and away • formaldehyde (for preserving specimens) is not allowed in schools; instead use 70% solution of ethanol in water • when using specimens stored in formaldehyde, they must be thoroughly rinsed in running water and soaked in water overnight • It is recommended that vacuum packed specimens be used. • specimens should be discarded in biohazard bags immediately after dissection as there are some species of bacteria that can begin to grow even on specimens which have been in preservatives. • students should use disposable gloves • wash hands before and after dissections • use a wax or Styrofoam pan to dissect; never dissect in your hands.
Plants	• handle with care • treat as though it were poisonous • do not allow students to put any part in or near their mouths • avoid skin contact with the juice or sap of plants • wash hands after handling plants and before eating.
Food	• must not be stored in refrigerators in laboratories • no food shall be stored or consumed in the lab or supply room.
Animals	• any animals kept in the lab must be maintained in a clean, healthy environment.

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.

Microorganisms and Diseases They Cause

Microorganism	Human Disease
Bacteria	Diptheria Tuberculosis Rheumatic Fever Pneumonia
Viruses	Chicken Pox Measles Mumps Poliomyelitis
Fungi	Athlete's Foot Systemic Mycosis
Rickettsiae	Typhus Q Fever Rocky Mountain Spotted Fever
Protozoa	Schistosomiasis Malaria Giardiasis

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.

Some General Biological Effects of Radiation

Where radiation causes the alteration or destruction of chemical compounds in cells, either by ionizing atoms or by an excessive increase in molecular kinetic energy, cell death or mutation is likely to occur. If cell death occurs, burn-like lesions develop slowly and require a long time to heal. When mutations occur, cancer is often a result.

Ionizing radiation loses energy to tissue molecules and atoms as it produces ions. Each ion formed represents energy transferred by the particle or photon to tissue atoms. Therefore, penetration of ionizing radiation is limited by the rate at which ions are formed as the radiation penetrates the tissues, and by the initial energy of the radiation. If high energy radiation acts on an organism, many ions must be formed before all the energy is transferred to the tissue. Alpha particles, because of their charge and mass, create many ions per millimetre of tissue penetrated, while uncharged gamma and X-rays, with no mass, create relatively few ions per millimetre of path length. As a consequence, alpha particles which lose their energy rapidly, barely penetrate the skin surface before they are stopped. The effect of alpha particles is usually limited to the skin and will be serious only if the alpha source is in prolonged contact with the skin, or is inhaled or ingested as a dust or solution which will result in prolonged exposure of internal tissues. Typical gamma and X-rays can easily penetrate below the skin and affect internal structures. For example, X-rays readily pass through muscle tissue but are strongly absorbed by bone. A high intensity X-ray beam can do significant damage in bone tissue.

The tissue penetrating ability of non-ionizing radiation is related to its wavelength. Short wavelength ultra-violet rays are absorbed by the skin and the cornea and conjunctiva in the eye, causing a burn-like reaction. Sunburn and the very painful arc welding "flash burn" of the eye are common effects of ultra-violet light. As wavelengths become longer their ability to penetrate the body becomes greater. Some radio wave frequencies easily pass right through the body. The main effect of infra-red, microwave, and some radio wave is the heating of body tissues, which causes the disruption of normal physiological processes. The results of this assault on the body range from death caused at high energy intensities, through cancer, damage of heat sensitive organs such as eyes (production of cataracts), testes (causing sterility) and digestive tract. Headaches and some behavioural changes may result at very low energy intensities.

The specific effect of all photon (electromagnetic wave) radiation on the body (i.e., the particular tissues affected, the type and degree of damage done) is dependent upon:

- ionizing or non-ionizing energy;
- the wavelength of the radiation, because specific tissue absorbs some wavelengths more readily than others;
- the intensity of the radiation absorbed;
- the time of exposure, because the unrepaired damage tends to be cumulative.

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 voltages > 5 KV may emit cathode rays capable of producing tissue damage. In addition, X-rays can be produced by any vacuum tube or gaseous discharge tube operated at voltages > 5 KV. In the absence of any specific information about cathode ray and X-ray emission from the equipment used, keep operating voltages as low as possible with 5 KV as the maximum.

Non-Ionizing Radiation

Ultra-Violet Lamps and Electric Arcs - Ultra-violet lamps, such as those used to detect the presence of certain compounds by their fluorescence, must be used in such a way that the source can never be looked at directly. Electric arcs produce very high intensities of ultra-violet light and must never be used as an open source. If an arc is used to provide intense visible light, it must be enclosed except for an exit pupil where a filter can be used to absorb ultra-violet light from the desired visible light beam.

Lasers - The beam of light from even low power lasers, when focused by the lens of the eye, can cause severe retinal damage with very brief exposure. Lasers must be used under the close direction of a teacher, in a well-lit room so that the pupils of the eye are small, and only when positioned in such a way that the beam cannot enter anyone's eye, either directly or by reflection. It should also be noted that the direct or reflected viewing of any intense visible light source—electric arc, burning magnesium ribbon, the sun, collimated or focused beams from ordinary tungsten lights—can cause retinal damage.

Microwave Generators - The microwave radiation generators used in school laboratories are low intensity. However, there is an indication that exposure to low intensity microwaves may have biological and psychological effects. Since these generators are a radiation source which is absorbed by tissue, care should be taken to minimize the exposure. Prevent access to the beam by shielding its path or restricting admittance to the area through which the beam passes.

Microwave ovens used in cafeterias, Home Economics and Science laboratories may present a hazard if faulty, or if tight closing of the door is prevented. They should be checked for microwave emission every three to six months.

Note: *Infra-red and radio wave sources used in schools are usually of very low intensity and used only occasionally. If this practice continues, they do not appear to present a significant hazard. Any change in these conditions should be accompanied by precautions to reduce the exposure of students and teacher to the radiation.*

A Radiation Protection Policy

Most of the radiation hazards in schools are of an insidious nature. Therefore, protection of staff and students from exposure to radiation will require careful planning of experimental set-ups and procedures and the maintenance of all radiation sources in good order. All potentially hazardous equipment and materials must be available for use only under the direct supervision of a teacher familiar with the safe use of the item. **The onus is on the teacher to be aware of potential dangers and to convey this information to the students. The teacher must instruct students in proper operating and handling procedures and must insist that they be followed.**

The aim of safe procedures for handling radiation sources is to do everything possible to reduce the exposure to radiation at all times. Three general principles can be used to minimize exposure.

- At all times stay as far from the source as possible. For collimated and focused beams of radiation, always stay out of the beam path. For uncollimated emissions, the intensity is inversely proportional to the square of the distance between you and the source. **Distance** is the best, and often simplest protection.
- Know what kind of **shielding** is effective in absorbing the radiation, and use it.
- Keep the **time** for potential exposure at a minimum. In most cases, your body is capable of quickly repairing, or compensating for, many small amounts of physiological damage spread over a long time. But its repairability can be overcome if the same total amount of damage is done during one continuous interval.

Storage of Radioactive Material

- Radioactive material must be stored in a locked cabinet or safe with appropriate marking.
- A suitable container made of lead or concrete must be used for shielding.
- Radioactive material must be stored in an area not frequently used by people, e.g., store room close to lab where material is used.
- Only minimum amounts of radioactive sources shall be stored.
- The location of radioactive material must be known to safety officer and school administration in case of fire.
- An inventory of radioactive material must be maintained and made available to the Atomic Energy Control Board upon request.

Transport

- For any transfer of radioactive material other than disposal, prior authorization from the Atomic Energy Control Board ***shall*** be obtained.

Disposal

- For disposal, the radioactive material shall be returned to the supplier or to: Commercial Products, Atomic Energy of Canada Limited, Ottawa, after making prior arrangements. Any other waste disposal method will require specific approval of the Atomic Energy Control Board.

Skin contact with radioactive compound

The immediate washing of contaminated areas with water and soap is the preferred method for removing loose contamination, subject to certain elementary precautions: (a) tepid water, not too hot, should be used; (b) soap should not be abrasive or highly alkaline; (c) washing can be helped by scrubbing with a soft brush only and in such a way as not to abrade the skin; (d) the skin should be washed for a few minutes at a time, then dried and monitored.

Washing could be repeated if necessary (as indicated by monitoring) providing there is no indication of the skin getting damaged. Attempts to remove contamination which resists mild procedures should only be made under medical supervision.

Use of organic solvents or of acid or alkaline solutions must be avoided.

Use of Radioactive Materials

- **Use of Isotopes** - Contact with materials containing radioisotopes can cause severe tissue damage.
- **Use of Cathode Ray and Gas Discharge Tubes** - Energetic electrons and X-rays emitted from these tubes may cause biological damage if high operating voltages are used.
- **Use of Ultra-Violet lamps and Electric Arcs** - Ultra-violet light can cause very painful inflammation of some parts of the eye. The eye can be permanently damaged by intense ultra-violet light from electric arcs. Prolonged exposure of skin can produce “sunburn”.
- **Use of Intense Visible Light Sources (Lasers, etc.)** - The light receiving retina in the back of your eye can be permanently damaged by direct viewing of very bright light sources.
- **Use of Microwave Generators (and Faulty Microwave Ovens)** - Microwaves can cause the body to overheat and permanently damage heat sensitive organs.

Protection

- Always follow procedures exactly as indicated by your teacher.
- Stay as far away as possible from radiation sources. ***DO NOT*** handle radioactive material.
- Use protective shielding between you and the radiation source.
- Work with radiation sources for only brief periods.
- Never look into the beam of a laser, ultraviolet source, or any other bright light.

Accident Procedures

- **Alert the teacher** - if you suspect that you have been exposed to radiation or feel any discomfort such as nausea, headache, or a pain in the eyes, tell your teacher.
- Turn off all electrical equipment; cover all radioactive sources with shielding before leaving your work area.

G. Carcinogens

A carcinogen is a substance which when absorbed by the body, may start uncontrolled cell growth. It is **NOT** recommended for carcinogens to be used or stored in schools unless an absolute need is demonstrated and appropriate use and storage safety procedures are instituted. Contact by any route (respiratory, skin or oral) should be minimized by fume hoods and the use of personal protective equipment. If it is determined that there is a definite need to use carcinogenic chemicals, obtain additional information on the risk involved. **REMEMBER** —Some carcinogens are more potent than others and risk increases with **level** and **duration** of exposure.

REMOVAL: These substances should be removed under the direction or supervision of WCB or a licensed commercial company. All provincial, local and federal regulations must be adhered to in the removal process. Once removed, the substances should not re-enter the school. Instructions should be added to the procedures for ordering chemicals to make sure that, once removed, these chemicals are not re-ordered.

Substances Declared Toxic or Carcinogenic to Human Health Under the *Canadian Environmental Health Protection Act* (CEPA) (1995):

Health Canada
http://www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/chemcarc.htm

- Arsenic (Inorganic Arsenic)
- Benzene
- Benzidine
- Bis (2-Chloromethyl) Ether
- Cadmium (Inorganic Cadmium)
- Chlorinated Paraffin Waxes
- Chloromethyl Methyl Ether
- Chromium (Hexavalent Chromium)
- 3,3-Dichlorobenzidine
- 1,2-Dichloroethane
- Bis (2-Ethylhexyl) Phthalate (DEHP)Dichloromethane
- Hexachlorobenzene
- Mineral Fibres (Refractory Ceramic Fibre)
- Nickel ("oxidic", "sulphid", and "soluble" forms)
- Polycyclic Aromatic Hydrocarbons
- Polychlorinated Dibenzodioxins
- Polychlorinated Dibenzofurans
- Trichloroethylene

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.

- **Heavy equipment and materials stored overhead** - An accident can cause "mechanical" injuries to the back, arms, legs and head if a heavy overhead item slips while being moved. Mechanical injuries are the result of excessive forces applied to the body.

Electrical Hazards

- **Faulty equipment** - Poor or broken connections (e.g., frayed connecting cords) may lead to overheating of the input lead or the device itself, or shorting of the circuit to some part of the equipment touched by people (e.g., the metal case). Damage to the equipment, or a fire or electric shock may result.
- **Improperly used equipment** - Equipment damage and overheating, and therefore, fire, are possible if equipment is in prolonged use at power ratings greater than that for which the item was designed.
- **Installations and modification that do not meet Building Code standards** - Building Code specifications are intended to provide safe access to electrical power. If changes or additions are needed in the existing system they must be made by an electrician. Improperly made alterations can present a fire or electrical shock hazard if excessive current can flow in the new circuits, or if connections are not properly made and insulated.
- **Electrical equipment used near water** - If equipment that is not properly insulated and grounded is used near water (e.g., near laboratory sinks) there is a danger of electric shock.
- **High voltage equipment (including Tesla coils and charged capacitors)** - Student wired laboratory set-ups and teacher made demonstration equipment frequently have exposed connections that present a very real danger of electrical shock when high voltages are being used (e.g. the connection of a high voltage source to a gas discharge tube).

A Mechanical and Electrical Hazards Protection Policy

Accident prevention will depend on the proper maintenance of all mechanical and electrical equipment and the careful instruction of students in the safe use of the equipment. **The onus is on the teacher to be aware of potential dangers and to convey this information to students.**

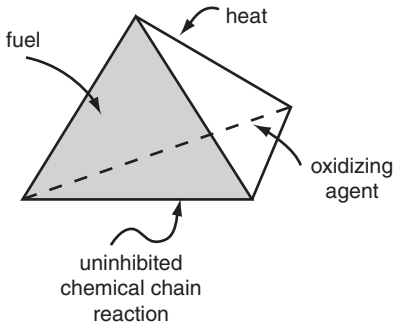
Teachers/Lab Technicians must:

- Maintain all equipment and tools in good working order;
- Instruct students in the safe use of all equipment and tools;
- Be sure that all rotating equipment, such as centrifuges, vacuum pumps, rock saws, grinders and demonstration motors, are operated with all covers, lids and guards in place;
- Require that eye protection be used during any grinding or pounding operations;
- Require that students using rotating equipment tie up loose clothing and long hair;
- Indicate clearly a **No Crowding Zone** around all major equipment, within which there must only be the equipment operator;

- 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.

Fires and Fire Extinguishers

Fire Classification	Fire Extinguisher
Class A - fires involving ordinary combustible materials such as wood, cloth, paper.	Water. Dry chemical extinguisher can also be used.
Class B - fires involving flammable liquids such as solvents, greases, gasoline, and oil.	Dry chemical foam, CO_2
Class C - fires involving electrical equipment.	Non-conducting agents such as dry chemical or carbon dioxide.
Class D - fires involving combustible metals such as magnesium, sodium, lithium, powdered zinc.	Special dry powder medium or dry sand.

Basic requirements as to the location and condition of fire extinguishers:

- Maintain in operable condition - have a **complete** check at least annually.
- Never re-use a used extinguisher - have it recharged.
- Have all extinguishers clearly marked as to class and use.
- Locate conspicuously - have location marked with signs—preferably near an exit door.
- Mount at an accessible height.
- Locate convenient to area of use.
- Check monthly.

Dealing With a Small Fire

- In all cases of fire, immediately ask all students to keep away. The teacher alone should deal with any fire.
- If only a small amount remains to burn and flames are unlikely to ignite other materials, leave to burn out.
- If more than a small amount remains to burn, wearing face shield and heat resistant glove, place a fire resistant cover over the mouth of the beaker. Avoid breathing fumes.
- If the fire appears to be controllable, and where there is little personal risk, the teacher will use the fire extinguisher available in the laboratory.
  - Direct the discharge at the base of the flames.
  - Start at one side and work across the base.
  - Always fight a fire from a position of escape.

Dealing with a Large Fire

If the fire is burning over an area too large to be extinguished:

- Vacate the room.
- Instruct a particular student to sound the nearest fire alarm
- Ensure that evacuation is not hampered by students attempting to retrieve outdoor clothing or other personal belongings.
- Monitor movement of students so as to prevent crowding, running and pushing.
- Escort students along the predetermined exit route to an assembly area outdoors.
- Ensure that all students are accounted for.
- If it is safe to do so:
  - Close all doors and windows to localize the fire before leaving.
  - Shut off electrical circuits and gas lines.
  - Attempt to notify the school office via the P.A.

Dealing with a person on fire

- Drop and roll the individual
- Douse the individual with water
  or/and
- Wrap the person in a fire blanket
- A person on fire should not, under any circumstances, run to get help.

Some Don'ts

- Don't throw water over a chemical fire.
- Don't use a fire extinguisher on standing beakers and flasks.
- Don't turn on water after a flaming container is placed in a sink.

** For more information visit the Office of the Fire Commissioner website at http://www.marh.gov.bc.ca/FIRECOM/

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?
- Is the equipment being used adequate and suitably arranged?
- Is the activity, particularly if it is inherently dangerous, being properly supervised?

Teachers and administrators must assess these four criteria when determining the types of outdoor activities to carry out with their students. An important factor is the level of qualification possessed by the leader and other adults on the trip. Adults leading trips into wilderness areas should have current first aid certification.

Leading students in wilderness areas of B.C. takes more than just "common sense". The leader should have visited the area before taking students into it, and students should in terms of environmental conditions, be well prepared.

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

Facilities

Science laboratories have a variety of shapes, sizes and uses. Consideration of these three factors is important in determining the relative safety of any particular activity.

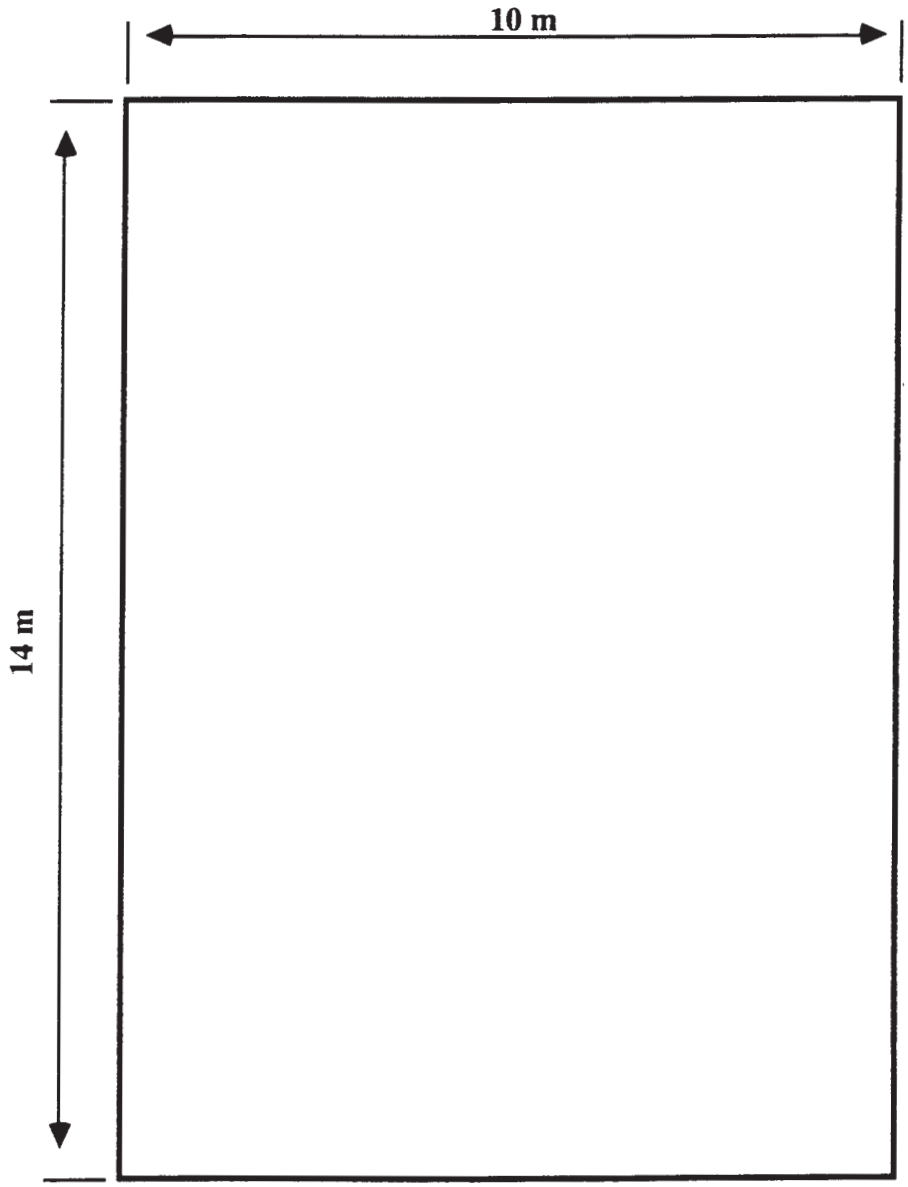
The following points deserve attention.

- Science activities generally require a flat, horizontal, solid bench for student work.
- Teachers should have easy eye contact with all students and with their work surface and area. This can be achieved only with students facing towards the teacher.
- The number of students who can safely participate in science in a given laboratory at any given time depends upon many factors. It is recommended that districts determine safety standards for the numbers of students that should be under the guidance of one teacher in a given facility. In situations where existing facilities render conditions unsafe for undertaking science activities, class size should be reduced.
- Science laboratories should never be crowded. Maximum occupancy of a room is often dictated by design. A rough guideline for overall dimensions may be found by allocating 5 square metres for each student. This area per student is derived by dividing student accessible area by the maximum number of students using the room at any given time. The student accessible area used in the calculation should not include teacher facilities or desk, cupboards, shelves, hallways or corridors. The Ministry of Education Area Standards designates a 'science module' allowance of 140m^2 in the design of new secondary schools. This space may be supplemented by using some of the facility's 'design space' allowance for the facility. The 140m^2 includes preparation areas as well as student accessible areas; sharing preparation facilities may be one method of increasing instructional space.
- All science teaching areas should include teacher facilities and desk, cupboards and shelves for adequate storage of materials and equipment. A separate, locked science storage/preparation room with adequate preparation facilities and chemical storage area should be provided.
- All laboratories must be adequately ventilated.

- 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

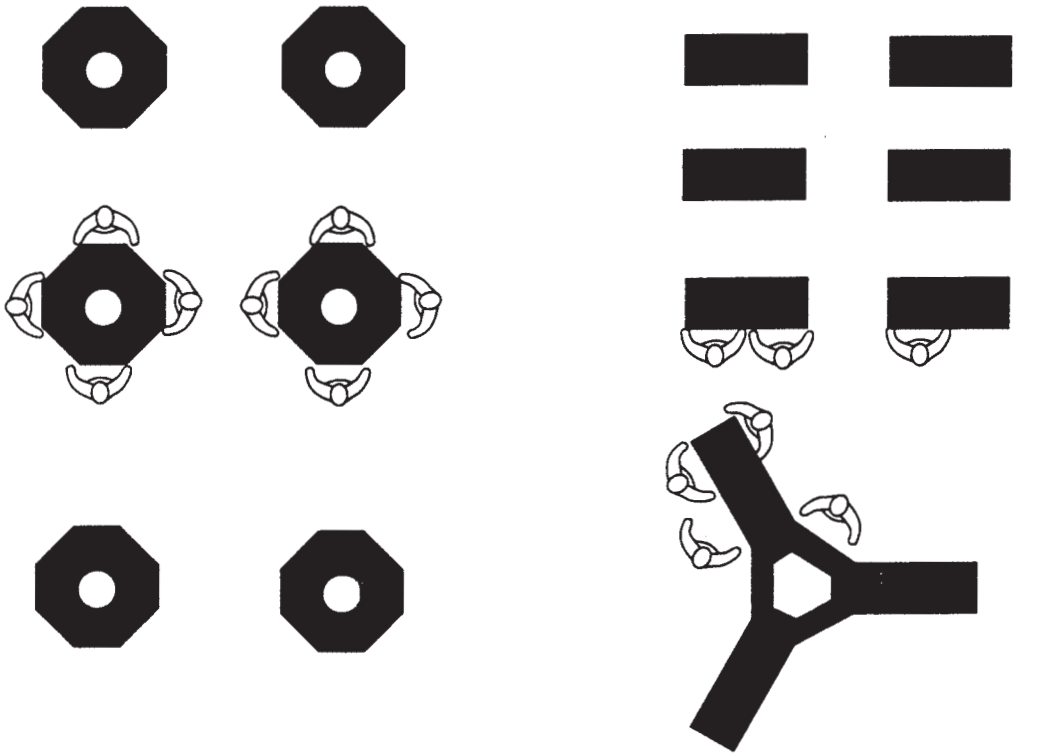
This is the standard size (area only) for a science room in B.C. Teacher, student, storage, preparation and safety facility space must all fit inside this box.



Scale: 1:100

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.



Service Island

Desk

Chair

Student

Stool

0.5 x 1.5 m. Lab Bench

1.5 m. Octagonal Serviced Bench

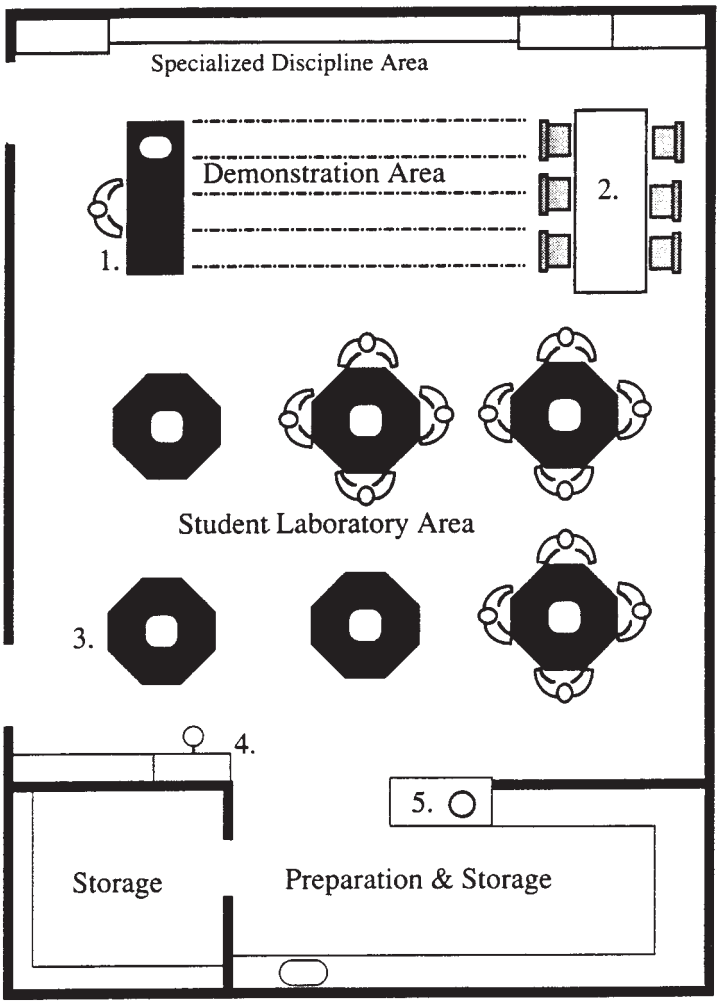
Scale = 1:100 (Approx.)

Demonstration Bench

10 Metre Counter

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. • (3) The location of an in-line vacuum break must be clearly identified.

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 - an average of 0.5 m/s (100 fpm) but not less than 0.4 m/s (80 fpm) at any point across the face, and - (b) an average of 0.75 m/s (150 fpm) but not less than 0.65 m/s (125 fpm) at any point across the face if the fume hood is used for carcinogenic substances listed in Table 5-4 in Part 5 (Chemical and Biological Substances), or for radioactive materials. • (3) A fume hood must be located to prevent cross drafts or other disruptive forces from lowering the air flow across the operational face to unacceptable levels. • (4) A fume hood and its ductwork must be constructed from materials compatible with its use. • (5) A fume hood must be clearly labelled with any restrictions on use that apply to it. • (6) A fume hood must not be used for storage of chemicals unless it is used exclusively for this purpose and is labelled with this limitation.
Extractor Fans	• Laboratories should be adequately ventilated by extractor fans other than the fume hood system. For normal laboratory purposes a minimum of 5 changes of air per hour or 15 L. per second per occupant is satisfactory.

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.

Suggested Duties

1. Inventory:
   - record stock
   - maintain security
   - prepare orders as needed
   - label and code chemicals
   - put away dangerous/other chemicals
2. General security:
   - storeroom, classroom
   - balances and other valuable and readily stolen items (e.g., cameras, etc.)
3. Regularly check safety equipment:
   - eyewash
   - shower
   - first aid
   - shut offs
4. Prepare and check experiments, and equipment before use in class.
5. Make up and dispose of solutions.
6. Biological work:
   - the care of animals, fish, cultures and plants
   - preparation of biological materials
   - disposal
7. Maintenance and minor repair of apparatus/equipment:
   - cleaning (e.g., pipettes, chemical storage bottles)
   - sterilization
   - sorting, replacing in location after use
8. Ensure that equipment is serviced regularly.
9. Provide safe demonstrations of chemical phenomena in laboratory experiments.
10. Assist in supervising large classes when hazardous chemicals are being used and in emergency situations.
11. Assist on field trips.
12. Keep files on safety information.
13. Report problems to teacher/school safety officer.
14. Operate waste disposal arrangements.

Safety Contacts List

1. **British Columbia Schools Protection Program – Risk Management**

Website:	http://www.bcspp.org/index.shtml
Email:	protection.program@bcspp.org
Telephone:	250-387-0525
Fax:	250-953-3050
Mailing Address:	Schools Protection Program, Risk Management, PO Box 3585, Victoria, BC, V8W 3W5

2. **Workers' Compensation Board of B.C.**

Website:	http://www.worksafebc.com
Street Address:	6951 Westminister Highway, Richmond, B.C. V7C 1C6
Mailing Address:	PO Box 5350 Stn Terminal, Vancouver, B.C. V6B 5L5
Telephone:	Vancouver - 604-273-2266 Toll free in BC: 1-800-661-2112

Prevention and First Aid Numbers

Cranbrook	250-417-7934	Courtenay	250-334-8745
Nanaimo	250-751-8040	Kamloops	250-371-6003
Prince George	250-561-3700	Terrace	250-615-6605
Vernon	250-545-1125	Victoria	250-881-3418
Abbotsford	604-556-2060	Kelowna	250-717-4313

3. **Labour Canada**

Website:	http://labour.hrdc-drhc.gc.ca/index.cfm/doc/english
Address:	1400 - 800 Burrard St., Vancouver, B.C. V6Z 2H8
Telephone:	Vancouver - 604-666-2205

4. **B.C. Safety Engineering Services**

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

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

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Council of State Science Supervisors. *Science and Safety – Making the Connection.* http://csss.enc.org/media/scisafe.pdf

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http://www.aristotle.net/~asta/equip1.htm

British Columbia Schools Protection Program, Risk Management.
http://www.bcspp.org/index.shtml

British Columbia Safety Council. http://www.safetycouncil.bc.ca/

Center for Disease Control and Prevention. http://www.cdc.gov/

Chemical Classification & Safety Signs.
http://pc65.frontier.osrhe.edu/hs/science/nfpa.htm

Chemical Info Net - A Chemical Health and Safety Resource for Schools.
http://www.cheminfonet.org/

Council of State Science Supervisors. http://csss.enc.org/safety.htm

Dalhousie University Laboratory Safety Handbook.
http://is.dal.ca/~ehs/lab1.htm

Flinn Scientific Inc. http://www.flinnsci.com/index.html and Flinn Safety Pages
http://www.flinnsci.com/homepage/sindex.html

Frontier High School Science Lab.
http://pc65.frontier.osrhe.edu/hs/science/clab.htm#pro

Health Canada. http://www.hc-sc.gc.ca/ehp/ehd/psb/whmis.htm and
http://www.hc-sc.gc.ca/ehp/ehd/rpb/index.htm

International Agency for Research on Cancer (IARC). http://www.iarc.fr

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Maryland Science Safety Manual. http://www.mdk12.org/practices/support_success/mspap/activities/safety/

Missouri Science Safety Manual. http://successlink.org/safety/

National Fire Protection Association. http://www.nfpa.org/Home/index.asp and http://www.orcbs.msu.edu/chemical/nfpa/nfpa.html

National Toxicology Program. http://ntp-server.niehs.nih.gov/default.html

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

Safety in the Elementary (K-6) Science Classroom. http://membership.acs.org/c/ccs/pub_8.htm

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Science Education Safety. http://www.aristotle.net/~asta/safety.htm

Science Fair Foundation BC. http://www.sciencefairs.bc.ca/

The Canadian Centre for Occupational Health and Safety (CCOHS). http://www.whmis.org/ and http://www.ccohs.ca

UBC/UVIC Laboratory Safety. http://web.uvic.ca/ohs/labsafety.html

University of Toronto. www.utoronto.ca/safety/

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

WHMIS at Work. http://www.worksafebc.com/pubs/brochures/howto/whmis.pdf

WHMIS BC Homepage. http://whmis.healthandsafetycentre.org/s/Home.asp

Workers' Compensation Board of British Columbia. http://www.worksafebc.com/

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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
III. Safety Instruction			
A. Safety Pretest given to students (for use in planning instruction)			
B. Safety rules posted (copy should be provided to each student)			
C. Safety posters displayed in room			
D. Appropriate warning signs posted (hazardous material)			
E. Safety contract between teacher & student/parent signed & on file			
F. Teacher includes safety as part of each pre-lab instruction			
G. Safety procedures documented in the teacher's lesson plans			
H. Appropriate facilities for special needs students			
I. Safer chemicals substituted in lab activities when possible			
J. Hot plates or microwave ovens substituted for open flames when possible			
K. Students instructed in proper handling of glass tubing			
L. Students instructed on biohazards in animal handling			
M. Field manuals available with safety instruction for field trips			
IV. Master Cut-offs			
A. Master control cut-off valve available, location known and accessible to teachers, administrators, and custodians,			
1. Gas			
2. Electricity			
3. Water			
B. Master control cut-off clearly labeled			
1. Gas			
2. Electricity			
3. Water			
C. Gas valves inspected for closure at end of each day			
D. Gas cut off with master control when not in use			
V. Fire Control			
A. ULC Listed 2A10BC dry chemical fire extinguisher			
1. Suitable size, easily handled			
2. Evidence of quarterly check			
3. Safety seal intact			
4. Easily visible location & unobstructed from view			
5. In every storeroom or prep room			
6. Located near escape route of lab			
7. Access to a 2nd fire extinguisher			
8. Clean (CO_2 or Halon) extinguisher available in areas where dust sensitive equipment used or stored (e.g. computer, electronic balance, microscopes)			
9. Teacher trained in use of fire extinguisher through actual fire situations			
10. Teacher trained within the last year			
11. Alternate plan if extinguisher malfunctions			
B. Presence of 5-10 L container of clean, dry sand for class D (flammable solids, i.e., sodium, potassium, etc. in each)			
1. Earth Science / Geology room			
2. Biology room			
3. Chemistry room			

Laboratory Safety Checklist	Yes/Date	NO	N/A
4. Physics room			
5. Storeroom			
6. Any area where chemicals are stored or used			
7. Teacher has knowledge of when & how to use			
C. Presence of a fire blanket			
1. Standard fire-proof woolen blanket in every lab and storeroom			
2. Visible location and known to teacher and students			
3. Last inspection for rips and holes (Please indicate date)			
4. Stored near eye-level			
D. Fire exits and drills			
1. Two fire exits in each laboratory clearly marked			
2. Two fire exits in each storeroom/prep room			
3. Unobstructed and unlocked fire exits			
4. Labeled and functioning doors on exits			
5. Posted and practised fire drill procedures			
6. Functioning general alarm system for entire building			
E. Smoke Alarm			
1. Presence of smoke alarm in each laboratory			
2. Presence of smoke alarm in each storeroom			
3. Indication of regular maintenance (indicate date of most recent maintenance)			
F. Automatic sprinkler system last inspection (date)			
G. No Smoking rule in lab and preparation areas			
VI. Availability of First Aid Treatment			
A. School nurse available			
B. Separate kit for chemical first-aid			
C. First Aid kit in each laboratory and storeroom/prep room			
D. Date of last inspection and restocking of kit			
E. First Aid kit visible and accessible			
F. Instructions for emergency action/first aid posters displayed prominently			
G. Teacher trained in CPR within the last year			
H. Teacher trained in first-aid within the last year			
I. Established first-aid policy (e.g., protect; treat only major injuries)			
VII. Ventilation			
A. Forced ventilation capability in each laboratory with manual control (fume hood or air conditioner not acceptable to evacuate room air at rate of 5 air changes per hour (preferably at floor level))			
B. Continuous ventilation in storeroom			
C. Exhaust (on roof) ventilated away from air intake			
D. Fume hood			
1. Ventilation to roof (away from intake)			
2. Not used as a storage area			
3. In every chemistry laboratory for use with hazardous, vaporous chemicals			
4. Evidence of maintenance (for exhaust rate and leakage) Please indicate most recent date			
5. Provides minimum of 0.5 metres per second of air movement at hood face with sash open 20 cm. above bench (can be measured with a district supplied velometer)			

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			

Laboratory Safety Checklist	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			
d) name of supplier			
e) chemical's strength or purity			
f) MSDSs properly filed			
6. Stored in compatible chemical families (not alphabetical or other unsafe methods)			
7. Acids stored separately on non-metal, non-wood shelves			
8. Flammables in dedicated and approved cabinet or safety cans			
9. Poisons under lock at all times			
10. Immersion fluids topped up? (sodium and other alkali metals with kerosene)			
11. Stored in a regulated area with entry allowed only for authorized personnel			
12. There is an "authorized persons only" sign on the door.			
13. Inside of storage rooms sufficiently fire resistant			
14. Teachers have received WHMIS training			
B. Cabinets			
1. Secured to floor and/or wall and free from corrosion			
2. Presence of lockable cabinets			
3. Are the following items kept locked in cabinets?			
a) hypodermic syringes			
b) drugs			
c) dangerous chemicals			
4. Presence of lab refrigerator			
Does it store			
a) only chemicals and living cultures (no food)			
b) explosive chemicals (ether, etc.) stored in explosive proof refrigerator			
C. Shelves			
1. Are equipped with lip edge to prevent bottle roll off			
2. Portable shelves are secured to wall or ceiling			
3. Chemicals stored at or below eye level			
4. Glass cylinders stored off the floor			
5. Chemicals stored off the floor			
6. Large containers stored in a tray to contain spillages			
7. Storage of tall items at back of shelf and heavy glassware on lower shelves, no chemical containers stacked double			
8. Glass rods and tubing stored horizontally with no pieces protruding over edge			
D. Gas Cylinders			
1. Capped			
2. Supported to prevent rolling or tipping			
3. Placed away from heat sources and open flames			
4. Clamped tightly in place after being positioned for use			

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.