New Brunswick Department of Education

DRAFT
Science Safety Guidelines

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Disclaimer

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Introduction

Background

A major concern of science educators today is how to provide students with the exposure to laboratory activities while maintaining a safe student 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 reduces the risk of injury to staff and students.

Teachers should be constantly alert to potential dangers. Common sense can go a long way toward maintaining a safe environment. Some risk is inherent in almost all science activities and to minimize these risks the following factors have to be considered:

- ability of teaching personnel to ensure a safe program
- support from superiors in promoting safety
- knowledge of subject matter and of chemicals and equipment used
- assurance of cooperation from students who have been taught their responsibilities in the labs

While most lab materials are recognized as safe, some materials are capable of presenting a hazard if not handled properly. Some schools lack the facilities to provide the conditions necessary for the safe use of all chemicals in their laboratories. The decision to use certain substances in the school laboratory 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 benefit and no substitute is available, then the experiment should be eliminated from the program.

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. If the potential cause can be detected and eliminated, fewer accidents should happen. Accidents are often the result of human error. They can be prevented by:

- an educational safety program
- proper supervision of students
- instruction in appropriate laboratory techniques
- good laboratory housekeeping

Responsibilities

Encouraging a positive safety attitude is a shared responsibility among the following four main groups:

- District Superintendent and District Education Council (DEC)
- school administration
- science teachers
- students

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

Responsibilities of Superintendent and District Education Council (DEC)

The District Superintendent and DEC has a responsibility to:

- ensure that schools comply with safety regulations.
- provide specific training so that staff may increase their knowledge of safety measures in order to provide a safe working and learning environment.
- provide facilities that ensure the safety of students with disabilities.
- initiate planning for the necessary improvements and procedures that ensures science safety.
- provide teachers with the necessary resources and equipment that will ensure safety in the laboratory, including a copy of this manual.

Responsibilities of School Administration

Individual school administrators and principals have the responsibility to:

- ensure that safety practices and guidelines are being followed in their schools.
- ensure that science laboratory activities are being taught and supervised only by teachers with the required expertise to teach such activities safely.
- ensure that substitute teachers are not given the responsibility of supervising laboratory activities unless they are familiar with the students and the specific topic of study and have the required expertise.
- support training to improve the safety knowledge of teachers, including training in first aid, cardiopulmonary resuscitation (CPR), and Workplace Hazardous Materials Information System (WHMIS)
- ensure that science classes be of an appropriate size to allow teachers to adequately supervise laboratory activities

- provide teachers with the necessary resources and equipment that will ensure safety in the laboratory, including a copy of these guidelines.
- ensure that science laboratory enrolment does not exceed the capacity of the available lab station, based on the Department of Education building guidelines
- make provisions for the safety of all students including those with disabilities, language difficulties or cultural concerns
- carry out routine safety inspections and identify problems to be rectified, where possible at the school level
- direct any safety concerns that cannot be corrected at the school level to the appropriate district personnel
- provide and ensure that an accurate inventory of laboratory equipment and materials is annually updated and a copy provided to the local fire department.

Responsibilities of the Science Teacher

Teachers have the responsibility to:

- provide for the safety of their students
- ensure students and their parents or guardian have read, understood and accepted their safety responsibilities prior to participation in laboratory activities, and have confirmed this by signing a safety contract (see Appendix F), .
- reasonably anticipate the potential problems and hazards associated with an activity and to take reasonable precautions to prevent foreseeable accidents
- instruct students in the proper and safe way to carry out science lab activities and shall supervise their students to see that their instructions are followed
- provide opportunity for students to practice safety procedures at the start of the course. This shall include, but not be limited to: emergency evacuation procedures, operation of eye-wash fountain/bottle, operation of the fire blanket and the Stop, Drop and Roll method of extinguishing fire, and introduction to the WHMIS system
- enforce rules which will result in reasonable and sensible behaviour
- ensure, prior to the commencement of a particular laboratory activity, that students are aware of particular dangers and necessary actions
- ensure that equipment used in science laboratories is in safe working order and should report, in writing, any faulty equipment or other hazards to the school administration
- not leave students unsupervised in the laboratory or storage area
- keep dated, written records of any accidents or injuries related to laboratory activities and reports of such incidents should be made to the school administration immediately

- take note of students who have medical conditions such as epilepsy, asthma, or severe allergies and who may require special attention
- take an up-to-date first aid course and receive instruction in the Workplace Hazardous Materials Information System (WHMIS) as outlined in Provincial and Federal Legislation
- ensure that substitute teachers are not given the responsibility to supervise laboratory activities unless they are familiar with the students and the specific topic of study and have the required expertise.
- provide a substitute teacher with a detailed lesson plan for an activity that may be carried out safely
- follow the safety procedures in this manual
- not conduct a laboratory activity if he or she feels that safety is being compromised. Written notification must be provided to the Principal and appropriate Program Specialists/Consultants stating the specific safety concerns and the actions required to correct the problem.

Responsibilities of Science Students

Science students have a responsibility to

- listen and follow the instructions of the teacher in the science lab and behave safely and responsibly
- not perform any experimental activity in the lab without the expressed permission of the teacher or without the teacher's supervision
- report to the teacher immediately any dangerous situations or accidents

A student will be suspended from participating in current and future laboratory activities after refusal to follow acceptable laboratory practices or behaviours that create a dangerous situation for the student or other students.

Legal Aspects of Science Safety

The following points are not intended to provide comprehensive coverage of the law governing science safety. They are included in order to increase teacher awareness of some of the inherent risks in many activities, and to promote a questioning and cautious attitude.

Negligence may be defined as conduct that falls below a standard of care established by law to protect others against an unreasonable risk of harm. There are at least three major types of negligence. They are as follows:

- Malfeasance - doing that which should not have been done
- Misfeasance - improper performance of a lawful act
- Nonfeasance - failure to do what should have been done

Guidelines to Safer Practices

- Teachers are expected to protect the health, welfare, and safety of their students
- Teachers are expected to be able to foresee the reasonable consequences of their actions and inactions. A teacher or administrator is expected to be aware of the foibles of human nature (students) and be able to anticipate what difficulties might arise in terms of safety problems, typical, or atypical student behaviour.
- Careful planning is expected for all activities. The following questions can be used as a guide when planning an activity.
  - What are the hazards?
  - What are the worst case scenarios?
  - How can I prepare for the worst case scenario?
  - What practices, safety equipment, and protective facilities are prudent and appropriate?
- Teachers must carefully instruct their classes and must give careful directions.
- Teachers should create an environment in which appropriate laboratory behaviour is maintained.
- The teacher's presence is necessary to ensure adequate safety supervision.
- An environment in which appropriate laboratory behaviour is maintained must be created.
- Any hazardous or potentially hazardous conditions must be reported immediately to supervisory personnel. Reports should be written and the teacher should retain a personal copy.
- Teachers should be aware of School District and provincial policies related to lab activities

Safety in the classroom is of paramount importance. Other components of education - resources, teaching strategies, and facilities attain their maximum utility only in a safe classroom or lab. To create a safe environment requires that a teacher

- ***Be informed by***

- being familiar with this manual
- reading safety articles in teachers' journals
- attending safety sessions at in-services or conventions
- exchanging professional knowledge

- ***Be aware by***

- organizing a safety class with students at the beginning of the year
- ensuring safety posters and safety equipment are prominently displayed
- developing awareness through a continuing emphasis on safety
- emphasising safety precautions just prior to an activity

- ***Be proactive by***

- acting on what is known and on what one is aware of
- modelling safe procedures at all times
- instructing students about safe procedures regularly
- closely supervising students at all times
- being aware of students' health or allergy problems
- displaying commercial, teacher made, or student made safety posters
- taking a first aid course

Elementary school (K-5)

Although experimentation in the elementary years will not be in as much depth as in high school, and the equipment and chemicals are not 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).

Chemical Hazards .

Any household chemical brought in to the school should be treated with the same precautions as other chemicals. Hazardous effects of all chemicals used improperly should be known.

*The following household chemicals should **not be used** in elementary school activities*

Chemical	***Hazards***
Bleach	• When mixed with acid, chlorine gas is produced. • When mixed with another bleach and/or cleaner, harmful gas is produced.
Drain Cleaner	• This substance is caustic (corrosive). • When mixed with water, extreme heat is produced. • Mixing with another drain cleaner can cause a violent reaction.
Gasoline and other Fuels	• There is a danger of this burning if near a flame.
Products Containing Methanol	• There is a danger of burning.
Asbestos	• There is a serious hazard to lung health.

Biological Hazards

The following section includes biological hazards that elementary students are likely to encounter. The following steps should be taken for plants and animals in the classroom:

- Obey all local, provincial, and federal laws regarding collecting and release of native and exotic animal species –live animals and rare or endangered plant species should not be collected from the wild environment, and live animals should not be released into the wild.
- Inform the principal before bringing any animals in to the school.
- Obey all local, provincial, and federal guidelines regarding the care and treatment of animals.
- Do not allow students to handle animals without proper instruction and supervision.
- Be aware of any diseases that could be carried by the animal.
- Keep animals in a clean, comfortable environment, with regular feeding and a water supply.
- Ensure arrangements are made for the care of animals during times when the school is closed.

Organisms	**Hazards and Precautions**
Live Animals in the Classroom	• Strays or wild animals may carry mites, insects or diseases and are therefore ***not allowed*** in the classroom. • Live animals cannot be released into the wild. • All mammals must have been inoculated against rabies. • Even with the above precautions teachers should be aware of any hazards with an animal interaction. For example: - Animals obtained from an established supplier will reduce but not eliminate the risk of disease transmission – turtles and chickens can carry salmonella. - Mammals, fish, and sea animals can cause wounds, infections, or allergic reactions. • To reduce the chance of scratches or bites, gloves should be worn when handling some animals • Hands must be washed well after any contact with animals. • Medical treatment should be obtained if a student is injured, bitten or scratched by an animal.
Plants in the classroom	• Do not collect any rare or endangered plants from the wild. • Unless known to be safe, treat the plant as poisonous – even many common house plants are poisonous. • Do not allow students to put any part of a plant in or near their mouths. • Avoid contact with the juice or sap of plants; they can irritate the skin. • Wash hands well after handling plants.

Other Hazards

Topic	Hazards and Precautions
Fire	• Use extreme caution when using a flame. • Long hair must be tied back. • Loose clothing can be dangerous around a flame. • Melting wax and flame can cause serious burns. • Students should not have access to matches or other igniters.
Light and Sound	• Viewing the sun during an eclipse should not be allowed at this level. • Students should not be exposed to extremely loud or continuous sounds - damage to the ear is irreversible and cumulative. • Eyes should not be directly exposed to bright lights which can cause permanent damage. • Lasers can cause eye damage if the beam enters the eye - use only a low power laser if doing a demonstration. • Students should not be permitted to use laser pointers or pens.
Machines	• Simple machines and other moving objects can catch loose clothing, hair, and pinch fingers. • Belts, pulleys, levers, hand mixers, etc. should not be used by students without adult supervision.

Middle School (6-8)

By Middle School, although it is hoped that students have had experience in safe practices while doing science activities and experiments in school, this should not be assumed. Strict adherence to safety guidelines must be maintained. As students become older and gain experience they can be given more opportunities to work with more sophisticated apparatus and materials.

The same guidelines, cautions and recommendations apply as were given for the elementary students. In addition, the following guidelines are provided for middle school students.

Chemical Hazards

Chemical	**Hazards and Precautions**
Gases	• Flammable gases such as hydrogen, methane and propane may form explosive mixtures with air at relatively low concentrations. • When H_2 is collected for testing, ensure only small (e.g. test tube) quantities are ignited. • When using H_2, ensure adequate ventilation. • Non-flammable gases such as nitrogen, when stored under pressure in steel containers, may explode when heated by an existing fire.
Any household chemical brought into the school should be treated with the same precautions as other chemicals. Hazardous effects of all chemicals used improperly should be known. *The following household chemicals should **not be used** in middle school activities*	
• *Bleach* • *Drain Cleaner* • *Gasoline and other Fuels* • *Products Containing Methanol* • *Asbestos*	As described for elementary school (previous section)
Fine Powdered Substances	• aluminum, iron or zinc in the form of fine powders may present a fire hazard

If using any other chemicals, consult the Workplace Hazardous Materials Information System (WHMIS) Guidelines found later in this document.

Biological Hazards

Organism	**Hazards and Precautions**
Animals and Plants in the classroom	As described for elementary school (previous section)
Handling micro-organisms	• avoid bacteria, fungi, etc. known to be pathogenic • clean and disinfect all work surfaces before and after handling micro-organisms • do not culture anaerobic bacteria, soil bacteria, or swabs from any surface which may contain micro-organisms from a human source

Electrical Hazards

Item	**Hazards and Precautions**
Voltage	• A battery source of max 3 V must be used to prevent shock hazards. • Use fuses or circuit breakers • Insulate live parts of circuits • Clearly identify high and low voltage connections of induction coils
Water	• Make sure hands are dry when working with circuits • Do not perform electrical experiments near water, wet floors, or wet benches • Stand on rubber mats or carpet when working with electricity • Outlets should be in waterproof boxes on the top of benches or suspended from the ceiling.
Standards	• Equipment should be CSA or ULC approved. • Periodically check for frayed or broken cords, exposed live wires, and leakage of current. • Avoid use of extension cords. • If it is necessary to use electrical cords, do not run cords across walkways or aisles.
Safety	• Avoid touching a live circuit with both hands - flow of electric current through the body is a danger. • Use high voltage equipment properly. • Do not grasp an electrical device that has just been used. • Ensure that electrical equipment is properly grounded.

Mechanical Hazards

Item	Hazards and Precautions
Equipment with moving parts	• Tie long hair back. • Avoid loose clothing, hats with protruding brims, and jewellery. • Wear safety glasses or goggles. • Periodically check equipment to see that it is in good working order. • Simple machines and other moving objects can catch loose clothing or hair and pinch fingers • Belts pulleys, levers, hand mixers etc. should not be used by students without adult supervision.
Glassware	• Make sure glassware is safe for heating - use brands such as Pyrex ® or Kimax ®. • Be careful to identify if glassware is hot or cold before touching. • Have tongs or heat resistant gloves readily available to handle hot glassware. • Cool hot glassware on ceramic tiles or ring stand base. • Always clamp flasks and beakers when heating them on a ring stand.

Fire Hazards

Item	Hazards and Precautions
Hot Plates	• Tie hair back. • Avoid loose clothing. • Ensure plates are cooled before storage.
Candles	• Tie hair back and avoid loose clothing. • Careful monitoring is required. • Candles can only be lit by the teacher. • Candles must not be moved by student.
Other Heat sources	• All other heat sources must be used by the teacher only. • Adequate ventilation must be provided.
Electrical Fires	• Follow guidelines listed to avoid electrical hazards. • Avoid having too large a current passed through electrical equipment or wiring which will cause overheating and a possible fire.

Other Hazards

Topic	Hazard and Precautions
Earth and Space	• Avoid all rock samples with toxic materials such as asbestos, uranium etc.
Light and Sound	• View the sun during an eclipse only with approved apparatus. Otherwise as described for elementary school (previous section)

High School (9-12)

The level of laboratory work progressively increases as students take higher level science courses in high school, allowing increased opportunity to work with more sophisticated apparatus and materials. This must be accompanied by an even greater adherence to safety guidelines than in earlier grades.

It is assumed that the guidelines, cautions, and recommendations given for earlier grades will continue to be followed. In addition the following additional guidelines are provided for teachers of high school science classes.

Chemical Hazards

General Guidelines

Chemicals	**Hazards and Precautions**
Preparation of H_2	• must only done by an experienced science teacher • use only in a well ventilated room • do not use around open flames
Acids	• acids are corrosive • know the correct procedures for dilution and clean-up of spills • dilution of HCl should be done in a fume hood; vapours are toxic • <u>always</u> add acid to water and not the reverse
Bases	• can be more corrosive than acids • KOH and NaOH pellets must be kept in a tightly sealed bottle • NH_4OH greater than 3 M must be used in a fume hood

Hazardous Materials

The list of potentially hazardous materials identified in this manual is not all-inclusive, nor does it address all the hazards that can be encountered when handling chemicals. What is emphasized in these sections are those chemicals that have been listed by the Department of Education as restricted or prohibited, or have been identified by the National Institute of Occupational Safety and Health (NIOSH) as hazards.

Prohibited Chemicals

The following chemicals are prohibited for use in any school. If they are found to be present, they should be disposed of immediately by trained personnel.

- Acrylonitrile
- Adreniline***
- Ammonium dichromate
- Arsenic
- Arsenic trioxide
- Asbestos (in any form)
- Azobenzene
- Barium Hydroxide***
- Benzene
- Benzotrifluoride (Trifluorotoluene)
- ***Benzoyl peroxide* (CH_2CHCN)***
- Beryllium
- Beryllium chloride
- Bromine
- Cadmium
- Carbon tetrachloride
- ***Carbon disulfide* (CS_2)***
- Carbon monoxide
- Castor beans
- Chlorinated ethers
- Chlorine gas***
- Chloroform
- Chromic acid
- Chromium
- Chromium Oxide (Chromium trioxide)
- Colchizine***
- Cynogen (Oxalic acid dinitrile)
- Dichloromethane (Methylene chloride)
- Dimethyl sulfate
- Dimethyl sulfide
- Dimethyl ether
- Dinitrobenzene
- ***Diisopropyl ether* ($((CH_3)_2CH)_2\ O$)***
- Ethylamine
- Ethylene dichloride
- Ethylene oxide
- ***Ethyl ether* ($C_4H_{10}O$)***
- Fluorine
- Formaldehyde
- Fuming acids (e.g., nitric, sulfuric)
- Gasoline
- Guanidine Carbonate
- Guanidine Nitrate
- Hydrocyanic acid
- Hydrofluoric acid
- Hydrogen peroxide (30%)
- Hydrogen sulfide
- Lead arsenate
- Metallic peroxides of Ba and Ca
- Mercury (and all its compounds)***
- Millon's Reagent
- Nickel (II) sulfate
- Nicotine***
- Nitrogen dioxide
- Nitroglycerin
- Osmium tetroxide
- Pecrates
- Perchlorates
- ***Perchloric acid* ($HClO_4$)***
- Perchloroethylene
- Petroleum naptha
- Phenol
- Phosgene
- Phosphorus (white)***
- Phosphorus chloride
- Phoshorus pentoxide***
- ***Picric acid* ($(2,4,6\text{-}(NO_2)_3C_6H_2OH)$)***
- Potassium cyanide***
- Potassium periodate***
- ***Potassium* (K)***
- Polychlorinated Biphenyl (Microscope immersion fluid PCBs)
- Powdered metals (e.g., Mg, Al, Pb, Ni)
- Sodium cyanide***
- Sodium arsenate
- Sodium arsenite
- Sodium peroxide
- Sulfur dioxide
- Silver cyanide***
- Vinyl chloride

**** Explosives*** –unstable substances capable of rapid and violent energy release. They should be removed only by persons trained in handling explosive materials.
****** Highly toxic*** – agents or substances that when inhaled, absorbed or ingested in small amounts can cause death, disablement or severe illness.

Restricted Chemicals

The following chemicals may only be used where schools possess adequate safety equipment and storage facilities to permit their safe use. These chemicals, where used, should be stocked in minimum quantities only.

- acetaldehyde
- acetylene
- ammonium perchlorate
- bromine (liquid) (Use bromine water where possible)
- calcium carbide
- cyclopropane
- diethyl ether
- dimethylamine
- ethyl acetate
- lithium (metal)
- lithium hydride
- methyl ethyl ether
- nitric acid (can explode)
- P.T.C. (Phenylthiocarbamide or 1-phenyl-2-thiourea)
- petroleum ether (Ligroin)
- sodium (metal)
- toluene

Carcinogens

Carcinogen – a substance capable of causing cancer or cancerous growths in mammals.

Known labels indicate that enough information exists which shows a definite relationship between exposure to a substance and cancer in humans.

Probable labels indicate there is limited evidence in humans and/or sufficient evidence in experimental animals.

Remember some carcinogens are more potent than others and risk increases with level and duration of exposure.

Known Carcinogens

- Arsenic powder
- Arsenic pentoxide
- Arsenic trichloride
- Arsenic trioxide
- Asbestos
- Benzene
- Benzidene
- Chromium powder
- Chromium (VI) oxide
- Lead (II) arsenate
- sodium arsenate
- sodium arsenite

Probable Carcinogens

- Acrilonitrile
- Cadmium powder
- Cadmium chloride
- Cadmium sulfate
- Carbon tetrachloride
- Chloroform
- Ethylene oxide
- Nickel powder
- o-Toluidine

Known Animal Carcinogens

- Acetamide
- Aniline (or any of its salts)
- Beryllium carbonate
- 1,2-Dichloroethane (Ethylene dichloride)
- 1,4-Dioxane (o-Dioxane)
- Formaldehyde
- Lead (II) acetate
- Nickel (II) acetate

Mutagens

Mutagens – substances capable of causing changes in the genetic material of a cell which can be transmitted during cell division.

The extent of the hazard to humans associated with exposure to mutagens is less clear than it is with carcinogens. However, it is recommended that similar caution should be exercised in handling substances which are mutagenic.

Mutagens

- Acetamide
- Acridine orange
- Ammonium chromate
- Ammonium dichromate
- Ammonium bichromate
- Anthracene
- Antimony oxide
- Beryllium carbonate
- Cobalt powder
- Colchicine
1,2-Dichloroethane
- Formaldehyde
- Hydroquinone
- Indigo carmine
- Lead (II) acetate
- Osmium tetraoxide
- Potassium chromate
- Potassium permanganate
- Pyrogallic acid (Pyrogallol oxide, $C_6H_3(OH)_3$)
- Silver nitrate
- Sodium azide
- Sodium dichromate dihydrate
- Sodium nitrate
- Sodium nitrite
- Thioacetamide
- Toluene
- Urethane (Ethyl carbamate)
- Ultraviolet radiation

Teratogens

Teratogens - substances which are capable of producing abnormalities in offspring resulting from exposure of the pregnant woman to the substance at a concentration that would be unlikely to have an effect on the woman. The human fetus is particularly at risk during the embryonic stage of development, which is between two and eight weeks.

Known or suspected teratogens

- Ethyl alcohol
- Iodide compounds
- Lead
- Methyl mercury
- Polychlorinated biphenyls
- Radioiodine

A number of drugs are also included in this list (e.g., heroin, cocaine, methadone, tetracycline, thalidomide). Ultraviolet radiation and diseases such as Rubella and Syphilis have been associated with congenital malformation.

Chemical Disposal

The disposal of waste chemicals and potentially hazardous materials is a common occurrence in school science laboratories. This manual cannot provide specific detailed information for the disposal of such materials, but what follows is a very general synopsis for disposal of various hazardous materials.

Hazard	**Disposal**
Chemicals	• follow procedures on MSDS sheets • adhere to New Brunswick Department of Environment regulations • do not use methods not approved by the Department of Environment • refer to The Flinn Chemical Catalogue for “do it yourself” disposal • chemicals can damage a septic system • encourage your District to initiate a district wide collection and disposal of hazardous waste; retain chemicals for this collection.
Glass	• collect broken glass in a properly labelled container • arrange for disposal with custodial staff

Chemical Spills

For all spills first ensure that no student has been injured by the material spilled. Refer to MSDS sheets for direction. Following this, the chemical spill may be dealt with as follows:

Spill	**Procedure**
Small spills	• weak acids and bases can be flushed down sinks with large amounts of water • solvents may be evaporated in the fume hood • for poisonous, corrosive, or reactive materials, refer to MSDS sheets
Large Spills	• acids should be neutralized with dry sodium carbonate, then with plenty of water • bases should be neutralized with dilute HCl or acetic acid, then with plenty of water • absorb with vermiculite or diatomaceous earth and disposed of according to the Department of Environment guidelines • for large spills of poisonous, corrosive, or reactive materials, evacuate the lab, notify administration and seek immediate assistance from the Department of Environment • commercial spill kits may be obtained from scientific supply companies
Solid	• sweep up with brush into a plastic dustpan and placed in a water container for disposal • see appendix for disposal methods • clean, broken glass should be placed in the glass disposal methods • broken glass contaminated with a hazardous solid should be placed with the spoiled solid for disposal
Liquid	• absorb with diatomaceous earth
Acids and Bases	• acid – sprinkle with solid sodium carbonate or sodium bicarbonate • when fizzing (CO_2) stops, sweep with a brush into a dustpan and dispose of in the glass container • base – neutralize with a weak acid such as solid citric acid, boric acid or sodium bisulfate • once neutralized, sweep up like a treated acid spill
Organic Liquids	• absorb with a spill pillow or scoopfuls of dry, solid absorbent • put in container for disposal according to table in the appendix

Biological hazards

In laboratory exercises it is impossible to guarantee an absolutely sterile environment for all teachers and students at all times. It is, then, wise to prohibit the use of potentially dangerous biological materials during laboratory work and demonstrations done in the classroom. This is particularly important because some infectious organisms have been found to survive long periods of drying.

Concerns have been raised by the Canadian medical community regarding the handling of mammalian tissue, partly in response to the emergence of pathogens such as the virus which causes Acquired Immune Deficiency Syndrome (AIDS) and other diseases such as Hepatitis.

The education value of investigations such as blood sampling cannot justify the increased health risk of these and other related procedures to students and staff. The New Brunswick Department of Education firmly believes that the health and well-being of all members of the education community must be a prime consideration in selecting learning activities.

A summary of general guidelines is given below. For further information, refer to *Biohazardous Materials Safety Manual* (Department of Education, 1990), a copy of which should be available in all schools.

General Guidelines

- Students and teachers are to be informed of procedures for decontamination and biohazardous waste disposal.
- Handling body substances of unknown status could endanger health.
- Hands are to be scrubbed at the end of every lab session and adequate facilities for this must be provided.
- Staff and students will follow the Youth Science Foundation guidelines and regulations pertaining to projects involving animals (see Appendix).
- Present stocks of formaldehyde are to be disposed.

Prohibited

Experiments or demonstrations involving

- mammalian blood
- urine and faecal materials
- cheek cell scrapings
- human cell or tissue sampling
- fresh or frozen mammalian tissue
- the use of human saliva is limited to the careful use of sterile techniques with swabs and Petri dishes

Specific Safety Guidelines - *Biology*

Organism	Hazards and Precautions
Handling micro-organisms	• Clean and disinfect all work surfaces before and after handling micro-organisms. • Avoid bacteria, fungi, etc. known to be pathogenic. • Cultures should be grown at room temperature plus a few degrees. • 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 before disposal. • Transparent tape should be used to seal Petri dishes before they are viewed by the class. • Avoid spattering cultures to prevent aerosol formation which is a common means of infection. • Flame wire loop and needles before and immediately after transfer of cultures. • Do not move throughout the lab with a wire loop containing a culture.
Animal Dissections	• do not dissect wild or stray animals found dead • any organs used should be federally and provincially inspected • use dissecting instruments with care; make sure they are rust free and clean • cut down and away • formaldehyde (for preserving or commercial preservative specimens) is not allowed in schools; instead use a 70% solution of ethanol in water • students should use disposable gloves • wash hands well before and after dissection • use a wax or Styrofoam pan to dissect- never dissect in your hands
Plants	• handle with care • treat it as though it were poisonous • do not allow students to put any part of a plant in or near their mouths • avoid contact with the juice or sap of plants • wash hands after handling plants, especially before eating

Disposal of Biological Materials

The disposal of waste chemicals and potentially hazardous materials is a common occurrence in school science laboratories. This manual cannot provide specific detailed information for the disposal of such materials, but what follows is a very general synopsis for disposal of various hazardous materials.

Hazard	**Disposal**
Biological Materials	• dissected specimens and organisms to be incinerated or sealed in heavy plastic and sent to a landfill site • cultures, where permitted, must be sterilized before disposal; sealed in a heavy gauge plastic bag and sent to a landfill site • liquid cultures must be autoclaved then flushed down the drain with large amounts of water • syringes, needles, scalpels, and razor blades are to be put in metal or plastic containers and labelled

Fire Hazards

Fire Causes and Prevention - *General*

Causes of Fire in the Lab	• ignition of solvent vapours • ignition of reactive chemicals • uncontrolled chemical reactions • inadequate storage and disposal • heating due to electrical faults • loose clothing and hair • misuse of gas cylinder • inadequate maintenance • static electric build up • inadequate lab design • inadequate temperature control
Prevention	• eliminate flammable or potentially explosive materials • proper handling of chemicals during storage, spills, and disposal • education of students
Evacuation	• evacuate students immediately • practice fire drills • plan escape routes and alternate routes • clearly mark exits • evacuate in an orderly manner
Control	• remove the fuel (e.g., shut off gas valve) • remove the oxidizers (usually air) by using fire blankets, foam, carbon dioxide, or sand • remove the energy sourceCcool the material below its ignition point with a substance such as water

Fire Causes and Prevention - *Chemistry*

Item	Hazards and Precaution
Using a Bunsen Burner	• tie hair back • avoid loose clothing • remove baseball caps with protruding brims • refrain from using matches or butane lighters for lighting a Bunsen burner
Flammable and Combustible Liquids	• be aware of the flashpoint of the liquids in use - flammable liquids, the flashpoint is below 37.8 °C - combustible liquids, flashpoint is between 37.8 °C and 93.3 °C - refer to the appendix for information on the flammability of substances • keep away from open flames and other heat sources • quantities in use should be kept to a minimum • adequate ventilation must be used • alcohol lamps, if used, must not be glass
Gases	• flammable gases such as hydrogen, methane and propane may form explosive mixtures with air at relatively low concentrations • when H_2 is collected for testing , ensure only small (e.g., test tube) quantities are ignited • when using H_2, ensure adequate ventilation • non-flammable gases such as nitrogen, when stored under pressure in steel containers, may explode when heated by an existing fire
Solids	• aluminum, iron, or zinc in the form of fine powders may present a fire hazard • white phosphorus, sodium, and potassium are prohibited in school laboratories
Reactions	• highly exothermic reactions may produce enough energy to start a fire if flammable or combustible substances are present • take adequate precautions when carrying out any demonstration which is not part of the core curriculum • do not allow students to mix any chemicals except as part of an authorized lab activity or under the supervision of a teacher
Electricity Fires	• caused when too large a current is passed through electrical equipment or wiring causing it to overheat

Fire Safety Equipment

There are a number of pieces of equipment that each school should have in order to aid in the control of a fire. The first of these is the fire extinguisher. There are specific fire extinguishers to use for different classifications of fires.

- There should be an adequate number of suitable fire extinguishers.
- The fire extinguishers must be maintained in operable condition and completely checked at least once a year.
- If used, they must be recharged before being used again.
- The class and use of the extinguishers must be clearly marked.
- They must be located in conspicuous places which are clearly marked by signs.
- They should be mounted at an accessible height and located near area of use.

In addition to fire extinguishers each lab should have the following:

- a fire blanket made of fire-proof wool/rayon material; not to be used where spillage and fire spreading is possible
- teachers trained in the use of the appropriate equipment
- sand

In case of fire, teachers should do the following:

- evacuate all students
- in most cases, the fire department should be called
- if it is a small fire in a container, allow it to burn out
- if larger, place a fire resistant blanket cover over the mouth of the container
- if it cannot be contained, evacuate and call the fire department
- **never** throw water on a chemical fire
- **never** use a fire extinguisher on standing beakers or flasks
- **never** turn on water after a flaming container has been placed in the sink

Fire Classification	**Fire Extinguisher**
Class A - those involving ordinary combustible materials such as wood, cloth, paper	• water • dry chemical extinguisher may also be used (ABC)
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 such as magnesium, sodium, lithium, powdered zinc	• special dry powder medium or dry sand

Electrical Hazards

Item	Hazards and Precautions
Voltage	• no experiments performed at greater than 30 V Otherwise the same as for Middle school (previous section)
• *Water* • *Standards* • *Safety*	As described for middle school (previous section)

Mechanical Hazards

Item	Precaution
• *Equipment with moving parts* • *Glassware*	As described for middle school (previous section)

Radiation Hazards

Item	Hazards and Precautions
Ultraviolet (UV) light	• make sure it does not shine in the eyes or on the skin • can cause Asunburn and eye damage (conjunctivitis) • use protective glasses and an ultraviolet barrier skin cream
Visible light	• intense light can cause eye damage • never look directly at a bright light source such as burning magnesium or the sun • be careful when using strobe lights as they may induce seizures
Lasers	• even at low power, can cause eye damage if the beam enters the eye • do not allow the light beam to enter an eye, either directly for by reflection from a polished surface/mirror • do not shine the beam on any reflecting surface • use only a low power laser • when in use, keep ambient light levels high so that students pupils are small • students may not use laser pointers or pens
Ionizing Radiation	• use low intensity sources containing uranium, thorium, potassium, or rubidium • do not allow sources to come in contact with the skin • if sources are in powder form, keep sealed to prevent contact with the skin or inhalation

Appendix A: Workplace Hazardous Materials Information System (WHMIS)

The Workplace Hazardous Materials Information System (WHMIS) was legislated by the Canadian federal and provincial governments on October 31, 1988 as part of the Occupational Health and Safety Act. This was to ensure that all workers in Canada have information on any chemicals that they may come in contact with in the workplace. The three components to WHMIS are:

Labelling
Material Safety Data Sheets
Education and Training.

Labelling

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

- name
- where a MSDS is available, a statement to that effect
- any hazards of the chemical
- precautionary measures to be followed
- where appropriate, first aid measures in case of exposure

If chemicals are removed and transferred to another container, the transfer container must be labelled 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.

Material Safety Data Sheet (MSDS)

All chemicals in stock in the schools must have an MSDS sheet. These provide more specific information about the hazards, possible health effects, and preventative measures. Teachers and students should be familiar with the type of information contained in a MSDS.

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.

Although the numbering of sections and the order of appearance may differ from supplier to supplier, the following nine categories must be on each MSDS:

	Category	**Information**
I	*Product Identification and Use*	• manufacturer's name • supplier's name
II	*Hazardous Ingredients*	
III	*Physical Ingredients*	• colour, form, solubility • melting and boiling points • vapour pressure, specific gravity
IV	*Fire and Explosion Data*	• flammability • flashpoint • fire fighting procedures
V	*Reactivity Data*	• stability and hazards
VI	*Toxicological Properties*	• LD-50 and LC-50 values (see Appendix C) • threshold limit values (TLV) (see Appendix C) • effects of exposure • carcinogenicity
VII	*Preventative Measures*	• protective clothing • protective equipment • spill and handling procedures
VIII	*First Aid Measures*	
IX	*Preparation date of MSDS*	

WHMIS Classification

A controlled product is a product that falls into one or more of the hazard classes described below. Manufacturers and suppliers classify these products and assign one or more of the appropriate hazard symbols.

	**CLASS A: COMPRESSED GAS** This class includes compressed gases, dissolved gases, and gases liquefied by compression or refrigeration.
	**CLASS B: FLAMMABLE AND COMBUSTIBLE MATERIAL** This class includes solids, liquids, and gases capable of catching fire in the presence of a spark or open flame under normal working conditions.
	**CLASS C: OXIDIZING MATERIAL** These materials increase the risk of fire if they come in contact with flammable or combustible materials.
	**CLASS D: POISONOUS AND INFECTIOUS MATERIAL** **Division 1: Materials Causing Immediate and Serious Toxic Effects** These materials can cause death or immediate injury when a person is exposed to small amounts. Examples: sodium cyanide, hydrogen sulphide.
	**CLASS D: POISONOUS AND INFECTIOUS MATERIAL** **Division 2: Materials Causing Other Toxic EFFECTS** These materials can cause life-threatening and serious long-term health problems as well as less severe but immediate reactions in a person who is repeatedly exposed to small amounts.
	**CLASS D: POISONOUS AND INFECTIOUS MATERIAL** **Division 3: Biohazardous Infectious MATERIAL** These materials contain harmful micro-organisms that have been classified into Risk Groups 2, 3, and 4 as determined by the World Health Organization (WHO) or the Medical Research Council of Canada.
	**CLASS E: CORROSIVE MATERIAL** This class includes caustic and acid materials that can destroy the skin or eat through metals. Examples: sodium hydroxide, hydrochloric acid, nitric acid
	**CLASS F: DANGEROUSLY REACTIVE MATERIAL** These products may self-react dangerously (for example, they may explode) upon standing or when exposed to physical shock or to increased pressure or temperature, or they emit toxic gases when exposed to water.

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 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.
- The employer is responsible for worker education and training within WHMIS.
- Science teachers have a responsibility to educate their students in the aspects of WHMIS.

For more information on WHMIS go to:

http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/index-eng.php
http://www.canadabusiness.ca/servlet/ContentServer?pagename=CBSC_NB/display&c=InfoResources&cid=1081944197442&lang=en
http://www.edu.gov.mb.ca/k12/docs/support/scisafe/index.html
http://www2.worksafebc.com/Topics/WHMIS/SymbolsAndLabels.asp?ReportID=24384

Appendix B: Chemical Storage

Traditionally, chemicals have been stored in schools using an alphabetical sequence. In some cases, flammables and acids are stored in appropriate cabinets but little else occurs. This makes it possible for highly reactive substances such as oxidizing agents and reducing agents to be placed side by side on a shelf, resulting in spontaneous reactions.

Ideal chemical storage would be to completely isolate each major class of material and even isolate some materials within each class. This, however, is not economically feasible considering the amount of chemicals stored in some of the high schools. In the appendix of this manual, you will find a sample of a storage plan

A good chemical storage facility has the following characteristics:

- locked doors isolating the storage room from preparation and classroom areas
- a well designed room permitting safe storage of all chemicals
- chemicals segregated into classes
- a colour coded labelling system
- good ventilation (5.0 L/m^2 floor area) with a fan that is permitted to run continuously
- well lit and away from direct sunlight and heat sources
- explosion proof lights
- switches and fan motor housing should be installed to prevent fires from electrical shorts or sparks in faulty switches
- avoid floor chemical storage
- no top shelf chemical storage nor any chemicals above eye level
- shelves (preferably wood) attached firmly to the walls
- avoid metal shelf supports or clips
- provide anti-roll lips on all shelves
- acids, flammables and severe poisons should be in three separate cabinets
- nitric acid should be stored separately

General Storage Suggestions

Storage Suggestions include the following:

- avoid floor chemical storage (even temporarily)
- avoid chemical storage on the top of the shelving unit
- avoid chemicals stored above eye level
- fasten shelf assemblies securely to a wall (avoid island shelf assemblies)
- make shelving assemblies of wood
- provide lips on all shelves to prevent roll-off
- avoid metal, adjustable shelf supports or clips (fixed, wooden supports are preferred)
- store both inorganic and organic acids in a dedicated acid cabinet with doors
- store nitric acid isolated from other chemicals
- store flammables in a dedicated metal cabinet with doors
- store extremely toxic poisons in a locked cabinet

Acids

Store acid bottles in a corrosion resistant plastic tray close to the floor. Concentrated nitric acid should be stored in a separate wooden compartment that has wooden dowel hinges and external locking attachments (no metal on inside surfaces). The cabinet must be vented to permit a continuous flow of air through it. Ideally, this cabinet should be in the chemical storage room.

Flammable Solvents

Flammable solvents must be stored in cool areas inside an approved (Underwriter Laboratories [UL] or Canadian Standards Association [CSA]) flammables cabinet. The cabinet must be vented to permit a continuous flow of air through it. If this is not possible, then it must be vented into a storage area that has continuous ventilation.

In general, a 120 L cabinet houses all the flammable solvents needed for most schools with more than 700 students. A 90 L cabinet is adequate for smaller schools. Many schools currently store too large a quantity of flammable solvents. In general, schools do not require more than 4 L of any one solvent in one year. It is recommended that a total of not more than 50 L of solvent be stored in any school.

Be certain the cabinet contains only flammable substances and absolutely no oxidizers (e.g., sodium peroxide*, a strong oxidizer will spontaneously react with solvents causing a fire/explosion hazard).
** Must not be present in school laboratories or storerooms*

Toxic Substances

Toxic substances have the capacity to injure the body by direct chemical action. They include corrosive as well as poisonous materials.

Poisons should be stored above waist height, preferably in a locked cabinet.

Chemical Storage Codes

There are several plans appropriate for storage as well as hazard ratings. The WHMIS plan will be used (similar to the Fisher Scientific Chem Alert Safe Storage Plan and the J.T. Baker SAF-T-DATA Label System).

Compatible chemicals are labelled with the same colour, grouped together in your chemical storage areas, and recommendations followed for proper storage as indicated in the following list of codes. Refer also to the chemical sections of the VWR Scientific, J.T. Baker, and Fisher Scientific catalogues for more information.

Blue	Health Hazard. Material has the potential to be a severe health risk. Toxic if inhaled, ingested, or absorbed through the skin. Store in a secure area.
Red	Flammable. Material is flammable, extremely flammable or combustible. Material should be stored in a flammable liquid storage cabinet or area. Keep away from strong oxidizers. Reactive and oxidizing agents.
Yellow	Material is highly reactive and may react violently with air, water, or other substances. The material is classified as one or more of the following: explosive, water reactive, strong oxidizer, or pyrophoric. Material should be stored separately. Keep away from flammable and combustible materials.
White	Corrosive. May harm skin, eyes, mucous membranes. Store in a corrosion proof cabinet or area. Store away from red-, yellow-, and blue-coded chemicals/reagents.
Orange/Gray	General chemical storage. Material poses minimal risk while being stored. Presents no more than a moderate hazard (2 on a scale of 0–4).
Striped	Material poses a special hazard. A careful review of all hazards related to the product should be conducted before a storage area is selected. A material could have a striped label because: it is incompatible with some materials that have the same colour class and/or there are sufficient hazards to suggest that the material should have more than one storage class. When multiple storage classes are necessary, the label will be striped, and the risk believed to be the most critical for that material will determine the colour.

Storage by Hazard Classes of Chemicals

When ordering chemicals, avoid ordering more than will be used in one or two years.Chemicals may be classified and stored in the following eight.

Hazard	**Comment**
Flammables and Combustibles	• stored in CSA approved cabinet away from strong oxidizing agents such as $KMnO_4$, K_2CrO_4, $K_2Cr_2O_7$, or HNO_3 • keep the cabinet in a cool place • vented • a 120 L cabinet should be sufficient for most schools • acetic acid stored here
Acids	• stored at bottom level, in an acid cabinet or acid-resistant plastic trays if stored in any other proper cabinet • cabinet must be vented • store away from bases, active metals (Na, Li, Ca) and cyanides, sulfides, and sulfites • nitric and acetic acids should be stored separately
Bases	• store away from acids • in corrosion resistant plastic trays at bottom level of cabinet • vent aqueous ammonia (Aammonium hydroxide@) periodically
Oxidizing Agents	• store away from flammable and combustible materials and reducing agents • nitric acid stored here
Reducing Agents	• includes metals and metal powders • store away from oxidizing agents • some, such as alkali metals, must be kept away from water sources
Compressed Gases	• store upright • in a cool, well ventilated place • away from other chemicals • secure to a wall or bench to prevent them falling
Toxic Substances	• store poisons above waist height in a locked cabinet
General Storage	• all other chemicals may be in alphabetical order • separate incompatible chemicals (see appendix for incompatibility of chemicals) • store organics and inorganics separately

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
- alphabetically store 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 (e.g., teachers are not to be present in the room other than when dealing with chemicals).

The disposal of biological materials, waste chemicals, and potentially hazardous materials is a necessary and common occurrence in school science laboratories. This section does not provide specific detailed information for the disposal of such materials, but indicates what resources the teacher or technician can consult to dispose of biological materials and waste chemicals properly.

Appendix C: Lab Safety Procedures and Equipment

Safety Guidelines for Students

General

- Maintain quiet, orderly behaviour during laboratory periods.
- Always be alert. Take care not to bump another student. Remain in your lab station while performing an experiment; an unattended experiment could result in an accident.
- Study the procedure of the experiment before performing it. If you are uncertain about the correct procedure to be follow, ask the teacher.
- Advise your teacher of any medical condition (contact lenses, allergies, respiratory problems, etc.) that might be aggravated by a particular experiment.
- Never attempt unauthorized experiments. No laboratory work may be carried on without the teacher's permission. Do not begin an experiment until directed to do so by the teacher.
- Stand up while doing an experiment unless directed otherwise by the teacher.
- Never wear expensive clothing if laboratory work is to be done.
- Avoid loose, bulky clothing, such as winter jackets, coats, etc. and dangling jewellery. Shorts, sandals, and bare feet are prohibited. Keep long hair tied back especially when an open flame is nearby.
- Never bring food or drink into the laboratory and do not drink from lab glassware.
- The storage room is out of bounds to all students except when permission has been granted to individuals by the teacher.

Personal Protection

- Wear safety glasses or face shields when instructed to do so by your teacher.
- Know the location and correct operation of all safety equipment.
- The most common type of student injury is a burn caused by touching objects which have just been heated. Determine whether an object is hot by bringing the back of your hand up close.

Lab Practices

- Keep all work areas clean and tidy. Clean and wipe dry all desks, tables, or laboratory work areas at the end of each laboratory activity.
- Never carry hot equipment or dangerous chemicals through a crowd of students.
- Always waft odours towards your nose with your hand. Never breathe them directly.
- Wash your hands after handling any chemicals. Check with your teacher to see if gloves should be worn.
- Learn to light a Bunsen burner correctly. Keep your head back from the burner during the process.
- Never leave an almost colourless Bunsen burner flame unattended. If the burner is to be kept lit, shut off the air vent and decrease the gas supply to produce a flame resembling that of a candle.
- Use a water bath when heating corrosive liquids in a test tube.
- Use the proper type of tongs when handling hot crucibles or beakers. Crucibles must be held at the very end of crucible tongs. Place hot crucibles on a ceramic square or on the base of a rink stand. Do not allow hot objects to contact laboratory table top.
- When evaporating a solution to dryness in an evaporating dish, place a watch glass over the dish as protection from spattering.

- When removing an electric plug from its socket, pull the plug and not the cord. Report frayed cords to the teacher. Bare electrical wires can be extremely dangerous.

Chemicals

- Never taste chemicals. Use caution when handling all chemicals.
- Mercury is highly toxic. Never handle it with your bare hands. Report any spilled or exposed mercury. It will ruin gold and silver jewellery on contact.
- Learn and use the correct method for pouring chemicals from reagent bottles. Hold the glass stopper above the hand and between the index and the middle finger so the same hand can grasp the bottle.
- When pouring chemicals from a beaker, use a stirring rod to direct the flow.
- Be especially careful with organic solvents, many of which are highly flammable and some of which are toxic.

Glassware

- Report sharp edges on prisms, mirrors, glass plates, metal objects, etc. to the teacher so they can be removed or repaired. Do not work with glass tubing that has jagged edges or edges which have not been fire polished.
- Check glass tubing to ensure that the flow of gas is not obstructed.
- Broken glassware should be placed in a container provided for that purpose. Be especially careful not to leave broken glass on benches or in sinks. A separate container should be used for insoluble residues. Never empty these into the sink.
- When heating a liquid or solid in a test tube, keep the tube moving in the flame. Hold the tube at an angle and heat the tube evenly on the sides and bottom. Point the tube's mouth away from others.
- Erlenmeyer flasks and beakers should be clamped to ring stands in addition to being supported on wire gauze and a ring.

Disposal

- Dispose of chemicals and specimens as instructed by the teacher.
- Flush sink drains thoroughly after using chemicals if they are disposed of in the sink.
- Never return unused solutions to stock containers or reagent bottles.

First Aid

- Rinse any skin burn immediately with lots of water. If an eye is involved, irrigate it without interruption for a minimum of 15 minutes. Refer to the Material Safety Data Sheet (MSDS) for the chemical involved for specific directions.
- Report all injuries to the teacher immediately, regardless how minor.

Spills

- Beware of what appears to be drops of water on laboratory benches. They may be corrosive liquid.
- Report all breakages and spilled chemicals to the teacher.

First Aid in the Laboratory

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All school science labs should be equipped with a number 3 first aid kit. A number 3 first aid kit will contain:

Equipment
- 1 first aid guide
- 1 first aid record book
- 1 pencil
- 12 safety pins
- 1 splinter tweezers
- 1 pair of 100 mm scissors
- 4 pairs of disposable latex gloves made of material that provides an equivalent level of protection against the spread of infections or contagious conditions
- one marked plastic bag for disposal of biohazardous waste
- one airway barrier device for rescue breathing

Dressings
- 6 sterile bandage compresses (100 mm x 100 mm)
- 32 sterile adhesive dressings (25 mm wide)
  - 32 sterile pads (75 mm wide x 75 mm long)

Bandages
- 6 triangular bandages (1 m)
- 3 roller bandages (50 mm wide)
- 2 rolls of adhesive tape (25 mm wide x 2.5 m long)

Antiseptics
- disinfectant in the form of
- a 100 mL bottle of adequate antiseptic
- 12 individually wrapped towelettes with an adequate antiseptic
- 24 hand cleaners

The above listing is the minimum required by law. In addition, the following would be recommended:
- 4.5 m tubular finger bandages with applicator
- 10 finger tip dressings
- 10 knuckle pad dressings

These kits should be checked periodically (at least once a month) as some items such as Band-aids tend to be used often and may need frequent replenishment.

The following table provides first aid guidelines for the most common accidents in the laboratory.

Injury	**Response**
Burns	• apply cold water
Cuts and Bruises	• stop any bleeding by applying direct pressure • cover cuts with a clean dressing • apply cold compresses to bruises
Fainting	• leave the person lying down • loosen any tight clothing • keep crowds away
Foreign Matter in the Eye	• flush with plenty of water
Poisoning	• note the suspected poisoning agent • call Poison Control Centre
Any spills on skin	• flush with large amounts of water and use safety shower

Personal Protective Equipment for Students

If injuries to students result from the failure to have or use personal protective equipment, negligence may be claimed. Safety training is an integral part of learning lab techniques and it is an excellent way of ensuring that safety become a lifelong practice.

Safety Item	**Comments**
Safety Glasses or Goggles	• students must wear eye protection • shared goggles should be sterilized between uses with an ultraviolet radiation or a disinfectant solution • prescription glasses do not provide adequate protection • safety glasses or goggles must have fitted side shields • contact lensesCsee Appendix E: Contact Lenses
Laboratory Coats	• should be made of 100% cotton • aprons do not provide sufficient protection and therefore are not recommended • each student should purchase his/her own lab coat
Disposable Gloves	• should be available for students when handling corrosive chemicals, toxic chemical, biological stains, or potentially infectious material • Note: some disposable gloves offer no protection against some organic solvents

Safety Equipment for Science Classrooms/Labs

The teacher and students should be familiar with the location and the use of safety equipment. It is imperative that the equipment be checked at least twice a year and should be located for easy access. The following is a minimum list of required safety equipment items.

Equipment	**Comments**
Fire Extinguisher	• ABC type dry chemical
Fire Blanket with Wall Stand	• replace existing asbestos blankets with wool/rayon type • only to be used for smothering clothing fires
Eye Wash Station	• plumbed eye wash preferred
First Aid Kit	• minimum required contents
Emergency Shower	• should be readily accessible
Safety Goggles	• teachers and students must wear these whenever there is likelihood of eye injury
Face Shield	• to be worn by the teacher when previewing unfamiliar activities • used when mixing solutions
Safety Shield	• to be used when previewing an unfamiliar activity
Glass Disposal Container	• a metal pail or cardboard box labelled Abroken glass, handle with care@
Chemical Spill Kit	• sourcesCchemical supply companies • used for acid, base, organic solvent, and mercury spills
Chemical Resistant Rubber Gloves	• used for cleaning up spills or for handling corrosive or toxic chemicals • for use when handling preserved organisms
Lab Coats/Aprons	• should be worn in the lab and made of 100% cotton
Heat Resistant Gloves and Tongs	• for use when handling hot objects • gloves should be made of treated textures silica or woven fabric • do not use asbestos gloves
Fume Hood	• must have a minimum airflow (velocity) of 0.5 m/s • should be fitted with a sink • must be provided with adequate lighting (500B700 lux ambient lighting

	• all controls for its operation must be located outside the fume hood • must be connected to a common duct • must not re-circulate discharged air into the lab or other work areas • must be checked regularly to ensure proper working order • must have a working extractor fan • should be inspected regularly
Hand Washing Facilities	• should be in or near each science class/lab
Bentonite/Kitty Litter	• used for chemical spills
Dustpan and Brush	• for brushing up used sand, vermiculite and broken glass • wash and clean thoroughly after each use
Heavy Duty Garbage Bags	• for disposal of all solid waste • double bag if necessary • label bags and dispose of each spill separately
Locked Storage	• used for dangerous chemicals
Acid Storage Cabinet	• store acids as per shelf recommended with renting to outside
Rubber Transport Bucket	• used to transport bottles of concentrated acid
Flammables Storage Cabinet	
Master Propane Gas Control	

Eye Protection

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

The eye is probably the most vulnerable part of the body surface from an injury standpoint. It is easily damaged and because it has few blood vessels, injuries heal more slowly and may not fully recover.

Injury	**Comment**
Foreign Bodies	• the most common danger • particles lodge on the surface and become very irritating • sharp objects may penetrate deeply 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 penetrates into the eye tissue
Radiation	• ultraviolet, visible, infrared can cause damage if the intensity level is sufficiently high • lasers require special eye protection

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Appendix D: Regulations for Animal Experimentation

Preface

Regulations pertaining to projects involving animals and the display of those projects reflect different standards.

While students' investigations of biological processes are to be encouraged, they are subject to the same laws, ethics, and regulations as any other research.

In the *Criminal Code of Canada*, the *Animals for Research Act of Ontario*, and similar legislation in other provinces, all vertebrates are afforded protection. Also, schools and science fairs are explicitly included in the definition of "research facility" in Ontario. The regulations below are written in view of these laws.

The display of a project is further restricted by the YSF in view of the need to maintain a positive public image towards science fairs. The restriction is due to a lack of essential expertise on the part of the student investigators and their immediate supervisors. There is also a desire to maximize the efficiency of animal use and to impress this on the students, especially regarding scientific merit.

RSF's should adhere to the following regulations and take steps to ensure that schools within their region are familiar with them and conform to them in school fairs. The regulations must certainly be adhered to for the CWSF, so it would be in the best interests of all concerned if all guidelines were followed faithfully from the outset.

Regulations

Lower orders of life (bacteria, fungi, protozoa, insects, plants, and invertebrate animals) can be used in experimentation to reveal valuable biological information. Vertebrate animals (birds, fish, mammals, reptiles, amphibians) are not to be used in any active experiments which may be deleterious to the health, comfort, or physical integrity of the animals. This permits observation of wild animals, animals in zoological parks, farm animals, and pets.

Only animals acquired from biological supply may be used in "experiments". Animals from pet stores (or from one's own breeding program) cannot be used for these purposes.

Observation of wild animals falls within the definition of hunting in some jurisdictions. Students should obtain advice and permission from conservation authorities to ensure that they are not interfering with the animals' life, and to ensure that their project is permissible. A permit may be required.

Behavioural experiments with positive rewards are permissible only if the animal is not placed in a stress situation. Training an animal to travel through a maze to receive a food reward is stressful, particularly if the animal is hungry, and is therefore not permissible. However, allowing an animal to make a free choice (of food, for example) is permissible, so long as the animal is not stressed before offering the choice (e.g., by withholding food). Studies of chick embryos are similarly restricted to observation, without intervention with drugs or other chemicals, or manipulation of physical condition to test the resiliency of the animal. If eggs are hatched, the chicks must be reared normally. Otherwise all embryos must be destroyed by freezing by the 18th day of incubation.

Cells and animals parts (including organs, tissues, plasma, or serum) purchased or acquired from biological supply houses or research facilities may be used for science fair projects. Evidence of the source of the materials (e.g., bill of sale) must be used at the display. The acquisition of animal parts should involve either the services of biological supply houses or research facilities, or involve salvage from sources where the animal has been killed for other legitimate purposes in a legal and humane manner. Salvage from found carcasses (e.g., road kills) is discouraged due to serious health risks.

If the acquisition involves salvage from a research project, then the disposition of the science fair project must be pat of the original research proposal, and such disposition must have been approved by the Research Committee of the institution involved. Reference to the original project should be made on the science project display.

If the acquisition involves salvage from the food industry, then the source must be acknowledged. If the acquisition involves hunting, fishing, or trapping, then those activities must be done in accordance with prevailing regulations, and precautions must be taken to ensure the safety of the student(s). The taking of animals other than for food, without explicit approval, can constitute cruelty. Permits for research are available from conservation authorities.

Research involving human being must involve the principles of informed consent. No human tissues or fluids are to be used in the science fair project due to the associated ethics and possible health hazards.

Biological experimentation is subject to legal restrictions, among others:

- Criminal Code of Canada, Section 446 Cruelty to Animals
- Health of Animals Act, Bill C-66
- Animals for Research Act (Ontario)
- Regulations for Housing, Care and Treatment of Animals Used for Biological or Medical Purposes (Alberta)
- Guidelines of the Canadian Council on Animal Care.

Visiting projects from other countries should be informed of these regulations sufficiently before the fair so that they do not display projects contradictory to the Canadian regulations and milieu

Appendix E: Chemicals Used in Science Activities

The following table contains a list of the chemicals commonly used in science activities in New Brunswick (particularly at the high school level) and the hazards and handling precautions associated with their use. The codes used in the table to indicate toxicity, flammability, and reactivity are assigned in accordance with the Guidelines on Toxic and Hazardous Chemicals used in Educational Institutions, published by Health and Welfare Canada with some modification. These codes are explained below.

Toxicity

A toxic substance can interact chemically with the body to produce harm or injury. However, the severity of the injury depends upon several factors.

- the dosage
- the duration of frequency of exposure
- the route of exposure (e.g., inhalation, skin, mouth, and eyes)
- the chemical state of the substance

Several terms are used to report the level of toxcity of a substance.

Lethal Dose Fifty (LD50)

- The LD50 of a substance is the dose of the substance which causes death in half (50%) of a group of test animals exposed to the substance.
- The LD50 is usually reported in mg/kg of body weight of the animal.
- Species of animal tested, and route of exposure is included.
- The lower the value of LD50, the more toxic the substance.
- If the substance is a gas or vapour and the animal is exposed by inhalation, the Lethal Concentration Fifty (LC50) is often reported in ppm (parts per million)

Toxic Dose Fifty (TD50)

- The TD50 of a substance is the dose of the substance in milligrams of a substance per kilogram of body weight required to show a specific toxic effect in 50% of a group of test animals.
- If the substance is a gas or vapour, the TC50 may be reported as the concentration of the substance in air showing a toxic effect in 50% of a group of test animals.

Threshold Limit Values (TLV)

Although not given in the table below, exposure limits may be included in MSDS.

Threshold Limit Values (TLV)—permissible exposure limits.

- These are the maximum concentrations in air of a substance that most people may be exposed to by inhalation without suffering adverse effects.
- The time weighted average TLV covers a person for 8 hours a day for 5 days a week.
- The short term exposure limit TLV covers exposure to by inhalation for no longer than 15 minutes without harm if no more than 4 exposures a day occur.
- The ceiling TLV is the maximum concentration that must not be exceeded even briefly.
- The lower the values of TLV, the more dangerous the substance.

Rating	Hazard	Explanation
4	Extremely Dangerous	· oral LD50 value no higher thatn 50 mg/kg · dermal LD50 value no higher thatn 40 mg/kg · inhalation LC50 value less than 50 ppm over 4 hours · highly corrosive materials causing tissue damage after brief exposure to minimal amounts
3	Dangerous	· oral LD 50 value between 50 and 500 mg/kg · dermal LD 50 value between 40 and 200 mg/kg · inhalation LC 50 value between 50 and 200 ppm over 4 hours · corrosive materials causing tissue damage on splash contact
2	Caution	· oral LD 50 value between 500 and 2500mg/kg · dermal LD 50 between 500 and 2500 mg/kg · inhalation LC 50 value between 200 and 1000 ppm over 4 hours · corrosive materials causing tissue damage on extended contact (1 hour)
1	Low	· oral LD 50 value greater than 2500 mg/kg · dermal LD 50 value greater than 1000 mg/kg · inhalation LC 50 value greater than 1000 ppm over 4 hours · non-corrosive materials

Flammability

Flammability is defined as the lowest temperature at which a liquid gives off enough vapour to be ignited at the surface of the liquid. Flammable liquids have a flashpoint below 37.8° C while combustible liquids have a flashpoint between 37.8 and 93.3° C.

Rating	Hazard	Explanation
4	Extremely Dangerous	• flammable gases in air • liquids or solids with a flashpoint less than 0° C and boiling point less than 35°C • solids that can ignite spontaneously with air or moisture
3	Dangerous	• liquids or solids with a flashpoint between 0° C and 20° C
2	Caution	• liquids or solids with a flashpoint between 20° C and 50° C • solids which may be ignited readily by heat or flame
1	Low Hazard	• liquids or solids with flashpoints less than 100° C

Reactivity

Rating	Hazard	Explanation
4	Extremely Dangerous	• explode spontaneously • react vigorously with water • very strong oxidizing or reducing agents • monomers that may polymerize violently
3	Dangerous	• may explode if heated or detonated • reacts with water to produce heat or hazardous gases • strong oxidizing or reducing agents • deteriorate during storage
2	Caution	• oxidizing agents that react with combustible materials to produce explosive mixtures • undergo rapid exothermic reactions
1	Low Hazard	• materials with low reactivity

Storage

This section of table gives information about the storage hazard class to which each chemical belongs. The codes used are as follows:

- A—Acids (non-oxidizing)
- B—Aqueous solutions of bases
- D—Do not store - prepare or obtain as required
- F—Flammable and combustible materials
- G—Gases
- GI—General storage (inorganic chemicals)
- GO—General storage (organic chemicals)
- O—Oxidizing agents
- PD—Permanently sealed samples for display purposes
- R—Reducing agents
- S—Special storage

Disposal

This section of the table gives information about the disposal of each chemical. The codes used are as follows:

- A—Dilute aqueous solutions may be flushed down the drain with large amounts of water
- B—Solids in their original containers may be placed with garbage for disposal
- C—Package separately for disposal in a labelled container. Contact a disposal company or Department of the Environment for advice
- D—Place with non-halogenated organic solvents in a labelled container
- E—Place with halogentated organic solvents in a labelled container
- F—Permanently sealed samples for display purposes should be reused
- G—Return gas cylinders to supplier

Chemical Chart

Key T = Toxicity F = Flammability R = Reactivity S = Storage D = Disposal

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Acacia						• See gum arabic
Acetic acid Concentrated, glacial CH_3COOH	4	2	3	F	A, C	• Corrosive, flammable • Dilute solutions (such as vinegar) are less hazardous • Keep away from bases and oxidizing agents
Acetone, C_3H_6O	1	4	1	F	D	• Highly flammable, irritant • Keep away from oxidizing agents
Aluminum, Al (forms other than powder)	1	1	1	R	C, F	• Powdered form is highly reactive • Keep away from oxidizing agents, halogens and acids
Aluminum chloride, $AlCl_3$	2	1	2	GI	A, C	• Anhydrous compound is corrosive; reacts vigorously with water to produce corrosive and toxic acidic vapours • Hydrated compound is less hazardous
Aluminum sulfate, $Al_2(SO_4)_3$	1	1	1	GI	A, C	• Low hazard
Ammonia (ammonium hydroxide) concentrated, $NH_3(aq)$	3	1	3	B	C	• Corrosive; releases toxic ammonia gas • Keep away from acids, metals, halogens (reacts with halogens to produce highly explosive products)
Ammonium acetate NH_4CH_3COO	1	1	1	GI	A, B	• Low hazard • Keep away from strong oxidizing agents and acids
Ammonium chloride, NH_4Cl	2	2	2	GI	A, B	• Also called sal ammoniac • Causes skin and eye irritation • Keep away from acids, bases, silver and lead salts

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Ammonium dihydrogen phosphate, $NH_4H_2PO_4$	1	1	1	GI	A, B	• Also called monobasic ammonium phosphate • Low hazard
Ammonium hydrogen phosphate, NH_4HPO_4	1	1	1	GI	A, B	• Also called dibasic ammonium phosphate • Low hazard
Ammonium hydroxide						• See ammonia
Ammonium nitrate, NH_4NO_3	1	1	3	S	A, C	• Highly reactive & explosive if heated • Can explode at lower temperatures if contaminated • Keep away from oxidizing and reducing agents, metals and organic materials
Ammonium sulfate, $(NH_4)_2SO_4$	1	1	1	GI	C	• Low hazard
Antifreeze						• See antifreeze
Antimony, Sb (forms other than powder)	2	1	1	PD	C, F	• Toxic, flammable in powdered form • Keep away from oxidizing agents acids • Keep only as sealed sample for display
Baking soda						• See sodium hydrogen carbonate
Barium chloride, $BaCl_2$	3	1	1	GI	C	• Highly toxic • Keep away from acids, oxidizing agents
Barium nitrate, $Ba(NO_3)_2$	3	1	2	O	C	• Highly toxic, oxidizing agent • Keep away from reducing agents and organic and combustible materials
Basic Copper (II) carbonate						• See copper (II) carbonate, basic
Benedict's solution	2	1	1	GI	C	• Mixture of copper (II) sulfate, sodium carbonate and sodium citrate • Basic and corrosive
Benzoic acid, C_6H_5COOH	2	1	1	GO	C	• Low hazard • Keep away from bases, oxidizing and reducing agents

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Biuret reagent	2	1	1	GI	C	• Mixture of copper (II) sulfate and sodium hydroxide in water solution • Basic and corrosive
Bluestone						• See copper (II) sulfate
Bromothymol blue, $C_{27}H_{28}Br_2O_5S$	1	1	1	GO	A	• Low hazard if dilute solutions are used
1-Butanol, C_4H_9OH	2	2	1	F	D	• Flammable • Irritant • Keep away from oxidizing agents, reactive metals
Calcium, Ca	3	2	3	R	C	• Flammable • Reacts vigorously with water to produce flammable hydrogen gas • Keep away from water, acids, oxidizing agents
Calcium carbonate, $CaCO_3$	1	1	1	GI	B	• Also called limestone, chalk, marble chips • Reacts with acid to generate carbon dioxide gas
Calcium chloride, $CaCl_2$	2	1	1	GI	A, B	• Irritant • Low hazard
Calcium hydroxide, $Ca(OH)_2$	1	1	1	GI, B	A, C	• Also called slaked lime • Saturated $Ca(OH)_2$ is limewater • Irritant
Calcium nitrate, $Ca(NO_3)_2$	1	1	3	O	A, C	• Oxidizing agent • Keep away from reducing agents, organic materials and acids
Calcium oxide, CaO	3	1	3	GI	C	• Also called lime • Corrosive • Reacts vigorously with water • Keep away from water, acids
Calcium sulfate, $CaSO_4$	1	1	1	GI	B	• Also called gypsum, plaster • Low hazard • Keep away from aluminum powder

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Carbon, C (forms other than powder)	1	1	1	GI	B	• Also called graphite, charcoal • Powdered form is more reactive and is a fire hazard • Keep away from oxidizing agents
Carbon dioxide, CO_2	1	1	1	G	G	• Solid form is known as dry ice – very cold; will cause frostbite; handle with tongs or gloves
Chalk						• See calcium carbonate
Charcoal						• See carbon
Chlorine, Cl_2 (aqueous)	2	1	2	O	C	• Handle with care • Keep away from reducing agents, metals acids and bases
Chromium, Cr (forms other than powder)	1	1	1	PD		• Powdered form is a fire hazard • Keep away from acids and oxidizing agents • Keep permanently sealed; only for display
Citric acid, $C_6H_8O_7$	1	1	1	GO		• Low hazard • Keep away from acids, oxidizing and reducing agents
Cobalt (II) chloride, $CoCl_2$	2	1	1	GI	C,F	• Hexahydrate is less toxic than anhydrous
Cobalt (II) nitrate, $Co(NO_3)_2$	2	1	3	O	A, B	• Oxidizing agent • Keep away from reducing agents and organic material
Copper, Cu (forms other than powder)	1	1	1	GI	C	• Powdered form is a fire hazard
Copper (II)carbonate,basic, $CuCO_3.Cu(OH)_2$	3	1	1	GI	C	• Also called cupric carbonate, basic copper (II) carbonate • Toxic • Reacts with acids to produce CO_2 gas
Copper (II) chloride, $CuCl_2$	3	1	1	GI	C, F	• Also called cupric chloride • Toxic
Copper (II) nitrate,						• Also called cupric nitrate

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
$Cu(NO_3)_2$	2	1	3	O	C	• Oxidizing agent • Keep away from reducing agents and organic material
Copper (II) oxide, CuO	2	1	1	GI	C	• Also called cupric oxide • Keep away from reducing agents, metals
Copper (II) sulfate, $CuSO_4$	2	1	1	GI	C	• Also called bluestone, cupric sulfate • Toxic; irritant • Available as pentahydrate or anhydrous
Cream of tartar						• See potassium hydrogen tartrate
Cupric carbonate						• See copper (II) carbonate
Cupric chloride						• See copper (II) chloride
Cupric nitrate						• See copper (II) nitrate
Cupric oxide						• See copper (II) oxide
Cupric sulfate						• See copper (II) sulfate
Dextrose						• See glucose
Dry ice						• See carbon dioxide
Epsom salts						• See magnesium sulfate
Ethanol, C_2H_5OH	1	3	1	F	D	• Also called ethyl alcohol • Flammable • Denatured alcohol is poisonous • Keep away from oxidizing agents, metals and acids
Ethyl acetate, $CH_3COOC_2H_5$	1	4	1	F	D	• Highly flammable • Keep away from oxidizing agents
Ethyl alcohol						• See ethanol
Ethylene glycol, $C_2H_6O_2$	2	1	1	GO	D	• Also called antifreeze • Toxic if ingested • Keep away from oxidizing agents

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Ferric chloride						• See iron (III) chloride
Ferric nitrate						• See iron (III) nitrate
Ferric oxide						• See iron (III) oxide
Ferrous sulfate						• Iron (II) sulfate
Gelatin	1	1	1	GO	A, B	• Low hazard
Germanium, Ge	1	1	1	PD	C, F	• Powdered form is flammable • Keep away from oxidizing agents • Keep permanently sealed; only for display
Glucose, $C_6H_{12}O_6$	1	1	1	GO	A, B	• Also called dextrose • Low hazard
Glycerin						• See glycerol
Glycerol, $C_3H_8O_3$	1	1	1	GO	A	• Also called glycerin • Low hazard • Keep away from oxidizing agents as violent reactions can occur
Graphite						• See carbon
Gum Arabic	1	1	1	GO	C	• Also called acacia • Low hazard • Keep away from oxidizing agents
Gypsum						• See Calcium sulfate
Hydrochloric acid, concentrated, $HCl_{(aq)}$	3	1	3	A	A, C	• Also called muriatic acid • Corrosive • Keep away from bases, metals • Dilute solutions are less hazardous
Hydrogen (3%) Peroxide (30%)	1 4	1 1	1 4	O O	A C	• Oxidizing agent • Do not store 30% solutions in schools • Keep away from reducing agents, organic materials and metals

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Iodine	2	1	2	GI	C	• Corrosive • Irritating vapour • Keep away from metals, ammonia
Iron, Fe (forms other than powder)	1	1	1	GI	C	• Often in form of steel wool • Powdered form is a fire hazard • Keep away from oxidizing agents, acids, non-metals
Iron (III) chloride	2	1	1	GI	A, B	• Also called ferric chloride • Corrosive • Anhydrous compound reacts vigorously with water producing acidic vapours. • Keep away from oxidizing agents, alkali metals
Iron (III) nitrate, $Fe(NO_3)$	2	1	2	O	A, C	• Also called ferric nitrate • Oxidizing agent; irritant • Keep away from reducing agents, organic material
Iron (III) oxide, Fe_2O_3	1	1	1	GI	B	• Also called ferric oxide • Low hazard
Iron (II) sulfate, $FeSO_4$	2	1	1	GI	C	• Also called ferrous sulfate • Low hazard
Isopropanol						• See 2-propanol
Lead, Pb (forms other than powder)	2	1	1	GI	C	• Powdered form is a fire hazard • Chronic exposure can cause poisoning
Lead (II) nitrate, $Pb(NO_3)_2$	2	1	3	O	C	• Oxidizing agent • Chronic exposure can cause poisoning
Lead (II) oxide, PbO_2	2	1	1	GI	C	• Chronic exposure can cause poisoning
Lime						• See calcium oxide
Limestone						• See calcium carbonate
Limewater						• See calcium hydroxide

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Lithium, Li	4	4	4	R	C	• Flammable solid • Reacts with water forming flammable H_2 gas • Store under mineral oil • Keep away from air, water, oxidizing agents, acids
Lithium chloride, LiCl	2	1	1	GI	C	• Low hazard
Litmus	1	1	1	GO	A, B	• Low hazard
Lugol's Iodine Stain	2	1	1	GI	C	• This is a solution of iodine in water • Irritant • Keep away from metals, ammonia
Lye						• See sodium hydroxide
Magnesium, Mg (forms other than powder)	1	2	2	R	C	• Powdered form is highly reactive and flammable • Reacts with water to form flammable H_2 gas • Keep away from water, oxidizing agents and water
Magnesium sulfate, $MgSO_4$	1	1	1	GI	C	• Heptahydrate is called Epsom salts • Low hazard
Manganese dioxide						• See manganese (IV) oxide
Manganese (IV) oxide, MnO_2	2	1	2	S	C	• Also called manganese dioxide • Oxidizing agent • Keep away from other oxidizing agents, reducing agents, and organic material
Marble chips						• See calcium carbonate
Mercury, Hg	3	1	1	PD	C,F	• Vapour highly toxic • Keep away from oxidizing agents, metals, ammonia • Keep permanently sealed; only for display

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Methane, CH_4	1	4	1	G	G	• Flammable gas • Simple asphyxiant • Keep away from oxidizing agents
Methanol, CH_3OH	2	3	1	F	D	• Also called methyl alcohol; wood alcohol • Flammable • Toxic • Ingestion can cause blindness • Keep away from oxidizing agents and metals
Methyl alcohol						• See methanol
Methylene blue, $C_{16}H_{18}ClN_3S$	2	1	1	GO	A	• Dilute solutions are low hazard
Methylene chloride						• See dichloromethane
Mineral oil	1	1	1	GO	D	• Also called paraffin oil • Possibly carcinogenic if inhaled • Combustible • Keep away from oxidizing agents
Muriatic acid						• See hydrochloric acid
Nickel, Ni (forms other than powder)	2	1	1	GI	C, F	• Powdered form is a fire hazard and possible carcinogen • Keep away from oxidizing agents
Nickel (II) chloride, $NiCl_2$	2	1	1	GI	C	• Toxic • Irritant
Nickel (II) nitrate, $Ni(NO_3)_2$	2	1	3	O	C	• Oxidizing agent • Toxic • Keep away from reducing agents, organic material

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Nitric acid, concentrated, HNO_3	4	1	4	O	A, C	· Corrosive · Oxidizing agent · Dilute solutions are less hazardous but still require care · Keep away from reducing agents, organic aterials, metals
Nitrogen, N_2	1	1	1	G	G	· Simple asphyxiant · Liquid form is extremely cold; handle with insulated gloves
Oil of cloves	1	1	1	GO	D	· Low hazard
Paraffin oil						· See mineral oil
Phenolphthalein, $C_{20}H_{14}O_4$	2	1	1	GO	A, B	· Dilute solutions are low hazard
Phenyl 2-hydroxybenzoate, $C_{13}H_{10}O_3$	2	1	1	GO	C	· Also called salol, phenyl salicylate · Low hazard
Phenyl salicylate						· See phenyl 2-hydroxybenzoate
Phosphoric acid, concentrated, H_3PO_4	3	1	4	A	A,C	· Corrosive · Keep away from metals, bases
Phosphorus, red, P_4	2	2	2	GI	C	· Flammable solid · Toxic · Keep away from oxidizing agents, metals, organic materials and bases
Plaster						· See calcium sulfate
Potassium bitartrate						· See potassium hydrogen tartrate
Potassium bromide, KBr	1	1	1	GI	A,B	· Low hazard
Potassium chlorate, $KClO_3$	2	1	4	O	C	· Oxidizing agent · May form explosive mixtures with combustible material · Keep away from reducing agents, organic material, metals, non-metals,

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Potassium chloride, KCl	2	1	1	GI	A,B	• Low hazard
Potassium chromate, K_2CrO_4	2	1	4	O	C	• Oxidizing agent • Carcinogen • Keep away from reducing agents, organic material
Potassium dichromate, $K_2Cr_2O_7$	3		2	O	C	• Oxidizing agent • Carcinogen • Keep away from reducing agents, organic material
Potassium hydrogen tartrate, $KHC_4H_4O_6$	1	1	1	GO	A,B	• Also called potassium bitartrate, cream of tartar • Low hazard
Potassium iodide, KI	2	1	1	GI	C	• Low hazard • Keep away from oxidizing agents
Potassium nitrate, KNO_3	2	1	3	O	A,C	• Pxidizing agent • Can form explosive mixtures with combustible material • Keep away from reducing agents and organic material
Potassium permanganate, $KMnO_4$	2	1	3	O	C	• Oxidizing agent • Keep away from reducing agents, organic material, acids
Potassium thiocyanate, KSCN	2					• Toxic • Keep away from acids
Propane, C_3H_8	1	1	2	GI	C	• Flammable gas • Simple asphyxiant • Keep away from oxidizing agents
2-propanol, $(CH_3)_2CHOH$	2	4	1	G	G	• Also called isopropanol, rubbing alcohol • Flammable • Toxic if ingested • Keep away from oxidizing agents
Sal ammoniac		3	1	F	D	• See ammonium chloride

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Salol						• See phenyl 2-hydroxybenzoate
Sand						• See silicon dioxide
Scarlet red						• See Sudan IV
Silica gel						• See silicon dioxide
Silicon, Si (forms other than powder)	1	2	2	PD	C,F	• Powdered form is flammable • Keep away from oxidizing agents • Keep permanently sealed; only for display
Silicon dioxide, SiO_2	1	1	1	GI	B	• Also called silicon (IV) oxide, silica gel, sand • Finely powdered form can cause lung damage if inhaled
Silicon (IV) oxide						• See silicon dioxide
Silver, Ag (forms other than powder)	1	1	1	GI	C,F	• Powdered form is a fire hazard • Toxic by inhalation
Silver nitrate, $AgNO_3$	3	1	3	O	C	• Oxidizing agent • Toxic, corrosive • Keep away from reducing agents, organic material, ammonia
Slaked lime						• See calcium hydroxide
Sodium, Na	4	4	4	R	C	• Flammable solid • Reacts vigorously with water to produce flammable H_2 gas Can spontaneously ignite in moist air • Store under mineral oil away from air • Keep away from water, acids, oxidizing agents
Sodium acetate, CH_3COONa	1	1	1	GI	A,B	• Low hazard • Keep away from oxidizing agents
Sodium bicarbonate						• See sodium hydrogen carbonate
Sodium bisulfate						• See sodium hydrogen sulfate

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Sodium bromide, NaBr	1	1	1	GI	A,B	• Low hazard
Sodium carbonate, Na_2CO_3	2	1	2	GI	A,C	• Also called washing soda • Corrosive and basic . Reacts vigorously with acids to form CO_2
Sodium chloride, NaCl	1	1	1	GI	A,B	• Low hazard
Sodium chromate, Na_2CrO_4	2	1	2	O	C	• Oxidizing agent • Carcinogen • Keep away from reducing agents and organic material
Sodium dihydrogen phosphate, NaH_2PO_4	1	1	1	GI	A,B	• Also called sodium phosphate, monobasic • Low hazard
Sodium hydrogen carbonate, $NaHCO_3$	1	1	1	GI	A,B	• Also called sodium bicarbonate, baking soda • Low hazard • Reacts vigorously with acids to form CO_2
Sodium hydrogen phosphate, Na_2HPO_4	1	1	1	GI	A,B	• Also called sodium phosphate, dibasic • Low hazard
Sodium hydrogen sulfate, $NaHSO_4$	2	1	2	GI	A,C	• Also called sodium bisulfate • Acidic • Corrosive
Sodium hydroxide, NaOH	4	1	4	GI,B	A,C	• Also called lye • Highly corrosive • Keep away from acids, metals
Sodium iodide, NaI	1	1	1	GI	C	• Low hazard • Keep away from oxidizing agents
Sodium nitrate, $NaNO_3$	1	1	3	O	A,C	• Oxidizing agent • Can form explosive mixtures with combustible material • Keep away from reducing agents, organic materials and metals

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Sodium phosphate, Na_3PO_4	2	1	1	GI	A, B	• Also called sodium phosphate, tribasic; trisodium phosphate, TSP • Basic, corrosive
Sodium phosphate, monobasic						• See sodium dihydrogen phosphate
Sodium phosphate, dibasic						• See sodium hydrogen phosphate
Sodium phosphate, tribasic						• See sodium phosphate
Sodium sulfate, Na_2SO_4	1	1	1	GI	A,B	• Low hazard
Sodium sulfite, Na_2SO_3	2	1	2	GI	C	• Reducing agent • Reacts with acids to form toxic SO_2 gas • Keep away from oxidizing agents, acids
Sodium thiosulfate, $Na_2S_2O_3$	1	1	1	GI	A,B	• Low hazard • Reacts with acids to form toxic SO_2 gas
Stannous chloride						• See tin (II) chloride
Starch	1	1	1	GO	A,B	• Low hazard
Steel wool						• See iron
Strontium chloride, $SrCl_2$	2	1	1	GI	C	• Low hazard
Sucrose, $C_{12}H_{22}O_{11}$	1	1	1	GO	A,B	• Also called table sugar • Low hazard
Sulfur, S_8	1	2	1	GI	C	• Combustible solid • Keep away from oxidizing agents, reducing agents and metals
Sulfuric acid, concentrated, H_2SO_4	4	1	4	A	A,C	• Highly corrosive and reactive • Dilute solutions are less hazardous • Keep away from bases, reducing agents, organic material, metals, oxidizing agents
Table sugar						• See sucrose •

CHEMICAL	*T*	*F*	*R*	*S*	*D*	*COMMENTS*
Tartaric acid, $C_4H_6O_6$	1	1	1	GO	A,B	• Low hazard •
Tin, Sn (forms other than powder)	1	1	1	GI	C	• Powdered form is a fire hazard •
Tin (II) chloride, $SnCl_2$	2	1	2	GI	C	• Also called stannous chloride • Irritant • Keep away from reducing agents, oxidizing agents, metals
Toluidine blue, $C_{15}H_{16}ClN_3S$	2	1	1	GO	A	• Also called toluidine blue 0 • Dilute solutions are low hazard
1,1,1-Trichloroethane	1	1	1	GO	E	• Irritant • Keep away from metals, bases
1,1,2-Trichlorotrifluoroethane, $C_2Cl_3F_3$	1	1	1	GO	E	• Keep away from metals
Washing soda						• See sodium carbonate
Wood alcohol						• See methanol
Zinc, Zn (forms other than powder)	1	2	2	R	C	• Reducing agent • Powdered form is reactive • Mixtures with combustible materials may ignite in contact with moist air • Keep away from non-metals, oxidizing agents, acids, organic materials
Zinc nitrate, $Zn(NO_3)_2$	1	2	3	O	A, C	• Oxidizing agent • Keep away from reducing agents, organic material, non-metals
Zinc sulfate, $ZnSO_4$	2	1	1	GI	A, C	• Low hazard

Appendix E: Chemical Suppliers

Boreal Laboratories Ltd.
399 Vansickle road
St. Catharine's ON L2S 3T4
Phone: (800) 387-9393
Fax: (800) 668-9106
www.boreal.com

Carolina Biological Supply Company
PO Box 6010
Burlington NC USA 27216-6010
Phone: (800) 334-5551
Fax: (800) 222-7112
www.carolina.com

Central Scientific Company (CENCO)
401 Vansickle Road
St. Catharine's ON L2S 3T6
Phone: (800) 268-4355 or (905) 984-8800
Fax: (905) 984-5118
www.cenconet.com

Fisher Scientific
PO Box 4508, Station E
Ottawa ON K1S 5A9
Phone: (800) 267-3556 or (613) 228-0542
Fax: (800) 463-2996 or (613) 226-7658
E-mail: help@fishersci.ca
www.fishersci.ca

Northwest Scientific Supply Company
301-3060 Cedar Hill Road
PO Box 6100, LCD1
Victoria BC V8P 5L4
Phone: (800) 663-5890 or (250) 592-2438
Fax: (800) 797-5773 or (250) 592-1341
E-mail: service@newscience.com
www.newscience.com

Sargent Welch-Cenco
403 Vansickle Road
St. Catharine's ON L2S 3Z7
Phone: (800) 727-4368
Fax: (800) 676-2540

Wards
397 Vansickle Road
St. Catharine's ON L2S 3T5

Phone: (800) 387-7822
Fax: (905) 984-5952
www.wardsci.com

Bibliography

The references consulted in the preparation of this safety manual are listed below. To make finding desired information a little easier, the references are listed either as general references or as being relevant to a specific topic in the manual. This is not an exhaustive list, but can provide a starting point for further reading.

Aldrich Chemical Company, Inc. *Aldrich Catalog Handbook of Fine Chemicals*, 1990.

Annapolis Valley Regional School Board, *Science Safety Manual for Science Teachers*. (http://sfiden.ednet.ns.ca/SFIden/SWAP/sciSM.html)

Armour, M.A. *Hazardous Laboratory Chemicals disposal Guide*. CRC Press. Boca Raton, Florida: 1991.

Bretherick, L., London; Butterworths. *Handbook of Reactive Chemical Hazards, 4th edition*. 1990.

Canadian Centre for Occupational Health and Safety. *Quantities and Units of Ionizing Radiation*. 1999. (http://www.ccohs.ca/oshanswers/phys_agents/ionizing.html)

Canadian Centre for Occupational Health and Safety. "Contact Lenses in the Workplace: The Pros and Cons." (June 29, 2000) (http://www.ccohs.ca/oshanswers/prevention/contact_len.html)

Canadian Centre for Occupational Health and Safety. "Emergency Showers and Eyewash Stations" (http://www.ccohs.ca/oshanswers/safety_haz/emer_showers.html)

Canadian Centre for Occupational Health and Safety. *How To Work Safely With Corrosive Liquids and Solids*. 1998. (http://ccohs.ca/oshanswers/prevention/corrosil.html).

Canadian Centre for Occupational Health and Safety. *How To Work Safely With Oxidizing Liquids and Solids*. 1998. (http://ccohs.ca/oshanswers/prevention/oxodozong.html).

Canadian Centre for Occupational Health and Safety. *WHMIS and WHMIS Labeling Requirements*. 1999. (http://www.ccohs.ca/oshanswers/legisl/msds_lab.html)

Canadian Centre for Occupational Health and Safety. *School Workers Health and Safety Guide*. (http://www.ccohs.ca/products/publications/school.html).

Canadian Red Cross Society, The. *First Aid, Eighteenth Edition*.1998.

Canadian red Cross Society, The. *First Aid: the Vital Link: Mosby Lifeline*. 1994.

Canadian Centre for Occupational Health and Safety. *WHMIS General Information*. 2000. (http://www.ccohs.ca/oshanswers/legisl/intro_whmis.html)

Canadian Centre for Occupational Health and Safety. *WHMIS Classification*. 1999. (http://www.ccohs.ca/oshanswers/legisl/whmis_classifi.html)

Canadian Centre for Occupational Health and Safety. *What Makes Chemicals Poisonous?.* 1997. (http://ccohs.ca/oshanswers/chemicals/chemical.htm)

Canadian Centre for Occupational Health and Safety. *How To Work Safely with Flammable and Combustible Materials.*1998 (http://ccohs.ca/oshanswers/prevention/flammable_general.html).

Chemical Inventory Control-An anointed Lists of Chemicals for Use in Education, N. Holbach, Consultants Ltd., August, 1990

Chemical Institute of Canada, The. Laboratory Safety Handbook and Ordre des Chimistes du Quebec., 1987.

Chemical Reactivity Worksheet, The. http://response.restoration.noaa.gov/chemaids/react.html.

Environmental Health Directorate, Health Protection Branch, Health and Welfare Canada *Guidelines on Toxic and Hazardous Chemicals Used in Educational Institutions*.1980.

"Fire Prevention and Life safety Code Guidelines for Schools." Fire Commissioner's Bulletin #12.

"First Aid Regulations, Regulations Made Pursuant to the Occupational Health and Safety Act." Statutes of Nova Scotia: 1997.

Fisher Scientific. *The Fisher Scientific Catalogue*, 2000.

Flinn Scientific, Inc. *The Flinn Chemical Catalogue/Reference Manual*, 1998

Furr, A. Keith, Ed. "The Chemical Rubber Co." *CRC Handbook of Laboratory Safety, 4th Edition,* (1995)

Gerlovich, J.A., T.F. Gerard, and K.A. Hartman. *Science, Safety, and the Law*. 1991.

Everett, K. and E.W. Jenkins, and John Murray. *A Safety Handbook for Science Teachers, Second Edition*. London: 1991.

Government of Newfoundland and Labrador. *Fire Emergency Manual*.

Halifax Regional School Board. *A Safety Manual for Science Teachers*. Halifax: 1997.

Halton D.M. "How Workplace Chemicals Enter The Body". *Canadian Centre for Occupational Health and Safety Bulletin*. 1997. (http://ccohs.ca/oshanswers/chemicals/chemical.htm).

Health and Safety Division, Newfoundland Department of Environment and Labour. "The Workplace Hazardous Materials Information System Regulations (WHMIS)." *Occupational Health and Safety Act*. 1988.

J.A. Young, Ed. *Improving Safety in the Chemical Laboratory: A Practical Guide.* Toronto: John Wiley and Sons, 1991.

Kaufman, James A. *Waste Disposal in Academic Institutions*, Chelsea, Michigan: Lewis Publishers, 1990.

Lenga, R.E., Ed. *The Sigma-Aldrich Library of Chemical Safety Data, Second Edition Volumes I, II*. Sigma-Aldrich Corporation. 1998.

Lunn, George and Eric B. Sansone*. Destruction of Hazardous Chemicals in the Laboratory*. Toronto: John Wiley and Sons, Inc., 1990.

Lunn, George and Eric B. Sansone. *Destruction of Hazardous Chemicals in the Laboratory, Second edition*. Toronto: John Wiley and Sons, Inc., 1990.

Manitoba Education and Training. *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions*. 1997

National Research Council of Canada. *National Fire Code of Canada*. 1990

National Science Teachers Association. *Safety in the Elementary Science Classroom*. 1993.

Occupational Health and Safety Act, 1997.

Phillips, John S., Victor S. Strozak, and Cheryl Wistrom. *Chemistry: Concepts and Applications*. Glencoe/McGraw-Hill, 1997.

Pipitone, D.A. *Safe Storage of Laboratory Chemicals*. John Wiley and Sons, Inc.: 1984.

Pitt, M.J. *Handbook of Laboratory Waste Disposal*, Ellis Horwood Limited, 1985.

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, Washington, D.C.: National Academy Press, 1995.

Richard G.W. and S. Saint-Laurent. *A Guide To The Handling and Disposal of Hazardous Substances in the Schools, Second Edition*. Gouvemement du Quebec, Ministre de l'Education, 1991.

Roman Catholic School Board for the Burin Peninsula. *Laboratory Safety Manual.* 1990.

Sax, N.I. and R.J. Jewis, Sr., van Nostrand Reinhold*. Dangerous Properties of Industrial Materials, Seventh Edition*. 1989.

Susan Budavari, Marydale, J. O'Neill, Ann Smith, Patricia E. Heclelman, Joanne F. Kinneary, Eds. *The Merck Index, An Encyclopedia of Chemicals, Drugs and Biologicals, Twelth Edition*. Merck and Co. Inc., 1996.

“Workplace Hazardous Materials Information System Regulations (WHMIS), Regulations Made Pursuant to the Occupational Health and Safety Act” Statutes of Nova Scotia: 1996.