Science and Safety

A Kindergarten to Grade 12
Resource Manual for Teachers,
Schools, and School Divisions

Manitoba

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Schools are encouraged to share this document with parents, guardians, and communities, as appropriate.

Any websites referenced in this document are subject to change. Educators are advised to preview and evaluate websites and online resources before recommending them for student use.

Print copies of this resource can be purchased from the Manitoba Text Book Bureau (stock number 80693). Order online at <www.mtbb.mb.ca>.

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Introduction

Hands-on activities are a fundamental part of science learning. Teaching science requires students' active involvement in developing safe and efficient procedures for conducting investigations. In the Early Years, students' exploratory activities with materials provide one of the key starting points for their concept and skill development. As students progress in school science, there is a natural increase in the sophistication of their investigations. Over time, students learn the techniques of controlled investigation and experimentation and, through practice, develop the skills of scientific inquiry and problem solving. Laboratory activities, carefully developed, can provide important connections for understanding the nature of science, the wide variety of creative ways in which science is conducted, and the interplay of evidence and theory.

The challenge for schools is to offer science activities that are simultaneously educationally rewarding, philosophically valid, and safe. These desired results can only be achieved through a team effort involving all of those who set and administer school policies, design and maintain the learning environment, plan and deliver science lessons, and select and prepare the materials used.

The goal of this K–12 science safety resource is to bring together information needed by administrators, planners, teachers, and support staff to help them make sound decisions regarding science safety. The document identifies areas for decision making and action at a variety of levels. It supports planning and action by providing information on safety legislation and standards, safety hazards, and examples of procedures for eliminating or minimizing hazards.

The materials in this safety resource have been compiled from sources believed to be reliable and accurate and to represent the best of current thinking on the subject. This resource is intended to serve as an informative source for planning good practices, but does not claim to provide the level of technical detail that some users may require, or to have anticipated every circumstance where safety may be a factor.

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Science and Safety

Part A: General Safety Management

CHAPTER 1: STARTING POINTS FOR PLANNING AND POLICY SETTING

Overview

This chapter sets the stage for safety planning for science classrooms. It outlines the roles of key stakeholders and lists sample actions that are appropriate to these roles. It also summarizes legislative requirements that affect planning for science safety and, finally, it provides general guidelines for promoting safety.

Due Diligence: An Approach to Science Safety

A first step in planning for science safety is to become aware of the potential hazards that science activities may present. Further steps focus on minimizing risks by taking reasonable safety precautions—in other words, by acting with due diligence.

In a legal context, due diligence means taking all reasonable steps to prevent accidents and injuries, thus avoiding the assumption of legal liability. However, due diligence is more than just a legal concept; it is a positive approach to avoiding accidents and injuries by identifying possible hazards, planning precautionary actions, and fulfilling one's responsibilities. This more general definition provides a common-sense starting point for safety planning.

Principals, administrators, teachers, and other staff can demonstrate due diligence by taking action in the following three key areas:

- ensuring <u>awareness</u> of potential risks and the related safety regulations
- ensuring <u>staff competency</u> in meeting these regulations, thereby avoiding unnecessary risk
- implementing <u>monitoring and compliance strategies</u> to ensure that regulations are met

Awareness of Legislated Safety Requirements

Principals, administrators, teachers, and other personnel need to know about the legislated requirements that apply to science courses offered in their schools. It is important to know about these regulations not only because they are legal obligations, but also because they help educators to better understand potential risks and the preventative measures that can be taken. Relevant legislation and requirements are summarized in this chapter inasmuch as they relate to safe practices in the science classroom.

Staff Competency

As outlined in the Manitoba Teachers' Society (MTS) Teachers Code of Conduct and the *Workplace Safety and Health Act and Regulations*, it is essential that teachers and other staff who perform potentially dangerous tasks are competent to handle these tasks. Competency means being aware of risks and being properly trained in relevant procedures. One of the legal responsibilities of administrators is to develop and implement plans to provide staff with this knowledge and training.

Evidence of staff competency may be required by provincial inspectors from the Department of Family Services and Labour.

Monitoring and Compliance

The third area of due diligence involves monitoring work environments and activities to ensure compliance with health and safety legislation. For principals and administrators, this means monitoring their schools or work sites to make sure that staff comply with legislation and work in a safe and healthy manner. For teachers and other staff, it means identifying and following safe procedures, and reporting situations that create potential risks.

Monitoring and compliance can be supported by

- discussing safety at staff meetings
- regularly reviewing plans, practices, and responsibilities related to science safety
- developing processes to keep staff aware of changes in legislation
- communicating regularly and sharing information on safety issues (e.g., if an individual encounters a problem with a piece of equipment, he or she makes others in the school and school division aware of the problem)
- evaluating unusual activities for safety considerations, and dealing with any health and safety issues before the activity begins
- reporting any violations of legislative requirements or divisional policy, using appropriate procedures
- giving regular attention to the following areas in planning:
    - *Emergency preparedness*: Are plans updated as required to reflect changes? Is student emergency contact information current? Are drills conducted regularly?
    - *Hazard identification and control:* Are hazards identified, evaluated, and dealt with appropriately? Are inspections conducted regularly? Are recommendations dealt with promptly?
    - *Accident/incident reporting and investigation:* Are all accidents reported to the appropriate authorities as required? Has a near-miss incident-reporting system been set up, and is it working effectively? Have

incident statistics been analyzed and are appropriate actions being taken in response?

- *Environmental protection:* Are all releases (leaks or spills) being reported? Is hazardous waste being properly identified, stored, and disposed of from the school?
- *Safe work practices:* Are safe operating procedures in place or being developed for hazardous activities? Are staff trained in these procedures? Are Material Safety Data Sheets accessible to staff in electronic and/or hard copy format?
- *Training:* Are all new staff given safety orientation training? Are existing staff members trained as necessary? Are training records kept?

Key Players: Roles and Recommended Actions

Responsibility for ensuring safety in the science classroom is shared by many members of the educational system, including the following:

- Government
- Universities and colleges
- School boards and superintendents
- School administrators
- Science teachers
- Science laboratory technicians
- Science students
- Parents

Individuals in each of these groups have roles to play in promoting safety in the science classroom. Sample role statements and recommended actions to fulfill each role are described below. Roles frequently overlap and need to be aligned with local circumstances. For example, some schools employ science laboratory technicians to help teachers prepare materials for laboratory activities, whereas, in other schools, materials preparation is done directly by the teacher. Whatever the staffing pattern may be, it is up to everyone involved to work together as a team to ensure that responsibilities are determined, understood, and fulfilled.

Government

Role: Make safety information available to Manitoba schools.

Responsibilities

- Develop and/or authorize resources that offer information and guidelines on safety in science classrooms and laboratories.

- Periodically update authorized science safety resources.
- Provide information sessions to highlight safety roles, strategies, and resources.

Universities and Colleges

Role: Make safety information available to education students who take courses in science curriculum and instruction.

Responsibilities

- Include safety knowledge and skills into curriculum and instruction courses delivered to students prior to their participation in classroom practicum.

School Boards and Superintendents

Role: Provide leadership and resources to support science safety.

Responsibilities

- Develop safety policies and procedures consistent with current legislated requirements, and facilitate the implementation of these policies.
- Ensure that school and divisional staff carry out their safety responsibilities.
- Provide training and support to ensure staff competency.
  - Ensure that each school has staff trained in first aid and emergency care.
  - Ensure that staff is trained in the Workplace Hazardous Materials Information System (WHMIS).
  - Ensure that staff, as required, is trained in Transportation of Dangerous Goods (TDG).
- Make staff assignments that support the safe operation of science facilities on an ongoing basis (e.g., by assignment of science department heads or science laboratory technicians).
- Establish a system to monitor the effectiveness of safety policies and practices in their schools.
- Establish a system to periodically assess the adequacy of science facilities and safety equipment in each school, and provide for their ongoing maintenance.
- Make provisions for the safety of students with special needs or language difficulties.

School Administrators

Role: Ensure safe policies and practices are in place at the school level, and support teachers in providing a safe working environment.

Responsibilities

- Ensure that staff have required safety training and expertise.
- Ensure that teachers and substitute/supply teachers of science have the expertise to teach the assigned curriculum safely.
- Ensure that staff who handle hazardous materials and prepare laboratories have the expertise to do so safely.
- Enable teachers and laboratory technicians to obtain training in science safety—in particular, to become familiar with the *Manitoba Workplace Safety and Health Act and Regulations* to meet the requirements of the Workplace Hazardous Materials Information System (WHMIS) and the *Transportation of Dangerous Goods Act*.
- Ensure proper disposal of chemical and organic wastes, in accordance with provincial regulations and local bylaws.
- In setting policies and practices for school organization, give consideration to
  - the number of students per science class
  - classroom size and facilities
  - curricular requirements
- Ensure that facilities used for science activities are safe and appropriate for the activities carried out in them, and that necessary safety equipment is available. (See the Safety Equipment and Supplies (on page 47) of Chapter 4 for further information.)
- Implement and maintain safe storage and waste disposal systems for hazardous substances used or produced in the school.
- Ensure that procedures are in place for hazard reporting, and that all safety concerns regarding facilities, equipment, and procedures are addressed.
- Ensure that schools have effective policies and practices to follow in case of accidents and emergencies.
- Maintain accurate records of accidents and first aid treatments provided, report accidents as required by the *Workplace Health and Safety Act*, and document near-misses.
- Cooperate with outside personnel and agencies in promoting science safety (e.g., local fire marshal, Manitoba Department of Family Services, and Department of Labour and Immigration).
- Stop any practices that jeopardize student or staff safety.
- Provide for the safety of students with special needs or language difficulties.

- Support and implement disciplinary measures to ensure safety in science classes.
- Ensure the school follows safety regulations and procedures.

Science Teachers

Role: Plan and prepare learning activities with a view to safety, and model and supervise safe practices in the science classroom/laboratory.

Responsibilities

- Make prudent decisions regarding the selection of laboratory activities, taking into account the learning environment, the knowledge and skills of the students, and the teacher's knowledge, expertise, and training to conduct activities in a safe and effective manner.
- Provide safety guidelines or lessons to students at the beginning of each year, term, or course. Outline students' roles and actions in maintaining classroom safety, and the location and use of safety equipment, and, where appropriate, obtain written confirmation from students that these responsibilities are understood and accepted. (See Appendix A for a sample safety contract for elementary students and for secondary students.)
- Explain and model safety procedures for each learning activity (e.g., the correct use of lab apparatus, safe handling of reagents/solutions, and reminders to students of their roles in a safe learning environment).
- Monitor students and correct behaviour that jeopardizes safety.
- Implement safety regulations specified by Board policy and relevant legislation.
- Maintain a confidential list of students with any physiological (e.g., allergies, asthma) or physical disabilities. Use a buddy system or other system for those with special needs.
- Contribute to developing and implementing a school laboratory safety policy and procedures.
- Be familiar with the location and use of safety equipment and the location of main gas valves and electrical breakers.
- Report any defects in science equipment, facilities, or practices to the school administrator responsible for safety.
- Verbally report any injuries or accidents to the school principal immediately, followed by a written report. Written reports of accidents are required under the *Workplace Health and Safety Act*. A recommended practice (but not legal requirement) is to document near-misses so that colleagues can avoid similar situations.
- Participate in health and safety training provided by the employer.

- Be trained in WHMIS if handling chemicals. (If responsibilities include shipping and/or receiving chemicals, Transportation of Dangerous Goods (TDG) training is required.)
- Inform administration when work conditions or responsibilities have changed and additional training is required.
- Take on roles and responsibilities of a science technician that have not been designated to someone else.

Science Laboratory Technicians

This section applies to staff who may have a variety of related titles, such as laboratory aid, laboratory assistant, or laboratory technician.

Role: In general terms, their responsibility is to assist in the preparation of science laboratory materials as requested by teachers for specific laboratory activities. However, their role may also include promoting and maintaining safety standards in laboratory and classroom activities, managing chemical inventories in accordance with WHMIS and other regulations, and ensuring that all science and safety equipment is in good condition.

Recommended Actions

- Maintain laboratory safety equipment and ensure it is accessible.
- Ensure all science equipment is in good working condition and report equipment that needs repair or replacement.
- Identify, document, and inform teachers of safety problems related to specific lab activities, and adapt activities when necessary to eliminate problems while still meeting curriculum goals.
- Follow WHMIS and TDG regulations when dealing with chemicals, organic materials, and waste.
- Conduct a yearly chemical inventory, ensuring Materials Safety Data Sheets (MSDS) are current, and submit the inventory to the school's designated person responsible for hazardous materials.
- Ensure proper disposal of chemical/organic wastes in accordance with the *Environment Act, Canada Water Act*, and local bylaws.
- Work with the science curriculum leader to promote safe procedures and maintain safety standards in all science activities.
- Keep safety in the forefront within the science department through meetings, articles, posters, and other methods.

Science Students

Role: Support safety in the science classroom by acting responsibly and knowing how to respond to unsafe situations and emergencies.

Recommended Actions

- Inform the teacher of health concerns and circumstances that could affect personal safety (e.g., allergies, medications, use of contact lenses).
- Come to the laboratory appropriately dressed for lab work (e.g., closed shoes, long hair tied back, secured clothing or jewellery).
- Wear safety equipment as required.
- Learn about the hazards posed by materials and equipment to be used in each activity, and about procedures to be used and/or avoided.
- Learn about the location and use of safety equipment.
- Follow all safety procedures and instructions, and act in a way that shows concern for everyone's safety.
- Begin activities only with the teacher's permission.
- Report unsafe situations or accidents to the teacher immediately.
- Dispose of all chemicals, specimens, and other materials as instructed by the teacher.
- Wash hands thoroughly after each experiment.

Parents

Role: Support the school's efforts to provide safety in the classroom laboratory.

Recommended Actions

- Inform the school about relevant student medical conditions (e.g., latex allergy).
- At home, model safe handling of household cleaners, correct use of lawn and garden equipment, the proper disposal of waste materials, and other habits that transfer well to the school science learning environment.

Legislated Requirements

The following sections highlight some important elements of key legislation as they relate to science safety, and outline how teachers, administrators, and other staff can meet these requirements (listed by category).

Note: The information provided in this section was current as of April 2013.

Many aspects of school safety are governed by more than one piece of legislation. For example:

- The "maximum permissible occupancy load" of science laboratories and classrooms is regulated by the *Manitoba Fire Code*, which refers back to the *Manitoba Building Code* for base figures on "occupancy load."

- The use of chemicals is regulated under the *Workplace Safety and Health Act*, *the Hazardous Products Act*, and the *Transportation of Dangerous Goods Act and Regulations*. Additional aspects of chemical safety are regulated by the *Canada Water Act*, R.S.C. 1985, c. C-11, and may be further regulated by municipal sewer and solid waste bylaws.

Fire and Building Codes

The Fires Prevention and Emergency Response Act and Regulations
http://web2.gov.mb.ca/laws/statutes/ccsm/f080e.php

This Manitoba Act provides regulatory information about the following:

- fire investigations and fire safety inspections (e.g., public schools must have a fire inspection in each three-year period of occupation)
- emergency and disaster response
- standards for building designs, equipment, and procedures required to minimize risk of fire and enable safe exit of occupants when fire occurs

The Manitoba Fire Code (available online at <http://web2.gov.mb.ca/laws/regs/pdf/f080-155.11.pdf>) is part of the regulations that fall under the *Fires Prevention and Emergency Response Act*. The *National Fire Code of Canada 2010* was adopted as the fire code for Manitoba. Particular sections of the code provide standards for

- fire protection equipment, including emergency lighting, sprinkler systems, fire extinguishers, and smoke alarms installation
- emergency procedures, fire drills, and fire department access
- required fire doors and hallways separation
- ventilation systems and strategies
- maximum permissible occupant load
- responsibilities of architects and professional engineers involved in building design

Factors used in determining the maximum permissible occupant load of a science room or laboratory include the type of use of the room, the room layout, the number and location of exits, and the size and location of furnishings. For advice on the maximum permissible occupant (student) load of a particular science facility, please request an evaluation by your local fire marshal or his or her designate.

The Buildings and Mobile Homes Act and Regulations
http://web2.gov.mb.ca/laws/statutes/ccsm/b093e.php

The Manitoba Building Code, 2011 (available online at <http://web2.gov.mb.ca/laws/regs/pdf/b093-031.11.pdf>) is part of the regulations that fall under The *Buildings and Mobile Homes Act*. The *National Building Code of Canada 2010* was adopted as the building code for Manitoba. It outlines standards for the design, construction, and alteration of buildings in order to ensure the safety of occupants. Particular sections of the code provide standards for

- fire safety systems
- electrical wiring
- proper ventilation
- barrier-free travel paths in high-hazard occupancy areas
- emergency routes and lighting of these routes

Occupational Requirements

The Manitoba Labour Relations Act, 2011
http://web2.gov.mb.ca/laws/statutes/ccsm/l010e.php

In cases of a Labour Board inquiry into employment conditions, this Act gives the board, a mediator, or an officer of the board authorized for that purpose the right of entry to inspect the school premises, interrogate employees, view any active work, materials, machinery, appliances, and, where warranted, examine school records relating to safety inspections, fire drills, and staff training programs.

The Workplace Safety and Health Act (2010) and Regulations

The *Workplace Safety and Health Act and Regulations* was established to ensure reasonable levels of health and safety in the workplace. The regulations deal with chemical hazards and harmful substances, hazard assessment, first aid, emergency preparedness, fire and explosion hazards, personal protective equipment, and ventilation. Manitoba's Workplace Safety and Health Division is responsible for the administration of the *Workplace Safety and Health Act and Regulations,* helping to keep the province's workers committed to a safe environment on the job. This division focuses on eliminating both workplace and public hazards through preventive measures such as education, training, cooperation, and investigations and inspections.

This Act has extensive implications for both employers and employees (the latter are referred to as "workers" in the Act). Note that Manitoba legislation does not explicitly consider students to be workers under this legislation except for those serving in a recognized apprenticeship program or off-campus work experience programs.

According to the Act:

- The employer is responsible for the health, safety, and welfare of workers on the job.
- The employer must provide information on and control hazards, and establish a written occupational health and safety program where 20 or more workers are regularly working.

- Employees must take steps to protect their own health and safety and the health and safety of their co-workers; for instance, when the nature of the work requires it, use all devices and wear all articles of clothing and personal protective equipment designated and provided by the employer for this protection in the workplace.
- Employees (such as teachers in schools) have rights and responsibilities under the Act to
  - have knowledge about workplace hazards
  - participate in the health and safety committee and its activities
  - refuse work if they believe on reasonable grounds that the work may endanger the worker or others
- Suppliers must supply written instructions (e.g., MSDS information) and ensure that the biological or chemical products they supply are safe for use in the workplace when used according to the instructions provided by the supplier.

The following sections of the *Workplace Safety and Health Regulations* in Manitoba are particularly relevant for science classrooms and the science laboratory environment:

Part 4 – General Workplace Requirements

- An employer must ensure that a worker does not eat or drink in a part of a workplace that is, or may be, contaminated by a hazardous substance.

Part 5 – First Aid

- Employers are to maintain first aid equipment, supplies, and access to safety services.
- This section also specifies contents of first aid kits.

Part 6 – Personal Protective Equipment

An employer must ensure

- that workers wear and use personal protective equipment when exposed to any risk of injury
- that the protective equipment be provided to workers at no cost and immediately repaired or replaced if it is defective or contaminated with a hazardous substance
- that safe work procedures for the use of protective equipment be developed by the employer

Note: See Chapter 4 for more details on personal protective equipment

Part 21 – Emergency Washing Facilities

- An employer must provide emergency washing facilities at a workplace where hazardous, irritating, or corrosive substances are used.
- The emergency washing equipment provided must meet the requirements and be installed, tested, and maintained in accordance with ANSI Standard Z358.1-4 and the equipment manufacturer's specifications.

Part 35 – Workplace Hazardous Materials Information Systems (WHMIS)

The WHMIS system

- acts to inform people of the hazards of materials they might be (or are) handling in the workplace and thereby allowing them to minimize risks
- provides information for controlled or regulated chemicals with higher inherent risks
- specifies standards for the following:
  - labelling of chemicals: Labels alerting the user to hazards of the product and precautions for safe use are mandatory for controlled products.
  - Materials Safety Data Sheet (MSDS): The MSDS provides extensive information about the product, including potential hazards, health effects, proper handling, and disposal. By regulation in Manitoba, the MSDS must be provided by the supplier with any substance covered under WHMIS.
  - WHMIS training and education: Knowledge about potential hazards and safety procedures is mandatory for teachers, laboratory technicians, or any other person working with or near controlled products. An employer must ensure that workers are trained about the safety and health hazards associated with the controlled products in their workplaces. The training program must be workplace-specific and effective, and it is recommended that such training be reviewed annually.

Although the WHMIS requirements are not well defined with respect to students, this is not the case when it comes to school staff and school divisions. School staff are bound by the WHMIS requirements as workers and as supervisors.

Each school division is bound by the regulations in the *Workplace Health and Safety Act and Regulations* that apply to the duties of employers in Manitoba. This means, among other things, that **science teachers and other school staff who work with potentially hazardous materials must be WHMIS trained**. This training would typically be provided by the employer to enable the employee to

- recognize risks of controlled products they are handling
- learn how to safely handle these materials
- know where the Materials Safety Data Sheets (MSDS) are filed and how to use the information on them
- apply proper labelling to containers holding controlled products

See Chapter 5 of this document for additional details on WHMIS, MSDS, and labelling of chemicals.

Part 36 – Chemical and Biological Substances

Employers must ensure the safety and health of workers who use, produce, store, handle, and dispose of chemical or biological substances in the workplace. As well, employers must develop and implement safe work procedures for chemical or biological substances that create or may create a risk to the safety or health of a worker.

Resources

Workplace Safety and Health

The following resources, which are available for download at the Safe Work Manitoba website, provide more specific information about Workplace Safety and Health Regulations.

- *The Workplace Safety and Health Act, 2010*
  http://web2.gov.mb.ca/laws/statutes/ccsm/w210e.php
- *The Manitoba Safety and Health Regulation, 2006*
  http://web2.gov.mb.ca/laws/regs/pdf/w210-217.06.pdf
- *Your Responsibilities for Safety and Health in the Workplace*
  http://safemanitoba.com/uploads/bulletins/bltn_201.pdf
- *Safe Work and the Supervisor, Responsibilities*
  http://safemanitoba.com/uploads/bulletins/bltn230_nov_2010.pdf
- *Worker Rights and Responsibilities*
  http://safemanitoba.com/uploads/bulletins/bltn231_nov_2010.pdf
- *Elements of a Workplace Safety and Health Program*
  http://safemanitoba.com/uploads/elements.pdf
- *WHMIS Guidelines*
  http://safemanitoba.com/uploads/guidelines/whmis.pdf
- *Workplace Safety and Health Regulation – Part 05 – First Aid*
  http://safemanitoba.com/uploads/regulations/part5.pdf
- *Emergency Washing Facilities*
  http://safemanitoba.com/uploads/bulletins/bltn104.pdf

- *Workplace Safety and Health Regulation – Part 06 – Personal Protective Equipment*
  http://safemanitoba.com/uploads/regulations/summary_part6___july_2011.pdf
- *Workplace Safety and Health Regulation – Part 36 – Chemical and Biological*
  http://safemanitoba.com/uploads/regulations/part36.pdf
- *Workplace Safety and Health Regulation – Part 35 – Workplace Hazardous Materials Information System*
  http://safemanitoba.com/uploads/regulations/part35.pdf

The Manitoba Labour Relations Act, 2011
http://web2.gov.mb.ca/laws/statutes/ccsm/l010e.php

In cases of a Labour Board inquiry into employment conditions, this Act gives the following to the board, a mediator, or an officer of the board authorized for that purpose: the right of entry to inspect the school premises, to interrogate employees, to view any active work, materials, machinery, appliances, and, where warranted, to examine school records relating to safety inspections, fire drills and staff training programs

A Guide to the *Labour Relations Act*
www.gov.mb.ca/labour/labbrd/pdf/lra_guide.pdf

The Public Schools Act of Manitoba, 2013
http://web2.gov.mb.ca/laws/statutes/ccsm/p250e.php

The *Public Schools Act* indicates the following responsibility for the care of students:
"Every school board shall ensure that each pupil enrolled in a school within the jurisdiction of the school board is provided with a safe and caring school environment that fosters and maintains respectful and responsible behaviours." (Section 41(1)(b.1))

Manitoba Teachers' Society Code of Professional Practice
www.mbteach.org/inside-mts/professionalcode.html

The Code of Professional Practice for Manitoba teachers indicates that a member's first professional responsibility is to her or his students and that a member acts with integrity and diligence in carrying out professional responsibilities.

Environmental Requirements

The Environment Act
http://web2.gov.mb.ca/laws/statutes/ccsm/e125e.php#10

The Environment Act was established to help protect and maintain the environment. The Act ensures the environmental assessment of projects that can have significant effects on the environment. The Act also states that all polluters— including schools—are expected to pay for the cost of their actions. If any potentially damaging substance is released into the environment,

- the release must be reported immediately
- immediate steps must be taken to confine, clean up, and dispose of the substance
- the environment must be returned to a condition that is satisfactory to Manitoba environmental protection

This provincial statute sets the standard on a broader regulatory level with regards to human environmental impact, whereas municipalities take responsibility for establishing specific guidelines and standards for waste management. Such standards are embedded in local bylaws, identifying prohibited or restricted materials and regulating where and what wastes may be disposed of via local landfill sites and the sewage system.

Manitoba Dangerous Goods Handling and Transportation Act
http://web2.gov.mb.ca/laws/statutes/ccsm/d012e.php

This Act sets out requirements for handling, storing, and disposing of dangerous goods. If a school generates more than 5 L or 5 kg of hazardous waste per month, it would need to register as a waste generator. It also indicates the level at which an accidental release of hazardous waste would need to be reported (*Environmental Accident Reporting Regulation*).

Canadian Environmental Protection Act (CEPA), 1999, (Statutes of Canada, 1999, Chapter 33)
www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=26A03BFA-1

The ***Canadian Environmental Protection Act*, 1999,** S.C. 1999, c. 33 and its regulations describe procedures for storage, transport, and disposal of hazardous wastes produced by industries as well as schools or school districts, and outlines how to deal with spills. Like the *Environment Act*, this Act states that all polluters are expected to pay for the cost of their actions.

According to Environment Canada, the CEPA (1999) provides guidelines, objectives, and codes of practice, which are not law, but can become the basis for laws and regulations.
www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=2952CB83-1

***Canada Water Act*, R.S.C. 1985**, (Chapter C-11)
http://laws-lois.justice.gc.ca/eng/acts/C-11/index.html

This Act defines *waste* as substances that alter water quality to the extent that its use would be detrimental to humans, animals, fish, or to plants that are useful to humans. It prohibits pollution of water in areas designated for restoring, maintaining, or improving water quality, and specifies the penalties for doing so.

Transportation of Dangerous Goods Act (TDG), 1992, (Statutes of Canada, 1992, Chapter 34)
www.tc.gc.ca/eng/acts-regulations/acts-1992c34.htm

The *Transportation of Dangerous Goods Act and Regulations* protects the general public and the environment during the transport of hazardous goods, including regulated chemicals ordered or disposed of by schools. The *TDG Act* provides a complementary system to WHMIS: during transportation, these products are called dangerous goods and are governed by the regulations of TDG. The *TDG Act* states that, during transport, dangerous goods must be identified by

- labels on containers
- placards on trucks
- shipping documents

These TDG regulations terminate with the reception of the regulated/hazardous chemicals by a receiver at the point of delivery. Once the regulated/hazardous goods have been unloaded from the transport vehicle and received, they become controlled products and fall under WHMIS regulations.

This information is important to staff and others in emergencies, as well as in routine activities. The TDG chemical classifications used in these labels and documents are international in scope, and as a result they are rigidly specified.

Local Bylaws

Most municipalities in Manitoba will have established bylaws related to waste management and disposal, particularly disposal of substances classified as *hazardous, prohibited,* or *restricted*. Local bylaws may restrict the limits of waste materials disposed of via the sewage system and, possibly, via the local landfill site(s).

In most cases, local bylaws support and reinforce the regulations of federal and provincial legislation, but they may also provide more specific disposal limits or other details. It is important to check with municipal offices or town/city councils for relevant bylaws in your area.

- City of Winnipeg: Sewer bylaw
  www.winnipeg.ca/clkdmis/DocExt/ViewDoc.asp?DocumentTypeId=1&DocId=5243
- City of Brandon: Sewer bylaw
  www.brandon.ca/images/pdf/bylaws/5957.pdf (see section 66, p. 35)
- City of Thompson: Sewer bylaw
  www.thompson.ca/modules/showdocument.aspx?documentid=184
- City of Portage-la-Prairie: Sewer bylaw
  www.city.portage-la-prairie.mb.ca/images/bylaws/Sewage%20By-Law%2096-7863.pdf

Other Legislation

***Hazardous Products Act*, 1985**
http://laws-lois.justice.gc.ca/eng/acts/H-3/

This Act defines what materials are designated as controlled products in Canada. Designation of *controlled products* has the following significance for schools:

- The Workplace Hazardous Materials Information System (WHMIS) requirements apply to all materials designated as *controlled products*. Suppliers of controlled products are required to provide a Material Safety Data Sheet (MSDS) for each product and to ensure the product or its container is labelled with required information and hazard symbols.
- The advertising, sale, and importation of *controlled products* for use in the workplace, including Canadian schools, is regulated under the Act.

Chapter 2: Implementing Safety in the Science Classroom or Laboratory

Overview

This chapter provides general guidelines for promoting safety in Early, Middle, and Senior Years schools. All activities involve potential risks. In order to manage risks, teachers need to evaluate the risks involved in each potential activity and make prudent choices in the selection and development of these activities. The selection of an experiment or demonstration should take into account what that activity will achieve, what potential hazards it involves, and how to control or minimize these hazards. Risk management also means ensuring that staff members have the proper safety education and training, including teaching safe attitudes and behaviours to students.

Early Years

All students enjoy hands-on activities. This is especially true in the Early Years. The opportunity to explore and investigate real materials is a powerful motivator for learning and provides starting points for concept and skill development. The benefits of hands-on activities are well known to teachers, who regularly incorporate them into their lessons, taking care to ensure student safety. Steps taken to ensure student safety involve all stages of planning, preparation, supervision, and activity follow-up. Sample strategies for ensuring safety in elementary science activities are described below, beginning with the early stages of planning.

Selecting Activities and Materials

- Consult teacher guides to become familiar with risks posed by the activities and materials under consideration.
- Access and review information on student allergies and health conditions that could limit their involvement in science activities.
- Select activities and materials, taking into account the following:
  - Potential hazards
  - Student allergies and health conditions
  - Students' knowledge, skills, maturity, and disabilities
  - The equipment and facilities available to safely carry out the activities
- Avoid bringing poisonous plants or wild animals—dead or alive—into the classroom, and do not engage in direct investigations of human body tissues and fluids.

Getting Ready

- Obtain and prepare safety supplies (e.g., obtain personal equipment, such as goggles and gloves).
- Prepare materials for safe use (e.g., organize materials to facilitate safe distribution).
- Prepare for clean-up and disposal of chemicals and other waste products (e.g., label waste containers).

Guiding Students

- Involve students in preparing the classroom for safe activity by clearing work surfaces and aisles.
- Introduce equipment and supplies to be used, and demonstrate how they can be used safely by identifying procedures to follow and actions to avoid.
- Ensure that all students are aware of risks inherent in the materials to be used.
- Ensure that students use personal protective equipment as required for the activity.
- Initiate short, simple tasks that provide the opportunity for students to practise safe procedures before moving on to more complex tasks.
- Model safety at all times.
- Consider having students sign a safety contract as a commitment to safety. See Appendix A for a sample contract for Early Years students. These contracts can be developed with students.

Following up

- Have students clean up their workspace, following safe and environmentally responsible procedures.
- Have students wash their hands after taking part in activities that involve chemical or biological materials.

Middle and Senior Years Schools

As in earlier grades, activities with real materials in Middle and Senior Years schools provide starting points for concept and skill development and can be powerful motivators for learning. In the Middle and Senior Years, experience with materials also provides opportunities to learn about the nature of science investigation and to critically examine the link between evidence and theory. With the increasing complexity of concepts studied, investigations may involve more complex equipment and a broader range of materials than those manipulated in Early Years, creating new challenges for ensuring student safety.

The selection of an experiment or demonstration should take into account what that activity will achieve, what potential hazards it involves, and how to control or minimize these hazards or even remove them completely.

Science teachers need to be familiar with the location, use, and limitations of all safety equipment in the science area. Such familiarity may require initial training and periodic refresher sessions.

> Accident prevention depends on forethought, identification of hazards, and careful instruction. The onus is on the teacher to be aware of potential dangers and convey this information to students. Teachers instruct students in proper handling procedures and expend every effort to ensure that procedures are followed consistently.

The selection of materials can help minimize risks. Inherent risks increase dramatically with the use of materials that are highly toxic, corrosive, or flammable. Even highly qualified teachers need to assess the risks of different alternatives and select the one that presents the fewest hazards for students—even though another choice might produce a more spectacular result. Alternatively, an activity might be carried out as a demonstration by a teacher with appropriate safety precautions in place. A common alternative is to use videos, animations, or simulations. Although these media may diminish the drama of a live demonstration, they effectively communicate what students need to know and understand. In addition, many of the approaches described in *Strategies for Minimizing Hazardous Waste Production* (see Chapter 9) are excellent ways to reduce safety risks. These strategies include microscale experiments, dispensing pre-measured quantities of chemicals, and using laboratory stations.

The general strategies for ensuring science safety have much in common with all stages of planning, preparation, supervision, and activity follow-up. The following general strategies are recommended. It is further recommended that Senior Years schools and learning environments refine and extend these practices to reflect the program, student characteristics, facilities, and staff roles within a particular school setting.

Selecting Activities and Materials

- Consult teacher guides and safety resources to become familiar with risks posed by the activities and materials under consideration.
- Access and review information on student allergies and health conditions that could limit their involvement in science activities.
- Select activities and materials, taking into account
  - potential hazards
  - student allergies and health conditions
  - the students' knowledge, skills, and maturity

- the equipment and facilities available to carry out the activity safely

- Avoid bringing poisonous plants or wild animals—dead or alive—into the classroom, and do not engage in direct investigations of human body tissues and fluids.

Getting Ready

- Obtain and prepare safety supplies (e.g., obtain personal equipment, such as goggles, aprons, and gloves). (See Chapter 4 for more information on safety equipment.)
- Prepare materials for safe use (e.g., prepare solutions in advance, organize materials to facilitate safe distribution). Follow the laboratory teacher guide for safe, effective organization of a laboratory experiment or investigation.
- Prepare for clean-up and disposal of chemicals and other waste products (e.g., label waste containers, identify solutions that may be safely disposed of down the sink). (See Chapter 9 for more information on disposal of chemicals.)
- Consult MSDS.
- Ensure that workspaces are adequately sized and well organized.

Guiding Students

- Set standards for safety preparation and behaviour in laboratories. Appendix B provides examples of science safety rules and procedures that could be used with students.
- Introduce WHMIS and MSDS symbols, data sheets, and safety procedures, and ensure that students understand the need for and application of these standards.
- Provide a general introduction to risks and safety procedures at the outset of the course. In this introduction, review procedures for
  - handling medical emergencies and accidents
  - handling chemical wastes and spills
  - reporting defective equipment and potential hazards
  - reporting accidents
- Familiarize students with the location and use of safety equipment (e.g., eyewash stations).
- Introduce equipment and supplies to be used in each activity, and describe how they can be used safely by identifying procedures to follow and actions to avoid. Review MSDS.
- Ensure that all students are aware of risks inherent in the materials to be used.

- Ensure that students use personal protective equipment as required for the activity.
- Provide the opportunity for students to practise safe procedures.
- Model safety at all times.
- Consider having students sign a safety contract as a commitment to safety. Retain the contract, but recognize that this is not a legal document. See Appendix A for a sample contract for Middle Years or Senior Years students. Students can participate in the development of the safety contract.

Following up

- Have students clean up their workspace, following safe and environmentally responsible procedures.
- Have students wash their hands after taking part in activities that involve the use of chemical or biological materials.

Safety and the Student

An important role of science educators is not only to ensure a safe learning environment, but to instill in students an understanding of their own responsibilities in the science classroom. Learning about science includes learning to respect the materials being used, and this respect can be modelled by example. In this way, science teachers are role models—advocates and practitioners of safety. Increasing students' awareness of safety issues in general (and knowledge of safety practices specifically) is one of the most important ways to reduce accidents.

Student Safety Training

Safety training is an integral part of learning laboratory techniques. Safety training is an excellent way of encouraging students to make safety a lifelong practice at home and in the workplace. As part of such training, general safety issues and student expectations are addressed at the beginning of each course. These are posted and periodically reviewed. See Appendix B for a sample of science safety rules and procedures for students. More specific safety issues inherent in the activities can be discussed as part of the pre-activity instruction.

Safety expectations can be developed with students in a number of ways:

General Safety Practices

- Encouraging students to recognize that good laboratory technique produces more consistent and reliable results, and is time-efficient.
- Handing out written copies of good laboratory practices and reviewing these with students throughout the term.
- Posting lists of safe practices in appropriate areas and reminding students of them on a regular basis.
- Modelling safe behaviour during all activities.

Specific Safety Concerns

- Reviewing specific safety issues and procedures before each activity, including relevant WHMIS information, required personal protection equipment, and emergency response procedures in case of accidents, and posting MSDSs for each activity.

Development of common expectations for student behaviours and procedures can be a helpful starting point in planning for safety training. By planning as a team of science teachers and by sharing common lists of expectations and procedures, the science staff in a school can ensure consistency in their messages and avoid student confusion about what they may and may not do. See Appendix C for Suggested Science Department Safety Policies and Procedures.

Making safety an integral part of every course helps to reinforce its importance. It also conditions students to think about safety whenever they undertake any activity in the laboratory.

Developing Safety Awareness and Responsible Habits

One of the most important ways to promote safety in science classrooms is to increase students' awareness of safe practices and to help them develop responsible attitudes. Good laboratory practices can be broken down into the following three time periods.

Before entering the laboratory

- Confine long hair and loose clothing.
- Wear only closed-toe shoes.
- Put on eye protection.
- Wear lab coats or aprons when necessary.
- Wear protective gloves when necessary.

- Know the hazards of the chemicals to be used.
- Understand response procedures in case of an accident.

While in the lab

- Behave responsibly and respect the safety of others at all times.
- Never work alone or unsupervised.
- Do not eat, drink, or keep food in the laboratory.
- Never pipette by mouth.
- Replace stoppers and caps of chemical containers immediately after use.
- Treat a substance as hazardous unless it is definitely known as safe—read the WHMIS label to be sure.

Prior to leaving the lab

- Dispose of hazardous wastes in specified containers or as instructed by the teacher.
- Turn off and put away all equipment, and clean all glassware.
- If gas has been used during the activity, ensure that the gas valve is off and the cold Bunsen burner has been put away.
- Wash hands thoroughly.

The more awareness students have of these issues, the greater chance they will develop safe and responsible habits of mind. See Appendix B for a more comprehensive list of *Dos* and *Don'ts*.

Outside the Classroom

Field Trips

Field trips are a valuable addition to any science course, giving students the opportunity to explore applications of science and to investigate living things in their environment. Potential hazards associated with off-site excursions depend on the nature of the trip and the site visited, but in general the possibility of accidents can be reduced if the field trip is well planned and organized. Field trip planning should be guided by divisional field trip policies, which will often identify standards in such areas as supervision and first aid preparation. Planning for adequate supervision should take into account the age and number of students, the kinds of hazards present at the site, and the types of activities to be carried out. Supervisors prepare for any potential onsite hazards. If any such hazards exist, teachers and supervisors decide if the hazards are too great of a risk to continue the activity. First aid preparation should also take into account a Manitoba Workplace Safety and

Health standard that specifies that a schedule B first aid kit must be on hand for 24 persons or fewer and two kits for every 25-50 students. Most divisions now mandate that a manifest of students participating in the trip, complete with contact information and medical alerts, be in the teacher's possession, with copies supplied to the school office and the bus driver.

Transportation is a further element of field trip planning. Local divisional and school policy should be reviewed to determine which modes of transportation are considered acceptable and which guidelines apply. For example, there may be local guidelines on the use of parent-supplied transport.

Outdoor Environments

Field trips to outside environment sites present their own set of challenges because students are exposed to the weather, physical hazards and local organisms. Taking the following precautions can reduce risks:

- Be thoroughly familiar with the site and any potential hazards. Always visit the site prior to the field trip.
- Provide students with a map of the site, identifying the specific locations to be visited, the routes by which they will get there and the potential hazards.
- Ensure that there will be adequate adult supervision.
- Specify the clothing and footwear to be worn.
- Have a supply of clean water for drinking and cleaning.
- Provide special requirements such as insect repellent.
- Use appropriate precautions and equipment if working on or near water (e.g., whistles, lifejackets, throw line, "buddy" system).
- Most school divisions have regulations that require supervisors and students to take pre-field trip training when water activities are planned. Teachers and supervisors should refer to local divisional guidelines.
- Maintain access to a vehicle at all times in case of an emergency.
- Carry a cell phone to access emergency services and information. If coverage is not available, a satellite phone should be rented.

Planning for biological studies in the field needs to include consideration of the following specific hazards:

- Allergic reactions, toxic effects, or accidental infections. Be aware of any student allergies to plants, animals, pesticides, herbicides, or other materials. Also, be aware of dangerous plants or animals that may exist in the area, such as stinging nettle, poison ivy, or venomous snakes, and bring appropriate first aid materials.
- Disease-carrying parasites such as ticks carrying Lyme disease. Students should check their clothing and other belongings for these organisms before returning to school.

- Diseases associated with handling animals (e.g., deer mice can carry hantavirus and bats often carry rabies).
- Water-borne diseases such as Giardiasis (Beaver Fever).

If specimens are collected on a field trip and maintained at school for a period of time, consideration must be given to MSDSs, proper storage and labelling of fertilizers, special foods, or other chemicals required to support these organisms.

Chapter 3: Emergency Preparedness and Response

Overview

This chapter provides information and strategies to prepare for contingencies in the science classroom, laboratory, and science preparation areas. The chapter includes sections on planning emergency responses, responding to accidents and medical emergencies, and preparing accident reports.

General Safety Audit

A general safety inspection can be a good starting point for preparing to deal with emergencies that are more likely to occur in or affect science laboratories. Typically this inspection would be done as part of the larger school emergency planning process, and would include a thorough evaluation of general safety concerns such as fire prevention and response, as well as response to medical emergencies, gas leaks, and other situations. In addition, special attention would be given to areas where chemicals are stored and used, since extra precautions and equipment are involved in these locations. An inspection checklist could be developed to assist in this process and to ensure that nothing is overlooked. See Appendix D for a sample inspection checklist devised for use in assessing safety in laboratory areas.

Emergency Preparedness Planning

The *Workplace Safety and Health Act* of Manitoba specifies that employers of every workplace with 20 or more workers must develop and implement a workplace safety and health program. Such a plan establishes procedures to deal with different kinds of emergencies and is tailored to the specific design, circumstances, and nature of the hazards of the school. Procedures must also tend to students with special needs. Any emergency that threatened the safety of students or staff would then be dealt with according to this plan.

The workplace safety and health program is developed for the school as a whole, but has direct implications related to science classrooms and laboratories. Science teachers should be aware of some of the requirements of such a program, which include

- developing adequate systems to identify and control hazards
- identifying what people, resources, and procedures are needed to deal with emergencies
- preparing of statement of responsibilities for safety and health (who is responsible for what)

- scheduling regular planned inspections
- developing plans to control chemical and biological hazards
- developing training plans for workers
- developing a procedure to investigate incidents, dangerous occurrences, and refusals to work
- developing ways to involve workers in the program
- evaluating and revising the program regularly

Considerations in Emergency Preparedness Planning

Emergency plans address a number of different safety hazards and emergency situations. As a minimum, the plan would include the following:

- safety measures for fire, including prevention measures specified in the federal and provincial fire codes, as well as municipal regulations together with procedures to follow in the event of a fire in a science laboratory or elsewhere in the school
- a building floor plan showing where all toxic substances are located
- procedures for dealing with the release or spill of toxic substances
- procedures for responding to a natural gas or propane leak
- procedures for responding to accidents and medical emergencies
- plans to ensure staff receive adequate orientation and training

Creating Your Own Emergency Plan

When developing an emergency plan, you should consider the following:

- Making sure the school has the necessary people, procedures, and resources in place
- Clearly defining who is responsible for what
- Training everyone to follow procedures and use appropriate equipment

An emergency plan for your classroom could contain the following elements:

- Identifying situations (fires, spills, leaks, etc.) that will require response
- Identifying what will be done when an emergency occurs, including when a problem can be handled by an individual teacher (When conditions exceed those parameters, a school team including members of the school administration could establish control and provide direction and support to the affected area. If the problem affects the school at large, then the plan is interfaced with the divisional or the community emergency or crisis management plan.)
- A means of alerting the school administration about the onset of a crisis situation is highly recommended as a routine for quickly assembling a pre-designated crisis management team once the plan is activated
- The plan should be self-assessing (This means a checklist of questions by which you can determine if the plan meets your needs or requires updating.)

Resources

Guide for Developing a Workplace Safety and Health Program. This document provides a lot of information related to workplace safety and health plans. Available online at <http://safemanitoba.com/uploads/guidelines/developingws_hprogramjuly2010.pdf>.

Evaluating Your Emergency Planning

To evaluate whether your emergency preparedness planning is adequate, consider whether your plan is realistic, comprehensive, and appropriate for the workplace, and whether it includes measures for implementation. With effective emergency planning,

- all potential emergencies are mentioned in the plan but it is the most probable events as determined by the hazard analysis and risk assessment that are developed into contingency arrangements
- the required supplies and equipment (e.g., fire extinguishers, first aid kits) are available and in good condition
- there is an effective process to announce the emergency to all staff members, students, and visitors
- drills are periodically carried out to test response to one incident at a time
- records and evaluation of drills indicate that the plan is feasible
- staff members understand the plan
- staff members are aware of their roles if there is an incident or if an evacuation is necessary; staff and their back-ups are sufficiently trained to carry out these roles
- the required number of staff are trained in emergency and standard-level first aid
- all staff members are trained and prepared so that they know how to declare an emergency and initiate the alarm, as well as how to determine the required level of response (e.g., standby, escalation, evacuation, or take cover)

Responding to Fire

Fire has always been one of the attendant hazards of laboratory operation. Laboratories make use of flammable materials including solids, liquids, and gases. A response procedure for a school fire would address the following elements:

- When to sound the local fire alarm
- When and how to evacuate the school

- Who is responsible for notifying the fire department and school superintendent
- Under what circumstances staff members may attempt to extinguish the fire, and procedures for doing so
- When and how to permit people to re-enter the building, or to carry out further evacuation procedures if staff and/or students will be unable to return
- Procedures for securing utilities
- Responsibilities and procedures for filing written reports with the supervisor of schools and the fire marshal

Responding to Toxic Substance Leaks and Spills

The response plan should include procedures for emergency response to leaks and spills of toxic, caustic, and reactive substances, particularly those that pose an immediate danger due to the quantity and location of the spill. The emergency plan should include the following:

- When and how to evacuate
- Who is responsible for requesting emergency services and informing appropriate school officials
- Procedures and responsibilities for providing the appropriate MSDS to the emergency responder, hospital, or physician
- Procedures and responsibilities for reporting the leak or spill and completing any follow-up investigation

For spills of small quantities of less dangerous substances, a full emergency response may not be required. See Chapter 8 for clean-up procedures.

Responding to a Natural Gas or Propane Leak

Natural gas and propane are flammable gases that are used as fuels in science laboratories. Both are delivered under pressure. Any leakage of gas from pipes or fittings creates a risk of fire and/or explosion, particularly if the leakage is in a confined area, and especially if it remains undetected for some time. A slow continuous leak can lead to migration of gas through a room or building until it reaches a source of ignition, resulting in an explosive flashback to the source. A fire near the source of a leak may also cause the gas container or pipe to explode.

Emergency planning should address the following elements for natural gas or propane leaks that cannot be immediately stopped:

- When and how to evacuate the area
- Who will alert the fire department and school district officials

- Under what circumstances staff members may attempt to localize and/or dissipate the leaking gas, and procedures for doing so

Responding to Accidents and Medical Emergencies

To handle medical emergencies and serious injuries, each school is required by the *Workplace Safety and Health Act* to have staff with emergency or standard-level first aid training. These individuals would have the expertise to administer the Heimlich manoeuvre, mouth-to-mouth breathing, and cardiopulmonary resuscitation (CPR).

This section outlines first aid for both minor and major injuries that could occur in the science laboratory or classroom. Included are the first steps to alleviate damage and to treat the injury, as well as when to engage local emergency services. School divisions may have additional procedures or regulations for responding to medical emergencies.

Notes

In each of the following cases, the school administration must be alerted immediately.

Corrosive Chemical on the Skin

The current MSDS should be present during the demonstration or laboratory experiment and must be reviewed prior to the activity being started to ensure that the appropriate first aid procedures are ready. Some controlled products may react with water, so it is critical that the correct initial first aid response is applied. In most cases, the general rule is to wash the area immediately and thoroughly with cool water or soap and water. The recommended time for this washing is 15–20 minutes. Remove contaminated clothing. If significant harm is detected or suspected, seek medical assistance.

According to the Canadian Centre for Occupational Health and Safety:

> "Most standard sources recommend that water flushing following skin or eye contact with a chemical should continue for 15 or 20 minutes. However, all chemicals do not cause the same degree of effects (some are non-irritants while others can cause severe corrosive injury). Therefore, it makes sense to tailor the duration of flushing to the known effects of the chemical or product, as follows:
>
> - five minutes for non-irritants or mild irritants
> - 15–20 minutes for moderate to severe irritants and chemicals that cause acute toxicity if absorbed through the skin
> - 30 minutes for most corrosives
> - 60 minutes for strong alkalis (e.g. sodium, potassium or calcium hydroxide)
>
> It is very important that water flushing start immediately following skin or eye contact with a chemical. It is better if complete water flushing occurs onsite. However, moving the victim to an emergency care facility earlier may be necessary, depending on the victim's condition (e.g., compromised airways, breathing, or circulation) and/or the availability of a suitable water supply. If it is necessary to transport the victim before completing flushing onsite, flushing should continue during emergency transport, taking proper precautions to protect emergency services personnel."
>
> *Source: www.ccohs.ca/oshanswers/chemicals/firstaid.html*

Splashes into the Eyes

Using the nearest eyewash station, immediately flood the eye(s) with a gentle stream of cool water for 15–20 minutes, holding the eye(s) open if necessary. After flushing, close the eyelid and cover with a loose, moist dressing. Proceed to get medical help to assess the condition of the eye(s) and ensure no further damage occurs. Alkalis produce more serious burns than acids, but flushing should be done immediately, regardless of the substance.

Foreign Object in the Eye

Seek emergency medical help.

To help someone with a foreign object in the eye, first, keep the person from touching it. Then, wash your hands, seat the person in a well-lit area, and try to locate the object in the eye visually. Examine the eye by gently pulling the lower lid downward and instructing the person to look upward.

Reverse the procedure for the upper lid. Hold the upper lid and examine the eye while the person looks downward.

If the object is on the surface of the eye, you may be able to flush it out or remove it manually. While holding the upper or lower lid open, use a moistened tissue or the corner of a clean cloth to remove the object by lightly touching it. Once removed, flush the eye with a saline solution or lukewarm water. If you cannot remove the object easily, cover the eye with a soft cloth and seek emergency medical assistance.

If the object is embedded in the eye, do not remove the object. Apply a dressing over the eye in such a way that it does not make direct contact with the eye surface. Cover the dressing with a cup or ring pad, and seek emergency medical assistance.

If pain, vision problems, or redness persist, seek emergency medical help.

Cuts

Put on disposable gloves to minimize risk of infection from the blood. If necessary, wash minor cuts with cool water to remove any foreign material. Dry the area and cover with a bandage. In the case of major cuts with severe blood loss, apply a large compress and then apply direct pressure with the heel of your hand and transport to the hospital. If a piece of glass or other sharp object is embedded in the wound, tent dress the area and add padding around the injury until it is higher than the embedded object. Secure padding with a wrapping of gauze and seek medical help. For major cuts with minor bleeding, cover with a gauze pad, and then transport the victim to hospital for further medical help. If glass or any other sharp object may still be in the wound, do not attempt to remove it. Be careful not to put undue pressure on the gauze while transporting the victim, since circulation may be cut off completely.

Ingestion of Chemicals

The primary source of information in Manitoba on prescribed treatment for ingested chemicals is the Manitoba Poison Centre at 1-855-7POISON (1-855-776-4766). This centre operates 24 hours a day, seven days a week. It provides specialized information and treatment recommendations related to chemical, biological, pharmaceutical, and environmental poisoning and exposure. If ingestion of a chemical occurs, they should be called immediately before proceeding with any treatment. Another source of information on treatment would be found on the MSDS on file for the chemical.

> Manitoba Poison Centre:
> 1-855-7POISON
> (1-855-776-4766).

Burns

Treatment of minor burns is basically a three-step process. Cool the burned area for about 15 minutes by running cool water over it, immersing it in cool water, or cooling it with a cold compress. Do not use ice, as this may freeze the area of treatment. Apply a triple-antibiotic ointment or a moisturizer to prevent drying. Loosely wrap the burned area with a sterile gauze bandage, avoiding excess pressure on the burned skin. If the burn is severe, cool the area as described above, wrap loosely with a moist dressing, and transport the person to a hospital for medical assistance. Seek medical assessment and/or treatment.

Burning Clothing

Rapid action in extinguishing burning clothing is critical to minimizing exposure of the victim and minimizing harm that may result. Several approaches are sometimes used and your local fire department or school district policy may recommend one of these as the preferred response. The "Stop, Drop, and Roll" method is commonly recommended by fire departments. In conjunction with this technique, other heavy clothing or a fire blanket may be used to smother the flames. Fire blankets are not a fire code requirement and are not recommended by all fire departments. **If a blanket is used, it must be removed immediately after the fire is out to minimize the trapping of heat and sparks against the victim's skin**. Other options for extinguishing burning clothes include using an ABC dry-chemical fire extinguisher, spraying the victim with water, or using an emergency shower, if available. Selection of any one of these options may be circumstantial. The use of the fire extinguisher, for example, may not be practical from a safety perspective if the fire is near the face and chemical spray will get into the victim's eyes.

Once the fire is extinguished, loose clothing can be removed if necessary, **but any clothing adhering to the burned skin should not be removed**. After the fire is out, follow the procedures for responding to burns described above.

Shock and Fainting

Lie the victim down if she is in shock and elevate her feet higher than her head. Loosen tight clothing, cover her with a blanket, and talk to her reassuringly. Do not give her anything to drink. If the person has fainted, place her in the *recovery position* (i.e., on her side with her head tilted back to keep the airway open). Ensure that the airway is clear and that she is breathing. Make her head comfortable, cover her with a blanket, and leave her lying down. If there is a chance of injury due to the collapse, avoid moving her if she is breathing until you can communicate with her to confirm no injury was sustained. However, if the airway is blocked and/or the victim is not breathing, her head may have to be tilted back or she may have to be laid on her back to begin artificial resuscitation or CPR. If other injuries are present or any symptoms persist, seek emergency medical assessment and/or treatment. If the casualty must be left alone, always place the victim in the recovery position and ensure the airway is open.

Inhalation of Toxic Fumes

Immediately call 911 to receive assistance from the local fire department whose response teams are trained in resuscitation measures and emergency first aid. They also have self-contained breathing apparatus in case the toxic fumes are persistent.

If available on-site, summon trained personnel who can administer oxygen and other medical procedures, as necessary.

Other Medical Emergencies

Being prepared to deal effectively with emergencies involving serious existing medical conditions such as asthma, anaphylactic shock, diabetes, or epilepsy requires open communication among school administration, counsellors, and parents. Teachers need to know if students have these conditions, as well as what to look for and what to do if the student becomes symptomatic. Basic training could be provided to assist teachers in dealing with, for example, seizures or insulin shock. If in doubt, seek medical assessment and/or treatment.

Accident Reporting

An *accident* is an undesired event that causes or may cause harm to individuals, property, or the environment. When an accident occurs, the first concern is the injured. Priority can then be placed on systematic investigation and proper reporting of the accident.

By law, certain work-related accidents must be reported as soon as possible to Manitoba Workplace Safety and Health. The act requires employers to

- report certain injuries or accidents, including any injury or accident that results in a fatality or in a worker being admitted to hospital
- report any unplanned or uncontrolled explosion, fire, or flood that causes (or could cause) a serious injury
- conduct an investigation whenever a serious injury or accident occurs, and prepare a report that is available for inspection

Manitoba Workplace Safety and Health may choose to investigate the accident.

Schools can improve safety and show compliance with accident-reporting requirements by ensuring that

- staff receive appropriate orientation and training, and that they understand their responsibilities
- all accidents and injuries are recorded, reported, and investigated, as appropriate

- staff know when and how to report accidents, including where to access reporting forms and instructions
- all required information is gathered and provided by supervisors for staff compensation claims
- general pre-planning has been done regarding accident investigation and reporting
- the underlying causes of accidents are determined
- measures are taken to prevent accidents from reoccurring

See Appendix E for a sample Accident/Incident Report Form. This sample shows the type of information that is required in an accident report, as well as who is required to complete the report.

Near-Miss Reporting

A near-miss is an event that could, but does not, result in an accident. Near-misses are also referred to as incidents or potential accidents.

Like accidents, near-misses are caused by unsafe acts or conditions. Examples of unsafe acts include handling of materials by someone without proper training, and failure to use personal protective equipment such as safety glasses. Examples of unsafe conditions include poor lighting, excessive noise, and poor housekeeping.

Documentation of near-miss situations, although not required by law, should be done internally with information about the incident shared with colleagues. In this way, near-miss reporting is a proactive means of improving safety awareness, identifying and tracking potential hazards, and ultimately preventing accidents. Whenever a near-miss is recorded, it is important to identify, as far as possible, the unsafe acts and conditions that contributed to the incident. Actions can then be taken to reduce the risk of a similar incident or accident occurring in the future.

Chapter 4: Facility Design and Safety Equipment

Overview

As the previous chapters have shown, many municipal, provincial, and federal laws and regulations govern safety in schools and their science facilities. Some of these relate to the plans we put in place and the procedures we use. Others relate to the physical environment: the design of the facility and the safety supplies kept in that facility. This chapter outlines guidelines and rules surrounding facility design and safety equipment.

Assessing the Suitability of Facilities for Science

The selection and planning of science activities must take into account the strengths and limitations of available facilities. Although some introductory activities do not impose any facility requirements, many others—particularly at the secondary level—require some minimal facility characteristics (e.g., flat-topped surfaces are needed for activities with containers of liquids). For some activities, the use of purpose-built laboratory facilities is a practical necessity.

Figure 1 ***Shelving***

In this diagram, heavy objects can be seen on the top of the cupboards. Controlled products should be stored no higher than at eye level to reduce the chance of an accident.

When deciding whether a given facility is adequate, the following factors should be considered:

- How many students will be allocated to the class? Keep in mind that overcrowding increases risks.
- How is the facility configured? Does it allow the teacher to see all the students? Does it provide easy passage from one area to another without increasing the risk of bumping into one another?
- Does the facility have sinks? How many will the class need? Is the number sufficient for clean-up and emergency flushing?
- Does the facility have appropriate emergency response equipment (e.g., an eyewash fountain, a fire extinguisher, etc.)?
- Does the facility have sufficient storage and/or adjacent preparation areas that minimize the need to transport equipment and supplies through the school? Are the storage and preparation areas lockable?
- Does the facility have adequate ventilation?
- Does the facility have an effectively functioning fume hood that can be used in teacher demonstrations and lab preparation?

The following pages present required, recommended, as well as optional equipment that should be available to students and staff in a well planned, safety-conscious laboratory or multi-use laboratory.

Room Safety Equipment and Utilities

Notes ✓-Required NR–Not Required REC–Recommended

Item or Component	K-4	5-8[1]	Grade 9 to 12[2]			
			General Science	Biology	Chemistry	Physics
Safety Equipment						
Fire extinguisher (Type ABC)	✓	✓	✓	✓	✓	✓
Fire blanket[3]	NR	REC	REC	REC	REC	REC
First aid kit (see details in document)	✓	✓	✓	✓	✓	✓
Emergency shower[4]	NR	NR	REC	REC	REC	NR
Eyewash[5]	NR	✓	✓	✓	✓	NR
Safety goggles	REC	✓	✓	✓	✓	✓
Safety goggle sterilizing cabinet[6]	NR	✓	✓	✓	✓	✓
Utilities						
Water	✓	✓	✓	✓	✓	✓
Sinks (stainless)	1 large	4	12	12	12	1
Hot water taps	At least 1	Min 2	12	12	12	1
Acid dilution tank[7]	NR	NR	NR	NR	NR	NR
Water master shut-off control	NR	✓	✓	✓	✓	✓
Electrical						
Duplex receptacles (GIF)	1 near sink	8	10	12	12	12
Electrical master shut-off control	✓	✓	✓	✓	✓	✓
Gas						
Duplex gas jets	NR	REC	8	REC	10	REC
Gas master shut-off valve	NR	REC	✓	REC	✓	REC

1. For Grades 5-8, the room would be a dedicated science laboratory to require the indicated equipment.
2. Although a lab may be dedicated for a specific subject, it is always better to outfit all laboratories with complete safety equipment to allow flexibility for use in all science courses.
3. All fire inspectors do not recommend fire blankets, as they require proper usage to avoid further damage to burned skin. Check with your local fire marshal.
4. Emergency shower must meet ANSI Standard Z358.1-2004.
5. Eyewash equipment must meet ANSI Standard Z358.1-2004.
6. A sterilizing cabinet is not required if other means of effective goggle sterilization are used.
7. These tanks must be serviced every three years and the servicing date recorded. Check local sewer bylaws for this requirement. Acid dilution tanks are not recommended in Winnipeg or Steinbach.

Item or Component	K-4	5-8	Grade 9 to 12			
Communication						
Emergency telephone	✓	✓	✓	✓	✓	✓
Wireless computers[1]	REC	REC	REC	REC	REC	REC

Room Design						
Item or Component	K-4	5-8[2]	Grade 9 to 12			
			General Science	Biology	Chemistry	Physics
Lab size of $112m^2$	N/A	REC	REC	REC	REC	REC
Demonstration table[3]	NR	REC	REC	REC	REC	REC
Movable tables[4]	REC	REC	REC	REC	REC	REC
Source of natural light (windows)	REC	REC	REC	REC	REC	REC
Two exits from room	REC	REC	REC	REC	REC	REC
Fume hood[5]	NR	NR	REC	REC	✓	REC
Work station for students with special needs	NR	✓	✓	✓	✓	✓
Chemical-resistant countertop or tabletop with storage cabinets	NR	✓	✓	✓	✓	✓
Storage (See Storage Facilities for Chemicals, Chapter 10)						
Separate chemical storage room including locking acid/base and flammables cabinets, and continuous room fan	NR	NR	✓	✓	✓	NR
Storage and Preparation Areas						
Science preparation area consisting of a large sink with h/c water, general storage shelves, and ventilation (not to be used as general teacher office area/ working station or chemical storage)	NR	✓	✓	✓	✓	✓
Adequate GFI electrical outlets to accommodate specialized equipment	NR	✓	✓	✓	✓	✓

1. To reduce the number of cables, which can cause clutter and accidents, consider using battery-operated computer equipment and wireless Internet.
2. For Grades 5-8, the room would be a dedicated science laboratory to require the indicated equipment.
3. The demonstration table would contain a large sink, hot and cold water, electrical duplex plugs, drawers, cupboards, and a heat-resistant top.
4. For dedicated labs in Grades 9 to 12, alternate pods or similar designs may be preferred.
5. Fume hoods must meet or exceed CSA and ANSI standards.

Safety Equipment and Supplies

Having the proper safety equipment and supplies in place in science areas of a school is critical to managing risks and dealing with emergencies that may arise. This section discusses essential safety equipment and some basic procedures for using these resources. Appendix D provides a laboratory safety checklist.

General Safety Equipment for Science Laboratories and Multi-use Laboratories.

This list identifies general safety equipment that is either essential or highly recommended in the science area of the school. Safety can be further enhanced by making sure that teachers, students, and technicians are familiar with the location and use of this equipment, that the equipment is easily accessible, and that safety posters are displayed. Consider assembling a "safety cart" that contains materials to handle spills, self-protection equipment, and a first aid kit. See Equipment for Clean-up and Disposal of Chemical Spills (on page 54) later in this chapter. Have this cart in an easily accessible, central location so it can be wheeled in to handle a safety situation.

Equipment	Comments
ABC-type dry chemical fire extinguisher	Install only extinguishers that are required by existing fire codes. Note that the number in the extinguisher type refers to its volume capacity and the letters identify the class of fire(s) that can be put out. Refer to the Fire Extinguishers section of this chapter for *Manitoba Fire Code* specifications on location of extinguishers. After use, the extinguisher will require service. Demonstrations should not be done with this extinguisher; a spare extinguisher should be reserved for that purpose.
First aid kit	One kit per lab is strongly recommended for schools. Please refer to the First Aid Kits section for more information.

Equipment	Comments
Eyewash station, emergency and personal (squeeze bottle)	According to occupational health and safety regulations, an emergency eyewash station is required in areas where corrosive chemicals are used. Eyewash stations should meet Canadian Standards Association (CSA) and American National Standards Institution (ANSI) specifications. The water supply should be tempered by mixing hot and cold water and, once activated, should run hands-free. The eyewash station must provide a continuous flushing fluid to both eyes at a minimum of 1.5 L per minute for 15 minutes. It can be plumbed in or portable. Portable bottles (squeeze bottles) do not meet this standard. All emergency eyewash stations, whether fixed or portable, require routine maintenance to ensure proper functioning and cleanliness. This requires that they be tested regularly to verify that they are operating properly. Such testing also prevents growth of microbes in stagnant residual water, and flushes out any dirt, rust, or pipe scale that may be present. To reduce rapid and frequent corrosion of the system in hard water areas, use a water softener or a system with its own supply of distilled or buffered water. In some situations, the most practical solution may be to purchase a portable emergency eyewash unit with its own water supply. Where portable eyewash squeeze bottles are provided, the bottles must be filled with buffered solution supplied by the manufacturer and changed regularly as per the manufacturer's instructions. A buffered saline solution preserved with a suitable antibacterial agent is also available.
Hand-washing facilities	Hand-washing facilities should be available in or near each science classroom.
Emergency shower	If large amounts of caustic or flammable controlled products are used, an emergency shower is required. This washing equipment must meet the requirements and be installed, tested, and maintained in accordance with ANSI Standard Z358.1-04 and the equipment manufacturer's specifications. The chemical preparation area should have a shower. However, because small quantities of chemicals are used by students, showers are not necessary in classrooms.
Fume hood	A fume hood is required for high school chemistry laboratories or any lab where there is a need to dilute corrosive substances, dispense volatile liquids, as well as dispense more toxic powdered substances to minimize inhalation of caustic fumes and air-borne powder. Fume hoods should meet ANSI specifications and should be inspected at least once a year by a qualified person. Inspections should be recorded on a tag attached to the fume hood.

Equipment	Comments
Safety shield	This is a portable, clear, free-standing screen that can be set up between a dangerous demonstration and the classroom. The shield should be polycarbonate (for strength) with a base that is sturdy and heavy. It should also be large enough to adequately screen the apparatus/equipment in the demonstration. If there is a possibility of an explosion or spray from the demonstration, the shield should be securely clamped or fastened to the table or desk to prevent it from being knocked over.
Ultraviolet goggle sterilizing cabinet	The cabinet must have interlocking doors and be locked while UV sterilization is running. Cabinet not required if other sterilization procedures are in place.
*Fire blankets (discretionary item)	Fire blankets are not a fire code requirement. They require proper usage to avoid further damage to burned skin. Check with your local fire marshal for more details. Blankets containing asbestos should be removed from the school.
Personal Protective Equipment (students)	
The following list identifies personal protective equipment that should be present in every classroom that is used as a science laboratory. If injuries to students result from the failure to have or to use personal protective equipment, negligence may be claimed. Appropriate safety equipment should be identified for use prior to each laboratory activity as part of a routine with students. Refer to Student Safety Training (on page 27) in Chapter 2 for more information on the use of personal protective equipment.	
Protective goggles	Eye protection must be CSA-approved and must be worn whenever there is the risk of eye injury. Goggles should be designed to completely enclose the eye area; fitted side-shields are one such option. If glasses are normally worn, goggles should fit over them. Goggles should be sterilized in a sterilizing cabinet after each use.
Laboratory coats or aprons	Laboratory coats and aprons should be made of approved material only, and should be worn when working with chemicals and, when appropriate, during other science activities (e.g., biology). Coats are preferable to aprons.
Non-latex disposable gloves (Neoprene®, nitrile, or Tactylon®)	Gloves should be worn when handling hazardous chemicals and in biological experiments. Gloves should be used in combination with other measures because gloves may only slow down transmission of some materials, not completely prevent it. Note that some students and staff may have latex allergies.

Equipment	Comments
Heat-resistant gloves	Heat-resistant gloves should be available when necessary. These gloves should be made of treated texture silica or woven fabric. Do not use asbestos gloves.
Beaker tongs	Use tongs with heat-resistant gloves when handling very hot beakers.
UV filtering glasses	Eye protection should be worn when UV sources are in use (e.g., discharge tubes, mercury, or ion arcs, lamps for fluorescent "black light" experiments). Appropriate glasses include any glasses labelled "Blocks 99% or 100% of UV rays," "UV absorption up to 400 mm," "Special Purpose," "BS," or "Meets ANSI UV requirements."
Personal Protective Equipment (for school staff)	
Acid-proof gloves (Gauntlets)	There should be one pair of acid-proof, elbow-length gloves for each staff member who uses a school laboratory in which acids and bases are used in any concentration. These should clearly be labelled for size and user. These gloves would be used for working with corrosive materials in the fume hood or for transporting acids and bases. These gloves must be ANSI standard approved.
Face shield	There should be at least two safety shield face masks for each high school chemistry and biology laboratory. These face shields must be ANSI standard approved.
Acid-proof aprons	There should be at least two acid-proof aprons available in any laboratory where acids and bases are used. These aprons must be ANSI standard approved.
Respirators	**It is not recommended that teachers handle major spills that require respirators.** If staff members are willing to deal with chemical spills and are trained to do so, they must be fit-tested with a respirator. These respirators should be labelled with the name of the staff member for whom the respirator has been fitted. Fit testing should be repeated every three years.

General Facility Equipment

Fire Extinguishers

The *Manitoba Fire Code* indicates that the number and location of fire extinguishers should be governed by factors such as floor space, hazard levels, and the physical design of the building. It also requires that a fire extinguisher be located in strategic sites along corridors, as well as in either the chemical storage room or just outside this room (and recommends one in both locations, given the increased hazard level in the area). Although not compulsory by code, placement of a fire extinguisher in every laboratory is recommended.

Figure 2 **Fire Extinguisher**

The following chart shows fire extinguisher types that may be appropriate for use in schools (the type will be identified on an inspection label on the unit). ABC extinguishers are recommended (a fire code recommendation) for all school locations because they avoid the need to classify the fire and select the appropriate extinguisher and only one operational procedure must be learned and remembered.

Type	Extinguishing agent	Use
Class A	Water	Fires involving ordinary combustible materials such as wood, cloths, or paper.
Class B	Dry chemical foam, carbon dioxide	Fires involving flammable liquids such as solvents, grease, gasoline, or oil, and fires involving ordinary combustible materials.
Class C	Dry chemical and carbon dioxide	Fires involving electrical equipment.
Class D	Special dry powder, medium or dry sand.	Fires involving combustible metals, magnesium, sodium, lithium, or powdered zinc.
Class ABC	Dry chemical	All materials and fire types.

Schools can maximize the value of fire extinguishers by

- placing extinguishers near an escape route, not in a 'dead end' location
- ensuring all teachers and support staff working in the science area know the location of all fire extinguishers, and understand when and how to use the kinds of fire extinguishers installed on-site
- having fire extinguishers inspected once a year by the local fire department or an approved agency, with inspection records kept by the principal or district administrator

First Aid Kits

First aid kits are required by schools under the *Workplace Health and Safety Regulations*. The following table indicates the number of kits that must be provided according to the number of workers employed at a workplace. These regulations do not apply to students but can serve as a guide. In addition to having a kit at a central location, schools will normally maintain additional kits at or near facilities where activities may pose particular risks. To meet the needs of science laboratories, the recommended approach is to stock a kit in each laboratory or at a location readily accessible to several laboratories.

Figure 3 **First Aid Kit**

Kits are available from St. John Ambulance, Canadian Red Cross, and most science supply companies.

The contents of first aid kits should be checked and replenished regularly. The kit container should be clearly marked and readily accessible, and should keep the contents dry and dust-free.

According to Schedule B of the *Workplace Safety and Health Regulations*, first aid kits must contain the following items:

Manitoba regulations require first aid kits in accordance with the following table	
Total number of workers employed	**Number of Schedule B first aid kits**
24 or fewer	**1**
25–50	**2**
51–75	**3**
76 or more	**4**
All schools must have at least one first aid kit located in the office. **First aid kits should also be located in higher risk areas such as industrial arts classes and dedicated science laboratories.**	

General:

- A recent edition of first aid manual
- A pair of impervious disposable gloves
- A disposable resuscitation mask with a one-way valve
- A disposable cold compress
- 12 safety pins
- Splinter forceps
- One pair of 12 cm bandage scissors
- 25 antiseptic swabs
- Waterless hand cleaner
- Waterproof waste bag

Dressings (must be sterile and individually wrapped):

- 16 surgical gauze pads (7.5 cm squares)
- 4 pads (7.5 cm X 10 cm, non-adhesive)
- 32 adhesive dressings (2.5 cm wide)
- 2 large pressure dressings

Bandages:

- 3 triangular bandages (1 m each)
- 2 conforming bandages (10 cm each)
- 2 rolls of 7.5 cm tensor bandage
- 2 rolls of 2.5 cm adhesive tape
- 1 roll of 7.5 cm elastic adhesive bandage

Equipment for Clean-up and Disposal of Chemical Spills

The following list identifies items to keep in the laboratory in a clearly identified and accessible location for clean-up and disposal of spills. See Chapter 8 for clean-up and disposal procedures for different kinds of chemical spills.

Items	Comments
Acid, base, and solvent spill kits	Spill kits are used for absorbing spills or diluting solutions of chemicals. Use these kits for clean-up of small spills (follow manufacturer's instructions).
Hazorb spill control pillows	These pillows are available from most safety supply companies. Pillows are used to absorb spilled liquids (follow manufacturer's instructions).
Several litres of asbestos-free vermiculite, bentonite, or diatomaceous earth in container with scoop	These materials can be used for spills of solid chemicals, especially powders and viscous or sticky liquids. Containers should be clearly labelled and contents disposed of safely.
Containers suitable for waste chemicals and solvents	Each chemical must be collected separately and labelled according to WHMIS specifications. Waste solvents should be collected only in a safety disposal can with an automatic pressure release closure.
Waste container for glass and sharp objects	A separate container for these items must be available to reduce the chance of injury to maintenance and janitorial staff responsible for normal garbage disposal.
Large container of dry $NaHCO_3$ (baking soda)	Baking soda can be used to neutralize strong acids before disposal. Swimming pool and spa suppliers stock inexpensive, large-volume containers of $NaHCO_3$.
Plastic dustpan and brush	Use the dustpan and brush for sweeping up used sand, vermiculite, or broken glass. Wash and dry both thoroughly after use.
Heavy-duty garbage bags	For disposal of all solid waste, including used sand, vermiculite, and contaminated broken glass. Dispose of each spill separately. Tie bags very securely, double bag if necessary, and label for disposal.
Biohazard bags or extra-thick garbage bags	For disposal of biological specimens and cultures.

Generic Spill Kit

A generic spill-kit mixture can be made simply by mixing equal volumes of sodium carbonate, bentonite (clay cat litter), and dry sand in a plastic container with a lid. Shake the container until the components are mixed. The contents can be mixed again just prior to use when cleaning up a chemical spill. This mixture is effective in the clean-up of the majority of spills. See Chapter 8, Managing the Release or Spill of Toxic or Corrosive Substances (on page 108), for more information on use.

Monitoring and Assessment

Ongoing monitoring and assessment are important steps in maintaining and improving the condition of science facilities, equipment, and materials. Regular performance of these activities supports a proactive approach to repairs and maintenance, which in turn reduces risks for accidents. Monitoring and assessment activities can take place through periodic inventory of equipment and materials and the completion of laboratory checklists such as the one provided in Appendix D.

Chapter 5: Workplace Hazardous Materials Information System (WHMIS)

Overview

WHMIS is a provincial legislative response to provincial employees' and employers' rights to know about the safety and health hazards of the materials they use in the workplace. This system and supporting documentation also provide sufficient information to ensure that people work safely with these materials. This chapter provides WHMIS classifications as well as information related to MSDS and labelling of chemicals.

Notes

A Globally Harmonized System (GHS) of classifying and labelling chemicals is in the process of being implemented in Canada. The GHS will not replace WHMIS, but WHMIS will be modified to incorporate this new, international system. This will mean changes to some of the WHMIS symbols, supplier labels, as well as MSDSs. However, the roles and responsibilities for suppliers, employers, and workers will not change significantly. The goal is to have updated WHMIS laws by June 2015. Information sheets on the proposed changes can be accessed at <www.ccohs.ca/products/publications/whmis_ghs/>.

WHMIS

Teachers, students, custodians, and other staff may be exposed to hazardous materials. Such exposure can cause or contribute to serious health effects. In addition, some hazardous materials may pose immediate physical or chemical risks, such as causing a fire or an explosion. WHMIS informs school staff about, and protects them from, such risks.

Although students are not specifically referred to in WHMIS, except in the case of registered apprenticeship or work experience programs, their presence in the school workplace suggests that a level of care be provided consistent with WHMIS standards. This suggests that students should be made aware of any potentially hazardous materials in areas accessible to them, and provided training in the safety skills needed to use these materials. The safest and most practical approach is to manage the environment so that student access to these materials is limited to times of teacher supervision.

The following are the three major components to the WHMIS:

1. **Labels** applied to containers of hazardous materials (called "controlled products" in the legislation). The labels alert the user to the dangers of the product and to the essential precautions for its safe use.
2. **Material Safety Data Sheets (MSDSs)** are prepared by the product supplier and supplied to the user. These sheets provide detailed information about

product composition, reactivity, health effects, protective equipment and procedures, and emergency procedures.

3. **Education and Training** related to hazards and associated safe work procedures is mandatory for those either working with or working in the proximity of the controlled product. The employer is responsible for developing a safe environment for staff, students, and whoever may be present on school premises. It is expected that all teachers and other staff members handling controlled products be trained sufficiently to use the information and training to protect themselves and the people on premises, including students. This training must be generic, as well as product- and site-specific, so that staff members know what hazardous materials they will encounter in their work location. Since the site-specific component of WHMIS training differs from school to school, science teachers who move to a new school should go through a safety orientation that covers such detail without having to repeat the generic WHMIS training. Training must also be job-specific and tailored for the trainees. A record of all training should be kept. WHMIS regulations require that training programs are reviewed annually or more frequently as needed.

Training of science teachers and support staff in WHMIS would generally include the following, with the addition of site-specific safety:

- legislation that regulates or defines safety standards in the school, particularly Workplace Safety and Health, environmental protection, WHMIS, and fire protection regulations
- due diligence and staff responsibilities
- school and/or district safety policies for science classrooms, laboratories, and field trips
- safety equipment, location, and use
- management of chemicals: location and safe storage, specific risks, safe use of controlled products, and disposal of chemicals
- location of MSDSs and how to read them
- response to spills and spill clean-up
- response to accidents, including first aid procedures
- accident and near-miss reporting procedures
- review of basic laboratory techniques and identification of inherent hazards (See Appendix F for examples of such techniques and their hazards.)

Notes

The provisions of the WHMIS legislation with respect to laboratory chemicals (under 10 kg) are slightly different than those dealing with industrial chemicals.

Information, as well as a student evaluation related to WHMIS, can be found in the support document *Keeping Your Facilities SAFE*, which is available on Manitoba Education and Advanced Learning's website at <www.edu.gov.mb.ca/k12/cur/science/index.html>.

All controlled products sold after October 31, 1988, must meet the legislated labelling, MSDS, and worker education requirements or the product cannot be used, handled, stored, or prepared for disposal.

The WHMIS definition of controlled product does not apply to radioactive materials, pesticides, explosives, consumer products, or materials covered under food and drug legislation (with respect to labels and MSDS, as a condition of sale).

Figure 4 ***WHMIS Classifications and Symbols***

Classes and Divisions	Hazard Symbol
Class A—Compressed Gas	
Class B—Flammable and Combustible Material	
Class C—Oxidizing Material	
Class D—Poisonous and Infectious Material 1. **Materials Causing Immediate and Serious Toxic Effects**	
Class D—Poisonous and Infectious Material 2. **Materials Causing Other Toxic Effects**	
Class D—Poisonous and Infectious Material 3. **Biohazardous Infectious Material**	
Class E—Corrosive Material	
Class F—Dangerously Reactive Material	

Labelling

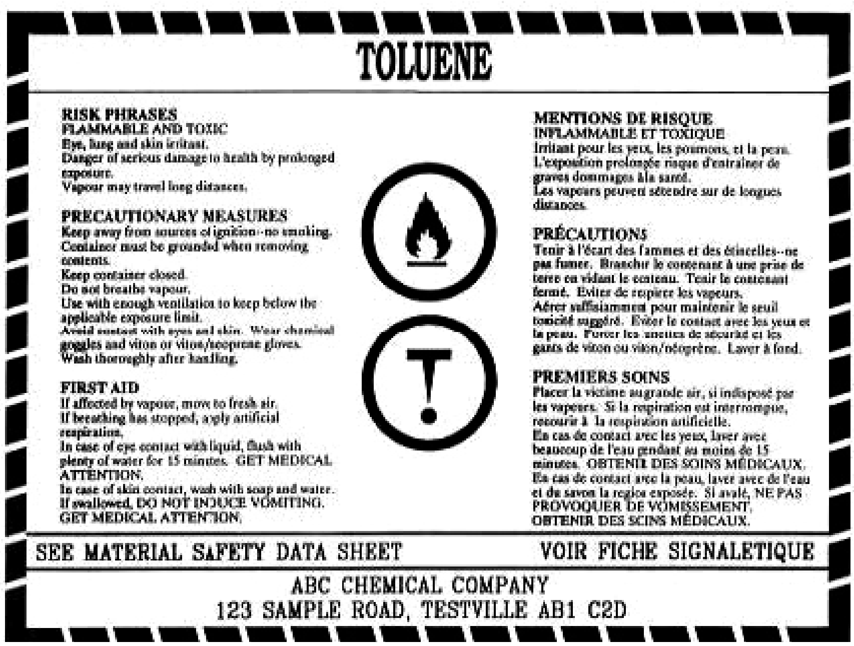
Proper labelling is one of the most important aspects of an effective and safe laboratory operation. Chemicals kept in the storeroom and materials that are generated in the laboratory for and by student experiment require proper labelling.

To protect handlers of potential hazards, labels must present the information clearly and legibly. The formal "supplier label" contains the following **seven elements** of information inside **a distinctively marked border:**

- product identifier
- supplier identifier
- WHMIS hazard symbol(s)
- risk statement(s)
- precautionary statement(s)
- first aid information
- a reference to the MSDS

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

Figure 5 **Chemical Label**



Labelling Chemical Containers

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

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

Outside the laboratory: Transfer containers **must carry a workplace label**. This form of label has three components:

- the chemical identifier
- instructions for safe use (combination of risk phrase and precautionary statement)
- a reference to the MSDS

Acceptable Format for the Workplace Label

Product Identifier
Phrases for Safe Handling Information
See Material Safety Data Sheet

Additional Labelling Requirements for Transportation

The federal *Transport of Dangerous Goods Act* (TDG) and the Manitoba *Dangerous Goods Handling and Transportation* Act outline the regulations for transporting dangerous goods and hazardous waste. According to paragraph 3 of the Manitoba Act: (http://web2.gov.mb.ca/laws/statutes/ccsm/d012e.php)

> No person shall handle or dispose of dangerous goods or cause dangerous goods to be handled or disposed of except in compliance with this act and the regulations.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS) must be supplied with all chemicals. Manufacturers routinely provide online information, electronic media, or data sheets with their products. Teachers and students should be familiar with the type of information contained on a MSDS and be able to interpret the sheets from a variety of chemical suppliers. Although the numbering of sections and the order of appearance may differ from supplier to supplier, the following must be on each MSDS:

I. PRODUCT IDENTIFICATION AND USE
   Manufacturer's name
   Supplier's name

II. HAZARDOUS INGREDIENTS

III. PHYSICAL DATA
   Colour, form, solubility
   Melting and boiling points
   Vapour pressure, specific gravity

IV. FIRE AND EXPLOSION DATA
   Flammability
   Flashpoint
   Firefighting procedures

V. REACTIVITY DATA
   Stability and hazards

VI. TOXOLOGICAL PROPERTIES
   Threshold Limit Values (TLV)
   Effects of exposure
   Carcinogenicity

VII. PREVENTATIVE MEASURES
   Protective clothing
   Protective equipment
   Spill and handling procedures

VIII. FIRST AID MEASURES

IX. PREPARATION DATE OF MSDS

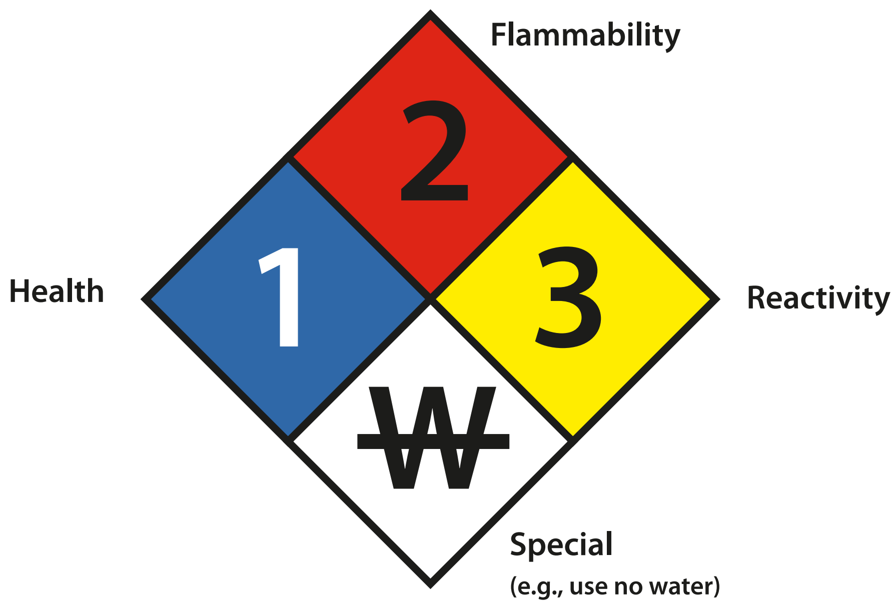
Teaching Students about MSDS

It is important that students have practical experience interpreting samples of MSDSs. A sample activity and resource sheets are available on Manitoba Education and Advanced Learning's website at <www.edu.gov.mb.ca/k12/cur/science>.

National Fire Protection Association (NFPA) Labelling

Other labels that may be seen include these NFPA symbols. A scale of 0 to 4 indicates the level of danger for each of the following categories: health, flammability, and reactivity. In addition, a special precautionary symbol may be used where necessary.

Figure 6 **NFPA Label**



Science and Safety

Part B: Specific Hazards

Chapter 6: Biological Hazards

Overview

While chemical hazards may be the most obvious safety concern in the science classroom, biology-related activities present their own risks. A review of the current Grade 11 and Grade 12 Biology curricula for Manitoba revealed no laboratory labs, investigations, or demonstrations that use pathogenic organisms, cultures, or plants that might cause injury or illness. However, there are many biology teachers who provide enriched study in both grades. This section discusses some biological hazards, suggests ways of reducing associated risks, and identifies official restrictions on biological materials in Manitoba schools.

Chemical Hazards in Biology Activities

Many activities in biology classes require the use of chemicals. As with any use of chemicals, accident prevention depends on assessing and minimizing risks related to the specific chemicals used.

General steps for managing risks include

- choosing the safest chemicals possible
- being aware of potential dangers
- instructing students in proper handling procedures and insisting that they are followed
- using appropriate protective equipment when required

See Chapter 9 for more information on selecting, storing, and using chemicals.

Accidental Infections: Specimens and Cultures

The most frequent known causes of laboratory-acquired infections are oral aspiration through pipettes, animal bites or scratches, and contact with an animal. Other common causes include cuts or scratches from contaminated glassware, cuts from dissecting instruments, spilling or dropping cultures, and airborne contaminants entering the body through the respiratory tract.

> Oral aspiration of any fluid MUST NOT BE DONE in a laboratory setting.

Use of Human Tissue and Fluid Specimens

The potential risk of transmitting hepatitis or HIV (human immunodeficiency virus) through the extraction and analysis of samples of human fluid or tissue has led to the complete elimination in Manitoba schools of these experiments or demonstrations. This prohibition applies to all activities involving extraction of human tissue and fluid samples, including cheek cells, blood, saliva, and urine.

Alternative materials that schools may want to consider in place of these samples include prepared slides and simulated urine and blood. These materials are available from scientific and educational suppliers. There are also excellent videos, computer software, and Internet resources available on these topics. In addition, Canadian Blood Services can visit schools and conduct safe blood-typing activities. For further information, contact Canadian Blood Services or email <whatsyourtype@blood.ca>.

Cultures

Most micro-organisms are not harmful to humans and can be safely cultured. However, culturing harmless micro-organisms still has the potential risk of unintended contamination by pathogenic forms that may be simultaneously introduced to the culture plate. Although the body can routinely destroy small numbers of these pathogenic forms, it may be overwhelmed by large numbers. Teachers can reduce this risk by being aware of the hazards presented by infectious agents and their possible sources, and by using proper handling, storage, and disposal techniques when working with cultures.

Figure 7 **Micro-organisms**

Some general practices to consider when culturing micro-organisms include the following:

- Do not intentionally culture anaerobic bacteria or pathogenic organisms. Pathogenic organisms can be bacteria, viruses, fungi, or protozoa.
- Select materials for study that reflect student and teacher skills and the needs of the curriculum.
  - At the elementary level, use only print and digital images of microorganisms, not live specimens.

    - At the Middle Years level, use print and digital images and, where live specimens are to be used, select only micro-organisms that occur naturally on mouldy bread, cheese, or mildewed objects.
    - In the Senior Years, use micro-organisms that occur naturally on bread, cheese, or mildewed objects as much as possible, and use other organisms with appropriate precautions. If swabs are taken (e.g., from door knobs or desks) and cultured, use precautions that allow for the possibility that some organisms might be pathogenic. Culture the plates for a minimum time period, view within a sealed container, and dispose as soon as possible in the regular garbage in a double strength or double plastic bag.
- Grow cultures only at room temperature or in the range of 25°C to 32°C.
- Incubation at 37°C encourages growth of micro-organisms capable of living in the human body.
- Use a culture medium that is properly sterilized by autoclaving to avoid contamination from other sources and to minimize the chance of culturing pathogenic forms of bacteria.
- Use disposable Petri dishes rather than glass ones. When no longer needed, the cultures and plates can be disposed of in the regular garbage in a double strength or double plastic bag.
- After inoculating the medium with micro-organisms, replace the cover and tape the plates shut. Subsequent observations can be made through the cover.

Proper procedures for cleaning a spill of a culture:

- Put on disposable gloves.
- Place paper towels over spill.
- Pour disinfectant such as 10% bleach solution on top of the towels and leave for 10 to 15 minutes.
- Wipe up the spill with the towels and discard into an airtight plastic bag or other appropriate container.
- If possible, autoclave all apparatus.

Dissection

Dissection is an integral part of biology that attracts much student curiosity and interest. Animals and/or organs for dissection come in either preserved or fresh form. Two potential hazards that exist from performing dissections are infections and accidental cuts from sharp scalpels.

Preserved Specimens

Specimens should be removed from the shipping solution using gloves and tongs, and rinsed thoroughly with water before proceeding. If smaller numbers of specimens are required, vacuum-packed specimens may be an alternative. Disposal of alcohol-based preserved specimens can be done via routine solid waste disposal (i.e., trash/local landfill).

Formaldehyde and Formalin-Preserved Specimens

Specimens sold for dissection now commonly come in an alcohol-based solution, avoiding the need to use formaldehyde or formalin. Formaldehyde and/or formalin-preserved specimens are still available but MUST NOT BE PURCHASED. Although cheaper than non-formaldehyde preservatives, the health risks and the cost to dispose of the liquids and tissues means that formaldehyde/formalin should not be in schools.

What to Do With Existing Formalin-/Formaldehyde-Preserved Specimens

Dissection specimens containing formalin or formaldehyde must not be used and need to be disposed of through a government-approved waste facility. Many schools may still have plastic containers of old preserved specimens that are likely formalin or formaldehyde. These specimens MUST be removed from the school immediately to avoid the risk of a plastic container rupturing and contaminating the laboratory.

For display specimens preserved in a formalin solution, there are chemicals that can be used to eliminate the formaldehyde, but the process is laborious and costly. It is recommended that these specimens be replaced.

Fresh Tissues

Fresh beef, pork and lamb, and fish organs and tissues are often used for dissection. Chicken, on the other hand, often carries salmonella and should not be used. Organs and tissues obtained from slaughterhouses or store meat departments will have been inspected for infectious agents. If kept refrigerated, they should be stable for 10 to 14 days. Handle as you would fresh meat.

High-risk materials, such as animal tissues that potentially carry infectious agents, are controlled by the federal *Health of Animals Act and Regulations* and in Manitoba by the *Livestock and Livestock Products Act*. Check with a local slaughterhouse at any time to determine what materials are available for dissection and what safety precautions may be necessary. Manitoba Agriculture, Food and Rural Development provides details of these and other legislative acts at <www.gov.mb.ca/agriculture/foodsafety/legislation/cfs06s02.html>.

Owl Pellets

Commercially purchased owl pellets are sterilized and do not pose any infectious hazards. This will not be the case with specimens that are personally collected in the wild by the teacher or any other individual. Salmonella is a common pathogen that can be transmitted through wild owl pellets. Be aware of students who have fur allergies.

General Hazards of Equipment and Techniques of Dissection

To minimize risks during dissections, consider the following safety precautions:

- Use preserved specimens or inspected animals or animal parts. Do not use specimens preserved in formalin- or formaldehyde-based preservatives.
- Use disposable dissecting gloves.
- Whenever possible, students should use dissecting trays to reduce contaminating student work areas.
- Discard remains of fresh specimens or alcohol-based preserved specimens in double bags or double-strength bags in regular trash away from student access.
- Clean equipment, wipe lab benches, and wash hands with a commercial cleanser after a dissection.
- A 10% bleach solution can be used to sanitize student desks.

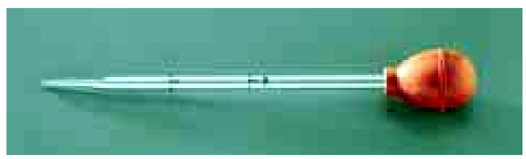
Figure 8 **Dissection Specimens**

Hazards of Activities Requiring Mouth Use

Some activities that involve the mouth include swabs in taste testing, PTC paper, spirometer mouthpieces, and plastic-wrapped thermometers. To minimize risks during these activities, consider the following guidelines:

- Avoid mouth pipetting (even if pipetting bulbs are not available), as it can result in accidental ingestion of fluid.
- Consider using tympanic thermometers, which avoids insertion into the mouth.
- Ensure that any components that are placed in the mouth are used only once, then sterilized or discarded.
- Ensure that students wash their hands thoroughly before and after each activity.
- After use, place refuse in a secured double-strength plastic bag and dispose of in a regular garbage container.

Figure 9 **Bulbed pipette**



Pipettes

Never pipette by mouth.

Pipettes are glass or plastic tubes, similar to eye droppers, which are used to transfer accurately measured amounts of liquid from one container to another. A pipette works by creating a vacuum above a liquid and drawing the liquid into the tube. Rubber bulbs (with or without valves) or specialized fillers are used to draw the liquid into the pipette. Pipettes come in several designs for various purposes and different levels of accuracy and precision. They are usually used for volumes between 1 and 100 millilitres and specialized micropipettes can measure and deliver between 1 and 1000 microlitres. Micropipettes generally have disposable, plastic tips that are ejected by a button into a waste container after each use.

Most of the danger with pipettes is from cuts and abrasions when using glass varieties. Serious cuts can occur when pipettes break while pushing them into the filler. Do not insert a pipette INTO a rubber bulb. The bulb is meant to be placed on top of the pipette, centred on the tube making a seal. If a solution is ever drawn up into the bulb, the bulb and pipette need to be cleaned to prevent someone from contacting the solution.

Suggestions for safe use of pipettes and micropipettes:

- Use plastic pipettes instead of glass as much as possible.
- Inspect pipettes for cracks and chips and check that there is a good seal between the pipette and the pump or bulb.
- Always select the most appropriate pipette for the task.
- Wear a lab coat.
- Wear gloves.
- Wear protective glasses.
- Organize the work space so there is minimal movement during transfer of liquids.
- Carefully insert pipettes into a filler.
- Do not insert a pipette into the hole of a rubber bulb—just bring them in contact.
- Hold pipettes vertically at all times to prevent liquid from entering the filler or bulb.
- Do not pipette from a nearly empty container. This may result in liquid shooting up into the bulb or pump.
- Wipe the counter before and after with an appropriate cleaner.
- Avoid touching used tips.
- Dispose of broken pipettes in a dedicated broken glass container.

Spirometer

Teachers will often use spirometers to measure lung capacity and tidal volume. In every case, individual paper mouthpieces must be used to prevent transfer of fluids from one student to another.

Syringes

The most serious hazards associated with syringe use are accidental inoculation.

Needled syringes must not be used in science classes.

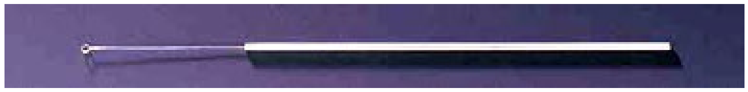
Inoculating Loops

Use care, as the film held by a loop may break and cause atmospheric contamination. A hot loop may cause a liquid to spatter when it is inserted. Allow it to cool first. A contaminated loop may produce an aerosol by boiling and volatilization when it is placed into a flame for sterilization, even before all pathogenic organisms are killed. Whenever inoculating loops are used, any actions that might result in the generation of an aerosol—jerky motions, shaking the loop, and agitating liquids—must be avoided.

Teachers should dip inoculating loops into ethanol before flaming (prevents aerosol formation).

Caution: Care must be taken because of the flammability of ethanol.

Figure 10 **Inoculating loop**



Centrifuging

Centrifuges require close monitoring to ensure the careful balancing of inserted tubes and their contents. The centrifuge lid should remain in place during the time of operation. After use, centrifuges can be cleaned with ethanol under a fume hood to disinfect the centrifuge before it is used by students again.

Gel Electrophoresis

Electrophoresis is a technique that uses electrical energy to separate molecules such as DNA and proteins by their mass and electrical charge. Electrophoresis activities may pose potential electrical, chemical, and physical safety hazards. Agarose, the most common gel medium, is considered safe but skin and eye irritation may occur. Furthermore, contamination may occur during the activity from the electrodes and other sources. The dyes used in colouring the agarose gel, however, may not be safe. Refer to the MSDS for this substance. It is not recommended to use gel media other than agarose, but refer to the specific MSDS if you do.

Electrophoresis equipment either uses batteries or power supplies. See Electrical Hazards (on page 82) in Chapter 7 for general safety measures.

Electrical shock is most likely to occur when connecting the leads in an electrophoresis apparatus.

General safety guidelines include the following:

- Turn off main power supply before connecting or disconnecting electrical leads.
- Remove jewelry.
- Wear gloves and keep your hands dry.
- Connect one lead at a time, using one hand only.
- Ensure that leads are fully seated.
- Don't run equipment unattended.
- Keep equipment clear of sinks, other water sources, or conductors.
- Turn off the power supply when inspecting or removing the gel

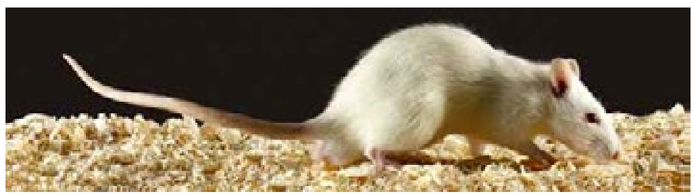
- Collect your gels in a leak-proof container
- Dispose of gels in double-bagged garbage bags.
- Wipe down the counter.
- Wash hands.

Plant and Animal Hazards

The study of live plants and animals in the classroom poses potential risks of injury, infection, and allergic reaction. To minimize these risks, consider the following common-sense precautions:

- Be very selective about organisms brought into the school. Check for student allergies and diseases the animal may carry.

Figure 11 **Rat**



- Consider how you will provide long-term care or dispose of the animal before acquiring it.
- Use domesticated animals or those available through reputable, licensed pet stores. Wild animals should never be brought into classrooms. (Permits may be obtained from Manitoba Conservation to collect wild fish.)
- Know and use proper handling techniques.
- Wear heavy gloves to protect against biting and scratching.
- Explain to students the importance of acting respectfully and responsibly around the animals. Ensure that students do not tease the animals or put their fingers or other objects into the cages.
- Maintain animals in a clean, healthy environment.
- Discourage students from bringing sick animals into the laboratory, and do not allow students to bring in any animals that have died from unknown causes.

When selecting plants, be aware that many plants can be poisonous or contain irritants. This includes a number of plants that are often used in the home. Make a point of checking for toxic properties of plants before using them in the classroom, and ensure that students wash their hands after handling plants or plant parts.

Figure 12 **Poisonous Plants**

Some common poisonous plants to be aware of include:

- plants poisonous to touch due to exuded oils:
  - Poison ivy (*T. radicans; R. diversiloba*)
  - Oleander (*N. oleander*)
- toxic house or garden plants:
  - Poinsettia (*E. pulcherrima*)
  - Dieffenbachia (*D. maculata*)
  - Castor bean (*R. communis*)
  - Mistletoe (*V. album*)
  - Lantana (*L. camara*, etc.)
  - Hyacinth (*Hyacinthus orientalis, Scilla nonscriptus, and Agraphis mutans*)
- other plants that are poisonous when eaten:
  - Tansy (genus *Tanacetum*)
  - Foxglove (*D. purpurea*)
  - Rhubarb leaves (*R. rhabarbarum*)
  - Baneberry (*Actaea pachypoda; Actaea rubra*)
  - Marsh marigold (*Caltha palustris*)

Cleanliness in Biology

Areas where organisms are kept or cultured must be given special attention with regards to cleanliness.

General safety guidelines to consider include the following:

- Do not store or consume food in these areas.
- Wash all used surfaces with a disinfectant (e.g., bleach) after each activity.
- Contact Health Canada, your local health authority, or a science supply catalogue for appropriate disinfectants.
- Clean shelves, cupboards, animal cages, autoclaves, fridges, and other items at weekly intervals using an appropriate disinfectant.
- Wash hands after handling any kind of organism(s).

If an autoclave is not available, sterilize equipment used in microbiology by boiling in a pressure cooker for 10 to 15 minutes. The heat provided by a microwave, on the other hand, is not uniform enough for this purpose. An ultraviolet light cabinet can be used to sterilize external surfaces. Liquid disinfectants and germicidal agents generally will not provide complete sterilization.

Figure 13 ***Autoclave***

Chapter 7: Physical Hazards

Overview

Physical hazards include mechanical, electrical, heat, sound, and radiation hazards that may occur in physics laboratory activities, as well as a variety of other science activities. Hazards in each of these categories have the potential to cause injuries (or, in some extreme cases, even death), but by taking general precautions, such as using appropriate protective equipment and emphasizing routine safety, physical hazards can be easily minimized.

Mechanical Hazards

- In general, safety can be increased by ensuring that equipment is well maintained.
- Turn off all equipment before leaving the area.
- Students must only use equipment with teacher supervision.

Rotating Machinery

Machinery with rotating parts can catch loose clothing, hands, or hair, potentially causing serious injuries. Uncovered parts may also fly off, thereby creating additional risk, especially for eye injuries.

To minimize risks, do the following wherever possible:

- Ensure rotating shafts, belts, and pulleys are covered by guards, lids, or covers.
- Check devices attached to a rotor before use to ensure that they are tightly fastened.
- Wear (and have students wear) eye protection when using uncovered, rapidly rotating parts, as in the demonstration of centripetal force and circular motion.
- Have students stand back as much as possible.
- Have a safety shield available in the science area.

Tools

Careless use of tools or use of tools in poor condition can cause injuries to the hands, eyes, head, and limbs.

To minimize risks:

- Regularly check tools for defects or damage.
- Damaged tools should be immediately removed from student use.
- Provide students with clear instructions on safe use before they have access to tools.

Cutting Tools (Scalpels, Razor Blades)

By design, these instruments are very sharp. Careless use can quickly result in deep cuts.

To minimize risks:

- Use extreme caution in handling cutting tools, and ensure that students do the same.
- Replacement of blades is best done by teachers or technicians.
- Wear eye protection when using cutting tools in case a blade breaks.

Magnets

Large, powerful magnets or electromagnets can attract other magnets or iron/nickel objects with surprising force, which can cause painful pinching of fingers or hands.

To minimize risks:

- Inform students of this hazard before such magnets are used.

Glassware

Any kind of glassware has the potential to break, creating the risk for cuts or spilled materials.

To minimize risks:

- Wear goggles for eye protection.
- Use heat-resistant glassware, which is less likely to crack when heated.
- Avoid using glass containers that are cracked or chipped, since they may crack further during the experiment.
- Clean up any broken glass immediately and dispose of in a special waste bin dedicated to broken glass.
- Do not pick up glass with your hands—use a dustpan and brush or broom.

Projectile Launchers

Projectile launchers are often used in the study of motion—sometimes as demonstration devices and sometimes as equipment for student laboratories. Equipment used includes such devices as ballistic pendulums, commercially available devices that launch plastic and steel balls, and classroom-constructed devices that launch a variety of materials. When decisions are made regarding the use of such equipment—such as which devices are to be used, who will use them, and how to use them—it is important to recognize factors that can introduce potential risk. These factors include the power of the launcher, the nature of the projectile, and the maturity, skill, and safety awareness of the user. The location and orientation of the launcher when the device is operated relative to the location of students is also a concern. These devices should never be oriented in a way that puts students in the line of fire.

To minimize risks:

- Wear goggles for eye protection.
- Participants and spectators should be behind the line of fire.
- Avoid using projectiles with sharp points.
- Ensure that misfiring does not place participants or spectators at risk.

Testing Structural Design to Failure

The Early and Middle Years science curricula contain many activities where students are required to make fair tests on various structures for design, stability, strength, and efficiency of performance. Such testing, particularly for strength, often requires stress-to-failure determination, which may require some precautions.

To minimize risks:

- Assess all inherent risks of testing to determine necessary precautionary measures.
- Wear goggles for eye protection.
- Minimize height at which testing is done on collapsing structures.
- Use of heavy weights should be closely supervised.
- Testing should be only attempted during teacher supervision.
- Testing should be done in a clearly marked area a safe distance from students.

Electrical Hazards

The two major risks related to electricity are electrical shock and fire. Some specific hazards and precautions are described below. An emergency power switch must be installed in every classroom or laboratory in which there is electrical equipment. A placard must also be visible to clearly label the emergency switch.

Faulty Wiring

Frayed cords and loose or broken connections will eventually create a short circuit. Fire, electrical shock, or equipment damage may result.

To minimize risks:

- Check external wiring of equipment before use.
- Verify normal function before making equipment available for student use.
- Ensure that the third ground prong on an extension cord or plug is still attached. Never cut the ground prong off of a device or extension cord.
- Do not disconnect power cords by tugging on the wire—always grab the plug end when disconnecting.

Heavy-duty Usage of Lightweight Equipment

Equipment damage and overheating, and therefore fire, are always possible if equipment is in prolonged use at power ratings greater than for which the item was designed.

To minimize risks:

- Always use equipment in the way its manufacturer intended.

Electrical Equipment Near Water

Use of electrical equipment near water creates the potential for a shock hazard if water gets into the electrical system. In addition, there is the potential for malfunction or failure of the equipment.

To minimize risks:

- Ensure equipment used near sinks or other water sources is properly insulated and grounded.
- Use ground-fault interrupter (GFI) plugs where available.
- Switch current off at the wall outlet or unplug immediately if water gets into the electrical equipment, and do not use again until completely dry.

Electrical Equipment Near Flammable Liquids or Their Vapours

The brushes of an electric motor will generate sparks, which can ignite flammable vapours under poorly ventilated conditions.

To minimize risks:

- Ensure that electrical equipment is used only in properly ventilated areas, away from flammable liquids.
- In the case of fume hoods, it is mandatory that the fume hood exhaust fan motor be explosion proof. This means that if there is a spark produced by the motor, the spark is completely encased and, due to the structure of the motor, is not allowed to make contact with the flammable vapours that may be outside the motor.

Shorting Dry Cell Circuits

Short circuits in devices not protected by a fuse can lead to overheating and to the risk of fire or injury. Such risks occur when a circuit is completed between terminals of a dry cell or dry cells without adding any resistance in the form of a bulb or other electrical device. Contact with overheated wires can lead to skin burns or a fire if the wires are near flammable materials. Severe short circuits can also cause dry cells to melt, give off toxic fumes, and possibly explode.

To minimize risks:

- Ensure a circuit has at least one source of resistance (e.g., bulb, electric motor).
- Whenever possible, all circuits should contain a mechanical switch.
- If an open switch is not included, connect the battery/batteries last into a circuit.

High Voltage Equipment

Some student-wired laboratory set-ups or teacher-made demonstration equipment may have the potential to deliver a high voltage discharge.

Common risks include the following:

- Capacitors that build up and store current can discharge on contact, generating a powerful shock.
- Polarized capacitors can explode if incorrectly connected into a circuit.
- Tesla coils can cause severe skin burns.
- Electrostatic generators, particularly the Van de Graaf, can cause serious shocks if students join hands.

- Isolation transformers that use 120V AC current can be fatal since only one wire needs to be attached.

To minimize risks:

- Ensure high voltage equipment is handled with extreme care.
- Ensure any use of such equipment is under the direct supervision and guidance of a qualified person.
- Ensure the equipment is in good working order before using it in the classroom.

Heat Hazards

Heating devices create fire and injury hazards. The potential risks posed by these devices vary with the heating device used and the way in which it is used.

To minimize risks:

- Provide test tube holders or tongs to handle hot equipment and containers.
- Provide heat-resistant gloves for handling heated objects or containers.
- Warn students about the dangers of reaching over an exposed flame or heat source.
- Provide heat-resistance glassware to prevent cracking and spilling of hot contents.
- Ensure students allow ample time for heated objects to cool before touching them.

Additional precautions for specific heat sources are described below.

Bunsen Burners

Figure 14 **Bunsen Burner**

Bunsen burners provide a direct and very efficient source of heat for laboratory purposes: however, there is a risk of burns, particularly to student fingers and hands. If the burner is used to heat water or a solution, the rapid heating can cause hot liquid to bubble out as it reaches its boiling point. In general, Bunsen burners would not be the preferred source of heat in Early Years settings and might also be avoided in Middle Years.

To minimize risks:

- Use Bunsen burners only if the activity requires high heat and if the maturity of the students is sufficient.
- Provide students with training on the use of Bunsen burners, particularly the routine of lighting and regulating flame intensity and air flow to produce a smokeless flame.
- To reduce the chance of "bumping," which is the superheating of some of the liquid being heated, boiling chips or glass beads should be used.
- Heating liquids in test tubes can be the most dangerous. First, the flame should be as low as possible and the test tube must be held firmly with a test tube clamp. For gentle heating, the test tube should be quickly rotated in and out of the flame and the contents swirled for even heating. If the liquid is not evenly heated, it may super-heat and bump out of the test tube.
- Point the test tube mouth away from anyone nearby when using Bunsen burners to heat a solution or water in a test tube.
- Never heat a stoppered test tube.
- Use hot plates when flammable liquids are being used anywhere in the laboratory.

Hot Plates

Figure 15 **Hot Plate**

Electric hot plates with thermostatic controls provide a safer, controllable, and reliable source of heat that meets the needs of science courses; however, they can still cause burns to skin. In addition, coiled hot plates, which might still be in use in some schools, have greater potential to cause burns because of the exposed coils. Hot plates require a long time to completely cool before they can be handled safely.

To minimize risks:

- Ensure hot plates, as well as the heated materials and containers, are handled with care using proper techniques.
- Avoid coiled hot plates, if possible, and take extra care if they must be used.

Candles

Candles provide low intensity heat and thus are limited in their usefulness. However, they can be a good source of heat for activities where low intensity is required. The main problem with candles is their instability, which can cause fires or spill hot wax when they tip over.

To minimize risks:

- Secure the candle firmly to a base to prevent tipping. Impaling the bottom of the candle onto a nail protruding from a board base is effective. Setting the candle into a small pool of hot molten wax is generally not adequate to prevent tipping over.

NOT RECOMMENDED: Alcohol Burners

Figure 16 ***Alcohol Burner***

These burners must not be used in any classroom or science laboratory at any grade level. There have been countless accidents from this type of burner. Alcohol is both odourless and invisible when burning. Teachers and students have been seriously burned by filling alcohol burners that have hot wicks.

NOT RECOMMENDED: Primus Cartridge Burners

It is NOT recommended that these burners be used at any grade level.

This type of burner, which is often used for camp cooking, presents a significant burn hazard associated with its use. One major drawback of this heat source is the inability to control the air supply to the flame. Thus, the heat intensity of the flame is always high (blue in colour), regardless of the size of the flame. Butane cartridges tend to be narrow and thus must be stabilized when in use. They cannot be refilled or recycled, and therefore present a concern to the environment.

NOT RECOMMENDED: Butane Burners

Figure 17 **Butane Burner**

While these burners are relatively easy to use and function much like a Bunsen burner, they are not recommended. They do have separate adjustments for gas and for air; however, the cartridges are not rechargeable and must be replaced once the gas is used up, making them more expensive to use than Bunsen burners and a concern to the environment.

Rocketry Hazards

Rockets are devices containing combustible propellants that produce thrust by expelling hot gases. Depending on their physical size and the size of the motor(s), rockets are classified as model rockets or high-powered (model) rockets. The guidelines and regulatory requirements that must be met for each of these are quite different.

Model Rockets

No special training or certification is required for building, installing, and firing model rockets made of lightweight materials weighing 1.5 kg or less. Rockets in this category are restricted to types A to G motors, producing up to a maximum of 160 Newton-seconds impulse, which in combination cannot exceed 320 Newton-seconds (N-s) total impulse. For less powerful A to F motors, the person must be over the age of 12 years and be supervised by an adult. To purchase "G" level motors, a person must be 18 years old or older. Model rockets use pre-manufactured solid propellant rocket motors with black powder or composites as propellants.

Flying of model rockets should be done in accordance with the *Canadian Rocketry Association Safety Code*. This can be found at <www.canadianrocketry.org>. Also, check with local authorities for bylaws regulating the firing of such rockets.

High-Powered (Model) Rockets

Rockets in this category have motors with an impulse over 160 Newton-seconds but not exceeding 40 960 N-s. Installing and firing such rockets is restricted to individuals over the age of 18, requires Canadian Association of Rocketry High Power certification, and is restricted to approved launches. Transport Canada has set out requirements for launching high-powered model rockets in Canada. These can be found at the Canadian Association of Rocketry website at <www.canadianrocketry.org/>. The major inherent risks associated with firing rockets include possible burns and the potentially lethal impact of misguided rockets.

Sound Hazards

Prolonged exposure to sound in excess of 85 decibels (dB) contributes to cumulative damage to inner ear hair cells, which may result in permanent loss of hearing at the specific frequencies to which the lost hair cells were sensitive. Such volumes might be created, for example, by loud music at school dances or by large generators in mechanical rooms. By contrast, high-impact noise causes eardrum perforation. Such noise is generated by pneumatic tools such as jackhammers. The eardrum perforations will heal, but each time this happens, scar tissue builds up on the eardrum and makes it less sensitive to sound waves. Any equipment or instruments generating significant sound should be monitored for loudness to ensure they do not exceed allowable occupational exposure limits set out in the *Workplace Safety and Health Act*.

Radiation Hazards

Radiation is not usually a hazard encountered in classrooms or the topic of discussions about safety in science. It is an invisible, often insidious hazard associated with the decay of radioactive materials such as isotopes of uranium and thorium, as well as emissions from electronic equipment or other sources. Radiation is the emission of energy in either particulate or electromagnetic form and is generally classified into two distinct categories: ionizing and non-ionizing.

Non-ionizing Radiation

Non-ionizing radiation increases the kinetic energy of molecules in body tissue, leading to heat production. This heat production is not enough to change the tissues chemically. Examples of this kind of radiation are sound waves, visible light rays, lower frequency ultraviolet rays, and microwaves.

Ultraviolet Radiation

When short wavelength radiation, such as ultraviolet rays, is absorbed by the skin or eyes at a high enough intensity or for a long enough time, the result can be sunburn and painful "welder's flash" burns on the eye. Prolonged or chronic exposure to ultraviolet radiation may also lead to premature skin aging. At sufficiently high intensities, non-ionizing radiation can disrupt essential physiological processes. However, in normal school laboratory practices where low-intensity radiation sources are used and exposure is minimized, levels will be well below specified limits and it will generally not be necessary to measure actual field strengths.

To reduce these risks:

- Minimize skin exposure.
- Never look directly at a source of ultraviolet rays without appropriate eye protection.

Potential sources of ultraviolet rays include lasers, stethoscopes, microwave ovens, UV bulbs, welders, fluorescent bulbs, gas discharge tubes, and burning magnesium ribbon.

Visible Light and Lasers

The direct or reflected viewing of any intense visible light source—electric arcs, burning magnesium ribbon, the sun, or even collimated or focused beams from ordinary tungsten lights—can cause retinal damage. For example, looking at the sun requires the use of a solar filter equivalent to that of a welding mask. The visible beam of light from a laser is focused by the lens of the eye and can cause severe retinal damage with very brief exposure if the laser is of sufficient power.

To reduce risks:

- Do not allow students to use lasers without close supervision.
- Use lasers in a well-lit room so that the pupils of the eye are small.
- Position lasers so that the beam cannot enter the eyes directly or by reflection.
- Demonstration lasers must be limited to 1 milliwatt beam of power and be within the wavelength range of visible light (400 to 780 nanometres). The normal blink response time of 0.25 seconds is sufficient to prevent retinal damage.

Stroboscopes

Rhythmical pulses of light, especially in the range of 3 to 7 Hertz, can cause unpleasant or dangerous physiological effects in some people, including nausea and epileptic seizures.

To minimize these risks:

- Avoid the range of 3 to 7 Hertz.
- Warn students of potential effects and monitor them closely for unusual behaviour or onset of nausea during use of stroboscopes.
- Excuse students who know that flashing light has a negative effect on them.

Microwaves

All microwave ovens produced since 1971 are covered by a federal radiation standard that assures such ovens are safe. This standard limits leakage of microwaves to values well below the level at which heating or burning of human tissue would occur, even at distances as close as 5 cm.

Ionizing Radiation

The term *ionizing radiation* refers to radiation in several forms:

- alpha particles
- beta particles
- gamma rays
- ultraviolet radiation, particularly at higher frequencies

The possession and use of materials that emit such radiation is tightly controlled by the Atomic Energy Control Board (AECB). Ionizing radiation has sufficient energy to break chemical bonds and damage human tissue, increasing risk of harmful genetic mutations and cancer. Potential harm is proportional to the energy absorbed, which in turn is affected by the amount of exposure. Although alpha particles can be stopped by a sheet of paper and beta particles by a layer of clothing, both are much more hazardous if ingested or inhaled. Both gamma and X-rays easily pass through the human body. Lead shielding is necessary to protect against such rays. Cathode ray tubes (CRTs) do not normally pose a radiation risk but can emit X-rays under high voltage conditions.

It should be noted that there is no readily applicable standard that specifies what amount of radiation exposure is safe. In general, the level of radioactivity in materials considered acceptable for Senior Years activities is so small that it approaches the level of normal background radiation. Such low levels do not require special licensing from the AECB, since potential health risks are minimal. These low-level sources are readily available through science supply companies. These have radioactivity levels measured in microcuries and can generally be disposed of via the local landfill. Check with your municipal office to ensure this is the case. Furthermore, no elaborate safety equipment or protective measures are necessary.

Radioactive materials available for purchase come in both sealed and unsealed containers. Sealed containers have the radioactive material permanently embedded within a metal, plastic, or other medium. Such sources are easier to handle and are generally safer to use than the unsealed sources of the same material. Sealed sources in license-exempt quantities are also readily disposable.

Protection from Ionizing Radiation

Special handling and shielding of radioactive materials is required in instances where activity levels exceed the exemption quantities set out in Schedule 1 of the *Nuclear Substances and Radiation Devices Regulations*. Materials that have such high levels of radioactivity are not recommended for school use. See <www.nuclearsafety.gc.ca/eng/regulatory_information/Regulations/index.cfm> for more information on these regulations.

To minimize the potential hazards of ionizing radiation:

- Use low-level radioactive material with emissions in millicuries.
- Keep the time for potential exposure to a minimum.
- Stay as far from the radiation source as possible. As a rule, if the distance is doubled, exposure is reduced by a factor of four.
- Monitor radiation levels throughout time of exposure with the use of a Geiger counter.
- Store in a suitably shielded container (e.g., a lead storage pot in a properly marked cabinet not frequently used by people).

Overview

Most of the chemicals used in schools do not pose serious dangers. However, there are some chemicals that require more careful handling and others that should be avoided altogether. It is important

- to know proper clean-up procedures, in case a spill does occur
- that teachers and students be familiar with the chemical and physical properties of chemicals they work with, particularly for regulated or hazardous substances
- to control risks by limiting chemical concentration and exposure (the higher the concentration of a chemical, the higher the toxic or corrosive hazard)

Toxic or corrosive properties are the most common hazards posed by chemicals in schools. A toxic substance is any substance that may cause damage by its chemical action when ingested, inhaled, absorbed, or injected into the body in relatively small amounts. Damage can occur when materials directly destroy tissue through corrosive action (e.g., NaOH reacts with moisture in the skin, interfering with chemical reactions of the body).

Notes

Refer to Appendix G for a list of chemicals that pose excessive hazard risks and should not be present in Manitoba schools.

General Safety Measures

Whenever chemicals are used, **the onus is on the teacher** to assess risks, determine proper handling procedures, and convey this information to students before beginning the activity. It is important that the handling procedures for all chemicals aim to minimize exposure, especially to those chemicals that present greater hazards.

The following general guidelines can be followed to increase safety when working with chemicals:

- Always follow WHMIS regulations and practices.
- Always read and have available MSDSs for all chemicals.
- Purchase only required chemicals in minimum quantities.
- Choose the safest chemicals and labs where possible.
- Store chemicals properly.

- Keep stock bottles and solutions out of lab areas.
- Inform students of the risks involved in their lab activities.
- Never eat or drink in labs or storage areas.
- Minimize exposure to chemicals and always use proper protective equipment.
- Do not wear contact lenses.
- Only perform labs that have been tested beforehand.
- Make sure students follow protocols exactly as instructed.
- Be prepared for accidents.
- Dispose of waste materials properly.
- Follow proper clean-up procedures after each lab activity is finished, including washing hands.
- Secure chemicals in locking cabinets and storerooms.

Corrosive Chemicals (Liquid, Solid, or Gases)

The most familiar corrosive chemicals encountered in laboratories are acids and bases. Corrosive chemicals are substances that are injurious to body tissues (from a minor irritation to physical destruction of tissues) or corrosive to metals by direct contact.

On humans, this corrosive quality is often due to the reaction of the substance with water or moisture in the tissue. This is the case with strong acids and bases of 1M or greater concentration, non-metal halides, dehydrating agents, halogens, and oxidizing agents. The most serious corrosion hazards come with substances that are in a mist or gaseous state, since they can be readily absorbed through the skin or inhaled into the lungs. Tissues of the body are affected by direct chemical reaction, destruction of proteins, and disruption of cell membranes.

Dangers from corrosive materials can occur through

- direct contact with skin
- contact with eyes and mucous membranes
- inhalation of vapours or dust
- ingestion of liquids or solids

Corrosive materials also pose a hazard when dangerous gases are produced as a result of reaction with other materials (e.g., nitric acid will react with copper to produce nitrogen dioxide).

Types of Corrosives and Their Hazards

Liquid Corrosives

Liquid corrosives are typically encountered in school laboratories as acids (hydrochloric, sulphuric, nitric, and acetic) and water solutions of bases (sodium hydroxide, potassium hydroxide, and ammonium hydroxide).

Acids act on body proteins and produce a barrier that, although extremely painful, limits the activity of the acid.

Bases penetrate deeply with little or no pain since no protein barrier is produced. For that reason, bases can cause greater skin or eye damage than acids.

Examples of liquid corrosives encountered in schools:

Hydrochloric acid	It can liberate gases such as hydrogen and hydrogen cyanide. It reacts with formaldehyde to produce chloromethoxychloromethane, a potent carcinogen.
Nitric acid	It can oxidize cellulose material, creating a self-igniting condition. It is extremely exothermic and potentially explosive when mixed with organic materials.
Sulphuric acid	It is a powerful oxidizer that can dehydrate organic material rapidly with the production of heat.

Solid Corrosives

It is a mistake to think of corrosive solids as being relatively harmless because they can be removed more easily than liquids. Solid corrosives are often rapidly dissolved by the moisture in the skin and even more rapidly by moisture in the respiratory and alimentary systems. Solid corrosives also may not produce immediately painful reactions, causing delayed injury.

The following are some examples of solid corrosives encountered in schools:

- alkali metal carbonates (e.g., K_2CO_3)
- alkali metal hydroxides (e.g., NaOH)
- alkali metal sulphides (e.g., Na_2S)
- alkaline earth hydroxides (e.g., $Ca(OH)_2$)
- elemental alkali metals (e.g., Na, K, Li)
- chromium salts
- iodine
- trisodium phosphate

Gaseous Corrosives

Perhaps the most dangerous form of corrosives, these gases enter the body via absorption through the skin and by inhalation. The corrosive gases are grouped by solubility and effect upon the respiratory system.

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

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

Common corrosive gases include the following:

- ammonia
- formaldehyde
- hydrogen chloride
- halogens
  - They will support combustion, and may ignite powdered metals on contact. They also react violently with organic substances.
  - Chlorine and bromine gas should not be used as reagents in school labs.

Specific Precautionary Measures with Corrosive Chemicals

In addition to the General Safety Measures (on page 93), it is important to

- use the following protective equipment:

See Safety Equipment and Supplies (on page 47).

  - lab coat or acid-proof apron
  - safety goggles/face shield
  - gauntlet-type acid-resistant gloves
  - outside of a fume hood, a safety screen
- use a fume hood
- have adequate exhaust ventilation where corrosive substances are stored
- have plenty of water available for flushing, including eyewash
- have plenty of sodium bicarbonate available for neutralizing liquid corrosive spills
- store corrosive chemicals properly
  See Storage Facilities for Chemicals (on page 113).

Principles of Corrosive Chemical First Aid

- Alert the teacher or nearby colleague.
- Call 911 (emergency services).
- Neutralizers and solvents (alcohol, etc.) should not be used by the first aider.
- In the event of contact with eyes:
  - **Immediately** flush the eyes with water and continue to flush for 15 minutes using tempered (not cold) water. Eyelids may have to be forced open so that the eyes may be flushed. Get medical attention if necessary. The first few seconds after contact are critical. Immediate flushing of the eyes may prevent permanent damage.
  - If the student is wearing contact lenses, remove them after flushing if they have not been washed out already. Continue flushing.
- In the event of contact with skin:
  - Strong chemicals burn the skin rapidly. Begin flushing the area with water **immediately**. Remove carefully and discard clothing (including socks and shoes), watches, and jewellery. Continue to flood the area while clothing is being removed.
- The precautionary warning on the product label should be consulted for full first-aid information. Provide the label information and MSDS to the attending physician.

Toxic Hazards

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

The potential for contact with toxic materials exists in activities in science. Chemistry experiments are the most obvious situations with potential hazard. However, a person may be exposed to toxic substances from unsuspected sources. Toxic materials may be involved incidentally as part of a laboratory or demonstration procedure. Careful consideration is to be given to all materials used and produced in an activity (e.g., the dust of heavy metal minerals may be inhaled during the breaking of rock samples).

Inadequate clean-up may lead to exposure to toxic materials after a lab procedure is finished. Substances left on benches or in beakers and bottles may expose others to these toxic materials. Students may ingest toxic materials they have been in contact with if they do not wash thoroughly before eating or smoking. Foods and beverages readily absorb many vapours and should never be brought into a lab. Chewing of gum should not be allowed.

Toxic materials damage the body by interfering with the function of cells in body tissue. Damage can occur when

- toxic materials interfere with chemical reactions of the body (e.g., CO_2 replaces O_2 in hemoglobin)
- disruption of the biological processes occurs (e.g., NO_2 causes pulmonary edema and allergic responses)

Toxic effects can be local or systemic as well as acute or chronic. Local effects are confined to the area of the body that has come in contact with toxic materials. Systemic effects occur throughout the body after absorption into the bloodstream. Acute effects are immediate, while chronic effects may take many years before they become evident.

Dangers from toxic materials can occur through

- direct contact with skin
- contact with eyes and mucous membranes
- inhalation of vapours or dust
- ingestion of liquids or solids
- direct entry to the bloodstream through punctures or open wounds

Symptoms

Poisoning may be suspected when any of the following are evident:

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

Special Caution: Many toxic vapours and liquids can have little or no odour, even in dangerous concentrations.

Toxic materials or controlled products are rated in Manitoba by an Occupational Exposure Limit (OEL), as defined in section 36 of the *Workplace Health Hazard Regulation* at <http://web2.gov.mb.ca/laws/regs/pdf/w210-217.06.pdf>. This is a regulation under the *Workplace Safety and Health Act*.

Specific Precautionary Measures with Toxic Chemicals

In addition to the General Safety Measures (on page 93), it is important to

- treat a substance as toxic unless definitely known otherwise
- close chemical containers (Vapours, dust, and liquids can easily escape during normal handling.)
- use fume hoods when heating toxic materials (Smoke and vapour may be released in much greater quantity when material is hot.)
- use fume hoods when transferring powders
- avoid crushing and grinding solids, which may release dusts into the air
- use toxic materials in areas with adequate ventilation (Toxic vapours can rapidly accumulate to dangerous levels in a room.)
- not lean over an open container containing a toxic material (Toxic vapours can be in high concentration immediately above an open bottle, even in well ventilated rooms.)
- cover all exposed areas with chemical-resistant clothing, including
  - protective gloves
  - aprons
  - lab coats
  - face shields

Principles of Toxic Chemicals First Aid

- Alert the teacher or nearby colleague. Speed is essential.
- Call 911 – emergency services.
- In the case of contact with skin or eyes, wash affected area immediately and continue to do so for at least 15 minutes.
- If a material has been inhaled or swallowed or if a victim is unconscious, in convulsions, or in pain, contact trained assistance immediately.

Insidious Hazards

Insidious chemical hazards could be easily overlooked or ignored, even during routine safety inspections, because their effects are not immediately obvious and are inconspicuous (can't be seen, tasted, smelled, or felt). They may cause, however, local or systemic, acute or chronic effects, depending upon the nature of the substance and duration of exposure.

Sources of Insidious Hazards

Insidious hazards include

- residues in the sink drain
  - If aqueous solutions are disposed of by flushing down the drain, this can lead to the build-up of toxic (e.g., mercury) or other hazardous materials that may be released into the laboratory air upon contact with a catalyst (e.g., nickel, metal).
- leaking gas cylinders
- leaking gas lines and jets
- ignition sources
- chemicals that slowly react to form toxic products or build pressure
- faulty pressure control equipment for compressed gases
- neglected containers of dried solutions and residues of chemical products from past demonstrations and activities
- improperly stored (see Chapter 9) or labelled (see Chapter 5) chemicals

Specific Precautionary Measures for Insidious Hazards

In addition to the General Safety Measures (on page 93), consider the following measures:

- Prepare a list of potential insidious hazards that should be updated regularly.
- Give specific attention to possible sources of insidious hazards during the safety inspection process.
- Avoid stock build-up of toxic, flammable, or corrosive materials.
- Have efficient and appropriate clean-up agents for spills.
- Collect waste materials in separate containers and do not mix them.

Mercury

Mercury is one of the most common insidious hazards. It evaporates and readily absorbs through the skin and respiratory system, which can have serious and cumulative effects on the gastrointestinal and central nervous systems. Mercury is also capable of forming explosive compounds, such as mercury fulminate.

The risks of using mercury and its compounds exceed its educational utility. Therefore, its use is not recommended in Manitoba schools. Mercury thermometers should be avoided because of potential breaks and spills. To avoid mercury spills, you should

- use organic-filled (like alcohol) or electronic thermometers rather than mercury thermometers
- use care in handling instruments containing mercury

Nevertheless, if mercury is spilled, it must be cleaned up and stored before disposal by a hazardous waste removal company. Proper handling of spills and subsequent storage should be as follows:

- Students should not be allowed to clean up spills.
- Use a commercial spill kit that includes the control of mercury vapours (aspirator, mercury absorbent, and vapour absorbent).
- Use gloves to clean and handle the spill kit.
- Clean up immediately and thoroughly when a spill occurs.
- Store mercury in a plastic bottle under a layer of water or oil.
- Keep the container sealed in a cool, well ventilated area.
- Avoid opening the container and allowing vapours to escape.
- Wear gloves when handling the container.

Unless mercury spills are promptly and thoroughly cleaned up and the area decontaminated, dangerous exposure to vapours will continue. In the past, the common practice for clean-up was to aspirate or sweep up any visible drops. Mercury droplets from 10 to 1000 micrometres in diameter also stick to vertical surfaces and penetrate into porous flooring. In some cases, relatively large amounts of mercury may be left undiscovered after spills. Prompt and thorough clean-up of mercury spills is essential or **cumulative exposure to mercury vapours can cause irreparable harm to those working in the area.**

School board policies should be followed in the case of a spill (from thermometer breakage, for example). If a spill occurs near students, they should move away from the area and inform their teacher immediately.

Carcinogens

A carcinogen is a chemical, physical, or biological substance that is capable of causing cancer. The damaging effects are subtle and imperceptible in the short term; thus, carcinogenic substances are another insidious hazard that may be present in the laboratory and chemical storage area. A substance is considered to be carcinogenic if it has been evaluated and rated as a human carcinogen, an animal carcinogen, or a potential carcinogen by the American Conference of Government Industrial Hygienists or the International Agency of Research on Cancer. These substances will also be categorized under **WHMIS** as Class D2. Health Canada has tabled a list of substances assessed for carcinogenicity on its website at <www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/carcinogenesis-carcinogenese_e.html>.

The website also has links to agencies to enable searches of the most current information. Carcinogenic properties of chemicals with excessive risks are also indicated in Appendix G.

Actual manifestation of cancer or tumors for most carcinogenic chemicals requires prolonged and often relatively constant exposure. Proper storage of such chemicals in airtight containers reduces this hazard by limiting exposure only to periods of chemical usage. However, the more frequent the use, the greater the exposure, particularly for powdered forms of these chemicals, which can be absorbed through the skin and lungs.

Fewer chemicals have carcinogenic properties compared to other risks, and those that do should be avoided, if possible. Whether to stock and use chemicals with carcinogenic properties will depend on curricular requirements, adequacy of facilities, and the ability to safely handle these chemicals with the frequency required. Serious consideration should be given to using alternative chemicals wherever possible.

Other Hazardous Materials

Cryogenic Substances (Liquefied/Solidified Gases)

Cryogenic substances are gases that are maintained in liquid or solid form at extremely low temperatures. The most common cryogens that are readily available to schools are solid carbon dioxide (dry ice) and liquid forms of hydrogen, oxygen, methane, and nitrogen. Cryogens pose several serious hazards. These include the following:

- **Explosive Pressure**: Cryogenic gas generates enormous pressure when it vaporizes within the container and when it is released through the valve. In the case of methane gas, for example, the expansion is 630 times that of the equivalent liquid volume.
- **Fire**: Flammable cryogenic substances present the same flammability hazard as their gaseous forms.
- **Embrittlement** of structural materials and human tissues: Most materials experience some degree of embrittlement at temperatures below –50°C. Contact with cryogenic liquids, their gases, or the surfaces of their containers can lead to frostbite or more extensive freezing of tissue that can be very destructive. Living tissue can become completely frozen and so brittle that it will shatter on impact.
- **Asphyxiation:** Except for liquid oxygen, expansion of cryogens may displace a sufficient volume of air to cause asphyxiation. This is particularly true of dry ice, which sublimes into carbon dioxide gas and readily displaces normal air.

Teachers might use cryogenic compounds to create special effects in a demonstration only. Students shouldn't be allowed to manipulate cryogenic substances. There is no outcome directly linked to the use of such substances in the Manitoba curricula. Follow regulations from your local school board in handling cryogens.

Anyone choosing to use cryogens should have a thorough knowledge of the characteristics of the substance at the temperatures and pressures being used, and the appropriate safety precautions for handling. They should also know how to recognize and eliminate leaks, and the requirements for short- and long-term storage.

Specific Precautionary Measures for Cryogens

In addition to General Safety Measures (on page 93), follow these measures:

- Use cryogens only in a properly ventilated space to avoid a build-up. Adequate ventilation is particularly important to prevent asphyxiation with the use of dry ice.
- Store containers of cryogenics in a cool, well ventilated space, in an upright secured position, and vent containers properly to avoid explosion.
    - Prolonged storage in a poorly ventilated area will cause metal valves to undergo chemical corrosion. If this occurs, store in a separate cool, dry room away from direct sunlight and sources of sparks or flame.
- Ensure warning signs and the name of the cryogen are all posted in locations where the substance is stored or used.
- Ensure vessels are appropriately labelled and filled only with the liquids that they were designed to hold.
- Perform operations slowly to minimize boiling and splashing.
- If liquid nitrogen is heavily contaminated with oxygen, handle it with precautions suitable for liquid oxygen.
    - The appearance of a blue tint in liquid nitrogen is a direct indication of oxygen contamination.
- Take appropriate precautions when releasing cryogenic gases.
    - If oxygen is used, remember that it does not burn but it does enhance burning of flammable materials; thus, open flames or sources of sparks should be removed from the area.
- Ensure that all eyes are protected by goggles and all skin is covered by
    - a face shield, pants, and boots
    - a laboratory coat or apron without pockets or cuffs
    - loose-fitting gloves that can be easily removed
- Remove watches, rings, bracelets, and other jewellery.
- Have another person nearby for emergency assistance.

Compressed Gases

Cylinders of compressed gases should be handled and stored in a similar fashion to cryogenic substances. Containers used to store gases should meet the National Fire Protection Association (NFPA) standard, prescribed for both Canada and the United States.

Figure 18 **Compressed Gases**

Flammable Substances

Generally, substances that are highly flammable—particularly those that are also highly volatile—should not be used by students. If minute amounts are provided for student use, make sure the area is well ventilated and far from open flames or sparks. Identify and eliminate any unwanted ignition sources that may exist, such as sparks that come with unplugging electrical cords and static electricity. Teacher demonstrations using flammable substances can be done under similar conditions or under the fume hood. Again, cabinets and containers used to store gases should meet the National Fire Protection Association (NFPA) standard, which is relevant both in Canada and the United States.

Reactive Chemicals

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

The mishandling of reactive chemicals is a well-known problem in science laboratories. Many explosions, fires, burns, and other bodily injuries have been caused by improper and careless handling of reactive chemicals. Misuse does not necessarily refer to problems occurring while the reactive chemicals are being used. It can also result from improper storage, record keeping, and labelling.

Types of Reactive Chemicals

Reactive chemicals can refer to substances that enter into violent reactions to spontaneously generate large quantities of heat, light, gas, or toxicants. Reactive chemicals can be classified as follows:

- **Explosive Substances** are concentrated forms of unstable substances that have the potential to explode. They pose too great a risk to warrant use, and they should not be kept in schools. Some explosive substances in lower concentrations, such as hydrogen peroxide, are relatively safe. For more information on explosive substances, refer to this group in the Reactive Chemicals table below.
- **Acid-sensitive chemicals** react with acids to release heat, hydrogen, explosive gases, and toxicants.
- **Water-sensitive chemicals** react with water to release heat and/or flammable or explosive gases.
- **Oxidation-reduction** reactions can occur in any phase, but they tend to generate heat and are often explosive.
- **Pyrophoric substances** burn when exposed to air.

Check the *Chemicals That Pose Excessive Risk* information table in Appendix G (on page G1) of this document. For a more comprehensive treatment of the hazards associated with chemical species, consult the online *Chemical Hazard Information Table* available at <www.edu.gov.mb.ca/k12/cur/science/index.html> and click on "Science Safety Resources."

- Storage
- Reactivity
- Disposal procedures
- Safety issues

Notes

It must be noted that the appearance of a controlled substance on this list does NOT necessarily mean that the substance should be used in Manitoba science classes.

The following table provides some of the information available in the controlled substance list.

Reactive Chemicals			
Reactive Nature of Chemical	Examples	Specific Hazards	Precautionary Measures
Explosive*	■ Fulminates* ■ Nitroglycerin* ■ Peroxides (benzoyl, sodium)* ■ Picric acid* ■ Azides* ■ Perchlorates (Na, K)* ■ Hydrazines* ■ Dioxane* ■ Ether (excluding petroleum ether)*	■ Substances that decompose with such speed that they cause a rapid expansion of air, sometimes accompanied by burning gases and flying objects ■ Easily detonated ■ Can explode from shock, friction, or heat ■ Unstable ■ Can form peroxides	Protect from shock, high temperature, sudden temperature changes, and other reactive substances
Acid Sensitive	■ Alkali metals ■ Alkaline hydroxides ■ Carbonates ■ Carbides* ■ Nitrides Metals ■ Sulphides ■ Cyanides*	Substances that react with acids to release heat, hydrogen, and/or other explosive gas and toxicants	■ Isolate from reactive substances ■ Wear and use adequate protection
Water Sensitive	■ Strong acids and bases ■ Acid anhydrides ■ Alkali metal hydrides ■ Carbides* ■ Aluminum chloride (anhydrous)	■ Substances that react with water, releasing heat, and/or flammable gases such as hydrogen ■ Ignition in moist air can cause explosions ■ May produce acetylene or methane ■ Spontaneous decomposition during extended storage may cause container to explode upon opening	■ Isolate from other reactive substances ■ Store in cool, waterproof area ■ Wear protective gear

Reactive Chemicals			
Reactive Nature of Chemical	Examples	Specific Hazards	Precautionary Measures
Oxidation-Reduction sensitive	Oxidizers ■ Oxygen Mineral acids ■ Perchlorates* ■ Peroxides* (H_20_2 excepted) ■ Nitrites and nitrates ■ Chromates and dichromates ■ Permanganates ■ Halogens ■ Chlorates* Reducers ■ Hydrogen ■ Phosphorous* ■ Alkalai metals ■ Metallic hydrides ■ Formaldehyde*	All generate heat and can be explosive	■ Isolate from each other and other potentially reactive substances ■ Use adequate protection
Special Organic Substances	■ Acrolein* ■ Benzene* ■ Diethyl ether*	■ Flammable and may also polymerize violently and form explosive peroxides ■ Explodes with many oxidants ■ May be carcinogenic (benzene)	■ Store in an airtight container in a cool place ■ Isolate from oxidants
Pyrophors	■ Phosphorous* (white or yellow)	■ Substances that burn spontaneously when exposed to air	■ Protect from air

* These chemicals must not be present in school laboratories or storerooms because of their reactive nature.

Managing the Release or Spill of Toxic or Corrosive Substances

Deciding how to handle a spill first requires understanding of the health hazards associated with the substance. There are three immediate questions that must be answered:

- Is this substance highly toxic or corrosive?
- Does it give off toxic or corrosive fumes?
- Are the fumes potentially explosive?

Answers to these questions can be found in the pertinent MSDS sheets that should be accessible to users at all times and be reviewed before commencing activities with the materials. **For substances that are highly toxic or corrosive (ones that have a health rating of 3 or 4), any spills and releases of these substances must be handled by specially trained professionals who are equipped to deal with such emergencies.** This may require evacuation of the school, particularly if toxic fumes are associated with the substance. See Responding to Toxic Substance Leaks and Spills (on page 36) in Chapter 3 for emergency procedures.

In the case of minor spills of acids and bases, local action by knowledgeable staff can be taken to neutralize the spill using materials prepared for that purpose. Once neutralized, the products can then be cleaned up and disposed. **Major spills should be handled by specially trained professionals.**

Prompt clean-up is also the appropriate measure to deal with manageable quantities of other materials that are not highly toxic or corrosive. All wastes resulting from these clean-ups should be contained separately. Placing all spilled or waste chemicals in a general waste bin may result in reactions with other chemicals or wastes placed in the container.

Corrosive Liquids

Minor spills of corrosive liquids can be handled using the following steps:

1. Put on protective clothing/equipment (face shield, rubber gloves, rubber boots, and lab coat) if the spill is concentrated.
2. Contain the spill with asbestos-free vermiculite, clay cat litter (bentonite), or diatomaceous earth.
3. Neutralize the substance. For acids, liberally apply sodium bicarbonate (baking soda) or sodium carbonate (soda ash), or apply a spill kit pillow. For bases, sprinkle boric acid or citric acid on the spill, or apply a spill kit pillow. Test with pH paper to ensure the substance is completely neutralized.
4. Dilute with plenty of water and mop up using an absorbent cloth.
5. Wash contents down the sink and clean spill area with water. Wipe dry with paper towels.

Notes

Municipal bylaws and waste regulations may permit some substances to be disposed of through drains. If permitted in your area, wash the material down with plenty of water. Alternatively, absorbent materials (asbestos-free vermiculite or diatomaceous earth) may be used to soak up the solution. The resulting mixture can then be bagged, labelled, and sent for disposal.

Flammable Liquids

Small amounts of solvents can be cleaned up as follows:

1. Immediately shut off all ignition sources, and open windows and vents leading directly to the outside for ventilation.
2. Contain and cover the spill with a mineral absorbent such as asbestos-free vermiculite, bentonite, or diatomaceous earth.
3. Scoop the contaminated absorbent into a heavy gauge garbage bag or plastic bucket with lid.
4. Wash the spill area with soap and water, using a disposable cloth.
5. Dispose of the contaminated cloth in the same garbage bag.
6. Allow to evaporate under the fume hood.

Other Liquids (excluding mercury)

Water-Soluble Liquids

1. If necessary, contain with towels, asbestos-free vermiculite, bentonite, or diatomaceous earth.
2. Dilute with water.
3. Mop up using paper towels or cloths. Very small spills can be swabbed directly into a sink and flushed with large volumes of water.
4. Check the *Chemicals That Pose Excessive Risk* information table in Appendix G (on page G1) of this document. For a more comprehensive treatment of the hazards associated with chemical species, consult the online *Chemical Hazard Information Table* available at <www.edu.gov.mb.ca/k12/cur/science/index.html> and click on "Science Safety Resources."

Water-Insoluble Liquids

1. If necessary, contain with towels, asbestos-free vermiculite, bentonite, or diatomaceous earth.
2. Cover the spill with mineral absorbent and scoop the contaminated material into a suitable container for disposal.
3. Wash the spill area with water and soap and wipe dry with paper towels.
4. Discard contaminated towels or cloth. Check the MSDS for final disposal details.

Solids

The critical factor in cleaning up solid chemicals is to avoid raising particles into the air and inhaling them.

1. Slowly sweep up granules or powder into a dustpan.
2. Mop up smaller amounts with a damp disposable cloth.
3. Wipe the area clean.
4. Determine appropriate disposal procedures from the MSDS.

Overview

Management of controlled, regulated, or hazardous chemicals requires a thorough understanding of their chemical properties, potential hazards, and what to do in case of an accident. The focus of this chapter is on implementing a sound, comprehensive chemical management plan that addresses chemical purchasing, storage, and inventory, as well as strategies for minimizing and managing chemical wastes. Ensuring such a plan is working effectively requires auditing (and revising if necessary) processes for

- ordering and receiving chemicals
- storing and handling chemicals
- disposing of chemicals

Chemical Acquisition

Choice of Chemicals

The selection of chemicals for use in school laboratories should be based on the following considerations:

- curriculum needs
- value of the laboratory experiences provided to students
- chemical hazards
- likelihood of chemicals being used in multiple activities or classrooms
- maturity, knowledge, and skills of the students
- availability of alternative activities and materials
- storage facilities and laboratory equipment available
- environmental considerations and costs related to disposal

In many cases, non-regulated chemicals that can be bought at the local store can be used as substitutes for more hazardous chemicals (e.g., hydrogen peroxide). Choosing these less hazardous chemicals often reduces the costs of purchase and disposal, as well as the hazards associated with use. MSDSs must be located and added to the MSDS binders. Also, a WHMIS label must be applied on the container.

There are many chemicals required in science courses, particularly in Senior Years, that must be ordered from chemical supply houses. When choosing chemicals, consider whether the benefits outweigh the risks. If they do not, look for safer substitutes. If an activity that is being attempted for the first time calls for chemicals not on the shelf, schools may wish to borrow rather than purchase the chemicals, particularly if it is uncertain that these chemicals will be used again in the future. If borrowing requires transport between locations, TDG regulations must be observed.

Quantity Ordered

When determining how much of a specific chemical to order, consider the following factors:

- Consumption rate
- Stability of the chemical (most inorganic salts and dilute acids and bases stocked in schools do not deteriorate with time)
- Future use of the chemical
- Available storage space
- Financial resources

As a general rule, a "less-is-better" approach to chemical purchasing lowers inherent risks. Buying only what is needed, based on the factors above, also leads to better organization and less costly waste disposal at the end of the year. For less-stable compounds, particularly those that decompose over time, keeping amounts ordered to a minimum will greatly reduce safety and storage concerns and disposal costs. A reasonable shelf life for such substances would be a maximum of three years. Suppliers sometimes sell large quantities of chemicals at considerable savings. Bulk purchase may be an option with frequently used chemicals, particularly those that are not considered hazardous or are not regulated.

There are several reasons why bulk orders may not be advisable:

- Adequate storage space may be limited.
- Curricular changes may occur or teachers may choose different experiments, eliminating the need for the chemical.
- Initial cost savings from bulk purchasing may be eliminated by added disposal costs if a large amount of the chemical no longer needed requires disposal.

Receiving Chemicals

Once the order has been placed with the supplier, individual school orders are usually delivered directly to each school. Once in the school, the receiving office personnel should immediately contact the science team representative to have the controlled products appropriately and safely transported to the controlled product storage room and entered in the school inventory with all the necessary information from the MSDS.

Whenever an order of chemicals arrives, the science team representative should follow the steps below or similar school or district procedures.

1. Check the integrity of each chemical and chemical container.
2. Check for WHMIS labelling and presence of MSDS.
3. Write on each container the date received, the name of the school, and the initials of the receiving teacher or staff member.
4. Enter the appropriate information into the school chemical inventory.
5. Store chemicals in the proper location.

Removal of Controlled Products

All controlled products that pre-exist WHMIS regulations and signage should be removed from schools. All containers are now made of a polycarbonate composite to reduce the chance of breakage, and are labelled with the appropriate signage.

School inventories must be periodically checked to ensure that the integrity of every container has been maintained. If any containers are damaged or unidentifiable, they should be removed from the inventory and placed on the list for environmental pick-up by a commercial waste broker. Once the product has been identified for removal, the inventory must be changed to reflect the removal. Links to approved waste removal and recycling companies can be found at <www.gov.mb.ca/trade/globaltrade/environ/waste.html>.

Notes

MSDSs for controlled products must be stored for at least 30 years from the moment the MSDS was received. (*Workplace Safety and Health Act* (C.C.S.M. c. 210) Workplace Safety and Health Regulation – Regulation 217/2006)

Storage Facilities for Chemicals

Please refer to Chapter 4 for more information about science facilities.

The hazards associated with chemical use can be greatly reduced by storing all chemicals in suitable storage facilities.

A recommended chemical storage area

- is a separate area outside of the classroom
- can be accessed only by authorized personnel
- has locking doors with a key that is different from those used to enter classrooms or preparation areas
- is adequately vented with a continuously running fan to prevent build-up of chemical fumes
- protects chemicals from direct sunlight and extreme temperatures

- has explosion-proof lights, switches, and fan motor housing to prevent fires caused by electrical shorts or sparks in faulty switches
- has ground fault interrupter (GFI) circuits installed, especially near sinks
- has ceilings and walls made of drywall or a similar non-combustible material
- has adequate cupboard space with doors for each category of chemicals, as determined by the quantity on hand and school requirements
- has sturdy, non-metallic shelves that are securely fastened to the wall or are part of a securely fastened or supported cupboard
- has storage cupboards that are not airtight

Figure 19 ***Storage Cupboards***

Acids, Bases, and Flammable Products

Flammables and concentrated acids should be stored in special cabinets purchased for these types of hazards. Such cabinets are available in metal, plastic, or wood.

- Wood cabinets: suitable for bases; not suitable for nitric acid.
- Plastic cabinets: suitable for acids.
- Metallic cabinets: suitable for flammables. Venting of these cabinets is not considered necessary but depends on air circulation or venting of the room in which they are stored.

Planning Shelf Space

The chemical storage area(s) in a school should be large enough to house all of the chemical stock used in science classes as well as the waste chemicals generated through use. A typical high school of 800 to 1000 students will require a room with approximately 100 linear metres of shelf space. A Middle Years school may require 50 metres of shelf space. The space requirements should reflect the science courses offered, including waste generated by these courses throughout the year. Schools offering Advanced Placement or International Baccalaureate courses will require additional space. A school may need to reassess or reconsider the amount of material necessary to have in storage if it is unable to accommodate its chemical stores in a facility similar to the one described in this section.

The chemical storage area should be equipped with appropriate safety equipment and supplies, including a first aid kit. See Chapter 4 for more information.

Chemical Storage Schemes

In the past, chemicals in schools may have been stored using a non-classified system, with products placed on shelves in alphabetical order. Although this arrangement of chemicals appeared to be orderly, it may result in highly reactive substances such as oxidizing agents and reducing agents being stored together, creating the risk of spontaneous reactions between incompatible chemicals.

The risk of accidents can be greatly reduced by replacing this kind of non-classified storage system with a scheme that separates incompatible groups and isolates chemicals that present special hazards. The suggested storage schemes that follow can be used as a guideline for safe storage of chemicals in schools. By separating flammable solvents from reactive chemicals and corrosive liquids from toxicants, these schemes mitigate the risk of spontaneous fire or release of poisonous fumes. These schemes are adaptable to facilities of various designs and to various chemical inventories. Schools may or may not have all of the hazard categories, and some schools may establish other categories to meet their particular needs.

Scheme 1: Grades 1–8
(A storage scheme for limited quantities of low-hazard chemicals)

Scheme 1 provides for adequate separation of chemicals for most Early and Middle Years schools up to Grade 8 where small quantities of low-hazard chemicals and dilute solutions are kept on hand. This scheme could also be adapted for Grade 9, but is not adequate for Senior Years schools. Scheme 2 provides a better model for Senior Years school use.

Oxidizing Agents	**General**	**Flammable Solids**
Acids	**Bases**	**Flammable Liquids**

Scheme 1 is based on six cupboards, but it may be expanded to seven or more to provide sufficient space for general storage items. The shelves in these cupboards need to be secure and strong enough to support the weight of all containers placed on them. These cupboards must be clearly labelled and must not be airtight.

In addition to the cupboards shown, a refrigerator may also be needed to store biological supplies. Further information on safe storage of chemicals is included in the storage category notes below.

1. *Acids:* Keep organic acids (e.g., acetic acid) and mineral acids (e.g., hydrochloric acid and sulfuric acid) on separate shelves. The acid cupboard should not contain any metal fixtures or objects.
2. *Bases:* This cupboard would shelve household ammonia, sodium hydroxide, and other hydroxides. It should not contain any metal fixtures or objects.
3. *Oxidizing agents:* Peroxides, bleach, and nitrates are examples of oxidizing agents. Most peroxides are not recommended for Early and Middle Years schools, but hydrogen peroxide would be shelved here. These materials must be kept away from any flammable liquids or solids, as well as materials such as paper or cloth.
4. *Flammable solids (should not be used in Middle Years schools):* Flammable solids include metal powders, carbon, charcoal, and similar materials. These materials must be kept away from oxidizing agents.
5. *Flammable liquids:* Flammable liquids such as methanol and ethanol should be stored in a clearly labelled, cool, and well ventilated cupboard, separated from other cupboards by at least a partition.
6. *General:* This category includes any materials not covered in the other categories, such as Epsom salts, baking soda, starch, glycerin, and vitamins.

Scheme 2: Senior Years Schools (9-12)

Scheme 2 provides for adequate separation of chemicals in schools that offer Grades 9 to 12 Science. The scheme is based on a greater number of chemical categories than shown in Scheme 1 and includes provision for refrigerated storage of some chemicals.

These shelves and cupboards should be clearly labelled.

Suggested Chemical Shelf Storage Plan		*Refrigerator Storage*
Section 1 Halides, Sulphates, Sulphites, Thiosulphates, Phosphates, Acetates, Sulphur	**Section 2** Sulphides, Selenides, Phosphides, Nitrides	
Section 3 Amides, Nitrates, Nitrites NOT Ammonium Nitrate – ISOLATE IT!	**Section 4** Borates, Chromates, Manganates, Permanganates	**Freezer** ▪ Ice ▪ Frozen Specimens
Section 5 Metals and Hydrides Store away from any water source. Store flammables in the flammables cabinet.	**Section 6** Chromates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Hydrogen Peroxide (3%)	**Refrigerator** ▪ Biochemicals ▪ Perishables ▪ Cl_2, Br_2 ▪ 30% Hydrogen Peroxide NO FOOD FOR HUMAN CONSUMPTION
Section 7 Hydroxides, Oxides, Silicates, Carbonates, Carbon	**Section 8** ▪ Miscellaneous ▪ Indicators Organics: Oils, Sugars, Starches	

Provide space between chemicals to facilitate access. Avoid storing chemicals more than three deep. Controlled products must not be stored above eye height.

Ammonium nitrate is a highly reactive oxidizing agent and must be stored away from other controlled products.

For any product purchased and stored, remember that smaller quantities are safer.

Setting Up a Chemical Inventory

A chemical inventory serves as an opportunity for schools to improve safety by recording and organizing information about hazardous materials in the school. Such an inventory is a necessary part of safety planning because it includes MSDS data, depends on standardized labelling, and encourages thoughtful ordering and disposal. A chemical inventory provides a consolidated information base for monitoring chemical usage and coordinating waste disposal and recycling to reduce costs. It also allows for an integration of computer support systems and encourages the sharing of information through computer networking. Finally, by establishing a system for monitoring chemical supplies on an ongoing basis, an inventory ensures program and support continuity when there are staff changes.

A computerized or electronic inventory is ideal because it is easy to update as chemicals come in or are removed from stock. The inventory can be stored centrally for easy access, with a copy supplied to the head caretaker and the individual(s) responsible for chemicals and hazardous materials in the school. An electronic chemical inventory system can be purchased from most science supply companies.

A chemical inventory could include the following information:

- Chemical name
- Storage location
- Storage category
- CAS Registry number
- Quantity
- Supplier
- Details related to form and concentration
- Recommended disposal methods
- Hazards
- Inventory control
  - Date added to inventory
  - Amount at beginning of school year
  - Amount remaining
  - Disposal date
- Notes

For those choosing to track chemicals using a paper-based inventory, a blank template of the sample inventory shown below is included in Appendix H of this document.

Chemical Inventory – Example

Completed by ____________ Review Date ____________

Chemical	Quantity	Storage category and location	Clarifying details	Supplier	CAS number	Disposal	Hazards	WHMIS classification	Date added	Amount remaining	Disposal date (empties)
Acetic acid	1 L	Acids cabinet	Concentration: 6 moles/L	Chem North	64-19-7	Neutralize	Corrosive, slightly toxic by skin or ingestion; chronic exposure can cause erosion of teeth	E, B	March -13	600 mL	

Inventory Control

Inventories should be updated at least once a year to reflect product use and curriculum changes. The decision regarding the quantity ordered and stocked needs to take into account consumption rate, as well as the stability of the chemical. See the section “Quantity Ordered” previously in this chapter for factors that affect chemical inventory. As chemicals are used or disposed of from the school site, they should be deleted from the inventory (while remembering to store the MSDS).

An annual check of chemicals on the shelves is a chance to

- remove chemicals unsuited for the planned lessons
- remove excess supplies, including chemicals no longer used because of lesson changes or activities selected
- remove contaminated, deteriorated, and unidentified chemicals
- ensure a current MSDS is available for each chemical (MSDSs are updated by supply companies usually every three years)
- ensure a WHMIS label is on every controlled product container
- confirm chemicals are in their proper location on the storage shelf
- ensure that opened containers are being used before new stock is opened
- visually inspect chemicals on the shelf to ensure they have not deteriorated or been contaminated by moisture or other substances

Labelling

Proper labelling is one of the most important aspects of an effective and safe laboratory. Labels alert the user to the hazards of the product and provide precautions for its safe use. Therefore, they must present the required information clearly and legibly. Please be sure to include a WHMIS label and supplier label with all products. Refer to Chapter 5 for more information on WHMIS.

Consumer Products and Other Hazardous Materials

Consumer products must be clearly labelled and indicate any inherent hazards in the product. When used in the workplace, these products become subject to WHMIS regulations, which require that

- they are correctly labelled
- workers know how to use, store, handle, and dispose of them safely

Examples of such products include bleach, hydrogen peroxide, mineral spirits, drain cleaners, and turpentine.

Waste Storage and Disposal

Storage of Wastes and Surplus Chemicals

Surplus chemicals and chemical wastes created in experiments present the same kinds of hazards as stock chemicals ordered from supply companies. Chemical waste from individual experiments should be collected in clearly labelled containers. With solutions, the water can be allowed to evaporate to leave a solid waste residue. Proper waste storage includes

- attaching appropriate identification and WHMIS labels
- using a separate section or sections of the storage area, designated with a label stating "For disposal. Do not use!"
- avoiding physical contact between waste groups when wastes are stored
- keeping an inventory of waste materials
- storing waste chemicals in separate, appropriate-sized containers for each experiment

Chemical Waste Inventory

Waste disposal records are the last stage in tracking a chemical's history at the school. These records are essential because

- they are needed to keep the chemical inventory up-to-date, and to remove unnecessary labels and MSDSs and store them elsewhere in cases where the chemical is no longer stocked
- shipping documents for chemical wastes (bills of lading for recyclables and manifests for hazardous waste) must be kept on file for a minimum of two years
- hazardous waste manifests can be useful in tracking and evaluating amounts of waste produced to help determine possible methods of reducing waste/surplus chemicals in the school or school district

Disposal of Wastes and Surplus Chemicals

Surplus chemicals and wastes generated from school activities will both require disposal. Selection of the best method for disposal of each waste will require consideration of the kind of hazard each presents, the severity of the hazard, its concentration, and whether the material is in pure form or part of an inseparable mixture. It also depends on local waste disposal regulations, provincial and federal regulations, and the expertise of school staff. Depending on municipal bylaws, some chemicals may be safely poured down the sink or thrown in the regular trash. See Chapter 1 for links to some municipal bylaws.

To avoid safety risks, periodically review the school's chemical inventory and remove chemicals that are not being used. Also, remove any chemicals that may have been used in the past but are no longer considered appropriate for use. For example, containers of dissection preservative containing formaldehyde should be safely disposed. **The fumes from such containers can combine with those of hydrochloric acid to form bis(chloromethyl) ether, a strong carcinogen at concentrations as low as 0.001 ppm (1 ppb).**

Conducting a chemical inventory review can help you identify and dispose of unneeded or dangerous chemicals, such as the following:

- Any chemicals that have deteriorated or become contaminated
- Chemicals not utilized in current teaching lessons and unlikely to be used in the future
- Chemicals for which MSDSs are not available
- Any seldom-used chemical in excess amounts (several containers of the same chemical or unnecessarily large bulk quantities)
- Unknown chemicals or chemicals without a WHMIS label
- Chemicals that have exceeded their shelf life
- Old solutions of formaldehyde or other dissection material preservatives

Waste Brokers

A *broker* is a company licensed by the province to pick up and transport controlled substances to a *receiver*, a licensed waste disposal facility. Disposal of waste from a school must be initiated through the school board office and the contract for removal will be between the school division and the broker.

Sites designed for drop-off and disposal of household wastes **are not** appropriate for disposal of school chemical wastes.

Waste Management and Environmental Responsibility

Proper storage and disposal of surplus chemicals and hazardous waste is not only part of science safety, but also an environmental issue. By being environmentally conscious in the day-to-day management of school laboratories and materials, teachers and other school personnel can prevent unnecessary damage to the environment and instill responsible attitudes in students.

Chemical disposal regulations prevent indiscriminate dumping of chemical waste in the trash or down the drain, when doing so would create an environmental risk. Landfills, once thought of as the dumping place for all manner of materials, are now designated by classes based on their design. These class designations indicate the scope of wastes that a landfill of that design can safely accept. Municipal authorities can provide information on the class of local landfills and the types of chemicals that can be disposed of through regular trash. Similarly, local sewer bylaws identify restrictions on materials that can be disposed via the drain.

For most chemicals, it is best to strive for a “no-chemicals-down-the-drain” philosophy, whereby chemical waste is disposed of by an alternative means that avoids environmental impact. This approach to waste management requires that students and/or teachers place chemical wastes into labelled waste containers on completion of their use. Caution in categorizing waste is needed to avoid placement of incompatible waste together. The waste is then managed in accordance with accepted best practices.

Strategies for Minimizing Hazardous Waste Production

Most of the strategies discussed here involve students using fewer chemicals, which results in less waste generated, less environmental impact, and lower waste disposal costs. Other strategies suggest ways to recover chemicals for reuse or to make multiple uses of the chemical.

Microscale Experiments

The traditional practice in school laboratories is for students to perform experiments using gram quantities of chemicals. An alternate approach is to have students carry out microscale experiments in which chemical quantities are reduced to no more than 100 mg (0.1 g).

Microscale experiments may require the use of different glassware and equipment, or the use of existing equipment in new ways. Instead of beakers and Erlenmeyer flasks, teachers may use small test tubes or drop plates. Disposable pipettes calibrated to allow delivery of 0.5 mL or 1 mL can be used to deliver chemical solutions.

Dispensing Chemicals

Teachers will sometimes find it necessary to weigh the relative merits of dispensing premeasured quantities of chemicals to students versus teaching students to measure quantities for themselves. The decision on which approach is best will usually hinge on an assessment of the hazards associated with the chemical. If it is a chemical that is non-toxic and non-hazardous, such as sodium carbonate, then waste generated by students during measurement is not a major concern. If, on the other hand, the substance is magnesium ribbon, it may be more prudent to pre-cut the appropriate length of ribbon for each student to avoid distributing pieces that are longer than necessary.

Use of Lab Stations

Setting up activities at specific well labelled sites or stations, equipped with appropriate chemicals and supplies, makes it easier to control and manage chemical use by students. This approach helps prevent students from having to carry chemicals from one place to another, thereby reducing the chance of spills or other accidents. This approach is particularly beneficial in activities where the chemicals can be reused, as it eliminates the need for providing a separate set of chemicals for each group of students.

Use of Demonstrations

Although there is a strong educational value in having students perform experiments on their own, demonstrating a chemical reaction to an entire class can be an effective means of achieving an instructional goal and reducing resulting wastes, particularly in cases where the chemicals involved are more hazardous.

Use of Videos and Computer Simulations

These resources can be used to demonstrate reactions or experiments that otherwise would not be possible due to equipment limitations or because they are too dangerous to perform in class. Such visual presentations or simulations of more dangerous reactions help to avoid associated risks and provide a near first-hand experience for students. These resources can be used either as part of a class presentation or individually, at stations, by students. There are many Internet sites that visually illustrate a demonstration in chemistry or general science that the classroom teacher may feel is beyond his or her level of expertise or the school budget.

Recovery and Recycling

One aspect of good chemical management is to recycle materials whenever possible. Before discarding uncontaminated chemicals or their solutions, consider other activities where these substances might be used. For example, copper sulfate solution, which is produced when teaching students how to make solutions, can be used for growing crystals, copper plating, or in replacement reactions in the same or other courses. Similarly, crystals grown in one class may be re-dissolved for use in another because these solutions do not require great purity. Chemical recovery requires some upfront planning and a space in the lab or chemical storage room where reconstitution can be done. Since most substances used are in solution form, reclaiming the material simply requires evaporating the water. If a recovered substance is stored in a container other than the original, then proper WHMIS labelling is required on the new container.

Distillation of Used Solvents

Recycling solvents requires the knowledge and experience of an expert chemist, as well as the appropriate equipment. This should not be attempted in schools.

Waste Treatment

There are several methods of processing hazardous waste to reduce volume and/or toxicity in preparation for disposal, including chemical treatments, neutralization of acids and bases, evaporation of aqueous solutions, precipitation of heavy metal salts, reduction of oxidizing agents, etc. See Appendix I for more information. **These treatments should only be carried out by staff who have knowledge of the chemistry involved and are experienced in working with chemicals. In all other cases, the chemicals in their original form should be disposed of through a qualified waste broker.**

Science and Safety

Appendices

Word files available for download at the following Science Safety Resources link:
www.edu.gov.mb.ca/k12/cur/science/index.html

APPENDIX A

Sample Safety Contract – Elementary

<table>
<tr><td>Class:</td><td></td><td>Student's Name:</td><td></td></tr>
<tr><td>Teacher's Name:</td><td colspan="3"></td></tr>
<tr><td>Room:</td><td colspan="3"></td></tr>
<tr><td colspan="4">I am learning to be a good scientist. I know that to learn science safely, I must be neat, organized, respectful, and responsible.</td></tr>
<tr><td>I will</td><td colspan="3"></td></tr>
<tr><td colspan="4">■ be prepared for science activities
■ listen to directions and make sure that I understand them before I start
■ follow directions
■ observe carefully
■ be calm and quiet so that I can learn more
■ handle equipment carefully and put it away when I am done
■ wash and return all things to their proper places, and then wash my workspace and my hands
■ follow all safety rules</td></tr>
<tr><td>Student's Signature:</td><td></td><td>Date:</td><td></td></tr>
<tr><td>Parent's Signature:</td><td></td><td>Date:</td><td></td></tr>
</table>

Sample Student Safety Contract – Middle Years and Senior Years

Class:		Student's Name:	
Teacher's Name:			
Room:			

I understand that accidents can be caused by being unprepared, careless, or in a hurry. I will come to class prepared to be responsible and behave in a manner that will ensure the health and safety of myself and others in the laboratory or classroom at all times.

I will

- follow all written and oral instructions given by the teacher
- ask any questions or state any concerns I have before beginning a laboratory procedure
- use protective devices for my eyes during laboratory activities
- use protective devices, as needed, for my face, hands, body, and clothing
- focus on the task at hand
- know the location and use of first aid and fire extinguishing equipment
- refrain from eating, drinking, chewing gum, grooming, or applying cosmetics in the laboratory
- keep my work area clean and free of clutter during laboratory class

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

Student's Signature:		Date:	
Parent's Signature:		Date:	
Teacher's Signature:		Date:	

Please list any known allergies or health problems, such as asthma, epilepsy, or heart condition, that may affect participation in science activities. If additional space is needed, please use the back of this sheet.

Do you wear contact lenses? ☐ YES ☐ NO

Students wearing contact lenses need to be identified in case of accidents that might require contact lens removal. Removal of contact lenses will be done by trained personnel in cases where the student cannot remove them on his/her own. All students will be required to wear safety goggles for certain activities, even if they wear contact lenses or prescription glasses.

Parent/ Guardian Signature:		Date:	

A P P E N D I X   B

Sample Science Safety Rules and Procedures

For secondary students (not an exhaustive list)

Science Safety Rules and Procedures

1. Read all directions before starting an experiment.
2. Behave responsibly in the science laboratory at all times.
3. Know the location and purpose of safety equipment.
4. Always alert the teacher immediately if an accident occurs.
5. If you wear contact lenses, notify the teacher. Some activities may require you to remove contact lenses.
6. When instructed, wear safety goggles and protective clothing.
7. Wear closed shoes during laboratory sessions.
8. Keep your hair tied back if it is long.
9. Do not use cracked or chipped laboratory glassware.
10. Use chemicals in the lab only.
11. Take only as much chemical as needed and never return excess chemicals to the original container.
12. Dispose of chemicals as directed by your teacher.
13. Hold bottles only by the base, not by the neck.
14. Do not taste anything unless you are instructed to do so.
15. Never eat or drink in the science classroom.
16. Never enter the chemical storeroom without permission.
17. Clean all equipment and glassware as instructed by your teacher.
18. Always clean off the counter and sink after an experiment.
19. Wash your hands thoroughly with warm water and soap at the end of the activity or laboratory session.

Appendix C: Suggested Science School Safety Policies and Procedures

Teacher classroom practice should be a good example of safety in action and be consistent with laboratory procedures set out for students. Sample policies and procedures for science teachers include the following:

Policies

1. Safety always precedes other priorities in planning for laboratory activities. If the design of an investigation compromises safety, it should be modified or avoided.
2. Materials to be used in student activities are prepared and the classroom environment set up in ways that minimize safety risks.
3. Teachers model safe behaviour and provide guidance, direction, and supervision to support student safety.
4. In preparation for science activities, students are made aware of potential risks, appropriate procedures, procedures to avoid, and procedures to follow in case of an accident.
5. Open-ended investigations proposed by students are not to be approved until a complete risk assessment has been done and precautions can be identified before any hazards are encountered.
6. In general, if the regular classroom teacher is absent, practical laboratory activities should not be done. Special concessions may be made if the substitute teacher is an experienced science teacher and is prepared to do the lab.

Procedures

1. Teachers hand out, discuss, and post laboratory rules and procedures for students.
2. Teachers diligently enforce laboratory rules.
3. Teachers require students to report all accidents.
4. Teachers do not leave students unsupervised in laboratories.
5. Teachers are aware of the location of all emergency equipment, such as fire extinguishers, first aid kits, and eyewash facilities, and know how to use them.
6. Teachers educate their students about the emergency procedures of the school and the fire exits in their area.
7. Teachers inform students of any hazards that may be associated with specific activities and the precautions they should take to minimize these risks.
8. Lock science laboratories when not in use.
9. Turn off gas taps at the end of each class/day.
10. Put away any electrical apparatus when not required for classroom use.

Appendix D: Sample Annual Inspection Checklist

The following checklist is intended to assist school and division staff in ensuring a safe environment in the science areas of the school. The laboratory safety checklist is to be completed by each science teacher annually as part of an overall safety program. It is not exhaustive and only intended to address the needs of science laboratories.

Area	Yes (date)	No	N/A
Layout and Space			
Aisle width is adequate to accommodate equipment and students with physical disabilities (1.2 to 1.5 metres).			
Workspace per student is adequate (1.5 to 2.0 metres width of workspace per student, depending on the activity).			
The teacher can see students in all locations of the room.			
The general light level is sufficient.			
Communication System			
A telephone or intercom is available in case of emergencies.			
Current emergency phone numbers are posted.			
Documentation			
Science safety rules and procedures are posted.			
Emergency procedures are posted.			
Chemical inventory is available and up-to-date.			
MSDSs are up-to-date and available for all controlled products.			
WHMIS and other training records are available.			
Safety Equipment			
Fire Extinguisher			
ABC fire extinguisher is present.			
Fire extinguisher is checked quarterly.			
The safety seal is intact.			
Fire extinguisher is in an easily visible location and unobstructed from view.			
Fire extinguisher is located near escape route of lab.			
Location of a second fire extinguisher is known.			
Teacher is trained in use of fire extinguisher within the last year.			
Alternate plan has been developed if extinguisher malfunctions.			

Area	Yes (date)	No	N/A
Smoke/Fire Detectors			
Smoke/fire detector is installed in each laboratory.			
Smoke/fire detector is installed in each storeroom and/or prep room.			
Where possible, there are two exits from science laboratory to the school corridor.			
Two fire exits are present in each storeroom/prep room.			
Doorway widths are sufficient to accommodate students with physical disabilities, allow movement of equipment carts, and serve as emergency exits.			
Fire exits are unobstructed and unlocked.			
Fire drill procedures are posted and practised.			
General alarm system for entire building is present and functioning.			
Emergency Shower			
An emergency shower is available and accessible.			
Emergency shower is regularly tested and maintained.			
Eyewash			
An emergency eyewash station is available and accessible.			
Eyewash can treat both eyes simultaneously with tempered water.			
Eyewash is regularly tested and maintained.			
Master Utility Controls			
Gas master shut-off valve is accessible and secure.			
Gas is cut off with master control when not in use.			
Water shut-off valve is accessible and secure.			
Electricity shut-off is accessible and secure.			
Protective Clothing			
Laboratory coats or aprons are available.			
Acid-proof apron for staff is available.			
Non-latex disposable gloves are available.			
Heat-resistant and chemical-resistant gloves are available for students.			
Acid-proof gloves are available for staff.			
Safety goggles are available.			
UV goggle sterilizing cabinet is available.			
Face shield for staff is available.			
First Aid Kit			
First aid kit is available in each laboratory and prep room.			
First aid kit is fully stocked.			
First aid kit is easily visible.			

Area	Yes (date)	No	N/A
Storage and Preparation Facilities			
Chemical storage area is adequate in size, well ventilated, secured from student access, and built with material that has a low flame-spread rating. See Chapter 9 for more specific guidelines.			
Quantity of chemicals stored is not excessive.			
Chemicals are labelled properly with the following information included on secure, waterproof labels: ❑ Date of acquisition ❑ Hazard alert ❑ Name of supplier ❑ Chemical's strength or purity			
Chemicals are stored properly (see Chapter 9).			
Shelves are equipped with raised lip edge or doors to prevent bottle roll-off.			
Chemicals are stored off the floor.			
Acids are stored separately in non-metal cabinets.			
Flammables are stored in dedicated and approved cabinets.			
Adequate area is available for the long-term storage of laboratory equipment, supplies, and safety equipment.			
Tall items are stored at back of shelf and heavy glassware is stored on lower shelves.			
Preparation area, including counter space, sink, and fume hood for making solutions and other materials for class use, is available. It allows for storage of MSDS and WHMIS information.			
Area is available for temporary storage of materials for later use, left-over materials from laboratory activities, and chemical waste storage for year-end disposal.			
Adequate refrigeration is available for storing fresh tissue/organs, enzymes, specific biological chemicals, agar plates, ice, and perishables.			
Housekeeping			
Work surfaces and sinks are clean and tidy.			
Aisles are unobstructed.			
Supplies and equipment (cleaned) are returned to proper storage area.			
No food or drink is present in the laboratory.			
Separate disposal bin is available for broken glass.			
Ventilation			
Air in the room is recycled and mixed with outside air at a rate of 4 to 12 complete laboratory air changes per hour, depending on the chemicals used, or a minimum of 15 L per second per occupant.			
The exhaust ventilation system is separate from that of the chemical fume hood.			

Area	Yes (date)	No	N/A
The hood(s) of the exhaust ventilation system is/are located away from doorways, windows, high traffic areas, or areas with disrupted airflow.			
Exhaust (on roof) is ventilated away from air intake.			
Electrical and Plumbing			
There are sufficient electrical outlets (i.e., located at intervals of 2 to 2.5 metres) to make extension cords unnecessary, and all power outlets meet *Manitoba Building Code* standards. Where hot plates will typically be in use, it is recommended that each 15-amp circuit be restricted to two double plug-in outlets to prevent overload and tripping of breakers during times of maximum usage.			
Outlets within 1.5 metres of water are equipped with ground-fault interrupters (GFIs).			
Fume hood controls are located outside the fume hood in an immediately accessible area.			
Laboratory drains are made of chemical-resistant material.			
Construction Materials			
Ceilings are constructed out of a material with a low flame-spread rating (e.g., drywall).			
Floors should be even and have a non-skid surface (sheet flooring is preferable to tiles or carpets; tile floors should be covered with a non-skid wax).			
Laboratory counter surfaces are made of material resistant to acids, alkalis, solvents, and heat.			

APPENDIX E: ACCIDENT/INCIDENT REPORT FORM

Part A – To be completed by individual(s) directly involved or injured in the incident.

❑ Medical Aid ❑ Lost Time ❑ Near-Miss ❑ Property Damage ❑ Spill/Contamination/Environmental Release

IDENTIFY – Person(s) involved

First Name	Last Name	
Date of incident (year/month/day) / /		Time of incident (Hours:Minutes) : AM/PM
Date of Medical Evaluation: (year/month/day) / /		Time of Medical Evaluation (Hours:Minutes) : AM/PM
❑ School Nurse ❑ Hospital ❑ Clinic or Family Physician		
Exact details of injury/illness and treatment (e.g., body part involved, cut, strain, bruise, illness symptoms, and date of onset, etc.)		
W.C.B. Form: (Please check) ❑ Has been prepared and forwarded ❑ Not required		
Description of Incident (add additional pages if necessary) State exactly the sequence of events leading to the incident: where it occurred; what the person was doing; the size, weight, and type of equipment or materials involved; etc.		
WITNESSES (If any) Name:	Department	Telephone

PROPERTY DAMAGE Identify property involved. Give machine name, tool name, etc.	Description of damage or loss	Estimated value of loss
Parent/Guardian to Notify:	Telephone:	
Completed by:	Date:	Print Name
	Forward to Supervisor Immediately	Signature

Part B – To be completed by supervisor within 24 hours.

Why did it happen? (conditions and/or actions contributing to injury/incident)		
Parent/Guardian Notification:		Name: Date: Time:
Corrective Actions to Prevent Reoccurrence		Action by Whom and Date to be Completed
Investigated by:		Title:
Telephone:	Date:	Signature

Appendix F: Basic Laboratory Techniques

1. Lighting a Bunsen Burner

   Become familiar with the style of Bunsen burner you have, noting how the air ports can be adjusted.

   Steps to follow are:

   a. Attach the rubber intake hose of the Bunsen burner to the nearest gas valve.

   b. Check that all gas valves at the laboratory benches are shut off, and then open the main gas valve.

   c. Close off air intake ports at the base of the barrel so as to produce a cool red flame upon lighting. This is done either by rotating the barrel clockwise until it stops or rotating a sleeve at the base of the barrel to cover intake ports.

   d. If there is a gas valve at the base of the barrel, check that it is open about one-half to one revolution.

   e. Fully open the valve attached to the intake hose. If there is no valve at the base of the barrel, then partially open the valve at the intake hose. Using a flint striker or a match, light the gas at the top of the barrel. If there is too much gas/air mixture coming through the barrel, it will create a strong current of gas that is difficult to light and that may blow out the match. If this happens, check the air intake ports to ensure they are closed. Once lit, you should have a cool red flame.

   f. The air ports can then be opened by turning the barrel counter-clockwise or rotating the sleeve to get the desired intensity of flame (blue flame is hottest).

   g. The gas valve can be opened further to get a bigger flame.

2. Pouring Solutions into a Funnel Filter

   Pour the liquid along a glass stirring rod, the end of which is in line with the centre of the filter in the funnel. This will avoid splashing the solution or liquid.

   [See Videos listed at the end of this appendix.]

3. Diluting Concentrated Acids and Bases

   Working with concentrated acids or bases safely requires careful handling and an understanding of the hazards involved.

> Never add the water to the concentrated acid or base, as this causes an excessive build-up of heat and spattering may result. The acid or base should always be added to the water.

The following steps help to reduce the inherent hazards associated with these concentrates:

a. Put on a long-sleeved laboratory coat, rubber gloves, and full face protection.

b. Determine the volume ratio of water and acid/base required for the concentration intended and the total volume of dilute acid/base needed. *Example: Let us assume 1 L of 10% sulfuric acid is required and 50% sulfuric acid is on the shelf. To get a 10% concentration requires a ratio of 2 mL of 50% acid to 8 mL of distilled water. Therefore, to make 1 L of 10% acid, add 200 mL of the acid to 800 mL of water.*

c. Measure the required amount of the concentrated acid or base in a graduated cylinder. This can be done in a fume hood to avoid inhaling fumes, particularly acid fumes that are very corrosive. Now add it slowly to the proportionate amount of water in another container. Using a glass stirring rod, stir the water as the acid or base is added to dissipate the heat.

d. Avoid inhaling concentrated acid vapours.

4. Cutting Glass Tubing

Follow the procedure as outlined.

a. Etch the glass with a triangular file.

b. With the etch facing away from you, hold the tubing with both hands so that the thumbs are pressing on each side of the etch. Apply gentle pressure on the thumbs to snap the tubing.

c. Glazing or fire polishing the cut end of the tubing in a hot Bunsen burner flame will remove the rough edges.

5. Inserting Glass Tubing into a Stopper

Safe insertion of tubing or a thermometer into a rubber stopper can be done as follows:

a. Ensure there are no rough edges on the end being inserted. If necessary, glaze the end in a hot flame and let cool.

b. Lubricate the glass with glycerin, Vaseline, or stopcock grease.

c. Wrap a cloth around the tubing or thermometer, or put on thick gloves before starting the insertion.

d. Grasp the tubing close to the end to be inserted with the fingers of one hand and the stopper in the fingers of the other. Avoid grasping either with the palm of your hand.

e. Insert with a rotating motion while applying gentle pressure. Avoid excessive force that can snap the tubing. If excessive force is required, check to ensure the hole is large enough to accommodate the tubing.

Notes

If glass tubing or thermometers remain in stoppers for prolonged periods of time, the stoppers will harden and the glass will bind to the stopper surface. Do not attempt to push or pull glass tubing or thermometers from rubber or cork stoppers that have hardened. It is best to cut away the stopper from the glass with a sharp knife or scalpel.

6. Boiling Liquids

   Liquids often boil in an uneven fashion called "bumping," because bubbles of steam cannot form regularly on the smooth container walls. This leads to irregular flashes of superheating that result in large bubbles of steam erupting violently to the surface, causing splashing and spitting or, at worst, expulsion of contents from full containers.

   Bumping can be prevented by adding a few boiling chips to the liquid before you start heating. These chips provide a rough surface upon which bubbles can form. Avoid adding the chips to liquids near boiling temperature because this can cause immediate boiling over of the liquid. "Porous" boiling chips cannot be reused since the pores become filled with liquid on cooling. "Sharp" chips like silicon carbide or coal are reusable until they become coated with residues and become ineffective.

7. Heating Flammable Liquids

   Heating flammable liquids should be done in a water bath heated by a hot plate. Test tubes of flammable liquid can be placed in a beaker of water large enough to immerse the test tube contents but small enough to keep the tubes upright. If the use of an open flame cannot be avoided in heating the water bath container, place the container on a wire gauze or alternative surface to ensure that the flame does not reach the flammable vapours. Alternatively, a larger metal tray of water placed on a stand plus a beaker of water set into the tray to hold test tubes of flammable liquid would be the safest arrangement when an open flame is used. If it is the beaker itself that holds the flammable liquid, then it may have to be weighed down to offset buoyancy while in the water bath.

8. Avoiding a Van de Graaff Discharge

   Operating a Van de Graaff generator in a draft-free room with low humidity may result in a build-up of electric charge on your body if your shoes are non-conducting and prevent flow of current to the floor. Once electrified, you will get an electric discharge if you touch any grounded object, such as the metal switch to turn the machine off. To avoid this unpleasant "zap," hold a small metal object in your hand while using the generator, and then touch it against ground before turning off the generator switch with your other hand.

9. Removing Stuck Glass Stoppers

   Follow the procedure outlined below:

   a. Stand the bottle in a large sink.
   b. Cover the stopper and the neck of the bottle with a cloth.
   c. Gently tap the stopper. If the jammed stopper is glass, use another glass stopper to tap against it, since glass stoppers will set up a resonance that will often successfully loosen the stopper stuck in the bottle.
   d. If possible, run the neck of the bottle under a stream of hot water to allow for expansion of the neck, and then repeat the tapping.
   e. If these measures fail, it will be necessary to break the neck of the bottle to remove its contents. Score around the neck with a glass file, then apply a point of hot glass to the score mark. The neck should break cleanly along the score mark.

10. Weighing Chemicals

    When handling chemicals, keep the following points in mind:

    a. Wear a protective apron and gloves when necessary.
    b. Always place the powdered chemical on paper (filter paper, hand towel, paper cup) or in a container when weighing necessary amounts. Avoid chemical contact with metal pan or balance.
    c. Use a fume hood when handling powders of more toxic or corrosive chemicals to avoid inhalation.
    d. Replace the cover or stopper on the chemical container as soon as possible, particularly for more volatile substances.
       [See Videos listed at the end of this appendix.]

11. Odourous Chemicals

    If required to smell the chemical or solution, hold the container slightly in front of and beneath your nose and waft the fumes towards your nostrils with your hand.

    Never smell a chemical or solution directly.

12. Use of Scalpels

    Remember the following points when using scalpels:

    a. Always cut away from fingers near the area being dissected.
    b. Never try to catch a scalpel that has been dropped.
    c. After completing a series of dissections, immerse in 5% sodium hypochlorite solution for at least 30 minutes to prevent carry-over of contaminants. Follow with a thorough cleaning of scalpels.

13. Use of an Autoclave

    Autoclaves are high-pressure steam or dry heat devices used to sterilize infected or potentially infected material, or to prepare for sterilized solutions or equipment. To operate an autoclave safely, remember the following points:

    a. Ensure the door is completely closed before starting the sterilization process.
    b. Use containment procedures when sterilizing known infected material. Wear full protection including a long-sleeved laboratory coat or gown, protective gloves, and a face mask as a minimum protection against infection.
    c. Always use a "hot hand" or glove to remove any article from the autoclave. It must never be presumed that the autoclave has cooled down.
    d. Carry out regular sterilization effectiveness testing using spore strips or an equivalent.
    e. Regularly check mechanical parts of the autoclave for normal functioning. Poorly maintained autoclaves can be lethal.

14. Pressure Cooker-Type Autoclave

    a. Ensure safety valve is clear and operative.
    b. Tighten wing nuts evenly by tightening two opposite nuts simultaneously.
    c. Do not allow the operational pressure (gauge reading) to exceed that specified in the operation manual. Generally, this will be between 101.3 kPa to 138 kPa (15–20 psi) pressure.
    d. Allow to cool before opening the stopcock to equalize pressure.
    e. Remove the cover only when the pressure has been equalized.

15. Shaking a Test Tube

    The proper and safe technique of shaking the contents of a test tube is as follows:

    a. Place a stopper into the tube.
    b. Shake the tube by flicking it with your finger or by holding the stopper with your thumb and turning the tube over several times.

Videos

Using a Balance. MIT Digital Lab Techniques Manual. www.youtube.com/watch?v=cG6QrqS4ruQ&list=PL07AC74BBD3085056

Filtration. MIT Digital Lab Techniques Manual. www.youtube.com/watch?v=P-UBuAFxJiA&list=PL07AC74BBD3085056

Appendix G: Chemicals that Pose Excessive Hazards

Chemical	Description of Hazards
Acetic anhydride – liquid (acetic oxide, ethanoic anhydride) $C_4H_6O_{3(l)}$	Corrosive; causes severe burns to any area of contact; severe eye and respiratory irritant; harmful if swallowed; flammable liquid and vapour; water reactive.
Acetyl chloride – liquid (ethanoyl chloride) $CH_3COCl_{(l)}$	Corrosive; causes severe burns to eyes and skin; harmful if inhaled or swallowed; highly flammable; reacts violently with water, forming toxic phosgene.
Acrolein – liquid (2-propenal, acrylaldehyde) $C_3H_4O_{(l)}$	Corrosive; causes severe irritation or burns to eyes and skin; highly toxic if inhaled or ingested; highly flammable; may be carcinogenic.
Aluminium chloride, anhydrous – powder $AlCl_{3(s)}$	Corrosive; causes irritation and burns to skin, eyes, and respiratory and digestive tracts; reacts violently with water, forming HCl.
Ammonia, anhydrous (liquid under pressure) – gas $NH_{3(g)}$ & $NH_{3(l)}$	Corrosive liquid and gas; irritating and causes burns to eyes and skin; may cause burns if ingested or inhaled; flammable vapour; air-gas mixture explosive.
Ammonium chromate – crystals $(NH_4)_2CrO_{4(s)}$	Corrosive; causes severe irritation, burns to skin, eyes, and mucous membranes; may be fatal by ingestion, inhalation, or skin absorption; strong oxidizing agent, may explode when heated; mutagen; human carcinogen.
Ammonium dichromate – crystals $(NH_4)_2Cr_2O_{7(s)}$	Corrosive; causes severe skin and eye irritation and burns to any area of contact; toxic by inhalation or ingestion; very strong oxidizing agent; combustible solid if ignited; decomposes if heated; known human carcinogen.
Ammonium sulfide – liquid $(NH_4)_2S_{(l)}$	Corrosive; strong skin, eye, and mucous membrane irritant; causes burns to any area of contact; may be fatal if swallowed or inhaled; harmful if absorbed through skin; highly flammable liquid and vapour; toxic hydrogen sulfide gas is released when heated.
Antimony powder – solid $Sb_{(s)}$	Dust causes skin, eye, digestive, and respiratory irritation; prolonged exposure may cause blood abnormalities and cardiac disturbances; inhalation of fumes causes metal-fume fever; chronic inhalation may cause liver, kidney, and cardiac changes; bulk metal combustible at high temperatures; dust-air mixture is explosive.

Chemical	Description of Hazards
Antimony trichloride – crystals (trichlorostibine) $SbCl_{3(s)}$	Corrosive; contact with skin and eyes causes severe irritation or burns; harmful if inhaled, ingested, or absorbed through skin; inhalation of dust may cause dizziness and difficulty breathing; ingestion causes nausea, vomiting, and loss of consciousness; water-reactive; releases heat and toxic fumes.
Arsenic and arsenic compounds	Toxic, carcinogens; arsenic powder is a very strong neurotoxin; arsenic compounds are toxic by inhalation and/or ingestion.
Asbestos – fibrous solid	Causes irritation of the eyes, nose, and throat; prolonged inhalation of particles causes asbestosis and cancer.
Azide compounds	Explosive in contact with metals, extremely reactive, highly toxic.
Benzene – liquid $C_6H_{6(l)}$	Toxic; causes irritation of the skin, eyes, and respiratory tract; toxic by ingestion, inhalation, and skin absorption; depresses the central nervous system; highly flammable; human carcinogen.
Benzoyl peroxide - crystals (dibenzoyl peroxide, acetoxyl, nericur) $(C_6H_5CO)_2O_{2(s)}$	Irritant of skin, eyes, and respiratory tract; harmful if swallowed or inhaled; possible mutagen and carcinogen; highly flammable; strong oxidizer, reaction with reducing compounds can cause fire; extremely explosive; sensitive to shock, friction, and heat.
Beryllium and its compounds	Very toxic if swallowed or inhaled; irritating to skin, eyes, and respiratory system; human carcinogens.
Bromine – liquid and gas Br_2 (l) or Br_2 (g)	Highly toxic by skin contact, inhalation, or ingestion; severe skin irritant, causes severe burns; very strong oxidizer; reacts violently with many organic compounds.
Cadmium (powder or chunks) and cadmium salts	Toxic by skin contact, inhalation, or ingestion; may be fatal if inhaled; carcinogenic with prolonged exposure.
Carbides	React with acids and water to release heat and/or flammable gases.

Chemical	Description of Hazards
Carbon disulfide – liquid (carbon bisulfide) $CS_{2(l)}$	Toxic; may be fatal if inhaled or ingested; harmful if absorbed through skin; affects the central nervous system and heart; may cause liver and kidney damage; has adverse reproductive and fetal effects; extremely flammable liquid and gas.
Carbon tetrachloride – liquid $CCl_{4(l)}$	Toxic; may be fatal by inhalation or skin absorption; highly toxic by ingestion; causes irritation to skin, eyes, and respiratory tract; readily absorbed through skin; reproductive toxin; flammable; emits toxic fumes; mutagen and possible human carcinogen.
Chlorine – gas $Cl_{2(g)}$	Extremely toxic if inhaled; strong oxidizer.
Chloroform – liquid (trichloromethane) $CHCl_{3(l)}$	Causes irritation to skin, eyes, and respiratory tract; may be fatal if swallowed, inhaled, or absorbed through skin; extended exposure may affect the central nervous system, cardiovascular system, liver, and kidneys; possible human carcinogen.
Chromic acid – solution (chromium VI oxide solution) $CrO_{3(aq)}$	Corrosive; causes burns to skin, eyes, and mucous membranes; highly toxic; powerful oxidizing agent; avoid contact with reducing agents and organic material; a human carcinogen as fume or dust.
Colchicine – powder $C_{22}H_{25}NO_{6(s)}$	Corrosive and highly toxic if swallowed; causes severe irritation of eyes; causes irritation of skin and respiratory tract; may be fatal if inhaled or absorbed through skin; may cause birth defects; affects the reproductive system; combustible if heated or ignited.
Collodion solution – liquid (pyroxylin solution) Mixture Ethyl ether Ethyl alcohol Nitrocellulose	Causes skin irritation, possible burns, and moderate eye irritation; harmful if inhaled, swallowed, or absorbed through skin; extended exposure to vapour can cause lung damage; may cause central nervous system depression or reproductive and fetal effects; may cause liver and kidney damage; prolonged exposure to air may form unstable explosive peroxides; extremely flammable; possible human carcinogen.
Copper metal – powder $Cu_{(s)}$	Causes irritation to skin, eyes, and mucous membranes; harmful if swallowed or inhaled; affects the liver and kidneys; chronic exposure may cause tissue damage.
1,2-dichloroethane – liquid (ethylene dichloride) $ClCH_2CH_2Cl_{(l)}$	Harmful if swallowed, inhaled, or absorbed through skin; affects the nervous system, liver, kidneys, and cardiovascular system; flammable liquid and vapour; possible human carcinogen.

Chemical	Description of Hazards
2,4-dinitrophenol – powder (aldefin) $C_6H_4N_2O_{5(s)}$	Toxic by inhalation and ingestion; danger of cumulative effects; flammable; may explode when heated.
1,4-dioxane – liquid (1,4-diethylene dioxide) $C_4H_8O_{2\ (l)}$	Most toxic by inhalation; easily absorbed through lungs; poisoning has poor warning properties; anhydrous form oxidizes, slowly forming explosive peroxides in storage; highly flammable; a possible human carcinogen.
Diethyl ether – liquid (ethyl ether) $C_4H_{10}O_{(l)}$	Causes skin, eye, and respiratory irritation; harmful by ingestion, inhalation, or skin absorption; may cause inebriation or coma; extremely flammable; unstable; reacts with air to form explosive peroxides while in storage.
Formaldehyde - solution (formalin, methanal) Mixture: HCHO CH_3OH H_2O	Toxic by inhalation, ingestion, and through skin absorption; extremely destructive to tissues of the mucous membranes and upper respiratory tract; ingestion may be fatal or cause blindness; flammable liquid and vapour; mutagen; probable human carcinogen.
Hydrazine	Flammable, corrosive, and highly toxic; unstable; carcinogen.
Hydrogen fluoride - solution (hydrofluoric acid) $HF_{(aq)}$	Extremely corrosive and toxic; vapour causes severe burns to skin, eyes, and respiratory tract; burns to skin may not be immediately painful or visible; may be fatal if swallowed or inhaled; causes bone damage; reaction with metals generates explosive hydrogen gas.
Hydrogen sulfide – gas $H_2S_{(g)}$	Very corrosive and toxic; low concentrations (50 ppm) cause eye and respiratory membrane irritation; death occurs in 1-4 hours at 300-500 ppm, immediate respiratory arrest in excess of 1000 ppm; toxic by ingestion or inhalation; severe exposures, short of death, may cause long-term symptoms including lung damage, memory loss, paralysis of facial muscles, or nerve tissue damage.
Lithium – solid $Li_{(s)}$	Corrosive; causes eye and skin burns; may cause severe respiratory or digestive tract irritation or burns; may cause kidney damage and central nervous effects; light sensitive; reacts with water; flammable solid.
Mercury – liquid (quicksilver) $Hg_{(l)}$	Corrosive; causes burns to skin, eyes, and respiratory tract; may be fatal if swallowed or inhaled; harmful if absorbed through skin; chronic exposure affects the central nervous system and kidneys.

Chemical	Description of Hazards
Mercury compounds	Toxic.
Methylene chloride – liquid (dichloromethane) $CH_2Cl_{2(l)}$	Causes irritation and possible burns to skin, eyes, and respiratory tract; may be absorbed through skin; may depress central nervous system function; combustible if heated or ignited; vapours may form explosive mixture with air; mutagen and possible human carcinogen.
Methyl ethyl ketone – liquid (2-butanone) $C_4H_8O_{(l)}$ or $CH_3COCH_2CH_{3(l)}$	Causes mild irritation to skin; vapour causes moderate irritation to eyes, nose, and respiratory tract; higher than 350 ppm exposure causes nervous system depression; very high concentrations cause unconsciousness and possible death; flammable liquid, vapour-air mixture explosive.
Nickel powder and nickel salts	Powder may cause irritation to skin, eyes, and respiratory tract; causes gastrointestinal irritation with nausea, vomiting, and diarrhea if ingested; powder pyrophoric, can ignite spontaneously; human carcinogen; nickel salts are carcinogenic with long-term exposure.
Nitrogen dioxide – liquefied gas $NO_{2(l)}$ & $NO_{2(g)}$	Very toxic and corrosive; short-term exposure causes irritation and possible burns to skin, eyes, and respiratory tract; potentially fatal if inhaled; strong oxidizer, contact with combustible material may cause fire.
Perchloric acid – solution $HClO_{4(aq)}$	Corrosive; causes severe burns at site of contact; very harmful through skin contact, inhalation, and ingestion; unstable, will decompose explosively at higher temperature or if allowed to dehydrate; contact with wood, paper, and other cellulose products may lead to explosion; strong oxidizer.
Phenol – solid (carbolic acid, hydroxybenzene, oxybenzene, phenic acid, phenyl hydrate, phenyl hydroxide, phenelic alcohol) $C_6H_6O_{(s)}$	Corrosive and toxic; absorbed rapidly through skin; causes severe burns to any area of contact; may be fatal if swallowed, inhaled, or absorbed through skin; affects central nervous system, liver, and kidneys; causes adverse reproductive and fetal effects; flammable.
Phosphorus, red $P_{(s)}$	Causes eye irritation; may be harmful if swallowed or if fumes are inhaled; flammable solid, may ignite from friction.
Phosphorus, yellow (white phosphorous) $P_{4(s)}$	Corrosive; causes severe skin and eye burns; harmful if absorbed through skin; acute inhalation causes serious damage to lungs and respiratory tract; may be fatal if swallowed; extremely flammable, ignites spontaneously on exposure to air; fumes from burning phosphorus extremely irritating.

Chemical	Description of Hazards
Phosphorus pentoxide – powder (phosphoric anhydride) $P_2O_{5(s)}$	Corrosive; fumes cause irritation to eyes and respiratory tract; causes burns to any area of contact; harmful if swallowed or inhaled; reacts violently with water to form phosphoric acid.
Picric acid – crystals (2,4,6-trinitrophenol) $C_6H_3N_3O_{7(s)}$	Toxic; causes skin and respiratory tract irritation, and severe eye irritation; harmful if swallowed, inhaled, or absorbed through the skin; affects the liver, kidneys, and blood; stable in water but explosive if allowed to dry; becomes increasingly shock-, heat-, and friction-sensitive as moisture is lost; flammable solid.
Potassium (metal) – solid $K_{(s)}$	Corrosive; causes burns to all areas in contact; harmful or fatal if swallowed; harmful if absorbed through skin; water reactive; flammable solid, ignites when exposed to air.
Potassium perchlorate	Powerful oxidizer; reactivity hazard.
Sodium (metal) – sticks $Na_{(s)}$	Corrosive; contact may cause burns; harmful if metal absorbed through skin; harmful or fatal if ingested; flammable solid, ignites spontaneously in air; reacts violently with water, releasing explosive hydrogen gas.
Sodium arsenite – powder $NaAsO_{2(s)}$	Toxic; causes irritation to skin, eyes, and respiratory tract; may be fatal by ingestion or inhalation; may cause liver and kidney damage; carcinogen.
Sodium fluoride – crystals $NaF_{(s)}$	Toxic; causes irritation to skin and eyes, and severe irritation to respiratory tract; irritation effects may be delayed; may be fatal if swallowed or inhaled; prolonged exposure affects the respiratory, circulatory, central nervous system, and kidneys; may cause mottling of teeth and bone damage.
Sodium peroxide – granules $Na_2O_{2(s)}$	Corrosive; causes burns to any area of contact; harmful if swallowed or inhaled; reacts with water; strong oxidizer; contact with combustible material may cause fire.
Sodium sulfide nonahydrate – crystals $Na_2S \bullet 9H_2O_{(s)}$	Corrosive; causes severe burns to any area of contact; harmful if swallowed or inhaled; unstable in storage; decomposes in contact with moisture and acids, forming toxic combustible hydrogen sulfide gas.
Strontium $Sr_{(s)}$	Corrosive; contact may case burns; harmful or fatal if swallowed; flammable solid, granules ignite spontaneously with air; reacts with water.

Appendix H: Chemical Inventory

Chemical inventory Completed by:							Review date:				
Chemical	Quantity	Storage category and location	Clarifying details	Supplier	CAS number	WHMIS classification	Disposal	Hazards	Date added	Amount remaining	Disposal date

Appendix I: Chemical Waste Treatment and Disposal

Notes

These treatments should only be carried out by staff who have knowledge of the chemistry involved and are experienced in working with chemicals. In all other cases, the chemicals in their original form should be disposed of through a qualified waste broker.

These processes can reduce disposal costs and environmental impact, especially for larger quantities. Since schools may still have chemicals on-site that are no longer used or are not recommended for use in schools (e.g., heavy metals such as lead), treatment processes for these substances have been included. Their inclusion, however, does not imply appropriateness for school use. Hazardous waste treatment includes evaporation of aqueous solutions and various chemical treatments.

Evaporation of Aqueous Solutions

When solutions contain chemicals not suitable for recovery, the volume of hazardous materials can be greatly reduced by allowing the solution to evaporate under a fume hood or in another well ventilated area. Transfer the solution to a wide-mouthed container, such as an evaporating basin or large beaker for maximum evaporation surface, and allow it to stand until a sludge remains. This sludge can be appropriately labelled for off-site disposal at such time as the volume of sludge sediment required dictates.

Chemical Treatment

Disposal of hazardous wastes is regulated by municipal by-laws (see Chapter 1). If your municipality does not allow the disposal of acids, bases, or heavy metal salts directly into sewer systems, a qualified waste broker should be contacted to remove the waste. Alternatively, the following treatments may be used by staff who have knowledge of the chemistry involved and are experienced in working with chemicals.

A number of substances can be chemically converted into an insoluble or less toxic form that may, in many cases, be disposed of by means other than a chemical waste facility. Appropriate personal protective equipment, including eye protection, gloves, and laboratory coat, should be worn when performing the reactions.

Neutralization of Acids and Bases

Waste quantities of acids, such as hydrochloric acid, sulfuric acid, nitric acid, and acetic acid, and bases such as sodium and potassium hydroxides, can be neutralized and washed into the drain. First, carefully add the concentrated acids or bases to 20 times their volume of water so that their concentration is reduced below 5%. This should be done in an ice bath under a fume hood using an adequately sized container (e.g., 100mL of concentrated waste will require 2 L of water). Caution: never add water to concentrated acid. Add 5% sodium hydroxide solution or solid sodium carbonate (soda ash) to the dilute solutions of waste acid until the pH is between 6 and 8. Waste dilute solutions of base can be treated with waste dilute solutions of acid or with 5% hydrochloric acid solutions. The neutralized solutions can be washed down the drain.

Precipitation of Heavy Metal Salts

There are experiments both in Grade 11 and Grade 12 Chemistry that may require small amounts of heavy metals, such as silver, copper, iron, cobalt, manganese, chromium, nickel, or tin.

An alternative to the evaporation of dilute aqueous solutions of heavy metal salts is to precipitate the metals as an insoluble salt that can be removed by filtration or by allowing the solid to settle and decanting the liquid. The residue can then be disposed of according to relevant guidelines. Specific directions for precipitating lead ions from solution as their silicate are described, as are the modifications needed to use this method for other heavy metal ions. The formation of the silicate can be summarized by the following generalized equation:

$$Pb^{2}+ (X)\,(aq) + Na_2SiO_{3(aq)} \rightarrow PbSiO_3(s) + 2Na(X)(aq) \qquad \text{where X is a negative anion}$$

Add a 0.01 molar solution of a soluble lead salt (e.g., 0.166 g of lead II nitrate in 50 mL of water) to a 0.03 mol/L solution of sodium metasilicate (0.392g $Na_2SiO_3 \bullet 9H_2O$ in 50mL of water). Stir well. Adjust the pH to about 7 by the addition of about 15 mL of 2 mol/L aqueous sulfuric acid. Collect the precipitate by filtration or allow the mixture to stand until the solid has settled to the bottom of the container and the liquid can be poured off. Allow the solid to dry, and then package and label for disposal.

For dilute solutions of lead salts of unknown concentration, the sodium metasilicate solution should be added until there is no further precipitation. Adjust the pH to a level between 7 and 8 with the addition of 2 mol/L sulfuric acid, and allow the solution to stand overnight before collecting the solid by filtration or by allowing it to settle and pouring off the liquid. Solutions of cadmium and antimony salts can be treated similarly. Several other heavy metal salts can also be precipitated in the same way as silicates. The quantities given for lead are also appropriate for 0.01 moles of these metals. The only modification necessary is a change in the pH at which the silicate is precipitated. This includes the Fe (II) & (III) ions, Zn(II), Al(III), Cu (II), Ni (II), Mn (II), and Co (II) ions, all of which can be precipitated without adjustment of the pH that results from the addition of the solutions of sodium metasilicate.

pH of Precipitation of Metal Ions Using Sodium Silicate

Metal Ion	pH for maximum precipitation	Concentration of metal ion remaining in solution
Iron II	9.5–10.0	5 ppm
Iron III	10.0–10.5	2 ppm
Zinc II	8.5	< 0.5 ppm
Aluminum III	8.5	< 2 ppm
Copper II	10.5–11.0	0.03 ppm
Cobalt II	9.5–10.0	0.08 ppm
Manganese II	9.5–10.0	0.2 ppm
Nickel II	9.5–10.0	0.3 ppm

Similarly, solutions of unknown concentration can be treated with sodium metasilicate solution until there is no further precipitation. Adjust the pH to the required value by the addition of 2 mol/L sulfuric acid or 5% sodium hydroxide solution, and allow the mixture to stand overnight before collecting the solid by filtration or by allowing it to settle and pouring off the liquid. After standing in the air to dry, the metal silicates should be placed in a labelled container for disposal. The liquids can be washed into the drain.

Reduction of Oxidizing Agents

Inclusion of this reduction process does not imply appropriateness for school use of some of the compounds identified here. The process is described, however, for the benefit of schools that may have these compounds on their shelves and are looking to discard them.

Solutions of compounds, such as potassium permanganate, sodium chlorate, sodium periodate, and sodium persulfate, should be reduced before being discarded into the drain to avoid uncontrolled reactions in the sewer system. The reduction can be accomplished by treatment with a freshly prepared 10% aqueous solution of sodium bisulfite or metabisulfite. Specific quantities and conditions for these reactions are detailed in the table below.

Oxidizing agent present in wastestream	Quantity and concentration of oxidizing agent in aqueous solution	Quantity of 10% aqueous sodium metabisulphite	Comments
Potassium permanganate	2L of 6%	1.3 L	Solution becomes colourless
Sodium chlorate	1L of 10%	1.8 L	50% excess reducing agent added
Sodium periodate	1L of 9.5%	1.7 L	Solution becomes pale yellow
Sodium persulphate	1L of 10%	0.5 L	10% excess reducing agent added

Treatment of Iodine and Iodine Solutions

Under the fume hood, cautiously add 1 gram of solid iodine to a solution of sodium thiosulfate (2.5 g sodium thiosulfate in 60 mL of water) also containing 0.1g of sodium carbonate. Stir the mixture until the iodine has all dissolved and the solution is colourless. Check the pH and, if needed, add solid sodium carbonate to bring the pH of the solution to a level between 6 and 8. The solution can then be washed into the drain. The following is a summary of the reaction:

$$I_2\,(s) + Na_2S_2O_3(aq) + Na_2CO_3(aq) \rightarrow 2NaI(aq) + Na_2SO_4(aq) + S(s) + CO_2(g)$$

Solutions of iodine can be dealt with as follows: Stir a sodium thiosulfate solution (4 g in 100 mL of water) containing sodium carbonate (0.1 g) into the iodine solution. Continue stirring until the solution becomes colourless. If necessary, add sodium carbonate to bring the pH to a level between 6 and 8. Treat the liquid for sulfides.

Treatment of Sulfides

Under a fume hood, place 1 mol/L $FeCl_3$ solution (three times the excess of solution to be disposed of) in a beaker, and then add disposal solution with continuous stirring. A precipitate will form. Neutralize with sodium carbonate, a reaction that will release CO_2 gas. A summary of the reaction can be given as follows:

$$2\ Fe^{3+} + 3\ S^{2-} \rightarrow Fe_2S_3(s)$$

Allow precipitate to settle and then either decant solution or filter. Flush neutral solution down the drain and dispose of the precipitate to an appropriate landfill. If flushing of iron is a sewer concern, then all the material may be evaporated to dryness and disposed of via solid waste disposal.

Science and Safety

References/Resources

REFERENCES/RESOURCES

Blood Safety and Blood Typing

Canadian Blood Services
www.blood.ca/
Email: whatsyourtype@blood.ca

Chemical Safety

Health Canada – Substances assessed for Carcinogenicity
www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/carcinogenesis-carcinogenese-eng.php

Electrical Safety

Canadian Centre for Occupational Health and Safety
www.ccohs.ca/oshanswers/safety_haz/electrical.html

Environmental Requirements

Environment Canada, Guidelines and Codes of Practice
www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=2952CB83-1

Canadian Environmental Protection Agency (CEPA)
www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=D44ED61E-1

Manitoba Waste Management
www.gov.mb.ca/trade/globaltrade/environ/waste.html

City of Winnipeg: Sewer by-law
www.winnipeg.ca/clkdmis/DocExt/ViewDoc.asp?DocumentTypeId=1&DocId=5243

City of Brandon: Sewer by-law
www.brandon.ca/images/pdf/bylaws/5957.pdf (See section 66, p. 35)

City of Thompson: Sewer by-law
www.thompson.ca/modules/showdocument.aspx?documentid=184

City of Portage-la-Prairie: Sewer by-law
www.city.portage-la-prairie.mb.ca/images/bylaws/Sewage%20By-Law%2096-7863.pdf

Lab Safety and Techniques

Filtration | MIT Digital Lab Techniques Manual
www.youtube.com/watch?v=P-UBuAFxJiA&list=PL07AC74BBD3085056

Using a Balance: MIT Digital Lab Techniques Manual
www.youtube.com/watch?v=cG6QrqS4ruQ&list=PL07AC74BBD3085056

Flinn Scientific: Laboratory Safety Training Videos
https://www.youtube.com/playlist?list=PLF706B7CE2FEF71C4

Flinn Scientific: Dispensing Chemicals and Acid Safety
https://www.youtube.com/watch?v=mPEDepKXfeE&list=PLF706B7CE2FEF71C4

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https://www.youtube.com/watch?v=49LjT7upENM&list=PLF706B7CE2FEF71C4

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https://www.youtube.com/watch?v=afD4hixwHmE&list=PLF706B7CE2FEF71C4

Legislation

Workplace Safety and Health Act (Manitoba)
safemanitoba.com/wsh-act

Environment Protection Act (Canada)
www.ec.gc.ca/lcpe-cepa/

Hazardous Products Act (Canada)
laws-lois.justice.gc.ca/eng/acts/H-3/

Transportation of Dangerous Goods Act (Canada)
www.tc.gc.ca/eng/acts-regulations/acts-1992c34.htm

Canada Water Act
laws.justice.gc.ca/en/C-11/24944.html

The Public School Act (Manitoba)
web2.gov.mb.ca/laws/statutes/ccsm/p250e.php

The Teachers' Society Act (Manitoba)
web2.gov.mb.ca/laws/statutes/ccsm/t030e.php

The Manitoba Hazardous Waste Management Corporation Act
web2.gov.mb.ca/laws/statutes/ccsm/h015e.php

Model Rocketry

Canadian Association of Rocketry
www.canadianrocketry.org/

Nuclear Substances and Radiation Devices

Canadian Nuclear Safety Commission
http://nuclearsafety.gc.ca/eng/about/regulated/nuclearsubstance_radiation/

Safety Planning

Guide for Developing a Workplace Safety and Health Program
http://safemanitoba.com/uploads/guidelines/developingws_hprogramjuly2010.pdf.

Alberta Learning. *Safety in the Science Classroom (K–12)*
http://education.alberta.ca/teachers/program/science/resources/safety.aspx

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